Evaluation of Traffic Crash Fatality Causes and Effects

A Study of Fatal Traffic Crashes in Florida from 1998-2000 Focusing on Heavy Truck Crashes

Final Report

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METRIC CONVERSION FACTORS

1 N $\times$ 1,000 = 1 kN

1 ft $\times$ 0.3048 = 1 m

1 inch $\times$ 2.52 = 1 cm

1 kip $\times$ 4.448 = 1 kN

1 mph $\times$ 1.609 = 1 km/h

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16. Abstract

The number of highway fatalities and heavy truck crashes in the state of Florida remains unacceptably high. The principal objective of the proposed research was to provide an in-depth analysis of the causes of fatal traffic crashes and traffic fatalities so that appropriate actions can be initiated to improve safety on Florida's highways. To determine the actual causes of the crash, it was necessary to obtain more detailed data, including data from Traffic Homicide Investigation (THI) reports, video log and crash scenes photographs, and site visits where necessary. All fatal crashes on state roads in 2000 were investigated, along with those involving heavy trucks in 1999 and 1998. Crash data, investigating both behavioral and roadway-related causes of fatal traffic crashes was collected in an Oracle database and studied through case study analysis, dynamic behavior analysis, and statistical analysis. Various countermeasures, both behavioral and roadway-related, were recommended. The results of this research can be used to develop countermeasures to address the crash types and contributing factors occurring frequently on state roads in Florida, and to direct additional research projects into specific areas of need identified by this research. A total of 2,080 cases were reviewed as part of this project. Run off the road (32%) and intersection crashes (28%) were the common crash types, followed by pedestrian (16%) and rear-end/sideswipe (14%) crashes. Human factors were the primary causative factor in 94 percent of the fatal crashes; the most common human factors were alcohol and/or drug use and driver errors, including inattention and decision errors. Around 30 percent of the crash contributing factors (including secondary and tertiary factors) were roadway, environmental, and vehicle factors. Not wearing a seat belt is the most common cause of fatality found in this study. Among drivers wearing seat belts, the most common contributing factors to the fatality were age and nearside impacts. In heavy trucks, 50 percent of fatalities occurred in vehicles that rolled over, and 26 percent occurred in vehicles that caught fire. Trailer rear and side underrides accounted for almost 28 percent of the fatal impacts among occupants in vehicles impacting trucks.

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EXECUTIVE SUMMARY

Problem Statement

The number of highway fatalities in the state of Florida remains unacceptably high, with 40 percent more fatalities per vehicle mile than the national average in 1999. In addition, heavy trucks are overrepresented in fatal crashes in the state, with more than twice the percentage of fatalities as in crashes involving passenger cars. Presently, the data available from the FDOT Crash Analysis Reporting system (CAR) database is limited. It incorporates only the coded data from Florida Traffic Crash Report (FTCR), not including the narrative or diagram. This deficiency makes it difficult to reconstruct the events of the crash, especially in complicated multi-event crashes. In certain cases, the database also has questionable accuracy due to potential errors in completing crash report and in transcribing data to the computerized database. Even when the FTCR narrative and diagram are available, as is currently possible with TIFF images of the original crash forms, they are often lacking in detail, especially regarding driver attitudes and actions, making it difficult to differentiate causative factors and assign fault.

Objectives

The principal objective of the proposed research was to provide an in-depth analysis of the causes of fatal traffic crashes and traffic fatalities so that appropriate actions can be initiated to improve safety on Florida's highways. The goal of this project was to go beyond the data currently available from the FTCR, incorporating data from additional resources, including Traffic Homicide Investigation (THI) reports, video log and crash scenes photographs, and site visits where necessary. The following major objectives were established: 1) Investigate all fatal crashes in 2000 and those involving heavy trucks in 1999 and 1998. 2) Identify data elements deemed to be potential contributory factors for fatal crashes and traffic fatalities. 3) Develop a computerized database and querying tool to further subsequent use of the resulting data. 4) Analyze crash data, investigating both behavioral and roadway-related causes of fatal traffic crashes through case study analysis, dynamic behavior analysis, computer simulation, and multivariate statistical analysis. 5) Based on data collected during this study, recommend various countermeasures, both behavioral and roadway-related.

Findings and Conclusions

Table ES.1 shows the distribution of crashes according to a variety of contributing factors. The table highlights key aspects of the data set and does not include minor or unknown crash contributors. As a result, the total of the sub-groups displayed in the table may not add up to 100 percent. Additional factors are discussed in subsequent paragraphs and in the body of the report. The last column of the table shows the row-wise percentage of the next higher crash category. For instance, 28% of the run off the road crashes on interstates involved median cross-overs.

Table ES.1: Notable Contributing Factors in Fatal Crashes on State Roads in Florida

Crash Factor		Crashes	Fatalities		
		Num.	Num.	% of Total	% of Category
Fatal crashes in study	All fatal crashes	2080	2350	100	100
	At-fault driver age < 25	419	505	21	21
	At-fault driver age 25 – 64	1056	1195	51	51
	At-fault driver age ≥ 65	301	337	14	14
	At-fault driver under influence of alcohol	463	536	23	23
	At-fault driver under influence of drugs	121	149	6	6
	At-fault driver inattentive or distracted	454	513	22	22
	Motor vehicle fatalities (vehicle types 01 through 09)	1540	1790	76	76
	Unbelted occupants	986	1126	48	63
	Ejections	419	460	20	41
	Occupant age ≥ 65	338	370	16	21
	Motorcyclist fatalities	133	140	6	6
	Motorcyclist at fault	75	78	3	56
	Bicyclist fatalities	62	62	3	3
	Bicyclist at fault	47	47	2	76
	Pedestrian fatalities	345	350	15	15
	Pedestrian at fault	284	286	12	82

Truck crashes	All truck crashes			575	680	29	29
		Truck at fault		178	225	10	33
			Inattentive truck driver	63	88	4	39
			Truck driver “taking” ROW	38	45	2	20
	1998			199	238	10	35
	1999			198	241	10	35
	2000			178	201	9	30
Non truck	All non-truck crashes			1505	1670	71	71
ROR Crashes	All ROR crashes			682	780	33	33
		Driver age < 25		203	241	10	31
		Driver under influence of alcohol		221	253	11	32
		Driver under influence of drugs		62	74	3	9
		Abrupt steering input		221	253	11	32
		Interstate		272	319	14	41
			With no rumble strips	193	230	10	72
			Median crossover	64	88	4	28
		Rural 2-3 lane		87	95	4	12
			Tight curve (≤ 1500’)	67	72	3	76
	Overcorrect			177	194	8	25
		Interstate		73	84	4	43
			With no rumble strips	44	53	2	63
	Fixed object impact			380	421	18	54
		Tree		118	134	6	32
			Interstate	45	53	2	40
		Guardrail		79	91	4	22
	Overturn			365	412	18	53
		Tripped on grass shoulder or soft soil		164	189	8	46
		Tripped on fixed object		92	100	4	24
Intersection Crashes	All intersection crashes			699	775	33	33
	Signalized movement			252	279	12	36
		Left turn w/ gap judgment		97	110	5	39
		Red light running		91	104	4	37
	Stop sign			228	259	11	33
		Left turn w/ gap judgment		98	108	5	42
		Stop sign running		42	50	2	19
	Unsignalized movement			217	235	10	30
		Left turn w/ gap judgment		105	118	5	50
Pedestrian	All pedestrian crashes			353	350	15	15
	Daytime			81	78	3	22
		Intersection crossings		10	10	0	13
		Crossings within 600’ from intersection		16	16	1	21
		Crossings greater than 600’ from intersection		15	16	1	21
	Nighttime w/street light			135	134	6	38
		Intersection crossings		15	15	1	11
		Crossings within 600’ from intersection		44	44	2	33
		Crossings greater than 600’ from intersection		41	42	2	31
	Nighttime w/out street light			123	124	5	35
		Intersection crossings		6	6	0	5
		Crossings within 600’ from intersection		24	24	1	19
		Crossings greater than 600’ from intersection		45	46	2	37
Rear-end/ sideswipe	All rear-end/sideswipe crashes			359	410	17	17
		Truck involved		197	238	10	58
Head-on/ oncoming	All head-on/oncoming			248	310	13	13
		Truck involved		110	131	6	42

In addition to the crash factors enumerated above, the following conclusions can be offered regarding the fatal crash data under study. About three-fourths of involved drivers, at-fault drivers, and pedestrians in the fatal crashes were male. Human factors were the primary causative factor in 94 percent of the fatal crashes; the most common human factors were alcohol and/or drug use and driver errors, including inattention and decision errors. Around 30 percent of the crash contributing factors (including secondary and tertiary factors) were roadway, environmental, and vehicle factors. Tire tread separation/blowout was the most common vehicle factor by far, accounting for 40 percent of the non-human primary factors. Not wearing a seat belt is the most common cause of fatality found in this study, contributing to fatality among 63% of vehicle occupants. Among drivers wearing seat belts, the most common contributing factors in the fatality were age, nearside impacts and vehicle-vehicle impact (as opposed to fixed object and overturning crashes, which were less frequently harmful to belted occupants).

In heavy trucks, 50 percent of fatalities occurred in vehicles that rolled over, and 26 percent in vehicles that caught fire. Trailer rear and side underrides accounted for almost 28 percent of the fatal impacts among occupants in vehicles impacting trucks. Heavy trucks were overrepresented in multi-vehicle and multi-fatality crashes. Over half of the other vehicle defects (not including tire defects) in the fatal crashes belonged to heavy trucks, even though trucks only accounted for 17 percent of the vehicles in the crashes. Trucks were at-fault in only about 30 percent of the crashes in which they were involved; they were more likely to be at-fault in rear-end, run off the road, and intersection-turning crashes.

Substantial numbers of ROR crashes occurred on rural limited access facilities, involving younger (aged 15-24) drivers and those under the influence of alcohol. Alcohol, speed, and abrupt steering input (including overcorrection and evasive maneuvers) are the most common driver contributing factors in ROR crashes. For roads with posted speeds of 65 and above, about one-third of the ROR drivers were traveling at least 10 mph over the speed limit. Seat belts were much more effective in preventing fatalities in crashes where the most harmful event was overturning than where the most harmful event was a fixed object or vehicle-vehicle impact. SUV's were involved in fatal crashes at lower rates than the rates at which they are driven. However, SUV's were found to have the highest rollover rates compared to other vehicle types. Large vans and compact pickup trucks also had higher than average rollover rates. The only significant differences in causative factors between SUV rollovers and non-SUV rollovers were high rates of tire tread separation and tire blowouts in the SUV rollovers.

Except for about ten cases, all fatal intersection crashes were judged to have been primarily caused by human factors. Inattention was the chief primary contributing factor to the fatal intersection crashes, followed by driving under the influence (alcohol or drugs or both) and decision errors. However, almost 20% of the fatal intersection crashes had roadway issues involved that had a direct bearing on the occurrence of the crash, mostly as secondary and tertiary issues. Sight distance was the most common roadway issue, followed by location of stop bars, wide or confusing design/geometry, lack of turn lanes/storage, and signal timing issues.

The most common types of pedestrian crashes were pedestrians crossing a roadway not in a crosswalk (53%) and pedestrians that had exited a vehicle prior to the fatal event (13%), followed by pedestrians who were crossing at intersections (10%). Where alcohol use was determinable, 69% of pedestrians crossing at non-intersection locations were under the influence. Among drivers, the most common contributing factor was speeding followed by driver alcohol/drug impairment. Pedestrians who were attempting to cross at non-intersection locations were most often trying to cross in a 45 mph segment (38%), and were attempting to cross 5 or more lanes (65%). In 57% of the cases where a pedestrian was walking along the roadway, there was not a sidewalk for the pedestrian to use. A total of 15% of the pedestrian crashes occurred on limited access facilities (interstate, toll road, other limited access facility, or ramp); half resulted from a disabled vehicle.

A large number of fatal bicycle crashes involved middle aged and older bicyclists, who are on the road at night, with poor bicycle lighting, and often either under the influence of alcohol, impairing their judgment as to the safe operation of their bicycle, or inattentive to surrounding traffic conditions. Bicyclist right-of-way violations occurred frequently at intersections, as did cases of bicyclists veering into the road, often in an attempt to change lanes or make a left turn. The only environmental condition that played a significant role in the crashes was darkness, frequently coupled with poor bicycle lighting. Information gained from the case reviews paints a picture of many bicyclists who use that mode of transportation by necessity rather than choice; however, lack of information about license status hindered making such conclusions.

Over 35% of the crashes that occurred during the late morning hours (8:00 AM –noon) were caused by drivers over age 75 while over 25% of the crashes that occurred during the early morning hours (midnight – 4:00 AM) were caused by younger drivers. Older drivers were significantly overrepresented in fault in left turn crashes versus oncoming traffic and versus cross traffic. Misjudgment of speeds of the vehicles, failure to observe the vehicle/all sides, disregarding traffic signals, and improper left turn were the major contributing factors. Younger drivers were highly overrepresented in fault in forward impacts with control loss and in left roadside departure crashes. The case-based analysis revealed that driving under the influence of alcohol, exceeding safe speed limits, and abrupt steering input were three major factors in fatal crashes caused by younger drivers in Florida, resulting in a large number of single-vehicle, high-speed, pedestrian/bicycle related, and loss of control type crashes.

Recommendations

Based on the case reviews and data analysis, a number of recommendations are offered to reduce the number of fatal traffic crashes in the state of Florida. A combination of education, enforcement, engineering, and other countermeasures are suggested. The most relevant countermeasures that address the highest number of traffic fatalities are summarized here, grouped according to the rough number of fatalities in the study set to which the measure might potentially apply. More information on the recommendations is provided in the report, and additional countermeasures are suggested that are not listed here because of limited space. In considering these suggestions, one should remember that the study looked only at causes of fatal traffic crashes. As a result, it does not include traffic volumes and other exposure measures that should be considered before imp lementing state-wide programs. Detailed design solutions are beyond the scope of the research, as the purpose of the research was to identify potential causes of fatal crashes and directions for additional research and study, not to detail design the solutions. In addition, these strategies vary according to a critical issue that was identified at a crash site and care needs to be taken that while addressing the critical issue, other issues are not compromised.

Countermeasures Addressing Over 1000 Traffic Fatalities: It is recommended that primary enforcement laws be adopted in Florida. Stricter enforcement of existing seat belt laws, especially regarding minor children, is recommended. Public education campaigns should focus on high risk occupants (SUV's, light trucks, and vans), with the message that seat belts are effective in preventing occupant ejection during a crash, a major cause of fatal and incapacitating injuries.

Countermeasures Addressing Between 500 and 1000 Traffic Fatalities: Countermeasures for belted occupants should focus on preventing the crash in the first place, reducing the severity of the crashes through the improvement of safety vehicle features, and improving emergency response time. It is recommended that support be given to increased usage of in-vehicle wireless communications for quick emergency response. Side curtain air bags and stronger body frames would prevent fatalities due to nearside impacts (a common crash type in which belted drivers die) and rollovers.

Because of the high rates of ROR crashes on road segments without rumble strips, including a large number of crashes on limited access facilities, rumble strips should be considered on all roads with high rates of or potential for ROR crashes. To avoid increases in overcorrection-type crashes, additional research into the effects of rumble strip design on sound volume should be undertaken.

Alcohol and drug use were most strongly correlated with ROR crashes on non-limited access facilities. Since it is most common among 25-44 year olds, enforcement is expected to be a more effective countermeasure than education. However, alcohol was a contributing factor across the entire spectrum of crashes, including drivers of all ages and all types of crashes.

Countermeasures Addressing Between 250 and 500 Traffic Fatalities: Educational programs direct at young drivers should focus on building driving responsibility. Issues specific to younger drivers that can be addressed through educational and enforcement programs are, in order, driving under the influence, exceeding safe speed limits, abrupt and excess steering input, disregarding traffic signals and stop signs, and improper lane change/overtaking.

Overrepresentation in fault occurs with speeding as few as five miles per hour over the posted limit, so increased enforcement and stiffer penalties for lower levels of speeding should be considered. Education and enforcement measures should be directed toward drivers on high-speed segments such as on rural interstates.

Since elderly occupants are more likely to die in traffic crashes, even if properly belted, the best countermeasure to reduce traffic fatalities among the elderly is to reduce crashes among the elderly. Basing re-licensing on regular physical examinations should be considered. In areas of high elderly population, ideas to reduce traffic crashes include improved transit support, increased deployment of aspects of the Florida Elder Road program, and intersection design and signalization that decreases reliance on judgment in making left turns. Prior to implementation of innovative designs such as roundabouts, thorough study should be conducted for the potential to confuse elderly drivers, leading to unsafe and illegal driving maneuvers. In areas with a large elderly population, the perception-reaction times for elderly drivers should be taken into account in determining signal warrants.

While fixed objects are a less frequent cause of tripping than soft soils, designs of guardrails, drainage culverts and culvert walls should be reevaluated regarding their potential to trip vehicles. Because fatalities due to fixed object impacts are less preventable by improved seat belt use, a comprehensive program should be developed to remove or relocate objects in hazardous locations, or provide crash cushions or other protective barriers in locations where this is impractical.

Since gap judgment seems to be a problem for left-turners facing cross traffic from stop signs, as well as oncoming traffic at unsignalized movements or with permissive signal phasing, various approaches should be considered on high volume divided roadways. Since speeding on the part of drivers of through vehicles was often coupled with poor gap judgment by left-turning vehicles, the consistency of speed limits approaching intersections should be evaluated, as well as the prominence and visibility of reduced speed limit signs. Offsetting left-turn lanes can reduce sight distance issues where queuing vehicles waiting to make left turns potentially block the view of opposing drivers. Given the fact that many of the locations might not meet warrants for signal installation, appropriate responses may include improving the availability of gaps through appropriate signal spacing and timing at nearby signalized intersections, and access management techniques and educational programs that promote right turn followed by U turns on multilane divided highways. A systemic approach to reevaluating unsignalized intersections with high crash rates is recommended, to assure that traffic signals are installed where warranted, or scheduled for installation to keep current with anticipated growth. Research should also be directed toward safety and effectiveness of non-traditional signage and non-traditional intersection designs such as roundabouts or jug-handle intersections that do not rely on driver gap judgment to execute a left-turn and eliminate conflict points.

Due to the low number of fatal crashes associated with redirection, and the high number of fatal crashes associated with median cross-over, median guardrails are should be considered on segments with high traffic volumes and narrow to medium median widths (up to 70’ on limited access facilities and up to 40’ on other facilities). However, guardrail designs should be evaluated regarding their potential for tripping vehicles, resulting in rollover crashes.

Countermeasures Addressing Between 100 and 250 Traffic Fatalities: Sites with soft shoulders, whether composed of grass, sand or other soft soils, should be evaluated for their potential to trip ROR vehicles. Potential countermeasures include improving the quality of the soil/grass shoulder, or providing additional paved shoulder width.

At intersections where red light running is a problem, the length of signal cycles should be evaluated, including the use of a longer all red phase. Red light running can also be addressed by strict enforcement and use of red light running cameras. Drivers should be educated about defensive driving, including the importance of remaining alert for drivers running stop signs or lights at intersections.

Increasing the level of highway lighting to improve visibility is recommended in areas where high pedestrian or bicycle traffic at night is anticipated. This includes potentially upgrading lighting standards for intersections with existing street lights, as well as adding lighting in mid-block locations with significant pedestrian activity. The presence of streetlights may give pedestrians a false sense of visibility, while being under the influence of alcohol may lead to sudden moves into the street, unexpected by drivers even if they saw the pedestrian on the shoulder. New lighting products, such as induction lighting, that could potentially reduce energy costs and improve brightness and color rendering, should be studied.

Since many of the non-intersection crossings were over 600’ from an intersection protected by a traffic signal, pedestrian facilities for such crossings need to be considered. Many of these crossings occur on multi-lane divided highways where traffic from side streets is primarily controlled by stop signs. Because of this, there are often long stretches without adequate crosswalks protected by traffic signals. As an alternative to adding signals to side street intersections, mid-block crosswalks protected by pedestrian activated traffic signals can be used to provide safe pedestrian crossings without increasing vehicular traffic on side streets.

Increased attention needs to be paid to proper adjudication of individual driving offenses, including driving under the influence and driver without a license. Increasing penalties for serious offenses and increased enforcement of unlicensed driving should also be considered.

Educational campaigns directed at “safe walking” strategies should developed. Establishment of “pedestrian no-cross zones” within a certain distance of intersections, along with public awareness and enforcement campaigns, are just a few of the types of measures that should be considered to discourage non-intersection crossings. Drivers should be warned of high pedestrian activity with signage, and reminded through educational campaigns that pedestrians sometimes behave unexpectedly.

Benefits

The results of this research can be used to develop educational, enforcement, and engineering countermeasures to address broad categories of crashes and contributing factors identified as occurring frequently on state roadways in Florida. The results can also be used to direct additional research projects into more specific areas of need identified by this research. The primary benefit to the state of Florida should be a reduction in the number of fatalities on state roadways in Florida.

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1 INTRODUCTION

Third only to California and Texas, the number of highway fatalities in the State of Florida remains unacceptably high, with 40 percent more fatalities per vehicle mile than the national average in 1999. In addition, heavy trucks are overrepresented in fatal crashes in the state, with more than twice the percentage of fatalities than in crashes involving passenger cars. To reduce fatalities, the State Safety Office of the Florida Department of Transportation (FDOT) proposed conducting research of traffic fatalities on the state roads of Florida. The goal of this project was to go beyond the data currently available from the Florida Traffic Crash Report (FTCR), incorporating information available from traffic homicide reports and site visits to create a comprehensive database of contributing causes of fatal crashes and fatalities resulting from them.

Presently, the data available from the FDOT Crash Analysis Reporting system (CAR) database is limited. It incorporates only the coded data from Florida Traffic Crash Report (FTCR), not including the narrative or diagram. This deficiency makes it difficult to reconstruct the events of the crash, especially in complicated multi-vehicle crashes. In certain cases, the database also has questionable accuracy due to potential errors in completing crash report and in transcribing data to the computerized database. Even when the FTCR narrative and diagram are available, as is currently possible with TIFF images of the original crash forms, they are often lacking in detail, especially regarding driver attitudes and actions, making it difficult to differentiate causative factors and assign fault.

To determine the actual causes of the crash, it was necessary to obtain more detailed data. Thus the goal of this project was to go beyond the data currently available from the FTCR, incorporating data from additional resources. A key source of information was obtained from the Florida Highway Patrol (FHP) and local law enforcement agencies in the form of Traffic Homicide Investigation (THI) reports. Photographs of the crash scenes were obtained from the law enforcement agencies and/or from FDOT's video log system. Where necessary, site visits were conducted to gain better insight into questionable sites. A comprehensive Oracle database was then created which incorporated all the information for review and analysis. A total of 2,080 cases were reviewed as part of this project.

In investigating contributing causes, the primary approach was a case study analysis of the crashes. The case-study analysis involved analyzing the crashes on a case-by-case basis, looking for driver, vehicle, environment, and roadway factors that might have contributed to the fatal crashes. The raw crash data, which are the data elements describing the vehicle, driver, roadway, environment, crash, etc., were voluminous, and it was not the goal of the project to reach statistically significant conclusions as to which elements correlated with high crash and/or fatality rates. Instead, the individual data elements plus photographic evidence were compiled to assess whether more general deficiencies (e.g. inadequate sight distances, inadequate pavement markings, inadequate pedestrian safety measures, etc.) exist at a specific site. Driver behavior and driver errors were noted, and vehicle speeds were reconstructed where possible. Various factors were categorized as primary, secondary, or tertiary contributors to the traffic crash. Based on the results of the study, a number of behavioral and roadway-related countermeasures are recommended.

Based on the results of the analytical studies, the project team has recommended various countermeasures, both behavioral and roadway-related, to address fatal crashes. As a general guide, countermeasures were recommended in four major categories: pedestrian safety improvements, driver behavior and performance, roadway and roadside safety, and commercial motor vehicle safety. Various strategies were identified by region and facility type. The most effective strategies were identified, considering costs, effectiveness, environmental impact, and other limitations.

2 OBJECTIVES

The principal objective of the proposed research was to provide an in-depth analysis of the causes of fatal traffic crashes and traffic fatalities so that appropriate actions can be initiated to improve safety on Florida's highways. The following major goals were established:

1. Investigate all fatal crashes in 2000 and those involving heavy trucks in 1999 and 1998.
2. Identify data elements deemed to be potential contributory factors for fatal crashes and traffic fatalities.
3. Develop a computerized database and querying tool to further subsequent use of the resulting data.
4. Analyze crash data, investigating both behavioral and roadway-related causes of fatal traffic crashes through case study analysis, dynamic behavior analysis, computer simulation, and multivariate statistical analysis.
5. Based on data collected during this study, recommend various countermeasures, both behavioral and roadway-related.

To refine the data collection and analysis procedures, a pilot study was conducted prior to a statewide study. Because the pilot study was intended to serve as a test of procedures and methods, two intermediate objectives were developed as part of the pilot study.

1. Develop protocols and procedures for collecting paper- and computer-based data on fatal traffic crashes, identifying important data sets and procedures for obtaining them.
2. Develop protocols and procedures for conducting site visits, including protocols for determining which sites need visits, and how to conduct those visits.

A document describing these protocols and processes was developed and provided to the Florida Department of Transportation as a guide for use in reviewing fatal traffic crashes. This document is attached to this report as Appendix A.

3 BACKGROUND AND LITERATURE REVIEW

The problem of transportation safety is one of great magnitude encompassing all modes of transportation, all economic levels, and all transport purposes. In terms of fatalities, injuries, and number of crashes, the dominant mode of transportation in the United States is the roadway system. According to the definitions given by the USDOT Bureau of Transportation Statistics, a "crash" is an event that produces injury and/or property damage, involves a motor vehicle in transport, and occurs on a traffic way or while the vehicle is still in motion after running off the traffic way.

Common vernacular could define "accident" as an event occurring by chance or from unknown causes. However, in the case of transportation safety events, only a small percentage of events that are dealt with can be considered as unavoidable events or true "accidents" (Horodniceanu et al 1979). Many argue that in the case of highways and roadways, crashes are not just a matter of luck or misfortune, but a combination of multiple conditions or actions. Most of these conditions and actions are predictable occurrences, and thus should not be considered "accidents." In this report, the terms "crash" or "collision" will be used in lieu of the term "accident."

The application of safety principles to the field of transportation has been primarily directed toward crash investigation, with the express purpose of finding those conditions and combinations of factors that lead to undesirable traffic crashes. For the most part, causes of crashes are categorized within four basic groups: person, vehicle, roadway, and environment. Consider the person to be defined as the vehicle operator, a vehicle passenger, a pedestrian, or a bystander; the vehicle as the transporting conveyance such as an automobile, truck, van, recreational vehicle, train, motorcycle, or bicycle just to name a few; the roadway as the total infrastructure of pavement, shoulder, signs, signals markings, safety devices, right-of-way, and the maintenance of each in addition to the prevailing traffic conditions; and the environment as the weather and lighting conditions, which affect visibility and traction at minimum.

3.1 Safety and Traffic Crashes

The term "cause" refers to an at-fault determinant of a crash or a determinate that increases crash risk or severity. Investigating causes of traffic crashes is complicated by the fact that a given crash seldom has a single unambiguous cause. Crash causes are often a sequence of causes. For example, the initial cause of a pedestrian crash may be the pedestrians darting out in the road. If the vehicle driver subsequently is distracted, fails to see the pedestrian and safely stop the vehicle or maneuver around the pedestrian, both the pedestrian action and the driver lack of attention will likely be listed as causes of the crash. In addition, there may be circumstances that took place prior to the crash that may have contributed to its occurrence. For instance, the pedestrian may have been distraught, an emotional condition that could have led to lack of care and diminished observational awareness of surroundings, while the driver of the vehicle may have had defective brakes which in turn reflects on poor vehicle maintenance.

The term "deterrent" refers to a preventive measure or a determinant that decreases crash risk or severity. Deterrents may be legislated, or they may be safety investments of transportation manufacturers and providers. As an example, a legislated deterrent to highway crash severity is the requirement of vehicle occupants to wear seat belts. Whether this legislation turns out to be a deterrent depends upon whether the wearing of seat belts reduces the severity of highway crashes and, whether the legislation affects the occupants' behavior so that seat belts are worn. The latter would likely be affected by the extent of the enforcement of the legislation and the effectiveness of the punishment for noncompliance (Loeb et al 1994).

Lack of highway safety is manifest in the occurrence of traffic crashes and their harmful events. Safety might be given an alternate meaning by recognizing that each crash is preceded by a conflict; some turn into crashes, the rest into near-misses. Each conflict, in turn, is preceded by some incipient danger. The events preceding traffic crashes as illustrated by Hauer are shown in Figure 3.1, adapted from Hauer (1997).

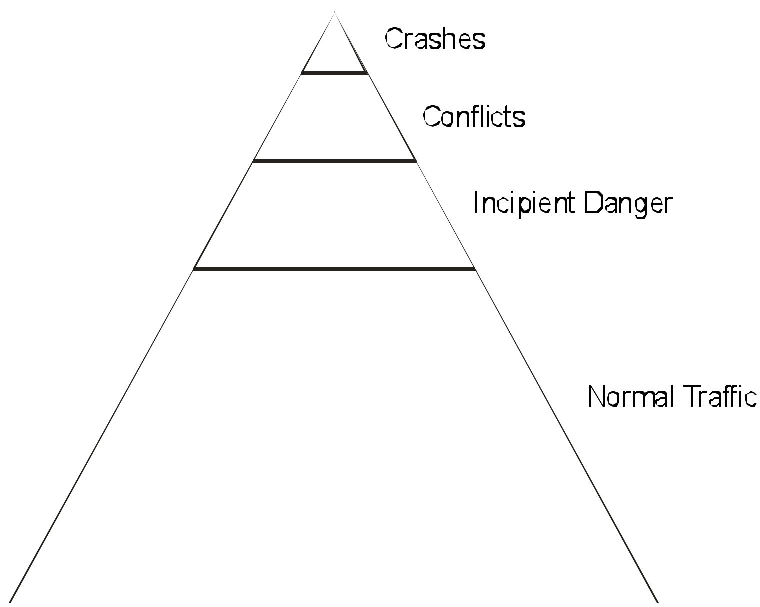

Figure 3.1 The Continuum of Events

The frequency of the events is represented by the volume of each of the layers. The figure clearly illustrates the concept that, per unit of time, there are fewer crashes than conflicts. The usual assumption is that the frequency of crashes is proportionally related to the frequency of conflicts, also known as hazards or unsafe situations. It is thereby reasoned that an increase in hazardous situations, hazards and conflicts would be revealed by an increase in the number of crashes.

Highway safety is different from people's subjective perception of safety, which is their feeling of security. The difference between safety and security may be best explained using an illustration of a pedestrian crossing an intersection. A pedestrian has a level of safety and security if crossing an intersection not marked by painted lines or a sign. After crosswalk edge lines have been painted a pedestrian may now feel protected by the two white lines of paint on the pavement and the presence of the sign, and thus has a higher level of security. However, their risk of being run over may have been increased, thus the safety actually decreased as pedestrian crashes increased at this site due to pedestrians being lulled into a false sense of security. The best types of changes are those where there is a clear improvement in both safety and security.

Crashes, when considered in relation to the number of activities of a transportation system, can be seen as rare events. This, however, is not true of hazards. A hazard, which is a condition with the potential for causing injury, death, loss, or damage to a system, is simply a causal component of a crash that has not yet happened. It is usually, but not always, determined by a simple cause-and-effect relationship, uncovered prior to a crash. When hazards are confused with total crash causations, problems occur in establishing the significance of a hazard. When otherwise tolerable hazards are combined, they may produce crashes. It follows that, rather than looking for the probable cause of a crash, which cannot always be accurately determined, it would be better to look for cause-and-effect relationships (hazards) that can be corrected prior to the occurrence of a crash. The advantage of such an approach is that it provides a capability for uncovering hazards through thinking, or preventive, analysis rather than an experimental, or postmortem, analysis. All state level projects require a transportation safety study, a preventative method, whereby prior to construction the project is analyzed from the perspective of identifying potential hazards and adjusting the design accordingly.

The term safety cannot merely be based on the number of traffic crashes that are observed for a given network, city, roadway, intersection, or even driver. Safety is better defined as the number of crashes, or even crash consequences (such as fatalities) expected to occur during a specified period. Presenting crashes or fatalities per year as a safety measure is consistent with the definition of safety herein. Consider a process, like transportation on a state highway system, whereby a measured process output is a reported traffic crash. If the process were fairly stable, that is there are no changes to the environment, users, and the level of use remains the same, then the process should remain the same even if the output of the process experiences random fluctuation. The stable property of the process is only revealed over an extended period of time.

A good analogy is rolling a die. Observation of only a few die rolls would likely reveal a different outcome each time, yet the nature of a die is not considered to have changed. The stable property of a fair die, dictating that each face has an equal probability of occurrence, is only discovered as the number of die rolls increases. In the case of a transportation system, safety can not to be equated with fluctuating crash counts; rather safety is an underlying stable property of the process, and as such has an expected frequency that changes in time. The key word here is expected; expected numbers can be any non-negative number greater than zero, not just integers. Crash counts are integer values. In this same way that a sample mean reflects the population mean, the count of crashes enables the estimation of the expected crash frequency of the process at some point in time.

3.2 Transportation Safety Data

A great deal of statistical information on safety data is available for the highway systems in the United States. Crash data gathering starts at local government levels. Reporting is done through local law enforcement or by individuals involved in crashes. Since the local law enforcement officers are generally concerned with violations of traffic laws, and individuals are concerned with their licenses and liabilities, objectivity in establishing real causation is sometimes distorted. From the local and state levels, the flow of information is directed toward the federal agencies, and the information is centralized and stored by the Federal Highway Administration (FHWA) and the National Highway Traffic Safety Administration (NHTSA) in their computerized information systems. NHTSA uses a multidisciplinary team approach for crash investigation. Much of the work in this area is statistical and is performed through special investigations of selected incidents.

To improve traffic safety, the United States Department of Transportation (DOT) National Highway Traffic Safety Administration (NHTSA) created the Fatality Analysis Reporting System (FARS) in 1975. This data system was developed by the National Center for Statistics and Analysis (NCSA) to assist the traffic safety community in identifying traffic safety problems and evaluating both motor vehicle safety standards and highway safety initiatives (FARS). Fatality information derived from FARS includes motor vehicle traffic crashes that result in the death of an occupant of a vehicle or a non-motorist within 30 days of the crash. FARS contains data on all fatal traffic crashes within the 50 states, the District of Columbia, and Puerto Rico. The usefulness of the FARS database is evident; however, it is important to note that one of the greatest shortcomings of this and other national databases is the lack of a central repository of state data on nonfatal crashes.

Kelman, comparing Canadian records, found that 4.6% of the codes of an average record had some error in them. It was noted that the most common errors had to do with the residence of the driver, type of vehicle, impact area, location on roadway, road character, direction of travel, apparent driver action, pedestrian condition and charges (Kelman 1977). In another study, Shinar et al (1983) concluded that the crash variables least reliably reported by the police were vertical road character (wrong in 41% of cases), crash severity (wrong in 30% of the cases), speed limit (wrong in 40% of the cases) and defective eyesight (wrong in 42% of the cases).

Inaccuracies in location data can be introduced in filling out a crash report form. For example an officer may record the word “Street” instead of the word “Road,” or indicate a crash on a freeway ramp as having occurred “mid-block.” When an analyst later searches the database for crashes occurring on Main Street or on freeway ramps, such records are almost irretrievably lost. In a study of crashes on freeway deceleration lanes in Toronto, it was found that around 40% were coded as mid-block (Janusz 1995). It is also not uncommon to find the same street name coded in several different ways.

3.3 Crash Causation

The occurrence of traffic crashes poses a challenge to the traffic safety engineers. Before investigating how to stop traffic crashes it is important to understand what causes these crashes. Thus the important question is “What are the causes for these traffic crashes?”, “What sequence of events lead to the crash and subsequent property damage and loss of life?” The causes of crashes and fatalities are usually complex and involve many factors. Based on the illustrations it is possible to construct a list of categories that could influence the occurrence of fatal crashes. If the factors that have contributed to the crash are identified it is then possible to modify and improve the transportation system. Crashes are caused by many factors, sometimes singly but more frequently in combination. Traffic crashes are caused due to interaction of vehicle, driver, roadway and environmental factors. These factors will be reviewed in the following section.

3.3.1 Driver Characteristics

The major contributing factor for many crashes is the performance of driver in both single vehicle and multi-vehicle crashes. The pre-crash driver behavior and attitude is very important in judging the driver's actions. These include the pre-crash driver psychology; distractions like cell phones, radios, cigarettes etc; medical conditions; alcohol and drug abuse; inattention to the roadway and surrounding traffic; speeding; and disregarding traffic laws and/or traffic control devices, which could result from confusion or unfamiliarity with the roadway.

Human factors are without doubt the most complex and difficult to isolate, as they are almost all very temporary in nature. What existed at the time of the crash may not exist moments later. Consider sensory capabilities, knowledge, judgment, attitude, alertness, health, driving skill, age, customs, habits, weight, strength and freedom of movement. Of these, the emotional factors are the greatest variable attributes and the most difficult to identify. They are also subject to the most modification with the least remaining evidence.

Perception and reaction time is the time it takes for the driver to perform a simple act in a vehicle. Perception is the ability of an individual to perceive an action about to take place, or taking place on the roadway directly ahead. The perception of this action leads to some type of reaction. The changes in perception-reaction time of drivers depend on age, whether the person is tired or under the influence of alcohol and/or drugs, and whether the stimulus is expected or unexpected. The driver age also plays an important role in the causation of crashes. Inexperienced driving is often associated with younger drivers. An older driver has longer perception-reaction time. It is well known that vision and hearing acuity also reduces with age. The time of the day also affects the driver's vision. The glare from the sunlight during the day or the glare from another vehicle affects the driver's vision. The glare recovery time changes with the age of the driver. It is longer for older drivers. Glare vision is important during night driving especially on two lane highways. The driver history also tells a lot about the driving mentality of the person. It can be safely concluded from the number and type of citations and charges given, the type of driving for example reckless driving, no regard for traffic signs, speeding, etc.

According to Van Kirk, drivers today are faced with many problems when driving in congested and overcrowded cities, specifically by having the senses overloaded by the vast amount of information that needs to be continuously processed – a condition also known as information overload (Van Kirk 2001). The types of information a typical city driver may encounter and need to react upon are numerous and include traffic signs, traffic signals, information about detours, billboard and other advertisements, neon and other commercial business signs, horns, loud music from passing vehicles, vehicles pulling away from curbs, vehicles changing lanes, pedestrians, and much more. Even in a situation of information overload, drivers are expected to be able to perceive a situation.

For example, consider a situation where a pedestrian darts out to cross the road. When the driver does perceive the situation, then the driver needs to look in rearview mirrors to judge the surrounding traffic before deciding to apply brakes or take an evasive steering maneuver. Where the speed limits are high the situation is aggravated because vehicles are traveling at much higher velocities thereby requiring that decisions be made more quickly and at a greater distance from the time of perception to prevent a collision. Human factor testing has shown that the average adult's perception and reaction time can range from 2 sec to as high as 10 sec depending on age, type and amount of information, weather conditions, vehicle conditions, and other factors. Because the exact perception reaction time of drivers involved in collisions is not known the best perception reaction times are usually assumed. The AASHTO Green Book suggests a perception reaction time of 2.5 seconds, but also contains guidance and observations on variations in driver population, conditions, and special circumstances (*A Policy* 1994). Various aspects of the state highway system in Florida were designed following the AASHTO recommendation.

3.3.2 Vehicle Characteristics

A small percentage of crashes are caused by mechanical failure of a vehicle, such as some form of tire failure, brake failure, or steering failure. The vehicle and roadway interaction like skid resistance play a major role in stopping the vehicle from encroaching the off road features like shoulder, median and other traffic signage. Other vehicle characteristics like wheelbase and height of center of gravity play an important role in rollover crashes. Improvements have been made in the manufacture of tires and vehicle design however defects can still occur or be the product of poor vehicle maintenance. A vivid example of defective tires, specifically within the time frame of this study, was the Firestone tire recall of 2000. In May 2000, the National Highway Transportation Safety Administration issued a letter to Ford and Firestone requesting information about the high incidence of tire failure on Ford Explorer vehicles. Ford obtained and analyzed the data on tire failure, and found that two tire models had very high failure rates, specifically noting that the tread peeled off. This problem was exacerbated by the fact that, when the tires failed, the Ford Explorer vehicles often rolled over causing severe crashes. Ford officials estimated the defect rate to be 241 tires per million for the tires in question. By contrast there are only 2.3 incidents per million tires on other tires according to Ford. By the beginning of August 2000, both Ford and Firestone decided to engage in a costly recall.

The design of a vehicle can be a contributory factor in the severity of crashes. Some of the features and recent improvements that affect the safety of a vehicle are presented below. In addition to these factors, other features not mentioned herein may affect safety, such as the center of gravity of vehicles, which may affect rollover tendency. The design of the front of a car is an example of a vehicle design feature that can affect the severity of an injury to a pedestrian struck by the car.

- **Airbags:** Passenger and driver-side dual airbags are now required in all vehicles sold in the United States. Recent advances in airbag technology have introduced side air bags that tests show are effective in preventing the driver and passengers from hitting their heads on rigid areas of the vehicle in side impact collisions. There are three designs of these airbags, a tubular airbag that inflates from the roof, a curtain design that deploys from the roof or an airbag deployed from the seat, inflating forward and up. Because the force of airbag deployment has the potential to injure a child or small-stature adult, many vehicles now come equipped with an airbag shut-off switch. This kill switch is most commonly found in late-model pickup trucks and two-seat roadsters/sport cars.

- **Antilock Braking System:** Antilock Braking Systems eliminate the need to “pump the brakes” when a quick stop is needed, preventing locking of the wheels and skidding. Because ABS pumps the brakes, the driver can apply constant pressure on the brake pedal and concentrate on steering the car. This is an attempt to allow drivers to regain control during inclement weather or quickly avoid a collision. ABS is available for nearly all new cars and trucks and is standard equipment on many.

- **Automatic Locking Retractor and Emergency Locking Retractor Seatbelts:** This feature is especially important to parents installing child safety seats. These seatbelts are designed to take up slack in the belt automatically and to lock in place when the passenger or child safety seat moves forward at a higher than normal rate of speed.
- **Back Up Sensing System:** A proximity sensor in the rear portion of the vehicle senses when the vehicle gets too close to an object and warns the driver. This feature is an option on many mini-vans and larger sized SUVs.
- **Crash Resistant Door Pillars:** Auto manufacturers have introduced this safety feature to deflect the force of a side-impact collision away from the head area and toward the legs. This is achieved by keeping the top portion of the vehicle's side post more rigid and allowing the lower portion to move inward.
- **Crumple Zones:** According to some safety experts, crumple zones are one of the most underrated safety features in modern vehicles. Automotive Engineers have designed the body parts of a vehicle to crumple in predetermined patterns to absorb the energy from a crash's impact and maintain the integrity of the passenger compartment, keeping the driver and passengers safer.
- **Electronic Stability System:** An Electronic Stability System coordinates the ABS, Traction Control, and the "yaw" of your vehicle. The individual systems are combined in an effort to reduce tire spinning, skidding, and traction-less cornering, keeping tires in maximum contact with the road. Found mostly on luxury models, stability systems are slowly working their way into more vehicles.
- **Head Restraints:** The system is designed to lower the number of whiplash injuries. Most vehicles simply have what is commonly referred to as a headrest that keeps the head from whipping back after a rear impact. More advanced systems allow the back of the seat and headrest to move down and back upon a rear impact, lessening the forward motion and cutting down on head and neck injuries.
- **Impact Absorbing Interior Materials:** Impact absorbing interior materials provide padding and cushioning on dashboards and armrests to cut down on the injuries and skin punctures caused by crashes.
- **Night Vision / Heads Up Display:** Provides a display of the dashboard instruments on the inside of the windshield. The pros and cons of this feature are mainly of personal taste and comfortableness of using the display. The luxury version option available on Cadillac models incorporates night-vision technology that allows the driver to see further down the road than the headlights illuminate.
- **Traction Control:** Helps maintain control while accelerating. Traction control stops the spin of a wheel due to wet conditions, loose gravel or excessive driver acceleration input (an overzealous foot) by braking it, reducing the fuel or cutting

spark plug ignitions. This features attempts to insure maximum contact between the tires and the road.

3.3.3 Roadway Characteristics

The roadway's conditions like the quality of pavements, shoulders, traffic control devices and intersections, can be a factor in the crash. Fewer traffic control devices and complex intersections with excessive signage lead to confusion. Highways must be designed for adequate sight distances for designed speed for the driver to have enough perception-reaction time. The traffic signals should provide enough time for decision sight distance when the signal changes from green to red. The super-elevation on highways and especially ramps should be carefully laid with correct radius and appropriate transition zones for the vehicles to negotiate curves safely. Another important factor is the frictional forces between the pavement and tires. If the tires lose contact with the pavement then the vehicle starts fishtailing.

Road factors include, but are not limited to lighting, view obstructions, recognizability, signs, signals, surface character, dimensions and protective devices. All factors are subject to modification by outside influences such as the road surface that becomes slick from rainfall. Modifying each of the listed road factors are weather, lighting, roadside devices, activities, surface deposits, damage, deterioration and age.

Some roads were not built to serve the current high-volume and/or high-speed traffic needs. The safety of these roads is limited by hazards such as sharp curves, poor signs and pavement markings, and lack of medians to separate oncoming traffic. These limitations could present an even greater threat to highway safety because of the expected growth in the nation's elderly population. By 2030, the elderly population is projected to be one in five Americans. Automobile fatalities are expected to increase 45% for drivers over age 75, and pedestrian fatalities are also expected to increase as the population ages. There are ways to make roadways more user-friendly for older drivers, while at the same time benefiting all drivers in the community.

3.3.4 Environment Characteristics

The climatic and environmental conditions can also be a factor in transportation crashes. The most common is weather. Weather on roads can contribute to crashes; for example wet pavement reduces friction and flowing or standing water greater than 1/8" deep can cause the vehicle to hydroplane. Many severe crashes have occurred during conditions of smoke or fog, which can greatly reduce visibility. Vehicles traveling at high rate of speed are unable to see the slowing and or stopped vehicles in front of them, which can lead into multi-vehicle pileup. This can be seen in one of the crashes where there was a sixteen-vehicle pile-up due to fog. Glare can reduce driver visibility, especially on east-west roadways during the hours of sunrise and sunset. During foggy conditions, glare off of streetlights and stop lights can also affect visibility, especially at night. Wind gusts can affect vehicle stability, especially of large trucks and lightweight vehicles such as bicycles and motorcycles.

3.4 Crash Investigation and Reconstruction

The state of Florida and the Federal Government require that an investigation be done to record the data and facts surrounding a particular crash that surpasses a given minimum threshold of property damage or involves human injury. In the case of a crash that is fatal, the law requires that a comprehensive and thorough investigation be conducted. In many police departments there is a special team that handles only fatal crashes. These traffic homicide investigators have more training, are better equipped, and usually have more experience in investigating fatal traffic crashes. The Florida Highway Patrol, which responds to almost all cases on interstates within the State of Florida, and sometimes in cases on other state roads, has a specific division of officers designated to handle traffic homicide cases.

Two major problems in investigating fatal crashes are variability in the amount of detail that reports contain and in the quality of the data. However the state does not have a uniform standard form for reporting homicide investigations. It is up to the particular law enforcement agency, or the investigator at the scene, to control the situation. Sometimes the extent of the investigation is limited to the fields of the Florida Traffic Crash Report – Long Form. Generally speaking, it is the investigator's duty to include as much detail as possible; however, the reality faced by officers at the scene may influence them to cut corners. Preparing a crash or homicide report may be just one of the many duties of an officer at the scene; other responsibilities such as clearing the roadway and attending to injuries can direct the officer's attention away from the task of gathering key information and preparing a report. Other factors, such as harsh environmental conditions, a tight schedule, nearing the end of a shift, and countless other issues may influence the information that a report contains. Many officers are not aware that the information on a crash report influences many engineering and traffic operations decisions on state roadways, and assume that crash reports are primarily used by drivers filing claims with their insurance companies.

Crash reconstruction and crash investigation are related but they are not the same thing. A crash investigation is the result of an observation or study of the crash scene by examination and also the documentation and preservation of evidence found, typically resulting in the filling out of a Florida Traffic Crash Report. By contrast, a crash reconstruction is more comprehensive, includes analysis of data from other sources, and attempts to rebuild or reconstruct that crash in part or moment by moment. It is the task of a crash reconstruction to develop a sequence of events that best fits the vehicle damage, injured persons, data found at the scene, witness statements, and other evidence.

3.5 Literature Review

A review of relevant literature in the field was performed. Given the breadth of the project's scope, a number of areas were defined for the literature review. A primary focus was to determine whether studies using similar "case-study" type approaches have been done in the past, and to study their procedures, results, and lessons learned. A second focus was to find literature addressing potential contributing causes that were identified for further study in this research, e.g. driver age, pedestrian crashes, etc. Given this, the literature review is divided into several subsections, each focusing on a particular aspect of the review. To improve the continuity of the report, this section presents only literature relevant to the overall approach of the research, while literature relevant to specific aspects of the project are discussed within those chapters. Methodologies and approaches from the studies presented in this section were used to develop the coding schemes for crash type and contributing factors presented in the next chapter.

A number of case study approaches have been undertaken in recent years. One of the key aspects of the case study approach is developing a system of categorizing crash types and contributing factors. At a national level, the General Estimates System (GES) has three items coded with respect to crash type; category, configuration and specific crash type (National 2002). GES codes for categorizing the collisions of drivers involved in crashes are shown in Figure 3.2, which is in fact a National Automotive Sampling System (NASS) crash data collection form (Eskandarian et al 2004). A study conducted by the National Highway Traffic Safety Administration (NHTSA) and the Federal Motor Carrier Safety Administration (FMCSA) focusing on causation in crashes involving large trucks utilizes summaries by crash type configuration in much the same way proposed herein (Thiriez 2002).

Hendricks et al (1999) performed a study on unsafe driving acts in serious traffic crashes to determine the specific driver behaviors and unsafe driving acts (UDA's) that lead to crashes, and the situational, driver and vehicle characteristics associated with these behaviors. They used an 11-step process to evaluate the crash, determine the primary cause of each crash, and uncover contributing factors. To meet the needs of the study, researchers redefined the NASS crash types to simplify and improve the analysis being performed. The crash types were recoded into seven classes with operational differences that were likely to be associated with driver behavior/performance. The crash types used in Hendricks et al (1999) are:

- **Crash Type 1:** Single Driver, Right or Left Roadside Departure Without Traction Loss [NASS Types I: A (except 02), I: B (except 07), and I:C].
- **Crash Type 2:** Single Driver, Right or Left Roadside Departure With Traction Loss (NASS Types I: A-02 and I: B-07).
- **Crash Type 3:** Same Direction, Rear End (NASS Type II: D).
- **Crash Type 4**: Turn/Merge/Path Encroachment (NASS Types II: F and IV: J and K).
- **Crash Type 5:** Same Traffic way, Opposite Direction (NASS Type III: G, H, and I).
- **Crash Type 6:** Intersecting Paths, Straight Paths (NASS Type V: L).
- **Crash Type 7:** Other, Miscellaneous, Backing, Etc. (NASS Type VI: M).

The schematic representation of the clinical analysis sequence (Figure 3.3), used to determine the causes of crashes in a study of unsafe driving acts in serious traffic crashes, broke crash causation into 5 main categories; vehicle condition, environmental condition, driver behavior, roadway condition, and other/unknown (Hendricks et al 1999). In that study it was reported that driver behavior caused or contributed to 99% of the crashes investigated, with the 6 causal factors that accounted for most of the problem behaviors, in decreasing order of frequency, being driver inattention, vehicle speed, alcohol impairment, perceptual errors, decision errors, and incapacitation.

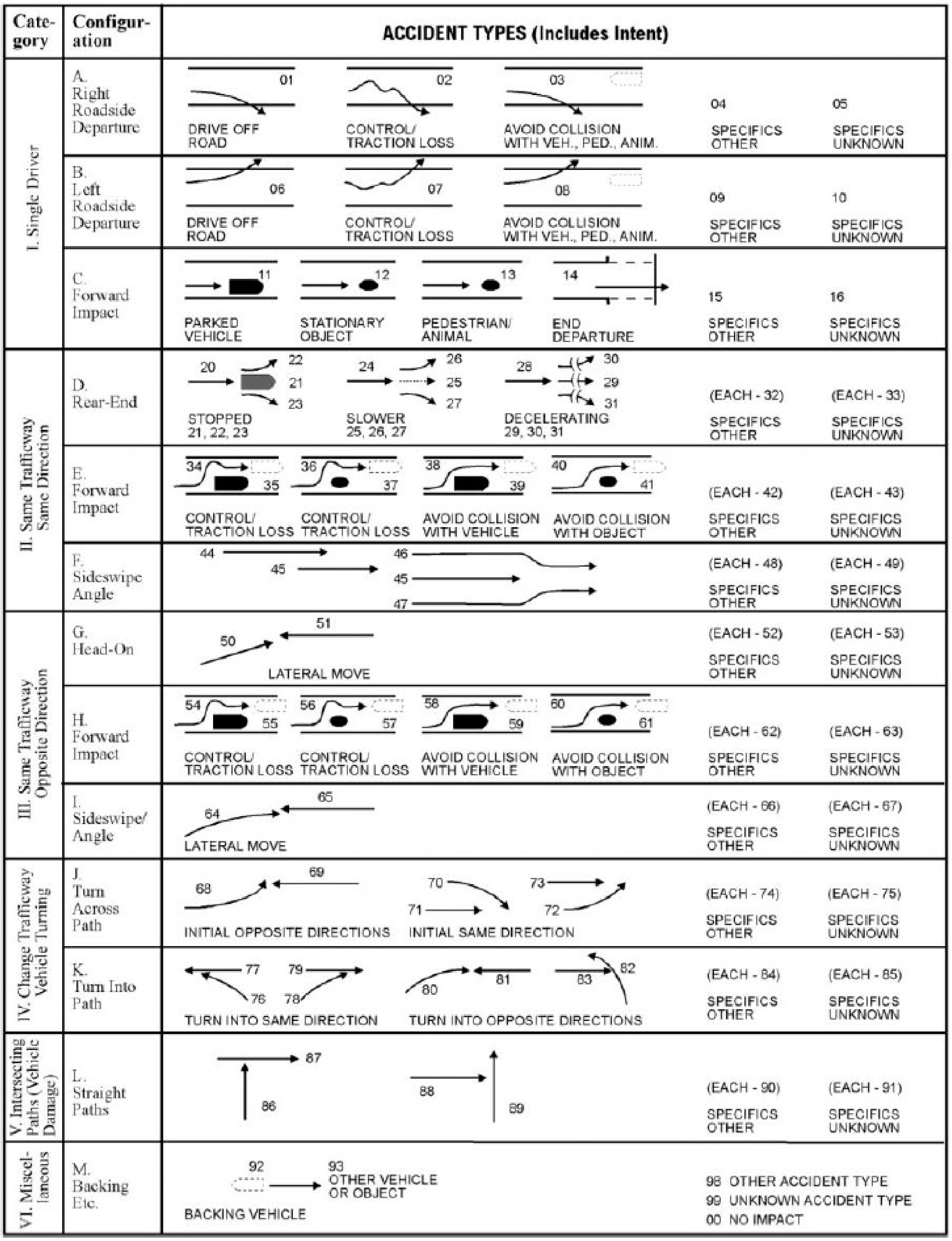

Figure 3.2 GES Coding and Editing Manual, Summary of Crash Types (Category V23)

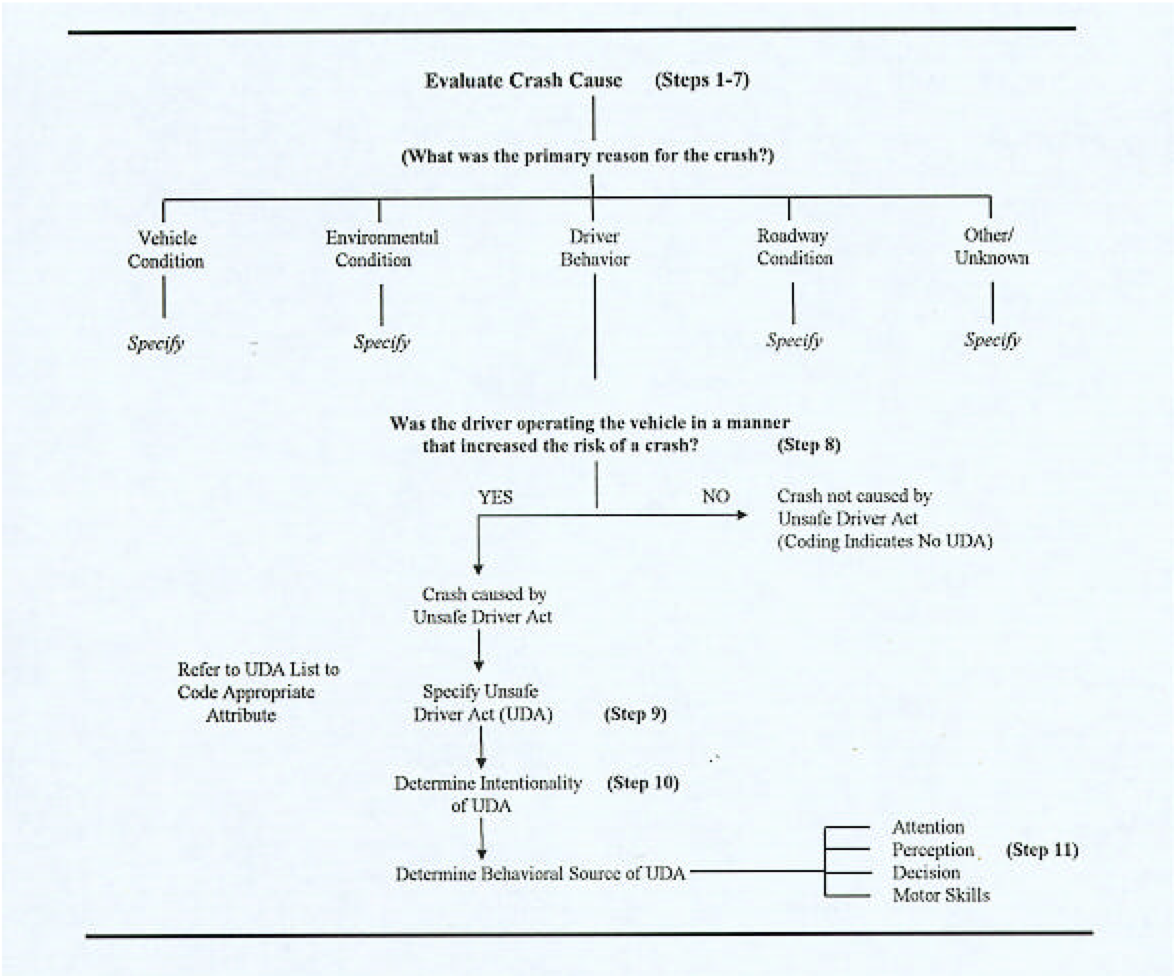

Figure 3.3: Schematic Description of the Clinical Analysis Method (from USDOT 1999)

The GES listing of crash type categories does not include a pedestrian crash type category. A study by researchers at the University of South Florida, focusing on pedestrian crashes in Florida in the early 1990's, includes more specific pedestrian crash types (Bates 2004). In that study, researchers supplemented the statewide database data (DHSMV data) by reviewing a sample of Florida Traffic Crash Reports, involving both fatal and nonfatal crashes, and identifying crash patterns and general crash types. The aforementioned study substantiated the classification system based on pedestrian behavior by finding that certain pedestrian behaviors, such as walking along the roadway with traffic, and crossing a roadway at a point other than an intersection are significant in fatal crashes.

Another issue in performing a case study analysis is distilling the information from as many as hundreds of data fields into results that can be used for analysis and conclusions. Parrish et al (2003) at the University of Alabama developed the Critical Analysis Reporting Environment (CARE) software system to analyze automobile crash data. CARE provides an intuitive interface that transportation safety engineers can use to obtain useful information from the coded fields typically available on automobile crash forms completed by law enforcement officials. CARE is mainly designed for transportation safety engineers and policymakers, without having to rely on statisticians for the interpretation of data. Instead of digging into advanced statistics, the system uses the concept of an "overrepresentation" as a simple extension of frequency distributions. It is a simple method of finding the statistical significance of the results obtained. Overrepresentations require the definition of two data subsets: the experimental subset and a comparison or control subset. To calculate the degree of overrepresentation for a particular attribute value, the first step is to determine that value's occurrence in both the experimental and control subsets, computed as a percentage, and then divide these two values. The overrepresentation factor method is very useful in representing large volumes of data & comparing numerous attributes.

Campbell at al (2003) from the Research and Special Program Association of the United States Department of Transportation used a similar methodology to examine the contributing factors to the single vehicle off-roadway (SVOR), rear end (RE) and the lane change (LC) crashes involving light vehicles such as passenger cars, sports utility vehicles, light truck and vans. The analysis was based on the National Automotive Sampling System's (NASS) 1997-2000 Crashworthiness Data System (CDS) and 2000 General Estimate System (GES). In this study, cross-correlation charts were created to account for the crash contributing factors in scenarios that involve multiple factors. The contributing factors to the crash were studied in detail, to identify the primary and secondary factors. For identifying the primary factors of the crash a priority scheme was developed based on the expert opinions of the researchers which breaks down the cases with multiple factors and assigns one contributing factor that overrides the others. The study revealed that inattention, speeding and alcohol or drugs were the most prevalent factors in rear end and lane change crashes, whereas, speeding, alcohol or drugs and inattention in descending order in single vehicle off-roadway crashes.

Recently, a number of state and local transportation agencies have undertaken site reviews known as Road Safety Audits. A Road Safety Audit (RSA) is defined by the Federal Highway Administration as the formal examination of an existing or future road or intersection by an independent team of experienced specialists (FHWA 2004). The RSA team typically assesses the safety performance and potential for crashes at a site, preparing a report that identifies potential safety issues. The primary focus of RSA's is to identify potential deficiencies before construction begins, i.e. during the planning and design phases of a new or reconstruction project. However, similar techniques can be used to evaluate existing roadways. These reviews are sometimes differentiated by the name Road Safety Audit Reviews or In-Service Road Safety Audits. A program in Pennsylvania has successfully implemented road safety audits in the design phase. In New York, the DOT is integrating RSA's within their pavement overlay program. In Michigan, a program of intersection audits is being conducted in conjunction with AAA Michigan. The field review (site visit) is a necessary component of the safety audit. Safety audits are comprehensive and attempt to consider all factors that may contribute to a crash, including driver error, visibility issues, and the needs of pedestrians, cyclists, and large trucks. The intent is to look at locations prior to the development of crash patterns to correct hazards before they happen.

4 METHODOLOGY

4.1 Data Collection and Database Development

The research investigates the contributing causes for crashes where there were one or more fatalities. The data is comprised of crashes that occurred on state roadways of Florida in 2000. In addition, for the years 1998 and 1999, state roadway crashes involving one or more Commercial Motor Vehicles (CMV's) are considered, including those crashes where the CMV was involved in a crash with other vehicles. This was done to provide a larger set of CMV crashes for analysis. For the purposes of this study, there are assumed to be no time dependent variations in the three years of CMV data. CMV's include both heavy trucks (with 2 or more rear axles) and truck tractors (cabs), which typically tow one or more trailers. These correspond to vehicle types 5 and 6 on the DHSMV crash report.

The main objective of the study undertaken was to review the contributing causes for crashes and fatalities. To investigate these objectives, the fatal crash data was collected and a comprehensive Oracle database was created to aid analysis. To study these fatal crashes in detail, the project was divided into four main tasks and their subtasks. The different tasks that were carried out are described below.

4.1.1 Data Collection

The primary step for this project was to collect fatal crash data for the study set described previously. The resources used in the case reviews are discussed in this section. For any fatal crash that occurs there are two types of reports created, namely, the Fatal Traffic Crash Report (FTCR) and the Traffic Homicide Investigation Report (THI). The FTCR's are prepared for all fatal and non-fatal crashes; in case of a fatality, a detailed THI report is prepared by crash investigating officers who are specially trained. These served as the principal resources in our study; however, a number of additional data sources were used.

4.1.1.1 Florida Traffic Crash Reports/Crash Analysis Report (CAR) Database

Law enforcement agencies report the traffic crashes on the FTCR form. The reporting officer at the crash scene prepares the FTCR. It is a brief report which gives the date and time; location of the crash; vehicles involved in the crash; vehicle information; the driver, passenger and pedestrian (if involved) information; summary of the crash; crash scene diagram; final rest positions of the vehicles, etc. It has various codes for the vehicle type, alcohol & drug use; safety equipment used; first & second harmful event, road conditions at the time of crash, traffic control devices present; contributing causes of driver/pedestrian and similar other information to aide officer in explaining the crash events. The Florida Department of Highway Safety and Motor Vehicles (DHSMV) collects the paper forms, warehouses the data and, for crashes on state roads, supplies crash data to the Florida Department of Transportation (FDOT). Many of the coded fields from the FTCR are stored electronically by the FDOT in the Crash Analysis Report (CAR) database. This data is location referenced, and indexed to a number of roadway characteristics, including degree of curvature and average daily traffic (ADT). Still there exists some percentage of missing/pending data since that information was never updated on the crash reports after the investigation was completed and results obtained. For instance, in a number of cases, blood alcohol test results that were obtained by the law enforcement agency after submission of the crash report to DHSMV were available on the THI report (see below), but the data was never updated in the CAR database. Further, the electronic data does not include the narrative (sequence of events) or the diagram of the crash scene. To gain access to this data, paper and digital images of the Fatal Traffic Crash Reports were furnished by the FDOT for this project.

4.1.1.2 Traffic Homicide Reports

The Florida Highway Patrol (FHP) and other law enforcement agencies usually conduct a detailed traffic homicide investigation when a crash is fatal. Traffic homicide reports are significantly more detailed reports than the crash reports, prepared by specially trained officers. The detailed report includes the scaled crash scene diagram and sometimes reconstruction information. It also furnishes any available background information prior to the crash of the drivers/pedestrians. This helps in understanding the state of the mind of driver, such as whether the person was under lot of stress, if he had a fight with someone, if there were alcohol/drugs involved, whether the person was fleeing from police, etc. The report gives the detailed information of the state of roadway during the time of crash. It describes the signage present, the speed zones posted, whether there was ongoing construction, roadway defects, etc. The THI report typically provides the drivers' histories, autopsy reports and the different citations issued. The driver history tells a lot about the type of driver, for instance, the person who has violated many statutes within a short period of time is classified as a reckless driver, and so on. The autopsy report not only tells us about any controlled substance present, but whether the death was as a result of the crash or other medical problems. When obtainable, traffic homicide reports were reviewed, as they were a significant source for verifying, augmenting, or correcting information found in the original crash report. Both paper and computer based reports were obtained.

4.1.1.3 Roadway Characteristic Inventory (RCI)

The Florida Department of Transportation's Transportation Statistics Office (TranStat) maintains an electronic inventory of the highway system known as the Roadway Characteristics Inventory (RCI). The RCI is a computerized database of physical and administrative data related to the roadway networks that are maintained by or are of special interest to the Department. In addition to data required by the Department, the RCI contains other data as required for special Federal and State reporting obligations. District and Central Office personnel maintain the RCI. While there are many other important databases maintained by the Department (several that contain more highly technical data such as bridge specifications, highway design, or pavement) the RCI remains the largest database with over one million records. This data was accessed to get additional quantitative roadway information where necessary. At this point the online querying capabilities of the RCI limit the data extraction to a case-by-case basis. This limited the study-wide augmentation of the roadway data. However, FDOT has already updated some of the crash records with a limited number of features from the RCI database. One of such feature is the Average Daily Traffic (ADT), a measure of roadway congestion. It is important to note that the roadway data is updated as road change overtime, thus it is not possible to get the exact characteristics of the crash.

4.1.1.4 Crash Scene Photos

Where available, crash scene photos were reviewed. Roadway features (e.g. signage, traffic control devices) were observed. Skid marks and other evidence to hypothesize on driver action (e.g. skid marks show evasive actions as if to avoid collision, lack of skid marks combined with small exit angle indicate driver fatigue issues) were examined.

Figure 4.1 shows the crash scene photographs of a single vehicle crash occurred in Duval County on State Road 9A resulting in one fatality. The crash happened on the ramp as can been seen from the photo 1, which involved Jeep Grand Cherokee a midsize sports utility vehicle. The driver failed to negotiate the curve and lost control of the vehicle. As can be seen from photo 1, it shows the tire marks that the vehicle first ran off the road on left side. The driver then overcorrected and ran off the road on right side as can be seen in photo 2. The vehicle overturned one and half times. The first overturn occurred on the pavement, which can be seen from scratches on the pavement in photo 3. The other half overturn occurred in the grass portion between the SR9A and the ramp. Photo 4 shows the gouge marks by the vehicle and the final rest position of the vehicle. From the photos it can be seen that driver overcorrected twice, first when he ran off of the road on left side and the second time when he ran off the road on the right side. At this point the right rear tire got deflated and the vehicle started overturning.

Photo 1: Left Road Departure

Photo 2: Right Road Departure

Photo 3: Scratches on pavement due to rollover

Photo 4: Final position of the Vehicle

Figure 4.1: Crash Scene Photos

4.1.1.5 Video Logs

The video logs were used to investigate potential roadway design and traffic operations issues that might have contributed to the crash and/or the fatality. The video logs are still photographs taken in both directions at regular interval from the right most lanes of the state maintained roads. As required video logs provided by the Florida Department of Transportation were accessed and reviewed. They were useful in finding sight distances, signage, crosswalks, speed transition zone, presence of pedestrian signals and other information. The main advantage of using the video logs limited the need for site visits. Figure 4.2 shows a snapshot of the video log viewer.

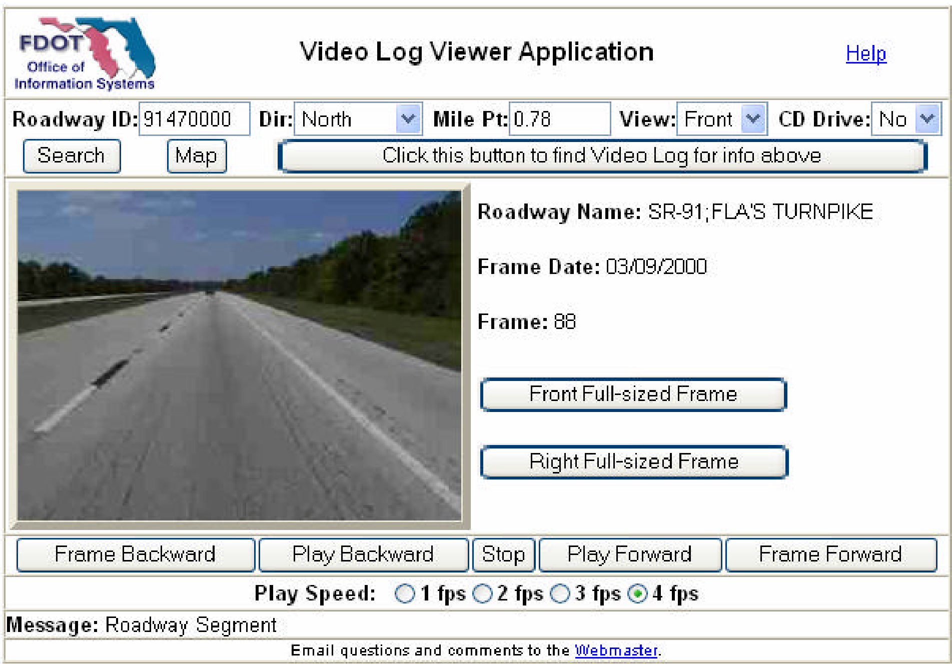

Figure 4.2: Example of Video Logs

4.1.1.6 Site Visits

While the video log proved to be more useful than expected in evaluating sight distances, clear zone distances, and intersections, site visits were necessary in certain cases to investigate the potential roadway contributing factors where all other resources were exhausted. Because of the time and expense associated with site visits, a number of protocols were established to prioritize the selection of sites:

1. **High Crash Frequency Sites:** These are sites that have had more than one fatal crash. Thus, sites with multiple crashes occurring within a mile from one another were considered high crash frequency sites. Crashes that had similar characteristics were given higher priority, as it was presumed that site-specific parameters might have had more effect.

2. **Similar Sites:** To take advantage of similarities in roadway geometries, i.e. the standard design procedures of interstate highways, sites with similar features were grouped together. These sites were identified from the case studies and video logs, and the research team will evaluate whether one or more sample sites can be chosen to visit.
3. **Significance of Crash Type:** Crash types that occur more frequently were given more attention. Efforts directed at reducing the rate of these crash types would have the most effect in reducing traffic fatalities in the state of Florida.
4. **Contribution of Geometry to Crash:** Crash sites where roadway geometry was judged to possibly be a primary contributor to the crash received site visits.

The primary goal of the research team was to identify any roadway factors that may have contributed to the crash at each site. Site visits were also conducted to collect various measurements and other data not available from the crash diagrams and FDOT video log. The site visits were well documented with digital videos and pictures. Depending on the site, team members videotaped the drive-through in the direction of both at-fault and not at-fault vehicles and measured and photographed various site features. Issues investigated during the site visits included traffic volumes, prevailing speeds, and other related aspects; adequacy of facilities, design, and signage/signalization; and site-specific aspects such as access management and potential view obstructions. Depending on the nature of the site, special attention was paid to the following items:

- Number and width of lanes and shoulders
- Existence, length and number of turning lanes
- Roadway alignment (vertical and horizontal curves)
- Roadway type (divided, channelized, median islands, raised curbs)
- Pavement type and condition
- Grades, cross-slopes, and superelevation
- As appropriate, roadside features, including drainage ditches, culverts, trees, crash cushions, etc. Clear zone distances as appropriate.
- Signage (type, size, visibility, location)
- Signalization (type, visibility, timing-now and historical, etc.)
- Traffic volume (observed and from data)
- Bike lanes, pedestrian crossings (type and signalization)
- For interchanges, ramp locations, signalization, turning radii, etc.

The following factors were considered as the site visits were conducted:

- Vehicle and pedestrian sight distances, taking into account vehicle/pedestrian position, size, and height, and potential obstructions.
- Visibility of traffic control devices, especially from turning lanes and accounting for sun glare. Position of signal heads with respect to travel lanes.

- Appropriateness of speed limits, given area location, roadway geometry, and traffic volumes.
- Suitability of site and features for pedestrian and bicycle traffic, as appropriate.

Interesting observations were made, useful to analyzing the causes, and also providing potential countermeasures, at many of the sites visited. Many of the site visits were judged to be significant; however it was determined during the pilot study that additional information about approach signage could be obtained from the video logs by viewing a greater distance. This reduced the number of site visits needed during the statewide study. Further, it was determined that detailed records of construction activities since the crash were needed before selecting sites to visit: a great deal of time was spent in the pilot study traveling to sites only to find that they had been reconstructed.

4.1.2 Data Entry & Case Review

To facilitate the analysis, a computerized database called “Fatal Crash Study” was created in Oracle. The basic structure of the database is presented in Appendix B. The data from both the crash report and THI report, as well as from other resources, was incorporated in the database. The main objective of this data entry was to go beyond the data that was available from existing computerized databases based primarily on the crash report. A thorough review of all cases was conducted to find and note any discrepancies on the two reports. After a careful reading of both the reports, a sequence of events was established for the crash. To have compatibility in the database, coding of the data was done so that there would be consistency and uniformity in the results obtained. It is important to note that crash data for every crash is discrete and unique. Hence, it was sometimes very difficult to code a crash as of particular type, since a crash can have several events like runoff road, overturned, entered median and hit an object, etc. Categorizing an incident as one particular crash type would not be appropriate. Every effort has been made to obtain consistency in crash types and contributing factors. A set of protocols, which was developed during the data entry, was very useful for maintaining the uniformity of the database. These protocols are the basis of the suggested crash review procedure in Appendix A. Due to the different academic backgrounds of the researchers there were some inconsistencies developed at this level too. But these were minimal and were eliminated when sighted. As the part of the review, the following research tasks were conducted.

1. Checking the data consistency between FTCR and THI reports. Inconsistencies were noted and database fields corrected in the Fatal Crash Study database, where necessary. One of the largest sources of inconsistencies involved alcohol and drug use. The alcohol or drug use field is usually left blank/pending. This field is usually never updated after obtaining the results of the test. Many times alcohol/drug testing is not recommended by the officers if the driver they think is not at-fault or if there are no clear symptoms of alcohol use. It is necessary to understand that any amount of alcohol even below legal limit may hinder the decision process. The traffic homicide report consists of results based on autopsy and other medical information but the crash report does not incorporate that.
2. Determining the crash type and sequence of events for the crash, after a careful review of both crash report and homicide report. In some cases, certain fields in the

FTCR's, like narrative, crash diagram etc., were left blank stating that the detailed information is to be found in THI report. Since the homicide investigations are not submitted along with the crash reports to the central repository, the data in the FDOT database is often incomplete for these crashes. And since homicide reports were not available for all of the crashes, it was impossible to even state the sequence of events of certain crashes.

The method used for summarizing crash level data by crash type was used to identify patterns of crashes occurring on state roadways, from which possible causes of crashes may be identified, leading to the identification of possible countermeasures. A total of 22 crash types, listed in Table 4.1, were developed for this particular study. This list represents seven main crash type categories that were most frequently encountered in the review of Florida Traffic Crash Report (FTCR) narratives and diagrams, and traffic homicide report narratives. The law enforcement officer’s narrative of the events surrounding the crash and the diagram of the crash scene were examined to discern patterns that were not otherwise identifiable from the FTCR coded data in the statewide database. The complete list in Table 4.1 was compiled following an initial review of all the cases in the study, and a literature review of related studies wherein crash data is being summarized by crash type codes (Bates 2004, Hendricks et al 1999, Thiriez et al 2002, Eskandarian 2004, *National* 2002).

Table 4.1: Crash Type Codes

Pedestrian
(10) Crossing Not at Intersection – First Half
(11) Crossing Not at Intersection – Second Half
(12) Crossing at Intersection (in crosswalk)
(13) In Road (standing, working, playing, laying, sitting, suicide)
(14) Walking Along Road With Traffic
(15) Walking Along Road Against Traffic
(16) Exit Vehicle (disabled vehicle, working on vehicle, prior vehicle crash, exit bus, ejected passenger)
(17) Vehicle Turn / Merge
(18) Unique (not likely to occur again)
(19) Other, Unknown
Single Vehicle Initiated
(20) Right Roadside Departure
(21) Right Roadside Departure w/Control Loss
(22) Left Roadside Departure
(23) Left Roadside Departure w/Control Loss
(24) Forward Impact (obstruction/end of pavement)
(25) Ramp Departure
(26) Other

Table 4.1: Crash Type Codes, continued

Same Traffic way, Same Direction	
	(30) Rear-end
	(31) Rear-end w/avoid impact
	(32) Sideswipe Angle
	(33) Control Loss
Same Traffic way, Opposite Direction	
	(40) Head-on
	(41) Forward Impact (control loss or avoid impact)
	(42) Sideswipe Angle
Change Traffic way, Vehicle Turning	
	(50) Initial Opposite Directions (oncoming traffic)
	(51) Initial Same Direction
	(52) Turn/Merge Into Same Direction
	(53) Turn Into Opposite Direction (cross traffic)
Intersecting Paths	
	(60) Driver Side Impact
	(61) Passenger Side Impact
	(62) Other
(70) Other	

The crash type codes in Table 4.1 were primarily chosen to enable the comparison of findings of this study with those found in other studies, and to establish a balance in the level of detail needed for meaningful analysis without being overly specialized. Classification details are given below:

- **Pedestrian:** Involves a collision between an in-transport vehicle and a qualifying non-motorist pedestrian. A pedestrian is defined as any person who is on a trafficway or on a sidewalk or path contiguous with a traffic way, and who is not in or on a non-motorist conveyance. This includes persons who are in contact with the ground, roadway, etc., but who are holding onto a vehicle. Other qualifying non-motorists (i.e. pedestrians) are defined as persons who are in or on the following non motorist conveyances: roller skates, roller blades, scooters, skateboards, non motorized wheelchairs or play vehicles (e.g., wagons) or persons who are not on a traffic way or sidewalk or path contiguous with a traffic way; but are in a parking lot, driveway, private road, gas station, alley, yard, garage, ball field, etc.
- **Single Vehicle:** The first harmful event involves a collision between an in-transport vehicle and an object or an off roadway rollover. A harmful event involving two in-transport vehicles is excluded from this category, as are harmful events involving collision between an in-transport vehicle and a pedestrian.
- **Same Traffic way, Same Direction:** The first harmful event occurred while both vehicles were traveling in the same direction on the same traffic way.

- **Same Traffic way, Opposite Direction:** The first harmful event occurred while both vehicles were traveling in opposite directions on the same traffic way.
- **Change Traffic way, Vehicle Turning:** The first harmful event occurred when the vehicle was either turning or merging while attempting to change from one traffic way to another traffic way. Traffic way for this variable is loosely defined to include driveways, alleys and parking lots where a vehicle is either entering or exiting.
- **Intersecting Paths:** The first harmful event involves situations where vehicle trajectories intersect.
- **Other:** The first harmful event involves a crash type, which cannot be described in any of the other categories and thus is included in this category. This category is selected, if there is insufficient information to choose between categories.

3. Determining the at-fault vehicle or pedestrian, as indicated by the traffic homicide investigator. Noted when there was an inconsistency with the FDOT at-fault determination (based primarily on vehicle sequence number), and where there were questionable causes or multiple faults. The typical practice among law enforcement officers is to use section one of the FTCR for data on the at-fault vehicle or pedestrian. The reporting officer enters data on the vehicle that he/she thinks is at-fault. However, this is not done all the time, especially in crashes with large number of vehicles or where a pedestrian was at-fault. The CAR database relies on an algorithm that identifies the first vehicle as the at-fault vehicle unless citations are given to drivers/pedestrians in other sections. Where a fatality is involved, the use of citations often does not detect fault on the part of a higher-numbered section because first, citations are often left pending further review by the homicide investigator, and second, citations are not given to drivers or pedestrians who die in the crash, even when they are at fault. A large number of cases with incorrect assignment of fault were found, especially in pedestrian cases. Even though the pedestrian is at-fault, the vehicle information is entered in section one. Thus the information is misinterpreted thinking that the vehicle is at fault.

   In addition, the result of homicide investigation sometimes differs with the original assessment of fault. This new information from the THI needs to be appended to the original report, which in many cases is not done. One such case involved the rear end collision of two vehicles. Vehicle one which had old driver was rear ended by the vehicle two with young driver. The driver of vehicle one died. The driver of vehicle two reported that the vehicle one abruptly pulled into the roadway from the shoulder and he had no time to react. Thus, vehicle one was entered as at-fault vehicle. After the homicide investigation it was realized that the crash scene was a construction zone and there was no room for the driver to have pulled onto the shoulder without disturbing a series of orange barrels on the shoulder. Instead there were some steel plates in the middle of roadway that caused the driver of vehicle one to hit the brakes, evidenced by elevating of the rear end of vehicle prior to impact and "hot-shock" of the brake light filaments. Further crash reconstruction showed that vehicle two had been speeding in excess of the posted construction zone speed and had rear-ended the first vehicle when it braked suddenly. This new information that the vehicle two is at-fault vehicle instead of vehicle one was never updated on crash report. This and many other cases lead to wrong or inconsistent data that must be corrected during the case review. It was possible to eliminate most of these errors after a careful study of the crash from the THI report and other detailed sources; however, this data source is only available in fatal crashes.

4. Reviewing the driver history where available. Driver history records were typically available with THI reports, and contained records past crashes and/or citations, including adjudications issued. Drivers were ranked based on their driving histories on a scale of 1 to 5, where a ranking of 1 indicated a clean record and a ranking of 5 indicated prior vehicular manslaughter conviction.

5. Reviewing crash circumstances and categorizing those identifying potential contributing causes as environmental, roadway, vehicle and person (driver/passenger/pedestrian). There were further subcategorized as potentially significant, moderate and minor depending on the influence of the factor on the crash. In evaluating potential factors, every attempt was made to differentiate causative factors, those factors that contributed to the crash, from conditions that merely existed at the time of the crash. Table 4.2 contains a list of contributing factors used in classifying the crashes. The factors were based on those identified during the literature review; however, the factors were modified somewhat to reflect the circumstances noted in this data set.

Table 4.2: Crash Contributing Factor Codes

Pedestrian Behavior
(10) Inattention / Distraction (emotional stress, headphones, working)
(11) Perceptual Error (inadequate surveillance, looked but didn't see)
(12) Decision Error (misjudged gap/speeds, not heed signal, dart out into road)
(13) Alcohol/Drug Impairment
(14) Other (standing/playing in roadway)
(19) Unknown
Driver Behavior
(20) Inattention
(21) Distraction (known external/internal distraction)
(22) Perceptual Error (inadequate surveillance, looked but didn't see)
(23) Decision Error (misjudged gap/speed, passing/pulling into traffic with vision obscured)
(24) Aggression (extreme speed, weaving in and out of traffic, illegal passing)
(23) Abrupt Steering Input/Overcorrection/Loss of Lateral Stability
(24) Speeding (driving above speed limit, too fast for conditions)
(23) Low Speed/Inappropriate Stopping in Road
(25) Alcohol/Drug Impairment
(26) Fatigue/Asleep at Wheel
(23) Medical Condition
(29) Unknown

Table 4.2: Crash Contributing Factor Codes, continued

Vehicle Condition	
	(31) Faulty Brakes
	(32) Worn/Smooth Tires
	(33) Tire Puncture/Blowout/Tread Separation
	(34) Other Mechanical Defect
	(35) Disabled Vehicle
Environmental Condition	
	(41) Heavy Rain
	(42) Smoke/Fog
	(43) Glare
	(43) Dark
	(43) Dusk/Dawn
Roadway Condition	
	(50) View Obstructions, Sight Distance
	(51) Roadway Curvature
	(52) Sign / Signal Issue
	(53) Maintenance Problem (potholes, standing water in road)
	(54) Construction
	(55) Wet/Slippery Road
	(59) Other
(60) Other / Unknown	

Understandably, it is a difficult task to determine which factors contributed to a crash, and the decision is often based on the judgment of the case reviewer. For instance, a BAC above 0.08% is *prima facie* evidence of impairment, and a person with that BAC is assumed to be under the influence, that is, affected by the alcohol. If the BAC is lower than 0.08%, it is more difficult to determine whether the alcohol affected the driver. Another example involves a driver who, after stopping at a stop sign, crosses a wide intersection, and is hit by crossing traffic. In judging whether the at-fault driver was inattentive or made a judgment (decision) error, the case reviewer must consider factors including the speed of the crossing vehicle, its proximity to the at-fault vehicle when it pulled from the stop sign, and the state of mind of the at-fault driver. Other factors, such as visibility of a motorcycle, the effect of rain or darkness, or the reason for making a sudden lane change, are also difficult to state conclusively. However, a conscientious effort has been made to correctly identify potential causative factors and label them as primary or secondary factors.

To help judge the relative importance of various contributing factors, the prioritization scheme shown in Table 4.3 was developed. As stated earlier, the methodology is based on ideas gleaned from the literature review, particularly Campbell et al (2003). Obviously there are exceptions, and each case was considered separately; however, this list provides a general idea of how factors were prioritized. The concept behind this prioritization scheme is the driver's responsibility to adapt to prevailing conditions. So, given a scenario of a driver rounding a curve at a high speed in wet weather, the first contributing factor would be the speed of the vehicle, followed by the environmental conditions, followed by the curvature of the roadway. However, an exception might be a roadway obstruction on an interstate. Given the driver's expectation of clear, high-speed travel lanes, a sudden obstruction (e.g. object falling from a vehicle, or vehicles from a prior crash) might be given the highest priority, followed by the driver's inattention to the conditions. Had the blockage occurred on a non-limited-access facility, driver inattention would likely be given the highest priority over the obstruction. Note also that the appearance of a roadway factor (e.g. curvature) is a means of indicating that the crash occurred on a curve, and that the curvature contributed to the crash (e.g. the vehicle proceeded straight and thereby left the roadway). It is in no way a suggestion that the curve did not meet design codes or standards, or was of deficient design thereby causing the crash to occur.

Table 4.3: Common Contributing Factors in Decreasing Order of Priority

Contributing Factor	Relative Priority
Deliberate unsafe driving act	Highest
Under influence of alcohol or drugs	
Vehicle defect	
Aggression	
Distraction	
Inattention, perception, or decision errors	
Vehicle speeding w/ or w/out control loss	
Environmental factors	
Roadway factors	Lowest

Determining the vehicle model and assigning the vehicle subtype to vehicles. The Florida Traffic Crash Report does not include a separate vehicle type for SUV's, even though many of the vehicles on the road are SUV's. Neither does it note the vehicle model, which is indicative of overall size and behavior. The vehicle model data was obtained from the THI reports when available. In case of missing THI reports, vehicle model was retrieved from VIN (Vehicle Identification Number) decoding software. VIN's from the FDOT database were used. VIN's that could not be decoded were verified against the crash report and the errors in reporting were noted. Vehicle subtype was assigned based on the classification by the Environmental Protection Agency (EPA) and United States Automotive Industry. The classification of the vehicles used by these agencies is shown in Table 4.4 and 4.5.

Table 4.4: Classification of Vehicles by Environmental Protection Agency

Sedans (based on passenger & luggage volume)	
Minicompact	Less than 85 cubic feet
Subcompact	85–99 cubic feet
Compact	100–109 cubic feet
Mid-size	110–119 cubic feet
Large	120 or more cubic feet
Station Wagons (based on passenger & cargo volume)	
Small	Less than 130 cubic feet
Mid-Size	130–159 cubic feet
Large	160 or more cubic feet
Trucks	
Vans, small Pickups	Trucks having a Gross Vehicle Weight Rating less than 4,500 lbs.
Large Pickups	Trucks having a Gross Vehicle Weight Rating of 4,500–8,500 lbs.

Table 4.5: United States Automotive Industry Classification

Size	Weight (pounds)	Wheelbase (inches)	Overall length (inches)
Subcompact	—	< 100	< 175
Compact	< 3,000	100–105	175–185
Midsize	< 3,500	105–108	185–200
Full size	3500+	110+	195+

4.1.3 Limitations

Although every effort was made to obtain a consistent and complete database, some inconsistencies still exists. Due to inability of some agencies to supply us with necessary information there were a number of missing and incomplete data elements. The main sources of inconsistencies in data were due to limitations from the crash report form, inconsistent or incorrect reporting by the investigating officers, and errors at the data entry level. The primary source of missing or incomplete data was the inability to obtain traffic homicide reports from certain agencies and the lack of completeness of crash and homicide reports from certain agencies. Where homicide reports were not received, the available data from the crash report was used to the degree possible to conduct the case review. A trend was also noted toward blank narratives and diagrams coupled with the use of "unknown" codes on the traffic crash report, pending completion of the homicide investigation. Where homicide reports were not received, this trend severely limited the usefulness of the crash report in conducting this study.

4.2 Data Analysis Techniques

A number of summary and cross tab analyses were performed to investigate correlations between different variables in the fatal crashes. The statistical analysis tools used for the analysis are explained below.

4.2.1 Overrepresentation and Confidence Intervals

Inferential statistics such as correlation and regression require a significant understanding of statistics. Hence a simplified, yet statistically significant approach of frequency distributions, called overrepresentation was also used for analyses. This method is based on the approach used in the CARE software (Parrish et al 2003). A characteristic is said to be overrepresented if it occurs in a set more frequently than it does in the complement of the set. Conversely, it is said to be underrepresented if it occurs less frequently in the set than in its complement. An overrepresentation factor is thus the ratio of percent of positive responses in the subset to the percent of positive responses in the complement of the subset. The overrepresentation factor can be used to contrast multiple characteristics by subdividing the responses or characteristics into multiple groupings (e.g. young drivers, middle aged drivers, older drivers) and computing an overrepresentation factor for each group.

The overrepresentation factor was computed for various crash sub-types as follows:

	Cases	Controls
Positive	A	B
Non-positive	C	D

$$ORF = \frac{R\_set}{R\_comp} = \frac{\frac{A}{A+C}}{\frac{B}{B+D}}$$

Where:

ORF = overrepresentation factor

R_set = Percent of positive outcomes for the set of cases, i.e. percent of crashes in the set (e.g. rollover crashes) that involved a certain characteristic (e.g. driver age)

R_comp = Percent of positive outcomes for the set of cases, i.e. percent of crashes in the complement of the set (e.g. non-rollover crashes) that involved a certain characteristic (e.g. driver age)

An ORF of 1.0 indicates that the characteristic occurs in the crash subset at the same rate that it does in the complement of the set. A number higher than one means that the characteristic occurs more frequently in the subset (i.e. is overrepresented), and an ORF less than one means that it occurs less frequently in the set than in its complement. The default over representation threshold used by the CARE researchers is 1.5 and that for under representation is 0.667. These numbers mean that a characteristic can be said to be highly over or under represented in a data set if the characteristic occurs 50 percent more or less frequently in the observed set than in the control set. Given the focus on crash prevention, under represented data values typically represent values for which there is no problem. Overrepresentations often indicate problems that must be addressed through countermeasures. The basis of the overrepresentation method is that it is unlikely that a countermeasure will reduce the crash rate of a set (e.g. alcohol-related crashes) below that of its complement (non-alcohol-related crashes). Thus by focusing on highly overrepresented characteristics within a set, there is an increased chance of having a productive result.

Another concept that can be used in conjunction with that of overrepresentation is that of maximum gain. The max gain is the number of cases by which a specific characteristic could be reduced if the overrepresentation factor were to be reduced to one. In other words, if a countermeasure were successfully applied to reduce overrepresentation of a certain crash characteristic (e.g. crashes on Saturday) back to the average rate of crashes involving the complement of the set (e.g. crashes on other days of the week), the maximum gain is the total reduction in crashes. Maximum gain is computed as follows, assuming that characteristic *A* is overrepresented in the cases:

	Cases	Controls
Positive	A	B
Non-positive	C	D

$$Max\_gain = A - \frac{A}{ORF\_A} = A - \frac{A}{\frac{(A/(A+C))}{(B/(B+D))}}$$

The overrepresentation method is very useful in differentiating trends between two different crash subsets. However, the reliability of this factor depends on the sample sizes of the two subsets in consideration. The smaller the sample size, the less significant the result. To improve its usefulness in looking at smaller data sets, such as those involved when examining only fatal crashes, the researchers in this project have extended the concept of overrepresentation to include confidence intervals. Confidence intervals quantify uncertainty in sample estimates of "true" population values. For example, from the sample data on SUV's, it is found that SUV's are rolling over on average at 3 times the rate of non-SUV's. It is known that the average rolling rate of SUV's will not be exactly 3 times that of the non-SUV's in the total population, but how far the sample estimate might be from the "true" average rolling rate can be qualified by a confidence interval.

The formula for the confidence interval for the overrepresentation factor (ORF) is shown below. The overrepresentation factor is very similar to a relative risk, which is the ratio of percentage of positive cases from the total population to the non-positive cases from the total population. Hence the confidence interval for overrepresentation factors was computed using techniques similar to those used for calculating confidence intervals for relative risk factors. If the lower limit of the confidence interval is greater than 1, then the characteristic is overrepresented in the crash subtype with the specified level of confidence, e.g. 95 percent. If the upper limit on the interval is below one, then the characteristic is underrepresented. Further, if the value of one falls between the upper and lower limits, the data does not support either overrepresentation or underrepresentation; either because of too small a sample size or an ORF that is too close to one.

	Cases	Controls
Positive	A	B
Non-positive	C	D

$$Var = \sqrt{\frac{\left(\frac{B}{A}\right)}{(A+B)} + \frac{\left(\frac{D}{C}\right)}{(C+D)}}$$

$$LL = ORF * e^{-z*Var}$$

$$UL = ORF * e^{z*Var}$$

Where:

LL = Lower limit of confidence interval

UL = Upper limit of confidence interval

z = z-statistic given the selected confidence interval, e.g. 1.96 for 95% confidence

Var = *Var* (ln *ORF*)=Variance of the natural log of the over representation factor

As an example, Table 4.6 and the calculations following it show the computation of overrepresentation factors and confidence intervals for rollover crashes in SUV's and non-SUV's. The exact ORF being computed is the degree to which rollover is over represented in SUV's when compared to rollover in non-SUV's. A 95 percent confidence interval is being computed, corresponding to alpha of 0.05 and a z-statistic of 1.96.

Table 4.6: Example Applying OR Methodology to Rollover Crashes

Rollover	SUV's	Non-SUV's	Total	OR	Min CI	Max CI	Level
Yes	127	405	532	3.04	2.47	3.74	Over
No	179	2558	2737	0.68	0.55	0.83	Under
Total	306	2963	3269				

$$ORF = \frac{\left(\frac{127}{306}\right)}{\left(\frac{405}{2963}\right)} = 3.04$$

$$Var = \sqrt{\frac{(405/127)}{(532)} + \frac{(2558/179)}{(2737)}} = 0.106$$

$$LL = 3.04 * e^{-1.96*0.106} = 2.47$$

$$UL = 3.04 * e^{+1.96*0.106} = 3.74$$

$$Max\_gain = 127 - \frac{127}{3.04} = 85$$

Given an ORF of 3.04, one can conclude that, in the set of crashes under review, SUV's are approximately three times as likely to have rolled over as vehicles in the control set. However, there is a 95% likelihood that the "true" value of the overrepresentation factor will lay between the minimum and maximum values of the 95% confidence interval, that is, between 2.47 and 3.74. Presuming that 3.04 is the exact overrepresentation of rollovers in SUV's, the maximum reduction in crashes that could be achieved by reducing the overrepresentation factor back to 1.0 (i.e. by reducing the SUV rollover rate to the rate of rollovers in the control set) is 85 fewer crashes.

4.2.2 Odds Ratio

Another statistical method used in dealing with mortality and risk is the odds ratio. Like the overrepresentation factor, the odds ratio is used to determine whether a certain characteristic occurs in a set more frequently than it does in the complement of the set. However, the odds ratio compares the odds of positive outcomes in a set of test cases to the odds of a positive outcome in a set of control cases. The odds of an event are the ratio of probability of the event relative to the probability that the event does not occur. In other words, odds of an event are calculated as the number of events divided by the number of non-events. While the overrepresentation factor is often used to contrast multiple outcomes (e.g. no injury, possible injury, severe injury, fatal injury), the odds ratio is often used when there are only two possible outcomes (e.g. "yes" and "no"), or in case-controlled studies (e.g. odds of possible, severe and fatal injuries vs. odds of no injury).

	Cases	Controls
Positive	A	B
Non-positive	C	D

Odds of positive outcome for cases = $\frac{A}{B}$

Odds of positive outcome for controls = $\frac{C}{D}$

Odds Ratio = $\frac{\left(\frac{A}{B}\right)}{\left(\frac{C}{D}\right)}$

An odds ratio greater than one indicates that the odds of a positive response are higher for the cases than for the controls. If the odds ratio is less than one, then it means that the odds of a positive response are higher for the controls than for the cases. The strength of association increases with deviation from one. A confidence interval can be computed for the odds ratio to provide a level of statistical significance given the sample size. The formulas are similar to those used for relative risk and overrepresentation factors, with the exception of the formula for variance.

$$Var = \sqrt{\left(\frac{1}{A}\right)+\left(\frac{1}{B}\right)+\left(\frac{1}{C}\right)+\left(\frac{1}{D}\right)}$$

$$LL = OR * e^{-z*Var}$$

$$UL = OR * e^{z*Var}$$

Where:

LL = Lower limit of confidence interval

UL = Upper limit of confidence interval

z = z-statistic given the selected confidence interval, e.g. 1.96 for 95% confidence

Var = *Var* (ln *OR*)=Variance of the odds ratio

5 OVERALL CRASH TYPES AND CAUSATIVE FACTORS

A primary objective of the research involved analyzing crash trends and investigating factors that contributed to the fatal traffic crashes. This chapter contains the results of that analysis, and is based on data items extracted from both the basic DHSMV crash reports (Florida Traffic Crash Reports) and more detailed information collected during the case reviews, especially information from the Traffic Homicide Investigation (THI) reports. In all cases, this data has been corrected using the results of the more detailed case studies of the crashes. This chapter provides an overview of all of the fatal crashes; subsequent chapters look in much more detail at key crash types and causes.

The data set consisted of 2080 fatal crashes across the state of Florida. Unless specifically noted, all data, tables, and figures in the remainder of this report present data on fatal crashes from the study set described previously. Table 5.1 shows the number of fatal crashes according to year. As stated previously, only heavy truck crashes were studied from 1998 and 1999 data; all crashes on state roads were studied in the year 2000. For comparison purposes, the total number of crashes in each year is shown also. Overall, CMV's accounted for approximately 28 percent of the crashes. CMV crashes are over twice as likely to involve a fatality, although the fatality rate of CMV crashes decreased somewhat in the year 2000.

Table 5.1: Fatal and Non-Fatal Crashes on State Roads in Florida

Crash Type	Crash Year					Total
	CMV Crashes			CMV Crashes	Other Crashes	
	1998	1999	2000	All Years	2000	
Total Crashes	7671	7901	8100	23,672	130,256	153,928
Fatal Crashes	199	198	178	575	1505	2080
Percent Fatal	2.59%	2.51%	2.22%	2.44%	1.16%	1.35%

Table 5.2 looks at the agency investigating the fatal crashes, a factor that is important when discussing the availability and quality of the homicide reports. The Florida Highway Patrol investigated approximately two-thirds of the fatal crashes in the state. Because we were able to obtain THI's from the Jacksonville Sheriff's Office and several other local law enforcement agencies, homicide reports were available for approximately 75 percent of the cases. Because bicycle and pedestrian cases were more likely to occur within municipal boundaries, fewer were investigated by FHP, meaning that we had fewer homicide reports on these cases. Conversely, because heavy truck crashes occur more frequently on interstates and in rural areas, over 80 percent were investigated by FHP.

Table 5.2: Agency Investigating Traffic Homicide Case

Crash Type	Total	FHP Investigated	
		Number	Percent
Truck	575	465	80.9
Bicycle	60	27	45.0
Pedestrian	353	166	47.0
Other	1092	766	70.1
Total	2080	1424	68.5

Table 5.3, Table 5.4, and Table 5.5 summarize crash types according to the categories described previously. Table 5.3 groups the categories into six major groups according to the primary causative event. So, a crash that involved a vehicle hitting a pedestrian attempting to cross the road is classified as a pedestrian crash, while one that involved a vehicle that ran off the road and hit a pedestrian is classified as a run off the road crash. (The degree of overlap between the crash types is explored in subsequent tables and chapters.) Overall, the most frequent type of fatal crash is run off the road and median crossover type crashes, followed by all intersection-related crashes. Head-on crashes without median cross-over are the least frequent of the major crash types in the study set.

Table 5.3: Major Crash Types of Fatal Crashes

Code	Crash Type	All Crashes	
		Number	Percent
10's	Pedestrian	328	15.8%
20's	Run off Road and Single Vehicle	668	32.1%
30's	Same Trafficway, Same Direction	293	14.1%
40's	Same Trafficway, Opposite Direction	181	8.7%
50’s	Change Trafficway, Vehicle Turning	402	19.3%
60's	Intersecting Paths	185	8.9%
70's	Unknown	23	1.1%
	Total	2080	100.0%

Breaking the crash groups down into the more detailed sub-categories mentioned in Table 4.1, the most frequent type of fatal crash overall is the right side of the road departure w/ no loss of control, followed closely by rear-end crashes with no avoidance or lane change, followed by vehicle turning, initially from opposite directions (i.e. left turning into oncoming traffic). Note that some of the crash sub-types occur very infrequently, while others are much more common.

Table 5.4: Crash Sub-Types of Fatal Crashes

Code	Crash Type	Crash Sub-Type	All Crashes	
			Num.	%
10	Pedestrian	Crossing Not At Intersection—First Half	71	3.4%
11	Pedestrian	Crossing Not At Intersection--Second Half	123	5.9%
12	Pedestrian	Crossing At Intersection In Crosswalk	33	1.6%
13	Pedestrian	Other In Road	29	1.4%
14	Pedestrian	Walking Along Road With Traffic	19	0.9%
15	Pedestrian	Walking Along Road Against Traffic	5	0.2%
16	Pedestrian	Exit Vehicle	28	1.3%
17	Pedestrian	Vehicle Turn/Merge	8	0.4%
18	Pedestrian	Unique	4	0.2%
19	Pedestrian	Other/Unknown	8	0.4%
20	Run Off Road/Single Vehicle	Right Roadside Departure	225	10.8%
21	Run Off Road/Single Vehicle	Right Roadside Departure With Control Loss	101	4.9%
22	Run Off Road/Single Vehicle	Left Roadside Departure	141	6.8%
23	Run Off Road/Single Vehicle	Left Roadside Departure With Control Loss	159	7.6%
24	Run Off Road/Single Vehicle	Forward Impact	8	0.4%
25	Run Off Road/Single Vehicle	Ramp Departure	32	1.5%
26	Run Off Road/Single Vehicle	Other	2	0.1%
30	Same Direction	Rear End	205	9.9%
31	Same Direction	Rear End With Avoid Impact	31	1.5%
32	Same Direction	Sideswipe Angle	43	2.1%
33	Same Direction	Sideswipe Angle With Control Loss	14	0.7%
40	Opposite Direction	Head-On	141	6.8%
41	Opposite Direction	Forward Impact With Control Loss	38	1.8%
42	Opposite Direction	Sideswipe Angle	2	0.1%
50	Change Trafficway/Turning	Initial Opposite Directions/Oncoming Traffic	199	9.6%
51	Change Trafficway/Turning	Initial Same Direction	17	0.8%
52	Change Trafficway/Turning	Turn/Merge Into Same Direction	20	1.0%
53	Change Trafficway/Turning	Turn Into Opposite Directions/Cross Traffic	149	7.2%
54	Change Trafficway/Turning	Single Vehicle Loss of Control While Turning	10	0.5%
55	Change Trafficway/Turning	Evasive Action to Avoid Turning/Merging Vehicle	7	0.3%
60	Intersecting Paths	Cross Traffic From Left of At-Fault	79	3.8%
61	Intersecting Paths	Cross Traffic From Right of At-Fault	84	4.0%
62	Intersecting Paths	Evasive Action Related To Intersecting Paths	8	0.4%
63	Intersecting Paths	Rear End Related To Intersecting Paths	0	0.0%
64	Intersecting Paths	T-Intersection Run Off Road	4	0.2%
65	Intersecting Paths	Backing	4	0.2%
66	Intersecting Paths	Other	2	0.1%
69	Intersecting Paths	Unknown Fault	4	0.2%

Table 5.4: Crash Sub-Types of Fatal Crashes, continued

Code	Crash Type	Crash Sub-Type	All Crashes	
			Num.	%
70	Other/Unknown	Unknown	23	1.1%
	Total		2080	100%

As described previously, the categorization shown in Table 5.3 reflects the primary crash type or causative factor. However, because fatal crashes are often complicated, multi-event crashes, certain crashes might fit into more than one category. Table 5.5 attempts to resolve this by showing the overlap between crash types. So, a pedestrian crash that also involved a same trafficway, same direction impact typically involved a vehicle rear-ending another vehicle and hitting a pedestrian in the road. A run off the road crash involving a same trafficway, same direction impact either involved a parked car on the shoulder, or overcorrection back into the travel lane, where a sideswipe or rear end crash occurred. The most common dual-typed crash involved running off the road and an opposite direction impact, typically a median cross-over resulting in a head-on collision. Same trafficway, same direction impacts involving intersecting paths, which are typically rear-end crashes related to intersections, were also fairly common.

Table 5.5: Primary and Secondary Crash Types of Fatal Crashes

Crash Type Code A	Crash Type Code B	All Crashes	
		Number	Percent
Pedestrian		247	11.9%
Pedestrian	Same Trafficway, Same Direction	12	0.6%
Pedestrian	Intersecting Paths	59	2.8%
Pedestrian	Change Trafficway, Vehicle Turning	10	0.5%
Run off Road and Single Vehicle		515	24.8%
Run off Road and Single Vehicle	Same Trafficway, Opposite Direction	83	4.0%
Run off Road and Single Vehicle	Pedestrian	23	1.1%
Run off Road and Single Vehicle	Same Trafficway, Same Direction	47	2.3%
Run off Road and Single Vehicle	Intersecting Paths	9	0.4%
Run off Road and Single Vehicle	Change Trafficway, Vehicle Turning	13	0.6%
Same Trafficway, Same Direction		236	11.3%
Same Trafficway, Same Direction	Same Trafficway, Opposite Direction	3	0.1%
Same Trafficway, Same Direction	Intersecting Paths	62	3.0%
Same Trafficway, Opposite Direction		180	8.7%
Change Trafficway, Vehicle Turning		360	17.3%
Change Trafficway, Vehicle Turning	Same Trafficway, Opposite Direction	4	0.2%
Change Trafficway, Vehicle Turning	Same Trafficway, Same Direction	5	0.2%
Intersecting Paths		189	9.1%
Unknown		23	1.1%
Total		2080	100.0%

Every attempt has been made to differentiate causative factors, which are those factors that contributed to the crash, from conditions that merely existed at the time of the crash. Table 5.6 summarizes the contributing factors identified during the case reviews. In this table, primary, secondary, and tertiary contributing factors are identified. Percentages are provided for the primary factors, which are the most important factors in causing the crash, and for the overall totals. Where the factors are human-related, the primary and secondary factors could both belong to the same person (e.g. alcohol use and speeding by driver one), or the factors might belong to two different persons in the crash (e.g. speeding by driver one and alcohol use by pedestrian one). The primary factor almost always belongs to the at-fault driver or pedestrian. Examining the table, it is evident that human factors are the most common primary contributing factors, accounting for almost 94 percent of the primary factors. Among human factors, alcohol and/or drug use is the most common factor. This is followed by driver errors, including inattention and decision errors. Roadway, environmental, and vehicle factors do not appear frequently as causative factors in the fatal crashes, but they appear more frequently as additional rather than primary factors. Overall, around 30 percent of the crash factors are related to roadway, environmental, and vehicle factors. Age, speed and abrupt steering input are three of the human factors that are more common as secondary than primary factors.

Table 5.6: Primary and Secondary Crash Contributing Factors

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.			Num.	Per.
Environment	Dark	1	0.0%	106	68	175	3.8%
	Dawn/Dusk	0	0.0%	5	6	11	0.2%
	Glare	0	0.0%	2	1	3	0.1%
	Heavy Rain	0	0.0%	5	4	9	0.2%
	Smoke/Fog	3	0.1%	26	11	40	0.9%
	Wet/Slippery	16	0.8%	47	74	137	3.0%
	Wind	1	0.0%	0	0	1	0.0%
	Total	21	1.0%	191	164	376	8.1%
Human	Age	2	0.1%	71	77	150	3.2%
	Aggression	36	1.7%	31	4	71	1.5%
	Alcohol	513	24.7%	41	16	570	12.3%
	Alcohol & Drugs	71	3.4%	3	1	75	1.6%
	Confusion	18	0.9%	32	5	55	1.2%
	Decision	199	9.6%	121	12	332	7.2%
	Distraction	16	0.8%	6	3	25	0.5%
	Drugs	70	3.4%	28	13	111	2.4%
	Fatigue	49	2.4%	17	5	71	1.5%
	History	0	0.0%	10	14	24	0.5%
	Inattention	454	21.8%	126	40	620	13.4%
	Inexperience	1	0.0%	21	9	31	0.7%
	Low Speed	1	0.0%	1	4	6	0.1%

Table 5.6: Primary and Secondary Crash Contributing Factors, continued

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.			Num.	Per.
Human	Medical	39	1.9%	10	1	50	1.1%
	Mental/Emotional	20	1.0%	17	9	46	1.0%
	Mobility	1	0.0%	10	4	15	0.3%
	Other	15	0.7%	0	2	17	0.4%
	Perception	74	3.6%	43	2	119	2.6%
	Physical Defect	0	0.0%	5	3	8	0.2%
	Police Pursuit	3	0.1%	4	1	8	0.2%
	Speed	153	7.4%	200	32	385	8.3%
	Steering Input	65	3.1%	140	67	272	5.9%
	Unfamiliar W/Area	1	0.0%	4	2	7	0.2%
	Unfamiliar W/Vehicle	0	0.0%	2	1	3	0.1%
	Unknown	144	6.9%	3	1	148	3.2%
	Visibility	1	0.0%	2	11	14	0.3%
	Total	1946	93.6%	948	339	3233	69.9%
Roadway	Access Point	0	0.0%	19	27	46	1.0%
	Bike Facilities	0	0.0%	0	3	3	0.1%
	Congestion	2	0.1%	14	16	32	0.7%
	Construction	2	0.1%	28	13	43	0.9%
	Curvature	4	0.2%	38	66	108	2.3%
	Design/Geometry	1	0.0%	34	20	55	1.2%
	Lighting	2	0.1%	91	92	185	4.0%
	Maintenance	0	0.0%	7	0	7	0.2%
	No Sidewalk	0	0.0%	11	3	14	0.3%
	Obstruction	11	0.5%	18	10	39	0.8%
	Other	0	0.0%	2	2	4	0.1%
	Pavement Markings	0	0.0%	4	9	13	0.3%
	Ped Facilities	0	0.0%	2	1	3	0.1%
	Shoulder Design	0	0.0%	1	5	6	0.1%
	Sight Distance	0	0.0%	17	12	29	0.6%
	Sign/Signal	2	0.1%	10	6	18	0.4%
	Speed Limit	0	0.0%	7	8	15	0.3%
	Standing Water	4	0.2%	3	2	9	0.2%
	Traffic Operations	0	0.0%	16	14	30	0.6%
	Total	28	1.3%	322	309	659	14.2%
Vehicle	Acceleration Rate	0	0.0%	4	4	8	0.2%
	Blind Spot	0	0.0%	13	7	20	0.4%
	Bus	0	0.0%	4	1	5	0.1%
	Defect	8	0.4%	10	10	28	0.6%

Table 5.6: Primary and Secondary Crash Contributing Factors, continued

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.			Num.	Per.
Vehicle	Disabled	0	0.0%	19	13	32	0.7%
	Emergency	0	0.0%	6	4	10	0.2%
	Jackknife	0	0.0%	6	6	12	0.3%
	Lighting	1	0.0%	18	14	33	0.7%
	Load Shift/Fall	4	0.2%	2	3	9	0.2%
	Low Speed	0	0.0%	3	1	4	0.1%
	Maintenance	0	0.0%	0	0	0	0.0%
	Maneuverability	1	0.0%	1	5	7	0.2%
	Other	3	0.1%	1	0	4	0.1%
	Overweight	1	0.0%	1	3	5	0.1%
	Size/Length	0	0.0%	0	1	1	0.0%
	Stability	0	0.0%	7	4	11	0.2%
	Tires	44	2.1%	12	7	63	1.4%
	Trailer	2	0.1%	4	7	13	0.3%
	Unknown	0	0.0%	0	1	1	0.0%
	View Obstruction	0	0.0%	10	9	19	0.4%
	Visibility	0	0.0%	33	20	53	1.1%
	Total	64	3.1%	154	120	338	7.3%
Other/Unknown		19	0.9%	0	0	19	0.4%
Total		2078	100%	1615	932	4625	100%

5.1 Roadway Characteristics and Contributing Factors

Table 5.6 above summarized the roadway factors that were deemed to have contributed to the fatal crashes. To summarize, obstructions (typically vehicles from previous crashes) were the most common primary roadway contributing factor. Inadequate lighting and curvature were the most common additional factors. Access points, construction, congestion, and roadway design/geometry issues each contributed in some manner to about one percent of the crashes. This section looks at a number of other roadway characteristics and factors in the crashes. Table 5.7 looks at the FDOT Crash Rate Class Category (CRCC) code, which includes facility type, geographic area, and number of lanes. The highest number of fatal crashes occur on rural two-three lane undivided roads, followed by suburban four-five lane divided highways, rural interstates, and urban divided highways with six or more lanes. Obviously, these are vastly different road classes, and the types of crashes occurring on these roads are largely different also. Table 5.8 combines crashes by facility type. Over one-third of the fatal crashes occurred on four-five lane non-limited access roads, one-quarter occurred on limited access roads, and over twenty percent occurred on two-three lane roads. Table 5.9 looks at crashes by geographic area. The same number of crashes occur in rural and urban areas, over 38 percent of the crashes, respectively. Another 23 percent of crashes occur in suburban areas

Table 5.7: Crash Rate Class Category in Fatal Crashes

Crash Rate Class Category	Number	Percent
Rural 2-3Ln 2Wy Undivd	287	13.8%
Suburban 4-5Ln 2Wy Divd Rasd	256	12.4%
Interstate Rural	222	10.7%
Urban 6+Ln 2Wy Divd Rasd	219	10.6%
Rural 4-5Ln 2Wy Divd Rasd	205	9.9%
Interstate Urban	194	9.4%
Urban 4-5Ln 2Wy Divd Pavd	110	5.3%
Urban 4-5Ln 2Wy Divd Rasd	96	4.6%
Suburban 6+Ln 2Wy Divd Rasd	91	4.4%
Suburban 2-3Ln 2Wy Undivd	81	3.9%
Toll Road Urban	50	2.4%
Urban 6+Ln 2Wy Divd Pavd	37	1.8%
Toll Road Rural	31	1.5%
Rural 2-3Ln 2Wy Divd Pavd	27	1.3%
Suburban 2-3Ln 2Wy Divd Pavd	25	1.2%
Urban 4-5Ln 2Wy Undivd	24	1.2%
Urban Other Limited Access	24	1.2%
Suburban 4-5Ln 2Wy Divd Pavd	23	1.1%
Urban One Way	21	1.0%
Ramp Rural	8	0.4%
Rural 6+Ln 2Wy Divd Rasd	8	0.4%
Urban 2-3Ln 2Wy Divd Undivd	8	0.4%
Suburban 4-5Ln 2Wy Undivd	6	0.3%
Urban 2-3Ln 2Wy Divd Pavd	6	0.3%
Rural 2-3Ln 2Wy Divd Rasd	3	0.1%
Rural Other Limited Access	3	0.1%
Suburban 6+Ln 2Wy Divd Pavd	2	0.1%
Suburban One Way	2	0.1%
Rural One Way	1	0.0%
Suburban 2-3Ln 2Wy Divd Rasd	1	0.0%
Urban 2-3Ln 2Wy Divd Rasd	1	0.0%
Urban 6+Ln 2Wy Undivd	1	0.0%
Total	2073	100.0%

Table 5.8: Crashes by Facility Type and Size

Facility Type and Size	Number	Percent
Limited access	525	25%
Ramp	8	0%
6+ Lanes	358	17%
4-5 Lane	721	35%
2-3 Lanes	437	21%
One way	24	1%
Total	2073	100%

Table 5.9: Crashes by Geographic Area

Geographic Area	Number	Percent
Rural	793	38.3%
Urban	793	38.3%
Suburban	487	23.5%
Total	2073	100.0%

Table 5.10 and Table 5.11 look at two important roadway contributing factors, curvature and construction. Table 5.10 summarizes crashes in which a driver failed to negotiate a curve. Curvature was mentioned as a contributing factor in about seven percent of the fatal crashes, most frequently as a tertiary factor. What this means is that other factors, typically speeding, alcohol use, and environmental factors were noted as primary as secondary factors, pushing curvature to the third most important position.

Notably, the horizontal degree of curvature field from the CAR database (augmented detail extract) did not match well to curvature as noted by the officers. One identifiable reason is that, when a crash occurs on a ramp, the curvature on the main roadway is given in CAR, whereas the crash involved the curvature on the ramp. However, in a number of cases, the only feasible explanation for the lack of agreement between the two data sources was a location mismatch between the curve location as specified in RCI and the crash location (as specified by the officer using the intersection-offset method and translated into the roadway segment and milepoint system).

Table 5.11 looks at the approximately 60 crashes that occurred in construction zones, according to either the roadway contributing cause field on the FTCR, or other information in the case review. Of those crashes coded as being in construction zones, six had no further mention elsewhere in the crash or traffic homicide reports. Presence of the construction zone was mentioned in another nineteen of the cases, but it was determined that the work zone had no effect on the crash. Of those cases where there was an effect, congestion was the most common contributing factor, followed by presence of equipment on the shoulder (that was involved in a vehicular impact). Lane closures, shifts, and narrowing were also common contributing factors.

Table 5.10: Crashes in Which Driver Failed to Negotiate Curve

Failed to Negotiate Curve	Number	Percent
Primary	3	0.14%
Secondary	37	1.78%
Tertiary	65	3.13%
Additional	35	1.68%
None	1940	93.27%
Any Factor	140	6.73%
Total	2080	100.00%

Table 5.11: Effect of Construction Zones on Fatal Crashes

Effect of Construction Zone	Number	Percent
Congestion	7	11.9%
Equipment on Shoulder	5	8.5%
Lane Closure	5	8.5%
Lane Shift	4	6.8%
Narrow Lane	4	6.8%
Road Surface/Condition	4	6.8%
Obstructed Travel Lane (Not Closed)	2	3.4%
Decreased Visibility	2	3.4%
Worker on Shoulder	1	1.7%
No Effect	19	32.2%
Not Mentioned in Report	6	10.2%
Total Coded as Construction Zone	59	100.0%

5.2 Environmental Characteristics and Contributing Factors

Table 5.6 above summarized the crashes in which environmental factors were named as primary or additional contributing factors. No environmental factors were common as primary crash contributors; as additional contributors, darkness and wet/slippery conditions each contributed to around three or four percent of the crashes. While only 40 cases involved smoke and/or fog, a number of these cases involved severely limited visibility due to forest fires and controlled burns.

This section looks in more detail at environmental conditions at the time of the crash. Table 5.12 summarizes the weather at the time of the fatal crashes. Overall fewer than ten percent of the crashes occurred in conditions of limited visibility due to rain and/or fog. Table 5.13 gives similar results, showing that wet or slippery roads occur in only about eleven percent of the fatal crashes. (Because case studies showed that officers use wet or slippery interchangeably, these two categories have been combined.) Referring to Table 5.6, wet roadways were a contributor in about 140 crashes, or about 60 percent of the time when roads were wet or slippery.

Table 5.12: Weather Condition at Time of Fatal Crashes

Weather	Number	Percent
Clear	1504	72.31%
Cloudy	385	18.51%
Rain	128	6.15%
Fog	50	2.40%
Other/UK	13	0.63%
Total	2080	100.00%

Table 5.13: Roadway Surface Condition at Time of Fatal Crashes

Surface Condition	Number	Percent
Dry	1848	88.85%
Wet/Slippery	232	11.15%
Icy	0	0.00%
Total	2080	100.00%

Table 5.14 summarizes lighting conditions at the time of the crashes. One can see that about half of the crashes are occur during daytime hours, while crashes occurring during darkness were about somewhat more likely to occur in areas with no street lights. Recall that Table 5.6 indicated that darkness was a key contributing factor in fewer than 200 fatal crashes, or about 20 percent of the crashes in which it was actually dark.

Table 5.14: Lighting Conditions in Fatal Crashes

Lighting Condition	Number	Percent
Daytime	989	47.55%
Dusk	35	1.68%
Dawn	54	2.60%
Dark, w/street lights	457	21.97%
Dark, no street lights	545	26.20%
Total	2080	100.00%

5.3 Vehicle Characteristics and Contributing Factors

Table 5.6 above summarized crash contributing factors, including vehicle contributing factors. The most common vehicle factor by far was tire tread separation/blowout, which accounted for 40 percent of the non-human primary factors. Vehicle condition, including vehicle defects, disabled vehicles, inadequate lighting, and tire issues, contributed in some way to about eight percent of the fatal crashes. This section examines vehicle type and other characteristics related to the vehicle. One factor that needed to be determined was vehicle model. Using information from both the homicide reports and VIN decoding software, the makes and models of most of the vehicles in the data set were determined. Because there is no option on the Vehicle Type field of the Florida Traffic Crash Report for SUV's, it was interesting to see how the officers had chosen to classify these vehicles (Figure 5.1). The SUV's were often classified as passenger cars and pickup trucks and sometimes as passenger vans or other (i.e. none of the above). Obviously, there is no clear understanding of how to classify a SUV on the present crash form. However, to improve consistency in the coding, all SUV's were recoded as pickups or light trucks for the purposes of this study.

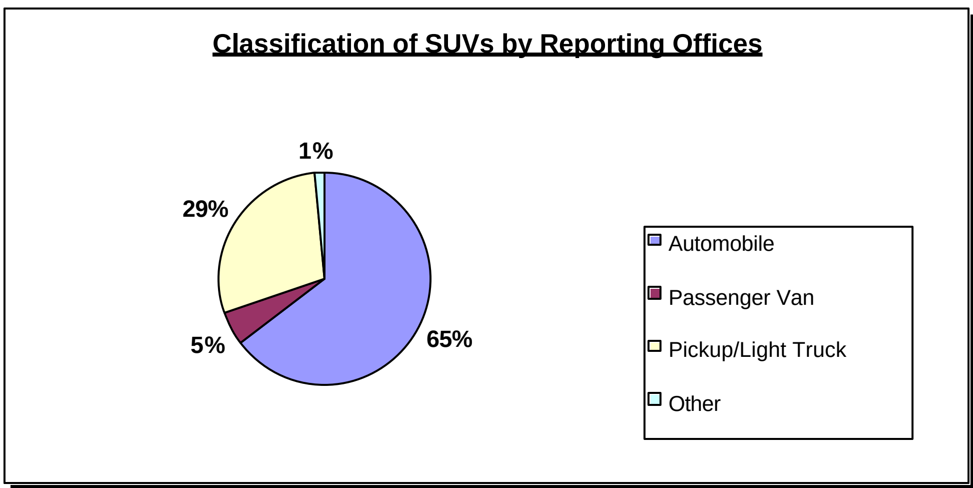

Figure 5.1: Classification of SUV's by Reporting Officers

To see how these crash involvement rates compare to the distribution of the vehicles on the roadway, data from National Household Travel Survey was used (*National* 2001). Figure 5.2 shows the proportion of household vehicle types on the road. Data from the year 2001 most closely matched the time frame of our study. Since only cars, vans, SUV's, pickups and other vehicles are considered in the Household Travel Survey, Figure 5.3 shows the percent involvement of only those vehicle types in the Florida fatal crashes. Comparing the two figures, it appears that autos, vans, pickup trucks are involved in fatal crashes at approximately the same rate at which they are owned/driven. Other vehicles are somewhat overrepresented in the crashes and SUV's are somewhat underrepresented.

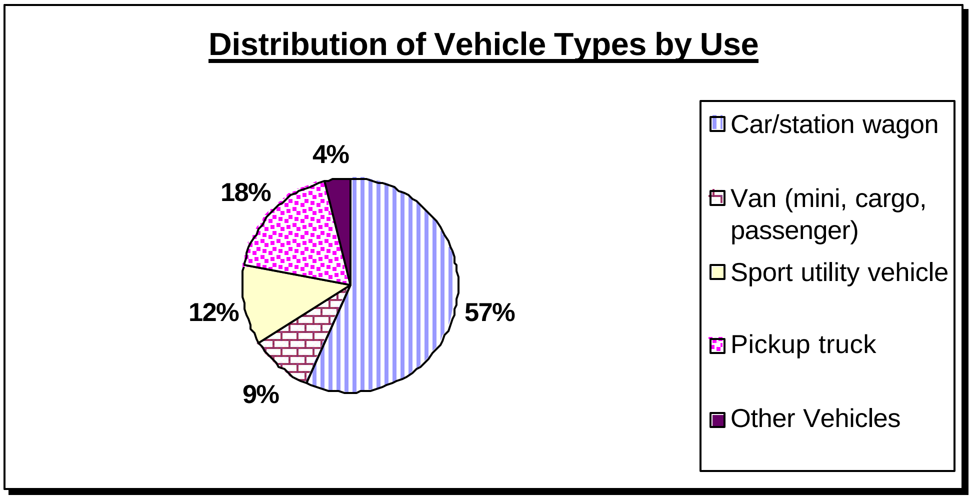

Figure 5.2: Proportion of Vehicle Types by Household Use

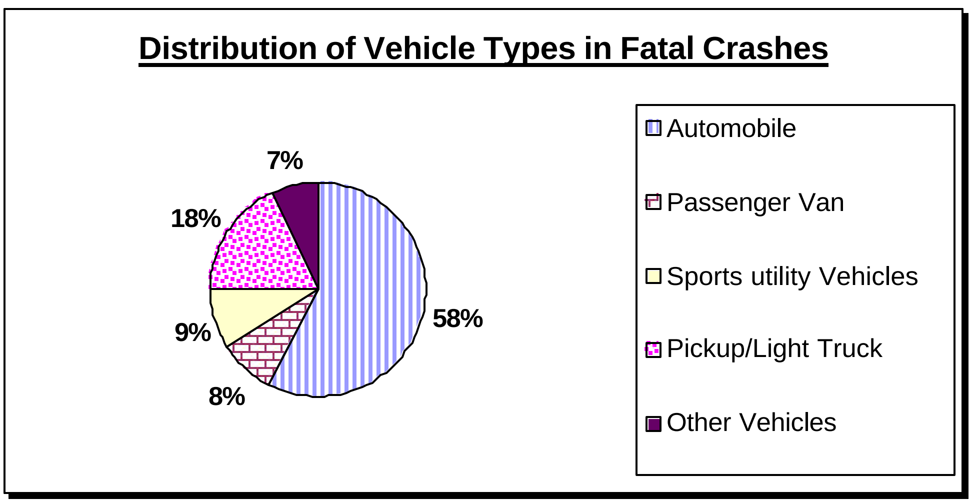

Figure 5.3: Comparison of Vehicle Types in Fatal Crashes

Table 5.15 looks at the distribution of vehicles in the fatal crashes, and Table 5.16 looks at vehicle type according to driver fault. Forty-four percent of the vehicles in the crashes were automobiles, and over 21 percent were pickups or light trucks. Given the emphasis on heavy trucks in this study, tractor trailers make of 12 percent of the vehicles, and other heavy trucks make up four percent. Looking at driver fault versus vehicle type (Table 5.16), automobile drivers and bicyclists are overrepresented in fault, while drivers of passenger vans, tractor trailers, motor homes, and buses are underrepresented in fault. In this and subsequent tables looking at fault, only drivers whose fault status is known are included in the overrepresentation calculations.

Table 5.15: Vehicle Types in Fatal Traffic Crashes

Code	Vehicle Type	Number	Percent
1	Automobile	1688	44.1%
2	Passenger Van	287	7.5%
3	Pickup/Light Truck	822	21.5%
4	Medium Truck	78	2.0%
5	Heavy Truck	163	4.3%
6	Truck Tractor	475	12.4%
7	Motor Home	7	0.2%
8	Small Bus	2	0.1%
9	Large Bus	27	0.7%
10	Bicycle	63	1.6%
11	Motorcycle	147	3.8%
12	Moped	4	0.1%
13	Train	6	0.2%
77	Other	14	0.4%
Unknown		43	1.1%
Total		3826	100.0%

Table 5.16: Vehicle Type Versus Driver Fault

Code	Vehicle Type	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
		Num.	Per.	Num.	Per.				
1	Automobile	946	51.2%	20	1.0%	**1.369**	1.273	1.473	Over
2	Passenger Van	114	6.2%	716	37.4%	**0.720**	0.572	0.907	Under
3	Pickup/Light Truck	417	22.6%	164	8.6%	**1.094**	0.969	1.236	Unsure
4	Medium Truck	29	1.6%	395	20.6%	**0.668**	0.421	1.060	Unsure
5	Heavy Truck	50	2.7%	45	2.4%	**0.480**	0.345	0.667	Unsure
6	Truck Tractor	129	7.0%	108	5.6%	**0.397**	0.327	0.481	Under
7	Motor Home	4	0.2%	337	17.6%	**1.382**	0.310	6.165	Under
8	Small Bus	0	0.0%	3	0.2%	**0.000**	N/A	N/A	N/A
9	Large Bus	1	0.1%	2	0.1%	**0.040**	0.005	0.293	Under
10	Bicycle	48	2.6%	26	1.4%	**3.553**	1.966	6.422	Over
11	Motorcycle	76	4.1%	14	0.7%	**1.125**	0.818	1.547	Unsure
12	Moped	3	0.2%	70	3.7%	**3.109**	0.324	29.860	Unsure
13	Train	0	0.0%	1	0.1%	**0.000**	N/A	N/A	N/A
77	Other	7	0.4%	6	0.3%	**1.209**	0.407	3.591	Unsure
Unknown		22	1.2%	20	1.0%	**1.140**	0.624	2.082	Unsure
Total		1846	100%	1913	1913	**1.000**			

5.4 Human Characteristics and Contributing Factors

This section discusses human characteristics and contributing factors to fatal traffic crashes. Table 5.17 examines alcohol use by drivers, primarily according to information on the traffic homicide reports. As stated previously, this information was found to be more accurate than that provided on the original crash reports, because it includes actual BAC (blood alcohol content) test results, including those done as part of autopsies. In numerous cases, the crash report indicated the crash was alcohol related, with a BAC pending or even described as "had been drinking;" however the BAC test result was negative (0.0 BAC). Likewise, several drivers listed as "not drinking or using drugs" on the crash report were found to have positive BAC or toxicology results upon testing.

However, as shown below in Table 5.17, toxicology results were not available in almost 60 percent of the persons involved in the crashes. Two reasons exist for this. First, almost 40 percent of drivers are never tested for blood alcohol. This is primarily because the investigating officers found no reason to suspect alcohol or drug use; therefore, no tests were conducted. As a result, most of these persons can be assumed to have been neither drinking nor using drugs at the time of the crash. These persons are listed as "0.00 Presumed" in the table. Second, for a number of cases (about 20 percent), the homicide report either wasn't available or did not report a BAC value for a driver when a BAC test was done. These are listed as "Unknown" in the table. In a limited number of cases, we were unable to retrieve a homicide report from an agency, yet the FDOT database had a BAC test result. These values were accepted as correct into our database, although comparison of known values showed a small error rate in the database, typically due to assigning a BAC value to the wrong person.

As shown in Table 5.17, around fourteen percent of the drivers were known to be drinking at the time of the crash. Of these, the most common BAC was between two and three times the legal limit of 0.08 mg/dl. All amount of alcohol use were strongly correlated with fault, as shown in Table 5.18. Although over 60 persons who were under the influence of alcohol were not found to be at fault in the resulting crash, drinking drivers were between 3.5 and 18 times as likely to be at fault in the crash, depending on the amount of alcohol ingested. Interestingly, those drivers who were tested to have a BAC of 0.00% were overrepresented in fault, while those who were presumed to have a BAC of 0.00% were underrepresented in fault. This is probably due to increased testing rates among at-fault drivers.

Table 5.19 through Table 5.20 examine drug use according to drug type and fault. Drug use is based on toxicology results from the homicide reports. The types of drugs used by the drivers were broken down into several major categories according to the anticipated impairment on the driver. In Table 5.19, the first category, "Illegal Drugs," includes drugs such as marijuana, cocaine, methamphetamines, and ecstasy. The second category, "Narcotic Analgesics, Sedatives, Hypnotics," includes barbiturates, narcotic pain relievers, tranquilizers, and other prescription medications believed to have an impairing effect on driving ability. The third category, "Prescription Or Non-Prescription Drugs W/Side Effects" includes cold medications, anti-seizure medications, blood-pressure medications, and other prescription and non-prescription drugs with potential side effects including drowsiness, dizziness, and blurred vision. It is likely that many more drivers were using such medications at the time of the crash; however, certain toxicology reports only included results of screens for *illegal* drugs.

Table 5.17: Alcohol Use by Drivers

BAC Content	Number	Percent
0.00 Tested	1039	27.2%
0.00 Presumed	1430	37.4%
< Limit	90	2.4%
1-2 X Limit	148	3.9%
2-3 X Limit	196	5.1%
3-4 X Limit	74	1.9%
> 4 X Limit	18	0.5%
> 0	9	0.2%
> Limit	2	0.1%
No driver	57	1.5%
Unknown	763	19.9%
Total	3826	100.0%

Table 5.18: Alcohol Use Versus Driver Fault

BAC Content	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0.00 Tested	662	35.9%	372	19.4%	**1.844**	1.652	2.057	Over
0.00 Presumed	361	19.6%	1062	55.5%	**0.352**	0.318	0.389	Under
< Limit	69	3.7%	20	1.0%	**3.575**	2.181	5.854	Over
1-2 X Limit	123	6.7%	25	1.3%	**5.099**	3.331	7.796	Over
2-3 X Limit	178	9.6%	18	0.9%	**10.248**	6.335	16.562	Over
3-4 X Limit	70	3.8%	4	0.2%	**18.135**	6.631	49.546	Over
> 4 X Limit	16	0.9%	2	0.1%	**8.290**	1.908	35.987	Over
> 0	7	0.4%	2	0.1%	**3.627**	0.754	17.428	Unsure
> Limit	2	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
No driver	0	0.0%	9	0.5%	**0.000**	N/A	N/A	N/A
Unknown	358	19.4%	399	20.9%	**0.930**	0.820	1.058	Unsure
Total	1846	100.0%	1913	100.0%	**1.000**			

Many drivers were under the influence of multiple drugs, both illegal and legal, either alone or in combination with alcohol: Table 5.19 includes only the "worst" category for each driver. No attempt was made to determine the potency or toxicity of various concentrations of the drugs, either alone or in combination. The numbers reported here indicate only that some concentration was found in either the blood or the urine of the driver. No reporting rates are presented for the drug use results; however, the drug screens were generally run with the BAC tests, so approximately 1500 drivers were tested for drug use, meaning that approximately eight percent of the tested drivers were found to be under the influence of a narcotic drug. Table 5.20 shows a breakdown of what drugs were be used by the drivers; this table shows the total number of times each drug was in use by a driver, despite the fact that certain drivers were using multiple drugs at the same time. The most common illegal drugs found during toxicology screens were marijuana and cocaine, followed by various sedatives and hypnotics. The gray-shaded rows in Table 5.20 indicate non-intoxicating substances, or those likely administered after the crash. They are shown here for completeness, but are not included in the summary results in other tables.

Table 5.21 looks at drug use according to fault. All drug use was more common in at-fault drivers than in not-at-fault drivers. However, the overrepresentation of prescription drugs could appear merely because at-fault drivers are more likely to be tested for drug use, and even non-impairing drugs are often indicated on the toxicology reports. By converse, not-at-fault drivers who are not tested for alcohol and drug use could easily be using various prescription or non-prescription medications.

Table 5.19: Drug Use by Drivers

Drug Use	Number	Percent
Illegal Drugs	107	2.8%
Narcotic Analgesics, Sedatives, Hypnotics	32	0.8%
Prescription Or Non-Prescription Drugs W/Side Effects	23	0.6%
None/Unknown	3610	94.4%
Parked/Driverless	54	1.4%
Total	3826	100.0%

Table 5.20: Breakdown of Drugs Used

Drug Used	Number	Percent
Marijuana	63	21.5%
Cocaine	50	17.1%
Sedative/Hypnotic	31	10.6%
Other prescription/non-prescription w/possible side effects	28	9.6%
Caffeine	27	9.2%
Narcotic Analgesic	15	5.1%
Cold Medication	14	4.8%
Nicotine	14	4.8%
Pain Medication (most likely administered post-crash)	13	4.4%
Amphetamines	9	3.1%
Ecstasy	6	2.0%
Non-Prescription Pain Medication	6	2.0%
Carbon Monoxide (most likely due to smoking or effects of crash)	6	2.0%
Other prescription/non-prescription w/no known side effects	6	2.0%
Other/unknown illegal drugs	5	1.7%
Total	293	100%

Table 5.21: Drug Use by Drivers According to Fault

Drug Use	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Illegal	96	5.2%	13	0.7%	**7.653**	4.303	13.609	Over
Narcotics/Sedatives	25	1.4%	7	0.4%	**3.701**	1.605	8.536	Over
Prescrip/Non-Prescrip	18	1.0%	6	0.3%	**3.109**	1.237	7.815	Over
None/Unknown	1707	92.5%	1887	98.6%	**0.937**	0.924	0.951	Under
Total		100.0%		100.0%	**1.000**			

Table 5.22 examines the driving history ranking of drivers involved in fatal traffic crashes. The driver history ranking was given for drivers who had a driving record included in the THI report, about one-third of the drivers. The driver histories tended to be very different, some spanning many more years than others, and included a variety of moving violations, prior crashes, and regulatory offenses (e.g. lapse in insurance), for which various adjudications, fines, suspensions, and were handed out. Because of the difficulty and time that would have been involved in distilling the information more quantitatively, a semi-qualitative driver ranking was assigned to each driver. The rating varied on a scale of one to five, with one being a clean history and five being a record involving serious traffic violations, such multiple DUI's or vehicular manslaughter. Table 5.23 shows that having multiple prior driving offenses strongly correlates to being found at fault in a fatal traffic crash. Incidentally, one CMV driver was at fault in two different fatal crashes during the study period.

Table 5.22: Driver History Ranking of Drivers

Driver History Ranking	Number	Percent
1 (Best)	364	9.5%
2	297	7.8%
3	296	7.7%
4	173	4.5%
5 (Worst)	86	2.2%
Unavailable	2556	66.8%
Parked/Driverless	54	1.4%
Total	3826	100.0%

Table 5.24 looks at driver license status at the time of the crash. Strictly looking at percentages, it is apparent that the vast majority of drivers had valid licenses at the time of the crash. (This category includes "unknown" status because the license was presumed to be valid if no information to the contrary was obtained---the crash report does not directly state whether the license was valid at the time of the crash.) However, over five percent of the drivers had either suspended or revoked licenses, no license, or were not in compliance with restrictions on their licenses. Looking at Table 5.25, having a license status other than valid is strongly correlated

with fault in the fatal crashes; however not all overrepresentation factors are statistically significant because of the small number of violators.

Table 5.23: Driver History Ranking Versus Driver Fault

Driver History Ranking	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
1 (Best)	182	9.9%	182	9.5%	**1.036**	0.852	1.260	Unsure
2	152	8.2%	144	7.5%	**1.094**	0.879	1.361	Unsure
3	151	8.2%	144	7.5%	**1.087**	0.873	1.353	Unsure
4	100	5.4%	73	3.8%	**1.420**	1.057	1.906	Over
5 (Worst)	59	3.2%	36	1.9%	**1.698**	1.128	2.558	Over
Unknown	1202	65.1%	1334	69.7%	**0.934**	0.893	0.976	Under
Total	1846	100.0%	1913	100.0%	**1.000**			

Table 5.24: Driver License Status of Drivers

Driver License Status	Number	Percent
Valid/Unknown	3505	91.6%
Suspended	114	3.0%
Revoked	15	0.4%
No Driver License	55	1.4%
Not Applicable	50	1.3%
Not In Compliance w/Restriction	33	0.9%
Parked/Driverless	54	1.4%
Total	3826	100.0%

Table 5.25: Driver License Status Versus Driver Fault

Driver License Status	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Valid/Unknown	960	52.0%	991	51.8%	**1.004**	0.944	1.068	Unsure
Suspended	87	4.7%	27	1.4%	**3.339**	2.179	5.118	Over
Revoked	10	0.5%	4	0.2%	**2.591**	0.814	8.246	Unsure
No Driver License	47	2.5%	8	0.4%	**6.088**	2.885	12.849	Over
Not Applicable	38	2.1%	14	0.7%	**2.813**	1.529	5.174	Over
Not In Compliance w/Restriction	15	0.8%	7	0.4%	**2.221**	0.907	5.434	Unsure
Unknown	689	37.3%	862	45.1%	**0.828**	0.767	0.895	Under
Total	1846	100.0%	1913	100.0%	**1.000**			

Table 5.26 and Table 5.27 examine the gender of drivers involved in the fatal crashes. Overall, about three-fourths of the drivers in the fatal crashes were male. Interestingly, almost the exact same percentages apply to both at-fault and not-at-fault drivers, meaning that gender has almost no correlation with fault. This means that males are much more likely to be *involved* in fatal crashes, since slightly over 50 percent of the population is male, but yet, they are slightly less likely to be *at fault* in the crash than the female drivers.

Table 5.26: Gender of Drivers

Driver Sex	Number	Percent
Male	2789	72.9%
Female	887	23.2%
Unknown	96	2.5%
Parked/Driverless	54	1.4%
Total	3826	100.0%

Table 5.27: Driver Gender Versus Driver Fault

Driver License Status	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Male	1354	73.3%	1425	74.5%	**0.985**	0.948	1.023	Unsure
Female	444	24.1%	436	22.8%	**1.055**	0.940	1.185	Unsure
Unknown	48	2.6%	52	2.7%	**0.957**	0.672	1.528	Unsure
Total	1846	100.0%	1913	100.0%	**1.000**			

Table 5.28 looks at the age of the drivers in the fatal crashes. Almost sixty percent of the drivers are in the 15-44 year old age groupings. Table 5.29 shows that drivers below age 25 and above age 74 were highly overrepresented in fault. Fault is underrepresented in most other age groups, significantly so in the 35-64 year old groups. Table 5.30 examines driver residence. Over sixty percent of the drivers in the fatal crashes were from the county of the crash; only 8.5 percent were known to be from other states or countries. There was almost no correlation between the residence of the drivers and fault, with a very slight trend toward locality of residence and overrepresentation in fault, as shown in Table 5.31.

Table 5.28: Age of Drivers

Driver Age	Number	Percent
0-14	2	0.1%
15-24	680	17.8%
25-34	758	19.8%
35-44	790	20.6%
45-54	609	15.9%
55-64	347	9.1%
65-74	232	6.1%
75-84	181	4.7%
85-94	59	1.5%
95-104	2	0.1%
Unknown	112	2.9%
Driverless	54	1.4%
Total	3826	100.0%

Table 5.29: Driver Age Versus Driver Fault

Age Group	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0-14	1	0.1%	1	0.1%	**1.036**	0.065	16.556	Unsure
15-24	419	22.7%	257	13.4%	**1.690**	1.467	1.946	Over
25-34	354	19.2%	404	21.1%	**0.908**	0.799	1.032	Unsure
35-44	345	18.7%	442	23.1%	**0.809**	0.714	0.917	Under
45-54	232	12.6%	374	19.6%	**0.643**	0.553	0.747	Under
55-64	138	7.5%	204	10.7%	**0.701**	0.570	0.862	Under
65-74	118	6.4%	113	5.9%	**1.082**	0.843	1.389	Unsure
75-84	130	7.0%	50	2.6%	**2.694**	1.957	3.710	Over
85-94	51	2.8%	8	0.4%	**6.606**	3.144	13.882	Over
95-104	2	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
Unknown	56	3.0%	60	3.1%	**0.967**	0.676	1.384	Unsure
	1846	100.0%	1913	100.0%	**1.000**			

Table 5.30: Residence of Drivers

Driver Residence	Number	Percent
County of Crash	2315	60.5%
Elsewhere in State	1007	26.3%
Non-Resident of State	307	8.0%
Foreign	20	0.5%
Unknown	123	3.2%
Driverless	54	1.4%
Total	3826	100.0%

Table 5.31: Driver Residence Versus Driver Fault

Driver Residence	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
County of Crash	1145	62.0%	1156	60.4%	**1.026**	0.976	1.080	Unsure
Elsewhere in State	487	26.4%	518	27.1%	**0.974**	0.876	1.083	Unsure
Non-Resident of State	141	7.6%	166	8.7%	**0.880**	0.710	1.092	Unsure
Foreign	7	0.4%	13	0.7%	**0.558**	0.223	1.395	Unsure
Unknown	66	3.6%	60	3.1%	**1.140**	0.846	1.710	Unsure
Total	1846	100.0%	1913	100.0%	**1.000**			

Table 5.32 looks at speed of the vehicles in the fatal crashes. The vehicles were most likely to be stopped, traveling between 55 and 59 miles per hour, or traveling between 70 and 74 miles per hour at the time of the crash. This in part reflects the most common posted speed limits on Florida highways. Table 5.33 compares vehicle speed to driver fault. While vehicles that are stopped are less likely to be found at fault than not, those which are traveling at very low speeds, between 5 and 24 miles per hour, are overrepresented in fault, all with statistical significance. Lower speed vehicles are likely to be those starting from a stop or proceeding slowly through intersections, or those performing unsafe maneuvers such as mid-block U-turns, backing, or traveling slowly on limited access roads. Fault was underrepresented between 30 and 59 miles per hour, but overrepresented at all speeds above 60 MPH.

Table 5.32: Vehicle Speed in Fatal Crashes

Vehicle Speed	Number	Percent
0-4	396	10.4%
5-9	128	3.3%
10-14	153	4.0%
15-19	94	2.5%
20-24	82	2.1%
25-29	40	1.0%
30-34	94	2.5%
35-39	122	3.2%
40-44	227	5.9%
45-49	372	9.7%
50-54	256	6.7%
55-59	412	10.8%
60-64	219	5.7%
65-69	230	6.0%
70-74	264	6.9%
75-79	69	1.8%
80-84	80	2.1%

Table 5.32: Vehicle Speed in Fatal Crashes, continued

Vehicle Speed	Number	Percent
85-89	25	0.7%
90-94	23	0.6%
95-99	9	0.2%
100-104	12	0.3%
105-109	2	0.1%
110-114	2	0.1%
115+	4	0.2%
Unknown	457	11.9%
Driverless	54	1.4%
Total	3826	100.0%

Table 5.33: Vehicle Speed Versus Driver Fault

Vehicle Speed	At-Fault		Not-At-Fault		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0-4	77	4.2%	278	14.5%	**0.287**	0.225	0.366	Under
5-9	80	4.3%	48	2.5%	**1.727**	1.215	2.456	Over
10-14	112	6.1%	40	2.1%	**2.902**	2.034	4.140	Over
15-19	72	3.9%	22	1.2%	**3.392**	2.113	5.444	Over
20-24	56	3.0%	25	1.3%	**2.321**	1.455	3.703	Over
25-29	25	1.4%	14	0.7%	**1.851**	0.965	3.549	Unsure
30-34	31	1.7%	59	3.1%	**0.544**	0.354	0.837	Under
35-39	35	1.9%	85	4.4%	**0.427**	0.289	0.629	Under
40-44	72	3.9%	150	7.8%	**0.497**	0.378	0.654	Under
45-49	111	6.0%	261	13.6%	**0.441**	0.356	0.545	Under
50-54	95	5.1%	161	8.4%	**0.611**	0.478	0.782	Under
55-59	173	9.4%	238	12.4%	**0.753**	0.626	0.906	Under
60-64	124	6.7%	95	5.0%	**1.353**	1.044	1.753	Over
65-69	139	7.5%	91	4.8%	**1.583**	1.225	2.046	Over
70-74	185	10.0%	79	4.1%	**2.427**	1.880	3.133	Over
75-79	59	3.2%	10	0.5%	**6.114**	3.137	11.915	Over
80-84	72	3.9%	7	0.4%	**10.659**	4.919	23.098	Over
85-89	25	1.4%	0	0.0%	**N/A**	N/A	N/A	N/A
90-94	23	1.2%	0	0.0%	**N/A**	N/A	N/A	N/A
95-99	9	0.5%	0	0.0%	**N/A**	N/A	N/A	N/A
100-104	12	0.7%	0	0.0%	**N/A**	N/A	N/A	N/A
105-109	2	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
110-114	2	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
115-119	2	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
120+	2	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
Total	1846	100.0%	1913	100.0%	**1.000**			

When vehicle speed is compared to the speed limit (see Table 5.34 and Table 5.35), about 40 percent of the drivers were traveling within ± 5 MPH of the posted limit. Around 16 percent were traveling at least 5 MPH over the limit. When speeding is compared to fault, drivers traveling at any speed over 4 MPH over the posted limit were highly overrepresented in fault. As the amount of speeding increases, the degree of overrepresentation increases; however, even at 5-9 miles over the limit, drivers were overrepresented in fault by a factor of over 2.0. Again, drivers traveling from 40 to 21 MPH under the limit were overrepresented in fault, for the same reasons mentioned previously, while drivers at most other speeds were underrepresented in fault.

Table 5.34: Speed Differential in Fatal Crashes

Speed Differential	Number	Percent
≤ -66	73	1.9%
-65 to -61	50	1.3%
-60 to -56	19	0.5%
-55 to -51	68	1.8%
-50 to -46	54	1.4%
-45 to -41	172	4.5%
-40 to -36	92	2.4%
-35 to -31	103	2.7%
-30 to -26	86	2.2%
-25 to -21	73	1.9%
-20 to -16	82	2.1%
-15 to -11	124	3.2%
-10 to -6	207	5.4%
-5 to -1	380	9.9%
0 to 4	1118	29.2%
5-9	190	5.0%
10-14	149	3.9%
15-19	91	2.4%
20-24	60	1.6%
25-29	49	1.3%
30-34	31	0.8%
35-39	12	0.3%
40-44	10	0.3%
45-49	4	0.1%
50-54	5	0.1%
55-59	3	0.1%
60-64	4	0.1%
≥65	4	0.1%
Unknown	513	12.0%
Driverless	54	1.4%
Total	3826	100.0%

Table 5.35: Speed Differential Versus Driver Fault

Speed Differential	At-Fault		Not-At-Fault		At-Fault ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
≤ -66	11	0.6%	50	2.6%	**0.228**	0.119	0.437	Under
-65 to -61	10	0.5%	34	1.8%	**0.305**	0.151	0.615	Under
-60 to -56	4	0.2%	13	0.7%	**0.319**	0.104	0.976	Under
-55 to -51	17	0.9%	46	2.4%	**0.383**	0.220	0.666	Under
-50 to -46	25	1.4%	28	1.5%	**0.925**	0.542	1.581	Unsure
-45 to -41	56	3.0%	107	5.6%	**0.542**	0.395	0.745	Under
-40 to -36	55	3.0%	36	1.9%	**1.583**	1.045	2.398	Over
-35 to -31	61	3.3%	40	2.1%	**1.580**	1.066	2.343	Over
-30 to -26	55	3.0%	30	1.6%	**1.900**	1.223	2.951	Over
-25 to -21	50	2.7%	23	1.2%	**2.253**	1.381	3.676	Over
-20 to -16	42	2.3%	39	2.0%	**1.116**	0.725	1.718	Unsure
-15 to -11	64	3.5%	59	3.1%	**1.124**	0.794	1.592	Unsure
-10 to -6	69	3.7%	136	7.1%	**0.526**	0.396	0.697	Under
-5 to -1	103	5.6%	273	14.3%	**0.391**	0.315	0.486	Under
0 to 4	476	25.8%	635	33.2%	**0.777**	0.703	0.859	Under
5-9	126	6.8%	63	3.3%	**2.073**	1.542	2.785	Over
10-14	116	6.3%	32	1.7%	**3.757**	2.553	5.527	Over
15-19	83	4.5%	8	0.4%	**10.752**	5.219	22.149	Over
20-24	55	3.0%	5	0.3%	**11.399**	4.574	28.412	Over
25-29	46	2.5%	3	0.2%	**15.890**	4.951	51.000	Over
30-34	29	1.6%	2	0.1%	**15.026**	3.591	62.883	Over
35-39	11	0.6%	1	0.1%	**11.399**	1.473	88.205	Over
40-44	10	0.5%	0	0.0%	**N/A**	N/A	N/A	N/A
45-49	4	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
50-54	5	0.3%	0	0.0%	**N/A**	N/A	N/A	N/A
55-59	3	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
60-64	4	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
65-69	3	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
70-74	0	0.0%	0	0.0%	**N/A**	N/A	N/A	N/A
≥ 75	1	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
Unknown	252	13.7%	250	13.1%	**1.045**	0.888	1.229	Unsure
Total	1846	100.0%	1913	100.0%	**1.000**			

5.5 Crash Types and Contributing Factors in Motorcycle Crashes

Because motorcycle crashes resulted in 146 fatalities, six percent of all fatalities in the study, and because they aren't looked at in detail elsewhere in this report, this section includes a few key charts dealing with motorcycle crashes. Table 5.36 looks at crash types in crashes in which motorcycles or other drivers were at fault. Of the common crash types, motorcyclists were highly likely to be at fault in right and left roadside departure crashes, and more likely to be at fault in rear end crashes than other drivers. Other drivers were highly overrepresented in fault in head-on crashes, and in most intersection crashes.

Table 5.36: Crash Types in Motorcycle Crashes

Crash Type	Motorcycle At Fault		Other At Fault		ORF
	Num.	Per.	Num.	Per.	
Crossing Not At Intersection--Second Half	1	1.3%	3	4.2%	0.300
Exit Vehicle	2	2.5%	1	1.4%	1.797
Right Roadside Departure	8	10.1%	0	0.0%	N/A
Right Roadside Departure With Control Loss	4	5.1%	1	1.4%	3.595
Left Roadside Departure	10	12.7%	1	1.4%	8.987
Left Roadside Departure With Control Loss	2	2.5%	2	2.8%	0.899
Forward Impact	2	2.5%	0	0.0%	N/A
Ramp Departure	4	5.1%	0	0.0%	N/A
Other	2	2.5%	0	0.0%	N/A
Rear End	8	10.1%	5	7.0%	1.438
Rear End With Avoid Impact	2	2.5%	2	2.8%	0.899
Sideswipe Angle	4	5.1%	0	0.0%	N/A
Sideswipe Angle With Control Loss	2	2.5%	1	1.4%	1.797
Head-On	3	3.8%	10	14.1%	0.270
Forward Impact With Control Loss	3	3.8%	2	2.8%	1.348
Sideswipe Angle	2	2.5%	1	1.4%	1.797
Initial Opposite Directions/Oncoming Traffic	10	12.7%	22	31.0%	0.409
Turn/Merge Into Same Direction	0	0.0%	2	2.8%	0.000
Turn Into Opposite Directions/Cross Traffic	3	3.8%	11	15.5%	0.245
Single Vehicle Control Loss While Turning	1	1.3%	1	1.4%	0.899
Evasive Action To Avoid Turning/Merging Vehicle	1	1.3%	0	0.0%	N/A
Not At Fault From Left	3	3.8%	5	7.0%	0.539
Not At Fault From Right	2	2.5%	1	1.4%	1.797
Total	79	100%	71	100%	1.000

Table 5.37 looks at primary contributing factors in the motorcycle crashes. The primary contributing factor in motorcycle crashes is almost always a human factor. When the motorcyclist is at fault, aggression, speed, abrupt steering input, and a combination of alcohol

and drug use are the most common primary contributing factors. The most common primary contributing factors when the other driver was at-fault were inattention and perception problems. Table 5.38 looks at additional (secondary and tertiary) factors in motorcycle crashes; recall that additional human and vehicle factors might belong to either the at-fault or the not-at-fault driver. When motorcyclists were at fault, wet/slippery conditions, inattention (on the part of the other driver), vehicle instability (on the part of the motorcycle), speed (on the part of both drivers) and curvature were common additional factors, as shown in Table 5.38. When other drivers were at fault, darkness, vehicle visibility (on the part of the motorcycle), and inexperience (on the part of the other driver) were the most common additional factors.

Table 5.37: Primary Contributing Factors in Motorcycle Crashes

Factor Class	Factor	Motorcycle At Fault		Other At Fault		ORF
		Number	Percent	Number	Percent	
Human	Aggression	10	13%	2	3%	**4.494**
	Alcohol	18	23%	18	25%	**0.899**
	Alcohol & Drugs	3	4%	1	1%	**2.696**
	Confusion	2	3%	2	3%	**0.899**
	Decision	7	9%	6	8%	**1.049**
	Drugs	3	4%	4	6%	**0.674**
	Fatigue/Asleep		0%	1	1%	**0.000**
	Inattention	9	11%	26	37%	**0.311**
	Perception	1	1%	2	3%	**0.449**
	Speed	13	16%	3	4%	**3.895**
	Steering Input	5	6%	2	3%	**2.247**
	Unknown	5	6%	3	4%	**1.498**
Roadway	Obstruction	2	3%	0	0%	**N/A**
Vehicle	Tires	1	1%	1	1%	**0.899**
Total		79	100%	71	100%	**1.000**

Table 5.38: Secondary and Tertiary Factors in Motorcycle Crashes

Factor Class	Factor	Motorcycle At Fault		Other At Fault		ORF
		Number	Percent	Number	Percent	
Environment	Dark	3	2.5%	7	6.2%	**0.410**
	Dawn/Dusk	1	0.8%	1	0.9%	**0.958**
	Wet/Slippery	4	3.4%	1	0.9%	**3.831**
Human	Age	0	0.0%	1	0.9%	**0.000**
	Aggression	1	0.8%	1	0.9%	**0.958**
	Alcohol	3	2.5%	4	3.5%	**0.718**
	Alcohol & Drugs	0	0.0%	1	0.9%	**0.000**
	Confusion	0	0.0%	1	0.9%	**0.000**

Table 5.38: Secondary and Tertiary Factors in Motorcycle Crashes, continued

Factor Class	Factor	Motorcycle At Fault		Other At Fault		ORF
		Number	Percent	Number	Percent	
Human	Decision	9	7.6%	8	7.1%	**1.077**
	Drugs	1	0.8%	2	1.8%	**0.479**
	Fatigue/Asleep	0	0.0%	2	1.8%	**0.000**
	History	1	0.8%	0	0.0%	**N/A**
	Inattention	14	11.9%	4	3.5%	**3.352**
	Inexperience	1	0.8%	3	2.7%	**0.319**
	Mental/Emotional	2	1.7%	0	0.0%	**N/A**
	Perception	1	0.8%	0	0.0%	**N/A**
	Speed	16	13.6%	5	4.4%	**3.064**
	Steering Input	7	5.9%	4	3.5%	**1.676**
	Unfamiliar w/Area	0	0.0%	1	0.9%	**0.000**
	Unfamiliar w/Vehicle	1	0.8%	0	0.0%	**N/A**
Roadway	Access Point	3	2.5%	0	0.0%	**N/A**
	Congestion	3	2.5%	1	0.9%	**2.873**
	Construction	2	1.7%	1	0.9%	**1.915**
	Curvature	15	12.7%	4	3.5%	**3.591**
	Design/Geometry	1	0.8%	3	2.7%	**0.319**
	Lighting	3	2.5%	1	0.9%	**2.873**
	Maintenance	2	1.7%	0	0.0%	**N/A**
	Obstruction	2	1.7%	2	1.8%	**0.958**
	Sight Distance	2	1.7%	2	1.8%	**0.958**
	Sign/Signal	1	0.8%	0	0.0%	**N/A**
	Traffic Operations	0	0.0%	2	1.8%	**0.000**
Vehicle	Defect	1	0.8%	2	1.8%	**0.479**
	Emergency	2	1.7%	1	0.9%	**1.915**
	Lighting	0	0.0%	2	1.8%	**0.000**
	Low Speed	0	0.0%	1	0.9%	**0.000**
	Stability	7	5.9%	2	1.8%	**3.352**
	Tires	1	0.8%	0	0.0%	**N/A**
	Trailer	0	0.0%	1	0.9%	**0.000**
	View Obstruction	2	1.7%	2	1.8%	**0.958**
	Visibility	6	5.1%	40	35.4%	**0.144**
Total		118	100.0%	113	100.0%	**1.000**

When all of these crash types and factors are put together, one gets the picture of two different sets of crashes involving motorcycles. Motorcyclists are more likely to be at fault in single vehicle crashes and those not occurring at intersections. At-fault motorcyclists are likely to be speeding and driving aggressively. Thirty percent of the at-fault motorcyclists had one of these factors as the primary contributing factor, and 32 percent were traveling at least 15 MPH over the posted speed at the time of the crash. Most of the behavior occurs on non-limited access facilities with speed limits of 45 MPH or below, where conflicts arise with other vehicular traffic traveling at much slower speeds. Loss of control, wet conditions and vehicle instability figure into many crashes where a motorcyclist is at fault. On the other hand, other drivers are most often at fault in intersection crashes involving motorcycles. Inattention on the part of the other driver, coupled with the size of the motorcycle and often darkness, combine to create a situation where the other driver violates the right-of-way of the motorcyclist, resulting in the fatal crash.

Given this situation, dual countermeasures are suggested. First, increased enforcement and additional educational programs should be directed at aggressive driving by motorcyclists. Second, greater attention should be paid to "share the road" type public service campaign, focusing on improving driver awareness of motorcyclists and the dangers of inattentive driving, especially at intersections and other conflict points. Most of the motorcycle crashes occur along the east coast of Florida, especially in Miami-Dade and Broward counties, and along the I-4 corridor and into the Tampa Bay region. A small number occur along the northern Gulf coast and in rural regions in the central part of the state. It is therefore recommended that both enforcement and education programs be concentrated in these regions, with enforcement activities focusing on non-limited access facilities, where both types of crashes can be addressed simultaneously.

5.6 Conclusions and Recommendations

A total of 2,080 fatal crashes occurred in the study set. Run off the road and intersection crashes were the common crash types, followed by pedestrian and rear-end/sideswipe crashes. Run off the road crashes were often associated with head-on collisions due to median cross-overs, and rear-end crashes frequently occurred at or near intersections. Human factors were the primary causative factor in 94 percent of the fatal crashes. Overall, however, around 30 percent of the crash contributing factors (including secondary and tertiary factors) were roadway, environmental, and vehicle factors. Among human factors, alcohol and/or drug use is the most common factor. This is followed by driver errors, including inattention and decision errors.

The most common vehicle factor by far was tire tread separation/blowout, which accounted for 40 percent of the non-human primary factors. Vehicle condition, including vehicle defects, disabled vehicles, inadequate lighting, and tire issues, contributed in some way to about eight percent of the fatal crashes. Obstructions (typically vehicles from previous crashes) were the most common primary roadway contributing factor. Inadequate lighting and curvature were the most common additional factors. Access points, construction, congestion, and roadway design/geometry issues each contributed in some manner to about one percent of the crashes. No environmental factors were common as primary crash contributors; as additional contributors, darkness and wet/slippery conditions each contributed to around three or four percent of the crashes. While only 40 cases involved smoke and/or fog, a number of these cases involved forest fires and controlled burns, indicating that control of traffic flow during such conditions of limited visibility is very important.

An important factor in examining crash causation is looking at characteristics of the at-fault driver. Automobile drivers and bicyclists are overrepresented in fault, while drivers of passenger vans, tractor trailers, motor homes, and buses are underrepresented in fault. Over 25 percent of the at-fault drivers were under the influence of alcohol at the time of the crash, and almost eight percent were using illegal or impairing drugs. Although over 60 persons who were under the influence of alcohol were not found to be at fault in the resulting crash, drinking drivers were between 3.5 and 18 times as likely to be at fault in the crash, depending on the amount of alcohol ingested. The same is true of drivers using drugs at the time of the crash.

A number of drivers had serious records of previous traffic violations prior to being involved in the fatal traffic crash, and having a history of multiple prior offenses, especially DUI's, prior suspensions or revocations, and other serious offenses. This indicates that increased attention needs to be paid to proper adjudication of individual driving offenses and potentially increased penalties for serious offenses. About four percent of the drivers had suspended or revoked licenses, or were not in compliance with restrictions on their licenses. Having any license status other than valid is strongly correlated with fault in the fatal crashes; however not all overrepresentation factors are statistically significant because of the small number of violators. Again, this is an issue for increased enforcement and stiffer penalties for driving without a proper license.

Educational programs should be developed and marketed toward according to the demographic characteristics of the typical at-fault driver. Three-fourths of the at-fault drivers in the fatal crashes were male, although female drivers were very slightly overrepresented in fault. Drivers below age 25 and above age 74 were highly overrepresented in fault. Overall, no effect of driver residence on fault was seen: over 60 percent of drivers involved in and at-fault in fatal crashes were from the county of the crash. Speeding is strongly associated with increased rates of fault in the fatal crashes, so increased attention should be directed toward speed enforcement and associated educational campaigns. Interestingly, overrepresentation in fault occurs with speeding as little as five miles per hour over the posted limit, so increased enforcement and stiffer penalties for lower levels of speeding should be considered.

6 FACTORS CONTRIBUTING TO FATALITIES

This chapter discusses injury rates and severities of persons involved in fatal traffic crashes, including drivers, passengers, and non-motorists. Injuries and fatalities are examined in terms of various contributing factors, such as safety equipment used, point of impact, occupant location, vehicle ejection and many others. Factors contributing to the crash are defined as the reasons that the crash occurred; factors contributing to the fatality are defined as the reasons that the crash was fatal. Factor contributing to fatalities and the summaries presented are case level unless noted otherwise.

Table 6.1 gives the total number and distribution of each type of person involved in the crashes in this study along with the number and percentages of fatalities and injuries. As shown in the table, three-fourths of the fatalities involved motor vehicle occupants other than motorcyclists, 15 percent involved pedestrians, 6 percent involved motorcyclists, and fewer than 3 percent involved bicyclists. Examining the percentages relative to the distribution within the study reveals that bicyclists and pedestrians were most likely to have died in fatal crashes, followed by motorcyclists and other motor vehicle occupants. Because the study was limited to crashes with at least one fatality, the majority of motorcyclists, bicyclists, and pedestrians involved in such a severe crash died as a result of the crash.

Table 6.1: Persons, Fatalities, and Injuries by Person Type

	Persons		Fatalities		Injuries	
	Number	Percent	Number	Percent	Number	Percent
Motorcyclists	181	2.7%	140	6.0%	39	1.7%
Bicyclists	63	1.0%	62	2.6%	1	0.0%
Other MV Occupants	5970	90.5%	1798	76.5%	2209	96.9%
Pedestrians	382	5.8%	350	14.9%	31	1.4%
Total	6596	100.0%	2350	100%	2280	100%

Table 6.2 looks at injury severity of drivers, passengers, and non-motorists. As might be expected, CMV drivers were much less likely to obtain severe injuries or fatalities than drivers of other vehicles, especially other drivers in the CMV crashes. Taking all of the vehicles together, drivers in fatal crashes were more likely to be killed than injured, and equally likely to be injured than not. Passengers were more likely to be injured than killed or not injured. Motorcycle drivers, pedestrians, and bicyclists, once involved in a fatal traffic crash, suffered almost exclusively severe or fatal injuries. Unlike motorcycle drivers, motorcycle passengers were much more likely to be injured than killed. In almost a third of the motorcycle crashes the other driver experienced an injury or was fatally injured. These reported results have been corrected to account for delayed fatalities that might not have appeared in the crash report completed on scene.

Table 6.2: Injuries by Drivers, Passengers, and Non-Motorists

	Injury Severity							Total
	None	Possible	Non-Incapacitating	Incapacitating	Fatal	Non-traffic Fatality	Unknown/Other	
All Drivers	30%	6%	11%	12%	38%	<1%	3%	100%
All Passengers	29%	8%	16%	24%	23%		<1%	100%
Pedestrians	<1%	<1%	2%	6%	92%			100%
Drivers in Pedestrian Crashes (Striking Vehicle)	75%	5%	7%	3%	1%		8%	100%
CMV Drivers	59%	9%	12%	6%	10%	<1%	4%	100%
Other Drivers in CMV Crashes	12%	5%	6%	13%	61%		3%	100%
CMV Passengers	68%	5%	10%	6%	7%		3%	100%
Motorcycle Drivers	1%		5%	7%	87%		1%	100%
Other Drivers in Motorcycle Crashes	65%	7%	8%	12%	4%		3%	100%
Motorcycle Passengers	3%	3%	13%	53%	28%			100%
Bicycle Drivers			2%		98%			100%
Other Drivers in Bicycle Crashes	83%	4%	1%	3%			8%	100%

Table 6.3 and Table 6.4 examine the injury severity for drivers and passengers grouped by vehicle sub-type (a classification scheme for this study based on VIN decoding) and based on ejection status. The table percentages given are grouped by vehicle sub-type; for instance in Table 6.3, automobile drivers who were not ejected and were not injured represent 21% of all automobile drivers.

Based on the results presented in Table 6.3 and Table 6.4 vehicle ejection is a significant factor contributing to driver and passenger fatalities, especially in the case of sport utility vehicles (SUV). The likelihood of serious injury or fatality is almost assured in cases where a driver or passenger is ejected or partially ejected. Ejection is most prevalent in SUV's followed by trucks and vans. The high percentage of driver ejections in the other/unknown category is influenced by the inclusion of motorcycle, bicycle, and moped drivers in the other/unknown category. Commercial motor vehicle (CMV) occupants have the lowest ejection and fatality rates. Only 4% of CMV drivers were ejected, compared to the 20% of SUV drivers. SUV drivers were twice as likely as automobile drivers to be ejected, and five times more likely than CMV drivers to be ejected. A very high percentage of SUV passengers (31%) were ejected, half of whom were fatally injured. By comparison, only a seventh of SUV passengers who were not ejected were fatally injured.

Table 6.3: Driver Injury Severity by Vehicle Sub-Type and Ejection

Vehicle Sub-Type	Ejection	Driver Injury Severity							Total
		None	Possible	Non-Incapacitating	Incapacitating	Fatal	Non-traffic Fatality	Unknown	
Automobile	No	21%	6%	10%	12%	39%	<1%	<1%	88%
	Yes	<1%	<1%	<1%	<1%	7%			9%
	Partial				<1%	1%			1%
	UK	<1%			<1%	<1%		1%	2%
Van	No	31%	7%	15%	15%	18%			85%
	Yes	<1%	<1%	<1%	1%	9%			12%
	Partial				<1%	<1%			1%
	UK							2%	2%
Truck	No	30%	8%	9%	13%	21%	<1%	<1%	82%
	Yes	<1%	<1%	<1%	2%	11%			14%
	Partial				<1%	1%			2%
	UK		<1%		<1%		<1%	2%	2%
SUV	No	25%	6%	17%	10%	21%			80%
	Yes				3%	15%			18%
	Partial					2%			2%
	UK	<1%						<1%	<1%
CMV	No	61%	9%	11%	6%	7%	<1%		93%
	Yes	<1%		<1%	<1%	3%			4%
	Partial								0%
	UK	<1%	<1%			<1%		3%	3%
Other / Unknown	No	18%	3%	5%	5%	13%	3%		47%
	Yes	1%	<1%	1%	2%	35%	3%	<1%	43%
	Partial				<1%	<1%			<1%
	UK	1%				<1%	4%	3%	10%

Table 6.4: Passenger Injury Severity by Vehicle Sub-Type and Ejection

Vehicle Sub-Type	Ejection	Passenger Injury Severity					Total
		None	Possible	Non-Incapacitating	Incapacitating	Fatal	
Automobile	No	25%	6%	12%	22%	24%	89%
	Yes	<1%	<1%	<1%	4%	5%	10%
	Partial					<1%	<1%
Van	No	18%	7%	24%	16%	11%	77%
	Yes	<1%		5%	10%	6%	21%
	Partial				<1%	2%	2%
Truck	No	28%	5%	12%	23%	11%	80%
	Yes	<1%	<1%	2%	6%	9%	18%
	Partial				<1%	2%	2%
SUV	No	14%	6%	19%	17%	10%	68%
	Yes		<1%	3%	12%	16%	31%
	Partial	<1%				<1%	<1%
CMV	No	67%	5%	9%	6%	6%	94%
	Yes	1%	1%	1%		1%	5%
	Partial				1%		1%
Other / Unknown	No	51%	18%	7%	6%	5%	89%
	Yes	<1%	<1%	1%	4%	4%	11%
	Partial				<1%	<1%	<1%

Table 6.4 and Table 6.5 look at how safety equipment use varies by vehicle sub-type and ejection of vehicle drivers and passengers. The first row is a summary of driver or passenger safety equipment use without vehicle type or ejection considered.

Clearly, not using safety equipment is tied to vehicle ejection. Nine percent of the automobile drivers were ejected while less than 1% of the automobile drivers had a seat belt or a seat belt and air bag in use and were ejected. The same trend is found for passengers of automobiles. The vast majority of ejected drivers and passengers (all vehicle sub-types) were not using any safety equipment or only had an air bag in use. Seat belt usage prevents vehicle occupants from being partially or fully ejected. Not wearing a seat belt contributes to vehicle ejection, which as found earlier leads to serious injury and fatality.

Table 6.5: Driver Safety Equipment Use by Vehicle Sub-Type and Ejection

Vehicle Sub-Type	Driver Ejection	Driver Safety Equipment Use								Total
		Not in use	Seat belt / Shoulder harness	Air Bag	Safety Helmet	Eye Protection	Unknown	Seat Belt and Air Bag	Safety Helmet and Eye Protection	
All Drivers (all ejection states)		25%	41%	7%	1%	<1%	6%	17%	2%	100%
Automobile	No	19%	36%	7%			2%	24%		88%
	Yes	5%	<1%	2%			<1%	<1%		9%
	Partial	<1%		<1%			<1%	<1%		1%
	UK	<1%	<1%				1%			2%
Van	No	15%	40%	5%			1%	24%		85%
	Yes	9%	<1%	1%			<1%	1%		12%
	Partial	<1%	<1%							1%
	UK						2%			2%
Truck	No	20%	40%	5%		<1%	2%	15%		82%
	Yes	10%	<1%	2%			<1%	<1%		14%
	Partial	1%		<1%				<1%		2%
	UK	<1%	<1%				2%			2%
SUV	No	14%	34%	6%			1%	25%		80%
	Yes	12%		5%				<1%		18%
	Partial	<1%		<1%						2%
	UK	<1%					<1%			<1%
CMV	No	14%	75%				3%	1%		93%
	Yes	3%	<1%				<1%	<1%		4%
	Partial									0%
	UK		<1%				3%			3%
Other / Unknown	No	11%	20%	1%	1%	<1%	7%	4%	1%	47%
	Yes	16%	1%	<1%	9%	1%	4%		10%	43%
	Partial	<1%		<1%			<1%			<1%
	UK	<1%	<1%		<1%		9%			10%

Table 6.6: Passenger Safety Equipment Use by Vehicle Sub-Type and Ejection

Vehicle Sub-Type	Ejection	Passenger Safety Equipment Use										Total
		Not in use	Seat belt / Shoulder harness	Child Restraint	Air Bag	Safety Helmet	Unknown	Seat Belt and Child Restraint	Seat Belt and Air Bag	Child Restraint and Air Bag	Safety Helmet and Eye Protection	
All Passengers (all ejection states)		44%	33%	2%	4%	<1%	5%	1%	10%	<1%	1%	100%
Automobile	No	28%	37%	3%	4%		3%	<1%	13%			89%
	Yes	7%	<1%		<1%		<1%		<1%		<1%	10%
	Partial	<1%	<1%				<1%					1%
Van	No	23%	37%	2%	4%		1%	1%	8%			77%
	Yes	16%	<1%		<1%		4%		<1%	<1%		21%
	Partial	2%	<1%				<1%					2%
Truck	No	29%	35%	3%	3%		2%		8%			80%
	Yes	16%	<1%		1%		<1%					18%
	Partial	2%										2%
SUV	No	24%	24%	1%	4%		2%	<1%	12%			68%
	Yes	26%	1%		3%		<1%		<1%			31%
	Partial			<1%					<1%			1%
CMV	No	39%	42%	1%	1%		10%					94%
	Yes	4%	1%									5%
	Partial	1%										1%
Other / Unknown	No	58%	15%	<1%	<1%	<1%	11%	2%	2%		<1%	89%
	Yes	4%	<1%		<1%	2%					3%	11%
	Partial	<1%			<1%							1%

Vehicle passengers were less likely than drivers to have an air bag in their seating position (14% versus 24%). They were also less likely to have been wearing a seat belt at the time of the crash (43% versus 58%). The largest difference between passengers and drivers in regards to not using safety equipment occurs in CMV's (44% versus 17%), followed by SUV's (50% versus 26%). Drivers of CMV's were much more likely to wear a seat belt than their passengers (75% versus 43%).

Table 6.7 examines injury severity, ejection status and safety equipment use among vehicle drivers. Motorcycles, bicycles, mopeds, ATV's and trains are excluded due to differences in available safety equipment among these vehicles. The significance of driver ejection on injury is very clear in Table 6.7. A much lower percentage of drivers who were not ejected were fatally injured (30%) compared to ejected drivers (75%) and partially ejected drivers (91%). Of drivers who were either partially or fully ejected a high percentage had no safety equipment in use or only an air bag (80% and 82% respectively). This is quite different from drivers who were not ejected where only 26% had no safety equipment in use or only an air bag. Seat belts are effective in preventing driver ejection during a crash. The vast majority of the ejected drivers were fatally injured. Of the drivers either partially or fully ejected, 73% and 70% respectively were fatally injured and were not using any safety equipment or only air bags. Drivers not using safety devices or using only an air bag have more negative outcomes (severe injuries or fatalities) than those who are wearing seat belts, especially in the case of partial or total ejection. In this study, all drivers who were partially ejected were either incapacitated or fatally injured. Clearly, not wearing a seat belt increases the chance of ejection which dramatically increases the likelihood of serious or fatal injury. Comparing safety equipment use and injury severity for drivers (all ejection states) reveals that when safety equipment is not in use fatalities are more prevalent (16% of drivers fatally injured, 3% of drivers not injured) compared to when seat belts are used (8% of drivers fatally injured, 22% of drivers not injured). Somewhat surprising is the fact that air bags used in combination with seat belts do not improve outcomes. The percentage of drivers using seat belts and air bags and receiving severe or fatal injuries (3% to 5%) does not differ greatly from those using seat belts and air bags and receiving no injuries (4%).

Table 6.7: Driver Injury Severity by Ejection and Safety Equipment Use

Driver Ejection	**Driver Safety Equipment Use (Excluding Motorcycles, Bicycles, Mopeds, ATV's and Trains)**	**Driver Injury Severity**							**Total**
		None	**Possible**	**Non-Incapacitating**	**Incapacitating**	**Fatal**	**Non-traffic Fatality**	**Unknown**	
No	Not in use	4%	1%	2%	3%	11%	<1%	<1%	20%
	Seat belt / Shoulder harness	25%	4%	6%	5%	9%	<1%		50%
	Air Bag	<1%	<1%	<1%	1%	3%			6%
	Unknown	1%		<1%	<1%	<1%		<1%	4%
	Seat Belt and Air Bag	5%	2%	4%	3%	6%		<1%	21%
	Total	36%	8%	13%	13%	30%	<1%	<1%	100%
Yes	Not in use	<1%	<1%	1%	7%	54%			63%
	Seat belt / Shoulder harness	4%	<1%	<1%	<1%	2%			7%
	Air Bag			<1%	2%	16%			19%
	Unknown	2%			<1%	2%		4%	8%
	Seat Belt and Air Bag	<1%	<1%	<1%	<1%	1%			3%
	Total	6%	2%	3%	10%	75%		4%	100%
Partial	Not in use				4%	60%			64%
	Seat belt / Shoulder harness				2%	2%			4%
	Air Bag				2%	13%			16%
	Unknown					7%			7%
	Seat Belt and Air Bag					9%			9%
	Total				9%	91%			100%

Table 6.7: Driver Injury Severity by Ejection and Safety Equipment Use, continued

Driver Ejection	Driver Safety Equipment Use (Excluding Motorcycles, Bicycles, Mopeds, ATV's and Trains)	Driver Injury Severity							Total
		None	Possible	Non-Incapacitating	Incapacitating	Fatal	Non-traffic Fatality	Unknown	
All Ejection States	Not in use	3%	<1%	2%	3%	16%	<1%	<1%	25%
	Seat belt / Shoulder harness	22%	4%	6%	5%	8%	<1%		44%
	Air Bag	<1%	<1%	<1%	1%	5%			7%
	Unknown	2%	<1%	<1%	<1%	1%		3%	7%
	Seat Belt and Air Bag	4%	2%	3%	3%	5%		<1%	18%
	Total	31%	7%	11%	12%	35%	<1%	4%	100%

As stated previously, motorcyclists in the fatal traffic crashes had a high rate of severe and fatal injuries. Since this study was limited to fatal crashes, the survivability of motorcycle occupants is low. As shown in Table 6.8, use of safety helmets did not significantly affect the outcome of motorcyclists. The subsequent calculations show that the odds of a motorcyclist dying in fatal crash when not wearing a helmet are 1.173 times the odds of dying when helmeted; however, the odds are not statistically significant because of the relatively small number of cases. In certain cases, the THI noted that the helmet worn by the motorcyclist was a novelty helmet not approved by DOT. In other cases, not wearing a helmet was specifically noted to contribute to the fatality, particularly when motorcycle occupants experienced head injuries.

Table 6.8: Injury Severity Versus Safety Equipment Use by Motorcyclists

Motorcyclist Safety Equipment Use (Drivers and Passengers)	Injury Severity					Total
	None	Possible	Non-Incapacitating	Incapacitating	Fatal	
Not in use			<1%	3%	15%	18%
Safety Helmet			<1%	5%	31%	36%
Eye Protection			<1%	<1%	3%	4%
Safety Helmet and Eye Protection	1%	<1%	5%	7%	29%	42%
Total	1%	<1%	6%	15%	77%	100%

Fatality	Helmet Worn	
	No	Yes
Yes	31	109
No	8	33

Odds of Death with no helmet = $\frac{31}{8} = 3.875$

Odds of Death with helmet = $\frac{109}{33} = 3.303$

Odds Ratio = $\frac{3.875}{3.303} = 1.173$ (95% CI: $0.492 < OR < 2.799$)

To fully evaluate the effect of helmet use on injury severity, the rate of helmet use in fatal crashes should be compared to the rate of helmet use in non-fatal crashes, as well as overall helmet use rates. In other words, 78 percent of the fatally injured motorcyclists were wearing helmets, but it is presently unknown what percent of motorcyclists wore helmets during the study period. (Florida's current helmet law, which allows riders age 21 and older carrying at least $10,000 in medical insurance to ride helmet-less, took effect July 1, 2000, which is in the middle of the study period.) This analysis is outside the scope of the present study.

Table 6.9 looks at injury versus safety equipment use by children ages five and under. A relatively small number of passengers (7.5% of all passengers) fell into this category; however attention is warranted due to the distinctive safety equipment that is available for this group of passengers. Using safety equipment improves outcomes. Of the fatal injuries the largest percentage are by those not using any safety equipment, whereas of the non injured the largest percentage are those that have a child restraint. Of the children ejected from vehicles, 80% did not have any safety equipment in use. Among children who were using a child restraint or a seat belt, vehicle ejection was highly uncommon, and did not result in fatality. Florida laws require that all children under the age of six be properly restrained regardless of where they are sitting in the vehicle (Florida State Statues § 316.613); however in this study nearly a third of the children passengers under the age of six did not have any safety equipment in use at the time of the crash. 50% of the time, if the driver was unbuckled, the children under age 6 in the vehicle were not restrained, either. The percentage of passengers not restrained increases to 71% when the group includes all passengers under the age of 18 traveling in vehicles where the drivers were not using seat belts.

Table 6.9: Injury Severity Versus Safety Equipment Use by Children Ages Five and Under

Children Ages Five and Under (Passengers) Safety Equipment Use	**Ejection**	**Injury Severity**					**Total**
		None	**Possible**	**Non-Incapacitating**	**Incapacitating**	**Fatal**	
Not in use	No	**7%**	**3%**	**3%**	**6%**	**2%**	22%
	Yes			**3%**	**3%**	**3%**	9%
Seat belt / Shoulder harness	No	**10%**	**4%**	**2%**	**3%**	**3%**	23%
	Yes				**<1%**		<1%
Child Restraint	No	**16%**	**5%**	**10%**	**6%**	**4%**	42%
	Partial	**<1%**					<1%
Air Bag	No					**<1%**	<1%
Seat Belt and Air Bag	No	**1%**	**<1%**				2%
	Yes				**<1%**		<1%
Child Restraint and Air Bag	Yes				**<1%**		<1%
Total		35%	13%	19%	20%	13%	100%

6.1 Most Common Factors Contributing to Fatalities

Each case was individually reviewed, and factors that specifically contributed to the fatality identified. Although hundreds of unique factors were identified for the 2350 fatalities, some factors were found to be common. The 20 most frequent factors found to contribute to fatalities in this study are listed in Table 6.10. The lack of vehicle occupant safety equipment use, namely seat belts, was the greatest contributing factor to fatality, contributing in nearly half the fatalities. Among the 1798 fatalities where seat belt use would be applicable (excluding pedestrians, motorcyclist, etc.) this percentage increases to 63%. The second most common factor, Vehicle-Vehicle impact, was identified 47% of the time. This factor may seem like an obvious cause of fatality, yet it reveals the prevalence of this type of collision, severe enough to cause fatality, versus another collision type of factor, for instance hitting a fixed object (9th on the list) which led to fatality 9% of the time. Vehicle ejection, the third most common factor, contributed to over a fourth of the fatalities. Partial ejection (13th factor) contributed in another 3%. Previously in this chapter the interaction between safety equipment use, vehicle ejection and injury severity was examined at length. In many cases, not wearing a seat belt contributed to vehicle ejection which led to fatality. The fourth most common factor, heavy vehicle impact (23% of the fatalities), is actually a severe vehicle-vehicle impact. This factor was assigned when the disproportionate mass of the vehicles increased the severity of a crash and led to fatality. As mentioned earlier, CMV drivers were far less likely to sustain an injury when the crash involved collision with a automobile or other lighter vehicle. Another severe type of vehicle-vehicle impact, a nearside impact (7th factor), was the direct cause of fatality 13% of the time.

Table 6.10: Most Common Factors Contributing to Fatalities

	Factor Contributing to Fatality	Count	% of Fatalities
1	Seat Belt Not in Use	1133	48%
2	Vehicle - Vehicle Impact	1103	47%
3	Ejection From Vehicle	615	26%
4	Heavy Vehicle Impact	537	23%
5	Occupant Age (65+)	463	20%
6	Pedestrian Impact With Vehicle	346	15%
7	Nearside Impact	311	13%
8	Vehicle Overturning	304	13%
9	Hitting Fixed Object	223	9%
10	Human Frailty (Age 80+)	169	7%
11	Motorcyclist (Lack of Occupant Protection)	146	6%
12	No Safety Helmet	99	4%
13	Partial Ejection From Vehicle	65	3%
14	Bicycle Impact With Vehicle	62	3%
15	Fire	60	3%
16	Excessive Vehicle Speed (90+ mph)	59	3%
17	Ran Over by Vehicle(s)	56	2%
18	Airbag Did Not Deploy	50	2%
19	Entering Water / Drown	20	<1%
20	No Safety Helmet: Head Injury	17	<1%
	Total Fatalities	2350	100%

Occupant age was noted in instances where a vehicle occupant was over age 64 and succumbed to fatal injuries; human frailty when a persons age was 80 and older (pedestrians included in this group). Many of these people may not have lived if they had been younger, however the factor was used to define not only physical frailty, but diminished perception and reaction and other limitations that aggravate with increasing age. For instance, a pedestrian over age 80 would not be expected to have the physical agility of much younger person or the ability to quickly maneuver to avoid being hit. The collision of a pedestrian and a vehicle leaves the pedestrian at a great disadvantage in terms of potential for fatality due to the disproportion in mass between vehicles and pedestrians. Even at low speeds a collision with a pedestrian can prove to be fatal for the pedestrian. The real cause of fatality in the 15% of incidents labeled as "pedestrian impact with vehicle" is the vulnerability and lack of protection of the pedestrians. The same is true for most, but not all, motorcyclist and bicyclist (11^{th} and 14^{th} most common factors). Cars, trucks, and the like have safety equipment such as safety belts and airbags, not to mention the mass of vehicle surrounding the occupant which can buffer and protect them from crash forces. Not wearing a safety helmet occurred among 48% of the 208 cyclist (12^{th} factor), however only 8% of these cyclist received head injuries that were specifically noted to contribute to the fatality (20^{th} factor). The remaining 5 factors - fire, excessive vehicle speed, ran over by vehicle, airbag did not deploy, and entering water / drown – show the diversity of factors that were found to contribute to fatalities in this study. Many more factors were found, however their delineation was so specific that inclusion in this broad scoped study is unjustifiable. Even the factors presented in Table 6.10 usually indicate a grouping and generalization of common factors. For instance, the grouping for entering the water and drowning (less than 1% of cases) include specific factors that led to fatality such occupants being trapped underwater in vehicles, not knowing how to swim, or being unable due to intoxication to swim, elderly occupants, and potential impact forces from vehicles falling from bridges.

The primary reasons why an occupant who was wearing a seat belt died differs from the reasons why an unbelted occupant died. The overrepresentation of factors that contributed to a fatality for seat belted occupants is given in Table 6.11. The results are an occupant level summary of the most common factors that contributed to fatalities. The overrepresentation factor and statistical confidence limits take into account the differences in sample size. Factors that are under-represented indicate that an event is more survivable if a seat belt is used. Wearing a seat belt would reduce the likelihood of fatality in crashes involving hitting a fixed object, vehicle overturning, and would reduce the likelihood of vehicle ejection – an event that has been clearly linked to fatality. Countermeasure efforts should aim at increasing seat belt usage. Primary seat belt enforcement is recommended. If the survivability of non belted occupants were increased by seat belt usage so that the percentage killed because of vehicle ejection decreased to the rate of those using seat belts, 412 people would not have been fatally injured in this study. Vehicle ejection is much less likely for belted occupants and thus the fatality rate much lower.

Table 6.11: Overrepresentation of Factors that Contribute to Fatalities in Occupants that Have Seat Belts in Use

Factor Contributing to Fatality	Seat Belt in Use		ORF	Min CI	Max CI	Level
	Yes	No				
Human Frailty (Age 80+)	90 (14%)	51 (5%)	**3.02**	2.17	4.20	Over
Occupant Age (65+)	232 (35%)	159 (14%)	**2.50**	2.09	2.98	Over
Nearside Impact	166 (25%)	143 (13%)	**1.99**	1.62	2.43	Over
Vehicle - Vehicle Impact	478 (72%)	562 (50%)	**1.46**	1.35	1.57	Over
Heavy Vehicle Impact	212 (32%)	322 (28%)	**1.13**	0.98	1.30	Unsure
Hitting Fixed Object	59 (9%)	158 (14%)	**0.64**	0.48	0.85	Under
Vehicle Overturning	37 (6%)	242 (21%)	**0.26**	0.19	0.36	Under
Ejection From Vehicle	31 (5%)	465 (41%)	**0.11**	0.08	0.16	Under
Total	662 (100%)	1133 (100%)				

Factors that are over-represented indicate events where an occupant is killed even though a seatbelt is used. Occupants age 80 who were fatally injured were three times more likely to be wearing their seat belt than not to be at the time of the crash. The elderly are much more likely to die even if they are using seat belts because of increasing decrements in physical condition and their frailty. Belted occupants were more likely to be killed from a nearside impact - a direct impact by another vehicle striking near their seating position, and the resulting injury. The prevalence of vehicle-vehicle impacts in belted cases and the absence of other crash types shows that other crash types, such as single vehicle events, did not prove to be as fatal to vehicle occupants who were wearing seat belts. In fatal crashes involving a heavy vehicle impact, crashes were so severe that occupants were equally likely to be killed irregardless of seat belt usage. The target of countermeasure efforts in heavy truck crashes should be crash prevention.

6.2 Conclusions and Recommendations

Not wearing a seat belt is the most common cause of fatality found in this study (a factor contributing to fatality among 63% of vehicle occupants). The most important step that can be taken to prevent fatalities is to increase seat belt usage. It is recommended that primary enforcement laws be adopted in Florida. Currently, Florida has secondary enforcement laws whereby police are allowed to ticket drivers for not wearing a seat belt only if drivers are stopped for another traffic violation. Twenty-four states plus the District of Columbia and Puerto Rico have tougher primary enforcement laws, allowing police to ticket drivers simply for not wearing a seat belt. Several states that do not have full primary enforcement have primary enforcement for people 17 and under. Wearing a seat belt would reduce the likelihood of fatality most notably in crashes involving hitting a fixed object or vehicle overturning (roll-over). Most importantly, wearing a seat belt would reduce the likelihood of vehicle ejection – an event clearly linked to fatality.

Vehicle ejection contributed to over a fourth of the fatalities in this study. The vast majority of ejected drivers and passengers (non-cyclists) were not using seat belts. Seat belt usage prevents vehicle occupants from being partially or fully ejected thereby reducing the chances of serious injury and fatality. In this study, all drivers who were partially ejected were either incapacitated or fatally injured. Ejection is most prevalent in SUV's (Sport Utility Vehicles) followed by trucks and vans. SUV drivers were twice as likely as automobile drivers to be ejected, and five times more likely than CMV (Commercial Motor Vehicle) drivers to be ejected. A very high percentage of SUV passengers (31%) were ejected, half of which were fatally injured. By comparison, only a seventh of SUV passengers who were not ejected were fatally injured. Less than 1% of ejected SUV drivers, and only 1% of ejected automobile drivers had seat belts in use at the time of the crash. Clearly, not wearing a seat belt increases the chance of ejection which dramatically increases the likelihood of serious or fatal injury. Targeted countermeasure efforts should focus on SUV, light truck, and van occupants. Stricter vehicles design standards may be needed that specifically address reducing the likelihood of passenger ejection and promote seat belt usage. There are numerous technologies that exist that prompt or force motorists to use seat belts. It is recommended that public education focus on high risk occupants (SUV's, light trucks, and vans). The message should be: seat belts are effective in preventing occupant ejection during a crash; the vast majority of the ejected occupants are fatally injured or incapacitated.

Of the children under age six ejected from vehicles, 80% did not have any safety equipment in use. Florida laws require that all children under the age of six be properly restrained regardless of where they are sitting in the vehicle; however in this study nearly a third of the children passengers under the age of six did not have any safety equipment in use at the time of the crash. 50% of the time, if the driver was unbuckled, the children under age 6 in the vehicle were not restrained, either. The percentage of passengers not restrained increases to 71% when the group includes all passengers under the age of 18 traveling in vehicles where the drivers were not using seat belts. Stricter enforcement of seat belt laws is recommended. Primary seat belt enforcement would give law enforcement the ability to stop vehicles in which the drivers are not wearing seat belts. If the driver is not wearing a seat belt, then the child passengers are probably unrestrained too.

The leading causes of fatality among belted occupants is related to increased age or being involved in a severe type of crash, such as a nearside impact. Countermeasures for belted occupants should focus on preventing the crash in the first place, reducing the severity of the crashes through the improvement of safety vehicle features, and improving emergency response time. Improved vehicle safety features include side curtain airbags, which would be helpful in nearside impacts, and stronger frames to resist passenger compartment deformation and intrusion. Elderly and mature persons are at higher risk and are more likely to die even if they are belted because of their physical frailty. Measures aimed at reducing the number of crashes involving elderly drivers should thereby reduce the number of fatalities involving the elderly. Improved transit support in regions with large elderly populations would provide alternatives to driving; increased deployment of aspects of the Florida Elder Road program, such as larger street signs and more advanced signage, would reduce the number of crashes due to confusion and last minute decisions around intersections. Other measures can be taken that would be post-event, helping elderly passengers and all occupants in a vehicle that has been involved in a crash. It is recommended that support be given to increase the usage of vehicle safety technology that prompts quick emergency response (in-vehicle wireless communications) and to assist in implementing the associated systems.

7 HEAVY TRUCK CRASHES

A primary objective of the research involved analyzing crash trends and investigating factors that contributed to the fatal traffic crashes involving heavy trucks. This chapter contains the results of that analysis. Over the three-year period of the study, approximately 200 crashes per year involved heavy trucks.

7.1 Background and Literature Review

A number of studies have been done to address the safety and fatality rate in crashes involving large tucks. In 1999, the General Accounting Office conducted a study to evaluate the effectiveness of the Federal Highway Administrations Office of Motor Carriers in improving the safety of large trucks (*General* 1999). The factors associated with the crashes were found to be related to the drivers' behavior, as well as vehicle, roadway and environmental factors. Much of the data pointed to the behavior of the passenger car driver as a significant cause of the crashes studied. Seiff found that over half of a random study of CMV's had brake violations serious enough to put the vehicles out of service (Seiff 1995). The same report quotes NHTSA research that brake performance could contribute to as many as one-third of all truck crashes, although most sources have found that fewer than two percent of truck crashes are related to brake problems. A study by researchers in New Zealand found that truck drivers who had driven more than eight hours after taking a compulsory ten hour off-duty period had an increased risk of being involved in a crash (Frith 1994). No other differences between a group of trucks involved in heavy crashes and a randomly selected group of control vehicles was found.

A New Jersey Institute of Technology study found that only 24 percent of fatal truck crashes occur on interstates, despite the high percentage of truck trips on those roadways (Daniel and Chien 2004). They found that 59 percent of fatal truck crashes occur on undivided highways that do not have controlled access and have signalized intersections. They suggest that truck safety research be focused on secondary roadways, and recommend Poisson regression and negative binomial crash prediction models to predict truck crash rates on urban arterials with heavy truck volumes and large numbers of signalized intersections.

Because of the height of the trailer relative to that of other vehicles, rear under-ride impacts are one of the more frequent and severe types of car-truck collisions. Rear underride prevention is addressed through two Federal Motor Vehicle Safety Standards (FMVSS) that apply to vehicles manufactured after January, 1998. FMVSS 223 and FMVSS 224 are interrelated regulations that set standards for rear impact guards for trailers rated over 10,000 pounds GVW. FMVSS 223 spells out the physical and performance requirements of the guards, while FMVSS 224 specifies how and on what types of trailers the guard should be mounted (CFR 571.223, S5.3). In general, the guards must extend to within 22 inches of the ground, fall within 12 inches of the rear-most point of the vehicle, and must be at least 3.94" thick. The guards must resist impact forces between 11,240 pounds and 22,480 pounds, depending on the application point. A number of researchers have looked at improved designs for truck bumpers and underride guards. Rakheja et al (1999) and Stanczyk (2004) both investigated designs of energy dissipating under-ride bumper guards. The guards work by limiting the magnitude of the vehicle intrusion (under-ride) and dissipating the energy of the crash.

The National Highway Traffic Safety Administration (NHTSA) and the Federal Motor Carrier Safety Administration (FMCSA) performed a significant study looking at causes of large truck traffic crashes. To date, only the results of the interim report are available (Theriez et al 2002). Known as the large truck crash causation study, this project aimed at reducing the number of commercial truck and bus crashes and the resulting personal and property loss resulting from them. The goal was to identify the contributing causes to serious truck crashes so that effective countermeasures could be implemented. A key aspect of this study is that it involved the dissemination of crash response teams to crash sites immediately upon notification of an injury crash involving a commercial motor vehicle. Team members reconstructed the events surrounding the crash and identified the critical event, the critical reason for the critical event, and associated factors. The associated factors included detailed information on driver, vehicle, roadway, and environmental factors prior to and during the crash. For instance, driver factors included categories such as physical condition; recognition and/or decision errors, emotional state, and driving experience. Other factors included traffic flow, vehicle and environmental condition, and for commercial motor vehicles, carrier information. The data collected during the study was entered into the Large Truck Crash Causation Study (LTCCS) database for further analysis. The assessment of the crash events was conducted on both the vehicle and crash level, and factors were analyzed based on their association with specific crash events, vehicle type, and driver at-fault status.

Results from the interim report, which are based on limited data and therefore are not conclusive, indicated that same trafficway, same direction and single vehicle road departure cases were most common. One-quarter of the truck drivers were between 41 and 50 years old while the other drivers were more generally distributed including a higher percentage of younger drivers. The most common critical event for single vehicle truck crashes was traveling too fast for conditions; for multi-vehicle crashes it was traveling in the same direction with higher speed, applied equally to the trucks and other vehicles. The most common critical reason was inadequate surveillance on the part of the truck driver, followed by inattention on the part of the other driver. Distraction, fatigue, and environmental factors figured into relatively few cases in the interim study.

In 1999, the Office of Motor Carrier Safety released a Tech Brief summarizing results of a study on unsafe driving acts (UDA's) committed by drivers in the vicinity of large trucks. Researchers reviewed statistical crash data; interviewed truck drivers, collision experts, and other experts; and analyzed collision reports. A set of UDA's was generated and prioritized in terms of frequency and severity. Experts were in close agreement regarding the severity of various UDA's, although there was more variation in assessments of frequency. The most severe UDA's were determined to be driving left of center, unsafe passing, driving while impaired, and failure to stop for a sign or light. The most frequent UDA's were determined to be following too closely, unsafe speed, driving inattentively, driving in the No-Zones, and improper merging. The study recommended education drivers on the driving characteristics of large trucks, as well as training law enforcement officers on which UDA's are code violations (e.g. following too closely). The study also recommends changes to the Uniform Vehicle Code and Model Traffic Ordinance that would permit officers to cite drivers for UDA's that are not currently illegal (e.g. driving in the No-Zone).

The AAA Foundation for Traffic Safety performed a study of Unsafe Driver Actions (UDA's) that contributed to fatal car-truck crashes (Kostyniuk et al 2002). The study used

FARS data plus detailed Michigan crash reports, and looked at fatal two-vehicle crashes involving either a car and a heavy truck or two cars. They found that car drivers were more likely to have committed UDA's than truck drivers, but that unsafe driving acts for fatal car-truck crashes were similar to those for fatal car-car crashes. Eighty percent of car drivers in the sample were assigned one UDA, compared to only 27% of the truck drivers. The five most common UDA's, which accounted for 67 percent of UDA's committed by car drivers, were failure to maintain a lane, failure to yield right-of-way, speeding, failure to obey a traffic control device, and inattention. The same five UDA's also accounted for 51 percent of the unsafe acts committed by truck drivers. Primary countermeasures included driver education about truck characteristics and unsafe driving actions, emphasizing "share the road" strategies.

7.2 Methodology

For the purposes of this study, heavy trucks were defined as those coded as vehicle types 05 (heavy truck) and 06 (truck tractor/cab) on the Florida Traffic Crash Report. In the report, the terms "heavy truck," "truck," "commercial motor vehicle," and "CMV" are used interchangeably to indicate vehicles of these types. As stated previously, two additional years of heavy truck data (1998 and 1999) were added to the year 2000 crash data to increase the number of heavy truck crashes under study. This was done to add more statistical significance to the results and conclusions regarding the heavy truck crashes. There is assumed to be no time-dependent variation in truck crashes over the three year period, a conclusion that is supported by the data itself. In addition, there were no major changes in the crash report form over this time period, making the data easier to combine and analyze.

Case reviews of truck crashes were conducted in a similar manner to those involving other vehicle types. Particular attention was paid to the dynamics of the heavy vehicle in crash reconstructions. A number of factors were identified that, while not exclusive to heavy trucks, seemed to apply most frequently to those vehicle types, including:

- **Blind spots:** Blind spots are regions in which a driver's view of the roadway is obstructed by a part of the vehicle's chassis. The size of a blind spot is affected by vehicle design and mirror positioning. These regions are commonly referred to as the "No-Zones" of heavy trucks, and include areas immediately to the front and rear of the vehicle, a large area to the right and front right of the vehicle, as well as a smaller areas to the left of the vehicle. In other vehicles, area to the left and right rear corners of the vehicles are candidates for blind spot visibility problems. Figure 7.1, taken from the Federal Motor Carrier Safety Administration's Share the Road campaign (www.sharetheroadsafely.org), illustrates the No-Zone areas. Obviously, in a case review, it is impossible to differentiate a true No Zone/Blind Spot issue from a "looked but failed to see" type perception error; so this code is used when the vehicles' relative positions indicate a potential blind spot visibility issue.

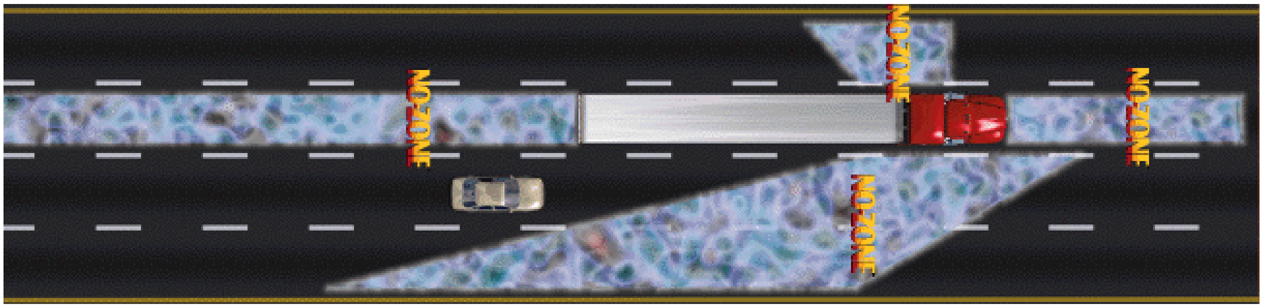

Figure 7.1: No-Zone Areas Around a Commercial Motor Vehicle

- **View Obstruction:** As opposed to the term blind spot, which occurs when a portion of a vehicle blocks the outward view of its *own* driver, a view obstruction indicates that a vehicle blocked the view of *another* driver involved in a crash. An example of this might be when a driver pulls into an intersection in front of vehicle in the inside lane because his/her view was obstructed by a vehicle in the outside lane. In this example, a driver decision error would also be coded in the crash. If the view obstruction is directly caused by the design of the roadway, e.g. an intersection with opposing left turn lanes where the queuing traffic blocks the opposing lane, or a median break that causes vehicles seeking refuge to block the view of turning traffic, then the issue is characterized as a roadway sight distance issue rather than a vehicle view obstruction.
- **Load Shift/Fall:** A load shift occurs when the cargo being carried by the vehicle shifts within the confines of the vehicle, often leading to instability or overturning, or falls from the vehicle onto the ground or another vehicle.
- **Trailer Jackknife:** Jackknife refers to loss of lateral stability of the trailer with respect to the tractor portion of the vehicle, causing the tractor and trailer portions of the vehicle to meet at an angle approaching or even exceeding 90°. A trailer towed by an automobile, light truck, or recreational vehicle is also subject to jackknifing. Jackknifing can be caused by abrupt steering input, sudden braking, or by improper adjustment of the trailer brakes. Jackknifing is listed as a vehicle factor only if it is a significant contributor to the crash (e.g. tractor-trailer jackknifes due to excessive braking, causing the trailer portion to infringe upon an adjacent lane), as opposed to being a result of the crash (e.g. after crossing the centerline and impacting an oncoming vehicle, a tractor-trailer jackknifes as it comes to a stop on the shoulder).

7.3 Data Set

Table 7.1 summarizes the number of truck and other crashes in the data set. The number of truck crashes per year was approximately constant, averaging approximately 192 crashes per year, although slightly lower in the year 2000. Because of the extra truck crashes, approximately 28 percent of the fatalities in the study set resulted from crashes that involved heavy trucks. In the year 2000, where both heavy trucks and other vehicles are included, approximately 11 percent of the fatal crashes involved heavy trucks.

Table 7.1: Number of Fatal Truck and Other Crashes by Year

Year	Truck	Other	Total	Percent
1998	199	0	199	100%
1999	198	0	198	100%
2000	178	1505	1683	11%
Total	575	1505	2080	28%

Table 7.2 examines the types of vehicles involved in the fatal crashes. As mentioned previously, all SUV's are categorized as light trucks in this chart. In total, around 17 percent of the vehicles in fatal crashes were CMV's; 75 percent were passenger cars, vans, and light or medium duty trucks (primarily automobiles); and 3.8 percent were motorcycles. While almost 28 percent of the crashes involved at least one CMV (See Table 7.1), only about 17 percent of the vehicles were CMV's, indicating that multi-vehicle crashes were much more likely to involve multiple cars, vans or light trucks, rather than multiple CMV's.

Table 7.2: Type of Vehicles involved in Fatal Crashes

Vehicle Type		Number	Percent
1	Automobile	1688	44.1%
2	Passenger Van	287	7.5%
3	Light Truck	822	21.5%
4	Medium Truck	78	2.0%
5	Heavy Truck	161	4.2%
6	Truck Tractor	477	12.4%
7	Recreational Vehicle	7	0.2%
8	Small Bus	2	0.1%
9	Large Bus	27	0.7%
10	Bicycle	63	1.6%
11	Motorcycle	147	3.8%
12	Moped	4	0.1%
14	Train	6	0.2%
77	Other	14	0.4%
Unknown		44	1.1%
Total		3827	100%

Table 7.3 looks at the different type of trailers that the CMV's were pulling at the time of the crash. Much miscoding of truck tractors (Vehicle type = 06) as heavy trucks (Vehicle type = 05) was seen on the part of reporting officers. These errors were corrected where possible; however, difficulty in exactly identifying vehicle models made this a difficult task. The majority of the CMV's (over 50 percent) were truck tractors towing a standard single box type trailer, while almost 20 percent were heavy trucks, with two rear axles but an integrated truck/trailer body. Flatbed trailers, tandem trailers, and boat trailers each accounted for about seven percent of the CMV's. Three percent of the CMV's were not pulling a trailer (bobtails or tractor/cab only).

Table 7.3: CMV Trailer Types

Trailer Types	Total	Percent
Heavy Truck – No trailer	122	19.1%
Tractor/Cab	19	--
Cab only (Bobtail) - No Trailer	19	3.0%
Single Semi Trailer	325	50.9%
Tandem Semi Trailer(s)	39	6.1%
Saddle Mount/Flatbed	46	7.2%
Boat Trailer	44	6.9%
Utility Trailer	6	0.9%
House Trailer	1	0.2%
Pole Trailer	16	2.5%
Towed Vehicle	1	0.2%
Other/Unknown	19	3.0%
Total	638	100.0%

Table 7.4 shows the number of vehicles per CMV and other crash. Over 47 percent of the other crashes in the study set are single vehicle crashes while only nine percent of the CMV crashes are single-vehicle crashes. Half of the single vehicle truck crashes involved pedestrians while only one-third of the other single vehicle crashes involved pedestrians. This means that CMV's are highly underrepresented in single vehicle crashes, both with and without pedestrians, but overrepresented in all multi-vehicle crashes. Table 7.5 looks at number of fatalities per crash, including both pedestrian and vehicle occupant fatalities. Over ninety percent of the crashes resulted in only one fatality; however, again, CMV's are overrepresented in multi-fatality crashes.

Table 7.4: Number of Vehicles per Crash

Number of vehicles	Truck Crashes		Other Crashes		CMV OR Factor	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
1+Ped	26	4.5%	255	16.9%	**0.267**	0.180	0.395	Under
1-No ped	26	4.5%	458	30.4%	**0.149**	0.101	0.218	Under
2	400	69.6%	644	42.8%	**1.626**	1.501	1.760	Over
3	82	14.3%	101	6.7%	**2.125**	1.614	2.798	Over
4	18	3.1%	35	2.3%	**1.346**	0.769	2.357	Unsure
5	13	2.3%	9	0.6%	**3.781**	1.625	8.796	Over
>5	10	1.7%	3	0.2%	**8.725**	2.410	31.588	Over
Total	575	100%	1505	100%	**1.000**			

Table 7.5: Number of Fatalities per Crash

Number of fatalities	Truck Crashes		Other Crashes		CMV OR Factor	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
1	494	86%	1371	91%	**0.943**	0.909	0.978	Under
2	63	11%	111	7%	**1.486**	1.107	1.993	Over
>2	18	3%	23	2%	**2.048**	1.114	3.767	Over
Total	575	100%	1505	100%	**1.000**			

7.4 Crash Types and Sub-Types

Table 7.6 and Table 7.7 summarize crash types according to the first crash type code assigned to the crash, which typically represents the first or most important event related to the crash. Table 7.6 provides a detailed breakdown according to the categories described in Chapter 4, while Table 7.7 groups the categories into the six major groups. While maximum and minimum confidence intervals are not shown in Table 7.6 due to space limitations, the level or degree of confidence is presented. Examining Table 7.6, it is evident that, for the most part, the types of fatal crashes in which heavy trucks are involved are vastly different from the types of fatal crashes in which no trucks are involved. Heavy trucks are highly overrepresented in pedestrian impacts where the pedestrian is in the road but not crossing or has exited a vehicle, all same direction and opposite direction impacts, and turning/merging from or into the same direction, although not all of these are significant at the 95 percent confidence interval.

Results from Table 7.7 are consistent with those from Table 7.6, because of consistency within the categories. The most common type of truck crash is a *Same trafficway, Same direction crash*, typically rear end crashes, and *Change Trafficway, Turning* crashes, typically involving oncoming or cross traffic. Trucks are underrepresented in pedestrian and run off the road collisions, overrepresented in same and opposite direction impacts, and represented in turning and straight intersection crashes at rates that are expected, based on their involvement in the overall crash set. The high rate of heavy trucks in same and opposite direction impacts likely indicate that crashes of these types are more likely to be severe crashes when heavy trucks are involved because of the additional mass and momentum of the large vehicle. On the other hand, heavy trucks are highly underrepresented in most other pedestrian crashes and in most run off the road and single vehicle crashes, including those related to turning vehicles. Since these would also be more severe events if a heavy truck were involved, the low representation of trucks in *fatal* pedestrian and single vehicle crashes likely indicates an overall underrepresentation of heavy trucks in *all* pedestrian and single vehicle crashes.

Table 7.6: Crash Sub-Types for Truck Crashes

Code	First Crash Type	First Crash Sub-Type	Truck Crashes		Other Crashes		CMV OR Factor	Level
			Num.	%	Num.	%		
10	Pedestrian	Crossing Not At Intersection--First Half	3	1%	68	5%	0.115	Under
11		Crossing Not At Intersection--Second Half	7	1%	116	8%	0.158	Under
12		Crossing At Intersection In Crosswalk	1	0%	32	2%	0.082	Under
13		Other In Road	15	3%	14	1%	2.804	Over
14		Walking Along Road With Traffic	5	1%	14	1%	0.935	Unsure
15		Walking Along Road Against Traffic	1	0%	4	0%	0.654	Unsure
16		Exit Vehicle	12	2%	16	1%	1.963	Unsure
17		Vehicle Turn/Merge	1	0%	7	0%	0.374	Unsure
18		Unique	0	0%	4	0%	0.000	N/A
19		Other/Unknown	1	0%	7	0%	0.374	Unsure
20	Run Off Road/Single Vehicle	Right Roadside Departure	36	6%	189	13%	0.499	Under
21		Right Roadside Departure With Control Loss	11	2%	90	6%	0.320	Under
22		Left Roadside Departure	25	4%	116	8%	0.564	Under
23		Left Roadside Departure With Control Loss	36	6%	123	8%	0.766	Unsure
24		Forward Impact	2	0%	6	0%	0.872	Unsure
25		Ramp Departure	6	1%	26	2%	0.604	Unsure
26		Other	0	0%	2	0%	0.000	N/A
30	Same Direction	Rear End	118	21%	87	6%	3.550	Over
31		Rear End With Avoid Impact	15	3%	16	1%	2.454	Over
32		Sideswipe Angle	18	3%	25	2%	1.885	Over
33		Sideswipe Angle With Control Loss	9	2%	5	0%	4.711	Over
40	Opposite Direction	Head-On	54	9%	87	6%	1.625	Over
41		Forward Impact With Control Loss	14	2%	24	2%	1.527	Unsure
42		Sideswipe Angle	1	0%	1	0%	2.617	Unsure

Table 7.6: Crash Sub-Types for Truck Crashes, continued

Code	First Crash Type	First Crash Sub-Type	Truck Crashes		Other Crashes		CMV OR Factor	Level
			Num.	%	Num.	%		
50	Change Trafficway/Turning	Initial Opposite Directions/Oncoming Traffic	60	10%	139	9%	**1.130**	Unsure
51		Initial Same Direction	7	1%	10	1%	**1.832**	Unsure
52		Turn/Merge Into Same Direction	11	2%	9	1%	**3.199**	Over
53		Turn Into Opposite Directions/Cross Traffic	41	7%	108	7%	**0.994**	Unsure
54		Single Vehicle Loss of Control While Turning	1	0%	9	1%	**0.291**	Unsure
55		Evasive Action To Avoid Turning/Merging Vehicle	1	0%	6	0%	**0.436**	Unsure
60	Intersecting Paths	Cross Traffic From Left of At-Fault	27	5%	52	3%	**1.359**	Unsure
61		Cross Traffic From Right of At-Fault	25	4%	59	4%	**1.109**	Unsure
62		Evasive Action Related To Intersecting Paths	2	0%	6	0%	**0.872**	Unsure
64		T-Intersection Run Off Road	0	0%	4	0%	**0.000**	N/A
65		Backing	4	1%	0	0%	**N/A**	N/A
66		Other	0	0%	2	0%	**0.000**	N/A
69		Unknown Fault	0	0%	4	0%	**0.000**	N/A
70	Other/Unknown		5	1%	18	1%	**0.727**	Unsure
	Total		575	100%	1505	100%	**1.000**	

Table 7.7: Crash Types of Fatal Truck Crashes

First Crash Type	Truck		Other		CMV OR Factor	Min CI	Max CI	Level
	No.	%	No.	%				
Pedestrian	46	8%	282	19%	**0.427**	0.317	0.574	Under
Run off Road and Single Vehicle Initiated	116	20%	552	37%	**0.550**	0.461	0.656	Under
Same Trafficway, Same Direction	160	28%	133	9%	**3.149**	2.555	3.880	Over
Same Trafficway, Opposite Direction	69	12%	112	7%	**1.613**	1.214	2.142	Over
Change Trafficway, Vehicle Turning	121	21%	281	19%	**1.127**	0.932	1.363	Unsure
Intersecting Paths	58	10%	127	8%	**1.195**	0.890	1.606	Unsure
Unknown	5	1%	18	1%	**0.727**	0.271	1.949	Unsure
Total	575	100%	1505	100%	**1.000**			

Because a number of crashes also had a second crash type code, Table 7.8 depicts both the first and second crash types for the truck crashes. In Table 7.8, the crash type code listed first tends to be the first code assigned to the crash, although this is not always true. For this reason, the codes are labeled "A" and "B" rather than "1" and "2," and the numbers cannot be grouped to match those in the previous table. Combining the first and second crash type code often provides a better understanding of the circumstances surrounding the crash. For instance, a pedestrian crash and a same direction crash indicates that the crash involved both an impact with a pedestrian and an impact with a vehicle initially traveling in the same direction, typically a rear end collision. In addition, because median crossovers and crashes with overcorrection back into travel lanes were included in run off the road crashes, a significant number of these crashes have a secondary code describing the subsequent events in the crash. For the purposes of the major categorizations presented here, the *Intersecting Paths* category includes all crashes related to intersecting paths, not just those in which vehicles on intersecting paths collided. For instance, a crash categorized primarily as a *Same Direction* crash and secondarily as an *Intersecting Paths* crash typically indicates a rear end collision that involved a vehicle stopped for cross traffic. Likewise a pedestrian crash coded as *Intersecting Paths* indicates that the crash happened at an intersection or driveway access point.

When the crashes are broken down according to first and second crash types, heavy trucks remain overrepresented in opposite direction and same direction crashes. Heavy trucks are also overrepresented in run off the road crashes involving secondary vehicle impacts, whether in the same or opposite directions, and in same direction impacts related to intersecting paths. Again, this is likely because the momentum of the large vehicle results in a more severe crash scenario. Finally, heavy trucks are overrepresented in pedestrian crashes where a same direction vehicle collision is also involved. These crashes typically result from a vehicle that is disabled, often from a previous crash, blocking the roadway, along with pedestrians who exited the vehicle but are also in the roadway. On the other hand, heavy trucks remain underrepresented in single event run off the road and pedestrian crashes, including pedestrian collisions occurring at intersections (i.e. *Intersecting Paths* category).

Table 7.8: Combined (First and Second) Crash Types of Fatal Truck Crashes

Crash Type Code A	Crash Type Code B	Truck		Other		CMV OR Factor	Min CI	Max CI	Level
		No.	%	No.	%				
Pedestrian		32	6%	213	14%	0.393	0.275	0.563	Under
Pedestrian	Same Direction	9	1%	5	0%	4.711	1.586	13.998	Over
Pedestrian	Intersecting Paths	4	1%	55	4%	0.190	0.069	0.523	Under
Pedestrian	Change Trafficway, Turning	2	0%	8	1%	0.654	0.139	3.072	Unsure
Opposite Direction		69	12%	111	7%	1.627	1.224	2.163	Over
Run off Road		44	8%	471	31%	0.245	0.182	0.328	Under
Run off Road	Opposite Direction	38	7%	45	3%	2.210	1.451	3.367	Over

Table 7.8: Combined (First and Second) Crash Types of Fatal Truck Crashes, continued

Crash Type Code A	Crash Type Code B	Truck		Other		CMV OR Factor	Min CI	Max CI	Level
		No.	%	No.	%				
Run off Road	Pedestrian	8	1%	15	1%	**1.396**	0.595	3.275	Unsure
Run off Road	Same Direction	26	5%	21	1%	**3.241**	1.838	5.713	Over
Run off Road	Intersecting Paths	0	0%	9	1%	**0.000**	N/A	N/A	N/A
Run off Road	Change Trafficway, Turning	0	0%	13	1%	**0.000**	N/A	N/A	N/A
Same Direction		119	21%	117	8%	**2.662**	2.102	3.372	Over
Same Direction	Opposite Direction	3	1%	0	0%	**N/A**	N/A	N/A	N/A
Same Direction	Intersecting Paths	39	7%	23	2%	**4.438**	2.675	7.363	Over
Opposite Direction		69	12%	111	7%	**1.627**	1.224	2.163	Over
Intersecting Paths		62	11%	127	8%	**1.278**	0.958	1.704	Unsure
Change Trafficway, Turning		109	19%	251	17%	**1.137**	0.928	1.393	Unsure
Change Trafficway, Turning	Opposite Direction	3	1%	1	0%	**7.852**	0.818	75.333	Unsure
Change Trafficway, Turning	Same Direction	3	1%	2	0%	**3.926**	0.658	23.436	Unsure
Intersecting Paths		62	11%	127	8%	**1.278**	0.958	1.704	Unsure
Unknown		5	1%	18	1%	**0.727**	0.271	1.949	Unsure
Total		575	100%	1505	100%	**1.000**			

7.5 Primary and Secondary Contributing Factors

This section looks at primary and secondary contributing factors for the truck crashes. Table 7.9 examines the frequency with which various primary contributory factors are named as primary, secondary, and tertiary for the truck and other crashes. Note that, in Table 7.9, the factor might belong to either the truck or the other vehicle. Further details about fault and assignment of the factors within the truck crashes are explored subsequently.

Table 7.9: Crash Contributing Factors in Truck in Other Crashes

Factor Class	Factor Detail	Primary		Secondary		Tertiary		Total	
		Truck	Other	Truck	Other	Truck	Other	Truck	Other
Environment	Dark	0	1	9	97	8	60	17	158
	Dawn/Dusk	0	0	2	3	1	5	3	8
	Glare	0	0	2	0	1	0	3	0
	Heavy Rain	0	0	2	3	2	2	4	5
	Smoke/Fog	2	1	20	6	2	9	24	16
	Wet/Slippery	4	12	17	30	17	57	38	99
	Wind	1	0	0	0	0	0	1	0
Human	Age	0	2	18	53	13	64	31	119
	Aggression	12	24	7	24	2	2	21	50
	Alcohol	99	414	8	33	5	11	112	458
	Alcohol & Drugs	19	52	0	3	0	1	19	56
	Confusion	6	12	8	24	1	4	15	40
	Decision	52	147	43	78	1	11	96	236
	Distraction	4	12	0	6	0	3	4	21
	Drugs	21	49	16	12	6	7	43	68
	Fatigue	11	38	8	9	2	3	21	50
	History	0	0	4	6	4	10	8	16
	Inattention	156	298	43	83	11	29	210	410
	Inexperience	0	1	8	13	1	8	9	22
	Low Speed	1	0	0	1	4	0	5	1
	Medical	8	31	2	8	1	0	11	39
	Mental/Emotional	8	12	3	14	2	7	13	33
	Mobility	0	1	1	9	0	4	1	14
	Other	4	11	0	0	0	2	4	13
	Perception	17	57	3	40	0	2	20	99
	Physical Defect	0	0	1	4	0	3	1	7
	Police Pursuit	0	3	0	4	0	1	0	8
	Speed	39	114	23	177	4	28	66	319
	Steering Input	23	42	21	119	20	47	64	208
	Unfamiliar w/Area	1	0	2	2	0	2	3	4
	Unfamiliar w/Vehicle	0	0	1	1	1	0	2	1
	Unknown	52	92	0	3	1	0	53	95
	Visibility	1	0	0	2	6	5	7	7
Roadway	Access Point	0	0	5	14	4	23	9	37
	Bike Facilities	0	0	0	0	0	3	0	3
	Congestion	0	2	7	7	7	9	14	18
	Construction	1	1	11	17	6	7	18	25

Table 7.9: Crash Contributing Factors in Truck in Other Crashes, continued

Factor Class	Factor Detail	Primary		Secondary		Tertiary		Total	
		Truck	Other	Truck	Other	Truck	Other	Truck	Other
Roadway	Curvature	1	3	10	28	11	55	22	86
	Design/Geometry	1	0	8	26	5	15	14	41
	Lighting	1	1	21	70	29	63	51	134
	Maintenance	0	0	1	6	0	0	1	6
	No Sidewalk	0	0	3	8	1	2	4	10
	Obstruction	7	4	8	10	6	4	21	18
	Other	0	0	2	0	0	2	2	2
	Pavement Markings	0	0	0	4	0	9	0	13
	Ped Facilities	0	0	0	2	0	1	0	3
	Shoulder Design	0	0	1	0	2	3	3	3
	Sight Distance	0	0	5	12	1	11	6	23
	Sign/Signal	0	2	2	8	0	6	2	16
	Speed Limit	0	0	4	3	4	4	8	7
	Standing Water	1	3	0	3	1	1	2	7
	Traffic Operations	0	0	9	7	6	8	15	15
Vehicle	Acceleration Rate	0	0	4	0	3	1	7	1
	Blind Spot	0	0	11	2	2	5	13	7
	Bus	0	0	0	4	0	1	0	5
	Defect	5	3	8	2	5	5	18	10
	Disabled	0	0	13	6	4	9	17	15
	Emergency	0	0	0	6	2	2	2	8
	Jackknife	0	0	6	0	6	0	12	0
	Lighting	1	0	6	12	5	9	12	21
	Load Shift/Fall	3	1	1	1	2	1	6	3
	Low Speed	0	0	2	1	1	0	3	1
	Maintenance	0	0	0	0	0	0	0	0
	Maneuverability	1	0	1	0	5	0	7	0
	Other	1	2	1	0	0	0	2	2
	Overweight	0	1	0	1	1	2	1	4
	Size/Length	0	0	0	0	1	0	1	0
	Stability	0	0	0	7	0	4	0	11
	Tires	6	38	1	11	3	4	10	53
	Trailer	0	2	1	3	1	6	2	11
	Unknown	0	0	0	0	0	1	0	1
	View Obstruction	0	0	5	5	3	6	8	11
	Visibility	0	0	2	31	2	18	4	49
Other/Unknown		4	15	0	0	0	0	4	15

Table 7.10 looks only at primary contributing factors, but provides additional detail in terms of overrepresentation factors and confidence intervals, with respect to factors in other (non-CMV) crashes. Only factors which appear as primary factors in either truck or other crashes are listed in Table 7.10. As with other types of crashes, human factors are the most common primary contributing factor in truck crashes. Within that class, inattention and alcohol are most common, followed by decision errors and unknown human errors. Alcohol use is underrepresented in truck crashes, while inattention is overrepresented. Among the less common factors, mental/emotional problems are overrepresented in truck crashes, probably due to the number of individuals committing suicide by driving or walking into the path of a heavy truck. Roadway and vehicle issues are not very common as primary contributing factors; however obstructions (typically vehicles from previous crashes) are overrepresented in truck crashes, as are vehicle defects, while tire problems are underrepresented.

Table 7.10: Primary Crash Contributing Factors in Truck Crashes

Factor Class	Factor Detail	Truck		Other		CMV ORF	Min CI	Max CI	Level
		Num.	Per.	Num.	Per.				
Environ-ment	Dark	0	0.0%	1	0.1%	**0.000**	N/A	N/A	N/A
	Smoke/Fog	2	0.3%	1	0.1%	**5.240**	0.476	57.681	Unsure
	Wet/Slippery	4	0.7%	12	0.8%	**0.873**	0.283	2.697	Unsure
	Wind	1	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
Human	Age	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
	Aggression	12	2.1%	24	1.6%	**1.310**	0.660	2.602	Unsure
	Alcohol	99	17.2%	414	27.5%	**0.627**	0.515	0.763	Under
	Alcohol & Drugs	19	3.3%	52	3.5%	**0.957**	0.571	1.605	Unsure
	Confusion	6	1.0%	12	0.8%	**1.310**	0.494	3.474	Unsure
	Decision	52	9.1%	147	9.8%	**0.927**	0.686	1.253	Unsure
	Distraction	4	0.7%	12	0.8%	**0.873**	0.283	2.697	Unsure
	Drugs	21	3.7%	49	3.3%	**1.123**	0.680	1.855	Unsure
	Fatigue	11	1.9%	38	2.5%	**0.758**	0.390	1.474	Unsure
	Inattention	156	27.2%	298	19.8%	**1.372**	1.159	1.623	Over
	Inexperience	0	0.0%	1	0.1%	**0.000**	N/A	N/A	N/A
	Low Speed	1	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
	Medical	8	1.4%	31	2.1%	**0.676**	0.313	1.462	Unsure
	Mental/Emotional	8	1.4%	12	0.8%	**1.747**	0.718	4.251	Unsure
	Mobility	0	0.0%	1	0.1%	**0.000**	N/A	N/A	N/A
	Other	4	0.7%	11	0.7%	**0.953**	0.305	2.980	Unsure
	Perception	17	3.0%	57	3.8%	**0.781**	0.459	1.332	Unsure
	Police Pursuit	0	0.0%	3	0.2%	**0.000**	N/A	N/A	N/A
	Speed	39	6.8%	114	7.6%	**0.896**	0.631	1.273	Unsure
	Steering Input	23	4.0%	42	2.8%	**1.435**	0.871	2.364	Unsure
	Unfamiliar w/Area	1	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A

Table 7.10: Primary Crash Contributing Factors in Truck Crashes, continued

Factor Class	Factor Detail	Truck		Other		CMV ORF	Min CI	Max CI	Level
		Num.	Per.	Num.	Per.				
Human	Unknown	52	9.1%	92	6.1%	**1.481**	1.069	2.052	Over
	Visibility	1	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
Roadway	Congestion	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
	Construction	1	0.2%	1	0.1%	**2.620**	0.164	41.821	Unsure
	Curvature	1	0.2%	3	0.2%	**0.873**	0.091	8.379	Unsure
	Design/Geometry	1	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
	Lighting	1	0.2%	1	0.1%	**2.620**	0.164	41.821	Unsure
	Obstruction	7	1.2%	4	0.3%	**4.585**	1.347	15.605	Over
	Other	0	0.0%	0	0.0%	**N/A**	N/A	N/A	N/A
	Sign/Signal	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
	Standing Water	1	0.2%	3	0.2%	**0.873**	0.091	8.379	Unsure
Vehicle	Defect	5	0.9%	3	0.2%	**4.367**	1.047	18.214	Over
	Lighting	1	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
	Load Shift/Fall	3	0.5%	1	0.1%	**7.861**	0.819	75.414	Unsure
	Maneuverability	1	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
	Other	1	0.2%	2	0.1%	**1.310**	0.119	14.420	Unsure
	Overweight	0	0.0%	1	0.1%	**0.000**	N/A	N/A	N/A
	Tires	6	1.0%	38	2.5%	**0.414**	0.176	0.973	Under
	Trailer	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
Other/Unknown		4	0.7%	15	1.0%	**0.699**	0.233	2.096	Unsure
Total		574	100%	1504	100%	**1.000**			

Table 7.11 combines secondary and tertiary contributing factors in truck crashes, and compares their rates to other crashes. Three human factors, namely inattention, decision errors, and steering input, were the most common additional (secondary or tertiary) factors in truck crashes, although none is highly over- or underrepresented with respect to non-CMV crashes. (Steering input is, however, underrepresented with a confidence of 95 percent.) Drugs, fatigue, and low speed are all significantly overrepresented as additional factors in truck crashes, while perception errors and speed are significantly underrepresented. Of the environmental factors, smoke and fog are highly overrepresented, because of the prevalence of smoke/fog in high speed rural crashes, especially on limited access facilities.

With respect to roadways, inadequate lighting and curvature are the most common additional factors, while construction, obstructions, congestion, and traffic operations issues are both common and overrepresented. Obstructions and congestion are again common contributing factors on high speed roads, and traffic operations issues often involve lack of turn lanes, resulting in rear end crashes. The most common additional vehicle factors involve disabled vehicles, vehicle defects, blind spots/no-zone issues, and view obstructions. Blind spots occur when a driver's view is blocked by his/her own vehicle; view obstructions occur when the vehicle blocks another driver's view. It is understandable then why CMV's are overrepresented in both of the crash types. Disabled vehicles tend to become roadway obstructions, thus reinforcing that correlation with truck crashes. Visibility issues, most common with bicycles and motorcycles, are underrepresented in truck crashes.

Table 7.11: Secondary and Tertiary Contributing Factors in Truck Crashes

Factor Class	Factor Detail	Truck		Other		CMV ORF	Min CI	Max CI	Level
		Num.	Per.	Num.	Per.				
Environment	Dark	17	2.5%	157	8.4%	**0.300**	0.183	0.490	Under
	Dawn/Dusk	3	0.4%	8	0.4%	**1.038**	0.276	3.901	Unsure
	Glare	3	0.4%	0	0.0%	**N/A**	N/A	N/A	N/A
	Heavy Rain	4	0.6%	5	0.3%	**2.214**	0.596	8.221	Unsure
	Smoke/Fog	22	3.3%	15	0.8%	**4.059**	2.118	7.779	Over
	Wet/Slippery	34	5.0%	87	4.6%	**1.082**	0.735	1.592	Unsure
	Wind	0	0.0%	0	0.0%	**N/A**	N/A	N/A	N/A
Human	Age	31	4.6%	117	6.3%	**0.733**	0.498	1.079	Unsure
	Aggression	9	1.3%	26	1.4%	**0.958**	0.451	2.034	Unsure
	Alcohol	13	1.9%	44	2.4%	**0.818**	0.443	1.509	Unsure
	Alcohol & Drugs	0	0.0%	4	0.2%	**0.000**	N/A	N/A	N/A
	Confusion	9	1.3%	28	1.5%	**0.890**	0.422	1.876	Unsure
	Decision	44	6.5%	89	4.8%	**1.368**	0.964	1.942	Unsure
	Distraction	0	0.0%	9	0.5%	**0.000**	N/A	N/A	N/A
	Drugs	22	3.3%	19	1.0%	**3.205**	1.746	5.883	Over
	Fatigue	10	1.5%	12	0.6%	**2.306**	1.001	5.314	Over
	History	8	1.2%	16	0.9%	**1.384**	0.595	3.219	Unsure
	Inattention	54	8.0%	112	6.0%	**1.334**	0.976	1.824	Unsure
	Inexperience	9	1.3%	21	1.1%	**1.186**	0.546	2.577	Unsure
	Low Speed	7	1.0%	2	0.1%	**11.07**	1.240	98.876	Over
	Medical	3	0.4%	8	0.4%	**1.038**	0.276	3.901	Unsure
	Mental/Emotional	5	0.7%	21	1.1%	**0.659**	0.249	1.741	Unsure
	Mobility	1	0.1%	13	0.7%	**0.213**	0.028	1.624	Unsure
	Other	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
	Perception	3	0.4%	42	2.2%	**0.198**	0.061	0.636	Under
	Physical Defect	1	0.1%	7	0.4%	**0.395**	0.049	3.208	Unsure
	Police Pursuit	0	0.0%	5	0.3%	**0.000**	N/A	N/A	N/A
	Speed	27	4.0%	205	11.0%	**0.365**	0.246	0.539	Under
	Steering Input	41	6.1%	166	8.9%	**0.684**	0.491	0.951	Under
	Unfamiliar w/Area	2	0.3%	4	0.2%	**1.384**	0.254	7.538	Unsure
	Unfamiliar w/Vehicle	2	0.3%	1	0.1%	**5.536**	0.503	60.948	Unsure
	Unknown	1	0.1%	3	0.2%	**0.923**	0.096	8.854	Unsure
	Visibility	6	0.9%	7	0.4%	**2.372**	0.800	7.034	Unsure

Table 7.11: Secondary and Tertiary Contributing Factors in Truck Crashes, continued

Factor Class	Factor Detail	Truck		Other		CMV ORF	Min CI	Max CI	Level
		Num.	Per.	Num.	Per.				
Roadway	Access Point	9	1.3%	37	2.0%	**0.673**	0.327	1.387	Unsure
	Bike Facilities	0	0.0%	3	0.2%	**0.000**	N/A	N/A	N/A
	Congestion	14	2.1%	16	0.9%	**2.422**	1.188	4.935	Over
	Construction	17	2.5%	24	1.3%	**1.960**	1.060	3.626	Over
	Curvature	21	3.1%	83	4.4%	**0.700**	0.437	1.121	Unsure
	Design/Geometry	13	1.9%	41	2.2%	**0.878**	0.473	1.627	Unsure
	Lighting	50	7.4%	133	7.1%	**1.041**	0.761	1.423	Unsure
	Maintenance	1	0.1%	6	0.3%	**0.461**	0.056	3.825	Unsure
	No Sidewalk	4	0.6%	10	0.5%	**1.107**	0.348	3.518	Unsure
	Obstruction	14	2.1%	14	0.7%	**2.768**	1.326	5.775	Over
	Other	2	0.3%	2	0.1%	**2.768**	0.391	19.610	Unsure
	Pavement Markings	0	0.0%	13	0.7%	**0.000**	N/A	N/A	N/A
	Ped Facilities	0	0.0%	3	0.2%	**0.000**	N/A	N/A	N/A
	Shoulder Design	3	0.4%	3	0.2%	**2.768**	0.560	13.680	Unsure
	Sight Distance	6	0.9%	23	1.2%	**0.722**	0.295	1.766	Unsure
	Sign/Signal	2	0.3%	14	0.7%	**0.395**	0.090	1.735	Unsure
	Speed Limit	8	1.2%	7	0.4%	**3.163**	1.151	8.690	Over
	Standing Water	1	0.1%	4	0.2%	**0.692**	0.077	6.180	Unsure
	Traffic Operations	15	2.2%	15	0.8%	**2.768**	1.360	5.631	Over
Vehicle	Acceleration Rate	7	1.0%	1	0.1%	**19.37**	2.388	157.18	Over
	Blind Spot	13	1.9%	7	0.4%	**5.140**	2.059	12.829	Over
	Bus	0	0.0%	5	0.3%	**0.000**	N/A	N/A	N/A
	Defect	13	1.9%	7	0.4%	**5.140**	2.059	12.829	Over
	Disabled	17	2.5%	15	0.8%	**3.137**	1.575	6.246	Over
	Emergency	2	0.3%	8	0.4%	**0.692**	0.147	3.250	Unsure
	Jackknife	12	1.8%	0	0.0%	**N/A**	N/A	N/A	N/A
	Lighting	11	1.6%	21	1.1%	**1.450**	0.703	2.991	Unsure
	Load Shift/Fall	3	0.4%	2	0.1%	**4.152**	0.695	24.792	Unsure
	Maintenance	0	0.0%	0	0.0%	**N/A**	N/A	N/A	N/A
	Maneuverability	6	0.9%	0	0.0%	**N/A**	N/A	N/A	N/A
	Other	1	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
	Overweight	1	0.1%	3	0.2%	**0.923**	0.096	8.854	Unsure
	Size/Length	1	0.1%	0	0.0%	**N/A**	N/A	N/A	N/A
	Stability	0	0.0%	11	0.6%	**0.000**	N/A	N/A	N/A
	Tires	4	0.6%	15	0.8%	**0.738**	0.246	2.216	Unsure
	Trailer	2	0.3%	9	0.5%	**0.615**	0.133	2.839	Unsure
	Unknown	0	0.0%	1	0.1%	**0.000**	N/A	N/A	N/A

Table 7.11: Secondary and Tertiary Contributing Factors in Truck Crashes, continued

Factor Class	Factor Detail	Truck		Other		CMV ORF	Min CI	Max CI	Level
		Num.	Per.	Num.	Per.				
Vehicle	View Obstruction	8	1.2%	11	0.6%	**2.013**	0.813	4.983	Unsure
	Visibility	4	0.6%	49	2.6%	**0.226**	0.082	0.624	Under
Other/Unknown		0	0.0%	0	0.0%	**N/A**	N/A	N/A	N/A
Total		676	100%	1871	100%	**1.000**			

One hundred seventy nine trucks were found to be at fault in 178 different crashes. Table 7.12 lists the contributing factors in crashes where a heavy truck was found to be at fault. The most common factor by far was inattention, which was a contributing factor in over 50 percent of the crashes and the primary contributing factor in almost 40 percent of the crashes. Decision errors were the primary contributing factor in almost 12 percent of the crashes, and speed was primary factor in almost nine percent. Alcohol and fatigue were somewhat common as contributing factors (primary and additional), and drugs and steering input were more common as secondary or tertiary factors. Primary human factors apply exclusively to the at-fault drivers, while secondary and tertiary factors often apply to the not-at-fault driver instead. Again, no roadway or vehicle issues were common as primary contributors, but inadequate lighting, obstructions, and traffic operations issues each contributed to over six percent of the crashes, respectively. The most common traffic operations issues were lack of turn lanes or inadequate storage for heavy trucks making left-turn or U-turn maneuvers.

Table 7.12: Contributing Factors in Crashes where a Heavy Truck was at Fault

Factor Class	Factor	Primary	Secondary	Tertiary	Total	Percent of Crashes	
						Primary Factor	Any Factor
Environment	Dark	0	2	3	5	0.0%	2.8%
	Dawn/Dusk	0	0	1	1	0.0%	0.6%
	Heavy Rain	0	1	1	2	0.0%	1.1%
	Smoke/Fog	0	9	0	9	0.0%	5.0%
	Wet/Slippery	2	9	5	16	1.1%	8.9%
Human	Age	0	0	2	2	0.0%	1.1%
	Aggression	2	1	0	3	1.1%	1.7%
	Alcohol	10	5	4	19	5.6%	10.6%
	Alcohol & Drugs	1	0	0	1	0.6%	0.6%
	Decision	21	8	1	30	11.7%	16.8%
	Distraction	1	0	0	1	0.6%	0.6%
	Drugs	5	5	1	11	2.8%	6.1%
	Fatigue	7	4	1	12	3.9%	6.7%
	History	0	0	2	2	0.0%	1.1%
	Inattention	69	16	5	90	38.5%	50.3%

Table 7.12: Contributing Factors in Crashes where a Heavy Truck was at Fault, continued

Factor Class	Factor	Primary	Secondary	Tertiary	Total	Percent of Crashes	
						Primary Factor	Any Factor
Human	Low Speed	0	1	1	2	0.0%	1.1%
	Medical	6	0	1	7	3.4%	3.9%
	Perception	0	1	0	1	0.0%	0.6%
	Speed	16	5	3	24	8.9%	13.4%
	Steering Input	9	6	6	21	5.0%	11.7%
	Unfamiliar w/Vehicle	0	0	1	1	0.0%	0.6%
	Unknown	10	0	0	10	5.6%	5.6%
	Visibility	0	0	1	1	0.0%	0.6%
Roadway	Access Point	0	2	2	4	0.0%	2.2%
	Congestion	0	5	3	8	0.0%	4.5%
	Construction	0	4	4	8	0.0%	4.5%
	Curvature	1	3	4	8	0.6%	4.5%
	Design/Geometry	1	2	1	4	0.6%	2.2%
	Lighting	0	6	6	12	0.0%	6.7%
	Obstruction	3	3	5	11	1.7%	6.1%
	Other	0	1	0	1	0.0%	0.6%
	Shoulder Design	0	1	2	3	0.0%	1.7%
	Sight Distance	0	1	0	1	0.0%	0.6%
	Sign/Signal	0	2	0	2	0.0%	1.1%
	Speed Limit	0	1	2	3	0.0%	1.7%
	Traffic Operations	0	4	7	11	0.0%	6.1%
Vehicle	Acceleration Rate	0	2	1	3	0.0%	1.7%
	Blind Spot	0	7	0	7	0.0%	3.9%
	Defect	5	8	4	17	2.8%	9.5%
	Disabled	0	4	3	7	0.0%	3.9%
	Emergency	0	0	1	1	0.0%	0.6%
	Jackknife	0	7	3	10	0.0%	5.6%
	Lighting	0	4	1	5	0.0%	2.8%
	Load Shift/Fall	2	1	2	5	1.1%	2.8%
	Low Speed	0	0	3	3	0.0%	1.7%
	Maneuverability	1	1	3	5	0.6%	2.8%
	Other	1	1	0	2	0.6%	1.1%
	Size/Length	0	0	1	1	0.0%	0.6%
	Tires	4	1	1	6	2.2%	3.4%
	Trailer	1	0	0	1	0.6%	0.6%
	View Obstruction	0	4	0	4	0.0%	2.2%
	Visibility	0	2	2	4	0.0%	2.2%
Total		179	150	100	429		

The next set of tables looks at reasons and causes of the crashes in which trucks were at fault. See Section 5.4 below for more information on the drivers of at-fault trucks. Each tables looks at a different type of crash, grouped basically according to the crash type codes given in Table 7.7. Slight differences in grouping are that forward impact crashes are grouped with other crashes rather than with single vehicle crashes, and crashes involving pedestrians who were on the shoulder are categorized as run off the road crashes, rather than as pedestrian crashes. Sideswipe crashes are also investigated separately from rear end crashes. Table 7.13 shows the number of each type of crash in which truck drivers were found to be at fault. Approximately one-quarter of the crashes were rear-end, run off the road, and intersection-turning crashes, respectively. In each of these crash types, the truck was more likely than the other vehicle to be at fault. The following tables look at critical reasons and contributing factors in the seven major crash types. The three other crashes are not investigated in detail here, but involved an animal in the road, debris falling from a truck onto another vehicle, and a dump truck bed impact with an overpass.

Table 7.13: Crash Types in Which Truck Drivers Were Found At Fault

Crash Type	At-Fault Truck Drivers		Not-At-Fault Truck Drivers	
	Number	Percent	Number	Percent
Rear End	45	25.3%	88	22.2%
Run Off Road	43	24.2%	73	18.4%
Intersection-Turning	40	22.5%	75	18.9%
Intersection-Straight v. Straight	16	9.0%	48	12.1%
Head-on	16	9.0%	55	13.9%
Pedestrians in Road	8	4.5%	37	9.3%
Sideswipe	7	3.9%	18	4.5%
Other	3	1.7%	3	0.8%
Total	178	100.0%	397	100.0%

Table 7.14 lists critical reasons for all 45 rear-end crashes in which heavy trucks were at fault. It also lists the most common contributing factors in the crashes. The most common reasons for the rear-end crashes were inattention to slow and stopped vehicles, including vehicles stopped due to previous crashes. Correspondingly, inattention and road obstructions, including vehicles from previous crashes and stalled vehicles, contributed to large numbers of fatal crashes.

CMV "taking" right-of-way is a factor applied only to CMV crashes and only in this set of tables, which attempts to describe a phenomenon seen in certain heavy truck crashes. Analyzing the case reports dealing with CMV's showed a tendency on the part of the CMV driver to "take" right-of-way, either moving onto or across the road in front of other traffic, or completely blocking it while waiting to a clear path to proceed, rather than wait for a sufficient gap to make a maneuver. This occurred in u-turn and left-turn from side street cases, both on divided and undivided highways, in entrance ramp merging cases, and in backing maneuvers. In such cases, it is difficult to differentiate decision errors (a deliberate ROW violation, expecting that the other driver will see the CMV and yield) from inattention or perception errors (looked but failed to see).

In some of these cases, the CMV did not legally violate the other vehicle's right-of-way, since the vehicle had time to recognize the hazard and respond accordingly (i.e. the CMV does not pose an imminent hazard to the other vehicle when it pulls out into the roadway, because the other vehicle has time to slow while the CMV simultaneously straightens and gains speed.) However, this taking of right-of-way, whether deliberate or not, coupled with inattention and sometimes alcohol use on the part of the other vehicle's driver, often resulted in fatal crashes. In the case of rear-end crashes, taking ROW is attributed to all three U-turning cases, in which the truck driver first swung far to the right, blocking both through lanes, and to three of the lane change/merge crashes, in which the CMV merged with insufficient gap from the shoulder or an on-ramp into the path of trailing vehicles.

Table 7.14: Critical Reasons and Common Contributing Factors in Rear-End Crashes

Reasons and Causes of Rear-End Crashes		Number	Percent
Critical Reason	Inattentive to other slow vehicle	7	15.6
	Stopped vehicles due to previous crash	6	13.3
	Inattentive to slow traffic due to congestion/construction	6	13.3
	Inattentive to turning vehicle	5	11.1
	Lane change/merge w/insufficient headway	4	8.9
	Poor visibility/too fast for conditions	4	8.9
	U-turning vehicle blocking through lanes	3	6.7
	Inattentive to low speed vehicle (bicycle/mower)	3	6.7
	Deliberate stop/park on interstate	2	4.4
	Vehicle defect-front vehicle, inattentive rear vehicle	2	4.4
	Fatigue/asleep	1	2.2
	Vehicle defect-rear vehicle	1	2.2
	Vehicle defect-both vehicles	1	2.2
Common Contributing Factors	Inattention	27	60.0%
	Obstruction	8	17.8%
	CMV "taking" ROW	6	13.3%
	Previous crash	6	13.3%

Table 7.15 looks at critical reasons and contributing factors in the 43 run off the road (ROR) crashes in which trucks were at fault. It is apparent that most ROR truck crashes involved a loss of control prior to the ROR event. The most common reasons for the ROR crashes were evasive action due to stopped or slow traffic and fatigue/asleep at the wheel, followed by loss of control for unknown reasons, or due to a speed that was too high for the prevailing wet conditions. Accordingly, evasive maneuvers were found to contribute to about one-fourth of the ROR crashes. Vehicle defects (including tire blowouts, brake defects, and

disabled vehicles parked on the shoulder) and environmental factors (primarily wet roads) each contributed to almost 20 percent of the crashes. Fatigue, alcohol and drug use, and inattention were also common contributing factors in the ROR crashes.

Table 7.15: Critical Reasons and Common Contributing Factors in Run Off the Road Crashes

Reasons and Causes of Run Off the Road Crashes		Number	Percent
Critical Reason	Evasive action due to slow/stopped traffic	7	16.3
	Fatigue/asleep at wheel	6	14.0
	Loss of control-unknown reason	5	11.6
	Loss of control-unsafe speed for conditions	4	9.3
	Failed to negotiate curve	3	7.0
	Incapacitation-medical	3	7.0
	Incapacitation-alcohol/drugs	3	7.0
	Evasive action due to vehicle intrusion on travel lane	2	4.7
	Vehicle defect	2	4.7
	Tire blowout	2	4.7
	Loss of control-load shift	2	4.7
	Drift off road-overcorrect	2	4.7
	Evasive-obstruction	1	2.3
	Jackknife-excessive braking	1	2.3
Common Contributing Factors	Evasive maneuver	10	23.3
	Vehicle defect	8	18.6
	Environment	8	18.6
	Curvature	6	14.0
	Fatigue	6	14.0
	Alcohol and/or drugs	6	14.0
	Inattention	6	14.0

Table 7.16 looks at reasons and contributing factors in the 40 turning crashes at intersections. The most common reason for this type of crash is a left turn in front of oncoming traffic, either by misjudging the gap, inattentiveness/failure to perceive the oncoming vehicle, or by “taking” the right-of-way as described earlier, an expectation that the oncoming vehicle will yield to the truck because it needs more time and space to maneuver. Other left turns in front of cross traffic are the second most common reason, a category that excludes a left turn where the CMV is stopped with the trailer blocking through lanes while the driver waits for sufficient gap space to proceed. Running red lights (on either turning or straight movements) and U-turning without yielding to the oncoming vehicle are also common reasons for the turning crashes. In all, almost three-quarters of the turning crashes where a CMV was at fault involved some taking of the right-of-way, either deliberately or through inattentiveness or decision errors. Inattentiveness specifically was suspected in about one-third of the cases, and running red lights contributed to around 17 percent of the cases.

Investigating the effect of signalization on the turning movements, eleven crashes (27 percent) occurred at signalized movements. Of these, seven (64 percent) involved running the signal. Another eleven crashes occurred on movements with stop signs. Ten of the eleven (91 percent) involved CMV's making a left turn, all but one across divided highways. Finally, 18 of the crashes (45 percent) occurred on unsignalized movements, including five involving u-turns and seven involving left-turns in front of oncoming vehicles.

Table 7.16: Critical Reasons and Common Contributing Factors in Intersection-Turning Crashes

Reasons and Causes of Intersection-Turning Crashes		Number	Percent
Critical Reason	Left turn, oncoming	10	25.0
	Other left turn, cross traffic	7	17.5
	Late through signal (ran red light)	4	10.0
	U-turn w/out yielding ROW to oncoming vehicle	4	10.0
	Other ran red light	3	7.5
	Left turn w/insufficient gap, trailer blocking cross traffic	3	7.5
	Turn/merge in front of trailing vehicle	3	7.5
	Right turn in front of through bicycle	2	5.0
	High speed turn, loss of control	2	5.0
	Stopped blocking through lanes	1	2.5
	Passing left-turning vehicle on left	1	2.5
Common Contributing Factors	CMV "taking" ROW	29	72.5
	Inattention	13	32.5
	Ran red light	7	17.5

Table 7.17 looks at reasons and causes of the 16 straight versus straight crashes in which heavy trucks were at fault. First, note that less than one-third of the intersection crashes involved only straight movements, while over two-thirds involved a turning vehicle. Of the straight v. straight crashes, the most common reasons involved running stop signs and red lights; stop sign running cases are broken into subcategories according to the reasons (limited visibility due to fog, unable to stop due to vehicle/brake defect, and other). Cases where the CMV stopped at a sign, then proceeded without sufficient gap space, were also common. Accordingly, the most common contributing factors were running red lights and stop signs, and "taking" the right-of-way, as defined previously. Overall, stop signs governed eight (fifty percent) of the at-fault vehicles, and traffic signals governed another four (25 percent). This means that fifty percent of the straight v. straight crashes at stop signs involved running the stop sign, and all of the straight v. straight crashes at red lights involved running the red light.

Table 7.17: Critical Reasons and Common Contributing Factors in Intersection-Straight Crashes

Reasons and Causes of Intersection-Straight Crashes		Number	Percent
Critical Reason	Ran red light	3	18.8
	Stopped, then proceeded without yielding ROW	3	18.8
	High speed/in safety zone (joint fault w/bicycle failed to yield)	2	12.5
	Backing across roadway	2	12.5
	Failed to see stop sign in fog	2	12.5
	Other ran stop sign	1	6.3
	Inattentive to emergency vehicle	1	6.3
	Slow moving construction vehicle crossing road	1	6.3
	Unable to stop at stop sign due to vehicle defect	1	6.3
Common Contributing Factors	Inattention	7	43.8
	Ran stop sign	4	25.0
	Ran red light	4	25.0
	CMV "taking" ROW	3	18.8

Table 7.18 looks at critical reasons and common contributing factors in the 16 head-on crashes in which heavy trucks were at fault. The most common reasons for the crashes were evasive maneuvers due to slow or stopped traffic and vehicle jackknife due to excessive braking, again due to slow or stopped traffic. Most other cases involved a loss of control followed by the impact with oncoming traffic: only one of the crashes involved a deliberate lane change/passing maneuver. The most common contributing factors, then, were evasive maneuvers and inattention, each contributing to over fifty percent of the cases. Environmental factors, including fog and rain, also contributed to about 37 percent of the head-on crashes.

Table 7.18: Critical Reasons and Common Contributing Factors in Head-On Crashes

Reasons and Causes of Head-On Crashes		Number	Percent
Critical Reason	Evasive maneuver to due slow/stopped traffic	4	25.0
	Jackknife due to excessive braking	3	18.8
	Other loss of control	3	18.8
	High speed, curvature	2	12.5
	Tire blow out	1	6.3
	Illegal/improper passing	1	6.3
	Trailer detached, blocked oncoming lane	1	6.3
	Unknown	1	6.3
Common Contributing Factors	Evasive maneuvers	9	56.3
	Inattention	8	50.0
	Environmental (fog, rain)	6	37.5

Table 7.19 looks at reasons and contributing factors for the seven crashes in which heavy trucks hit pedestrians in the road. The most common reason by far was rear-ending stopped vehicles and pedestrians in the road. Accordingly, inattentiveness on the part of drivers was a common contributing factor, along with those factors that placed the pedestrians in the road: previous crashes, construction activities, and disabled vehicles.

Table 7.19: Critical Reasons and Common Contributing Factors in Pedestrian Crashes

Reasons and Causes of Pedestrian in Road Crashes		Number	Percent
Critical Reason	Rear end stopped vehicles and pedestrians	4	57.1
	Lane change into path of stopped vehicles and pedestrians	1	14.3
	CMV right turn striking pedestrian with trailer	1	14.3
	Disabled vehicle rolls over pedestrian attempting repair	1	14.3
Common Contributing Factors	Inattentive driver	4	57.1
	Previous crash obstructing road	4	57.1
	Construction worker in road	3	42.9
	Disabled vehicle	2	28.6

Table 7.20 looks at reasons and factors in the seven sideswipe crashes. The most common factor was a deliberate but inattentive lane change, followed by an evasive maneuver to avoid slower traffic. Inattentiveness contributed to over 70 percent of the crashes, as did blind spot/no-zone issues. Evasive maneuvers contributed to over 40 percent of the crashes.

Table 7.20: Critical Reasons and Common Contributing Factors in Sideswipe Crashes

Reasons and Causes of Sideswipe Crashes		Number	Percent
Critical Reason	Inattentive lane change	4	57.1
	Evasive maneuver due to slower traffic	2	28.6
	Loss of control/jackknife	1	14.3
Common Contributing Factors	Inattention	5	71.4
	Blind spot/no-zone	5	71.4
	Evasive maneuver	3	42.9

7.6 Vehicle Characteristics and Contributing Factors

Table 7.21 summarizes vehicle defects and other vehicle-related contributing factors involving trucks. Because this is vehicle-level data, the factors describe the characteristics of either the CMV or the other vehicle, whereas previously the factors described crash level conditions (i.e. factors contributing to crashes in which trucks were involved). A total of 303 vehicle factors were identified as primary or secondary contributing factors in the fatal crashes, of which 82 belonged to heavy trucks. This implies that a vehicle factor was applied to about 8 percent of all vehicles involved in fatal crashes, either alone or in combination with another factor, but that vehicle factors applied to almost 13 percent of the heavy trucks in the fatal crashes. Said another way, heavy trucks account for fewer than 17 percent of the vehicles involved in fatal crashes, but were responsible for almost 22 percent of the vehicle factors. In Table 7.21, the red font indicates a factor which is overrepresented in trucks, when compared to the proportion of trucks in the set of fatal crashes. (Because not all vehicles have vehicle factors assigned to them, and because more than one factor can apply to a single vehicle, traditional overrepresentation factors were not computed in this table.)

True vehicle defects account for approximately 40 percent of the vehicle factors; the remaining 60 percent of the vehicle factors are more closely related to vehicle behavior or characteristics than true defects. Most additional vehicle factors were more common in heavy trucks than in other vehicles. For instance, a low acceleration rate contributed to eight fatal traffic crashes; in 87.5 percent of the time (seven cases), the vehicle with the low acceleration rate was a heavy truck. Eleven trucks jackknifed, leading to fatal crashes, and eight trucks had blind spots/no-zone issues that contributed to the truck crashes. Over half of the other vehicle defects belonged to heavy trucks, but only seven percent of the tire defects were assigned to trucks. Recalling from Table 7.10 that truck crashes were more likely to have a vehicle defect as a contributing factor, it appears equally true that the heavy truck in those crashes is more likely to be the vehicle with the defect. Still, only 4.2 percent of the trucks involved in the fatal crashes had vehicle (tire and other) defects.

Table 7.21: Vehicle Contributing Factors for Heavy Trucks

Factor	Trucks					All Vehicles	Percent Truck
	Primary	Secondary	Tertiary	Additional	Total	Total	
Acceleration Rate	0	5	2	0	7	8	87.5%
Blind Spot	0	7	1	0	8	21	38.1%
Bus	0	0	0	0	0	5	0.0%
Defect	5	7	4	7	23	44	52.3%
Disabled	0	2	0	0	2	32	6.3%
Emergency	0	0	1	0	1	10	10.0%
Jackknife	0	5	4	2	11	14	78.6%
Lighting	0	0	1	1	2	36	5.6%
Load Shift/Fall	1	1	2	1	5	10	50.0%
Low Speed	0	1	1	0	2	4	50.0%
Maneuverability	1	1	5	0	7	7	100.0%
Overheight	1	0	0	0	1	4	25.0%
Overweight	0	0	0	2	2	7	28.6%
Size/Length	0	0	1	1	2	2	100.0%
Stability	0	0	0	0	0	11	0.0%
Tires	5	0	0	0	5	69	7.2%

Table 7.21: Vehicle Contributing Factors for Heavy Trucks, continued

Factor	Trucks					All Vehicles	Percent Truck
	Primary	Secondary	Tertiary	Additional	Total	Total	
Trailer	1	0	0	0	1	16	6.3%
View Obstruction	0	3	1	0	4	19	21.1%
Visibility	0	0	0	0	0	52	0.0%
Total Factors	14	30	22	14	80	367	21.8%
Total Vehicles	-	-	-	-	638	3827	16.7%

7.7 Roadway Characteristics and Contributing Factors

Table 7.9 through Table 7.11 (shown previously) summarized the roadway factors that were deemed to have contributed to the heavy truck crashes. To summarize, obstructions (typically vehicles from previous crashes) were overrepresented as primary roadway contributing factors in truck crashes. Construction, obstructions, congestion, and traffic operations issues were both common and overrepresented as additional factors, and inadequate lighting and curvature were the most common additional factors, although not overrepresented in truck crashes. This section looks at a number of other roadway factors involved in truck and other crashes. Table 7.22 examines crashes by facility size and type. About 30 percent of fatal truck crashes occur on four to five lane highways and another 30 percent occur on limited access facilities. Heavy trucks are significantly overrepresented in crashes on limited access facilities and two to three lane roadways. Trucks are underrepresented on all non-limited access roads with more than three lanes. Note that while most of these rates are not highly over- or underrepresented, most are significant at the 95 percent confidence interval.

Table 7.22: Truck Crashes by Facility Type and Size

Facility Type and Size	Truck Crashes		Other Crashes		CMV ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Limited access	174	30.3%	308	20.6%	**1.472**	1.255	1.726	Over
Ramp	16	2.8%	35	2.3%	**1.191**	0.664	2.135	Unsure
6+ Lanes	51	8.9%	307	20.5%	**0.433**	0.327	0.573	Under
4-5 Lane	177	30.8%	544	36.3%	**0.848**	0.737	0.975	Under
2-3 Lanes	150	26.1%	287	19.2%	**1.362**	1.146	1.618	Over
One way	7	1.2%	17	1.1%	**1.073**	0.447	2.573	Unsure
Total	575	100.0%	1498	100.0%	**1.000**			

Table 7.23 looks at truck crashes by geographic area. Truck crashes are highly overrepresented in rural areas and underrepresented in urban areas. While less than one third of the non-CMV crashes occur in rural areas, over half of the CMV crashes occur on rural roads.

Table 7.23: Truck Crashes by Geographic Area

Geographic Area	Truck Crashes		Other Crashes		CMV OR Factor	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Rural	319	55%	474	32%	**1.753**	1.579	1.946	Over
Urban	141	25%	652	44%	**0.563**	0.483	0.658	Under
Suburban	115	20%	372	25%	**0.805**	0.669	0.970	Under
TOTAL	575	100%	1498	100%	**1.000**			

Table 7.24 summarizes crashes in which a driver failed to negotiate a curve. Curvature was mentioned much more frequently as an additional factor in truck crashes, and much less frequently as a tertiary factor. This implies that other factors, including potentially vehicle factors, which were more common in truck crashes, were more likely to be prioritized before curvature in truck crashes. Overall, however, failure to negotiate curvature was somewhat more common in truck than in non-CMV crashes, with an OR factor of 1.281.

Table 7.24: Crashes in Which Driver Failed to Negotiate Curve

Failed to Negotiate Curve	Truck		Other		CMV ORF
	Number	Percent	Number	Percent	
Primary	1	0.2%	2	0.1%	**1.309**
Secondary	10	1.7%	27	1.8%	**0.969**
Tertiary	11	1.9%	54	3.6%	**0.533**
Additional	24	4.2%	11	0.7%	**5.711**
None	529	92.0%	1411	93.8%	**0.981**
Any Factor	46	8.0%	94	6.2%	**1.281**
Total	575	100.0%	1505	100.0%	**1.000**

7.8 Environmental Characteristics and Contributing Factors

Table 7.9 through Table 7.11 above summarized the crashes in which environmental factors were named as primary or additional contributing factors. No environmental factors were common as primary crash contributors; as additional contributors, smoke and fog were highly overrepresented, because of the prevalence of smoke/fog in high speed rural crashes, especially on limited access facilities, and darkness was underrepresented. This section looks in more detail at environmental conditions at the time of the crash. Table 7.25 summarizes the weather at the time of the CMV and other crashes: CMV crashes are overrepresented during rain and fog; however, only fog was named as a common *contributor* to the crashes. This means that while it was more often raining during the truck crashes, rain was thought to contribute to truck crashes no more frequently than it did to other crashes. Table 7.26 gives similar results, showing that wet or slippery roads are neither common nor overrepresented in truck crashes. (Because case studies showed that officers use wet or slippery interchangeably, these two categories have been combined.)

Table 7.25: Weather Condition at Time of Truck Crashes

Weather	Truck Crashes		Other Crashes		CMV OR Factor	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Clear	390	67.8%	1114	74.0%	**0.916**	0.860	0.977	Under
Cloudy	107	18.6%	278	18.5%	**1.007**	0.824	1.232	Unsure
Rain	47	8.2%	81	5.4%	**1.519**	1.074	2.147	Over
Fog	27	4.7%	23	1.5%	**3.073**	1.777	5.314	Over
Other/UK	4	0.7%	9	0.6%	**1.163**	0.360	3.763	Unsure
Total	575	100.0%	1505	100.0%	**1.000**	1.00		

Table 7.26: Roadway Surface Condition at Time of Truck Crashes

Surface Condition	Truck Crashes		Other Crashes		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Dry	502	87.3%	1346	89.4%	**0.976**	0.942	1.012	Unsure
Wet/Slippery	73	12.7%	159	10.6%	**1.202**	0.927	1.558	Unsure
Icy	0	0.0%	0	0.0%	**N/A**	N/A	N/A	N/A
Total	575	100.0%	1505	100.0%	**1.000**			

Table 7.27 summarizes lighting conditions at the time of the crashes. One can see that the truck crashes are somewhat more common during daytime, while crashes occurring during darkness were about three times more likely to occur in areas with no street lights. Overall, CMV crashes are overrepresented at dawn and with no street lights, but underrepresented in areas with streetlights. This is more likely a reflection of where truck crashes occur, on interstates and rural roads, although inadequate street lighting was commonly cited (although not overrepresented) as a secondary contributing factor in truck crashes in Table 7.11.

Table 7.27: Lighting Conditions in Truck Crashes

Lighting Condition	Truck Crashes		Other Crashes		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Daytime	297	51.7%	692	46.0%	**1.123**	1.020	1.237	Over
Dusk	7	1.2%	28	1.9%	**0.654**	0.287	1.490	Unsure
Dawn	27	4.7%	27	1.8%	**2.617**	1.549	4.423	Over
Dark, w/street lights	70	12.2%	387	25.7%	**0.473**	0.374	0.599	Under
Dark, no street lights	174	30.3%	371	24.7%	**1.228**	1.054	1.430	Over
Total	575	100.0%	1505	100.0%	**1.000**			

7.9 Human Characteristics and Contributing Factors

This section discusses human characteristics and contributing factors to fatal traffic crashes. While Table 7.9 through Table 7.11 looked at human factors in heavy truck crashes, Table 7.28 looks at contributing human factors belonging specifically to the truck and other drivers involved in all fatal traffic crashes. As with Table 7.21 above, the red font indicates a factor which is overrepresented in truck drivers, when compared to the proportion of truck drivers in the set of fatal crashes. Again, because many drivers have than one factor applied to them, traditional overrepresentation factors were not computed in this table. Instead, the proportion of the factors belonging to truck drivers is computed, and can be compared to the overall percentage of truck drivers in the data set (16.7 percent of all drivers). Overall, only 6.5% of all human factors belong to truck drivers, so it is apparent that human factors are more often applied to drivers of non-CMV's: a total of 210 human factors were applied to 638 truck drivers (0.33 factors per driver), while overall, 3220 factors were applied to 3827 drivers (0.84 factors per driver).

As shown in Table 7.28, the most common contributing factor attributed to truck drivers was inattention, accounting for 43 percent of the total human factors attributed to truck drivers (90 of 210 factors). Despite the fact that inattention is also common among non-CMV drivers, it is substantially overrepresented in truck drivers: overall, almost 15 percent of inattention cases were attributed to truck drivers, while only 6.5 percent of all factors were attributed to truck drivers. Other factors that occur frequently among truck drivers are decision errors, speed, and excess steering input, although these occur much less frequently than inattention. Compared to other drivers, a high percent of fatigue, medical, and low speed cases were attributed to truck drivers. Drugs shows up frequently as a secondary factor, but overall occur at a rate near even. Note that "low speed" in this situation refers to a driver who is purposefully traveling at a low speed or stopped in a travel lane, rather than low vehicular speed due to a vehicle defect or low acceleration rate, which were included in the vehicle factors (see Table 7.21 above).

Table 7.28: Human Causative Factors for Truck and Other Drivers

Factor	Truck Drivers				All Drivers				Percent Truck			
	Prim.	Sec.	Tert.	Tot.	Prim.	Sec.	Tert.	Tot.	Prim.	Sec.	Tert.	Tot.
Age	0	0	0	0	2	71	75	148	0.0%	0.0%	0.0%	0.0%
Aggression	2	0	0	2	36	31	3	70	5.6%	0.0%	0.0%	2.9%
Alcohol	3	1	2	6	515	40	17	572	0.6%	2.5%	11.8%	1.0%
Alcohol & Drugs	1	0	0	1	71	4	1	76	1.4%	0.0%	0.0%	1.3%
Confusion	0	0	0	0	18	32	5	55	0.0%	0.0%	0.0%	0.0%
Decision	18	10	1	29	199	120	12	331	9.0%	8.3%	8.3%	8.8%
Distraction	1	0	0	1	17	7	2	26	5.9%	0.0%	0.0%	3.8%
Drugs	4	4	0	8	72	27	11	110	5.6%	14.8%	0.0%	7.3%
Fatigue	7	3	0	10	50	17	5	72	14.0%	17.6%	0.0%	13.9%
History	0	0	1	1	0	10	14	24	N/A	0.0%	7.1%	4.2%
Inattention	64	19	7	90	449	127	40	616	14.3%	15.0%	17.5%	14.6%

Table 7.29: Human Causative Factors for Truck and Other Drivers, continued

Factor	Truck Drivers				All Drivers				Percent Truck			
	Prim.	Sec.	Tert.	Tot.	Prim.	Sec.	Tert.	Tot.	Prim.	Sec.	Tert.	Tot.
Inexperience	0	0	0	0	2	20	8	30	0.0%	0.0%	0.0%	0.0%
Low Speed	0	1	4	5	1	3	5	9	0.0%	33.3%	80.0%	55.6%
Medical	6	0	0	6	39	10	1	50	15.4%	0.0%	0.0%	12.0%
Mental/Emotional	0	0	0	0	20	17	8	45	0.0%	0.0%	0.0%	0.0%
Mobility	0	0	0	0	1	10	4	15	0.0%	0.0%	0.0%	0.0%
Other	0	0	0	0	15		2	17	0.0%	N/A	0.0%	0.0%
Perception	1	1	0	2	75	43	2	120	1.3%	2.3%	0.0%	1.7%
Physical Defect	0	0	0	0	0	5	3	8	N/A	0.0%	0.0%	0.0%
Police Pursuit	0	0	0	0	3	4	1	8	0.0%	0.0%	0.0%	0.0%
Speed	15	6	1	22	153	201	30	384	9.8%	3.0%	3.3%	5.7%
Steering Input	8	6	3	17	65	140	67	272	12.3%	4.3%	4.5%	6.3%
Unfamiliar w/Area	0	0	0	0	1	4	2	7	0.0%	0.0%	0.0%	0.0%
Unfamiliar w/Vehicle	0	0	0	0	0	2	1	3	N/A	0.0%	0.0%	0.0%
Unknown	10	0	0	10	134	3	1	138	7.5%	0.0%	0.0%	7.2%
Visibility	0	0	0	0	1	2	11	14	0.0%	0.0%	0.0%	0.0%
Total Factors	140	51	19	210	1939	950	331	3220	7.2%	5.4%	5.7%	6.5%
Total Drivers				638				3827				16.7%

Table 7.30 shows the distribution of fault in fatal traffic crashes. CMV drivers are underrepresented in fault, and are almost half as likely to be found at fault as non-CMV drivers. Multiple drivers were found to be at fault in 40 cases, of which one involved multiple CMV at-fault drivers and 29 involved multiple non-CMV drivers. Because not-at-fault drivers or vehicles often contributed to the crash Table 7.31 also lists the factors associated with the not-at-fault trucks and their drivers. The most common factor was inattention, followed by low speed and decision errors. A total of 40 factors were applied to the not-at-fault-trucks and drivers, meaning that about nine percent of the 445 not-at-fault trucks had driver or vehicle factors.

Table 7.30: Fault in Fatal Truck Crashes

At-Fault Driver	Heavy Truck		Other		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Yes	179	28.1%	1667	52.3%	**0.537**	0.472	0.611	Under
No	445	69.7%	1468	46.1%	**1.514**	1.421	1.613	Over
Unknown	1	0.2%	18	0.6%	**0.278**	0.037	2.076	Unsure
Driverless	13	2.0%	35	1.1%	**1.856**	0.988	3.488	Unsure
Total	638	100.0%	3188	100.0%	**1.000**			

Table 7.31: Factors by Not-At-Fault Trucks and Drivers

Factor	Secondary	Tertiary	Total
Acceleration Rate	3	1	4
Alcohol	1	1	2
Blind Spot	0	1	1
Decision	4	1	5
Defect	2	2	4
Disabled	1	0	1
Inattention	7	3	10
Jackknife	0	1	1
Low Speed	0	6	6
Maneuverability	0	2	2
Speed	1	0	1
Tires	1	0	1
View Obstruction	1	1	2
Total	21	19	40

Table 7.32 looks at fault according to crash type for all of the crashes in which heavy trucks were involved. The most common crash types in which CMV's were at fault were rear-end crashes, change trafficway/oncoming traffic crashes, left roadside departure with control loss, and right roadside departures without control loss. In all, these four crash types made up about 50 percent of the crashes in which CMV's were at fault. Of those crash types, CMV's were highly overrepresented in fault in both roadside departure (run off the road) crash types. Conversely, the non-CMV driver was more likely to be at fault in intersection-straight crashes where the not-at-fault vehicle approached from the right, and in crashes involving a head-on collision (crossed centerline or wrong way), and those involving a left roadside departure. In thirteen cases, the CMV was driverless, and in one case, fault could not be established.

Table 7.32: Fault Versus Crash Type in Truck Crashes

Crash Type	Crash Subtype	At-Fault		Not-At-Fault		Driverless/ Unknown Fault	At-Fault ORF
		Num.	Per.	Num.	Per.		
Change Trafficway/Turning	Evasive Action To Avoid Turning/Merging Vehicle	0	0.0%	1	0.2%	0	**0.000**
	Initial Opposite Directions/Oncoming Traffic	19	10.6%	41	9.2%	0	**1.143**
	Initial Same Direction	4	2.2%	4	0.9%	0	**2.467**
	Turn Into Opposite Directions/Cross Traffic	12	6.7%	23	5.2%	0	**1.287**
	Turn/Merge Into Same Direction	4	2.2%	11	2.5%	0	**0.897**
	Single Vehicle Control Loss While Turning	1	0.6%	0	0.0%	0	**N/A**

Table 7.32: Fault Versus Crash Type in Truck Crashes, continued

Crash Type	Crash Subtype	At-Fault		Not-At-Fault		Driverless/ Unknown Fault	At-Fault ORF
		Num.	Per.	Num.	Per.		
Intersecting Paths	Backing	2	1.1%	3	0.7%	0	**1.644**
	Not-at-Fault From Left	9	5.0%	20	4.5%	0	**1.110**
	Not-at-Fault From Right	4	2.2%	27	6.1%	0	**0.365**
	Not-at-Fault From Unknown Direction	1	0.6%	0	0.0%	0	**N/A**
Opposite Direction	Forward Impact With Control Loss	8	4.4%	7	1.6%	0	**2.819**
	Head-On	7	3.3%	49	11.0%	0	**0.302**
	Sideswipe Angle	1	0.6%	1	0.2%	0	**2.467**
Pedestrian	Crossing At Intersection In Crosswalk	0	0.0%	1	0.2%	0	**0.000**
	Crossing Not At Intersection--First Half	0	0.0%	3	0.7%	0	**0.000**
	Crossing Not At Intersection--Second Half	0	0.0%	8	1.8%	0	**0.000**
	Exit Vehicle	4	2.8%	12	2.7%	0	**1.028**
	Other In Road	3	1.7%	12	2.7%	1	**0.617**
	Other/Unknown	0	0.0%	2	0.5%	0	**0.000**
	Vehicle Turn/Merge	1	0.6%	0	0.0%	0	**N/A**
	Walking Along Road Against Traffic	0	0.0%	1	0.2%	0	**0.000**
	Walking Along Road With Traffic	0	0.0%	4	0.9%	0	**0.000**
Run Off Road/Single Vehicle	Forward Impact	2	1.1%	0	0.0%	0	**N/A**
	Left Roadside Departure	4	2.2%	30	6.8%	0	**0.329**
	Left Roadside Departure With Control Loss	18	10.0%	27	6.1%	0	**1.644**
	Ramp Departure	2	1.1%	4	0.9%	1	**1.233**
	Right Roadside Departure	14	7.8%	20	4.3%	5	**1.818**
	Right Roadside Departure With Control Loss	5	2.8%	3	0.7%	4	**4.111**
Same Direction	Rear End	43	23.9%	91	20.5%	2	**1.166**
	Rear End With Avoid Impact	3	1.7%	15	3.4%	0	**0.493**
	Sideswipe Angle	5	2.8%	16	3.6%	0	**0.771**
	Sideswipe Angle With Control Loss	2	1.1%	7	1.6%	0	**0.705**
Unknown		1	0.6%	2	0.5%	1	**1.233**
Total		179	100%	445	100%	14	**1.000**

Table 7.33 examines alcohol use by CMV and other drivers, according to information on the traffic homicide reports. As shown in Table 7.33, very few (four) of the CMV drivers were known to be drinking at the time of the crash. However, almost 14 percent of the other drivers

were known to be under the influence at the time of the crash (BAC over legal limit). CMV drivers are highly underrepresented in all of the BAC values. Because CMV drivers are less likely to be tested than non-CMV drivers, a higher percentage are presumed to be sober than are actually tested and proven to be sober. This occurs despite a statutory requirement that CMV drivers be tested for alcohol use when involved in a fatal traffic crash. Of the four CMV drivers found to be under the influence at the time of the crash, three were also found to be at fault in the crash.

Table 7.33: Alcohol Use by Truck Drivers

BAC Content	Truck Drivers		Other Drivers		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0.00 Tested	157	24.6%	882	27.7%	**0.889**	0.768	1.030	Unsure
0.00 Presumed	341	53.4%	1089	34.2%	**1.565**	1.434	1.707	Over
< Limit	1	0.2%	89	2.8%	**0.056**	0.008	0.402	Under
1-2 X Limit	1	0.2%	147	4.6%	**0.034**	0.005	0.242	Under
2-3 X Limit	2	0.3%	194	6.1%	**0.052**	0.013	0.207	Under
3-4 X Limit	0	0.0%	74	2.3%	**0.000**	N/A	N/A	N/A
> 4 X Limit	0	0.0%	18	0.6%	**0.000**	N/A	N/A	N/A
> 0	0	0.0%	9	0.3%	**0.625**	0.078	4.985	Unsure
> Limit	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
No driver	17	2.7%	40	1.3%	**2.124**	1.212	3.722	Over
Unknown	118	18.5%	645	20.2%	**0.914**	0.766	1.091	Unsure
Total	638	100.0%	3188	100.0%	**1.000**			

Table 7.34 through Table 7.36 examine drug use according to vehicle type and fault. Table 7.34 shows that truck drivers were much less likely to be using illegal or other impairing drugs than non-CMV drivers. However, more truck drivers were using drugs and drinking alcohol at the time of the fatal crash. Table 7.35 shows that most drivers with illegal or impairing drugs in their systems were found to be at fault in the fatal crashes. Finally, Table 7.36 shows the exact drugs found on the toxicology screens of the CMV drivers. The shaded rows indicate drugs that are not impairing or were administered post-crash, and thus were not counted in the previous two charts. The number of drugs found is still higher than the number of drivers using drugs, though, because three drivers were under the influence of multiple illegal drugs.

Table 7.34: Drug Use by Truck Drivers

Drug Use	Truck Drivers		Other Drivers		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Illegal Drugs	10	1.6%	97	3.0%	**0.515**	0.235	0.913	Under
Narcotic Analgesics, Sedatives, Hypnotics	2	0.3%	30	0.9%	**0.333**	0.080	1.390	Unsure
Prescription Or Non-Prescription Drugs W/Side Effects	2	0.3%	21	0.7%	**0.476**	0.112	2.025	Unsure
None/Unknown	625	97.8%	3040	95.4%	**1.027**	1.013	1.041	Over
Total	638	100.0%	3188	100.0%	**1.000**			

Table 7.35: Drug Use by Truck Drivers According to Fault

Drug Use	CMV Driver	
	At-fault	Not
Illegal Drugs	9	1
Narcotic Analgesics, Sedatives, Hypnotics	0	2
Prescription Or Non-Prescription Drugs W/Side Effects	2	0
Total	11	3

Table 7.36: Breakdown of Drugs Used by Truck Drivers

Drug Used	Number	Percent
Marijuana	5	25%
Cocaine	4	20%
Amphetamines	4	20%
Caffeine	2	10%
Sedative/Hypnotic	1	5%
Narcotic Analgesic	1	5%
Cold Medication	1	5%
Non-prescription Pain Medication	1	5%
Pain Medication (most likely administered post-crash)	1	5%
Total	20	100

Table 7.37 examines the driving history ranking of CMV and other drivers involved in fatal traffic crashes. The ranking scale varies from one, which is the best prior driving history, to five, which is the worst, as described in Chapter 4. It can be seen that CMV drivers are underrepresented in having a history ranking of 1 or 2, and overrepresented in having a history

ranking of 3 or 4. This indicates that CMV drivers tended to have worse driving records prior to being involved in the fatal crashes, when compared to other drivers. Note that a driver history ranking was available for roughly one-third of the drivers.

Table 7.37: Driver History Ranking of Truck Drivers

History Ranking	Truck Drivers		Other Drivers		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
1	47	21.1%	317	31.9%	**0.660**	0.500	0.863	Under
2	41	18.4%	256	25.8%	**0.713**	0.524	0.955	Under
3	71	31.8%	225	22.7%	**1.405**	1.135	1.774	Over
4	46	20.6%	127	12.8%	**1.613**	1.177	2.196	Over
5	18	8.1%	68	6.8%	**1.179**	0.727	1.973	Unsure
Total	223	100.0%	993	100.0%	**1.000**			

Table 7.38 looks at driver license status at the time of the crash. Strictly looking at percentages, it is apparent that the vast majority of CMV drivers have valid licenses at the time of the crash. (This category includes "unknown" status because the license was presumed to be valid if no information to the contrary was obtained---the crash report does not directly state whether the license was valid at the time of the crash.) However, over four percent of the drivers of CMV were not in compliance with restrictions on their licenses; primarily this involved truck drivers who did not possess valid commercial driver licenses. Another one percent of the CMV drivers had suspended licenses: this number was underrepresented in comparison to drivers of other vehicles.

Table 7.38: Driver License Status of Truck Drivers

History Ranking	Truck Drivers		Other Drivers		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Valid/Unknown	603	94.5%	2956	92.7%	**1.019**	0.998	1.041	Unsure
Suspended	8	1.3%	106	3.3%	**0.377**	0.185	0.770	Under
Revoked	1	0.2%	14	0.4%	**0.357**	0.047	2.709	Unsure
No Driver License	0	0.0%	55	1.7%	**0.000**	N/A	N/A	N/A
Not Applicable	0	0.0%	50	1.6%	**0.000**	N/A	N/A	N/A
Not In Compliance w/Restriction	26	4.1%	7	0.2%	**18.56**	8.091	42.57	Over
Total	638	100.0%	3188	100.0%	**1.000**			

Table 7.39 examines the gender of CMV and other drivers involved in the crashes. When broken down by both gender and vehicle type, it becomes apparent that there are very few females driving CMV's that are involved in fatal crashes. This is probably because the overwhelming majority of CMV drivers are male. Of the nine female truck drivers, only one

was found to be at-fault (11 percent), while 175 of the 603 male truck drivers (29 percent) were at fault. CMV drivers with license violations were slightly more likely to be at fault in the crash (30% at-fault compared to 25% at-fault).

Table 7.39: Gender of Truck Drivers

Driver Sex	Truck Drivers		Other Drivers		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Male	603	96.8%	2186	69.4%	**1.395**	1.358	1.434	Over
Female	9	1.4%	878	27.9%	**0.052**	0.027	0.099	Under
Unknown	11	1.8%	87	2.8%	**0.639**	0.344	1.190	Unsure
	623	100.0%	3151	100.0%	**1.000**			

Table 7.40 looks at the age of truck and other drivers in the fatal crashes. Most of the truck drivers are in the 25-64 year old age groupings. Truck drivers are underrepresented below 25 years old and above 65 years old, and overrepresented between ages 35 and 64. Looking only at non-CMV drivers involved in crashes with CMV's shows little difference in the age distribution. This indicates that age of non-CMV drivers has no influence on whether the driver is involved in a crash with CMV versus another type of vehicle. Table 7.41 shows that, within the set of truck drivers, drivers of age 25-34 are significantly although not highly overrepresented in fault. Fault is underrepresented in all other age groups, significantly so in the 45-54 year old group.

Table 7.40: Age of Truck Drivers

Driver Age	Truck Drivers		Other Drivers		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0-14	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
15-24	22	3.4%	658	20.6%	**0.167**	0.110	0.253	Under
25-34	144	22.6%	614	19.3%	**1.172**	0.998	1.376	Unsure
35-44	195	30.6%	595	18.7%	**1.638**	1.427	1.879	Over
45-54	151	23.7%	458	14.4%	**1.647**	1.400	1.939	Over
55-64	85	13.3%	262	8.2%	**1.621**	1.289	2.039	Over
65-74	14	2.2%	218	6.8%	**0.321**	0.188	0.547	Under
75-84	0	0.0%	181	5.7%	**0.000**	N/A	N/A	N/A
85-94	0	0.0%	59	1.9%	**0.000**	N/A	N/A	N/A
95-104	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
Unknown/driverless	27	4.2%	139	4.4%	**0.971**	0.648	1.453	Unsure
	638	100.0%	3188	100.0%	**1.000**			

Table 7.41: Fault According to Age of Truck Drivers

Age Group	At-Fault		Not-At-Fault		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
15-24	7	3.9%	15	3.4%	1.151	0.477	2.776	Unsure
25-34	54	30.0%	90	20.3%	1.480	1.108	1.977	Over
35-44	58	32.8%	137	30.6%	1.070	0.832	1.376	Unsure
45-54	30	16.7%	120	27.0%	0.617	0.430	0.884	Under
55-64	22	12.2%	63	14.2%	0.861	0.547	1.356	Unsure
65-74	4	2.2%	10	2.3%	0.987	0.314	3.105	Unsure
Unknown	4	2.8%	10	2.3%	0.987	0.314	3.105	Unsure
	179	100.0%	445	100.0%	1.000			

Table 7.42 examines driver residence. As might be expected, CMV drivers were much less likely than other drivers to be from the county of the crash. Other drivers were almost twice as likely to be from the county of the crash as were CMV drivers. There was almost no correlation between the residence of truck drivers and fault, as shown in Table 7.43.

Table 7.42: Residence of Truck Drivers

Driver Residence	Truck Drivers		Other Drivers		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
County of Crash	231	36.2%	2085	65.4%	0.554	0.498	0.616	Under
Elsewhere in State	268	42.0%	739	23.2%	1.812	1.622	2.025	Over
Non-Res. of State	108	16.9%	199	6.2%	2.712	2.180	3.373	Over
Foreign	5	0.8%	15	0.5%	1.666	0.608	4.566	Unsure
Unknown	11	1.7%	112	3.5%	0.491	0.266	0.906	Under
Driverless	15	2.4%	38	1.2%	1.972	1.092	3.564	Over
Total	638	100.0%	3188	100.0%	1.000			

Table 7.43: Fault According to Residence of Truck Drivers

Driver Residence	At-Fault		Not-At-Fault		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
County of Crash	61	34.4%	170	38.1%	0.905	0.716	1.143	Unsure
Elsewhere in State	80	44.4%	187	42.1%	1.055	0.867	1.284	Unsure
Non-Res. of State	34	18.9%	74	16.7%	1.133	0.785	1.636	Unsure
Foreign	0	0.0%	5	1.1%	0.000	N/A	N/A	N/A
Unknown	4	2.2%	7	1.6%	1.410	0.418	4.756	Unsure
Driverless	0	0.0%	2	0.5%	0.000	N/A	N/A	N/A
Total	179	100.0%	445	100.0%	1.000			

Table 7.44 looks at speed of the trucks and other vehicles in the fatal crashes. Trucks are most likely to be stopped, traveling between 55 and 59 miles per hour, or traveling between 70 and 74 miles per hour at the time of the crash. Compared with other vehicles, trucks are overrepresented in speeds between 50 and 74 MPH, and at zero MPH. Trucks are underrepresented at all speeds above 75 MPH, and no trucks were traveling above 89 MPH at the time of the crash. Table 7.45 compares vehicle speed to fault for truck drivers. While trucks that are stopped are less likely to be found at fault than not, those which are traveling at very low speeds, between 5 and 24 miles per hour, are overrepresented in fault, most with statistical significance. Examining crash types, 33 of these 36 cases involved intersections, including two involving backing vehicles, three involving impacts with bicycles, and five involving u-turning at unsignalized movements. Fault was also overrepresented at high speeds (above 65 MPH), although the relatively few number of vehicles meant that none of the levels were significant. When vehicle speed is compared to the speed limit, 24 out of 638 (3.8%) CMV's were traveling at least ten miles over the posted limit, compared to 398 out of 3188 non-CMV's (12.5%). Seventeen of the speeding truck drivers were found to be at fault in the crash, and seven were not.

Table 7.44: Speed of Trucks and Other Vehicles

Vehicle Speed	Trucks		Other Vehicles		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0-4	89	13.9%	307	9.6%	**1.449**	1.162	1.805	Over
5-9	23	3.6%	105	3.3%	**1.095**	0.703	1.705	Unsure
10-14	18	2.8%	135	4.2%	**0.666**	0.410	1.081	Unsure
15-19	17	2.7%	77	2.4%	**1.103**	0.657	1.852	Unsure
20-24	10	1.6%	72	2.3%	**0.694**	0.360	1.337	Unsure
25-29	3	0.5%	37	1.2%	**0.405**	0.125	1.310	Unsure
30-34	14	2.2%	80	2.5%	**0.874**	0.499	1.533	Unsure
35-39	15	2.4%	107	3.4%	**0.700**	0.411	1.194	Unsure
40-44	30	4.7%	197	6.2%	**0.761**	0.523	1.107	Unsure
45-49	59	9.2%	313	9.8%	**0.942**	0.723	1.228	Unsure
50-54	48	7.5%	208	6.5%	**1.153**	0.852	1.560	Unsure
55-59	87	13.6%	325	10.2%	**1.338**	1.073	1.668	Over
60-64	55	8.6%	164	5.1%	**1.676**	1.250	2.247	Over
65-69	52	8.2%	178	5.6%	**1.460**	1.085	1.965	Over
70-74	59	9.2%	205	6.4%	**1.438**	1.090	1.897	Over
75-79	8	1.3%	61	1.9%	**0.655**	0.315	1.363	Unsure
80-84	5	0.8%	75	2.4%	**0.333**	0.135	0.820	Under
85-89	1	0.2%	24	0.8%	**0.208**	0.028	1.536	Unsure
90-94	0	0.0%	23	0.7%	**0.000**	N/A	N/A	N/A
95-99	0	0.0%	9	0.3%	**0.000**	N/A	N/A	N/A
100-104	0	0.0%	12	0.4%	**0.000**	N/A	N/A	N/A
105-109	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A

Table 7.44: Speed of Trucks and Other Vehicles, continued

Vehicle Speed	Trucks		Other Vehicles		CMV ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
110-114	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
115-119	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
120+	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
Unknown	45	7.1%	466	14.6%	**0.483**	0.360	0.647	Under
	638	100.0%	3188	100.0%	**1.000**			

Table 7.45: Speed Versus Fault for Truck Drivers

Vehicle Speed	At-Fault		Not-At-Fault		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0-4	13	7.2%	63	14.2%	**0.509**	0.287	0.901	Under
5-9	11	6.1%	12	2.7%	**2.261**	1.016	5.030	Over
10-14	8	4.4%	10	2.3%	**1.973**	0.792	4.919	Unsure
15-19	11	6.1%	6	1.4%	**4.522**	1.698	12.044	Over
20-24	6	3.3%	4	0.9%	**3.700**	1.057	12.956	Over
25-29	2	1.1%	1	0.2%	**4.933**	0.450	54.066	Unsure
30-34	1	0.6%	13	2.9%	**0.190**	0.025	1.440	Unsure
35-39	1	0.6%	14	3.2%	**0.176**	0.023	1.330	Unsure
40-44	4	2.2%	26	5.9%	**0.379**	0.134	1.072	Unsure
45-49	14	7.8%	45	10.1%	**0.767**	0.432	1.363	Unsure
50-54	8	5.0%	40	8.8%	**0.569**	0.282	1.151	Unsure
55-59	25	13.9%	62	14.0%	**0.995**	0.646	1.530	Unsure
60-64	15	8.3%	40	9.0%	**0.925**	0.524	1.632	Unsure
65-69	18	10.0%	34	7.7%	**1.306**	0.758	2.251	Unsure
70-74	23	12.8%	36	8.1%	**1.576**	0.962	2.582	Unsure
75-79	4	2.2%	4	0.9%	**2.467**	0.624	9.756	Unsure
80-84	3	1.7%	2	0.5%	**3.700**	0.623	21.958	Unsure
85+	1	0.6%	0	0.0%	**N/A**	N/A	N/A	N/A
Unknown	11	6.1%	33	7.4%	**0.822**	0.425	1.591	Unsure
	179	100.0%	445	100.0%	**1.000**			

7.10 Factors Contributing to Fatalities

Occupants of heavy trucks are much less likely to suffer a fatal injury than occupants of other vehicles. Table 7.46 looks at fatality rate by vehicle type. While automobiles are overrepresented in fatalities when compared to other vehicles, medium and heavy trucks are only 20 percent as likely to have an occupant fatality. However, as shown in Table 7.47, rollover is strongly associated with occupant fatalities, especially in light and heavy trucks.

Table 7.46: Fatality Rate by Vehicle Type

Vehicle Subtype	Vehicles w/Fatalities		Vehicle w/No Fatalities		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Automobile	826	59.8%	630	36.5%	1.639	1.520	1.768	Over
Passenger Van	108	7.8%	148	8.6%	0.912	0.719	1.157	Unsure
Pickup/Light Truck	377	27.3%	402	23.3%	1.173	1.039	1.324	Over
Medium Truck	13	0.9%	69	4.0%	0.236	0.131	0.424	Under
Heavy Truck	58	4.2%	479	27.7%	0.151	0.116	0.197	Under
Total	1382	100.0%	1728	100.0%	1.000			

Table 7.47: Fatality Rate in Vehicles that Rolled Over by Vehicle Type

Vehicle Subtype	Rollover Vehicles w/Fatalities		Rollover Vehicle w/No Fatalities		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Automobile	116	30.5%	706	70.9%	0.431	0.368	0.504	Under
Passenger Van	43	11.3%	65	6.5%	1.734	1.202	2.502	Over
Pickup/Light Truck	186	48.9%	189	19.0%	2.579	2.189	3.040	Over
Medium Truck	6	1.6%	7	0.7%	2.247	0.760	6.642	Unsure
Heavy Truck	29	7.6%	29	2.9%	2.621	1.588	4.326	Over
Total	380	100.0%	996	100.0%	1.000			

Another factor strongly associated with truck fatalities was fire. Table 7.48 looks at fatalities in vehicles in which there was a fire. Over thirty percent of the vehicle fires occurred in heavy trucks, mostly in tractor-trailers and often following overturning or impacts with fixed objects. The table also shows that about half of the vehicle fires that occurred in non-CMV's occurred in conjunction with a CMV impact.

Table 7.48: Fatalities in Vehicles that Caught Fire

Vehicle Type	Total		Heavy Truck Involved		No Truck Involved	
	Number	Percent	Number	Percent	Number	Percent
Automobile	27	45.8%	13	33.3%	14	70.0%
Passenger Van	2	3.4%	1	2.6%	1	5.0%
Pickup/Light Truck	9	15.3%	5	12.8%	4	20.0%
Medium Truck	1	1.7%	0	0.0%	1	5.0%
Heavy Truck	19	32.2%	19	48.7%	0	0.0%
Motor Home	1	1.7%	1	2.6%	0	0.0%
Total	59	100.0%	39	100.0%	20	100.0%

Other factors that contributed to fatalities in CMV's were similar to factors contributing to fatalities in other vehicles; however, fatalities occurred at lower rates because the larger mass tended to protect more of occupants. Ten percent (72 of 717) of the occupants of heavy trucks died in the set of fatal traffic crashes. Of those who died:

- 19 (26%) were ejected,
- 19 (26%) were in vehicles that caught fire,
- 36 (50%) were in vehicles that rolled over,
- 41 (57%) were unbelted, and
- 43 (60%) were in vehicles that ran off the road.

A total of 557 of the 1106 occupants of other vehicles died in crashes in which a heavy truck was involved. These crashes involved 480 different vehicles, of which the vast majority (92 percent) were passenger vehicles (types 01 through 03). Forty percent (219) of the fatalities were using seat belts or child safety seats at the time of the crash. Table 7.49 looks at the impact point on both the CMV and the non-CMV in those impacts where at least one non-CMV occupant died. If occupants of more than one non-CMV died in the same crash, multiple records are tallied in the table below. In multi-event crashes, the impact between the CMV and the vehicle with a fatality was identified. In fewer than five percent of the crashes, the non-CMV was involved in multiple vehicle or fixed object impacts. In about four percent of the crashes, occupants died in vehicles that did not directly impact the heavy truck; in several of these, the CMV was actually a phantom/non-contact vehicle. Table 7.50 looks at the combination of impact points on both vehicles for the most common cases, and provides the most common types of crashes in which these impacts occurs.

Examining the tables, it is evident that the most common impact point on either the heavy truck or the other vehicle is the front end. Seventeen percent of the cases involved other vehicles rear-ending CMV's and another 17 percent involved CMV frontal impacts into the passenger side of the other vehicle (as in the case of the other vehicle left-turning in front of an oncoming CMV). Fourteen percent were head-to-head collisions, and twelve percent were CMV frontal impacts into the driver side of the other vehicle, again typically intersection crashes. CMV's rear ending other vehicles happened at less than half the rate of other vehicles rear-ending CMV's; however, recall that the rear vehicle is not always at fault in these types of collisions.

Of more interest in terms of vehicle design are the 88 impacts that involved the rear of the CMV trailer (18.3 percent of the impacts) and the 45 impacts that involved underriding the side of the trailer (9.4 percent of the impacts). Two-thirds of these crashes occurred during non-daylight hours, most where street lighting was present, and sixty percent involved trucks traveling at or below 20 mph at the time of the collision. Trailer underride type crashes are particularly severe because of the potential for impacts to the hood and roof of the passenger vehicle, resulting in passenger compartment deformation and intrusion.

Table 7.49: Impact Point on CMV's and Other Vehicles in Crashes with Non-CMV Fatalities

First/Most Important Impact Point		Heavy Truck		Other Vehicle	
		Number	Percent	Number	Percent
Trailer	Side (underride)	45	9.4%	N/A	0.0%
	Wheels (direct side impact)	12	2.5%	N/A	0.0%
	Rear end	88	18.3%	39	8.1%
Truck	Front end	248	51.7%	233	48.5%
	Driver side	28	5.8%	71	14.8%
	Passenger side	14	2.9%	92	19.2%
Other/Unknown		5	1.0%	5	1.0%
No contact with CMV		19	4.0%	19	4.0%
Multiple vehicle/fixed object impacts		21	4.4%	21	4.4%
Total		480	100.0%	480	100.0%

Table 7.50: Combined Impact Points and Crash Types in Crashes with Non-CMV Fatalities

Combined Impact Points	Typical Crash Type	Number	Percent
CMV rear vs. Other front	Other rear-end CMV	83	17.3%
CMV front vs. Other passenger side	Other left turn-oncoming CMV or Straight vs. straight	83	17.3%
CMV front vs. Other front	Head-on	68	14.2%
CMV front vs. Other driver side	Straight v. straight or Other left-crossing CMV	59	12.3%
CMV trailer side vs. Other front	Straight v. straight or CMV left-crossing other	40	8.3%
CMV front vs. Other rear	CMV rear-end other	38	7.9%
CMV driver side vs. Other front	Straight v. straight or Other left-crossing CMV	23	4.8%
Other	Forward impact w/control loss or Other	46	9.6%
Multiple	Forward impact w/control loss or Other	21	4.4%
No contact w/CMV	N/A	19	4.0%
Total		480	100.0%

7.11 Conclusions and Recommendations

This chapter looks at characteristics and contributing factors in crashes involving heavy trucks. Because of the skew toward heavy trucks, truck crashes make up a total of 28 percent of the crashes in the database, but they only make up 11 percent of the crashes in the year 2000, the only year in which all fatal crashes on state roads are studied. Trucks were overrepresented in multi-vehicle and multi-fatality crashes. They are overrepresented in rear end and side swipe crashes, turning/merging crashes, and crashes involving pedestrians in the road but not crossing. Truck crashes were more likely to occur on limited access facilities and on two-three lane roads than on larger non-limited access facilities. Truck crashes were overrepresented on rural roadways when compared to urban and suburban roads.

As with other types of crashes, human factors are the most common primary contributing factor in truck crashes: within that class, inattention and alcohol are most common. Roadway issues are not very common as primary contributing factors; however obstructions (typically vehicles from previous crashes) are overrepresented in truck crashes. Congestion, construction, obstructions (primarily disabled vehicles or vehicles from previous crashes), and traffic operations issues are overrepresented as secondary or tertiary contributing factors. Traffic operations issues tended to involve lack of facilities for storage or maneuvering of large trucks, including turn lanes. Smoke/fog was overrepresented as a secondary contributing factor in truck crashes, often in combination with stopped traffic due to obstructions or congestion and inattention on the part of the driver.

Trucks were at-fault in approximately 30 percent of the crashes in which they were involved. Approximately one-quarter of these crashes were rear-end, run off the road, and intersection-turning crashes, respectively. In each of these crash types, the truck was more likely than the other vehicle to be at fault. Overall, the most common factor in crashes where a truck was at fault was inattention, which was a contributing factor in over 50 percent of the crashes and the primary contributing factor in almost 40 percent of the crashes. Inattention on the part of the truck drivers contributed to over 70 percent of sideswipe crashes, 60 percent of rear-end crashes, 50 percent of head-on crashes, 43 percent of intersection-straight crashes, and 32 percent of intersection-turning crashes. Evasive maneuvers contributed to 56 percent of the head-on, 43 percent of the sideswipe, and 23 percent of the run off the road crashes in which trucks were at fault. These two factors are often interrelated, as inattention to prevailing traffic conditions often necessitated the evasive maneuver.

Another common factor among truck crashes was the "taking" of right-of-way by the CMV, by pulling out in front of another driver without sufficient gap space to complete a maneuver, or stopping with the trailer portion of the CMV blocking one or more travel lanes. This type of ROW violation could be attributed to inattention, perception errors (looked but failed to see), or decision errors (deliberate ROW violations, expecting that the other driver will see the CMV, understand that it needs more time and space to maneuver, and yield accordingly). Taking of ROW by the CMV contributed to over 70 percent of the intersection-turning crashes, 19 percent of the intersection-straight crashes, and 13 percent of the rear-end crashes in which CMV's were at fault. Other contributing factors that were common among specific types of CMV crashes were blind spot/no-zone issues, which contributed to over 70 percent of the sideswipe crashes in which CMV's were at fault, and environmental factors, which contributed to around 37 percent of head-on crashes and almost 20 percent of run off the road crashes in which trucks were at fault.

Looking at all vehicles involved in fatal crashes, it appears that trucks were more likely to have a vehicle defect other than a tire defect or another vehicle factor that contributed to the fatal crash. Other factors include low acceleration rate, a tendency to jackknife, and blind spots/no-zones. Over half of the other vehicle defects (not including tire defects) in the fatal crashes belonged to heavy trucks, even though trucks only accounted for 17 percent of the vehicles in the crashes. Vehicle defects directly contributed to over ten percent of the crashes where CMV's were at fault, especially in run off the road and head-on crashes. The most common defects involved brake failures that prevented the vehicle from making a timely stop, although steering defects and other disabling conditions also contributed to a number of fatal crashes.

Overall, CMV drivers were highly underrepresented in fault in the crashes, when compared to other (non-CMV) drivers. Truck drivers were more likely to be at-fault in turning crashes where the vehicles were initially moving in the same direction (including rear end crashes related to these maneuvers), forward impacts involving control loss, and most run off the road crashes other than left side departures without control loss. Again, looking at all drivers involved in all fatal crashes, fatigue, inattention, deliberate low speed, and medical factors were the most common among CMV drivers when compared to other drivers. On the other hand, truck drivers were very rarely under the influence of alcohol or illegal drugs. CMV drivers were more likely to have poor driving records prior to being involved in the fatal crash, and more likely to not be in compliance with restrictions on their driver licenses (e.g. to not have the commercial driver license required for operating the CMV). Truck drivers were less likely to be from the county of the crash; however, residence of the truck driver had no bearing on fault in the crash. Truck drivers aged 25 to 34 were overrepresented in fault when compared to older truck drivers. Trucks were more likely than other vehicles in the crash to be either stopped or traveling at speeds above 55 mph during the crash; truck drivers at speeds above 70 mph were more likely to be at fault in the crash, although the highest overrepresentation in fault was among truck drivers traveling between five and 19 mph. With respect to the posted speed, speeding was much less common among truck drivers than non-CMV drivers, but speeding was still correlated with fault in the fatal crashes.

In impacts involving both non-CMV's and CMV's, fatalities in the non-CMV's were much more common. Approximately 10 percent of the CMV occupants died, whereas slightly over fifty percent of the non-CMV occupants involved in crashes with heavy trucks died. Fire and rollover were strongly associated with fatalities in the CMV's themselves: 50 percent of fatalities in heavy trucks occurred in vehicles that rolled over, and 26 percent occurred in vehicles that caught fire. While most of the other vehicles hit the front of the CMV, trailer rear and side underrides accounted for almost 28 percent of the fatal impacts.

The main recommendations offered to reduce the number of truck crashes deal with either the truck drivers or the trucks themselves. Regarding the truck drivers, the problem of taking ROW from other vehicles must be addressed. One potential education issue is that truck driver probably assumes that the driver of the other vehicle sees him when he pulls out onto a road and will yield right-of-way. However, in many fatal crashes, the other driver is inattentive, speeding, or under the influence of alcohol, and as a result is unable to stop in time to prevent the crash. CMV drivers should not start a maneuver unless they have a sufficient gap in traffic to complete it safely. However, given the high number of truck crashes at intersections that involved u-turns and left turns across or onto divided highways without benefit of traffic signals, additional study of the effect of such roadway designs on large trucks should be considered. It is possible that, at certain levels of traffic volumes and in certain roadway configurations, the truck driver simply cannot make the necessary maneuver without blocking traffic or otherwise failing to yield the right-of-way.

Inattentiveness on the part of truck drivers also must be addressed. Inattentiveness was a key cause of rear-end crashes; run off the road and head-on collisions also resulted from inattentiveness coupled with evasive steering maneuvers. Many of these crashes occurred because of stopped vehicles due to congestion, construction, or previous crashes on interstates or other high speed facilities, and many were associated with adverse environmental conditions and speed too fast for conditions. Countermeasures in this area would include driver education and increased enforcement of speeding and tailgating, especially on high-speed limited access facilities. Efforts to reduce roadway obstructions, including Road Ranger patrols to assist with disabled and crashed vehicles, and attention to Maintenance of Traffic plans during construction activities, would also show benefits in reducing these types of crashes.

Other driver issues that are common among truck drivers include fatigue and medical issues. Fatigue could be a root cause of many driver behaviors that were attributed to inattentiveness as well. Fatigue in truck drivers can be addressed by closer enforcement of regulations on maximum hours of service and possibly by legislative changes in such regulations.

Regarding the severity of the crashes, the fact that almost 30 percent of the impacts involved underrides of the side or rear of the CMV trailer indicates that standards for the impact protection of the trailer might need to be revisited. However, this would depend on the current age of the vehicle fleet: because of the dates of this study, most of the trailers were built prior to the January 1998 date on which the newest standard for rear bumper underride guards came into effect. Currently, there are no requirements for side underride guards, a crash type responsible for 45 fatal crashes. Efforts to evaluate conspicuity of the trailers were hampered by the lack of information on striping presence and condition. Most traffic homicide reports did not address the issue at all. Improved reporting in this area is recommended. However, trailer impacts occurred only slightly more frequently in non-daytime hours than the average truck crash (58 percent compared to 52 percent).

Maintenance of commercial motor vehicles is an area in which improvements could be made. Increased rates of inspection for out-of-service violations, coupled with stiffer penalties on owners and commercial motor carriers who operate unsafe vehicles would decrease the rate of vehicle defects among commercial motor vehicles. Similarly, improved enforcement of commercial driver license regulations and stiffer penalties for driving offenses are also recommended. Because of the high at-fault rates among young truck drivers, improved training programs for CMV drivers are also suggested.

8 RUN OFF THE ROAD CRASHES

Fatal run off the road (ROR) crashes, including those with median crossovers and overcorrection back onto the roadway, make up a fairly large percentage, approximately 33 percent, of the total fatal crashes in the study set. To address the problem of fatal crashes involving running off the roadway, a study is undertaken here to suggest various countermeasures that could help prevent such crashes.

8.1 Background and Literature Review

ROR crashes have always been a concern in the United States of America, as they account for a large number of fatal crashes each year. As defined in this study, ROR crashes involve vehicles that leave the travel lane and encroach onto the shoulder and beyond and either overcorrects, overturn, hit one or more of any number of fixed or non-fixed objects, or otherwise result in a harmful event to the vehicle occupants or other persons. Traditionally, ROR crashes usually involve only a single vehicle, although an ROR vehicle hitting a parked vehicle could be considered as multi vehicle crash.

For the purposes of this study, a roadway is defined as that part of traffic way designed, improved and ordinarily used for motor vehicle travels. "Run off the road" crashes involve vehicles that leave the outermost travel lane and encroach onto the shoulder or into a grass median and beyond. ROR crashes typically involve impacts with one or more of any number of natural or artificial objects, such as bridge walls, embankments, guardrails, parked vehicles and trees, although the impact could be with a vehicle on another roadway or a pedestrian, or the vehicle could be tripped by soft soils or a side slope, resulting in an overturning type crash.

The National Cooperative Highway Research Program (NCHRP) has developed a number of guides relevant to ROR collisions. A multi-volume report provides guidance for implementing a strategic highway safety plan. Volume 6 of this report deals with run off the road crashes and addresses in detail the type of problems leading to run off the road crashes, and various strategies recommended for addressing ROR crashes (Neuman, 2003b). Volume 3 (Neuman, 2003a) of the same report addresses tree collisions in particular, and Volume 7 addresses issues related to roadway curvature and presented strategies to minimize collisions on horizontal curves (Neuman, 2004).

One preventative measure addressing ROR crashes are rumble strips. Rumble strips are crosswise grooves milled or pressed into the paved shoulder. Vehicles passing over shoulder rumble strip produce a sudden rumbling sound and cause the vehicle to vibrate, thereby alerting inattentive, drowsy, or sleeping drivers of encroachment on the shoulder and possibly on the roadside. Rumble strip have been used primarily on expressways and freeways, although some states have installed them on two lane rural roads with high number of single vehicle crashes. While shoulder rumble strips have been designed primarily to reduce ROR crashes, they can also reduce head on crashes. In this application, rumble strips are installed in centerline to avoid head on collisions. Previous studies have concluded that rumble strip installation on the roadway have reduced the ROR crashes by 20 to 50 percent.

Chen et al (2003) conducted a study of various types of shoulder rumble strips in use since 1993. Two major issues in the study were first, to find the optimal rumble strips design and second, to investigate effectiveness of the optimal pattern on safety and economy. It was concluded from the research that the milled rumble strip pattern produced 12 times more sound than rolled rumble strips. Analysis of 25 sites totaling 392.89 roadway miles with milled rumble strips on rural interstate in state of Virginia revealed that during the three year implementation period in Virginia every 17 miles of milled CSRS saved one life and eradicated 22 crashes.

Guardrails are widely used in all motorized countries to reduce the consequences of crashes in which vehicles run off the road or cross the median of a divided highway. The basic idea of an ideal guardrail system is one that safely redirects errant vehicles without endangering other traffic and without causing injuries or fatalities among the occupants. A study was conducted of the safety value of guardrails and crash cushions (Elvik 1994). The study addressed whether median barriers, guardrails, and crash cushions affect the probability and severity of crash occurrence using a meta analysis of the results of many different studies. It also investigated whether results of the studies varied according to study design and other variables characterizing study quality or the context where studies were conducted. A total of 32 studies, containing a total of 232 numerical estimates of the effect of median barriers, guardrails, or crash cushions on the probability and/or severity of crashes were retrieved. The meta-study concluded that median barriers increase crash rates, but reduce crash severity. Other guardrails and crash cushions are found to reduce both crash rate and crash severity. Numerical estimates of the effects of crash cushions are particularly uncertain. Based on the studies included in the meta analysis, the best current estimate of the effect of median barrier are a 30% increase in crash rate, a 20% reduction in the chance of sustaining a fatal injury. Guardrails reduce the chances of sustaining fatal injury by about 45% given that crash has occurred.

In 2001, the Florida Department of Transportation adopted a strategic objective to improve transportation safety by identifying and implementing key strategies that should reduce fatalities on Florida roadways (Stroz and Nosse, 2001). The strategic objectives focused on five areas, such as keeping vehicles in proper travel lanes and minimizing the effects of leaving the travel lane, improving the safety of intersections, improving access management and conflict point control, improving information and decision support systems, and improving pedestrian and bicycle safety. The first of these focus areas, keeping the vehicle in the proper travel lane and minimizing the effect of leaving travel lane, has recently been the focus of numerous FDOT safety projects. In District 5, for example, several district-wide studies have been recently completed and are scheduled for implementation as a result of these analyses. In the studies, various methods such as the Poisson's "rate quality control" method, which uses rate analysis at a fixed confidence level, were used to prioritize locations. Locations where ROR crashes are most likely to occur are treated with various countermeasures to prevent future crashes.

A notable study investigating rollover on side slope and ditches was conducted by the Federal Highway Administration in the state of Virginia (Viner et al, 1994). National data was analyzed to define the nature and importance of the problem of ROR vehicles that roll over on slopes and ditches. Data from two different databases were used to obtain insight on vehicle orientation and driver maneuvers in such crashes. Based on the data, ROR crashes were divided by land use and most harmful event, including slope rollover, fixed object tripped, slope no rollover, or untripped. The study also investigated the nature of slope rollover crashes according to highway and location factors. It was concluded that most slope rollover vehicles are skidding as they leave pavement. Driving too fast on curves is the predominant cause of skidding.

Freeway entrance and exit ramp interchanges and other access points on the roadway are the sites of far more crashes per mile driven then other segment of interstate highway. A study done by the Minnesota Department of Transportation found that more then 90% of crashes on access points on highways are ROR crashes (McCartt et al 2004). A similar study in northern Virginia examined the type and characteristics of ramp-related motor vehicle crashes on urban interstate roadways. This study examined a sample of 1150 crashes that occurred on heavily traveled urban interstate ramps in northern Virginia. Based on the reviews of diagrams and narratives descriptions from police crash reports, the most common crash type were identified and examined for different roadway locations and ramp designs and by whether at fault drivers were entering or exiting the freeways. From the study it was concluded that about half of all the crashes occurred when at fault drivers were in process of exiting the interstate, 36% occurred when drivers were entering, and 16% occurred at the mid point of access roads or on ramps connecting two interstate freeways. The three major crash types—ROR, rear end and sideswipe crashes—accounted for 95% of the crashes. ROR crashes, which were the most common type of crash on ramps, frequently occurred when vehicles were exiting the interstate at night, in bad weather, or on curved portions of ramps.

Although not used in this study, a number of national databases of crash data exist. One such database is the Fatality Analysis Reporting System (FARS). The FARS database contains data from the state crash reports for all fatal crashes occurring in United States. The data is generally tabular in nature and consist of coded elements describing the crash, vehicle and drivers data. NHTSA decided in 1996 to make FARS data easier to obtain by using Internet technology. This FARS (Fatality Analysis Reporting System) Web-Based Encyclopedia offers a more intuitive and powerful approach for retrieving fatal crash information. As FARS maintains all the national data this database can be used to compare the national statistics with state data. All the national data is available on web site http://www-fars.nhtsa.dot.gov/main.cfm .

A similar national database known as the National Automotive Sampling System (NASS) provides nationally representative data on fatal and nonfatal motor vehicle traffic crashes. The goal of the NASS program is to obtain a better understanding of the vehicle-trauma experience and to determine the national crash trend experience, consequently formulating the foundation for a comprehensive understanding of both the relationship between vehicle crash severity and occupant injury, and the scope of the highway safety problem. Where as FARS data is primarily coded fields from state crash reports, the NASS data is much more broad information collected in a case study manner. Highly specialized NASS researchers under contract to the agency collect data at the crash scene, inspect the vehicle(s) for specific damage and countermeasure performance, identify injuries from hospital or other medical records, and determine causes of injury. All the national data are online and can be used by visiting the web site http://www-nrd.nhtsa.dot.gov/departments/nrd-01/summaries/NASS_98.html.

8.2 Methodology

The overall study has been undertaken in view of 1) minimizing the number of vehicles leaving the roadway and 2) minimizing the consequence of leaving the roadway. The study examined ROR crashes by number of factors including crash type, vehicle and posted speed, driver's age, etc. The main idea behind the objective of the study undertaken was to suggest measures to reduce the number of road fatalities so as to:

- Keep vehicles from encroaching on the roadside,
- Minimize the likelihood of crashing or overturning if the vehicle travels off the shoulder, and
- Reduce the severity of crashes that occur.

The first objective addresses driver behavior; however, there are other strategies for fulfilling this objective that target highway design features that could contribute to crash (e.g., shoulder drop offs and pavement with low skid resistance). The second objective employs strategies that focus on the highways, with more concentration devoted to non-freeway facilities, especially to higher speed rural roads. Facilities such as freeways have fairly wide shoulders and more forgiving, wider clear zones. Features within the clear zone are shielded from traffic by barriers and crash attenuation devices. On the other hand, there is an extensive system of mostly two lane rural high-speed roadways that do not have these features. Crash data analysis shows that this rural two-lane system is particularly vulnerable to ROR crashes and should be targeted for appropriate measures. Some of the same strategies appropriate for these two lane, rural, high-speed roads can also be implemented on suburban and urban streets and on freeways. Vehicle design, restraint features and usages, and design of roadside features and roadside geometry are all valid target for the third objective, reducing the severity of ROR crashes.

Keeping the above objectives in mind, the area of study was confined to ROR crashes in the state of Florida. As case reviews showed that a large number of crashes involved overcorrection by the driver after encroaching on the shoulder, these crashes were also included in the set of ROR crashes, including those resulting in a vehicle-vehicle impact after the overcorrection. ROR crashes were categorized according to direction of departure, loss of control, and outcome. Various roadway parameters such as distance of the fixed object from the roadway, presence of rumble strips, geographic location, and facility type were recorded. Roadway and traffic operations issues, such as involvement of access points, sight distance issues, and presence of roadway curvature, construction, congestion, and/or obstructions, were also noted. As most of the ROR crashes had driver behavior as a major factor, driver error and demographic characteristics were studied for the ROR crashes. Various driver behaviors like inattention/distraction (emotional stress, external/internal distraction), perceptual errors, decision errors, vehicle speed, etc. were looked for in the ROR crashes. Various environmental conditions like rain, fog, darkness, and other visibility issues were noted during the study. An in-depth study of ROR crashes where the vehicle failed to negotiate the curve was done to find the causes of crashes on the curvature.

8.3 Case Studies

All the crashes were reviewed based on the data obtained from the available sources. Video log was the most important tool used for the review of the crashes. The main idea in conducting a case study is to:

- Illustrate the case review techniques
- Determine in qualitative manner, additional factors that contributed to crash
- Focus on roadway contributing factors

- Recommend countermeasures where necessary

To illustrate the results obtained and methodology adopted to review the crashes, a case study is shown. The case study is a multiple fatality crash with roadway curvature and is classified as failed to negotiate curve. In this crash, V1 entered a curve, D1 lost control, and V1 crossed the median and hit an oncoming vehicle. Roadway characteristics were as follows:

- Video log showed good roadway surface but no rumble strips on shoulder
- There is very little drainage on the roadside which resulted in standing water on the roadway.
- Drag factor 0.72
- Radius of curvature 501.25 feet
- Posted speed 65 mph with advance warning sign for road curve

Critical speed calculations are as follows:

$$R = 501.25$$

$$e = 1.0$$

$$f = 0.13$$

$$R = \frac{V^2}{15(e + f)}$$

$$V = 92.17mph$$

Where:

R = radius of curvature

e = superelevation

f = coefficient of friction

V = critical speed

Human characteristics were as follows:

- D1 age 25
- D1 not wearing safety belt
- V1 speed 55 mph

Environmental contributing factors:

- Rain prior to crash
- Standing water in outside lane

It was concluded that the primary contributing factor was improper drainage, resulting in standing water in the outside lane, which caused the vehicle to hydroplane. Figure 8.1 and Figure 8.2 illustrate the circumstances of the crash.

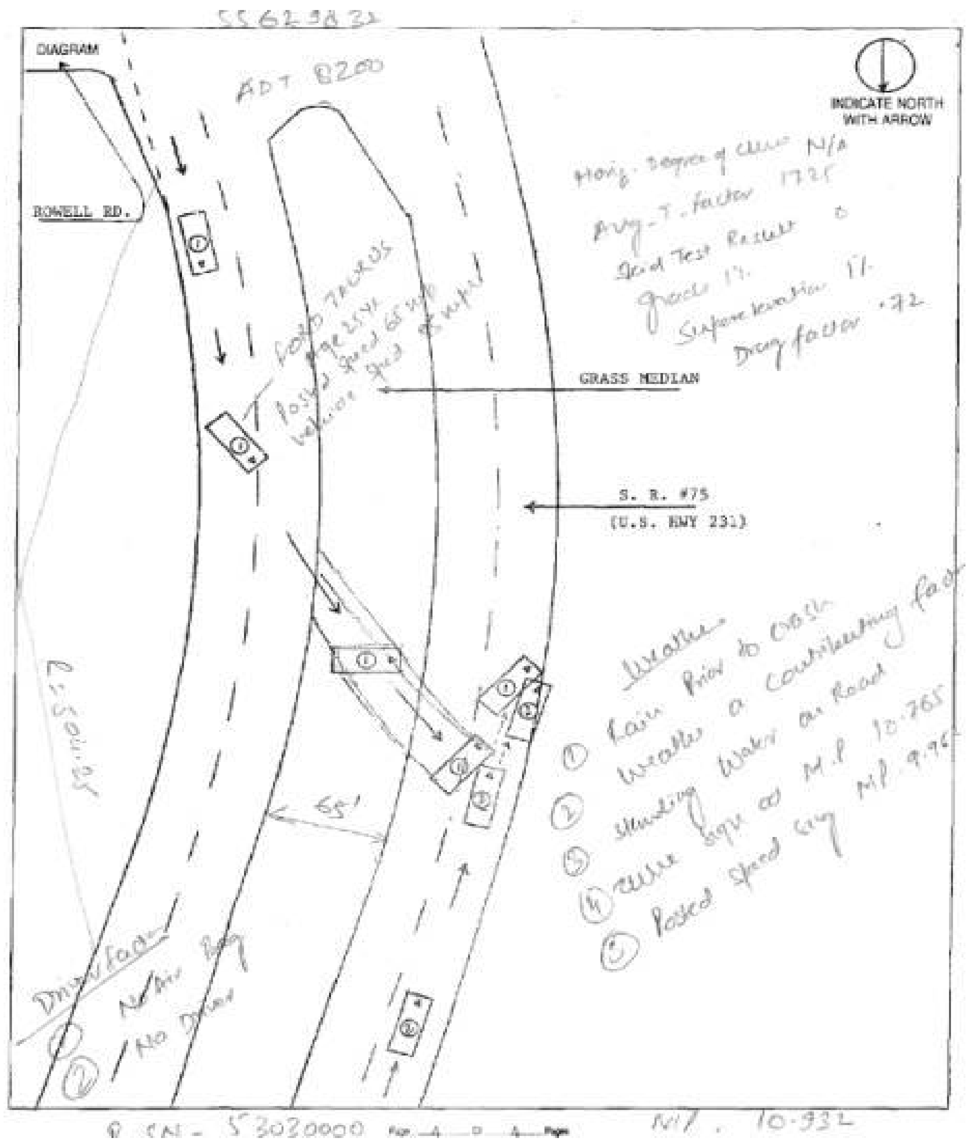

Figure 8.1: Reconstruction Diagram for Case Study

8.4 Data Set

Table 8.1 and Table 8.2 show the distribution of ROR crashes by year and type. Table 8.1 looks only at primary ROR crashes, those where leaving the roadway was the first event in the crash, followed by any number of events including fixed object impacts, overcorrection, and/or other events. Table 8.2 also shows the number of secondary ROR crashes, those in which one or more vehicles left the roadway after another event, including impact with another vehicle, a pedestrian, and/or an obstruction in the roadway. As shown in Table 8.2, another 15 percent of the crashes involved running off the road as a secondary event. These crashes, because they are not primary ROR crashes, are considered only in certain parts of the study where crash outcomes are investigated.

Figure 8.2: Video Log Image for Case Study

Table 8.1: Fatal ROR Crashes by Crash Year

	1998 (Heavy Trucks)	1999 (Heavy Trucks)	2000 (All Cases)	Total
No. of ROR Crashes	41	39	598	678
No. of ROR Vehicles	41	41	604	686

Table 8.2: Distribution of Primary and Secondary Fatal ROR Crashes

Crash Type	Sub Type	Number	Percent
Run Off Road Crashes	Primary	678	32.60%
	Secondary	322	15.48%
Other		1080	51.92%
Total Fatal Crashes		2080	100.00%

Table 8.3 looks at the primary crash types of fatal ROR crashes, according to the coding scheme described in Chapter 4. Approximately 50 percent of the ROR crashes involved a departure to the right of a mainline road, with about one-third of those involving a loss of control or loss of lateral stability. Another 45 percent of the crashes involved a left roadside departure from the mainline, with slightly over half involving a control loss. About five percent involved departing a ramp, and less than one percent involved running straight off the end of the road.

Table 8.3: Primary Crash Type of ROR Crashes

Crash Type Code	Crash Type	Number	Percent
20	Right side departure	228	33.7%
21	Right side departure w/control loss	109	16.0%
22	Left side departure	142	20.9%
23	Left side departure w/control loss	162	24.0%
24	Straight/End of pavement	5	0.7%
25	Ramp departure	32	4.7%
	Total	678	100.0%

Table 8.4 examines both the primary and secondary crash type of ROR crashes. It is apparent from the chart that the majority of the ROR crashes had no second crash type code. Those with significant number of occurrences include head-on collisions after left side departures (3.5%) and left side departures with control loss (6.5%). Head-on crashes following right roadside departures typically involved overcorrection back across the roadway into the opposing travel lanes.

Table 8.4: Primary and Secondary Crash Type of ROR Crashes

Primary Crash Type	Secondary Crash Type	Number	Percent
Right side departure	No second code	175	25.8%
	Pedestrian	14	2.1%
	Rear impact	20	2.9%
	Sideswipe	2	0.3%
	Head-on	14	2.1%
	Turning/evasive	3	0.4%
Right side w/control loss	No second code	91	13.4%
	Pedestrian	3	0.4%
	Rear impact	5	0.7%
	Sideswipe	2	0.3%
	Head-on	0	0.0%
	Turning/evasive	8	1.2%
Left side departure	No second code	101	14.9%
	Pedestrian	4	0.6%
	Rear impact	5	0.7%
	Sideswipe	7	1.0%
	Head-on	24	3.5%
	Turning/evasive	1	0.1%

Table 8.4: Primary and Secondary Crash Type of ROR Crashes, continued

Primary Crash Type	Secondary Crash Type	Number	Percent
Left side w/control loss	No second code	110	16.2%
	Pedestrian	1	0.1%
	Rear impact	3	0.4%
	Sideswipe	0	0.0%
	Head-on	44	6.5%
	Turning/evasive	4	0.6%
Straight/end of pavement		5	0.7%
Ramp departure	No second code	28	4.1%
	Sideswipe	3	0.4%
	Head-on	1	0.1%
Total		678	100.0%

The investigating agency is responsible for the investigating the crashes; the source of over 80 percent of the ROR crashes were investigated by Florida Highway Patrol. For crashes investigated by the Florida Highway Patrol, traffic homicide reports were obtained, which are the most complete source of information on the crash. Therefore, the data used for the study of run off road crashes can be considered good and complete. For other crash reports obtained from Sheriff's offices and city police department, efforts were made to obtain the traffic homicide report but very few reports were obtained. Other source like RCI and video logs were viewed to obtain as much information related to the crash as possible.

Table 8.5: Distribution of ROR Crashes by Investigating Agency

Investigating Agency	Number	Percent
Florida Highway Patrol	553	81.56%
City Police Department	88	12.98%
Sheriff's Office	37	5.46%
Total	678	100.00%

Table 8.6 shows the distribution of ROR crashes by county. This information gives us an idea where most of the run off road crashes occurred. This is important to know as Florida is a large state where a large number of people travel year-round because of tourism, and therefore there are certain area like beaches and big cities where the traffic volume is very high. Counties like Hillsborough, Duval, Orange, Broward, and Dade have the highest number of ROR crashes. Each of these counties has more then 5% of the ROR crashes with Broward counties at the top with almost 11% of the crashes. All these counties are located on the southern coastal areas of the state of Florida where traffic volume round the year is heavy. However, looking at the overrepresentation factor, one can see that a number of more rural counties with smaller

populations are overrepresented in ROR crashes. Collier, Holmes, Jefferson, and Indian River counties have the highest overrepresentation factor, indicating the highest ratio of ROR crash involvement to other crash involvement. These counties have relatively few crashes, but high concentrations of ROR crashes, especially on stretches of rural interstates running through the counties. Combining both pieces of information, the highest gains from reducing the rate of ROR crashes to the rate of other crashes in the county would come from ROR crash reductions in Collier, Broward, and Indian River counties. Figure 8.3 shows all of the ROR crashes plotted by their location of crash using GIS, and Figure 8.4 shows the distribution of ROR crashes by counties. All the counties with very high concentration of crashes can be seen in Figure 8.4.

Table 8.6: Distribution of ROR and No ROR crashes by County

County	ROR	% ROR	No ROR	% No ROR	ORF	Max Gain
Charlotte	4	0.59%	24	1.71%	**0.345**	N/A
Citrus	5	0.74%	11	0.78%	**0.940**	N/A
Collier	27	3.98%	14	1.00%	**3.988**	**20**
Desoto	3	0.44%	7	0.50%	**0.886**	N/A
Glades	0	0.00%	7	0.50%	**0.000**	N/A
Hardee	3	0.44%	5	0.36%	**1.241**	1
Hendry	1	0.15%	2	0.14%	**1.034**	0
Hernando	5	0.74%	7	0.50%	**1.477**	2
Highlands	5	0.74%	18	1.28%	**0.574**	N/A
Hillsborough	37	5.46%	99	7.06%	**0.773**	N/A
Lake	13	1.92%	24	1.71%	**1.120**	1
Lee	16	2.36%	40	2.85%	**0.827**	N/A
Manatee	9	1.33%	32	2.28%	**0.582**	N/A
Pasco	15	2.21%	40	2.85%	**0.775**	N/A
Pinellas	16	2.36%	65	4.64%	**0.509**	N/A
Polk	23	3.39%	87	6.21%	**0.547**	N/A
Sarasota	14	2.06%	24	1.71%	**1.206**	2
Sumter	9	1.33%	15	1.07%	**1.241**	2
Alachua	15	2.21%	24	1.71%	**1.292**	3
Baker	3	0.44%	6	0.43%	**1.034**	0
Bradford	5	0.74%	8	0.57%	**1.292**	1
Columbia	7	1.03%	11	0.78%	**1.316**	2
Dixie	0	0.00%	4	0.29%	**0.000**	N/A
Gilchrist	1	0.15%	2	0.14%	**1.034**	0
Hamilton	1	0.15%	3	0.21%	**0.689**	N/A
Lafayette	0	0.00%	2	0.14%	**0.000**	N/A
Levy	3	0.44%	13	0.93%	**0.477**	N/A
Madison	3	0.44%	6	0.43%	**1.034**	0
Marion	7	1.03%	27	1.93%	**0.536**	N/A

Table 8.6: Distribution of ROR and No ROR crashes by County, continued

County	ROR	% ROR	No ROR	% No ROR	ORF	Max Gain
Suwannee	1	0.15%	7	0.50%	**0.295**	N/A
Taylor	4	0.59%	7	0.50%	**1.182**	1
Union	0	0.00%	2	0.14%	**0.000**	N/A
Bay	5	0.74%	15	1.07%	**0.689**	N/A
Calhoun	3	0.44%	4	0.29%	**1.551**	1
Escambia	7	1.03%	26	1.85%	**0.557**	N/A
Franklin	3	0.44%	2	0.14%	**3.102**	2
Gadsden	1	0.15%	7	0.50%	**0.295**	N/A
Gulf	1	0.15%	1	0.07%	**2.068**	1
Holmes	5	0.74%	1	0.07%	**10.339**	5
Jackson	4	0.59%	11	0.78%	**0.752**	N/A
Jefferson	8	1.18%	2	0.14%	**8.271**	7
Leon	14	2.06%	16	1.14%	**1.809**	6
Liberty	0	0.00%	0	0.00%	**N/A**	N/A
Okaloosa	6	0.88%	15	1.07%	**0.827**	N/A
Santa Rosa	8	1.18%	5	0.36%	**3.309**	6
Wakulla	3	0.44%	5	0.36%	**1.241**	1
Walton	7	1.03%	6	0.43%	**2.412**	4
Washington	1	0.15%	4	0.29%	**0.517**	N/A
Brevard	26	3.83%	36	2.57%	**1.493**	**9**
Clay	2	0.29%	10	0.71%	**0.414**	N/A
Duval	34	5.01%	51	3.64%	**1.379**	**9**
Flagler	4	0.59%	6	0.43%	**1.379**	1
Nassau	7	1.03%	9	0.64%	**1.608**	3
Orange	34	5.01%	53	3.78%	**1.327**	**8**
Putnam	3	0.44%	11	0.78%	**0.564**	N/A
Seminole	4	0.59%	20	1.43%	**0.414**	N/A
St. Johns	13	1.92%	16	1.14%	**1.680**	5
Volusia	14	2.06%	43	3.07%	**0.673**	N/A
Broward	74	10.91%	100	7.13%	**1.530**	**26**
Dade	43	6.34%	140	9.99%	**0.635**	N/A
Indian River	14	2.06%	5	0.36%	**5.790**	**12**
Martin	15	2.21%	15	1.07%	**2.068**	**8**
Monroe	5	0.74%	19	1.36%	**0.544**	N/A
Okeechobee	6	0.88%	6	0.43%	**2.068**	3
Osceola	10	1.47%	22	1.57%	**0.940**	N/A
Palm Beach	31	4.57%	67	4.78%	**0.957**	N/A
St. Lucie	8	1.18%	10	0.71%	**1.654**	3
Total	678		1402			

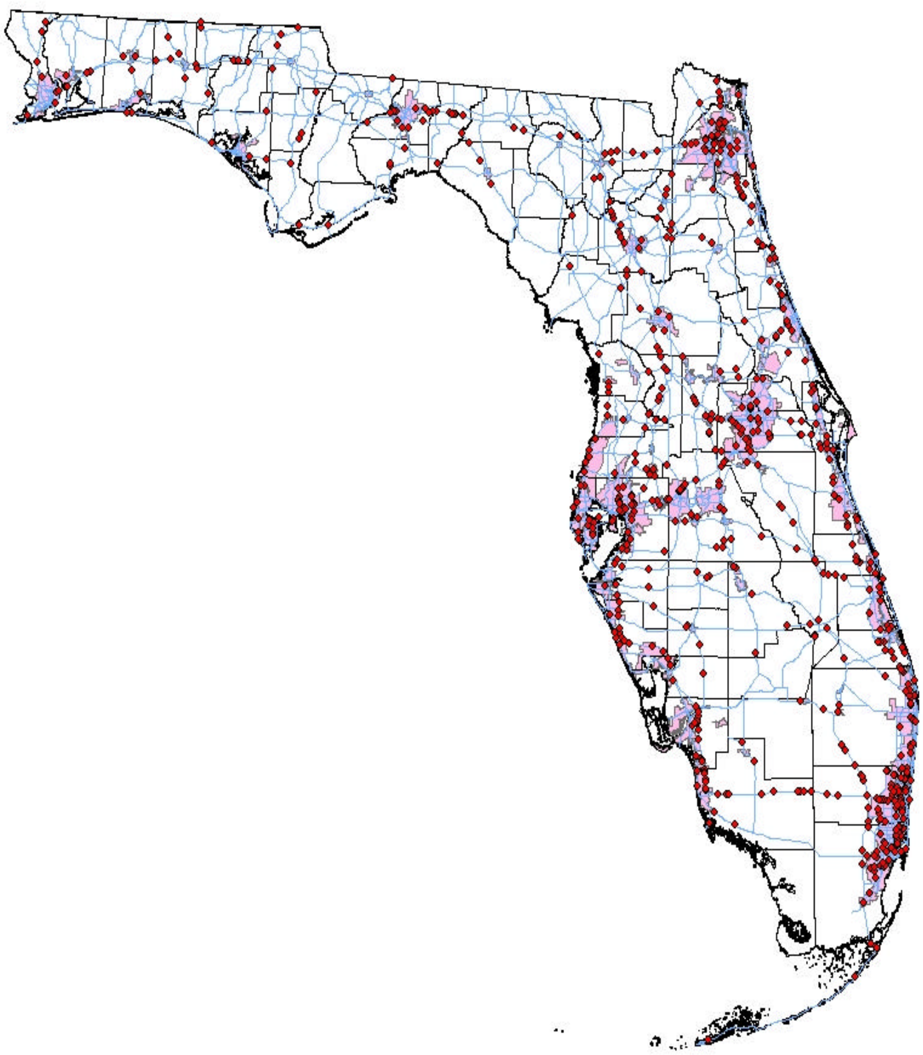

Figure 8.3: ROR Crashes in Florida

Table 8.7 gives the distribution of run off road and non-run off road crashes by geographic location. This was important to know because roadway characteristic typically change from rural to urban locations. Table 8.7 shows that ROR crashes are overrepresented on rural roads, although not quite by a factor of 1.5, and underrepresented on suburban roads. Run off road crashes by crash location has been examined in more detail in the section on roadway characteristics.

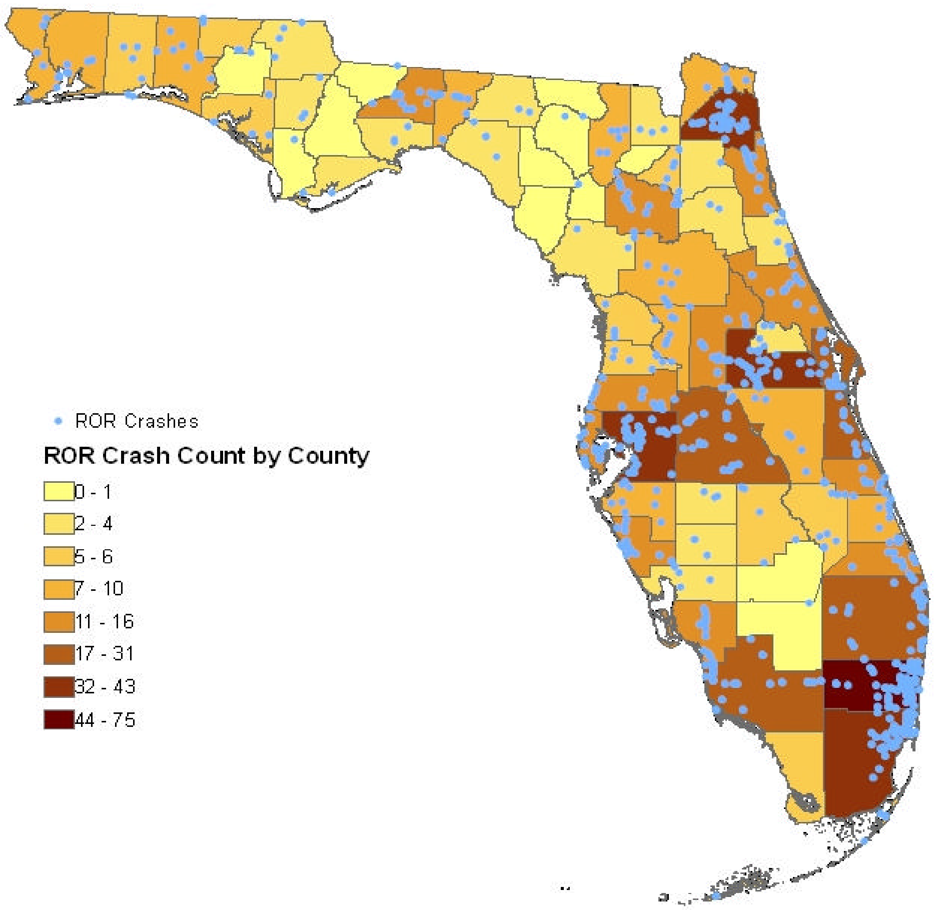

Figure 8.4: Distribution of ROR Crashes by County

Table 8.7: Distribution of ROR Crashes by Geographic Location

	Rural	**Urban**	**Suburban**	**Unknown**
ROR Crashes	328	251	98	1
Non- ROR Crashes	465	540	389	8
Over-representation Factor	1.459	0.961	**0.521**	**0.258**
Min CI	1.346	0.843	0.458	0.054
Max CI	1.718	1.089	0.667	2.159
Level	Over	Unsure	Under	Unsure

The distribution of ROR crashes by month of the year is shown in Table 8.8. While just looking at the distribution of ROR crashes shows a great variation in the rate of ROR throughout the year, with May having almost twice the number of ROR crashes as February, the overrepresentation factors show that February is the only month in which ROR crashes are highly underrepresented, and that there are no months in which ROR crashes are highly overrepresented. However, Figure 8.5 does show a marked decrease in representation of ROR crashes in the months of January, February, and, March, where there are higher rates of non-run off the road crashes as compared to run off road crashes. One potential reason for this is that many non-residents visit the state during those months, especially older drivers from northern regions of the country. As shown in Chapters 9.8 and 13.6, older drivers are more likely to be involved in intersection crashes and less likely to be involved in primary ROR crashes. The highest rates of intersection crashes, crashes involving older drivers, and crashes involving non-residents occur during February and March, when the rates of ROR crashes are the lowest.

Table 8.8: Distribution of ROR Crashes by Month of Year

Month	ROR		Non-ROR		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Jan	51	7.5%	128	9.1%	**0.824**	0.603	1.125	Unsure
Feb	44	6.5%	139	9.9%	**0.655**	0.472	0.907	Under
Mar	56	8.3%	153	10.9%	**0.757**	0.565	1.014	Unsure
Apr	65	9.6%	118	8.4%	**1.139**	0.854	1.520	Unsure
May	81	12.0%	130	9.3%	**1.288**	0.992	1.674	Unsure
Jun	56	8.3%	89	6.4%	**1.301**	0.943	1.794	Unsure
Jul	49	7.2%	89	6.4%	**1.138**	0.813	1.594	Unsure
Aug	55	8.1%	122	8.7%	**0.932**	0.687	1.264	Unsure
Sep	51	7.5%	97	6.9%	**1.087**	0.784	1.507	Unsure
Oct	58	8.6%	114	8.1%	**1.052**	0.777	1.424	Unsure
Nov	45	6.6%	104	7.4%	**0.895**	0.638	1.254	Unsure
Dec	67	9.9%	119	8.5%	**1.164**	0.876	1.548	Unsure
Total	678	100.0%	1402	100.0%	**1**			

Table 8.9 shows the number of vehicles involved in the ROR crashes. The data set shows that over 70 percent of the crashes involved only single vehicle and all other run off road crashes involved multiple vehicles. Multi-vehicle run off road crashes include those where the second vehicle was on the shoulder, those where the vehicle crossed a grass median to impact an oncoming vehicle, and those where the vehicle overcorrected back onto the road resulting in a vehicle-vehicle impact. Table 8.9 shows a small number of crashes involving four or more vehicles; these are multi-vehicle pile up crashes, typically on rural interstate highways. Most of the two vehicle crashes are crashes where vehicle crossed the grass median and hit an oncoming vehicle or, after overcorrection, hit a vehicle moving in the same direction.

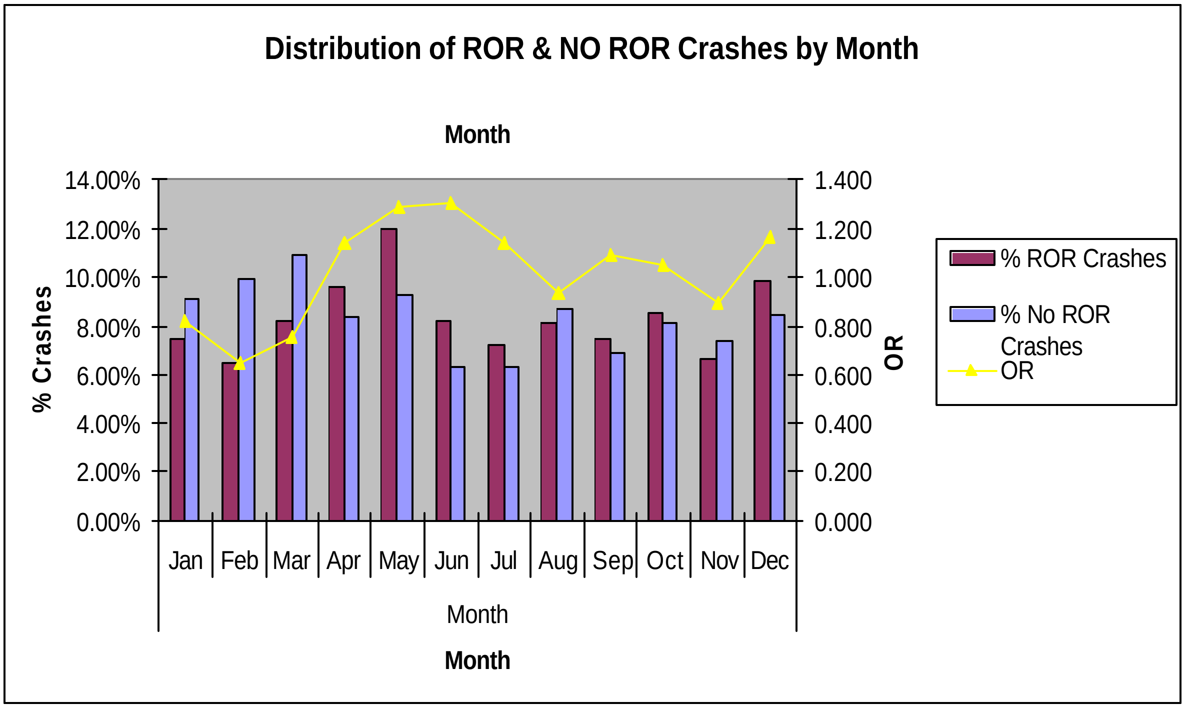

Figure 8.5: Distribution of ROR Crashes by Month

Table 8.9: Distribution of ROR Crashes by Number of Vehicles Involved

ROR Crashes	Number of Vehicles							
	1	2	3	4	5	6	10	Total
Number	478	113	59	16	7	4	1	678
Percent	70.50%	16.67%	8.70%	2.36%	1.03%	0.59%	0.15%	100.00%

Table 8.10 shows direction in which the vehicles initially ran off the road. This distribution is helpful in knowing other trends in crashes like fixed objects, overcorrection and other roadway related issues, which are discussed in detail later in the report. Table 8.10 shows that vehicles ran off the road to the right and left in fairly equal proportions. Running straight off the road, as in at the end of the pavement at a T-intersection, was much less common. Note that the total number of vehicles that ran off the road is slightly higher than the total number of ROR crashes because, in a few cases, two or more vehicles left the roadway during the same crash without first impacting a pedestrian, obstruction, or another vehicle; that is, the crash consisted of two or more separate primary ROR events.

Table 8.10: Distribution of ROR Vehicles by ROR Direction

ROR Direction	Number	Percent
Right	353	51.46%
Left	326	47.52%
Straight	7	1.02%
Total	686	100.00%

8.5 Crash Contributing Factors

This section of the report looks at the combination of internal or external factors that were deemed to have contributed to the ROR crashes. Numerous factors contributing to the occurrence of run off road crashes were identified from the information provided by the crash report and traffic homicide report, as well as other sources of information. As with other types of crashes, four important classes of crash contributing factors were identified for the study of ROR crashes: Human, Environment, Vehicle, and Roadway. These contributing factors are prioritized as primary, secondary and tertiary contributors to the crash. Primary crash contributing factors are the primary reason that the crash occurred. Secondary and tertiary crash contributing factor are those factors that additionally contributed or might have contributed to the crashes; however, without the primary factor, the crash usually would not have taken place. Table 8.11 shows that human factors make up the highest percentage of the crash contributing factors in ROR crashes. Human factors make up almost 87 percent of the primary crash contributing factors. This figure is not surprising, as most crashes would not occur without some human error; however, the idea is to look into the other crash contributing factors including roadway, vehicle and environmental factors. Indeed, human factors make up fewer than half of the tertiary contributing factors, and roadway factors make up over 27 percent of the tertiary factors. Note that about one-third of the crashes have no secondary factor identified, and two-thirds have no tertiary factor.

Table 8.11: Distribution of ROR Crashes by Contributing Factor Classes

Factor Class	Sub Class	Number	Percent
Primary	Human	588	86.73%
	Environment	17	2.51%
	Vehicle	50	7.37%
	Roadway	23	3.39%
	Total	678	100.00%
Secondary	Human	351	76.14%
	Environment	34	7.38%
	Vehicle	25	5.42%
	Roadway	51	11.06%
	Total	461	100.00%

Table 8.11: Distribution of ROR Crashes by Contributing Factor Classes, continued

Factor Class	Sub Class	Number	Percent
Tertiary	Human	107	48.42%
	Environment	42	19.00%
	Vehicle	12	5.43%
	Roadway	60	27.15%
	Total	221	100.00%

Table 8.12 shows the entire set of crash contributing factors considered in the study. As has been discussed above, the human factors contribute the highest percentage of all the crash contributing factors. From the table, a general trend of alcohol/drug use as the most common human contributing factor can be seen. In a small number of crashes where alcohol was involved, the BAC% was below the legal limit in the State of Florida of 0.08%. In such cases it is difficult to ascertain if alcohol has really been a primary factor in such crashes. In such cases, other contributing factors become very important in establishing the real contributing factor behind the crash. The degree of alcohol use in ROR crashes is discussed in more detail below. Speed also appears as a major issue; again, there are many other factors associated with speed, including alcohol/drug use, mental state, aggression and other related factors. This is why speed is often seen as a secondary contributing factor, with one of the related factors identified as the primary contributor. When grouped together, speed is almost as common as alcohol/drug use, each occurring in 35 to 40 percent of the cases. Abrupt steering input, due to overcorrection after leaving the roadway, evasive maneuvers, or other driver actions, occurred in 32 percent of the cases, primarily as a secondary or tertiary factor.

The most common environmental factor in the ROR crashes was wet or slippery roads, which occurred in 78 of the ROR crashes, less than 12 percent. (Wet roads have been defined to be an environmental factor, generally related to rain, while standing water on roads generally is a drainage or maintenance issue, thus is classified as a roadway factor.) The most common vehicle factor was a tire blowout/tread separation, which was a contributing factor in 50 cases and the primary factor in 41 cases (six percent).

The most common roadway factor identified in the fatal ROR crashes was roadway curvature, followed by presence of an access point. Each of these occurred in less than seven percent of the cases. As stated previously, the statement that curvature or access points contributed to the crash does not indicate that the roadway design is poor or insufficient in any way. It merely indicates that the roadway feature was involved in and contributed to the crash, in the opinion of the case reviewer. Access points were typically involved when a merging or turning vehicle either ran off the road or contributed to another vehicle running off the road. Curvature was mentioned when a vehicle failed to negotiate the curve. However, curvature shows up most frequently as a tertiary factor because drivers who failed to negotiate the curve were typically speeding and/or under the influence of alcohol or drugs, or the road surface was wet due to rain.

While human, vehicle, and environmental factors are temporal and exist only at the time of the crash, roadway factors, if present, certainly need to be corrected because they are, for the most part, constantly present and potential crash contributors in the future. As roadway issues need in depth study, a large number of roadway-related issues are examined in more detail in subsequent parts of this chapter, including roadway curvature, fixed objects on roadside, usefulness of guardrails and attenuators, change in roadway geometry, presence of rumble strips, and other issues.

Table 8.12: Distribution of ROR Crashes by Crash Contributing Factors

Class	Factor	Primary	Secondary	Tertiary	Total
Human	Alcohol	182	10	3	195
	Drugs	31	10	2	43
	Confusion	2	4	0	6
	Police Pursuit	2	2	1	5
	Aggression	11	5	1	17
	Decision Error	12	12	4	28
	Distraction	11	4	1	16
	Medical	25	7	0	32
	Alcohol and Drugs	26	0	0	26
	Abrupt Steering Input	57	106	53	216
	Inattention	39	44	13	96
	Fatigue/Asleep	38	5	2	45
	Speed	95	131	17	243
	Age	0	7	5	12
	Inexperience	1	2	3	6
	Mental/Emotional	1	8	0	9
Environment	Smoke/Fog	1	2	3	6
	Dark	0	1	7	8
	Wind	1	0	0	1
	Wet/Slippery	15	32	31	78
Vehicle	Defect	6	0	0	6
	Disabled	0	6	5	11
	Stability	0	4	0	4
	Trailer	0	2	1	3
	Jackknifed	0	2	1	3
	Load shift/Fall	3	1	2	6
	Tire	41	8	1	50
Roadway	Lighting	0	0	2	2
	Congestion	1	3	6	10
	Obstruction	3	3	0	6
	Access Point	9	14	16	39
	Construction	1	6	3	10
	Shoulder	0	0	4	4

Table 8.12: Distribution of ROR Crashes by Crash Contributing Factors, continued

Class	Factor	Primary	Secondary	Tertiary	Total
Roadway	Transition	0	0	1	1
	Curvature	3	14	29	46
	Standing Water	5	4	2	11
	Maintenance	0	4	0	4
	Obstructed View	0	1	0	1
	Sight Distance	1	0	1	2
Unknown		55	0	0	55

Primary crash contributing factor were examined according to the drivers' ages. As human factors contribute the most in the crashes, the idea was to see whether the age of the driver involved in the ROR crash has some relation to the primary factor contributing to the crash. Table 8.13 shows that younger driver make up the highest percentage of crashes where alcohol/drug use, abrupt steering input, and speed are the primary crash contributing factors, but for the drivers of age 45 and above, the number is quite substantial as well. Table shows an increase in medical issues as a crash-contributing factor where drivers of age 65 and above are involved. To properly evaluate this information, one must consider the ages of drivers involved in ROR and other crashes. For additional information, refer to Table 1.4.1, which shows that around 50 percent of ROR crashes involved drivers between 15 to 35 years old, and more than 27% of the crashes involved drivers between 15 and 25 years old.

Table 8.13: Distribution of Primary Crash Contributing Factor by ROR Driver's Age

Factor Class	Factor Detail	Driver Age					
		15-24	25-34	35-44	45-54	55-64	>65
Human	Confusion	0	1	1	0	0	0
	Police Pursuit	1	0	1	0	0	0
	Aggression	6	3	2	0	0	0
	Decision Error	2	3	2	0	1	2
	Distraction	2	1	3	2	1	1
	Medical	1	0	5	5	2	12
	Alcohol and/or Drug	56	71	56	35	9	7
	Steering Input	18	9	10	7	9	4
	Inattention	12	7	5	7	4	5
	Fatigue/Asleep	10	9	6	6	3	4
	Speed	45	21	13	8	4	7
	Age	0	0	0	0	0	0
	Inexperience	1	0	0	0	0	0
	Mental/Emotional	1	0	0	0	0	0

Table 8.13: Distribution of Primary Crash Contributing Factor by ROR Driver's Age, continued

Factor Class	Factor Detail	Driver Age					
		15-24	25-34	35-44	45-54	55-64	>65
Environment	Fog	0	0	0	0	0	1
	Lighting	0	0	0	0	0	0
	Dark	0	0	0	0	0	0
	Wind	0	0	0	0	1	0
	Wet/Slippery	5	3	5	1	0	1
Vehicle	Defect	2	1	1	1	0	1
	Disabled	0	0	0	0	0	0
	Stability	0	0	0	0	0	0
	Trailer	0	0	0	0	0	0
	Jackknifed	0	0	0	0	0	0
	Load shift/Fall	1	1	2	0	0	1
	Tire	13	9	8	5	2	4
Roadway	Congestion	0	0	0	0	1	0
	Obstruction	0	1	1	0	1	0
	Access Point	3	1	2	1	1	1
	Construction	0	0	1	0	0	0
	Shoulder	0	0	0	0	0	0
	Transition	0	0	0	0	0	0
	Curvature	0	1	0	0	2	0
	Standing Water	2	2	0	1	0	0
	Maintenance	0	0	0	0	0	0
	Obstructed View	0	0	0	0	0	0
	Sight Distance	0	0	1	0	0	0
Unknown		11	10	5	7	13	7

8.6 Driver Characteristics

In the study, it has been found that driver behavior caused or contributed to at least 85 percent of the crashes investigated. Various driver characteristics have been considered to find out about the driver as a factor in ROR crashes. The main idea behind identifying the driver behaviors that led to collisions between passenger vehicles and large trucks or other vehicles is to develop counter measures to further reduce the incidence and severity of these crashes. It is expected that countermeasures addressing driver behavior will primarily be educational or enforcement in nature.

Table 8.14 examines fault in the ROR crashes. As evident from the table, almost all of the drivers who ran off the road were found to be at fault in the resulting crashes. Those who were not found at fault typically ran off the road to avoid a vehicle turning or merging into their path with insufficient headway; these vehicles were often phantom vehicles. In one case, the

CMV trailing the ROR driver was found to be at fault for following too closely, thereby not allowing the overcorrecting driver to regain control of his vehicle. A few cases of dual fault were noted, including a case where a phantom vehicle ran a red light causing a drunk driver to run off the road, and a case where two vehicles were racing, causing one to run off the road. Because of the high rate of fault in the ROR drivers, all other charts that examine ROR drivers are basically identical to charts examining at-fault drivers in ROR crashes.

Table 8.14: Fault in ROR Crashes

At Fault	Number	Percent
Yes	663	96.4%
No	25	3.6%
Total	688	100.0%

Table 8.15 examines the age of drivers who ran off the road. It shows that drivers aged 15 to 24 are highly overrepresented in ROR crashes. Overrepresentation in ROR crashes generally decreases as drivers get older. Although few of these numbers are at significant levels, note that the maximum confidence intervals for drivers in the age groups of 35-44, 55-64, and 65-74 are only slightly above 1.0. This means that we can be reasonably confidant that drivers above age 35 are underrepresented in ROR crashes.

Table 8.15: Distribution of Run off Road Crashes by Driver's Age

Age	ROR Drivers		No ROR Drivers		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
<15	0	0.00%	0	0.00%	**0.00**	N/A	N/A	N/A
15-24	188	27.41%	488	15.53%	**1.77**	1.521	2.037	Over
25-34	146	21.28%	605	19.25%	**1.11**	0.940	1.306	Unsure
35-44	123	17.93%	661	21.03%	**0.85**	0.709	1.014	Unsure
45-54	83	12.10%	523	16.64%	**0.73**	0.592	0.905	Under
55-64	50	7.29%	293	9.32%	**0.78**	0.613	1.042	Unsure
65-74	32	4.66%	198	6.30%	**0.74**	0.551	1.064	Unsure
75-84	20	2.92%	161	5.12%	**0.57**	0.398	0.920	Under
85-94	5	0.73%	54	1.72%	**0.42**	0.202	1.088	Unsure
95-104	0	0.00%	2	0.06%	**0.00**	N/A	N/A	N/A
Unknown	39	5.69%	158	5.03%	**1.13**	0.832	1.485	Unsure
Total	686	100.00%	3143	100.00%	**1.00**			

Table 8.16 shows the variation in crash type by driver gender. The table shows that male drivers make up a much higher percent of ROR drivers. However, because males make up such a high percent of all drivers in fatal crashes, overrepresentation factors for males and females are

very close to one. Neither result is statistically significant because confidence intervals (not shown in the figure) include one.

Table 8.16: Distribution of Run off Road Crashes by Driver Gender

Gender	ROR Drivers		No ROR Drivers		ORF
	Number	Percent	Number	Percent	
Male	500	72.89%	2289	72.83%	1.001
Female	176	25.66%	712	22.65%	1.133
Unknown	10	1.46%	142	4.52%	0.323
Total	686	100.00%	3143	100.00%	1.000

Table 8.17 and Figure 8.6 examine alcohol use by the ROR drivers. According to Florida statutes for alcohol use while driving, the acceptable limit is 0.08 mg/dl or 0.08%. To investigate the effect of varying degrees of alcohol use by the driver and its influence on driver, alcohol use was divided into various categories in reference to this limit. Further, because of differences in reporting, certain BAC values were reported only as “greater than 0.08” or “greater than 0.00,” without an exact value. The latter category also includes drivers where the evidence indicated that they were drinking (odor of alcoholic beverage, eyewitness accounts, etc.), but where no BAC test result was available. Finally, a number of drivers were deemed to have not been drinking, either through examination at the crash scene using various field sobriety instruments or because of age or other factors, but were not actually subjected to a toxicology screening test. These drivers are listed with a BAC of “0.00 presumed” to differentiate them from those who were tested are proven to have a BAC of 0.00 mg/dl. However, these two groups are also combined to enable a more even comparison with other (non-ROR) drivers.

Table 8.17 shows that ROR drivers are highly overrepresented in having a test result of 0.00 mg/dl, but underrepresented in being presumed not to be drinking. This occurs because toxicology screens are a standard component of the autopsy conducted on traffic fatalities, and a much higher percent of ROR drivers died than other drivers because of the high rate of single vehicle ROR crashes. When these two results are combined, as shown in the shaded row, ROR drivers are underrepresented in being completely sober. Accordingly, ROR drivers are overrepresented in all major (greater than one percent of all ROR drivers) categories of alcohol use. While only 52 percent of ROR drivers are completely sober, over 18 percent have BAC values over twice the legal limit. Over five percent have values greater than zero but under the legal limit, a number that is highly overrepresented when compared to all other drivers. This alcohol presence, though less than the legal limit, may have influenced the normal faculties of the driver. Another possibility is that there is sometimes a significant delay between the crash and the actually BAC test, meaning that some drivers might have been over the prima facie limit for impairment at the time of the crash, even though the toxicology result is somewhat less than 0.08 mg/dl. Figure 8.6 shows these results graphically.

Table 8.17: Distribution of ROR Crashes by Alcohol Use

Alcohol Use	ROR Driver		No ROR Driver		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0.00 Tested	276	40.09%	764	24.31%	**1.797**	1.570	2.057	Over
0.00 Presumed	83	12.10%	1348	42.89%	**0.231**	0.185	0.287	Under
0.00 (Tested & presumed)	358	52.19%	2112	67.20%	**0.601**	0.525	0.687	Under
< Limit	38	5.54%	52	1.65%	**2.436**	1.894	3.133	Over
1-2 X Limit	45	6.56%	103	3.28%	**1.746**	1.355	2.250	Over
2-3 X Limit	94	13.70%	102	3.25%	**2.943**	2.499	3.466	Over
3-4 X Limit	33	4.81%	41	1.30%	**2.564**	1.971	3.337	Over
>4 X Limit	3	0.44%	15	0.48%	**0.930**	0.330	2.619	Unsure
> 0	3	0.44%	6	0.19%	**1.864**	0.738	4.708	Unsure
> Limit	1	0.15%	1	0.03%	**2.793**	0.697	11.188	Unsure
UK	110	16.03%	655	20.84%	**0.765**	0.634	0.923	Under
Total	686	100.00%	3143	100.00%	**1.000**			

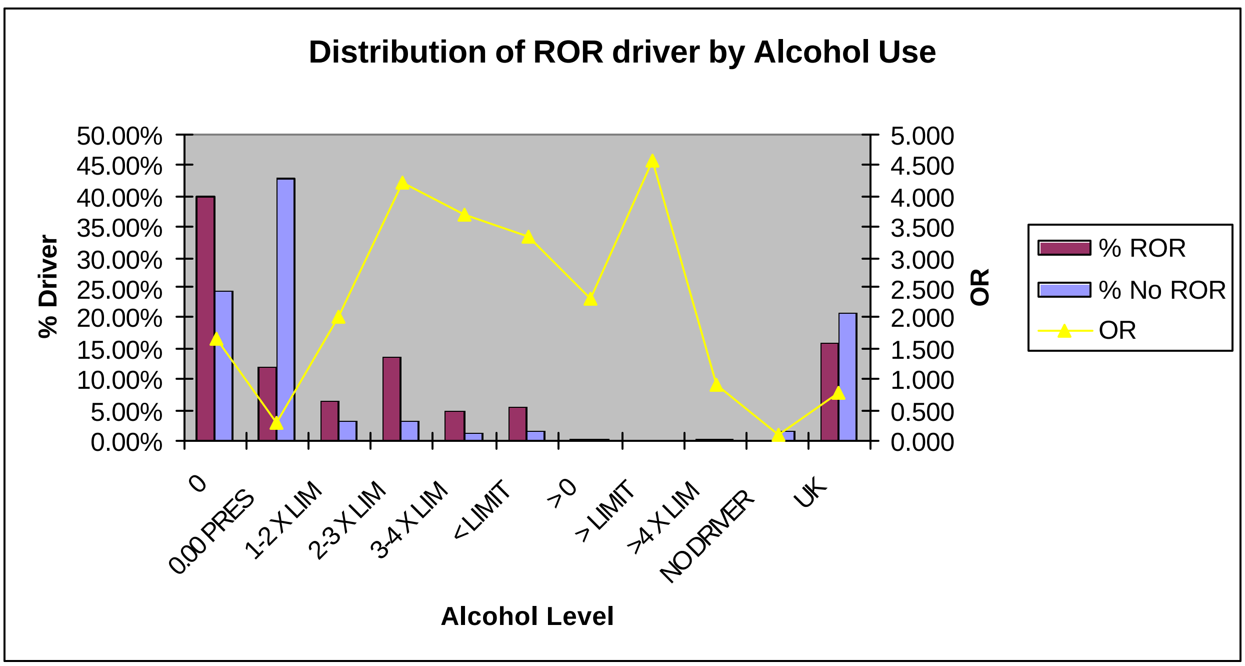

Figure 8.6: Distribution of ROR Drivers by Alcohol Use

It was speculated that the number of occupants might have an effect on the number of ROR crashes, either through solo drivers falling asleep at the wheel or through inattentiveness by drivers when there are many occupants in the car. Table 8.18 shows that most (58%) of the vehicles involved in ROR crashes had only one occupant. However, because a higher percent of vehicles in other crash types had only one occupant, this number is slightly overrepresented. On the other hand, ROR crashes are more common with greater than two occupants in the vehicle. When all crashes with more than two occupants are combined, ROR is overrepresented by a factor of 1.578, which is statistically significant. This potentially indicates that greater than two occupants is a distraction that might lead to increased numbers of ROR crashes.

Table 8.18: Distribution of ROR Vehicles By Number of Occupants

No. Of Occupants	ROR Vehicle		No ROR Vehicle		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
1	399	58.16%	2007	63.86%	**0.91**	0.717	0.943	Under
2	150	21.87%	647	20.59%	**1.06**	0.904	1.254	Unsure
3	53	7.73%	144	4.58%	**1.69**	1.213	1.964	Over
4	24	3.50%	85	2.70%	**1.29**	0.863	1.773	Unsure
5	16	2.33%	38	1.21%	**1.93**	1.100	2.533	Over
6	3	0.44%	18	0.57%	**0.76**	0.279	2.276	Unsure
7+	8	1.17%	17	0.54%	**2.16**	1.010	3.192	Over
All >2	104	15.16%	302	25.62%	**1.578**	1.283	1.941	Over
Unknown	33	4.81%	187	5.95%	**0.81**	0.601	1.144	Unsure
Total	686	100.00%	3143	100.00%	1.00			

Table 8.19 shows the distribution of ROR vehicles by posted speed. About two-thirds of the ROR crashes occur on roads with speed limits of 55 and above. Speeds could not be computed for about 10 percent of the cases, and several cases involved ramps with no posted limit. For cases where the ROR vehicle speed was known, speeding is an issue in a large number of ROR crashes. In addition, speeding is a larger problem on roads with higher posted speed limits. For roads with posted speeds of 65 mph and above, about one-third of all ROR crashes involved vehicles traveling at least 10 mph over the limit. For roads with posted speeds of 40 mph and below, about half as many ROR crashes involved speeding vehicles. Table 8.20 provides a little more detail on the degree of speeding in ROR crashes.

Table 8.19: Distribution of ROR Vehicles by Speed

Posted Speed	Number at or below posted speed	Number above posted speed	Percent above posted speed	Number >10 above posted speed	Percent >10 above posted speed	Total Vehicles
40-	12	32	13.01%	21	16.41%	65
45-50	19	45	18.29%	27	21.09%	91
55-60	75	71	28.86%	39	30.47%	185
65+	130	98	39.84%	41	32.03%	269
Total	236	246	100.00%	128	100.00%	686

Table 8.20: Distribution of ROR crashes by Posted Speed and Vehicle Speed

Posted speed	Vehicle Speed													
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	105-114	115-124	125-134	UK	Total
15	0	0	0	0	0	0	0	0	0	0	0	0	0		0
20	0	0	0	0	0	0	0	0	0	0	0	0	0		0
25	0	0	0	0	1	0	1	0	0	0	0	0	0		2
30	0	0	3	2	0	2	0	1	0	0	0	0	0		8
35	0	0	1	8	4	4	1	1	1	1	0	0	0		21
40	0	0	0	4	6	3	4	1	0	1	0	0	0		19
45	1	1	1	6	31	13	11	3	1	1	1	0	0		70
50	0	0	0	0	4	3	2	0	0	0	0	0	0		9
55	0	0	1	2	14	76	25	15	6	2	1	1	1		144
60	0	0	0	0	3	19	6	5	2	1	0	0	0		36
65	0	0	0	0	4	13	60	15	9	2	0	0	0		103
70	0	0	0	1	1	16	117	48	17	7	0	0	1		208
UK														66	66
Total	1	1	6	23	68	149	227	89	36	15	2	1	2	66	686

8.7 Environmental Characteristics

As explored previously, relatively few ROR crashes involved environmental contributing factors. Fewer than 12 percent of the ROR crashes occurred on wet or slippery roads, and smoke or fog was cited as a contributing factor in about one percent of the ROR crashes. Table 8.21 shows the distribution of ROR crashes by crash type and lighting condition. Overall, approximately 48 percent of the ROR crashes occur during daylight and another 47 percent occur during hours of darkness. Right side departures are somewhat more common during hours of darkness, possibly due to correlation with fatigue and alcohol use.

Table 8.21: Distribution of ROR Crashes by Crash Type and Lighting Condition

Crash Type	Daylight	Dusk	Dawn	Dark (Street Light)	Dark (No Street Light)	Unknown	% Dark
Right departure	107	3	7	44	68	1	49%
Right w/control loss	41	0	4	29	33	0	58%
Left departure	78	2	5	29	32	0	42%
Left w/control loss	87	3	4	23	43	1	41%
Straight	0	0	0	2	3	0	100%
Ramp	11	0	0	10	3	0	54%
Total	324	8	20	137	182	2	47%
Percent	48%	1%	3%	20%	27%	0%	

8.8 Roadway Characteristics

There are several roadway characteristics that might potentially contribute to a ROR crash. This section provides a closer look at a number of those characteristics, including roadway curvature, presence of rumble strips and guardrails, location of fixed objects along the side of the roadway, distance of the fixed object from the roadway, shoulder characteristics, etc.

Table 8.22 looks at the ROR and other crashes by Crash Rate Class Category (CRCC), which is a field that categorizes the roadway according to geographic location, facility type, and number of lanes. Road systems in the state of Florida have been divided into many types, but for the convenience of comparison, types of road systems with very few ROR or other crashes were grouped together according to just the geographic location. All road systems with more than five ROR crashes or more than 19 other crashes are shown separately. The data is sorted in descending order according to the number of ROR crashes. Because the CRCC field is not reliable with respect to whether a crash occurred on a ramp, those crashes are combined with interstate crashes of the same geographic location.

Examining Table 8.22, it is evident that over 40 percent of all ROR crashes occur on interstates. ROR crashes are highly overrepresented on both urban and rural interstates, as well as on urban and rural toll roads: on these four classes of roads, ROR crashes account for 70 percent of all fatal crashes. The posted speed is typically higher on interstate rural and urban roads than on other road classes therefore speed is often an issue on those classes of road. In many of the ROR crashes on urban limited access roads, access points also contributed to some extent. After interstates, ROR crashes are most common on undivided two to three lane rural roads, which accounts for about 12 percent of the ROR crashes, and four to five lane divided rural roads with raised medians, which accounts for almost 10 percent of the ROR crashes. Although high in number, ROR crashes are slightly underrepresented on these roads as well as on suburban two-three lane undivided roads. ROR crashes are significantly underrepresented on most other road classes that have at least 30 fatal crashes altogether.

Table 8.23 and Figure 8.7 examine the age of the drivers in ROR crashes on the various road classes. Table 8.23 shows that a higher number of drivers in the age group of 15-24 ran off road on rural interstate then on urban interstates. In Figure 8.7, which shows only the road classes with significant numbers of crashes, it appears that there is not much difference in the distribution of driver ages among the different classes of roads. In almost every class, the youngest drivers have the highest rates of ROR crashes, and the older drivers have much lower rates of ROR crashes. Younger drivers do appear to have lower crash involvement rates on two to three lane rural and suburban roads, and higher rates on interstates and other multi-lane roads. Aged 25-34 year old drivers have the highest crash rates on suburban two-three lane roads, and those aged 35-44 have the highest rates on rural two-three lane roads. Older drivers are involved in ROR crashes at a significantly higher rate on four to five lane urban roads than on other road classes. This might suggest that older drivers have difficulty negotiating busy urban streets.

Table 8.22: Distribution of Crashes by Crash Road Class Category

Road Class	ROR		No ROR		ORF	Min CI	Max CI	Level
	Num.	Percent	Num.	Percent				
Interstate Rural	150	22.1%	76	5.5%	**4.043**	3.117	5.245	Over
Interstate Urban	123	18.1%	71	5.1%	**3.549**	2.690	4.683	Over
Rural 2-3Ln Undivided	81	11.9%	204	14.7%	**0.813**	0.640	1.035	Unsure
Rural 4-5Ln Divided Raised	66	9.7%	139	10.0%	**0.973**	0.736	1.285	Unsure
Suburban 2-3Ln Undivided	22	3.2%	59	4.2%	**0.764**	0.472	1.236	Unsure
Suburban 4-5Ln Divided Raised	53	7.8%	203	14.6%	**0.535**	0.401	0.713	Under
Suburban 6+Ln Divided Raised	14	2.1%	77	5.5%	**0.373**	0.212	0.653	Under
Toll Road Rural	24	3.5%	7	0.5%	**7.024**	3.042	16.220	Over
Toll Road Urban	31	4.6%	19	1.4%	**3.343**	1.902	5.873	Over
Urban 4-5Ln Divided Paved	15	2.2%	95	6.8%	**0.324**	0.189	0.553	Under
Urban 4-5Ln Divided Raised	10	1.5%	86	6.2%	**0.238**	0.125	0.456	Under
Urban 6+Ln Divided Raised	40	5.9%	179	12.9%	**0.458**	0.329	0.637	Under
Urban Other Limited Access	12	1.8%	12	0.9%	**2.049**	0.925	4.536	Unsure
Urban 6+Ln Divided Paved	4	0.6%	33	2.4%	**0.248**	0.088	0.698	Under
Suburban 2-3Ln Divided Paved	3	0.4%	22	1.6%	**0.279**	0.084	0.930	Under
Rural 2-3Ln Divided Paved	6	0.9%	21	1.5%	**0.585**	0.237	1.443	Unsure
Urban 4-5Ln Undivided	4	0.6%	20	1.4%	**0.410**	0.141	1.194	Unsure
Other Rural	3	0.4%	12	0.9%	**0.512**	0.145	1.809	Unsure
Other Urban	10	1.5%	27	1.9%	**0.759**	0.369	1.558	Unsure
Other Suburban	7	1.0%	27	1.9%	**0.531**	0.232	1.213	Unsure
Total	678		1389		1.000			

Table 8.23: Crash Road Class by ROR Driver's Age

Road Class	Driver Age								
	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+	Total
Interstate Rural	51	33	21	22	11	4	5	0	147
Interstate Urban	35	31	25	14	13	4	3	0	125
Rural 2-3Ln Undivided	15	16	19	18	5	5	2	0	80
Rural 4-5Ln Divided Raised	22	15	10	3	7	4	3	1	65
Suburban 4-5Ln Divided Raised	15	5	10	10	6	4	2	1	53
Urban 6+Ln Divided Raised	14	11	6	3	3	1	1	1	40
Toll Road Urban	7	7	10	4	2	1	0	0	31
Toll Road Rural	5	6	6	4	0	1	0	1	23
Suburban 2-3Ln Undivided	3	8	4	2	2	1	2	0	22
Urban 4-5Ln Divided Paved	5	1	3	2	2	2	0	0	15
Suburban 6+Ln Divided Raised	3	4	3	0	1	3	0	0	14

Table 8.23: Crash Road Class by ROR Driver's Age, continued

Road Class	Driver Age								
	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+	Total
Urban Other Limited Access	2	5	2	2	1	0	0	0	12
Urban 4-5Ln Divided Raised	4	2	2	2	0	0	0	0	10
Other Urban	3	2	3	0	1	0	0	1	10
Other Suburban	1	2	1	1	0	0	1	0	6
Other Rural	3	1	2	0	0	0	0	0	6
Rural 2-3Ln Divided Paved	1	2	2	0	0	1	0	0	6
Urban 6+Ln Divided Paved	1	2	0	0	0	1	0	0	4
Suburban 2-3Ln Divided Paved	0	0	1	0	0	1	1	0	3
Urban 4-5Ln Undivided	0	1	1	0	0	1	0	0	3
Unknown									11
Total	190	154	131	87	54	34	20	5	686

Table 8.24: Crashes by Failed to Negotiate Curve

	Number	Percent
Failure to Negotiate Curve	57	34.76%
No Failure to Negotiate Curve	107	65.24%
Total	164	100.00%

Because roadway curvature is a major issue in ROR crashes, Table 8.25 and Table 8.26 examine the issue in more detail. Table 8.25 shows the distribution of ROR crashes on roadways with and without curvature. Almost 25 percent of the run off road crashes occurred on roadways with some degree of curvature, which makes ROR crashes significantly overrepresented on such roads, although not by 50 percent. Table 8.26 looks further at whether the ROR crashes on curves were deemed to have been caused by the curvature. Interestingly, failure to negotiate the curve was identified through the case review as a contributing factor in only a little over one-third of the cases.

Table 8.25: Distribution of ROR Crashes on Roads with Curvature

	ROR		No ROR		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Curvature	164	24.2%	233	16.6%	**1.455**	1.219	1.738	Over
No Curvature	514	75.8%	1169	83.4%	**0.909**	0.866	0.954	Under
Total	678		1402		**1.000**			

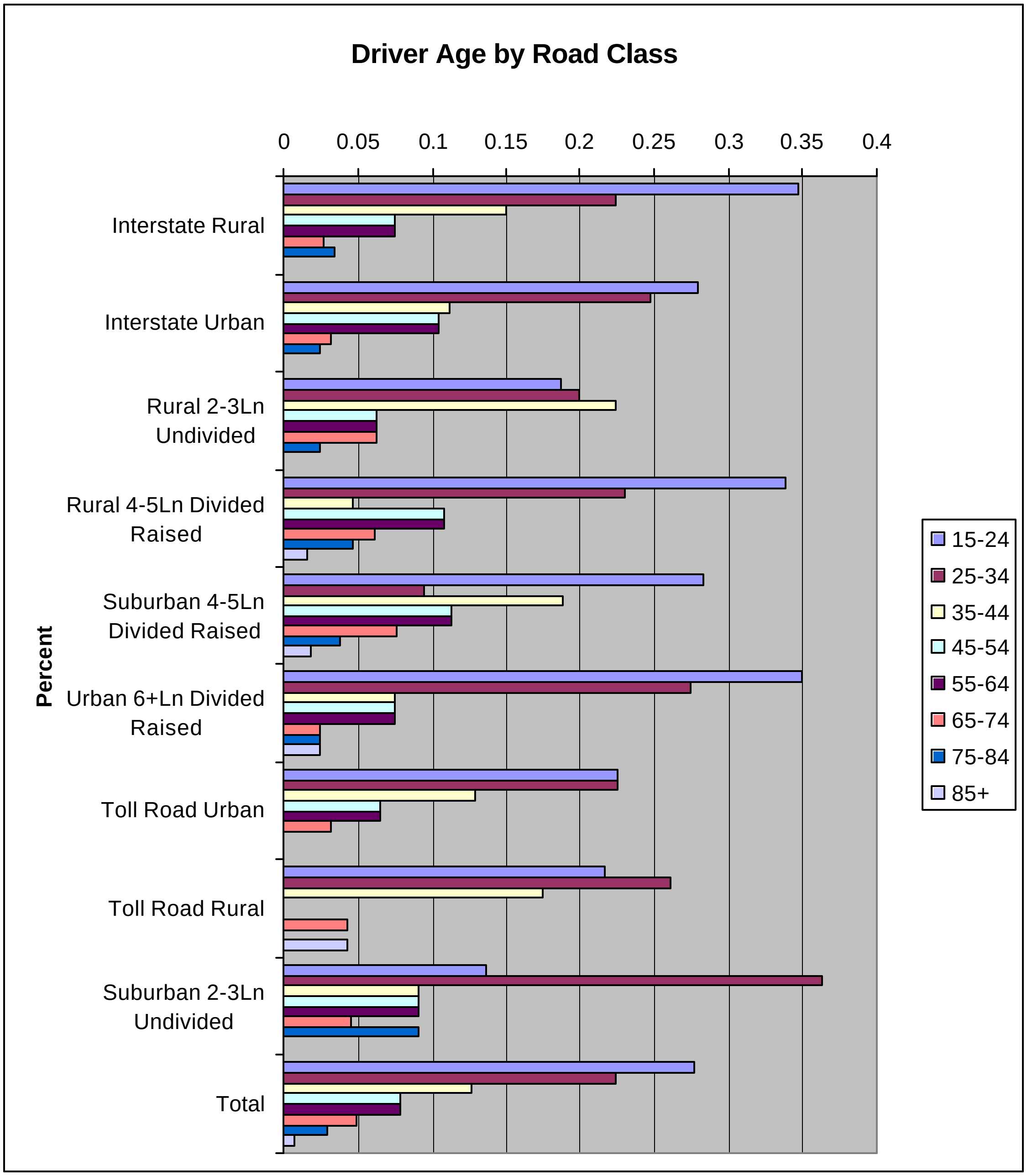

Figure 8.7: Distribution of ROR Driver Age by Crash Rate Class

Table 8.26: Crashes by Failed to Negotiate Curve

	Number	Percent
Failure to Negotiate Curve	57	34.76%
No Failure to Negotiate Curve	107	65.24%
Total	164	100.00%

Continuing with the discussion, Table 8.27 shows the distribution of ROR crashes according to the radius of curvature on the roadway. It is important to note that the radius of curvature values were taken from the homicide investigation reports, and often disagreed with the values available from the Roadway Characteristics Inventory database. The two primary reasons for the discrepancies were failure to identify the crash as occurring on a ramp, and failure to properly location the crash on the roadway segment. About 30 percent of the ROR crashes occurred on shallow curves, those with radii greater than 3500 ft., where the posted speed is typically 55 to 70 mph. Another 26 percent occurred on fairly sharp curves, with radii of 500 ft. to 1499 feet (typically 35 to 55 mph posted speed), and nine percent of the crashes occurred on very sharp curves, with radii less than 500 ft. (Typically 35 mph or less posted speed).

Table 8.27: Number of ROR Vehicles Grouped by Radius of Curvature

Radius of Curvature	Number	Percent
<500	15	8.98%
500-1499	43	25.75%
1500-2499	34	20.36%
2500-3499	25	14.97%
≥3500	50	29.94%
Total	167	100.00%

Table 8.28 looks at vehicle speed on curves of various radii. Vehicle speed is plotted with respect to the posted speed on the curve. From the chart, it appears that speeding is more of a factor on roads with tighter curves: approximately one-third of the vehicles running off the road on curves with radii less than 1500' were traveling at least 10 mph over the posted limit. On curves of greater than 2500' radii, only about half as many vehicles were traveling over 10 mph over the limit.

Table 8.28: Vehicle Speed on Curves of Varying Radii

Vehicle Speed	<500	500-1499	1500-2499	2500-3499	>3500	Total
At or below limit	3	11	9	14	15	52
≤10 over limit	7	18	17	7	26	75
>10 over limit	5	14	8	4	9	40
Total	15	43	34	25	50	167
Percent >10 over limit	33.3%	32.6%	23.5%	16.0%	18.0%	24.0%

As there are many other issues associated with ROR crashes on curves, it was therefore necessary to look into other crash contributing factors. Table 8.29 looks at the primary contributing factor identified by case review for all crashes on curves. Overall, alcohol and drug use is the most common factor associated with ROR cases on curves, followed by speed and abrupt steering input. While speed is highly overrepresented in ROR crashes on sharp curves, most other factors are close to an even representation between tight and shallow curves.

Table 8.29: Distribution of Primary Crash Contributing Factor by Roadway Curvature

Factor Class	Factor Detail	Roadway Curvature			Percent	ORF
		<1500	>1500	Total		
Human	Confusion	0	0	0	0.00%	**N/A**
	Police Pursuit	0	1	1	0.17%	**0.00**
	Aggression	8	2	10	1.72%	**0.92**
	Decision Error	7	1	8	1.37%	**1.61**
	Distraction	9	2	11	1.89%	**1.04**
	Medical	19	2	21	3.61%	**2.19**
	Alcohol/Drug	168	49	217	37.29%	**0.79**
	Abrupt Steering Input	43	10	53	9.11%	**0.99**
	Inattention	33	6	39	6.70%	**1.27**
	Fatigue/Asleep	30	5	35	6.01%	**1.38**
	Speed	57	13	70	12.03%	**1.01**
	Inexperience	1	0	1	0.17%	**0.00**
	Mental/Emotional	1	0	1	0.17%	**0.00**
Environ	Fog	1	0	1	0.17%	**0.00**
	Wind	1	0	1	0.17%	**0.00**
	Wet/Slippery	9	2	11	1.89%	**1.04**
Vehicle	Defect	4	1	5	0.86%	**0.92**
	Load shift/Fall	5	0	5	0.86%	**0.00**
	Tire	37	3	40	6.87%	**2.84**
Roadway	Congestion	1	0	1	0.17%	**0.00**
	Obstruction	2	0	2	0.34%	**0.00**
	Access Point	2	1	3	0.52%	**0.46**
	Construction	0	1	1	0.17%	**0.00**
	Curvature	1	1	2	0.34%	**0.23**
	Standing Water	5	0	5	0.86%	**0.00**
	Sight Distance	1	0	1	0.17%	**0.00**
Unknown		28	9	37	6.36%	**0.72**
Total		473	109	582	100.00%	**1.00**

Table 8.30 looks at the presence of rumble strips in ROR crashes. While rumble strips are most common on interstates and rural roads, locations where most of the ROR crashes occur, rumble strips were present in only 15 percent of the fatal ROR crashes. Rumble strips are used

to alert drivers who run off the road due to driver inattention, fatigue, falling asleep, and incapacitation due to alcohol use. Table 8.31 shows that rumble strips are underrepresented in crashes involving alcohol and drug use, indicating that relatively fewer alcohol-involved ROR crashes occur on roads with rumble strips. Rumble strips are also somewhat negatively associated with inattention. However, fatigue/asleep and distraction have a strong positive association with rumble strip presence. This is possibly due to an association between rumble strips and overcorrection, a phenomenon explored in more detail in the next subsection. Rumble strips are also positively associated with tire blowout and tread separation; however, one would not expect the presence of rumble strips to affect the number of tire blowout cases, because the resulting change in vehicle dynamics is primarily responsible for those ROR crashes.

Table 8.30: Distribution of ROR Vehicles by Rumble Strip Presence

Rumble Strips	Number	Percent
Yes	107	15.60%
No	579	84.40%
Total	686	100.00%

Table 8.31: Distribution of Crash Contributing Factor by Rumble Strip Presence

Factor Class	Factor Detail	Rumble Strips		No rumble strips		ORF
		Num.	%	Num.	%	
Human	Confusion	0	0.00%	3	0.52%	0.00
	Police Pursuit	1	0.93%	1	0.17%	5.41
	Aggression	0	0.00%	12	2.07%	0.00
	Decision Error	1	0.93%	9	1.55%	0.60
	Distraction	4	3.74%	9	1.55%	2.40
	Medical	3	2.80%	27	4.66%	0.60
	Alcohol/Drug	27	25.23%	216	37.31%	0.68
	Abrupt Steering Input	8	7.48%	46	7.94%	0.94
	Inattention	7	6.54%	37	6.39%	1.02
	Fatigue/Asleep	10	9.35%	31	5.35%	1.75
	Speed	16	14.95%	80	13.82%	1.08
	Age	0	0.00%	0	0.00%	0.00
	Inexperience	0	0.00%	1	0.17%	0.00
	Mental/Emotional	1	0.93%	0	0.00%	0.00
Environ	Fog	0	0.00%	1	0.17%	0.00
	Lighting	0	0.00%	0	0.00%	0.00
	Dark	0	0.00%	0	0.00%	0.00
	Wind	0	0.00%	1	0.17%	0.00
	Wet/Slippery	4	3.74%	12	2.07%	1.80
Vehicle	Defect	0	0.00%	5	0.86%	0.00

Table 8.31: Distribution of Crash Contributing Factor by Rumble Strip Presence, continued

Factor Class	Factor Detail	Rumble Strips		No rumble strips		ORF
		Num.	%	Num.	%	
Vehicle	Disabled	0	0.00%	0	0.00%	0.00
	Stability	0	0.00%	0	0.00%	0.00
	Trailer	0	0.00%	0	0.00%	0.00
	Jackknifed	0	0.00%	0	0.00%	0.00
	Load shift/Fall	2	1.87%	3	0.52%	3.61
	Tire	11	10.28%	30	5.18%	1.98
Roadway	Congestion	0	0.00%	1	0.17%	0.00
	Obstruction	0	0.00%	3	0.52%	0.00
	Access Point	0	0.00%	6	1.04%	0.00
	Construction	0	0.00%	1	0.17%	0.00
	Shoulder	0	0.00%	0	0.00%	0.00
	Transition	0	0.00%	0	0.00%	0.00
	Curvature	0	0.00%	3	0.52%	0.00
	Standing Water	0	0.00%	4	0.69%	0.00
	Maintenance	0	0.00%	0	0.00%	0.00
	Obstructed View	0	0.00%	0	0.00%	0.00
	Sight Distance	0	0.00%	0	0.00%	0.00
Unknown		12	11.21%	37	6.39%	1.75
Total		107	100.00%	579	100.00%	1.00

Table 8.32 looks at the road class according to whether there were rumble strips present at the time of the crash. Presence of rumble strips is highly overrepresented in ROR crashes on rural interstates and all toll roads. Rumble strips are evenly represented in ROR crashes on urban interstates, and underrepresented on all other road classes. This is likely due to the fact that rumble strips are more likely to be used on rural interstates, due to the high number of ROR crashes occurring on those roads.

Table 8.32: Distribution of Rumble Strips by Road Class

Road Class	Rumble Strips		No Rumble Strips		Percent w/Rumble Strips	ORF
	Num.	Percent	Num.	Percent		
Interstate Rural	53	49.53%	95	16.41%	35.8%	2.99
Interstate Urban	25	23.36%	102	17.62%	19.7%	1.31
Rural 2-3Ln Undivided	4	3.74%	77	13.30%	4.9%	0.28
Rural 4-5Ln Divided Raised	2	1.87%	64	11.05%	3.0%	0.17
Suburban 2-3Ln Undivided	0	0.00%	23	3.97%	0.0%	0.00
Suburban 4-5Ln Divided Raised	0	0.00%	53	9.15%	0.0%	0.00
Suburban 6+Ln Divided Raised	0	0.00%	14	2.42%	0.0%	0.00

Table 8.32: Distribution of Rumble Strips by Road Class, continued

Road Class	Rumble Strips		No Rumble Strips		Percent w/Rumble Strips	ORF
	Num.	Percent	Num.	Percent		
Toll Road Rural	11	10.28%	13	2.25%	45.8%	4.54
Toll Road Urban	11	10.28%	20	3.45%	35.5%	2.95
Urban 4-5Ln Divided Paved	0	0.00%	16	2.76%	0.0%	0.00
Urban 4-5Ln Divided Raised	0	0.00%	10	1.73%	0.0%	0.00
Urban 6+Ln Divided Raised	0	0.00%	41	7.08%	0.0%	0.00
Urban Other Limited Access	1	0.93%	11	1.90%	8.3%	0.49
Urban 6+Ln Divided Paved	0	0.00%	4	0.69%	0.0%	0.00
Suburban 2-3Ln Divided Paved	0	0.00%	3	0.52%	0.0%	0.00
Rural 2-3Ln Divided Paved	0	0.00%	6	1.04%	0.0%	0.00
Urban 4-5Ln Undivided	0	0.00%	4	0.69%	0.0%	0.00
Other Rural	0	0.00%	5	0.86%	0.0%	1.07
Other Urban	0	0.00%	10	1.73%	0.0%	0.00
Other Suburban	0	0.00%	8	1.38%	0.0%	0.00
Total	107	100.00%	579	100.00%	15.6%	1.00

Table 8.33 looks at the median width for those ROR crashes where the ROR vehicle hit one or more vehicles in the opposing lanes. The table shows that the most common median width is between 30 and 45 feet, but that 37 percent of the median crossover cases occur when the median width is between 60 and 75 feet. This indicates that even a wide median is often not sufficient protection against median crossover.

Table 8.33: Distribution of ROR vehicle crossing median

Median Width	ROR Crossed Median	
	Number	Percent
<30	8	7.41%
30-45	48	44.44%
45-60	2	1.85%
60-75	40	37.04%
75-90	6	5.56%
90-105	4	3.70%
Total	108	100.00%

Table 8.34 looks at the first shoulder type and width in ROR crashes. It shows that approximately 50% of the ROR crashes occurred on shoulder widths between 10-14 feet and about 31% were on shoulder width less then 5 feet. About 74% of the crashes were on paved shoulders with or with out rumble strips, but ROR crashes were much more common where

rumble strips were not in use. Table 8.35 shows that almost 91% of the second shoulder types are lawn or grass shoulders, and that about 58% of vehicle ran off road where shoulder type 2 width was less than 5 feet.

Table 8.34: ROR Vehicles by Shoulder Type 1

Shoulder Type 1	<5	5-9	10-14	>15	Total	Percent
Raised Curb	2	0	0	0	2	0.3%
Paved w/ or w/out Striping	142	85	279	2	508	74.1%
Paved with Rumble Strips	2	4	34	0	40	5.8%
Lawn/Grass	4	37	25	0	66	9.6%
Curb and Gutter	63	0	0	0	63	9.2%
Other	2	0	3	0	5	0.7%
Curb with Resurfaced Gutter	2	0	0	0	2	0.3%
Total	217	126	341	2	686	100.0%
Percent	31.6%	18.4%	49.7%	0.3%	100.0%	

Table 8.35: ROR Vehicles by Shoulder Type 2

Shoulder Type_2	<5	5-9	10-15	Total	Percent
Raised Curb	2	0	0	2	0.4%
Paved w/ or w/out Striping	3	0	0	3	0.6%
Lawn/Grass	244	187	8	439	91.3%
Gravel/Marl	0	1	0	1	0.2%
Curb and Gutter	27	1	0	28	5.8%
Other	5	1	0	6	1.2%
Curb with Resurfaced Gutter	2	0	0	2	0.4%
Total	283	190	8	481	100.0%
Percent	58.8%	39.5%	1.7%	100.0%	

8.9 Contributing Factors in Overcorrection Crashes

Run off the road crashes involving overcorrection make up around 25% of the total number of ROR crashes. In overcorrection cases, vehicles run off the road and in an attempt to return to the original travel lane, over steered and either lose lateral stability or simply overshoot the lane. Note that overcorrection can also result from lateral movements without leaving the travel lanes, as in the case of an attempted lane change into an occupied lane, followed by overcorrection and loss of control. However, the cases considered in this chapter are limited to those where the vehicle left the travel lanes onto either a paved or grass shoulder prior to overcorrecting.

Table 8.36 shows the number and percent of vehicles overcorrecting after running off the road to either the left or the right. Vehicles that hit a roadside feature, such as a barrier, guardrail, or attenuator, and were redirected back into traffic, are also included in the table. The numbers are very similar regardless of the direction in which the vehicle left the roadway: approximately 25 percent of the vehicles were overcorrected back onto the road, four percent were redirected back onto the road, and about 70 percent continued off the roadway in the original direction of travel. Overcorrection was slightly more common after running off the road to the left, but the difference is neither large nor statistically significant. Overall, the low number of fatal redirection crashes, especially in comparison to the high number of other fatal ROR crashes, appears to indicate that redirection is not a significant contributor to fatal traffic crashes.

Table 8.36: Distribution of ROR Vehicles by Overcorrection and Direction

	ROR to Right		ROR to Left	
	Number	Percent	Number	Percent
Overcorrection	86	24.09%	89	27.05%
No Overcorrection	257	71.99%	227	69.00%
Redirected	14	3.92%	13	3.95%
Total	357		329	

Table 8.37 looks at the initial cause of the ROR event that resulted in the overcorrection. These numbers were taken from the crash contributing factors and generally correspond to the primary contributing factor. Alcohol is the most common contributing factor, followed by speed, inattention, and fatigue/asleep. With the exception of speed, the contributing factors paint a picture of a driver that drifts off the road at a gentle angle, then abruptly oversteers back onto the road surface, resulting in the crash. The speeding drivers, as well as the aggressive drivers tend to be attempting to maneuver around other vehicles when they get too close to the edge of the pavement, leave the roadway, and overcorrect.

As vehicle overcorrection involves primarily human factors that contribute in the crash, it was therefore important to look driver age as a contributing factor in the crash. This information is presented in Table 8.38. A little over 37 percent of the overcorrecting drivers were under age 25, while only 27 percent of all ROR drivers were under age 25. While we don't know how many drivers ran off the road, and corrected back onto the roadway without a crash event, these numbers likely mean that younger drivers are more prone to overcorrection after running off the road than older drivers. Drivers in the 35 to 44-age range are also involved in overcorrection crashes at a higher rate than they are in all ROR crashes.

Table 8.37: Initial Contributing Factor in ROR Overcorrection

Contributing Factor	Number	Percent
Access Point	1	0.6%
Aggression	5	2.8%
Alcohol	53	29.8%
Alcohol and Drugs	10	5.6%
Congestion	1	0.6%

Table 8.37: Initial Contributing Factor in ROR Overcorrection, continued

Contributing Factor	Number	Percent
Curvature	1	0.6%
Distraction	5	2.8%
Drugs	11	6.2%
Fatigue/Asleep	17	9.6%
Fog	1	0.6%
Inattention	18	10.1%
Inexperience	1	0.6%
Medical	2	1.1%
Obstructed View	1	0.6%
Obstruction	1	0.6%
Speed	23	12.9%
Tires	7	3.9%
Unknown	20	11.2%

Table 8.38: Distribution of ROR Overcorrection Crashes by Driver's Age

Overcorrection Result	Age									
	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+	Total	%
ROR, Same	21	14	2	11	3	2	2	0	26	14.9%
ROR, Opposite	29	11	8	7	2	0	1	0	26	14.9%
Vehicle Impact, Same	7	4	2	2	2	2	0	0	5	2.9%
Vehicle Impact, Opposite	8	6	7	5	1	2	1	0	19	10.9%
Total	65	35	19	25	8	6	4	0	175	100.0%
Overcorrect Drivers (%)	37.1%	20.0%	10.9%	14.3%	4.6%	3.4%	2.3%	0.0%		
All ROR Drivers (%)	27.4%	21.3%	17.9%	12.1%	7.3%	4.7%	2.9%	0.7%		

Table 8.39 examines whether there were rumble strips present at the time of the ROR overcorrection crash. From the table, it is evident that when there were rumble strips present, about 36 percent of the ROR crashes resulted in overcorrection. On the other hand, when there were no rumble strips present, only 24 percent of the crashes resulted in overcorrection. This implies that drivers are almost fifty percent more likely to overcorrect upon running off a roadway with rumble strips, a number that is statistically significant at the 95 percent confidence level.

The next table confirms what was shown previously by looking at overcorrection versus shoulder type. Table 8.40 shows that, on roads with paved shoulders about 25 percent of the ROR vehicles overcorrected, but on roads with rumble strips, over 32 percent overcorrected. Again, however, note how few of the ROR crashes occurred on roads with rumble strips. Further, almost half of the ROR crashes that occurred on lawn (grass) shoulders resulted in overcorrection. Table 8.41 shows that overcorrection is most common when the second shoulder type is a lawn or grass shoulder, primary because this type accounts for most of the second shoulders on state roads.

Table 8.39: ROR Overcorrection by Presence of Rumble Strips

	Rumble Strips		No/UK Rumble Strips		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Overcorrect	38	35.6%	138	24.0%	**1.484**	1.104	1.996	Over
No Overcorrect	62	58.7%	421	72.4%	**0.810**	0.684	0.959	Under
Redirect	7	5.8%	20	3.6%	**1.604**	0.663	3.880	Unsure
Total	107	100.0%	579	100.0%	**1.000**			

Table 8.40: Overcorrection on Shoulder Type 1

Shoulder Type 1	Overcorrected		Redirected	Total	Percent Overcorrected
	Yes	No			
Raised Curb	0	2	0	2	0.0%
Paved w/ or w/out Striping	129	357	22	508	25.4%
Paved with Rumble Strips	13	25	2	40	32.5%
Lawn/Grass	31	34	1	66	47.0%
Curb and Gutter	2	59	2	63	3.2%
Other	2	3	0	5	40.0%
Curb with Resurfaced Gutter	0	4	0	4	0.0%
Total	177	484	27	688	25.7%

Table 8.41: Overcorrection on Shoulder Type 2

Shoulder Type 1	Overcorrected		Redirected	Total	Percent Overcorrected
	Yes	No			
Raised Curb	0	2	0	2	0.0%
Paved w/ or w/out Striping	0	3	0	3	0.0%
Lawn/Grass	130	294	15	439	29.6%
Gravel/Marl	0	1	0	1	0.0%
Curb and Gutter	2	23	3	28	7.1%
Other	0	4	2	6	0.0%
Curb with Resurfaced Gutter	0	2	0	2	0.0%
Total	132	329	20	481	27.4%

Table 8.42 looks at the initial outcome of the overcorrection. Fewer than 30 percent of the overcorrecting vehicles hit another vehicle, with about twice as many crossing either a

centerline or a grass median and impacting a vehicle in the opposite direction as sideswiping or rear ending a vehicle in the same travel direction. Although not shown in Table 8.42, vehicles that initially drifted right, then overcorrected to the left were more likely to impact a vehicle in the opposite direction, while vehicle that initially drifted to left were more likely to impact a vehicle in the same direction. This makes sense, because vehicles initially leaving the roadway to the left are more often on multi-lane divided highways. Again referring to Table 8.42, fewer than three percent of the overcorrecting vehicles returned to the roadway again, but overturned due to loss of lateral stability resulting from the excess steering input. Thirty-six percent of the vehicles crossed the entire paved surface and exited the roadway on the opposite side from the initial ROR event. About one-third of all overcorrect cases, returned to the roadway, but exited again in the same direction as the initial ROR event. These vehicles potentially suffered no worse an outcome, since they left the roadway again in the same direction; however, the abrupt steering input typically induced a rotation about the yaw axis, resulting in tripping and overturning, which might otherwise not have happened.

Table 8.42: Outcome of ROR Overcorrection

Outcome	Number	Percent
Vehicle Impact, Same	19	10.86%
Vehicle Impact, Opposite	31	17.71%
ROR, Same	57	32.57%
ROR, Opposite	63	36.00%
Overturn	5	2.86%
Total	175	100%

Having found that approximately 29 percent of overcorrecting vehicles hit another moving vehicle, Table 8.43 and Table 8.44 examine other outcomes, namely fixed object impacts and rollovers. Table 8.43 shows that in 41% of the cases where the ROR vehicle overcorrected, it eventually hit a fixed object, as compared to 59% of the cases where it did not overcorrect. This means that fixed object impacts are about two-thirds as likely in overcorrection crashes. On the other hand, Table 8.44 shows that 63% of the vehicles overturned after overcorrecting, a rate that is almost one and a half times that of the ROR vehicles that didn’t overcorrect. As overturn is one of the outcomes of the ROR crashes, it has been examined with other fatality contributing factors later in the chapter. In addition, the overall rate and effects of rollover in fatal crashes has been discussed in a separate chapter of the report.

Table 8.43: Distribution of Fixed Object Impacts by Overcorrection

	Overcorrection		No overcorrection	
	Number	Percent	Number	Percent
Fixed object	83	41.3%	286	59.0%
No fixed object	119	58.7%	198	41.0%
Total	202		484	

Table 8.44: Distribution of Overturn Crashes by Overcorrection

	Overcorrection		No overcorrection	
	Number	**Percent**	**Number**	**Percent**
Overturn	127	63.2%	208	42.9%
No overturn	77	38.3%	276	56.9%
Total	202		484	

Table 8.45 looks at the most harmful event in overcorrection crashes. The results are fairly consistent with what was presented earlier, but specifically identifies the most harmful event, according to the case review. In over fifty percent of the overcorrection cases, the overturn was identified as the most harmful event. In 25 percent, a vehicle impact was the most harmful event. Interestingly, however, no harmful event is highly overrepresented in overcorrection cases, meaning that the outcomes of overcorrection cases are, in general, not that different than the outcomes of other ROR crashes.

Table 8.45: Most Harmful Event in ROR Overcorrection Crashes

Most Harmful Event	Overcorrection		No Overcorrection		ORF
	Number	**Percent**	**Number**	**Percent**	
Hit vehicle	51	25.25%	83	17.15%	**1.47**
Hit fixed object	32	15.84%	164	33.88%	**0.47**
Hit pedestrian	2	0.99%	21	4.34%	**0.23**
Multiple events	9	4.46%	19	3.93%	**1.13**
Hit bicycle	1	0.50%	4	0.83%	**0.60**
Entered water	2	0.99%	15	3.10%	**0.32**
Overturn	104	51.49%	169	34.92%	**1.47**
Others	1	0.50%	9	1.86%	**0.27**
Total	202	100.00%	484	100.00%	**1.00**

8.10 Fatality Contributing Factors and ROR Outcomes

This section of the report investigates fatality contributing factors in ROR crashes and looks in depth at ROR crash outcomes. The primary outcome of most ROR crashes is either a fixed object impact, a rollover, or both. However, case reviews showed that a number of other outcomes occurred in the set of ROR crashes. Table 8.46 begins by looking these "other outcomes." "Other" outcomes are defined as any outcome other than a fixed object impact or overturning, and were present in around 30 percent of the ROR crashes, with impacts with oncoming vehicles representing about half of the other outcomes. Running off the road into water was fairly uncommon, occurring less frequently than hitting a parked vehicle after running off the road. Twenty-two pedestrians and five bicyclists were also hit by vehicles that ran off the road. For these purposes, running off the road is defined as crossing a solid white line onto either a paved or unpaved shoulder, emergency lane, parking lane, or other part of the road not intended for vehicular travel.

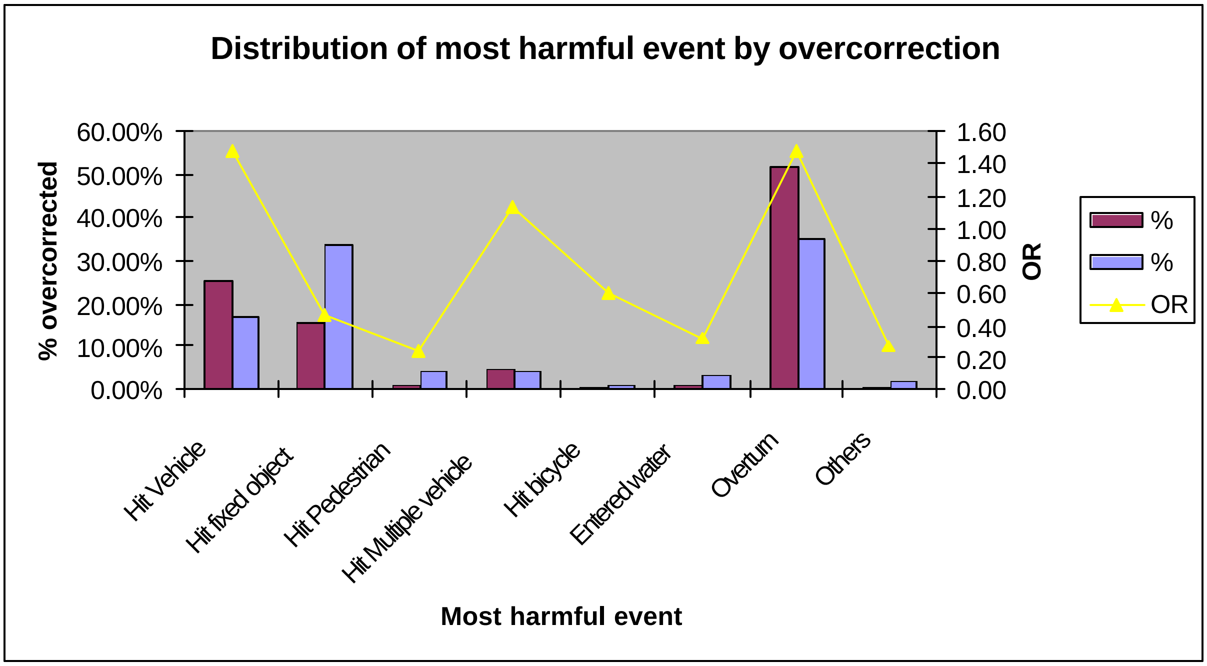

Figure 8.8: Most Harmful Event for ROR Overcorrection Crashes

Table 8.46: Other Outcomes of ROR Crashes

Other Outcome	Number	Percent
Bicycle On Shoulder	5	0.7%
Entered Water	28	4.1%
Hit Oncoming Vehicle	104	15.1%
Hit Parked Vehicle	20	2.9%
Hit Pedestrian and Parked Vehicle	13	1.9%
Hit Pedestrian	9	1.3%
Sideswipe and Oncoming	1	0.1%
Sideswipe/Rear End	23	3.3%
No Other Outcome	485	70.5%

Table 8.47 looks at the most harmful event in the primary and secondary ROR crashes. The most harmful event was determined by a case review of each ROR crash. Overturning was the most frequently cited harmful event, labeled as the most harmful event in almost 40 percent of the primary ROR crashes. Overturning was cited as most harmful event in only 15 percent of the secondary ROR crashes, making it highly underrepresented. Vehicle-vehicle impacts were

the most harmful event in about 20 percent of the ROR crashes; referring back to Table 8.46, it is evident that, if a vehicle-vehicle impact occurred in a ROR crash, it was typically the most harmful event in the crash (135 out of 161 primary crashes).

Entering the water was cited as the most harmful event in only 17 ROR crashes. It is important to note that the harmful event code for "Ran Off Road into Water" was frequently cited in cases where no water was found during the case review. One possibility was that officers used that code since no code for "Ran Off Road" existed. In one case, the officer actually marked out the words "Into Water," creating a "Ran Off Road" code where none existed. For the purposes of this report; however, all officer coding errors have been corrected, and the numbers represent the true circumstances of the crash. Fixed object impacts were cited as most harmful in approximately 30 percent of the crashes. In crashes where the fixed object acted only as a tripping mechanism, overturning was identified as the most harmful event, despite the fact that the fixed object initiated the overturn.

Table 8.47: Most Harmful Events in ROR Crashes

Most Harmful Event	Primary ROR		Secondary ROR		ORF
	Number	Percent	Number	Percent	
Entered Water	17	2.48%	1	0.29%	**8.537**
Fixed Object	196	28.61%	13	3.78%	**7.571**
Impact w/Ground	8	1.17%	1	0.29%	**4.018**
Multiple	28	4.09%	59	17.15%	**0.238**
Overturn	274	40.00%	53	15.41%	**2.596**
Vehicle-Train	0	0.00%	3	0.87%	**0.000**
Vehicle-Bicycle	5	0.73%	2	0.58%	**1.255**
Vehicle-Pedestrian	22	3.21%	6	1.74%	**1.841**
Vehicle-Vehicle	135	19.71%	206	59.88%	**0.329**
Total	685	100.00%	344	100.00%	**1.000**

Table 8.48 shows the distribution of run off road crashes where vehicle entered water bodies. These vehicle entered canals, water ponds, and lakes and were the cause of fatality to the occupants in most of the crashes. As the table shows, around one-third of the vehicles hit and penetrated a fence before they entered the canal or other water body. For cases where the fixed object was a concrete wall or guardrail, the vehicle typically fell from a bridge. In approximately one-third of crashes where a vehicle entered water, there was no fixed object or barrier.

Table 8.49 shows that only three vehicles entering water hit a fixed object within 15 feet of the edge of the outside travel lane. The highest percentage of fixed objects in these cases, including fences and guardrails, were between 60 and 90 feet from road.

Table 8.48: Distribution of Vehicles Entering Water by Fixed Object Impacted

Fixed Object	No of Vehicles	Percent
Concrete Culvert	2	7.14%
Concrete Wall	2	7.14%
Fence	9	32.14%
Guardrail	2	7.14%
Pole	1	3.57%
Tree	3	10.71%
None	9	32.14%
Total	28	100.00%

Table 8.49: Distribution of Vehicle Entering Water by Fixed Object Distance

Fixed Object	0-4'	5-9'	10-14'	15-19'	20-24'	30-60'	60-90'	90-120'	Total
Concrete Culvert	0	0	0	0	0	1	1	0	2
Concrete Wall	0	1	0	0	1	0	0	0	2
Fence	0	0	0	0	0	4	5	0	9
Guardrail	0	1	0	0	0	0	1	0	2
Pole	0	0	1	0	0	0	0	0	1
Tree	0	0	0	0	0	1	1	1	3
Total	0	2	1	0	1	6	8	1	19

ROR vehicles hitting fixed objects is a serious problem, acting as the most harmful event in almost one-third of the ROR crashes. Table 8.50 shows the distribution of fixed objects by type. Trees make the largest portion of fixed objects with around 30%, followed by poles and guardrails.

Table 8.50: Distribution of Fixed Objects by Type

Fixed Object	No of Vehicles	Percent
Concrete Barrier Wall	33	8.9%
Bridge column	10	2.7%
Concrete Wall (Private)	7	1.9%
Building	4	1.1%
Culvert	13	3.5%
Open Culvert	3	0.8%
Curb	6	1.6%
Fence	28	7.6%
Guardrail	73	19.8%
Sign Pole	22	6.0%

Table 8.50: Distribution of Fixed Objects by Type, continued

Fixed Object	No of Vehicles	Percent
Signal Pole	9	2.4%
Utility Pole	39	10.6%
Tree	114	30.9%
Attenuator	1	0.3%
Others	7	1.9%
Total	369	100.0%

Table 8.51 examines the number of vehicles that tripped as a result of fixed object impacts. Of the fixed object impacts, fewer than 20 percent tripped the vehicle, resulting in a rollover. Of the tripped rollovers, approximately 27% of the vehicles were tripped by trees, followed by guardrails, which tripped the vehicle in about one-fourth of the cases. Guardrails and fences are somewhat overrepresented; however, concrete culverts, culvert walls, and concrete barrier walls are highly overrepresented in tripping the impacting vehicle. Referring to Table 12.18 in the chapter on rollovers, note that another 236 vehicles tripped on the grass or soft soil on the shoulder, while only nine vehicles overturned due to the slope of a ditch or embankment. While overturning was not necessarily the most harmful event in all of these crashes, it indicates that tripping on soft shoulders is a much more important issue in Florida than tripping on fixed objects or rolling over due to steep slopes.

Table 8.51: Fixed Objects as Tripping Mechanisms in ROR Crashes

Fixed Object	Tripping Mechanism		Not Tripping Mechanism		ORF
	Number	Percent	Number	Percent	
Concrete Barrier Wall	9	9.3%	24	8.8%	**1.05**
Bridge column	2	2.1%	8	2.9%	**0.70**
Concrete Wall (Private)	2	2.1%	5	1.8%	**1.12**
Building	0	0.0%	4	1.5%	**0.00**
Culvert	9	9.3%	4	1.5%	**6.31**
Open culvert	2	2.1%	1	0.4%	**5.61**
Curb	6	6.2%	0	0.0%	**N/A**
Fence	11	11.3%	17	6.3%	**1.81**
Guardrail	23	23.7%	50	18.4%	**1.29**
Sign Pole	4	4.1%	18	6.6%	**0.62**
Signal Pole	1	1.0%	8	2.9%	**0.35**
Utility Pole	5	5.2%	34	12.5%	**0.41**
Tree	21	21.6%	93	34.2%	**0.63**
Attenuator	0	0.0%	1	0.4%	**0.00**
Barricade	1	1.0%	0	0.0%	**N/A**
Steel Beam	1	1.0%	0	0.0%	**N/A**

Table 8.51: Fixed Objects as Tripping Mechanisms in ROR Crashes, continued

Fixed Object	Tripping Mechanism		Not Tripping Mechanism		ORF
	Number	Percent	Number	Percent	
Attenuator	0	0.0%	1	0.4%	**0.00**
Boulder	0	0.0%	1	0.4%	**0.00**
Mail Box	0	0.0%	2	0.7%	**0.00**
Message Board	0	0.0%	1	0.4%	**0.00**
Total	97	100.0%	272	100.0%	**1.00**

Table 8.52 gives the distribution of ROR fixed objects by distance from the edge of the outside travel lane in the direction of the ROR departure. This line was used as a reference because it represented the final point at which the crash became a ROR crash, according to our definition of running off the road. The highest percentage of the vehicles hit fixed objects within 30-60 feet of the reference line. However, the main concern is about the ones that hit fixed objects between five and 14 ft. from the reference line, about 39% of the vehicles.

Table 8.52: Distribution of ROR Vehicles by Fixed object Distance

Fixed Object Distance (Ft.)		Number	Percent
0-30		214	57.84%
	0-4	13	3.51%
	5-9	68	18.38%
	10-14	74	20.00%
	15-19	30	8.11%
	20-24	13	3.51%
	25-29	16	4.32%
30-60		91	24.59%
	30-34	23	6.22%
	35-39	13	3.51%
	40-44	20	5.41%
	45-49	14	3.78%
	50-54	11	2.97%
	55-59	10	2.70%
60-90		34	9.19%
	60-64	9	2.43%
	65-69	8	2.16%
	70-74	2	0.54%
	75-79	10	2.70%
	80-84	3	0.81%
	85-89	2	0.54%

Table 8.52: Distribution of ROR Vehicles by Fixed object Distance, continued

Fixed Object Distance (Ft.)		Number	Percent
90-120		8	2.16%
	90-94	3	0.81%
	95-99	3	0.81%
	110-114	2	0.54%
120+		8	2.16%
Unknown		15	4.05%
Total		370	100.00%

Table 8.53.and Table 8.54 show ROR vehicles distributed by type of fixed object and direction of vehicle departure. Overall, about 60% of the impacts occurred within 30' of the edge of the travel lane, and 88% occurred within 60' of the lane edge. Guardrails, poles, and trees make the maximum number of crashes where vehicle hit within 0 to 30 feet from the reference line. These poles are those on the curbs or on the roadside. Concrete walls and trees make up the highest percentage of impacts following left-side departures. Trees are actually most common at 30 to 60 feet from the roadway.

Table 8.53: Distribution of ROR Fixed Object by Distance and Vehicle Direction

ROR Fixed Object	Fixed Object Distance							
	ROR Direction	0-30	30-60	60-90	90-120	120+	Total	%
Barrier Wall	Left	18	1	1	0	0	20	5.4%
	Right	10	3	0	0	0	13	3.5%
Building	Left	2	0	0	0	0	2	0.5%
	Right	2	0	0	0	0	2	0.5%
Bridge column	Left	3	0	0	0	0	3	0.8%
	Right	7	0	0	0	0	7	1.9%
Concrete Wall (Private)	Left	1	1	0	0	0	2	0.5%
	Right	2	3	0	0	0	5	1.4%
	Straight	0	0	0	0	0	0	0.0%
Culvert	Left	4	0	0	0	0	4	1.1%
	Right	8	1	0	0	0	9	2.4%
Curb	Left	4	1	0	0	0	5	1.4%
	Right	1	0	0	0	0	1	0.3%
Open culvert	Left	0	0	1	0	0	1	0.3%
	Right	2	0	0	0	0	2	0.5%
Fence	Left	0	3	5	0	0	8	2.2%
	Right	1	8	6	1	3	19	5.1%
	Straight	1	0	0	0	0	1	0.3%

Table 8.53: Distribution of ROR Fixed Object by Distance and Vehicle Direction, continued

ROR Fixed Object	Fixed Object Distance							
	ROR Direction	0-30	30-60	60-90	90-120	120+	Total	%
Guardrail	Left	34	2	3	0	0	39	10.6%
	Right	30	0	1	0	2	33	8.9%
	Straight	1	0	0	0	0	1	0.3%
Signal Pole	Left	2	0	0	0	0	2	0.5%
	Right	5	2	0	0	0	7	1.9%
Sign Pole	Left	7	0	0	0	0	7	1.9%
	Right	13	1	0	0	0	14	3.8%
	Straight	1	0	0	0	0	1	0.3%
Utility Pole	Left	7	1	2	0	0	10	2.7%
	Right	27	2	0	0	0	29	7.9%
Tree	Left	17	12	8	5	3	45	12.2%
	Right	26	32	10	0	0	68	18.4%
	Straight	1	0	0	0	0	1	0.3%
Attenuator	Left	1	0	0	0	0	1	0.3%
	Right	0	0	0	0	0	0	0.0%
Others	left	0	1	0	0	0	1	0.3%
	right	6	0	0	0	0	6	1.6%
Total		244	74	37	6	8	369	100.0%

Table 8.54: Distribution of Fixed Objects by Fixed Object Distance

Fixed object	0-30	30-60	60-90	90-120	120+	Total	%
Concrete Barrier Wall	28	4	1	0	0	33	8.9%
Bridge column	10	0	0	0	0	10	2.7%
Concrete Wall (Private)	3	4	0	0	0	7	1.9%
Building	4	0	0	0	0	4	1.1%
Culvert	12	1	0	0	0	13	3.5%
Open culvert	2	0	1	0	0	3	0.8%
Curb	5	1	0	0	0	6	1.6%
Fence	0	8	10	1	2	21	5.7%
Fence (Private)	2	3	1	0	1	7	1.9%
Guardrail	65	2	4	0	2	73	19.8%
Sign Pole (DOT)	13	7	0	0	0	20	5.4%
Sign Pole (Private)	1	1	0	0	0	2	0.5%
Signal Pole (DOT)	8	1	0	0	0	9	2.4%
Utility Pole	34	3	2	0	0	39	10.6%
Tree (Private)	4	2	0	0	0	6	1.6%

Table 8.54: Distribution of Fixed Objects by Fixed Object Distance, continued

Fixed object	0-30	30-60	60-90	90-120	120+	Total	%
Tree (DOT)	12	1	1	0	1	15	4.1%
Tree (Other)	28	41	17	5	2	93	25.2%
Attenuator	1	0	0	0	0	1	0.3%
Others	6	1	0	0	0	7	1.9%
Total	238	80	37	6	8	369	100.0%

Table 8.55 examines injury severity of vehicle occupants according to the type of fixed object impacted. Overall, around 55% of the occupants in vehicles that hit fixed objects had fatal injuries as a result. This is understandable because the study set only looks at fatal crashes. This table also shows that fatality rates did not vary that much depending on the type of object hit. However, of the frequently impacted objects, guardrails were associated with a somewhat lower fatality rate, while trees, poles and culverts had the highest percentage of fatalities.

Table 8.55: Distribution of Injury Severity by Fixed Object Impacted

Fixed Object	Injury Severity					Total Occupants	Percent Fatal
	1	2	3	4	5		
Concrete Barrier Wall	18	1	9	8	35	71	58.30%
Bridge column	0	0	0	1	12	13	60.00%
Concrete Wall (Private)	0	0	0	2	7	9	60.00%
Building	0	0	0	2	3	5	51.40%
Culvert	3	0	3	3	14	23	62.50%
Open culvert	0	2	1	0	3	6	45.50%
Curb	4	0	1	2	6	13	80.00%
Fence	5	4	13	7	31	60	50.80%
Guardrail	28	5	32	41	82	188	42.60%
Sign Pole	3	0	0	4	22	29	45.00%
Signal Pole	3	0	1	1	11	16	66.40%
Utility Pole	3	7	4	16	42	72	63.20%
Tree	14	3	22	35	128	202	100.00%
Attenuator	1	0	0	1	1	3	40.00%
Others	3	0	4	3	7	17	55.00%
Total	85	22	90	126	404	727	

Table 8.56 and Figure 8.9 show injury severity according to safety equipment use for occupants of ROR vehicles with at least four wheels. More than 67% of the unbelted occupants had fatal injuries within 90 days of the crash. However, the data also shows a high rate of fatal injuries when safety belts were in use, around 51%. In a few cases, these fatalities were related

to safety belt failure or partial ejection during vehicle overturning; however, most were due to vehicles hitting fixed objects.

Table 8.56: Distribution of Injury Severity by Safety Equipment Use

Safety Equipment	Injury Severity						
	1	2	3	4	5	Total	Percent
Not in use	14	11	43	110	330	508	50%
Safety belt/Shoulder harness	18	13	31	27	95	184	18%
Child restraint	0	3	2	3	1	9	1%
Air bag	4	0	5	26	104	139	14%
Seat belt and child restraint	5	0	3	7	22	37	4%
Child restraint and air bag	1	0	1	0	1	3	0%
Seat belt and air bag	10	6	26	26	74	142	14%
Total	52	33	111	199	627	1022	100%
Percent	5%	3%	11%	19%	61%	100%	

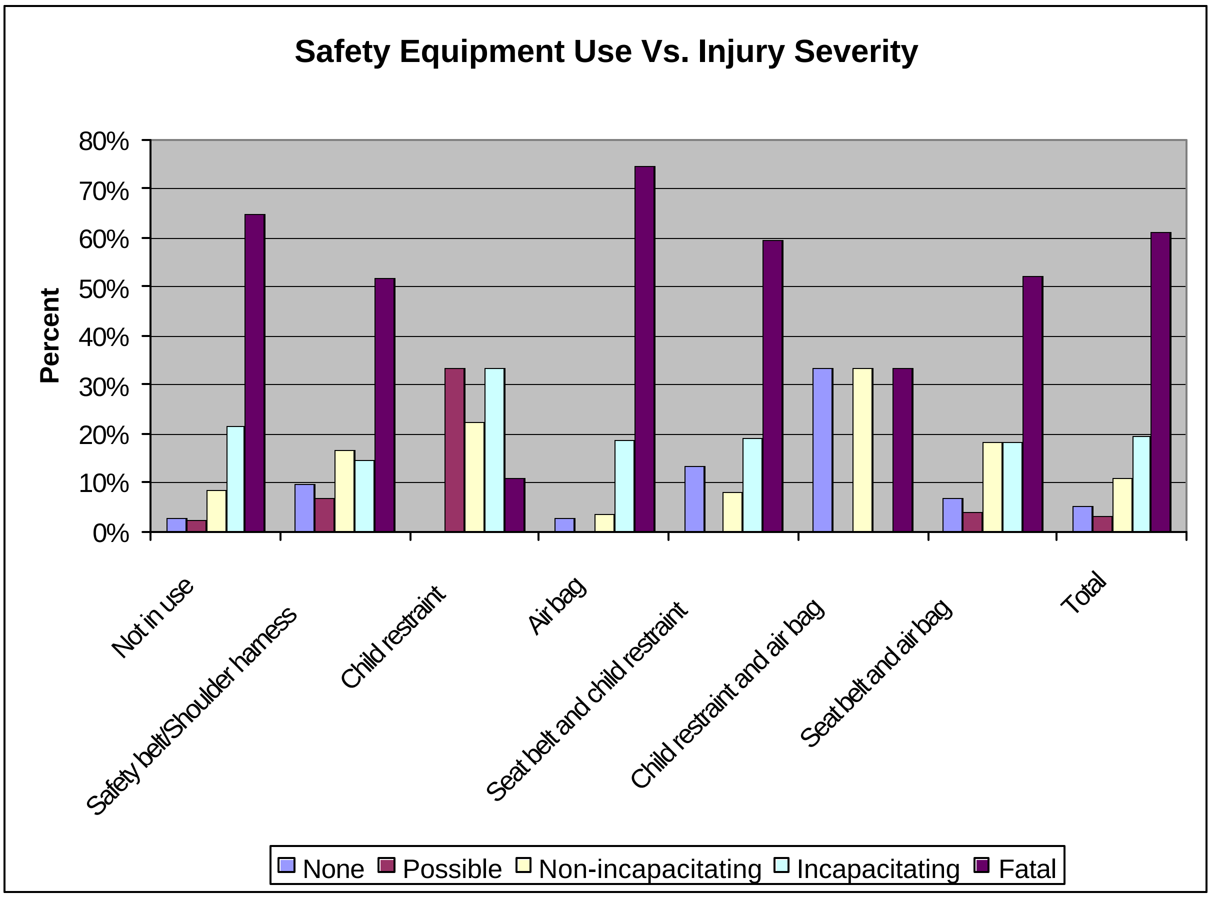

Figure 8.9: Distribution of Injury Severity by Safety Equipment Use

Table 8.57 repeats the same information for ROR motorcyclists. Note that 70 percent of the motorcyclists that ran off the road were using a safety helmet at the time of the crash. Despite this, almost 90 percent of the occupants suffered fatal injuries in the ROR crash. Regardless of the safety equipment used, at least 85% of the occupants of the motorcyclists died.

Table 8.57: Distribution of Injury Severity by Safety Equipment Use for Motorcyclists

Safety Equipment	Injury Severity						
	1	2	3	4	5	Total	Percent
Not in use	0	0	1	0	7	8	24%
Safety helmet	0	0	0	1	8	9	26%
Eye protection	0	0	0	0	2	2	6%
Safety helmet and eye protection	1	0	0	1	13	15	44%
Total	1	0	1	2	30	34	100%
Percent	3%	0%	3%	6%	88%	100%	

Table 8.58, Table 8.59, and Table 8.60 look at safety equipment use and injury severity for ROR crashes with most harmful events of fixed object, overturn, and vehicle-vehicle. Table 8.61 summarizes the results according to most harmful event and seat belt use. To look only at the effect of seat belts, all categories where a seat belt or child restraint was used were combined, as were the categories with no seat belts. Only 36 percent of belted occupants died in rollover crashes, compared to almost twice the percentage in other crash types. This indicates that the rollover is comparatively a less severe event for belted occupants, and that increased rates of seat belt use would be particularly effective in preventing deaths in rollover crashes. In fixed object and vehicle-vehicle crashes, seat belt use was less effective in preventing fatal injuries, indicating that the most effective countermeasure in fixed object and vehicle-vehicle crashes is to reduce the number or severity of the collisions, rather than focusing on increasing seat belt use.

Table 8.58: Injury Severity Versus Safety Equipment Use in ROR Fixed Object Impacts

Safety Equipment	Injury Severity						
	1	2	3	4	5	Total	Percent
Not in use	3	4	7	22	97	133	47.2%
Safety belt/Shoulder harness	1	1	6	4	31	43	15.2%
Child restraint	0	0	0	1	0	1	0.4%
Air bag	1	0	2	6	39	48	17.0%
Seat belt and child restraint	0	0	1	1	10	12	4.3%
Child restraint and air bag	3	0	5	11	25	44	0.4%
Seat belt and air bag	1	0	0	0	0	1	15.6%
Total	9	5	21	45	202	282	100.0%
Percent	3%	2%	7%	16%	72%	100%	

Table 8.59: Injury Severity Versus Safety Equipment Use in Overturn ROR Crashes

Safety Equipment	Injury Severity						
	1	2	3	4	5	Total	Percent
Not in use	5	4	29	66	164	268	61%
Safety belt/Shoulder harness	5	6	19	13	22	65	15%
Child restraint	0	3	0	1	1	5	1%
Air bag	0	0	1	13	47	61	14%
Seat belt and child restraint	1	0	1	3	7	12	3%
Child restraint and air bag	0	0	1	0	1	2	0%
Seat belt and air bag	0	2	8	7	12	29	7%
Total	11	15	59	103	254	442	100%
Percent	2%	3%	13%	23%	57%	100%	

Table 8.60: Injury Severity Versus Safety Equipment Use in Vehicle-Vehicle ROR Crashes

Safety Equipment	Injury Severity						
	1	2	3	4	5	Total	Percent
Not in use	1	1	5	15	41	63	34%
Safety belt/Shoulder harness	2	3	4	8	30	47	26%
Child restraint	0	0	1	1	0	2	1%
Air bag	1	0	2	5	11	19	10%
Seat belt and child restraint	1	0	1	2	4	8	4%
Child restraint and air bag	0	0	0	0	0	0	0%
Seat belt and air bag	1	2	5	7	29	44	24%
Total	6	6	18	38	115	183	100%
Percent	3%	3%	10%	21%	63%	100%	

Table 8.61: Injury Severity by Seat Belt Use and Most Harmful Event

Injury Severity	Fixed Object		Overturn		Vehicle-Vehicle	
	Not in use	Seat belt	Not in use	Seat belt	Not in use	Seat belt
None	4	5	5	5	2	3
Possible	4	1	4	11	1	5
Non-incapacitating	9	11	30	28	7	10
Incapacitating	28	16	79	21	20	16
Fatal	136	56	211	36	52	59
Total	181	89	329	101	82	93
Percent Fatal	75.1%	62.9%	64.1%	35.6%	63.4%	63.4%

Table 8.62 and Figure 8.10 examine injury severity according to ejection rates in ROR crashes. As shown in Figure 8.10, over 55 percent of the occupants who were not ejected suffered fatal injuries in the ROR crashes; however over 70 percent of those who were ejected suffered fatal injuries, and over 90 percent of those who were partially ejected suffered fatal injuries.

Table 8.62: Injury Severity According to Ejection Rates

Injury Severity	Ejection				
	No	Yes	Partial	Total	Percent
1	48	4	0	52	5.1%
2	31	2	0	33	3.2%
3	95	16	0	111	10.9%
4	119	77	3	199	19.5%
5	354	240	33	627	61.4%
Total	647	339	36	1022	100.0%
Percent	63.3%	33.2%	3.5%	100.0%	

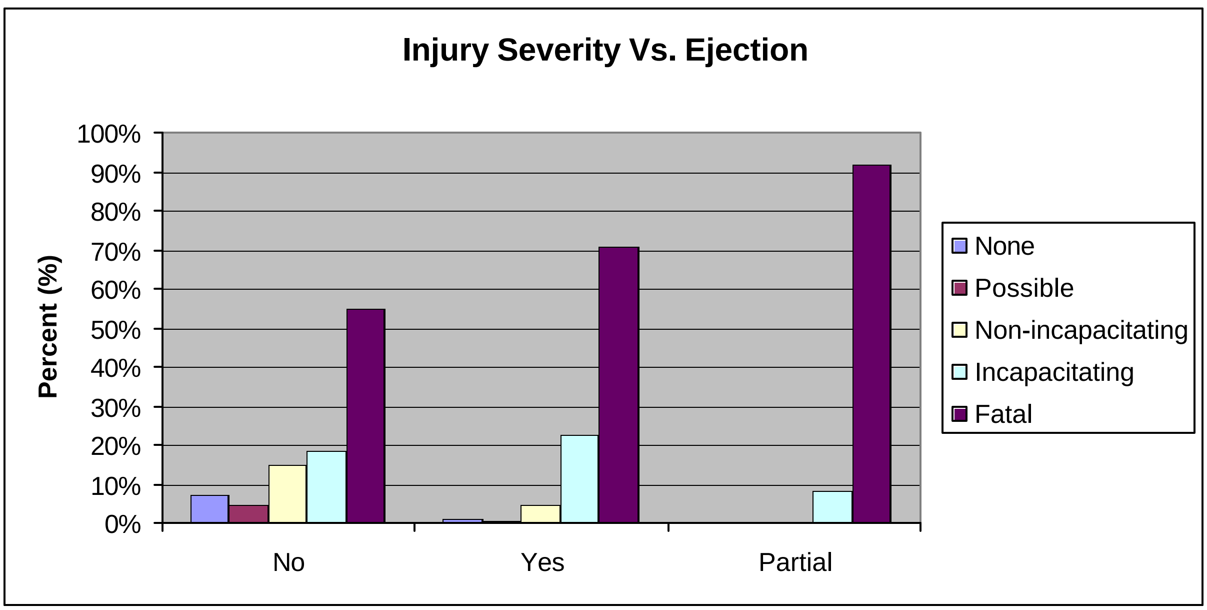

Figure 8.10: Injury Severity Versus Ejection

Table 8.63 and Figure 8.11 look at ejection rates according to safety equipment use. As shown in Table 8.63, 312 of the 339 occupants ejected in ROR crashes were not wearing seat belts (92 percent). Figure 8.11 shows this graphically, indicating that, when seat belts or child restraints were used, at least 70 percent of the occupants remained in the vehicle. Only eight percent of ejected occupants were wearing seatbelts; however, 20 percent of partially ejected occupants were wearing seat belts. This indicates that seat belt designs could be improved to prevent lateral movement and partial ejection, more common in rollover crashes. However, given the fact that ejection correlates strongly with high fatality rates, and wearing seat belts is inversely correlated with ejection, wearing seat belts can be strongly encouraged to reduce ejection and subsequent severe injuries.

Table 8.63: Ejection According to Safety Equipment Use

Safety Equipment	Ejection				
	No	Yes	Partial	Total	Percent
Not in use	240	245	23	508	49.7%
Safety belt/Shoulder harness	172	11	1	184	18.0%
Child restraint	9	0	0	9	0.9%
Air bag	66	67	6	139	13.6%
Seat belt and child restraint	26	10	1	37	3.6%
Child restraint and air bag	3	0	0	3	0.3%
Seat belt and air bag	131	6	5	142	13.9%
Total	647	339	36	1022	100.0%
Percent	63.3%	33.2%	3.5%	100.0%	

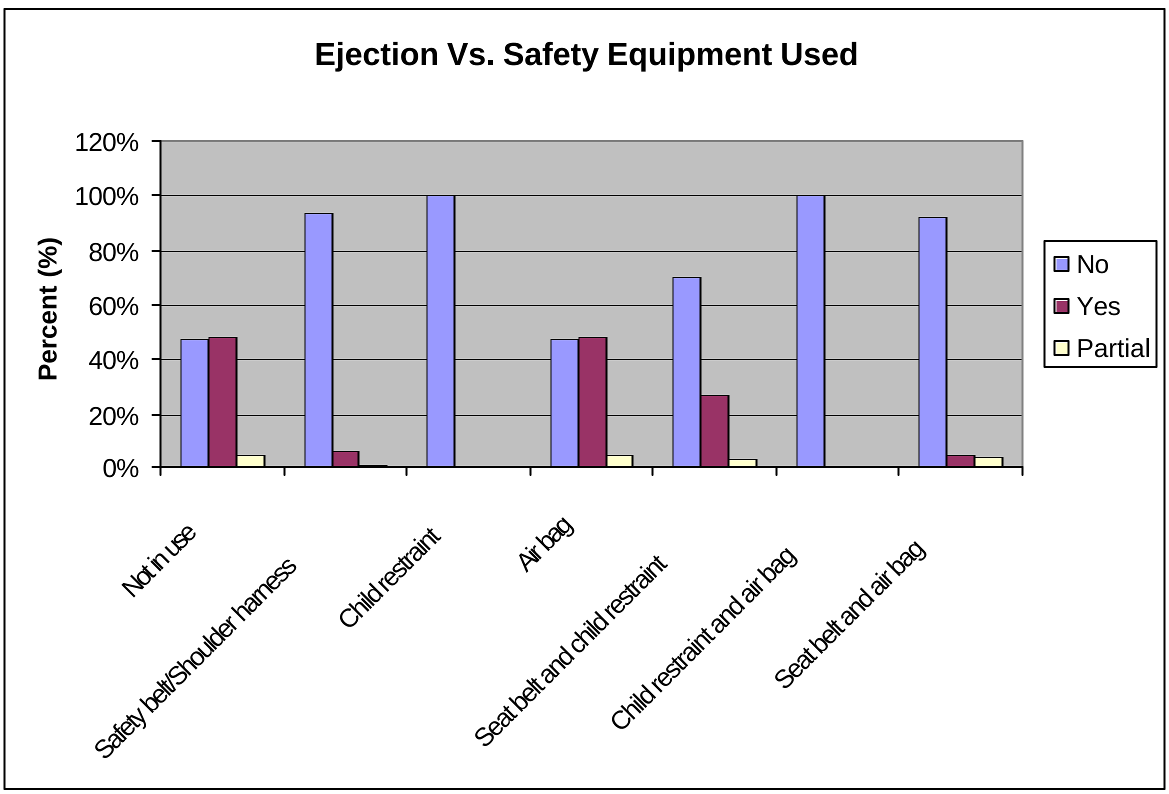

Figure 8.11: Ejection Versus Safety Equipment Used

To summarize, 627 occupants of vehicles in ROR crashes suffered fatal injuries. Of those occupants,

- 348 (56 percent) were in automobiles (Vehicle type = 01).
- 273 (44 percent) were ejected or partially ejected. As shown in Table 8.64, the most harmful event for ejected occupants who died is overturning.
- 434 (69 percent) were not wearing seat belts. As shown in Table 8.65, the most harmful event for *belted* occupants who died was a fixed object impact.
- 254 (41 percent) were in crashes where overturning was the most harmful event.
- 202 (32 percent) were in crashes where a fixed object impact was the most harmful event.

Table 8.64: Most Harmful Event for Ejected Occupants

Most Harmful Event	Number	Percent
Entered Water	1	0.4%
Fixed Object	50	18.3%
Impact w/ground	3	1.1%
Multiple	6	2.2%
Overturn	188	68.9%
Vehicle-vehicle	25	9.2%
Total	273	100.0%

Table 8.65: Most Harmful Event for Belted Occupants

Most Harmful Event	Number	Percent
Entered Water	9	4.7%
Fixed Object	66	34.4%
Impact w/ground	1	0.5%
Multiple	10	5.2%
Overturn	43	22.4%
Vehicle-vehicle	63	32.8%
Total	192	100.0%

8.11 Comparison of Contributing Factors in ROR Crashes on Limited and Non-Limited Access Facilities

Various crash contributing factor s for limited access and non-limited access road have been classified to see some pattern. This is an interesting comparison for a number of reasons. First, dividing the roadways into limited and non-limited access divides the set of ROR crashes almost perfectly in half. Second, the characteristics of limited access roads are much different than those of other roads, especially in the design of the roadside and its "forgiveness" of a ROR event. Third, the rates of ROR and non-ROR crashes are much different on limited access roads when compared to non-limited access roads: as shown in Table 8.22, ROR crashes are significantly overrepresented on almost all classes of limited access roads when compared to other types of crashes, yet they are underrepresented on most non-limited access roads.

Table 8.66 gives the distribution of ROR crashes on limited and non-limited access roads. Over half of the ROR crashes on limited access roads occur on the left side, with one-third involving control loss. On non-limited access roads, over 60 percent of the crashes are due to right roadside departure, most without control loss. This different pattern is due to the high rate of left-side departments involving high-speed vehicles on the limited access road with medians.

Table 8.66: Primary Crash Type of ROR Crashes on Limited and Non-Limited Access Roads

Crash Type Code	Crash Type	Limited Access		Non limited Access		ORF	Min CI	Max CI	Level
		Num.	Per.	Num.	Per.				
20	Right side departure	83	24.1%	143	42.9%	**0.56**	0.448	0.701	Under
21	Right side departure w/control loss	48	13.9%	61	18.3%	**0.76**	0.537	1.074	Unsure
22	Left side departure	81	23.5%	60	18.0%	**1.30**	0.967	1.755	Unsure
23	Left side departure w/control loss	105	30.4%	57	17.1%	**1.78**	1.337	2.365	Over
24	Straight/End of pavement	0	0.0%	6	1.8%	**N/A**	N/A	N/A	N/A
25	Ramp departure	28	8.1%	6	1.8%	**4.51**	1.889	10.738	Over
	Total	345	100.0%	333	100%	**1.00**			

Table 8.67 shows crash contributing factors on limited access roads. Comparing the various crash contributing factors with non-limited access road from Table 8.68, alcohol is more prevalent as a contributing factor in ROR crashes on the non-limited access roads, as is speed. Inattention and fatigue are about twice as common on limited access facilities. Curvature, wet conditions, and abrupt steering input are about equally common. Recall that approximately the same number of ROR crashes occur on limited as on non-limited access facilities.

Table 8.67: Crash Contributing Factors for ROR Crashes on Limited Access Roads

Class	Factor	Primary	Secondary	Tertiary	Total
Human	Alcohol	79	6	1	86
	Drugs	18	6	2	26
	Confusion	0	3	0	3
	Police Pursuit	1	1	1	3
	Aggression	5	4	0	9
	Decision Error	3	0	2	5

Table 8.67: Crash Contributing Factors for ROR Crashes on Limited Access Roads, continued

Class	Factor	Primary	Secondary	Tertiary	Total
Human	Distraction	8	3	2	13
	Medical	11	4	0	15
	Alcohol and Drugs	8	1	0	9
	Abrupt Steering Input	26	61	29	116
	Inattention	33	24	5	62
	Fatigue/Asleep	30	4	1	35
	Speed	38	55	11	104
	Age	0	2	3	5
	Inexperience	0	2	1	3
	Mental/Emotional	2	5	0	7
	History	0	1	4	5
Environment	Smoke/Fog	0	1	1	2
	Dark	0	3	6	9
	Wind	1	0	0	1
	Wet/Slippery	7	20	21	48
Vehicle	Defect	4	0	0	4
	Disabled	0	7	5	12
	Stability	0	2	0	2
	Trailer	0	1	1	2
	Jackknifed	0	3	2	5
	Load shift/Fall	3	1	2	6
	Tire	34	7	3	44
Roadway	Lighting	0	3	17	20
	Congestion	1	3	4	8
	Obstruction	2	3	1	6
	Access Point	0	6	7	13
	Construction	1	4	2	7
	Shoulder	0	1	1	2
	Transition	0	0	2	2
	Curvature	2	13	21	36
	Standing Water	3	0	1	4
	Maintenance	0	2	0	2
	Obstructed View	0	2	0	2
	Unfamiliar area	0	0	1	1
	Sight Distance	0	0	1	1
Unknown		23	0	2	25
Total		343	264	163	770

Table 8.68: Crash Contributing Factors for ROR Crashes on Non-Limited Access Roads

Class	Factor	Primary	Secondary	Tertiary	Total
Human	Alcohol	105	4	1	110
	Drugs	13	4	1	18
	Confusion	3	2	0	5
	Police Pursuit	1	3	0	4
	Aggression	6	3	1	10
	Decision Error	7	8	2	17
	Distraction	5	1	0	6
	Medical	19	3	0	22
	Alcohol and Drugs	17	0	0	17
	Abrupt Steering Input	26	53	27	106
	Inattention	12	15	7	34
	Fatigue/Asleep	11	5	1	17
	Speed	57	71	7	135
	Age	0	5	2	7
	Inexperience	1	3	4	8
	Mental/Emotional	0	3	2	5
	History	0	2	2	4
	Unfamiliar w/Area	0	2	0	2
Environment	Smoke/Fog	1	1	4	6
	Dark	0	8	9	17
	Wind	0	0	0	0
	Wet/Slippery	9	14	17	40
Vehicle	Defect	1	1	2	4
	Disabled	0	0	0	0
	Stability	0	2	2	4
	Trailer	0	1	1	2
	Jackknifed	0	1	0	1
	Load Shift/Fall	0	0	1	1
	Tire	7	3	2	12
Roadway	Lighting	0	1	16	17
	Congestion	0	0	3	3
	Obstruction	1	1	0	2
	Access Point	6	7	10	23
	Construction	0	5	4	9
	Shoulder	0	0	4	4
	Transition	0	2	0	2
	Curvature	2	14	26	42
	Standing Water	1	3	1	5
	Maintenance	0	3	0	3

Table 8.68: Crash Contributing Factors for ROR Crashes on Non-Limited Access Roads, continued

Class	Factor	Primary	Secondary	Tertiary	Total
Roadway	Obstructed View	0	0	0	0
	Sight Distance	0	0	3	3
Unknown		27	0	0	27
Total		338	254	162	754

Table 8.69 shows that ROR crashes by driver age on limited and non-limited access roads are fairly evenly distributed. It can be seen that for driver age between 15-34 and 45-54 run off road crashes on limited access are over represented and for rest all other groups are under represented; however, very few of these differences are either large or statistically significant.

Table 8.69: ROR Crashes by Driver's Age on Limited and Non-Limited Access Roads

Age	Limited Access		Non-Limited Access		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
15-24	102	29.39%	89	26.25%	**1.12**	0.88	1.43	Unsure
25-34	83	23.92%	70	20.65%	**1.16**	0.87	1.53	Unsure
35-44	65	18.73%	66	19.47%	**0.96**	0.71	1.31	Unsure
45-54	46	13.26%	41	12.09%	**1.10**	0.74	1.62	Unsure
55-64	27	7.78%	28	8.26%	**0.94**	0.57	1.56	Unsure
65-74	10	2.88%	23	6.78%	**0.42**	0.21	0.88	Under
75-84	8	2.31%	12	3.54%	**0.65**	0.27	1.57	Unsure
85-94	1	0.29%	4	1.18%	**0.24**	0.03	2.17	Unsure
95-104	0	0.00%	0	0.00%	**0.00**	0.00	0.00	
Unknown	5	1.44%	6	1.77%	**0.81**	0.25	2.64	Unsure
Total	347	100.00%	339	100.00%	**1.00**			

Results from Table 8.70 show that most levels of alcohol use are underrepresented or neutral on limited access facilities, while being tested or presumed to have 0.00% BAC is overrepresented on limited access facilities. It shows that more ROR drivers on non-limited access road are driving under influence of alcohol. This is in keeping with the fact that alcohol use contributed to fewer crashes on limited access roads.

Table 8.70: ROR Crashes by Alcohol Use on Limited and Non-Limited Access Roads

Alcohol Use	Limited Access		Non-Limited Access		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
0.00 Tested	167	48.13%	109	32.15%	**1.50**	1.24	1.81	Over
0.00 Presumed	57	16.43%	26	7.67%	**2.14**	1.38	3.32	Over
< Limit	22	6.34%	17	5.01%	**1.26**	0.68	2.34	Unsure
1-2 X Limit	19	5.48%	26	7.67%	**0.71**	0.40	1.27	Unsure
2-3 X Limit	36	10.37%	57	16.81%	**0.62**	0.42	0.91	Under
3-4 X Limit	17	4.90%	17	5.01%	**0.98**	0.51	1.88	Unsure
>4 X Limit	0	0.00%	3	0.88%	**0.00**	N/A	N/A	N/A
> 0	0	0.00%	3	0.88%	**0.00**	N/A	N/A	N/A
> Limit	0	0.00%	1	0.29%	**0.00**	N/A	N/A	N/A
UK	29	8.36%	80	23.60%	**0.35**	0.24	0.53	Under
Total	347	100.00%	339	100.00%	**1.00**			

Table 8.71 and Table 8.72 give the vehicle speed distribution on limited access and non-limited access roads. Table 8.71 shows that almost 80 percent of the crashes on limited access facilities occurred on segments with speed limits of 65 mph and up. However, speeding was increasingly a problem at lower speed limits. On other roads, the same trend can be seen, although it is not quite so exaggerated. Overall, about 10 percent of the ROR crashes on non-limited access roads occur on segments with speed limits of 65 mph and up.

Table 8.71: Distribution of ROR Vehicles by Speed on Limited Access Roads

Posted Speed	Number at or below posted speed	Number above posted speed	Percent above posted speed	Number >10 above posted speed	Percent >10 above posted speed	Total Vehicles
40-	0	3	50.00%	3	50.00%	6
45-50	0	7	63.64%	4	36.36%	11
55-60	13	24	50.00%	11	22.92%	48
65+	115	88	36.82%	36	15.06%	239
Total	128	122	40.13%	54	17.76%	304

Table 8.73 shows lighting condition as a factor in ROR crashes on limited access roads. It can be seen that about 53 percent of the ROR crashes on limited access roads occurred in the daylight. Table 8.74 shows that only 43 percent of the crashes on non-limited access facilities occur during the daylight. Of crashes occurring in darkness, streetlights are about equally common in crashes on limited and non-limited access facilities. This is notable because limited access facilities are unlit over most of their length, yet a high percentage (42 percent) of the nighttime crashes occur on segments with street lights. On limited access roadways, right side

departure is more strongly associated with darkness, probably due to fatigue occurring at night. On non-limited access roads, control loss was somewhat more common at night.

Table 8.72: Distribution of ROR Vehicles by Speed on Non-Limited Access Roads

Posted Speed	Number at or below posted speed	Number above posted speed	Percent above posted speed	Number >10 above posted speed	Percent >10 above posted speed	Total Vehicles
40-	12	29	49.15%	18	30.51%	59
45-50	19	38	47.50%	23	28.75%	80
55-60	63	47	34.06%	28	20.29%	138
65+	15	11	35.48%	5	16.13%	31
Total	109	125	40.58%	74	24.03%	308

Table 8.73: ROR Crashes by Crash Type and Lighting Condition on Limited Access Roads

Crash Type	Daylight	Dusk	Dawn	Dark (Street Light)	Dark (No Street Light)	Unknown	% Dark
Right departure	39	0	1	16	27	0	52%
Right w/control loss	21	0	2	11	14	0	52%
Left departure	48	1	3	15	14	0	36%
Left w/control loss	63	2	3	9	28	0	35%
Straight	0	0	0	0	0	0	0%
Ramp	11	0	0	10	4	0	56%
Total	182	3	9	61	87	0	
Percent	53%	1%	3%	18%	25%	0%	

Table 8.74: ROR Crashes by Crash Type and Lighting Condition on Non-Limited Access Roads

Crash Type	Daylight	Dusk	Dawn	Dark (Street Light)	Dark (No Street Light)	Unknown	% Dark
Right departure	69	3	6	26	39	0	45%
Right w/control loss	19	0	2	19	21	0	66%
Left departure	28	1	2	12	17	0	48%
Left w/control loss	25	1	1	13	16	1	51%
Straight	0	0	0	3	3	0	100%
Ramp	4	0	0	3	0	0	43%
Total	145	5	11	76	96	1	
Percent	43%	1%	3%	23%	29%	0%	

Table 8.75 gives the distribution of ROR crashes on limited and non-limited access roads according to whether roadway curvature was present. Table 8.75 shows that 22% of the ROR crashes on limited access roads occurred on curves, while 26% of the ROR crashes on non-limited access roads occurred on curves. This means that curvature is slightly underrepresented on limited access roads, although the differences are neither large nor significant.

Table 8.75: ROR Crashes on Roads with Curvature on Limited and Non Limited Access Roads

	Limited Access		Non-Limited Access		ORF	Min CI	Max CI	Level
	Number	Percent	Number	Percent				
Curvature	76	22.2%	88	26.3%	**0.84**	0.65	1.10	Unsure
No Curvature	267	77.8%	247	73.7%	**1.06**	0.97	1.15	Unsure
Total	343	100.0%	335	100.0%	**1.00**			

Table 8.76 shows the radius of curvature in ROR crashes on limited access and non-limited access involving roadway curvature. As would be expected, most curves on limited access facilities are shallow curves with large radii. On ramps of limited access facilities, most of the crashes occurred on tight curves. On non-limited access roads, both tight and shallow curves were common in ROR crashes.

Table 8.76: Curvature in ROR Crashes on Limited Access and Non-Limited Access Roads

Radius of Curvature	Limited Access Mainline		Limited Access Ramps		Non-Limited Access	
	Number	Percent	Number	Percent	Number	Percent
<500	3	4.84%	15	40.54%	5	5.75%
500-1499	11	17.74%	6	16.22%	27	31.03%
1500-2499	7	11.29%	1	2.70%	23	26.44%
2500-3499	13	20.97%	0	0.00%	11	12.64%
≥3500	28	45.16%	0	0.00%	21	24.14%
UK	0	0.00%	15	40.54%	0	0.00%
Total	62	100.00%	37	100.00%	87	100.00%

Table 8.77 shows overcorrection outcome on limited and non-limited access. It can be from the total number of cases that overcorrection is equally common on limited and non-limited access facilities. On non-limited access roads, the result of overcorrection was much more likely to be impact with a vehicle in the opposite direction. This is because more of these crashes occur on segments with no or small medians, increasing the likely of a head-on collision. In the same way, an impact with a vehicle traveling in the same direction is much more common on limited access facilities. Overall, however, the most common outcomes of overcorrection on both limited and non-limited access roads are running off the road again on the opposite side from the initial ROR direction.

Table 8.77: Outcome of ROR Overcorrection on Limited and Non-Limited Access

Outcome	Limited Access	Percent	Non Limited Access	Percent	ORF
Vehicle Impact, Same	13	14.44%	7	8.24%	**1.75**
Vehicle Impact, Opposite	10	11.11%	22	25.88%	**0.43**
ROR, Same	31	34.44%	24	28.24%	**1.22**
ROR, Opposite	34	37.78%	29	34.12%	**1.11**
Overturn	2	2.22%	3	3.53%	**0.63**
Total	90	100.00%	85	100.00%	**1.00**

Table 8.78 shows other outcomes of ROR on limited and non-limited access roads. The results show that bicycle and pedestrian impacts are much more common following ROR events on non-limited access facilities; however impacts with both a pedestrian and a parked vehicle are highly overrepresented on limited access facilities. Running off the road into water and sideswipe/rear-end crashes of vehicles traveling in the same direction (after overcorrection) are both highly overrepresented on limited access facilities also.

Table 8.78: Other Outcomes of ROR Crashes on Limited and Non-Limited Access Roads

Other Outcome	Limited Access		Non-Limited Access		ORF
	Number	Percent	Number	Percent	
Bicycle On Shoulder	0	0.00%	5	1.47%	**N/A**
Entered Water	19	5.48%	9	2.65%	**2.06**
Hit Oncoming Vehicle	57	16.43%	47	13.86%	**1.18**
Hit Parked Vehicle	11	3.17%	9	2.65%	**1.19**
Hit Pedestrian and Parked Vehicle	12	3.46%	1	0.29%	**11.72**
Hit Pedestrian	1	0.29%	8	2.36%	**0.12**
Sideswipe and Oncoming	1	0.29%	0	0.00%	**N/A**
Sideswipe/Rear End	17	4.90%	6	1.77%	**2.77**
No Other Outcome	229	65.99%	254	74.93%	**0.88**
Total	347	100.00%	339	100.00%	**1.00**

Table 8.79 shows the most harmful event of both the primary and secondary ROR crashes on limited and non-limited access facilities. Table 8.79 shows that more than one third of crashes on limited access roads had overturn as the most harmful event, compared to about 29 percent of the crashes on non-limited access roads. Fixed object crashes, on the other hand, were somewhat underrepresented on limited access roads. Crashes on limited access roads were roughly twice as likely to involve multiple events or entering water as those on non-limited access roads. Because secondary ROR crashes are also included in this chart, vehicle-vehicle impacts are very common on both limited and non-limited access roads.

Table 8.79: Most Harmful Events in ROR Primary and Secondary Crashes on Limited and Non Limited Access Roads

Most Harmful Event	Limited Access		Non Limited Access		ORF
	Number	Percent	Number	Percent	
Entered Water	12	2.49%	7	1.28%	**1.96**
Fixed Object	84	17.46%	124	22.59%	**0.77**
Impact w/Ground	5	1.04%	6	1.09%	**0.95**
Multiple	55	11.43%	32	5.83%	**1.96**
Overturn	168	34.93%	158	28.78%	**1.21**
Vehicle-Train	0	0.00%	3	0.55%	**0.00**
Vehicle-Bicycle	1	0.21%	6	1.09%	**0.19**
Vehicle-Pedestrian	15	3.12%	13	2.37%	**1.32**
Vehicle-Vehicle	141	29.31%	200	36.43%	**0.80**
Total	481	100.00%	549	100.00%	**1.00**

Distribution of fixed object crashes in Table 8.80 show that, overall, fixed object crashes are somewhat less likely on limited access roads. On limited access roads, guardrails and trees are the most commonly impacted fixed objects, followed by concrete walls and poles; on non-limited access roads, trees and poles are most common, followed by guardrails and concrete walls. Barrier walls and guardrails are highly overrepresented on limited access facilities, while poles, culvert walls, bridge columns, and other less frequently impacted structures are underrepresented.

8.12 Conclusions

Examining all the run off the road crashes one gets a picture of a substantial number of ROR crashes occurring on rural limited access facilities, involving younger drivers and those under the influence of alcohol. Running off the road to the left was almost as common as running off the road to the right, due to the high number of divided highways in which the ROR event involved median crossovers. About five percent of the ROR crashes involved ramp departures, and fewer than one percent involved end of pavement at T-intersections.

Approximately 25 percent of the crashes in the study set are not traditional ROR crashes, but crashes where the vehicle left the roadway at a gentle angle, then over-steered back onto the roadway, resulting in a loss of control and a subsequent crash either with another vehicle, a fixed object on the same or opposite side of the road, or overturning because of loss of lateral stability. Overcorrection cases were strongly associated with alcohol, inattention, and fatigue/asleep, all factors that might cause the driver to drift off the roadway, and high speed, which tends to be associated with the vehicle's tires encroaching on the shoulder during aggressive passing maneuvers. Younger drivers are more prone to overcorrection crashes, and overcorrection was about 50 percent more likely to occur on road segments with rumble strips. The most common outcome of overcorrection was running off the road again, either on the opposite side (36 percent of the cases) or on the same side (33 percent of the cases). Fewer than 30 percent hit another vehicle (either in the same or opposite direction) following an overcorrection. Fewer than five percent of the fatal crashes occurred after redirection by either a guardrail or a longitudinal barrier.

Table 8.80: Distribution of Fixed Objects by Type on Limited and Non-Limited Access

Fixed Object	Limited Access		Non-Limited Access		ORF
	Num.	Per.	Num.	Per.	
Concrete Barrier Wall	26	15.3%	7	3.5%	4.35
Bridge column	6	3.5%	4	2.0%	1.76
Concrete Wall (Private)	0	0.0%	7	3.5%	0.00
Building	0	0.0%	4	2.0%	0.00
Culvert	3	1.8%	10	5.0%	0.35
Open culvert	2	1.2%	1	0.5%	2.34
Curb	1	0.6%	5	2.5%	0.23
Fence	15	8.8%	13	6.5%	1.35
Guardrail	52	30.6%	21	10.6%	2.90
Sign Pole	10	5.9%	12	6.0%	0.98
Signal Pole	2	1.2%	7	3.5%	0.33
Utility Pole	5	2.9%	34	17.1%	0.17
Tree	46	27.1%	68	34.2%	0.79
Attenuator	1	0.6%	0	0.0%	N/A
Others	1	0.6%	6	3.0%	0.20
Total	170	100.0%	199	100.0%	1.00

Alcohol, speed, and abrupt steering input are the most common driver contributing factors in all ROR crashes, where alcohol is by far the most common primary contributing factor. Over twenty five percent of the ROR drivers had BAC's that were over the legal limit at the time of the crash, and another five percent had some alcohol in their system. Abrupt steering input relates to both overcorrection following an unintentional drifting off the road, and to evasive maneuvers due to traffic conditions and in response to other driver behaviors. Inattention was cited as an important factor in about 15 percent of the crashes, and fatigue or sleep in about seven percent. Wet or slippery conditions was by far the most common environmental factor, which was at least the third most important factor in about 12 percent of the cases.

Vehicle contributing factors were fairly uncommon with the exception of tire tread separation and tire blowouts, which occurred in around eight percent of the crashes. Roadway curvature and access points were cited as one of the three most important contributing factors in about eight percent of the cases, respectively. While these features may be present in many more cases, this means that they were among the three most important factors in relatively few of the cases. For instance, curvature was found to be present in 164 cases (almost 25 percent), but it was the most important factor three times, the second most important factor 14 times, and the third most important factor 29 times. In the remaining cases, other factors such as alcohol and drug use, speed, environmental conditions, were the most important crash contributors, moving curvature further down and eventually off the list.

Compared to other crash types, young (aged 15-24 year old) drivers are overrepresented in ROR crashes. All levels of alcohol use, from levels below the legal limit to levels three to four times the legal limit, are overrepresented in ROR drivers. ROR vehicles have more than two occupants about 50 percent more frequently than vehicles in other types of crashes, possibly indicating that drivers distracted by large numbers of passengers are more likely to run off the road. In some cases, however, the number of passengers was greater than the number of seating positions, meaning that the true problem might be lack of safety equipment use making the crash more likely to be fatal.

Speeding was an issue in many fatal ROR crashes; the percent of speeders actually increased as the posted speed increased. For roads with posted speeds of 65 and above, approximately one-third of the ROR drivers were traveling at least 10 mph over the speed limit.

About 50 percent of the ROR crashes occurred on interstates and other limited access facilities, with over 22 percent occurring on rural interstates. ROR crashes are highly overrepresented on all limited access facilities, but underrepresented on most suburban and urban facilities. ROR crashes are somewhat underrepresented on total two-three lane undivided roads and on rural four-five lane roads with raised medians; however, over 20 percent of the ROR crashes occurred on these road classes. Younger drivers are more likely to be involved in ROR crashes on interstates and roads with more lanes, and less likely to be involved in ROR crashes on rural and suburban two-three lane roadways.

ROR crashes are overrepresented on curves; road segments with curvature account for almost one-fourth of all ROR crashes. However, almost 30 percent of the curvature cases involved curves with radii of at least 3500', which are relatively shallow curves. Another 35 percent of the curves had radii less than 1500', typically posted at 55 mph or below, with a total of nine percent on curves with radii less than 500'. In general, higher speeds were more of an issue on tighter curves, with about one-third of the ROR drivers exceeding the speed limit by 10 mph on curves of radius less than 1500'. Medical factors, decision errors, and tire issues were overrepresented as primary factors in roads with smaller radii. This might indicate that the combination of unavoidable medical and vehicle factors with tight curves requiring proper speed and handling left drivers unable to control the vehicle, resulting in the ROR crash. Other issues such as speed, alcohol use, distraction, and aggression, were no more common in tight curves than in more shallow curves; factors such as inattention and fatigue/asleep were only slightly overrepresented.

Based on an analysis of both THI reports and video log photos, rumble strips were present in only about 15 percent of the fatal ROR crashes. Rumble strips were most common on limited access roadways, but still were only present about 20 percent of the time on urban interstates, about 35 percent of the time on urban toll roads and rural interstates, and about 45 percent of the time on rural toll roads. Their use was negligible on all other road classes. Given this, it appears that increasing the use of rumble strips could potentially reduce the number of ROR crashes in Florida. However, when contributing factors are examined, rumble strips have slight to somewhat negative associations with crashes caused by alcohol and drug use and abrupt steering input, neutral association with inattention, and a positive association with fatigue/asleep and distraction. This could be because of the small numbers of cases where rumble strips are present in the study set, or it could be because of the correlation between presence of rumble strips and occurrence of overcorrection crashes, as described previously.

The most common outcomes of ROR crashes were overturning and fixed object impacts, although other outcomes included entering water, hitting parked vehicles or vehicles on adjacent/parallel roadways, and hitting pedestrians. Because of the high number of crashes involving multiple events (hitting a fixed object and entering water, or hitting a fixed object and overturning), case study reviews identified the most harmful event where possible. In 40 percent of the cases, the most harmful event was overturning, and in almost 30 percent of the cases, the most harmful event was a fixed object impact. Although the overturning was typically the most harmful event, a fixed object actually tripped the vehicle in 67 cases, which is about 25 percent of the cases where overturning was the most harmful event. Culverts and culvert walls frequently served as tripping mechanisms, as did guardrails and bridge barriers. Overall, the most common fixed objects impacted were trees, followed by guardrails and concrete walls. Most of the impacted objects were within 30' from the edge of the travel lane with the exception of trees. They were most commonly between 30' and 60' from the outer edge of the outside lane. Poles, including those supporting utility cables and stoplights are the most commonly hit object within 30' of the edge of travel.

Running off the road into water occurred very infrequently. In about one-third of the cases (9 of 28), the body of water was a canal protected only by a fence located between 30 and 90 feet from the roadside. In two cases, the vehicle vaulted a guardrail and/or bridge barrier, falling into the river or canal flowing under the roadway. In these cases, along with about six more cases where the vehicle fell from overpasses, the inability of the guardrail/barrier system to contain the vehicle seems to be the more important issue than whether the vehicle landed in water or on the ground.

The most common factor associated with fatalities in ROR crashes was not wearing a seat belt. Air bag use showed a positive association with fatal injuries, likely because the field was more frequently checked in the more severe crashes where the air bag actually deployed. Most motorcycle occupants died regardless of the safety equipment used. Seat belts were much more effective in preventing fatalities in crashes where the most harmful event was overturning than where the most harmful event was a fixed object or vehicle-vehicle impact. This is because of the strong association between lack of seat belt use and occupant ejection, and the strong association between ejection and fatality, especially in overturning cases. Seventy percent of the ejected occupants who died in the fatal ROR were ejected in crashes where overturning was the most harmful event, compared to fewer than 20 percent in crashes where fixed object impact were the most harmful event. Conversely, this means that fixed object and ROR-related vehicle-vehicle impacts tend to be more severe crash events, more likely to be fatal even when the vehicle occupant is properly belted. Thirty-four percent of the belted occupants who died were in crashes where a fixed-object impact was the most harmful event, and 33 percent were in crashes where a ROR-related vehicle-vehicle impact was the most harmful event.

Results fom comparing crash contributing factors on limited and non-limited access roads shows that left roadside departure with control loss is more of a problem on limited access road. Alcohol and speed are more of a problem on non-limited access roads then on limited access roads, but other human crash contributing factors like inattention and fatigue/asleep makes up a higher percent of the ROR crashes on limited access roads. Results show that more than one-third of the drivers on non-limited access roads were over the legal limit for blood alcohol. About one-third of crashes on limited access facilities that involve curvature actually occur on the ramps; over 40 percent of the curvature-related crashes on mainlines occur on segments with radii of curvature greater than 3500'. Overall, curvature is somewhat more frequent on non-limited access roads than on mainlines of limited access facilities; these curves tend to involve radii of varying degree, with over 36 percent having radii of curvature less than 1500'.

Overcorrection occurs at about the same rate on limited and non-limited access facilities, although the outcome is much more likely to be a head-on collision if the overcorrection occurred on a non-limited access road. A higher percent of vehicles hit only pedestrians or entered water after running off the road on limited access roads than on non-limited access roads; however, impacts with pedestrians and vehicles occurred almost exclusively on limited access roads. Vehicles hitting guardrails and concrete walls make up a large percent of fixed object impacts on limited access roads, whereas more vehicles hit poles on non-limited access roads. Tree crashes are very common on both facility types, but somewhat overrepresented on non-limited access facilities.

8.13 Recommended Countermeasures

Given all of these facts about fatal ROR crashes, the following countermeasures are recommended. In general, educational and enforcement measures are listed first, followed by engineering and traffic operations type countermeasures.

Education and enforcement measures should be directed toward reducing alcohol and drug use, which contributed to almost 40 percent of the ROR crashes. While the highest percent of ROR drivers are below age 25, alcohol and drug use is most common among 25 to 34 year olds, and also common among 35-44 year olds. This indicates that enforcement is likely a more effective countermeasure than education. DUI enforcement programs would be somewhat more effective on non-limited access roads.

Educational programs should be developed to train drivers how to properly respond to emergency driving situations. Two situations particularly common in ROR crashes are overcorrection and tire blowout/tread separation. When the vehicle has drifted onto the shoulder, the driver should be educated on the need to maintain firm control of the steering wheel without abrupt steering input (i.e. without jerking the wheel), remove his/her foot from the accelerator but avoid braking, gently redirect the vehicle back into the travel lane, then accelerate back to the prevailing traffic speed. In the event of a tire blowout, the technique is the same, except that the driver should slowly pull off onto the shoulder and bring the vehicle to a controlled stop, rather than reentering the travel lane. Two websites with such safety information are:

- www.nsc.org/library/facts/blowout.org
- www.cyberdriveillinois.com/publications/rules_of_the_road//rr_chpat10.html

Education and enforcement directed at seat belt use should be considered. The data does not support various urban legends involving seat belt use, such as "I wouldn't be able to get out of the belt if I drove into water," and "If I'm thrown from the vehicle in the crash, it will be much safer than being confined in the vehicle." (The former is very rare, and outcomes are generally independent of seat belt use, including occupants who free themselves from the vehicle only to drown attempting to reach the shore. The latter simply isn't supported by the data.) Real data on seat belt use and crash outcomes could be used as the basis for public service advertising campaigns.

Education and enforcement measures should be directed toward speeding drivers, especially on high speed segments such as on rural interstates, and on segments where ROR crashes are common on relatively tight (radius less than 1500') curves.

Appropriate warning signs (maximum safe speed, chevrons), pavement markings (painted chevrons or other shoulder delineators), and roadside safety hardware (guardrails) should be considered for use on curves with high rates of or potential for ROR crashes. Appropriate warning or regulatory speed limit signs should be placed on exit ramps to ensure that drivers slow down sufficient prior to reaching the ramp curvature. Many exit ramps do not have mandatory or cautionary speed limits posted.

Due to the low number of fatal crashes associated with redirection, and the high number of fatal crashes associated with median cross-over, especially on limited access facilities, median guardrails are recommended on segments with high traffic volumes and narrow to medium median widths. Guardrail designs should be evaluated regarding their potential for tripping vehicles, contributing to rollover crashes.

Sites with soft shoulders, whether composed of grass, sand or other soft soils, should be evaluated for their potential to trip ROR vehicles. Potential countermeasures include improving the quality of the soil/grass shoulder, or providing additional paved shoulder width. While a less frequent cause of tripping, designs of drainage culverts and culvert walls should be reevaluated, given the fact that when hit, they result in rollovers more frequently when compared to other types of fixed objects. Overcorrection on non-limited access facilities, about half of the cases, typically involves dropping off the paved shoulder onto the grass. Although drop-offs are a relatively infrequent factor in ROR crashes in Florida; the severity of such drop-offs could be evaluated in conjunction with a program to improve soft shoulders.

Because of the high rates of ROR crashes on road segments without rumble strips, including a large number of crashes on limited access facilities, rumble strips should be considered on all roads with high rates of or potential for ROR crashes. Two concerns regarding rumble strips are the potential for interfering with bicycle use on the shoulders, and their potential association with overcorrection crashes. For the former reason, rumble strips are not recommended on roads with speed limits below 50 mph where shoulders are used by bicyclists unless there is minimum clear path of 0.3m (1 foot) from rumble strip to travel way, and/or 1.2 m (4 feet) from rumble strips to the outside edge of paved shoulder. Regarding the overcorrection issue, it has been suggested that varying the position, depth, and placement method (e.g. rolled into fresh pavement rather than milled into existing pavement) can affect the sound volume resulting from driving over the rumble strips. Additional research into this issue should be undertaken.

Although running off the road into water and running off the road into pedestrians and/or parked vehicles are relatively infrequent, the specific nature of the crashes points towards a few effective countermeasures. Regarding running off the road into water, a large percent of these crashes occurred on a single road segment, which is I-75 in Collier county, more commonly known as Alligator Alley. Specific remediation concerning this roadway segment, including relocating the canal or providing an improved barrier system, might be warranted. Regarding pedestrian and vehicle impacts, the vast majority of these occur on limited access facilities and often involve disabled vehicles or other vehicles parked on the shoulders. Increased use of incident management patrols (e.g. the Road Ranger program), as well as increased awareness of the dangers of standing on the shoulder of a high speed roadway in an emergency situation, might serve to reduce the number of this type of collision.

Because fixed object impacts are more severe than other types of ROR crashes and less preventable by improved seat belt use, roadside designs should be reevaluated in an effort to ameliorate the effect of fixed objects. A comprehensive program should be developed to remove or relocate objects in hazardous locations, or provide crash cushions or other protective barriers in locations where this is impractical. This program should be undertaken on both limited and non-limited access facilities, as few differences in the rates of fixed object crashes were seen between the two facility types. FDOT should work to educate private owners regarding the danger and potential liability of not providing a safe clear zone for the traveling public.

9 INTERSECTION CRASHES

A significant share of the fatal crashes in Florida involve intersections. Almost one third of the total fatal crashes in Florida either occur at or are influenced in some way by the presence of an intersection. Due to such high precedence of crashes involving intersections, an in-depth review of the fatal crashes at or influenced by intersections is undertaken in this chapter.

9.1 Background and Literature Review

One of the most primary requirements of any efficient transportation system is safety of the users. The highways of our country should provide the required mobility and accessibility accompanied with safety for its smooth functioning. Efforts are being made to improve the safety of our highways, which are still exposed to a significant number of fatalities due to traffic crashes. An intersection is, at its core, a planned point of conflict in the roadway system. With different crossing and entering movements by both drivers and pedestrians, an intersection is one of the most complex traffic situations that motorists encounter. Add the element of speeding motorists who disregard traffic controls and the dangers are compounded.

At-grade intersections are one of the highest frequency crash-prone locations. Literature reveals that almost 50 percent of the total crashes nationwide occur at intersections and almost 25 percent of traffic fatalities are caused due to intersection or intersection related crashes (*Traffic* 2003).

Intersections need to be designed and operated for all users such as:

- Pedestrians
- Bicyclists
- Older drivers and younger drivers
- Pedestrians of all ages and cognitive and physical abilities/disabilities
- Transit/light rail/trolley vehicles
- Trucks including loading/unloading maneuvers
- Emergency vehicles
- Proximate driveways serving commercial properties
- Commuters

Judicious decisions need to be made for the safety and priority of intersection users and there will always be a certain tradeoff in preference of one for the other. An intersection needs to provide balance between smooth traffic operations for vehicular and pedestrian traffic, and safety of all.

Literature reveals that left turn collisions and red light running crashes are found to be common types of crashes occurring at intersections. Most of the crashes at un-signalized intersections are right angle collisions involving two vehicles (Agent et al, 2003). Failure to yield the right-of-way is the major cause of crashes at intersections (*Human*, 2004). In addition to driver error, a number of other factors can also contribute to the failure to yield right-of-way.

Understanding the way people react to vehicle conflicts is a part of improving intersection safety. Drivers vary widely in their skills and their willingness to take risks at intersections. Also contributing may be sight triangle issues that need to be addressed at some intersections that do not provide sufficient sight distances with certain obstructions blocking the line of sight of the drivers or with inappropriate design of intersection, e.g. not offering enough forward sight distance due to curvature in the road.

There are various factors, which may be driver related, roadway related, environment related or even vehicle related that contribute to the crashes at intersections. The FHWA Intersection Safety Briefings issue of September 2004 says, "Many signs and signals, even when new, are not large or bright enough-especially at night or in dim lighting-for drivers to act safely on the information these traffic control devices are providing. Many drivers may have good vision but are not able to see well at night because of poor sensitivity to the contrast between light and dark."

Older drivers usually are much less inclined to take risks with narrow margins of error than are younger drivers, especially those in their teens and 20s. However, older drivers often take risks unknowingly because of the diminished motor skills, poor vision and reduced cognitive ability that can come with old age. This can lead them to make poor judgments at intersections that can result in crashes. Drivers 85 years of age and older are more than 10 times as likely as drivers in the 40-to-49 age group to have multi-vehicle intersection crashes while the youngest driver age groups have the highest traffic violation and crash involvement rates. This is often due to poor judgment and inexperience, especially among teenage drivers. This problem is also due to a willingness of young drivers to take risks that include speeding, dangerous maneuvers and violating red light signals and stop signs (*States*, 2001).

Figure 9.1 below shows the typical conflict points for a vehicle turning left at an intersection. Incidentally, more than 50% of the crashes at intersections involve a left turn maneuver by one of the vehicles involved in the crash. The intersections involve through and turning movements of traffic in the same direction as well and the slowing vehicles that need to turn are a potential source for back end collisions. Figure 9.2 below shows the conflict points for a right turning vehicle. The lower image in Figure 9.2 shows a potential angled collision, which can also be a rear end collision. Figure 9.3 shows the conflict point for straight crossing vehicles. Figure 9.3 shows a passenger side impact; a similar situation can also give rise to a driver side impact. (Figures were obtained from Campbell et al 2004.)

Reduction of fatal intersection crashes can only be accomplished by careful use of good road design, traffic engineering choices, comprehensive traffic safety laws and regulations, consistent enforcement efforts, sustained education of drivers and pedestrians, and the drivers' and pedestrians' willingness to obey and sustain the traffic safety laws and regulations. The crashes at intersections can be counteracted by introduction of suitable intersection control and providing sufficient sight distances on all the legs of the intersection.

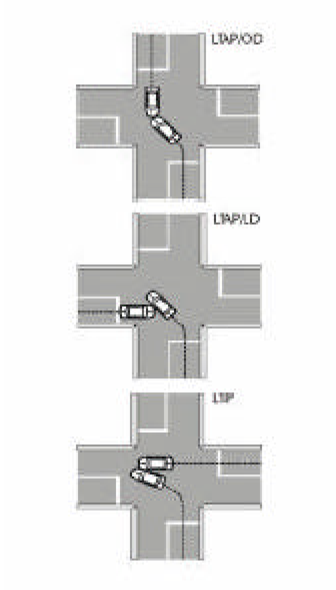

Figure 9.1: Conflict Points For a Left Turning Vehicle at an Intersection

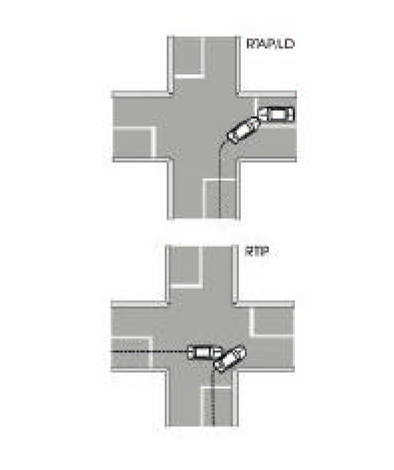

Figure 9.2: Conflict Points For a Right Turning Vehicle at an Intersection

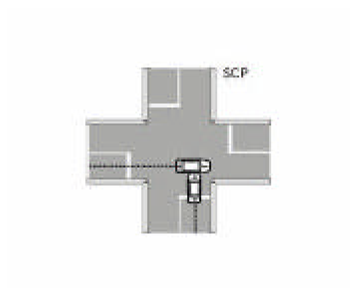

Figure 9.3: Conflict Point for Straight Crossing vehicles at an Intersection

9.2 Methodology

For the purposes of this study, fatal intersection crashes have been defined as the fatal crashes that occurred either at the intersection or the occurrence of the fatal crash was directly influenced by the presence of an intersection. The methodology used to analyze the fatal intersection crashes was based on individual review of each crash followed by the statistical significance and correlation of pertinent crash parameters. The case reviews identified primary and secondary casual factors, and attributed factors by classes (roadway, vehicle, human, or environment) and subclasses. The charts were used to identify the parameters that had high precedence of crashes, so that countermeasures can be targeted towards improving on these parameters. The parameters chosen here were selected based on their contribution towards the crash and an effort was made as to determine the factors that add to the risk of a fatal crash at an intersection.

9.2.1 Intersection Crash Types and Contributing Factors

The scope of the definitions given here is limited to this individual chapter of the report, dealing with fatal intersection crashes.

- *Sight Distance Issue:* Classically as defined by Garber and Hoel (1999), sight distance is the length of the roadway a driver can see ahead at any particular time. Decision sight distance is defined as the distance required for a driver to detect unexpected or otherwise difficult-to-perceive information source or hazard in a roadway environment that may be visually cluttered, recognize the hazard of its threat potential, select an appropriate speed and path, and initiate and complete the required safety maneuvers safely and efficiently (Alexander and Lenenfeld 1975). In case of intersections for a driver with secondary right of way that is the driver who is supposed to yield to other vehicles before entering the intersection, the driver needs to have a clear view in both directions of the intersecting roadway, to safely judge and complete his desired maneuver. These definitions were kept in mind while determining the sight distance issues at a crash site. Factors causing sight distance issues are curves in road, trees, shrubs or other fixed objects obstructing the line of sight, other vehicles stopped due to the traffic control at an intersection can also cause an obstruction to the line of sight of a driver. Figure 9.4 shows a typical sight distance issue caused by the trees obstructing the line of sight at an intersection. (Figures obtained from *Safety* 1992.)
- *Roadway Geometry Issue:* The geometry of the road, for example presence of curve, which limits the sight distance, skewed intersections causing difficult maneuvers across the intersections, wide intersections leading to judgment and perception errors by drivers were looked into while determining the roadway geometry issues at an intersection where the fatal intersection crash occurred. Figure 9.5 below shows the crash diagram for DHSMV crash number 58107041; as seen from figure the intersection has complex geometry and potentially confusing lane assignment. In addition, the intersection is also followed and preceded by a curve, which adds the element of limited sight distance for drivers on all four legs of the intersections and as such the intersection geometry has significant and potential contribution towards the occurrence of the crash.

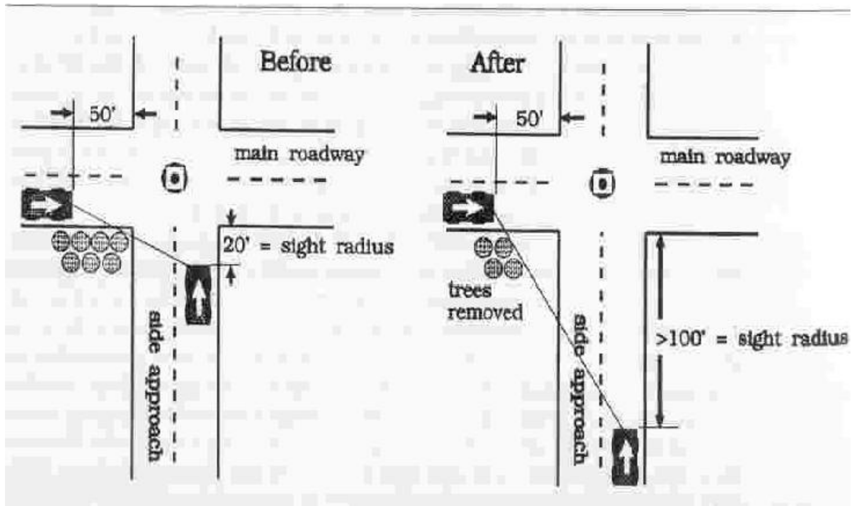

Figure 9.4: A Typical Intersection with a Sight Distance Issue Due to Trees

- *Traffic Operation Issue:* The roadway lane assignment and usage, traffic controls, signal phasing etc are the factors looked at while determining the traffic operations issues at an intersection. Unavailability of turning lanes, improper or excessive access to a high-speed road, inadequate or absent traffic control, lane assignment leading to confusing or conflicting vehicular movements were some of the factors identified while looking for traffic operation issues in the fatal intersection crashes.

- *Signalization Issue:* This forms a subset of traffic operations, and while identifying the contribution of signalization in the occurrence of the fatal intersection crashes, facts such as the signal phasing, absence of signal where deemed needful were looked into and the signalization issues were identified. If the signal is not noticeable well in time, it may lead to rear end or even red light running crashes, which was noted as a potential contributing factor in certain fatal intersection crashes.

- *Signage Issue:* Traffic signs, whether regulatory or control, play a vital role in the smooth operation on the roadway. Drivers need to be advised about the kind of intersection they would be approaching. Certain fatal intersection crashes were identified with potential signage issues such as a 55 MPH road terminating in a stop-controlled T-junction without any prior warning signage. In geographical areas that are known to have foggy conditions, signs need to be highly retro-reflective and may be even supplemented with flashing warning lights etc.

- *Environment Issue:* Inclement weather conditions, fog, heavy rains, wet and slippery roadway due to rain make the driving conditions hazardous and even a careful driver may get into a crash due to such environmental issues.

- *Pedestrian Facility Issue:* As mentioned earlier, one of the major intersection safety concerns is the elimination of vehicle and pedestrian conflict. To achieve this objective, the roadway needs to provide adequate pedestrian facilities such as crosswalks and side walks to and from all pedestrian generators. Issues such as whether the area is properly lighted or not, whether it has proper crosswalk or not, whether it has a pedestrian signal or not were studied while identifying the pedestrian issues in fatal intersection crashes. Again, the in-depth analysis of pedestrian cases has been undertaken in a separate chapter and is not discusses in detail in this chapter.

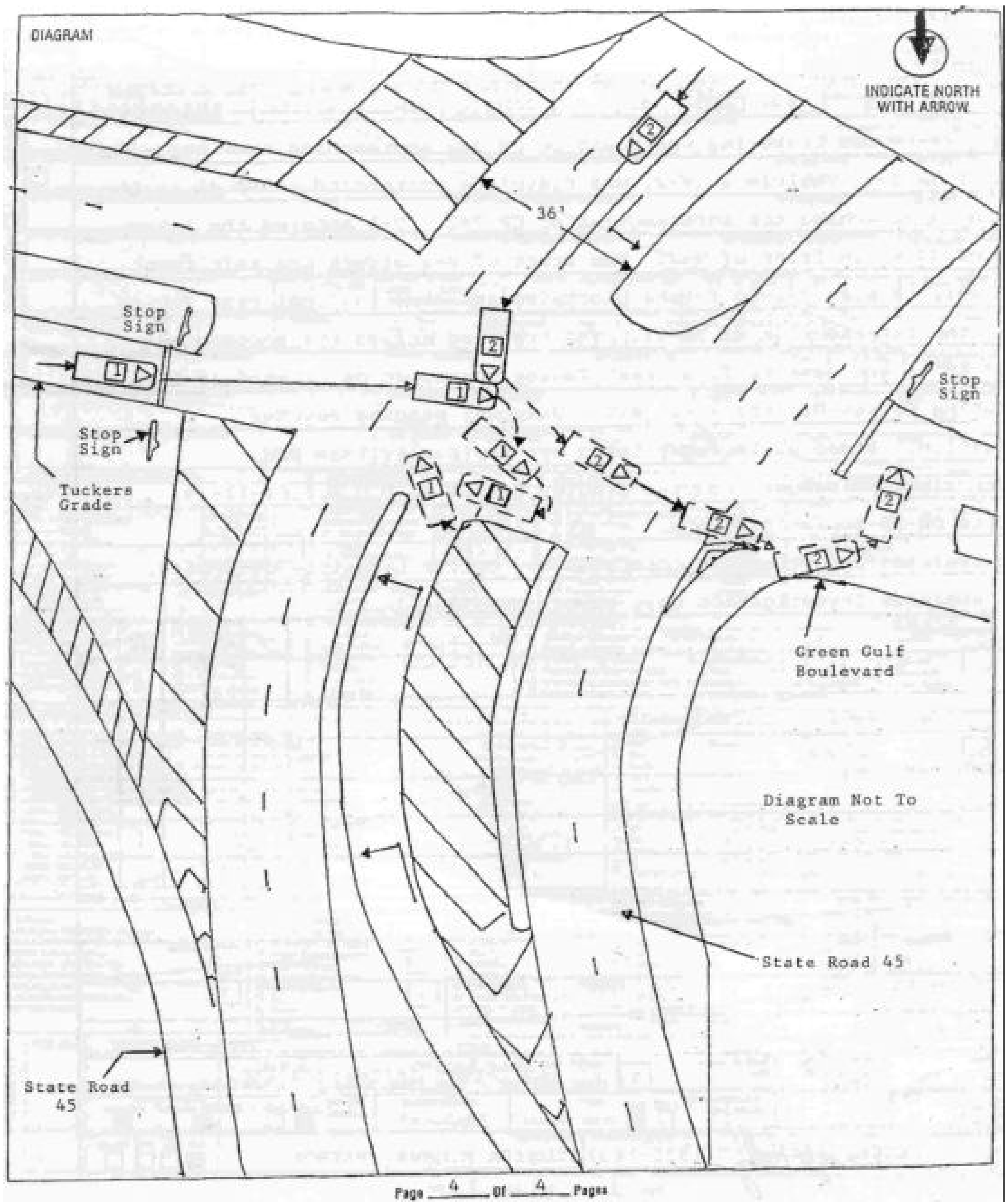

Figure 9.5: A Typical Intersection with Potential Roadway Geometry Issues

9.2.2 Identifying Intersection and Intersection Related Crashes

The identification of the fatal intersection crashes was done based on two primary criteria. Firstly, all the crashes that had the following site location codes were filtered out and identified as potential fatal intersection crashes.

- 2 = At Intersection
- 3 = Influenced by an Intersection
- 4 = Driveway Access

Driveways were included in the set of intersection crashes because many of the attributes (e.g. conflict points) and countermeasures would be very similar. In fact, many of the "driveway" crashes involved commercial business access points that are channelized, stop sign controlled, and indistinguishable from standard intersections between public roads. However, it was noted that there were numerous inconsistencies in definitions and coding used by different officers. Examples include differentiating between driveways and intersections, determining what crashes are *influenced* by an intersection, and distinguishing between an exit/entrance ramp and an intersection, for instance when a crash occurs at a signalized intersection at the end of an exit ramp. For this reason, a second criterion used was based on the proximity of the crash to a known intersection.

To conduct this proximity check, GIS was used to spatially layout the fatal crashes on a Florida State roadway base map. The roadway base map was obtained from the GIS directory available on the http://www.dot.state.fl.us/planning/statistics/gis/default.htm website in poly-line M form. The crashes from the table were added to this layer as route events using Roadway ID as the identifier and location milepost as the point of event. Using another point layer, all the intersections in the state of Florida were laid out on the base map. The proximity check for the fatal crashes was done using the selection tool, "Select By Location" provided in ArcView GIS Software. The features in the crash layer (crash points) were selected based on their distance from the features in the intersection layer. A 100 feet radius was used for the proximity check. A separate layer was formed using the selected features from the crash layer. The DHSMV crash numbers and other crash attributes were obtained in a table for from the attribute table of this new layer. All the crashes on the list were then reviewed to confirm if the presence of an intersection had any bearing on the occurrence of the crash. It should be noted here that although a few cases were identified as fatal intersection crashes through this process most of the crashes though geographically near (within 100 feet of) an intersection, were not actually related to the intersection. The Figure 9.6 below shows the different filtering stages of the data to extract the fatal intersection crashes. Initially, from the total of over 2000 fatal crashes, about 950 crashes were identified as potentially intersection-related crashes, but the number was finally refined to around 700 crashes, as shown in Figure 9.6.

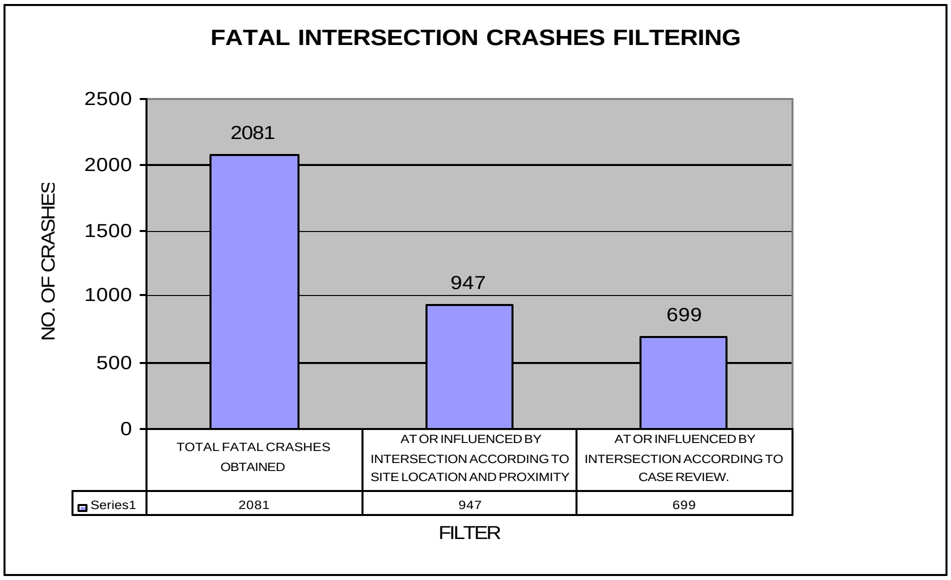

Figure 9.6: Fatal Intersection Crashes Filtering

9.2.3 Case Review of Fatal Intersection Crashes

After all the fatal intersection crashes were identified, each crash case was approached systematically and reviewed and the crash reconstruction diagrams were studied. Next, the fatal crashes were broken down by whether they occurred at a traffic signal, stop sign, or at no traffic control device. The crashes were then examined to see if the driver violated the traffic signal or stop sign. Additionally, the type of violation was noted, whether the driver failed to obey or failed to yield at the sign/signal. Next, the fatal crashes were broken down by whether they occurred at a traffic signal, stop sign, or at no traffic control device. The crashes were then examined to see if the driver violated the traffic signal or stop sign. Additionally, the type of violation was noted, whether the driver failed to obey or failed to yield at the sign/signal. The vehicle movements and traffic control present were used to identify the crash type. The crash report was studied to identify the driver error. Each case was assigned a primary, secondary and tertiary contributing factor based on judgment after thoroughly reviewing the crash report.

Each case was checked for driver and non-driver issues. Non-driver issues such as sight distance issues, other roadway geometry issues, traffic operations issues, signalization/signage issues, environment issues, and pedestrian facilities issues were identified for each case. Further driver issues such as DUI, speeding, inattention, improper/illegal turn, ran red light/stop sign, rear end, and misjudged gap were also coded. It should be noted here that certain fields such as misjudged gap or inattention have been identified based on the best judgment after reviewing the case. It is to a certain extent an estimate since what exactly went on in the mind of the driver cannot be determined after the crash, especially if the driver was a victim in the crash. It may be questionable as to whether the victim saw the vehicle and then proceeded into the intersection or was simply inattentive and just failed to see the vehicle. A review of driver action (e.g. stopping at a stop sign or green ball in the case of a permissive left prior to entering the intersection) and speed, and the speed and position (i.e. near or far lane) of the oncoming/crossing vehicle was used to help determine the likely cause of the crash.

Another aspect that needs attention here is that “gap” here is not the classical definition of the available gap, which is defined as the time space between two consecutive vehicles. For the purposes of intersection fatal crash driver error, gap may be understood as the time required for a through vehicle to cover the distance to the intersection and enter the intersection at the speed which it is moving on the major road from its current position. This gap is irrespective of the previous vehicle that went through that particular intersection. It should also be understood that misjudging of gap could also be, to a certain extent, due to inattentiveness and as such some crashes may show “misjudged gap” and “inattention” both as driver error issues.

9.3 Case Studies

This section shows four sample case studies, explaining how the case reviews of the fatal intersection crashes were conducted. It should be understood that the roadway issues mentioned here are potential issues, which apparently have a certain degree of contribution towards the occurrence or the severity of the crash. The observations and the issues noted have been derived after a thorough review and study of the crash report; the homicide investigation report and the video log reviews of the crash roadway.

9.3.1 Case Study 1

Figure 9.7 shows the crash reconstruction diagram for the crash described in the first case study. Details of the crash are as follows:

- DHSMV # 51808559
- D1 – 37 Years of Age DUI @ 25 MPH on 25 MPH Posted Speed Limit.
- D2 – 32 Years of Age Not DUI @ 35 MPH on 35 MPH Posted Speed Limit.
- Time of Crash – 8:33 PM
- Stop Control for D1.
- No Control for D2.
- Straight Vs. Straight Movements

The crash occurred when vehicle 1 (V1) pulled into the path of vehicle 2 (V2) from the stop sign. Both the vehicles were within the speed limits but driver of vehicle 1 (D1) was driving under the influence of alcohol and as such the primary contributing factor to the crash is DUI. However, looking at the roadway issues, it is seen that certain sight and traffic operation issues do have a secondary contribution to the occurrence of the fatal intersection crash. The path of V1 crosses across the path of V2 prior to the stop bar. Also stopped vehicles in adjacent lane obstruct the line of sight from D1’s point of view. Figure 9.8 shows the view of intersection in the crash under study. The picture shows a sharp curve right after the intersection, which further limits the sight distance from D1’s point of view.

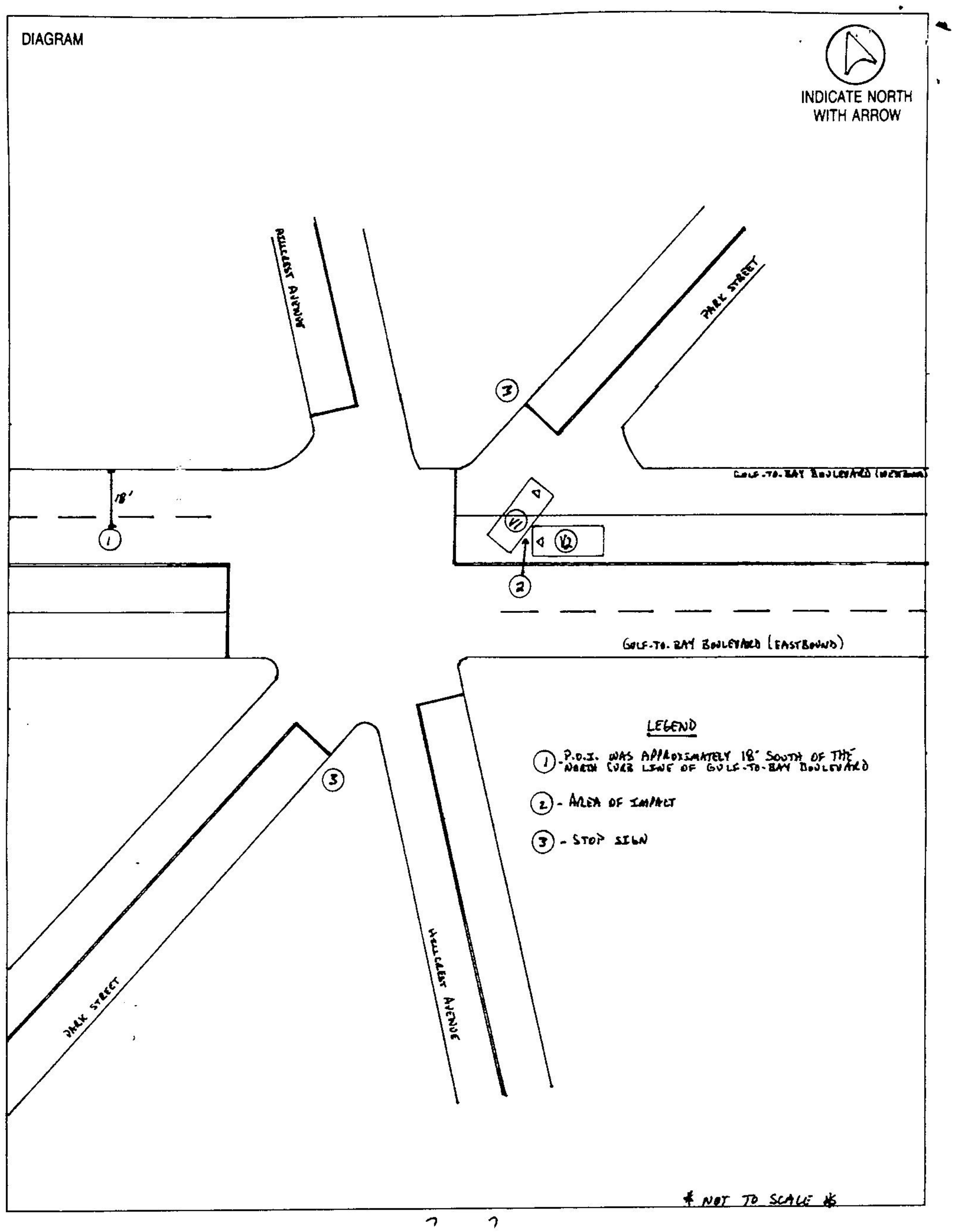

Figure 9.7: Crash Diagram for DHSMV # 51808559

Following are certain observations made regarding the roadway issues that have a secondary or tertiary contribution towards the fatal intersection crash.

- Complex confusing intersection movements.
- Line of sight issue.

- Curve just to the west of intersection, sight distance issue.
- Pavement marking issue.
- Traffic operation issue.

Figure 9.8: Intersection in DHSMV Crash # 51808559

9.3.2 Case Study 2

Figure 9.9 shows the reconstruction diagram for DHSMV crash number 58106133. Details of the crash are as follows:

- DHSMV # 58106133
- D1 – 91Years of Age Not DUI @ 15 MPH on 45 MPH Posted Speed Limit.
- D2 – 48 Years of Age Not DUI @ 40 MPH on 45 MPH Posted Speed Limit.
- Time of Crash – 12:20 PM
- Signalized Intersection.

- Left Turn Oncoming Movements.

D1 is 91 years of age trying to make a left turn in front of oncoming traffic. Speeding and DUI are not contributing factors in the crash, but driver age leading to misjudging of the gap is the primary contributing factor. As seen from Figure 9.10 and Figure 9.11, the intersection is on a curve and offers limited sight distance. Also from Figure 9.11, the line of sight for D1 is potentially obstructed by trees in the median and it is rather difficult for a left turner in D1's position to have a clear view of vehicles coming up the curve from V2's direction. Following are the observations made regarding the potential roadway issues contributing to the crash.

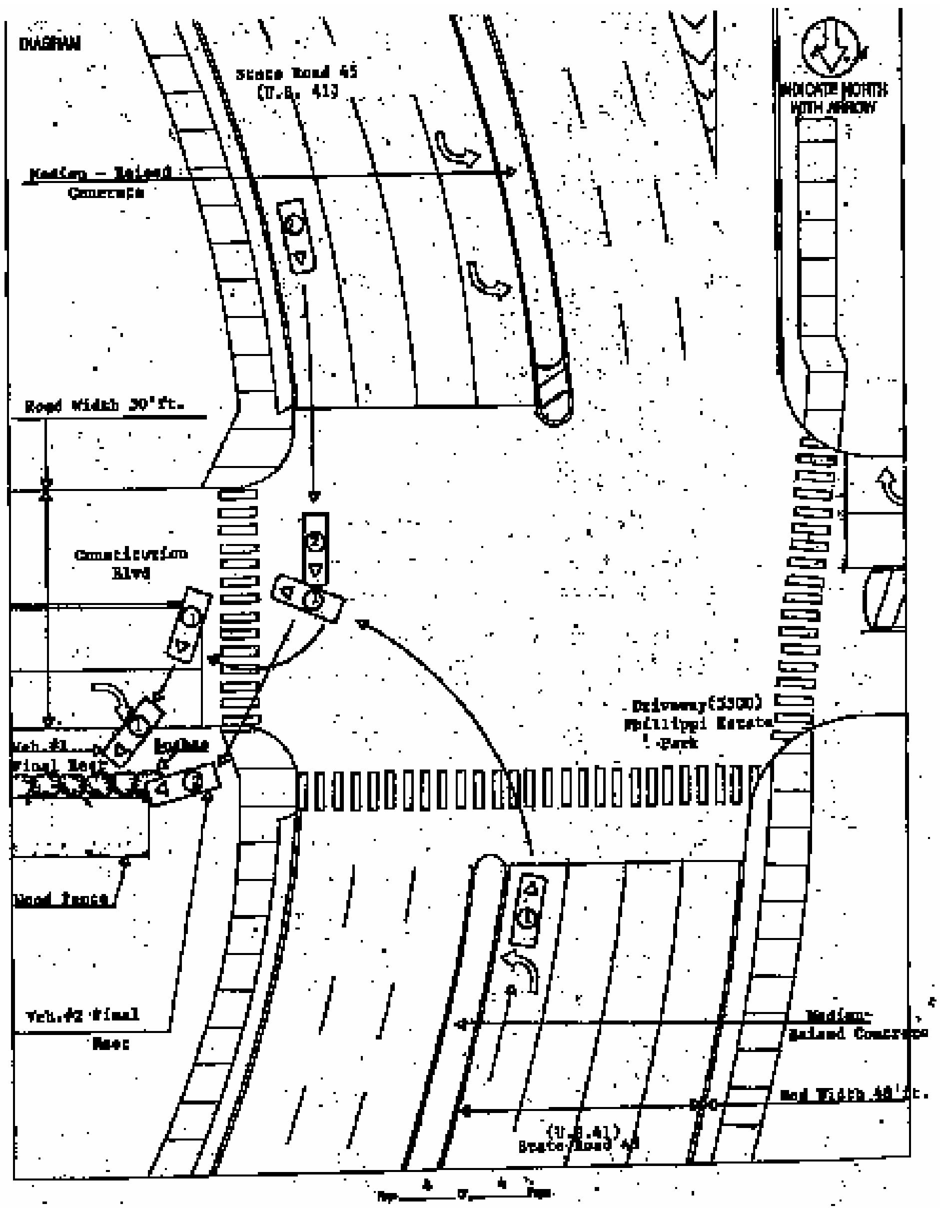

Figure 9.9: Crash Diagram for DHSMV Crash # 58106133

- Wide intersection.

- 3 travel lanes to cross – D1, 91 years of age.
- Signal phasing issue.
- Sharp curve on both approaches to intersection – sight distance issue.
- Trees in median obstruct clear view of oncoming vehicles down the curve.

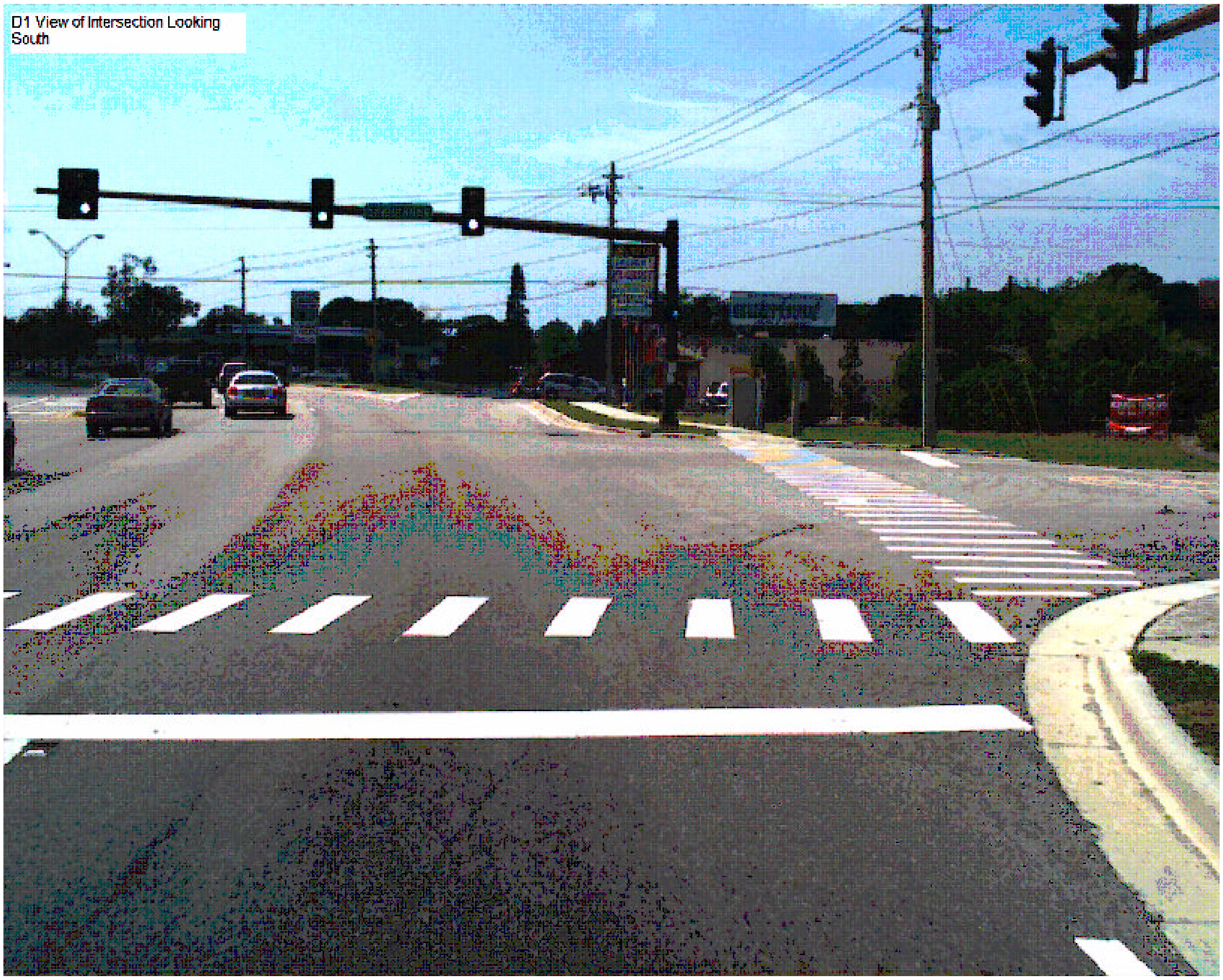

Figure 9.10: D1's View of Intersection in DHSMV Crash # 58106133

Figure 9.11: D2's View of Intersection for DHSMV Crash # 58106133

9.3.3 Case Study 3

Figure 9.12 shows the reconstruction diagram for the crash in the case study. The crash is a rear end crash with inattentive D2 rear-ending V1, which left the scene of crash. Details of the crash are as follows:

- DHSMV # 50014426
- D1 – Hit and Run – CMV Making U – Turn.
- D2 – 32 Years of Age Not DUI @ 55 - 65 MPH on 55 MPH Posted Speed Limit.
- Unknown Time – Officer Notified at 8:07 AM.
- Uncontrolled Movements.
- Rear End.

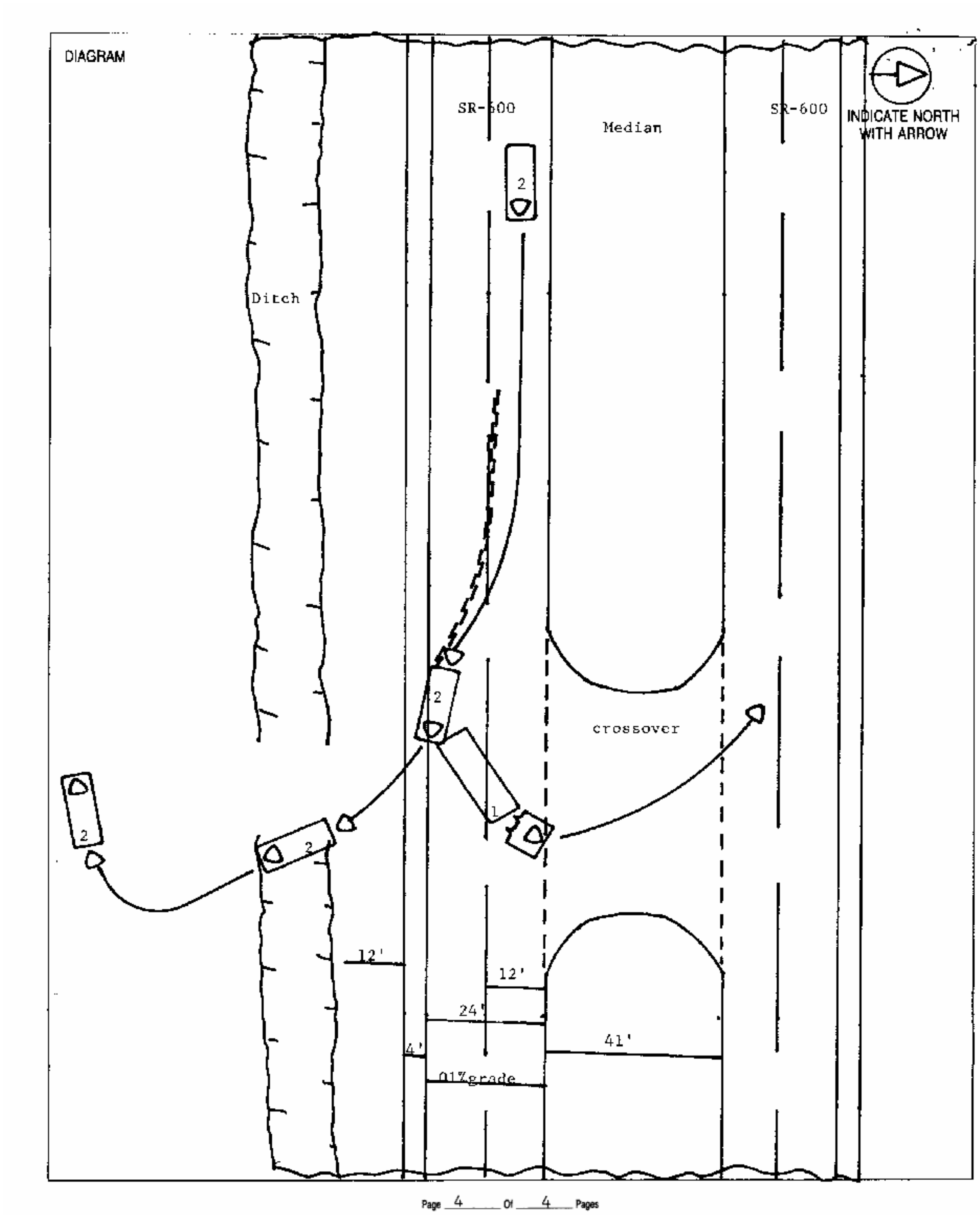

Figure 9.12: Crash Diagram for DHSMV Crash # 50014426

Figure 9.13 below shows the driver's view of the roadway just before the crash. The picture is a view from approximately 150 feet to 200 feet prior to the crash location. It can be noticed that D2's view of the roadway is restricted due to the vertical curve in the road. The break in the median where the CMV was trying to make a U-turn is right totally hidden for the drivers moving up the curve at 55 MPH and as such it is a potentially significant sight distance issue contributing to the crash and so also, the absence of a storage turn lane is a potential traffic operation issue contributing to a certain degree in the fatal crash. Another issue mentioned in the report is possible insufficient lighting on the sides of the CMV reducing its visibility.

Figure 9.13: D2's View Prior to Crash in DHSMV Crash # 50014426

Following are the observations made regarding the potential contributing factors in the fatal intersection crash.

- Horizontal and vertical curve just prior to crash site.
- Insufficient sight distance for speed limit.
- CMV U-turn – No turn lane – traffic operation issue.
- Possibly insufficient lighting on sides and rear of CMV – vehicle issue.

9.3.4 Case Study 4

Figure 9.14 shows the reconstruction diagram for DHSMV crash number 57427968. Details of the crash are as follows:

- DHSMV # 57427968
- D1 – 18 Years of Age Not DUI @ 55 - 60 MPH on 45 MPH Posted Speed Limit.
- D2 – 66 Years of Age Not DUI @ 15 MPH on 35 MPH Posted Speed Limit.
- V3 and V4 – Secondary Impact.
- Time of Crash – 11:24 PM
- Signalized Intersection.

The crash occurred when an inattentive D1 ran the red light and hit V2 in the left side. The primary contributing factor to the crash is the running of red light due to inattentiveness by D1 and also speeding by D1. But it would not be fair to dismiss the fact the visibility of the signal is rather low as it comes up right after a vertical sag in road and the overpass seen in Figure 9.15 certainly hinders a clear sight to the signal. The study of the video logs for the roadway revealed that it changes character from rather rural or suburban to urban at this intersection and there isn't enough warning signage for the same, which may have a potential contribution in the fatal intersection crash considering that D1 was from elsewhere in state and was probably unfamiliar with the roadway.

Following are certain observations made regarding the potential contributing factors to the crash.

- Speed zone changes north of crash site from 55 MPH to 45 MPH.
- No signal prior to crash site for more than 2.5 miles.
- Signal not easily noticeable on roadway – the overpass bridge blocks view.
- No warning signage for signalized intersection, change in traffic character – rural to urban.
- View from D2's point of view also blocked to allow the drivers to be defensive.
- View from inside left turn lane on NB roadway not clear – potential for left turn oncoming crash.

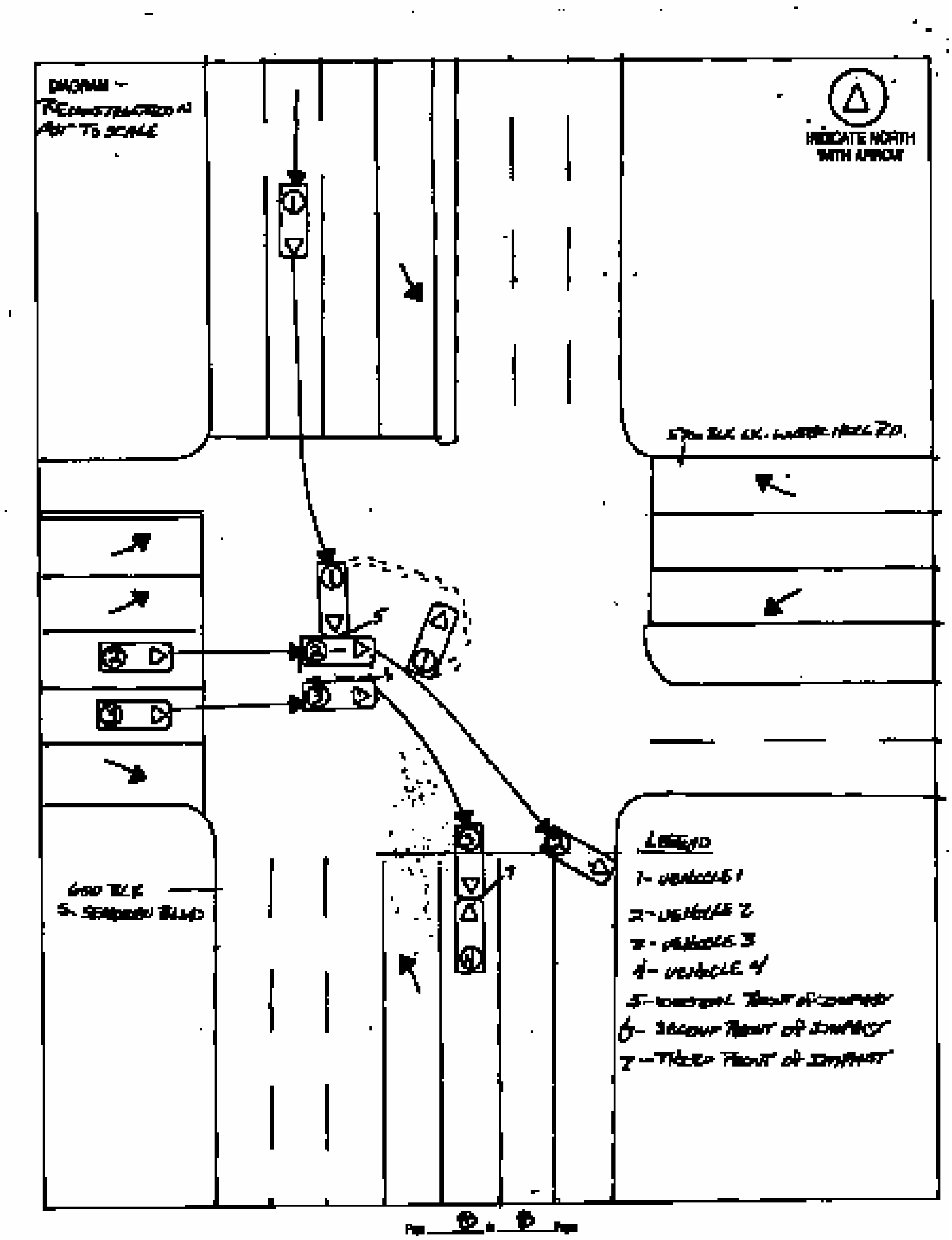

Figure 9.14: Crash Diagram for DHSMV Crash # 57427968

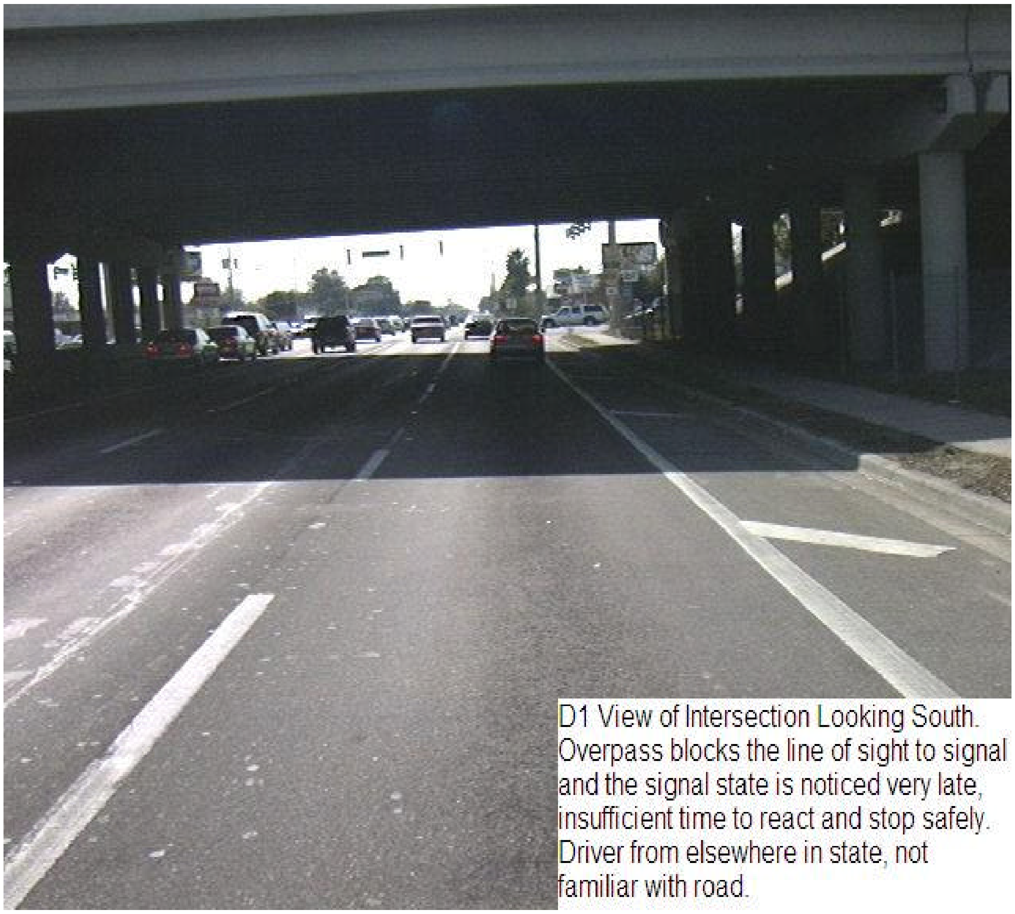

Figure 9.15: D1's View of Roadway Just Before the Crash in DHSMV # 57427968

9.4 Data Set

Table 9.1 below shows the distribution of the fatal intersection crashes by year. As can be seen from the table and as mentioned earlier, the available data is limited only to crashes involving heavy trucks for the years 1998 and 1999. It can be seen that the fatal intersection crashes are evenly distributed over the three years and the percentage occurrence is consistent with the national average found in literature. (*Traffic* 2003) except for the year 1998 when a higher percentage of fatal crashes, all of which involved heavy trucks) occurred at intersections.

Table 9.1: Fatal Intersection Crashes by Year

	1998	1999	2000	Total
	(Heavy Trucks)	(Heavy Trucks)	(All Cases)	
Total	199	198	1683	2080
Intersection Crashes	84	71	544	699
% Intersection Crashes	42.21%	35.86%	32.32%	33.61%

Table 9.2 below shows the crash distribution for the year 2000. The percentage distribution of the crashes within the year is consistent with the overall data. It can be seen that the involvement of heavy trucks in fatal intersection crashes is not over represented here.

Table 9.2: Fatal Intersection Crashes for Year 2000

Total	Heavy Trucks	Other	Total
	178	1505	1683
Intersection Crashes	59	485	544
% Intersection Crashes	33.15%	32.23%	32.32%

Table 9.3 shows the distribution of fatal intersection crashes by the county. The counties with more urban land area have more number of intersections and this is naturally represented by higher number of crashes in these counties. Dade County has highest number of fatal intersection crashes with 73 fatal intersection crashes and Hillsborough and Polk County are ranked second and third with 53 and 50 fatal intersection crashes respectively.

Table 9.3: Fatal Intersection Crashes by County

County	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Alachua	10	1.43%	29	2.10%	**0.681**	0.334	1.390	Unsure
Baker	2	0.29%	7	0.51%	**0.564**	0.118	2.710	Unsure
Bay	7	1.00%	13	0.94%	**1.064**	0.426	2.654	Unsure
Bradford	2	0.29%	11	0.80%	**0.359**	0.080	1.616	Unsure
Brevard	19	2.72%	43	3.11%	**0.873**	0.513	1.486	Unsure
Broward	45	6.44%	130	9.41%	**0.684**	0.493	0.948	Under
Calhoun	1	0.14%	6	0.43%	**0.329**	0.040	2.730	Unsure
Charlotte	18	2.58%	10	0.72%	**3.556**	1.650	7.663	Over
Citrus	8	1.14%	8	0.58%	**1.976**	0.745	5.242	Unsure
Clay	4	0.57%	8	0.58%	**0.988**	0.298	3.269	Unsure
Collier	9	1.29%	32	2.32%	**0.556**	0.267	1.158	Unsure
Columbia	2	0.29%	16	1.16%	**0.247**	0.057	1.071	Unsure
Dade	73	10.44%	110	7.97%	**1.311**	0.989	1.737	Unsure
Desoto	3	0.43%	7	0.51%	**0.847**	0.220	3.264	Unsure
Dixie	2	0.29%	2	0.14%	**1.976**	0.279	13.996	Unsure
Duval	29	4.15%	57	4.13%	**1.005**	0.649	1.557	Unsure
Escambia	16	2.29%	17	1.23%	**1.859**	0.945	3.658	Unsure
Flagler	1	0.14%	9	0.65%	**0.220**	0.028	1.729	Unsure

Table 9.3: Fatal Intersection Crashes by County, continued

County	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Franklin	0	0.00%	5	0.36%	**0.000**			
Gadsden	1	0.14%	7	0.51%	**0.282**	0.035	2.289	Unsure
Gilchrist	2	0.29%	1	0.07%	**3.951**	0.359	43.501	Unsure
Glades	4	0.57%	3	0.22%	**2.634**	0.591	11.737	Unsure
Gulf	0	0.00%	2	0.14%	**0.000**			
Hamilton	1	0.14%	3	0.22%	**0.659**	0.069	6.319	Unsure
Hardee	4	0.57%	4	0.29%	**1.976**	0.496	7.876	Unsure
Hendry	1	0.14%	2	0.14%	**0.988**	0.090	10.875	Unsure
Hernando	7	1.00%	5	0.36%	**2.766**	0.881	8.683	Unsure
Highlands	8	1.14%	15	1.09%	**1.054**	0.449	2.473	Unsure
Hillsborough	53	7.58%	84	6.08%	**1.247**	0.895	1.737	Unsure
Holmes	1	0.14%	5	0.36%	**0.395**	0.046	3.376	Unsure
Indian River	1	0.14%	18	1.30%	**0.110**	0.015	0.820	Under
Jackson	5	0.72%	10	0.72%	**0.988**	0.339	2.879	Unsure
Jefferson	0	0.00%	10	0.72%	**0.000**			
Lafayette	1	0.14%	1	0.07%	**1.976**	0.124	31.539	Unsure
Lake	11	1.57%	26	1.88%	**0.836**	0.415	1.682	Unsure
Lee	23	3.29%	33	2.39%	**1.377**	0.815	2.327	Unsure
Leon	6	0.86%	24	1.74%	**0.494**	0.203	1.203	Unsure
Levy	7	1.00%	9	0.65%	**1.537**	0.575	4.109	Unsure
Madison	2	0.29%	7	0.51%	**0.564**	0.118	2.710	Unsure
Manatee	20	2.86%	21	1.52%	**1.882**	1.027	3.448	Over
Marion	18	2.58%	16	1.16%	**2.223**	1.140	4.332	Over
Martin	6	0.86%	24	1.74%	**0.494**	0.203	1.203	Unsure
Monroe	7	1.00%	17	1.23%	**0.814**	0.339	1.952	Unsure
Nassau	5	0.72%	11	0.80%	**0.898**	0.313	2.575	Unsure
Okaloosa	5	0.72%	16	1.16%	**0.617**	0.227	1.678	Unsure
Okeechobee	2	0.29%	10	0.72%	**0.395**	0.087	1.798	Unsure
Orange	24	3.43%	63	4.56%	**0.753**	0.475	1.194	Unsure
Osceola	12	1.72%	20	1.45%	**1.185**	0.583	2.411	Unsure
Palm Beach	27	3.86%	71	5.14%	**0.751**	0.487	1.159	Unsure
Pasco	20	2.86%	35	2.53%	**1.129**	0.657	1.941	Unsure
Pinellas	37	5.29%	41	2.97%	**1.783**	1.154	2.755	Over
Polk	49	7.01%	61	4.42%	**1.587**	1.102	2.286	Over
Putnam	4	0.57%	10	0.72%	**0.790**	0.249	2.511	Unsure
Santa Rosa	4	0.57%	9	0.65%	**0.878**	0.271	2.841	Unsure
Sarasota	12	1.72%	26	1.88%	**0.912**	0.463	1.796	Unsure

Table 9.3: Fatal Intersection Crashes by County, continued

County	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Seminole	10	1.43%	14	1.01%	**1.411**	0.630	3.161	Unsure
St. Johns	7	1.00%	22	1.59%	**0.629**	0.270	1.464	Unsure
St. Lucie	3	0.43%	15	1.09%	**0.395**	0.115	1.360	Unsure
Sumter	6	0.86%	18	1.30%	**0.659**	0.263	1.652	Unsure
Suwannee	1	0.14%	7	0.51%	**0.282**	0.035	2.289	Unsure
Taylor	4	0.57%	7	0.51%	**1.129**	0.332	3.844	Unsure
Union	0	0.00%	2	0.14%	**0.000**	N/A	N/A	N/A
Volusia	20	2.86%	37	2.68%	**1.068**	0.625	1.826	Unsure
Wakulla	3	0.43%	5	0.36%	**1.185**	0.284	4.946	Unsure
Walton	3	0.43%	10	0.72%	**0.593**	0.164	2.147	Unsure
Washington	1	0.14%	4	0.29%	**0.494**	0.055	4.411	Unsure
Total	699	100.0%	1381	100.0%	**1.000**			

Table 9.4 shows the distribution of fatal intersection crashes by the month. The crashes are generally evenly spread within the year except for the months of February, March and April. The highest number of crashes in the month of February with the least number of days is noticeable. The higher occurrence of crashes during these months of early spring season could be possibly due to higher tourist volume in Florida or people moving out more due to better weather after winter months.

Table 9.4: Fatal Intersection Crashes by Month

Month	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
January	58	8.3%	121	8.8%	**0.947**	0.702	1.278	Unsure
February	77	11.0%	106	7.7%	**1.435**	1.086	1.897	Over
March	76	10.9%	133	9.6%	**1.129**	0.865	1.474	Unsure
April	63	9.0%	120	8.7%	**1.037**	0.775	1.388	Unsure
May	54	7.7%	157	11.4%	**0.680**	0.506	0.913	Under
June	40	5.7%	105	7.6%	**0.753**	0.529	1.071	Unsure
July	51	7.3%	87	6.3%	**1.158**	0.830	1.617	Unsure
August	66	9.4%	111	8.0%	**1.175**	0.878	1.571	Unsure
September	50	7.2%	98	7.1%	**1.008**	0.726	1.400	Unsure
October	53	7.6%	119	8.6%	**0.880**	0.645	1.200	Unsure
November	58	8.3%	91	6.6%	**1.259**	0.918	1.728	Unsure
December	53	7.6%	133	9.6%	**0.787**	0.580	1.068	Unsure
Total	699	100.0%	1381	100.0%	**1.000**			

Although not very obvious a trend can be seen in fatal intersection crashes over the different days of the week from Table 9.5. Highest number of crashes on Fridays indicates the possible aggressive tendency of drivers trying to get away for the weekend. Fatal crash occurrence at intersections is over represented during the start of the week while weekends show under representation of fatal intersection crashes.

Table 9.5: Fatal Intersection Crashes by Day of Week

Day Of Week	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Monday	102	14.59%	168	12.17%	**1.200**	0.954	1.508	Unsure
Tuesday	108	15.45%	170	12.31%	**1.255**	1.004	1.569	Over
Wednesday	109	15.59%	155	11.22%	**1.389**	1.107	1.744	Over
Thursday	87	12.45%	192	13.90%	**0.895**	0.707	1.134	Unsure
Friday	115	16.45%	217	15.71%	**1.047**	0.851	1.288	Unsure
Saturday	99	14.16%	261	18.90%	**0.749**	0.606	0.927	Under
Sunday	79	11.30%	218	15.79%	**0.716**	0.563	0.911	Under
Total	699	100.00%	1381	100.00%	**1.000**			

A study of the fatal intersection crashes by the hour of the day shows that the evening peak hour witnesses most number of crashes. This observation from Table 9.6 is as expected since the evening peak hour has maximum number of drivers trying to get home from work. Broadly looking, the daytime fatal intersection crashes are far more frequent than those at nighttime. Intersections primarily experience daytime traffic and limited nighttime traffic, hence the trend. The daytime hours from 8 am to 2 pm experience a uniform average hourly crash rate of around 30 fatal crashes per hour, which further increases to reach a maximum of 53 fatal crashes in the hour of 6 pm to 7 pm. The average fatal intersection crashes per hour then decreases from 7 pm until 3 am after which the number starts to increase steadily till morning peak traffic hour.

Table 9.7 indicates that the lighting conditions do not really affect the probability of fatal intersection crashes. More than 50% of the fatal intersection crashes occur in daylight conditions. The most prominent driver error issue in fatal intersection crashes is inattention or misjudging of gap, which isn't really affected by the lighting condition. In dark conditions, a higher number of fatal intersection crashes occurred when artificial street lighting was present. The number of fatal intersection crashes is same during dawn and dusk lighting conditions.

Table 9.6: Fatal Intersection Crashes by Hour of the Day

Hour of Day	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
19 (7 PM)	41	5.87%	66	4.78%	**1.227**	0.840	1.792	Unsure
20	44	6.29%	80	5.79%	**1.087**	0.760	1.551	Unsure
21	24	3.43%	78	5.65%	**0.608**	0.388	0.951	Under
22	34	4.86%	66	4.78%	**1.018**	0.679	1.523	Unsure
23	16	2.29%	57	4.13%	**0.555**	0.321	0.958	Under
0	33	4.72%	65	4.71%	**1.003**	0.666	1.509	Unsure
1	10	1.43%	55	3.98%	**0.359**	0.184	0.700	Under
2	13	1.86%	71	5.14%	**0.362**	0.202	0.648	Under
3	4	0.57%	68	4.92%	**0.116**	0.043	0.317	Under
4	18	2.58%	46	3.33%	**0.773**	0.451	1.322	Unsure
5	15	2.15%	65	4.71%	**0.456**	0.262	0.793	Under
6	32	4.58%	68	4.92%	**0.930**	0.616	1.400	Unsure
7 (7 AM)	19	2.72%	40	2.90%	**0.938**	0.547	1.607	Unsure
8	31	4.43%	48	3.48%	**1.276**	0.819	1.984	Unsure
9	29	4.15%	36	2.61%	**1.592**	0.984	2.571	Unsure
10	27	3.86%	46	3.33%	**1.160**	0.727	1.847	Unsure
11	39	5.58%	35	2.53%	**2.201**	1.407	3.440	Over
12	36	5.15%	45	3.26%	**1.581**	1.029	2.425	Over
13	31	4.43%	55	3.98%	**1.114**	0.723	1.712	Unsure
14	34	4.86%	62	4.49%	**1.083**	0.720	1.629	Unsure
15	44	6.29%	66	4.78%	**1.317**	0.909	1.906	Unsure
16	39	5.58%	53	3.84%	**1.454**	0.971	2.175	Unsure
17	33	4.72%	54	3.91%	**1.207**	0.790	1.842	Unsure
18	53	7.58%	56	4.06%	**1.870**	1.298	2.690	Over
Total	699	100.0%	1381	100.0%	**1.000**			

Table 9.7: Fatal Intersection Crashes by Lighting Condition

Lighting Conditions	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Daylight	400	57.22%	577	57.22%	**1.367**	1.252	1.497	Over
Dusk	16	2.29%	19	2.29%	**1.664**	0.860	3.213	Unsure
Dawn	16	2.29%	38	2.29%	**0.832**	0.467	1.480	Unsure
Dark (Streetlights)	155	22.17%	302	22.17%	**1.014**	0.854	1.202	Unsure
Dark (No Streetlights)	107	15.31%	437	15.31%	**0.484**	0.399	0.585	Under
Unknown	5	0.72%	7	0.72%	**1.411**	0.449	4.427	Unsure
Total	699	100.00%	1381	100.00%	**1.000**			

9.5 Fatal Intersection Crashes by Geographical Area

Fatal intersection crashes are distributed by geographical area as described in Table 9.8 and Figure 9.16. The fatal intersection crashes are significantly overrepresented in the suburban regions and the same are quite underrepresented in the rural areas. In the urban areas, the fatal intersection crashes are evenly represented with approximately 40% of both intersection and non-intersection crashes occurring in urban areas.

Table 9.8: Distribution of Fatal Intersection Crashes by Geographical Area

Geo. Area	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Urban	275	39.34%	516	37.36%	**1.053**	0.938	1.180	Unsure
Suburban	233	33.33%	255	18.46%	**1.805**	1.554	2.110	Over
Rural	191	27.32%	610	44.17%	**0.619**	0.540	0.707	Under
Total	699	100.0%	1381	100.0%	**1.000**			

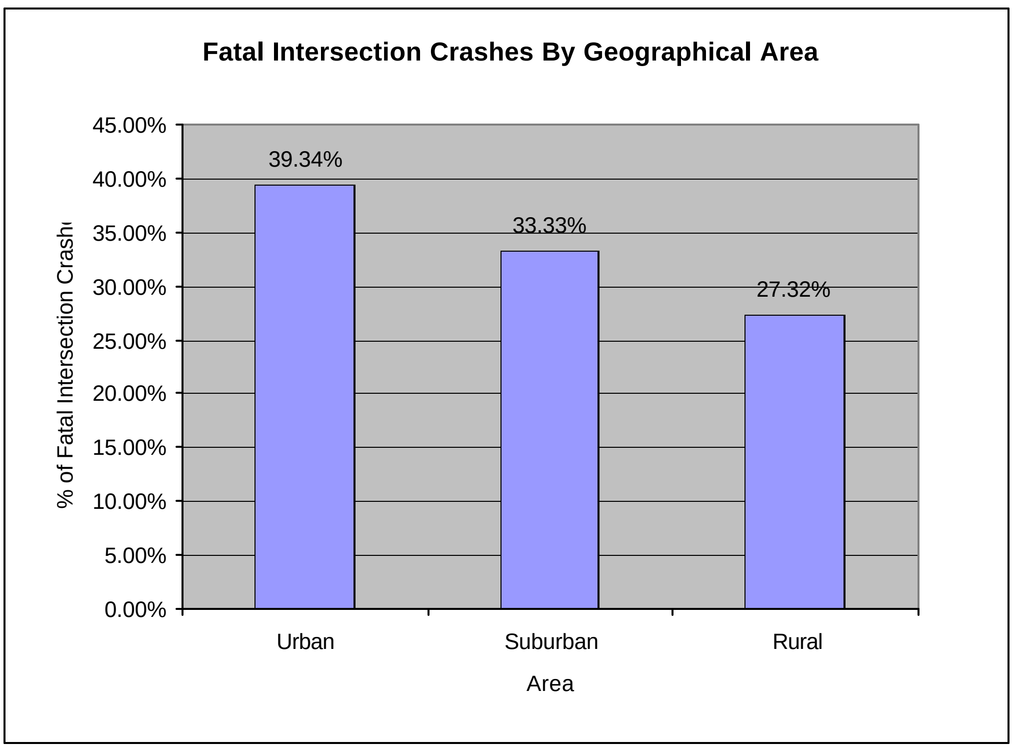

Figure 9.16: Fatal Intersection Crashes by Geographical Area

Table 9.9 and Figure 9.17 show the distribution of fatal intersection crashes within the geographical areas according to the traffic control on the at-fault driver. As expected, the urban intersections have the highest percentage of crashes at signal controlled intersections. Recall, however, that most movements with no control are opposed by movements with stop sign control.

Table 9.9: Distribution of Fatal Intersection Crashes by Traffic Control in Geographical Area

Signalization	Total At Intersections		Urban		Suburban		Rural	
	Num.	Per.	Num.	Per.	Num.	Per.	Num.	Per.
Traffic Signal	252	36.1%	132	47.3%	86	36.9%	34	17.8%
Stop Sign	187	26.8%	54	19.4%	69	29.6%	67	35.1%
Flashing Light	12	1.7%	4	1.4%	3	1.3%	5	2.6%
Yield Sign	7	1.0%	0	0.0%	3	1.3%	4	2.1%
Stop Sign and Flashing Light	19	2.7%	5	1.8%	6	2.6%	9	4.7%
Other	23	3.3%	8	2.9%	3	1.3%	12	6.3%
No Control	199	28.5%	76	27.2%	63	27.0%	60	31.4%
Total	699	100.0%	279	100.0%	233	100.0%	191	100.0%

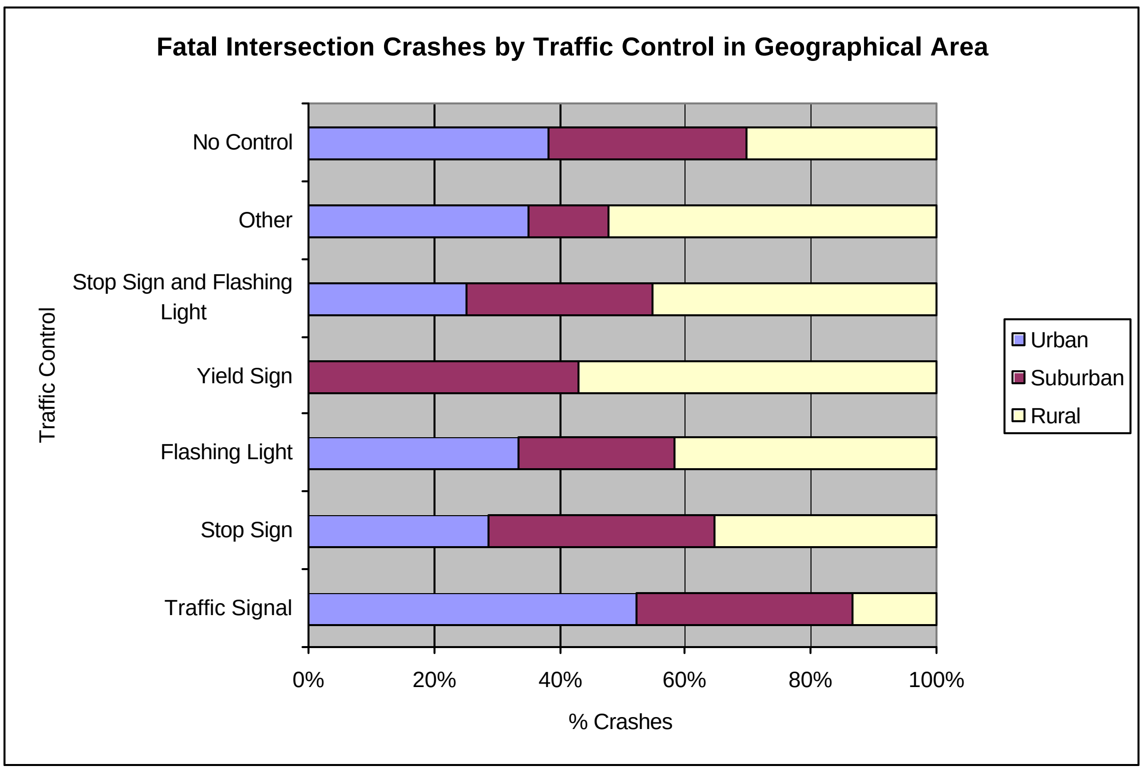

Figure 9.17: Fatal Intersection Crashes by Traffic Control in Geographical Area

Table 9.10 and Figure 9.18 show the distribution of fatal intersection crashes in geographical areas according to the crash hour. It can be noted that the morning peak hour suffers most fatal intersection crashes in the suburban areas with more than 55% of the fatal intersection crashes within the morning peak hour occurring in the suburban areas. This observation can validated with the fact that during that hour most people are driving from residential, generally rural area, to business area and get into a crash on their way, which more often happens to be in the suburban areas. On similar grounds the higher proportion of fatal intersection crashes in rural areas in the earlier morning hours of 6 am can be explained. Thus also, the almost 50% fatal intersection crashes in urban areas in the later part of morning peak, 9 am to 10 am, can be explained. This trend of fatal intersection crashes in rural – suburban – urban areas from earlier in the morning to later in the morning till start of office hours is in consistency of the commute of drivers from residential to urban areas during those hours. Similar trend cannot be observed though for evening hours for drivers returning from urban to rural area.

Table 9.10: Fatal Intersection Crashes by Hour of Day in Geographical Area

Hour of Day	Total At Intersections		Urban		Suburban		Rural	
	Num.	Per.	Num.	Per.	Num.	Per.	Num.	Per.
19 (7 PM)	41	5.87%	20	7.27%	9	3.86%	12	6.28%
20	44	6.29%	17	6.18%	13	5.58%	14	7.33%
21	24	3.43%	14	5.09%	3	1.29%	7	3.66%
22	34	4.86%	13	4.73%	14	6.01%	7	3.66%
23	16	2.29%	7	2.55%	6	2.58%	3	1.57%
0	33	4.72%	11	4.00%	12	5.15%	10	5.24%
1	10	1.43%	2	0.73%	6	2.58%	2	1.05%
2	13	1.86%	9	3.27%	4	1.72%	0	0.00%
3	4	0.57%	1	0.36%	1	0.43%	2	1.05%
4	18	2.58%	8	2.91%	6	2.58%	4	2.09%
5	15	2.15%	8	2.91%	2	0.86%	5	2.62%
6	32	4.58%	9	3.27%	7	3.00%	16	8.38%
7 (7 AM)	19	2.72%	7	2.55%	6	2.58%	6	3.14%
8	31	4.43%	5	1.82%	17	7.30%	9	4.71%
9	29	4.15%	14	5.09%	9	3.86%	6	3.14%
10	27	3.86%	11	4.00%	9	3.86%	7	3.66%
11	39	5.58%	17	6.18%	9	3.86%	13	6.81%
12	36	5.15%	15	5.45%	14	6.01%	7	3.66%
13	31	4.43%	9	3.27%	12	5.15%	10	5.24%
14	34	4.86%	11	4.00%	17	7.30%	6	3.14%
15	44	6.29%	19	6.91%	16	6.87%	9	4.71%
16	39	5.58%	17	6.18%	12	5.15%	10	5.24%
17	33	4.72%	14	5.09%	11	4.72%	8	4.19%
18	53	7.58%	17	6.18%	18	7.73%	18	9.42%
Total	699	100%	275	100%	233	100%	191	100%

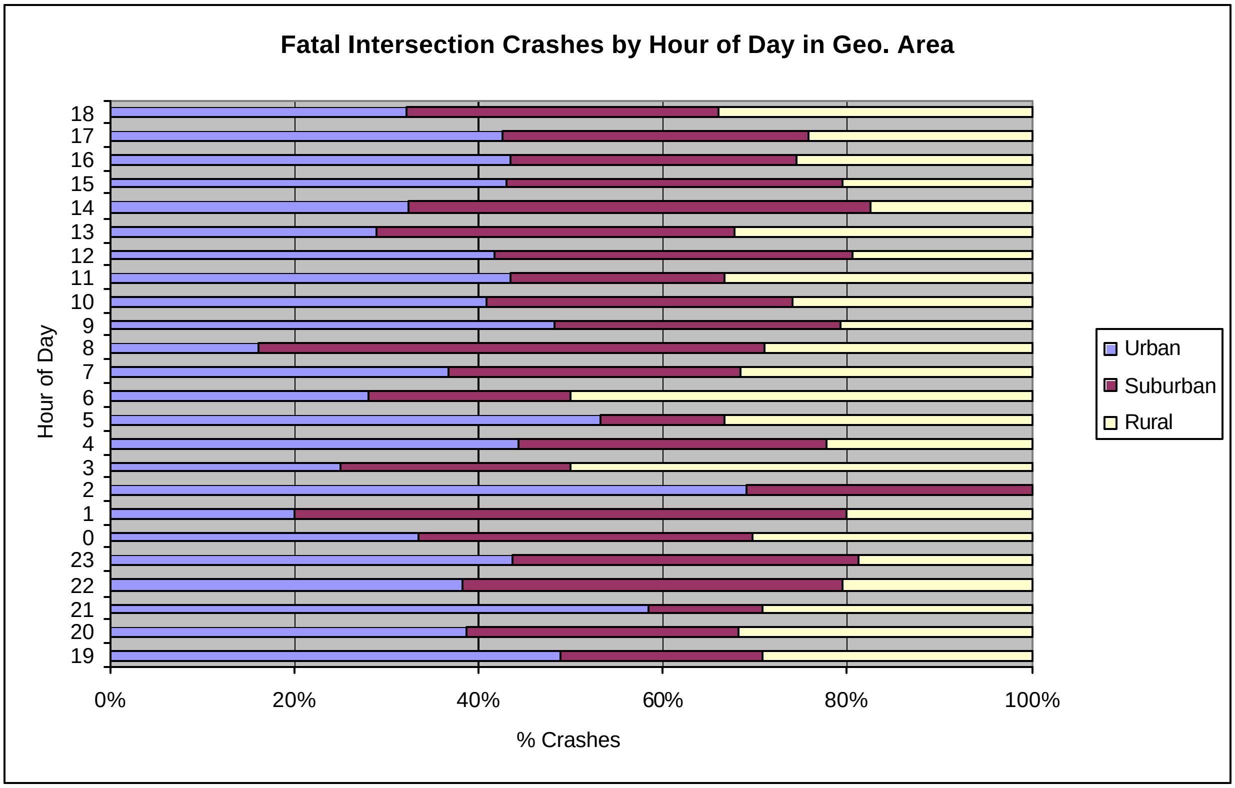

Figure 9.18: Fatal Intersection Crashes in Rural and Urban Area by Crash Hour

Table 9.11 and Figure 9.19 show the distribution of fatal intersection crashes in rural and urban areas by lighting conditions. The geographical area here is more broadly classified in just two categories of rural and urban. As for total fatal intersection crash distribution in rural and urban areas, the fatal intersection crashes are over represented in rural areas for almost all lighting conditions except the ones in dark with streetlights, which is as expected since more number of intersections in urban area will be artificially lighted than in rural areas.

Table 9.11: Fatal Intersection Crashes in Rural and Urban Area by Lighting Conditions

Lighting Condition	Rural		Urban		Rural ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Daylight	221	55.7%	179	59.3%	**0.939**	0.826	1.068	Unsure
Dusk	11	2.8%	5	1.7%	**1.674**	0.588	4.766	Unsure
Dawn	13	3.3%	3	1.0%	**3.296**	0.948	11.465	Unsure
Dark (Streetlights)	63	15.9%	92	30.5%	**0.521**	0.392	0.692	Under
Dark (No Streetlights)	87	21.9%	20	6.6%	**3.309**	2.084	5.255	Over
Unknown	2	0.5%	3	1.0%	**0.507**	0.085	3.016	Unsure
All Not Daylight	176	44.3%	123	40.7%	**1.088**	0.914	1.297	Unsure
Total	397	100%	302	100%	**1.000**			

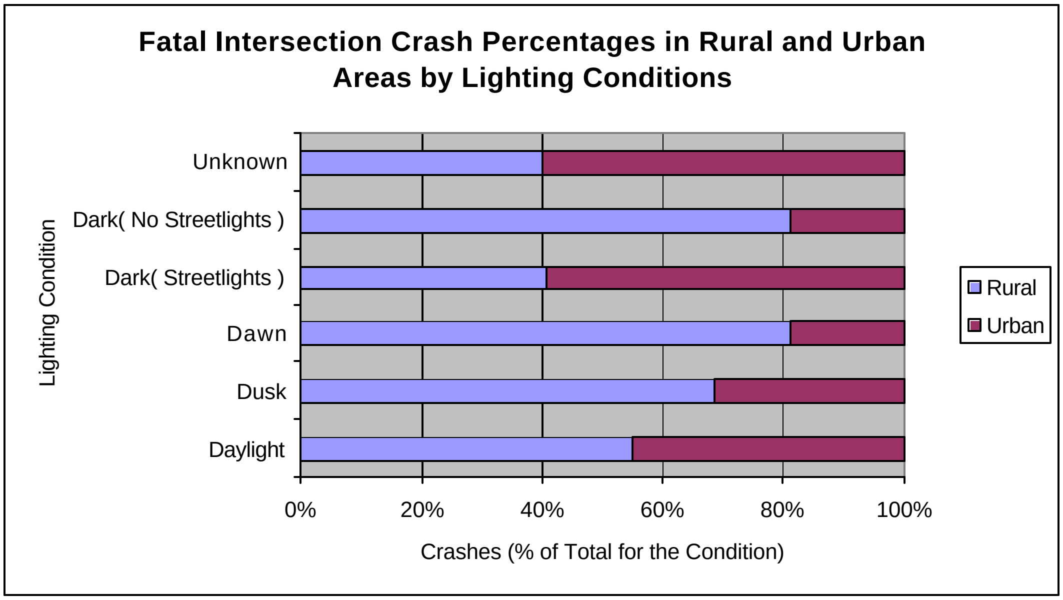

Figure 9.19: Fatal Intersection Crashes in Rural and Urban Areas by Lighting Conditions

9.6 Fatal Intersection Crashes by Crash Type and Vehicle Movement

Table 9.12 shows the distribution of fatal intersection crashes classified broadly by crash type. The crash types mentioned in the table are self-explanatory and haven't been used elsewhere in the chapter so they aren't separately defined here. The table shows that fatal intersection crashes are primarily dominated by Angled Collisions. Almost 10% of fatal intersection crashes are those that involve pedestrians; these are ranked second followed by rear end collisions, which account for around 8% of total fatal intersection crashes. There are negligible head-on collisions at or due to intersections.

Table 9.12: Fatal Intersection Crashes Classified Broadly by Crash Type

Broad Crash Type	Number	Percent
Angled Collision	540	77.3%
Rear End	60	8.6%
Head On	3	0.4%
Pedestrian	69	9.9%
Bicycle	27	3.9%
Total	699	100.0%

The fatal intersection crashes are further looked at according to the crash type as defined previously in the report; the distribution of fatal intersection crashes by crash type is shown in Table 9.13. The pedestrian crashes are grouped together and the sub classification in the group is not shown since the pedestrian crashes have whole different chapter dedicated to their analysis. A closer look at the distribution some vital information about the fatal intersection crashes. More than 50% of fatal intersection crashes occur within the crash type group Change Traffic Way/Turning. The Intersecting Paths crash group constitutes around 25% of the fatal intersection crashes.

Within the Change Traffic Way/Turning crash group from Table 9.13, the Initial Opposite Directions/Oncoming Traffic, that is, left turn-oncoming crashes are highly over represented, with more than 50% of fatal intersection crashes of the type within the crash group. In addition, the Turn into Opposite Direction/Cross Traffic group is highly overrepresented, with around 40% of fatal intersection crashes of the type within the group. It is worth noting here that both of these highly overrepresented crash types involve left turning movement by at least one of the vehicles involved in the crash. Since these two crash types mentioned form more than 90% of the fatal intersection crashes within their crash group, which represents more than 50% of the total fatal intersection crashes, it can be said that in more than 50% of the fatal intersection crashes a left turning vehicle is involved. A revealing observation is that in the Change Traffic Way/Turning crash group, the number of crashes of type Turn into Opposite Direction/Cross Traffic is far more than those of type Turn/Merge into Same Direction. This indicates that when the drivers are turning left across a roadway, they are more often hit by vehicle in the near lanes on the crossing road (i.e. those from the left) than the far lanes where they want to merge (i.e. those from the right). This may be because drivers check for far lane traffic where they are merging and are inattentive or fail to judge the gap adequately for vehicles in the near lanes. In the Intersecting Paths crash group from Table 9.13, it can be seen that the not at fault approaching from left and right are almost equally distributed within the category. There is just a scattered occurrence of vehicle backing into the intersecting path of a vehicle.

Table 9.13: Fatal Intersection Crashes by Crash Type

Crash Type Group	Crash Type	No. of Crashes	% of Total Crashes
Pedestrian	Pedestrian Crash At or Influenced by Intersection	69	9.87%
Run Off Road / Single Vehicle	Right Roadside Departure	4	0.57%
	Right Roadside Departure With Control Loss	9	1.29%
	Left Roadside Departure	1	0.14%
	Left Roadside Departure With Control Loss	3	0.43%
	Forward Impact	4	0.57%
	Other	1	0.14%
Same Direction	Rear End	56	8.01%
	Rear End With Avoid Impact	2	0.29%
	Sideswipe Angle	1	0.14%
Opposite Direction	Head-On	2	0.29%
	Forward Impact With Control Loss	1	0.14%

Table 9.13: Fatal Intersection Crashes by Crash Type, continued

Crash Type Group	Crash Type	No. of Crashes	% of Total Crashes
Change Traffic way / Turning	Initial Opposite Directions/Oncoming Traffic	197	28.18%
	Initial Same Direction	15	2.15%
	Turn/Merge Into Same Direction	14	2.00%
	Turn Into Opposite Directions/Cross Traffic	148	21.17%
	Evasive Action To Avoid Turning/Merging Vehicle	1	0.14%
Intersecting Paths	Not At Fault Approaching from Left	82	11.73%
	Not At Fault Approaching from Right	85	12.16%
	Backing	4	0.57%

Table 9.14 below shows the distribution of the fatal intersection crashes according to the movements of the vehicles involved in a crash. The table shows that there is maximum number of fatal intersection crashes when both the vehicles in the crash are moving straight across the intersection, followed by left turn-oncoming movements. However, on a closer look, it can be noticed that most fatal intersection crashes occur when one of the vehicles involved in the crash is making a left turn. Thus left turners contribute to more than 50% of fatal intersection crashes.

Table 9.14: Distribution of Fatal Intersection Crashes According to the Relative Movements of Vehicles Involved

General Movement of Vehicles	Number	Percent
Left Turn Vs. Oncoming	190	27.26
Left Turn Vs. Crossing	138	19.80
Straight Vs. Straight	238	34.15
Rear End	62	8.90
Other	69	9.90
Total	697	100

Table 9.15 and Figure 9.20 represent the distribution of vehicles involved in fatal intersection crashes by the vehicle movement and the driver fault involvement. It shows that a turning vehicle involved in a fatal intersection crash is much more likely to be at fault than it being not at fault in the fatal intersection crash. A left turning or U-Turning vehicle is at fault more than 80% of the times when it is involved in a fatal intersection crash while a right turning is at fault around 70% of the times when involved in a fatal intersection crash. A straight-ahead vehicle has not at fault to at fault distribution as almost 60 – 40. The absence of a bar for properly parked vehicle is obvious.

Table 9.15: Fatal Intersection Crashes by Vehicle Movement

Vehicle Movement	No. of Vehicles	Driver At Fault	Driver Not At Fault	Unknown
Straight Ahead	941	352	579	10
Slowing / Stopped / Stalled	115	10	104	1
Making Left Turn	313	256	55	2
Backing	2	2	0	0
Making Right Turn	28	19	9	0
Changing Lanes	5	5	0	0
Properly Parked	7	0	0	0
Making U - Turn	13	12	1	0
Passing	4	2	2	0
All Other	29	21	7	1
Unknown	4	2	1	1

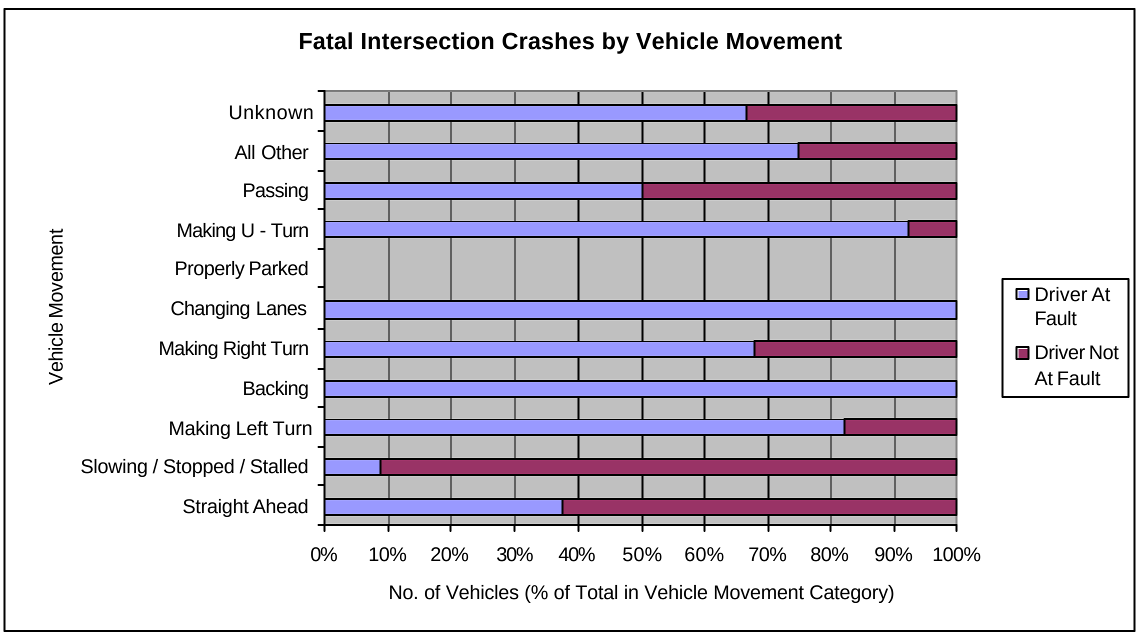

Figure 9.20: Fatal Intersection Crashes by Vehicle Movement

Table 9.16 and Figure 9.21 show the distribution of vehicles involved in fatal intersection crashes according to the point of impact for the vehicle with the driver fault involvement. Almost 65% of the times a vehicle with point of impact as the front end is not at fault in a fatal intersection crash as this point of impact mostly suggests the vehicle movement as straight ahead striking a turning or crossing vehicle. The times when the vehicle with front end impact is at fault is when it rear ends another vehicle, or when the crossing vehicle strikes the side of a crossing straight ahead or oncoming vehicle, which is likely only in 35% of the vehicle with front end impact in fatal intersection crashes. The numbers for other point of impacts are also in consistency with the vehicle movement numbers in fatal intersection crashes. Table 9.16 and Figure 9.21 also show that a vehicle when rear-ended is least likely to be at fault in a fatal intersection crash.

Table 9.16: Vehicles Involved in Fatal Intersection Crashes by Point of Impact

Point of Impact	No. of Vehicles	Driver At Fault	Driver Not At Fault	Unknown
Front End	549	193	352	4
Right Front Corner	102	37	62	3
Right Front Quarter Panel	58	33	22	3
Right Front Door	153	118	34	1
Right Rear Door	35	23	11	1
Right Rear Quarter Panel	15	8	7	0
Right Rear Corner	11	6	4	1
Rear End	41	5	36	0
Left Rear Corner	11	5	5	1
Left Rear Quarter Panel	19	10	9	0
Left Rear Door	30	16	14	0
Left Front Door	143	99	42	2
Left Front Quarter Panel	58	31	24	3
Left Front Corner	124	40	81	3
Hood	6	2	4	0
Roof	7	2	5	0
Under Carriage	10	2	8	0
Overturn	11	8	3	0
Windshield	3	1	2	0
Trailer	48	25	23	0
Unknown	27	17	10	0

9.7 Fatal Intersection Crashes by Roadway Characteristics and Issues

Traffic control plays a vital role in the intersection crashes with highest number of fatal intersection crashes occurring at or due to signal controlled intersections. Table 9.17 and Figure 9.22 show the distribution of fatal intersection crashes according to the traffic control present on the movement of the at-fault driver. For example, uncontrolled movements in left turn oncoming crashes often have stop signs on the other movement, or it could be a driveway, which is completely uncontrolled with only an implicitly expected driver action of yielding to traffic on the main roadway. The fatal intersection crashes on signalized movements comprise almost 35% of the total fatal intersection crashes. Around 30% of the fatal intersection crashes occurred on uncontrolled movements. Stop sign controlled movements contribute around another 30% to the fatal intersection crashes. The portion of fatal intersection crashes on movements controlled by other traffic control devices is not too large and makes up the remaining 5%. The other traffic controls include such controls as posted No U–Turn signs.

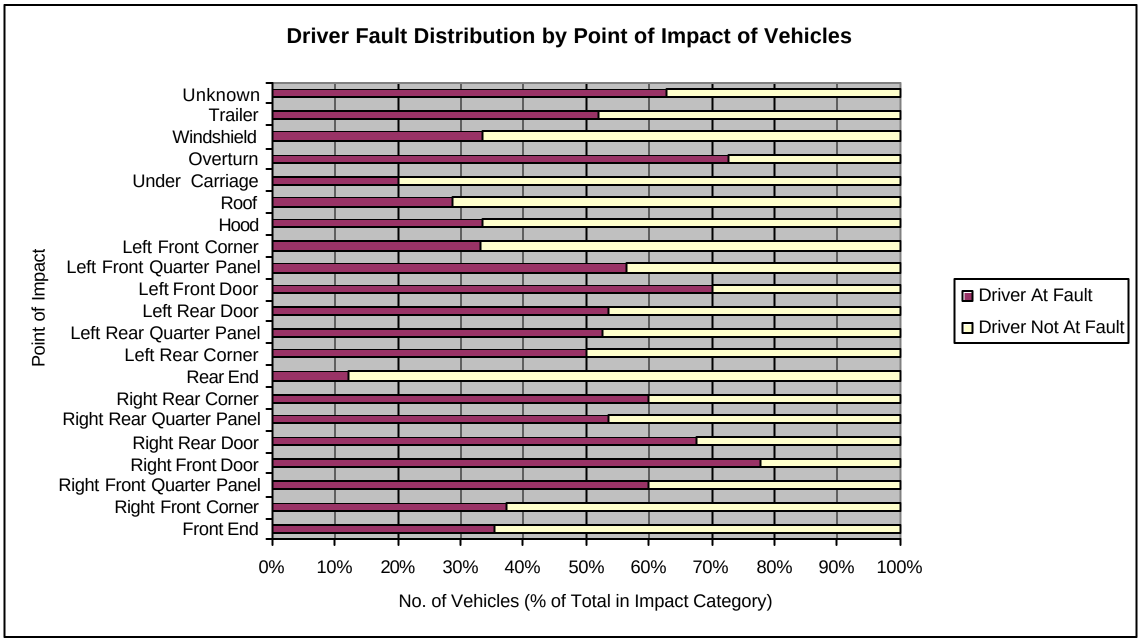

Figure 9.21: Driver Fault Distribution by Point of Impact of Vehicles

Table 9.17: Fatal Intersection Crashes by Traffic Control

Traffic Control	Number	Percent
Traffic Signal	252	36.05%
Stop Sign	187	26.75%
Flashing Light	12	1.72%
Yield Sign	7	1.00%
Stop Sign and Flashing Light	19	2.72%
Other	23	3.29%
No Control	199	28.47%
Total	699	100.0%

Table 9.18 below shows the distribution of the fatal intersection crashes according to the class and category of the roadway on which the crash occurred. The categories of roadway used here are same as for the report except the category Ramp Junctions/Other in the table is a combined category for ramp junctions on Rural, Urban Interstates and Urban Toll Roads and Other Limited Access Roads because of the scattered few instances of fatal intersection crashes on these roadway class categories. For the non intersection crashes, the Ramp Junctions/Other

category also includes all the limited access roadways that these ramp junctions are on. It is evident from the table that 4–5 divided roadways combine to account for over 50% of all intersection crashes. Within the 4–5 lane roadways, the suburban class roadways experience the largest number of fatal intersection crashes (almost 20% of the fatal intersection crashes) followed by urban class roadways then rural roadways. Also, 6+ lanes urban class divided roadways contribute another 16% of total fatal intersection crashes. In the undivided roadways, the rural 2–3 lane roadways have the highest number of fatal intersection crashes, with almost 70% of the fatal intersection crashes on undivided roadways occurring on this category of roadway. This observation indicates two possibilities: that, in addition to the highest number of 2–3 lane undivided roadway intersections occurring in rural areas, these intersections may need more forgiving roadway design in terms of speed limits and sight distances. Note that intersection crashes are overrepresented in almost all non-limited roadways, and are significantly underrepresented only on suburban and rural 2–3 lane undivided roadways.

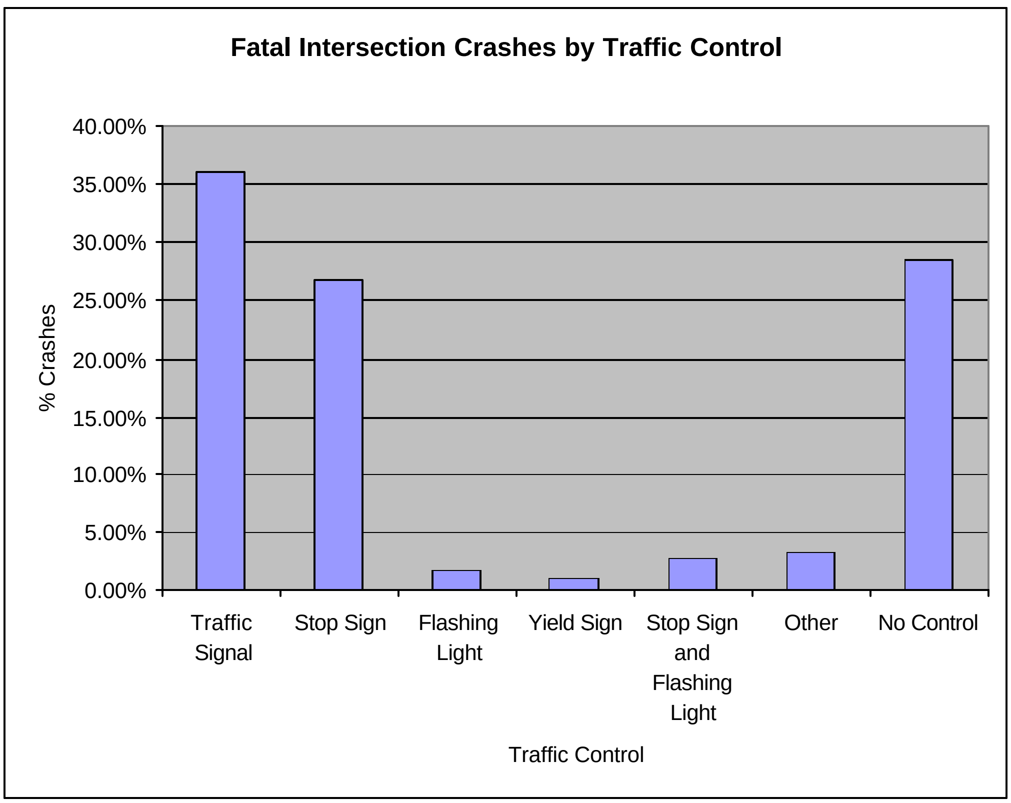

Figure 9.22: Distribution of Fatal Intersection Crashes by Traffic Control

Figure 9.23 shows the distribution of fatal intersection crashes according to the maximum posted speed limit on the intersecting roadways. Around 40% of the fatal intersection crashes occurred at or due to intersections with maximum posted speed limit of 45 MPH and a little over 20% occurred at or due to intersections with maximum posted speed limit of 55 MPH. Speed limit on the road plays a vital role on the driver behavior and so also the stopping sight distance.

A roadway with higher speed limit should have proper signage for the presence of an intersection or an access point in the roadway and the driver on the major roadway should be alerted and expect cross traffic.

Table 9.18: Distribution of Fatal Intersection Crashes by Crash Road Class Category

Road Category	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
Ramp Junctions/Other	12	1.72%	516	37.36%	**0.046**	0.026	0.081	Under
Urban 2-3ln 2wy Divided Raised	1	0.14%	0	0.00%	**N/A**	N/A	N/A	N/A
Urban 2-3ln 2wy Divided Paved	4	0.57%	2	0.14%	**3.951**	0.726	21.520	Unsure
Urban 2-3ln 2wy Undivided	1	0.14%	7	0.51%	**0.282**	0.035	2.289	Unsure
Suburban 2-3ln 2wy Divided Raised	1	0.14%	0	0.00%	**N/A**	N/A	N/A	N/A
Suburban 2-3ln 2wy Divided Paved	16	2.29%	9	0.65%	**3.512**	1.560	7.908	Over
Suburban 2-3ln 2wy Undivided	17	2.43%	64	4.63%	**0.525**	0.310	0.889	Under
Rural 2-3ln 2wy Divided Raised	2	0.29%	1	0.07%	**3.951**	0.359	43.501	Unsure
Rural 2-3ln 2wy Divided Paved	14	2.00%	13	0.94%	**2.128**	1.006	4.502	Over
Rural 2-3ln 2wy Undivided	62	8.87%	228	16.51%	**0.537**	0.412	0.701	Under
Urban 4-5ln 2wy Divided Raised	56	8.01%	40	2.90%	**2.766**	1.863	4.107	Over
Urban 4-5ln 2wy Divided Paved	56	8.01%	56	4.06%	**1.976**	1.380	2.829	Over
Urban 4-5ln 2wy Undivided	11	1.57%	13	0.94%	**1.672**	0.753	3.712	Unsure
Suburban 4-5ln 2wy Divided Raised	142	20.31%	117	8.47%	**2.398**	1.911	3.009	Over
Suburban 4-5ln 2wy Divided Paved	12	1.72%	11	0.80%	**2.155**	0.956	4.860	Unsure
Rural 4-5ln 2wy Divided Raised	96	13.73%	112	8.11%	**1.693**	1.310	2.190	Over
Urban 6+Ln 2wy Divided Raised	111	15.88%	108	7.82%	**2.031**	1.583	2.604	Over
Urban 6+Ln 2wy Divided Paved	19	2.72%	18	1.30%	**2.085**	1.102	3.948	Over
Suburban 6+Ln 2wy Divided Raised	46	6.58%	45	3.26%	**2.020**	1.353	3.015	Over
Suburban 6+Ln 2wy Divided Paved	1	0.14%	1	0.07%	**1.976**	0.124	31.539	Unsure
Rural 6+Ln 2wy Divided Raised	6	0.86%	2	0.14%	**5.927**	1.199	29.290	Over
One Way	13	1.86%	18	1.30%	**1.427**	0.703	2.895	Unsure
Total	699	100%	1381	100%				

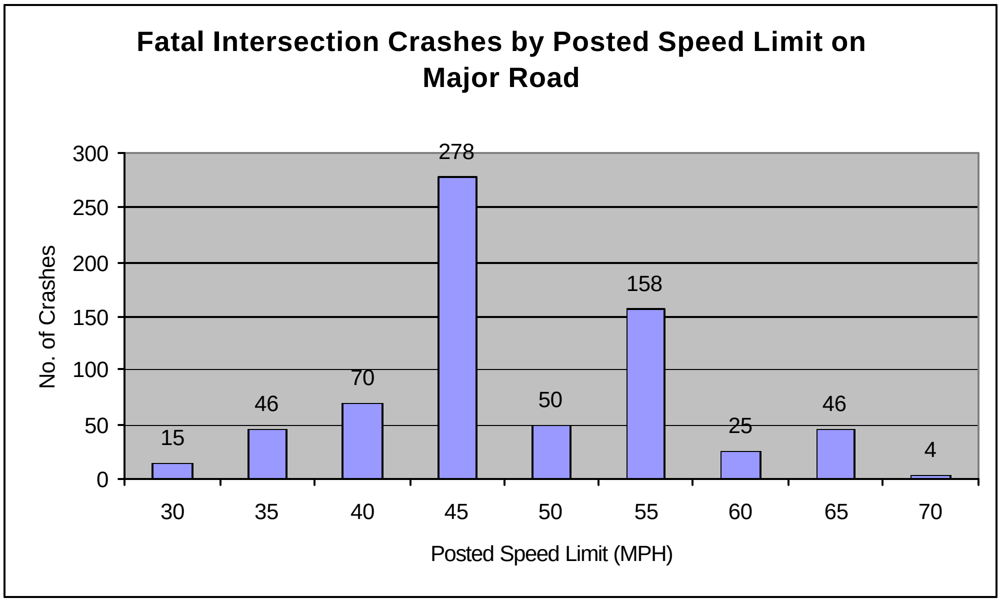

Figure 9.23: Fatal Intersection Crashes by Maximum Posted Speed Limit

Table 9.19 shows the distribution of fatal intersection crashes according to the difference in the posted speeds on the intersecting roads. It is evident that majority of the crashes occurred at intersections where the involved roads had the same posted limit. This includes the left turn oncoming and rear end crashes, which primarily occur for vehicles on the same roadway. These also include the pedestrian crashes where only one vehicle is involved. There are also noticeable numbers of fatal intersection crashes that occurred on intersecting roadways with posted speed limits differing by 10–20 mph. The higher differences of 40–45 mph are on ramp junctions, with the intersecting roadway being a freeway or other limited access, high speed facility.

Table 9.19: Fatal Intersection Crashes According to Difference in Speeds on Intersecting Roads

Speed Difference on Intersecting Roads	Number	Percent
0	581	83.1%
5	17	2.4%
10	24	3.4%
15	28	4.0%
20	20	2.9%
25	13	1.9%
30	9	1.3%
35	1	0.1%
40	2	0.3%
45	4	0.6%
Total	699	100.0%

Table 9.20 shows the distribution of fatal intersection crashes according to the ADT on the major road in the intersection. It may seem surprising to find that roadways carrying small ADT's have the highest number of fatal intersection crashes, but this is correlated with the fact that there are fewer intersections on roads with higher ADT volumes. The highest number of fatal intersection crashes occurs on roadways in the ADT range of 10,000–20,000, which is around a quarter of the total fatal intersection crashes. This rate further declines as the ADT range increases to 20,000–30,000 and beyond. Roadways with ADT ranging between 50,000 and 60,000 have around 6 percent of fatal intersection crashes. The number of fatal intersection crashes on roadways with ADT higher than 70,000 is minimal.

Table 9.20: Fatal Intersection Crashes by ADT on Major Road

ADT Range	Number	Percent
More than 190000	1	0%
130000 - 190000	2	0%
90000 - 130000	4	1%
70000 - 90000	2	0%
60000 - 70000	19	3%
50000 - 60000	44	6%
40000 - 50000	74	11%
30000 - 40000	126	18%
20000 - 30000	159	23%
10000 - 20000	167	24%
0 – 10000	97	14%
Unknown	4	1%
Total	699	100%

Table 9.21 shows the distribution of the fatal intersection crashes by the number of lanes on the major roadway. Four-lane roads top the list of fatal intersection crashes when sorted by number of lanes, with almost 50% of fatal intersection crashes occurring on four-lane roads, followed by six-lane roads and two-lane roads with around 20% of fatal intersection crashes occurring in each category. The high precedence of fatal intersection crashes on four-lane roads may be due to the higher number of roads with four lanes statewide.

A further closer look into the fatal intersection crash distribution by number of lanes according to the roadway type being divided or undivided is shown by Figure 9.24. The figure shows that almost in each case the fatal intersection crashes on divided roadways is higher than those on undivided roadways. The two-lane roadways stand out as an exception to this general trend with almost 80% of the fatal intersection crashes on two-lane roadways occurring on undivided roadways. Also fatal intersection crashes on five-lane roadways are almost equally distributed over divided and undivided roadways. There are a few cases where the roadway type, whether divided or undivided, was not known and are also shown in Figure 9.24.

Table 9.21: Fatal Intersection Crashes by Number of Lanes on Major Roadway

Number of Lanes	Intersection		Non-Intersection		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
4	335	47.93%	577	41.78%	**1.147**	1.039	1.267	Over
6	158	22.60%	272	19.70%	**1.148**	0.965	1.365	Unsure
2	136	19.46%	379	27.44%	**0.709**	0.596	0.843	Under
3	25	3.58%	30	2.17%	**1.646**	0.976	2.777	Unsure
5	21	3.00%	21	1.52%	**1.976**	1.086	3.593	Over
8	11	1.57%	45	3.26%	**0.483**	0.251	0.928	Under
7	8	1.14%	6	0.43%	**2.634**	0.918	7.562	Unsure
1	4	0.57%	26	1.88%	**0.304**	0.106	0.867	Under
12	1	0.14%	4	0.29%	**0.494**	0.055	4.411	Unsure
10	0	0.00%	20	1.45%	**0.000**	N/A	N/A	N/A
9	0	0.00%	1	0.07%	**0.000**	N/A	N/A	N/A
Total	699	100.0%	1381	100.0%	**1.000**			

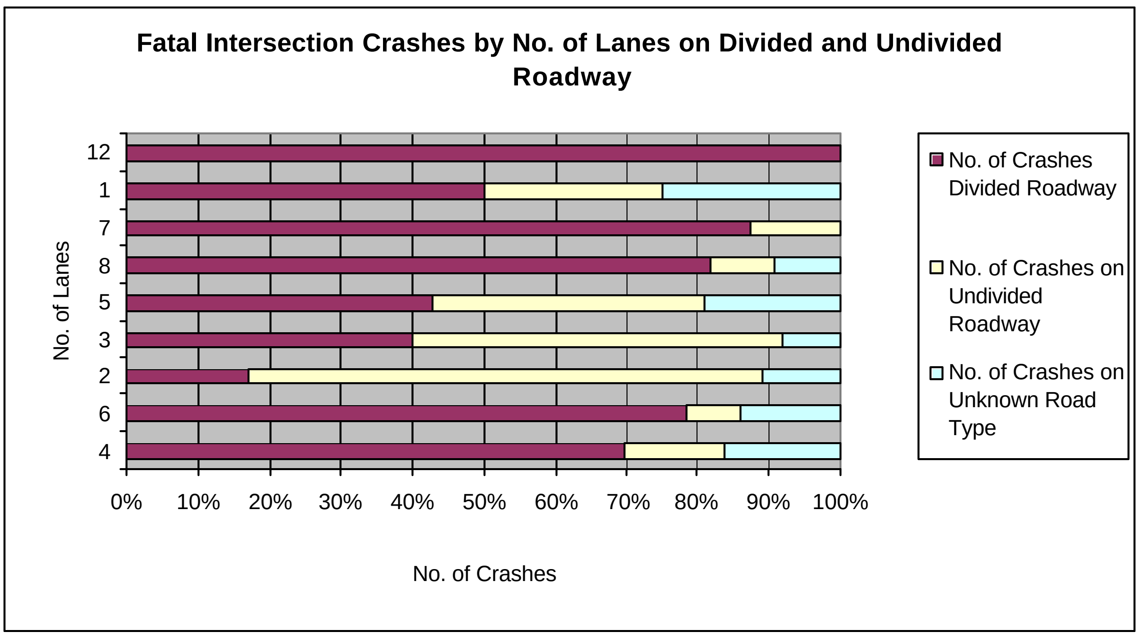

Figure 9.24: Fatal Intersection Crashes by Number of Lanes on Divided and Undivided Roadway

Median width of the road at an intersection affects the sight triangles and as such is a potential factor when it comes to fatal intersection crashes. Table 9.22 shows the distribution of the fatal intersection crashes according to the median width of the major roadway in the fatal intersection crash. It can be seen that roadways with a median width in the range 20–30 feet suffer from fewer fatal intersection crashes as compared to the ranges above and below it, as shown in Table 9.22.

Table 9.22: Distribution of Fatal Intersection Crashes by Median Widths of the Major Roadway

Median Width Range	Number	Percent
Undivided – 5 Feet	103	14.7%
5 - 10 Feet	31	4.4%
10 - 20 Feet	211	30.2%
20 - 30 Feet	114	16.3%
30 - 40 Feet	140	20.0%
40 - 50 Feet	60	8.6%
More Than 50 Feet	40	5.7%
Total	699	100.0%

Table 9.23 and Table 9.24 show the prevalence of roadway issues in fatal intersection crashes. The numbers in Table 9.23 do not add up as columns to give total number of fatal intersection crashes since a particular crash may involve a combination of roadway factors, or no roadway factors at all. For example, the number *68* in the first row of Table 9.23 indicates that there are 68 fatal intersection crashes that involved a sight distance issue with or without another roadway issue. Thus, it says that almost 10% of the fatal intersection crashes have a potential sight distance issue, which may or may not be coupled with any other roadway issue. Similarly, the number *27* in the second column of this row of Table 9.23 indicates that there are 27 fatal intersection crashes with a potential sight distance issue coupled with or due to a roadway geometry issue.

Table 9.23: Roadway Issues in Fatal Intersection Crashes

Issue	Sight Distance Issue	Roadway Geometry Issue	Traffic Operation Issue	Signalization Issue	Signage Issue	Environment Issue	Pedestrian Facility Issue
Sight Distance Issue	68	27	13	0	4	17	4
Roadway Geometry Issue		37	13	2	3	2	0
Traffic Operation Issue			70	15	15	4	5
Signalization Issue				28	5	0	3
Signage Issue					24	2	1
Environment Issue						44	7
Pedestrian Facility Issue							27

Table 9.24: Percentage of Fatal Intersection Crashes with Roadway Issues

	Sight Distance Issue	Roadway Geometry Issue	Traffic Operation Issue	Signalization Issue	Signage Issue	Environment Issue	Pedestrian Facility Issue
Sight Distance Issue	10%	4%	2%	0%	1%	2%	1%
Roadway Geometry Issue		5%	2%	0%	0%	0%	0%
Traffic Operation Issue			10%	2%	2%	1%	1%
Signalization Issue				4%	1%	0%	0%
Signage Issue					3%	0%	0%
Environment Issue						6%	1%
Pedestrian Facility Issue							4%

As mentioned earlier, a fatal intersection crash is not the result of an isolated driver error or an isolated roadway issue. More often it is a combination of driver errors; if there is a roadway issue, it adds to the probability of crash occurrence. Table 9.25 and Table 9.26 show the coupling of driver error issues with roadway issues in the fatal intersection crashes. The table shows the number of crashes due to a particular driver error coupled with the contribution of a roadway issue. Thus, for example, the first column of Table 9.25 shows the crashes that had DUI as a driver error issue at the same time as various roadway issues. It is seen that there are 14 fatal intersection crashes with a potential sight distance issues while the driver was DUI, whereas in 149 fatal intersection crashes, there was no roadway issue involved that contributed to the occurrence of the crash. As described for the previous table, the numbers do not add up since a particular crash may involve a combination of driver error and roadway issues. Table 9.26 looks at percent of crashes with various driver and roadway issues combined. The highest interaction occurs with rear end crashes where traffic operations issues (typically lack of turn lanes) were involved: this accounted for over 30 percent of all rear-end crashes.

Table 9.25: Driver Issues with Roadway Issues in Fatal Intersection Crashes

Issue	DUI	Speeding	Inattention	Improper Turn	Ran Red Light	Ran Stop Sign	Rear End	Misjudged Gap
Sight Distance Issue	14	17	35	3	4	7	4	36
Roadway Geometry Issue	4	8	19	4	7	3	6	18
Traffic Operation Issue	8	19	32	10	11	7	19	21
Signalization Issue	2	7	13	1	10	2	0	7
Signage Issue	5	5	15	3	2	10	2	7
Environment Issue	11	8	24	2	4	4	2	12
Pedestrian Facility Issue	9	2	7	0	2	1	0	5
Non Issue	149	132	338	45	92	55	35	193

Table 9.26: Percentage Comparison of Driver Issues and Roadway Issues

Issue	DUI	Speeding	Inattention / Careless	Improper Turn	Ran Red Light	Ran Stop Sign	Rear End	Misjudged Gap
Sight Distance Issue	8%	**10%**	8%	5%	3%	9%	6%	**14%**
Roadway Geometry Issue	2%	5%	4%	7%	6%	4%	10%	7%
Traffic Operation Issue	4%	**11%**	7%	17%	9%	9%	**31%**	8%
Signalization Issue	1%	4%	3%	2%	8%	3%	0%	3%
Signage Issue	3%	3%	4%	5%	2%	**14%**	3%	3%
Environment Issue	6%	5%	6%	3%	3%	5%	3%	5%
Pedestrian Facility Issue	5%	1%	2%	0%	2%	1%	0%	2%
Non Issue	82%	75%	79%	75%	78%	74%	56%	75%

Table 9.27 shows the distribution of contributing cause factors according to their significance in the occurrence of the fatal intersection crashes. It is not too surprising to note after all the case reviews that the primary contributing cause in almost all the fatal intersection crashes is a human factor. The scattered instances when a roadway factor was a primary contributing factor were due to either a signalization issue or a sight distance issue in a few cases. Typically, however, the roadway issue is a secondary issue. In the instance of DHSMV crash number 57580668, a very wide intersection, with 7 lanes and a median to cross, a through pedestrian movement and a left turning vehicle movement were permitted at the same time. Figure 9.25 below shows the crash reconstruction diagram for the fatal intersection crash mentioned above. It may be noted here that since the intersection has a mall at one corner and a major grocery store at the other, there is definitely significant pedestrian and vehicular movement at the crosswalks. A pedestrian-only phase would prevent such a conflict. Further, given the fact that the pedestrian was 87 years of age, the length of the pedestrian phase relative to the crossing speed of an elderly pedestrian should also be considered.

Table 9.27: Fatal Intersection Crashes by Contributing Causes

Contributing Factor	Primary Factor	Secondary Factor	Tertiary Factor
Roadway	6	67	59
Environment	3	46	43
Vehicle	6	47	36
Human	678	307	88
Other/Unknown	6	0	0
None	0	232	473

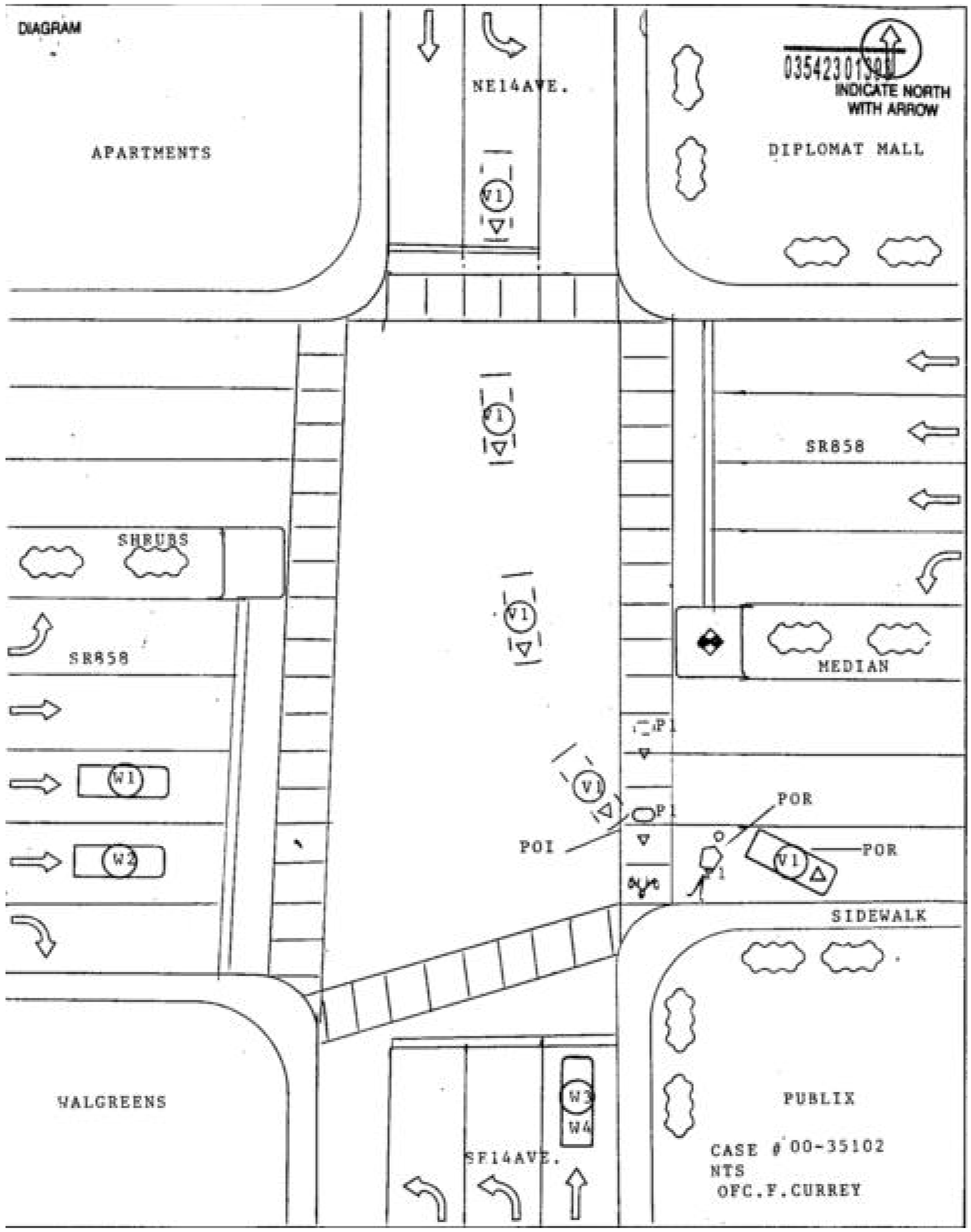

Figure 9.25: Crash Diagram for DHSMV Crash Number 57580668

Table 9.28 below shows the distribution of the primary contributing factors in the crashes with the factor details. It can be seen that inattention on the account of the driver is the most prevalent primary contributing factor in fatal intersection crashes followed by driving under the influence of alcohol or drugs or both. The human contributing factors as such have already been talked about in the driver characteristics section. Looking at the roadway related primary contributing factors, signs/signalization is a major cause of concern in about one percent of the intersection cases.

Table 9.28: Distribution of Fatal Intersection Crashes by Primary Contributing Factors

Primary Contributing Factor Class	Detail	No. Of Crashes
Human	Inattention	271
	DUI	147
	Decision	130
	Perception	40
	Speed	25
	Aggression	9
	Medical/ Mental	7
	Other	56
Roadway	Sign/ Signal	6
	Sight Distance	2
Environment	Wet Slippery	3
	Dark	1
Vehicle	Brakes/ Other	2

Looking into the secondary contributing factors to the fatal intersection crashes in Table 9.27, it is seen that roadway issues had a secondary contribution in a little over 10% of the fatal intersection crashes. Hence, a closer look is presented in Table 9.29 showing the various roadway factors acting as secondary contributing causes in the fatal intersection crashes. As mentioned earlier, adequate sight distance and a clear line of sight is very important for the safe functioning of an intersection, and as such an inadequacy of the same is found to be the most prevalent roadway factor contributing secondarily in the causation of fatal intersection crashes. Traffic operations issues also are significant secondary contributors towards the fatal intersection crashes. Traffic operations issues, as defined earlier, are a combination of issues such as lane usage, pavement markings, posted speed limits on roadways and other factors, which are essential for smooth operations on a roadway. Traffic control, signage and signalization as such form a part of traffic operations but are looked at separately due to their significant proportion within the group. Inadequate or improper signage or signalization also contributed secondarily to more than a dozen fatal intersection crashes in the study set.

Table 9.29: Secondary Contributing Roadway Factors in Fatal Intersection Crashes

Roadway Contributing Factor	Secondary Factor
Sight Distance	27
Traffic Operations	21
Signage / Signalization	14
Roadway Geometry	7
Access Management	3
Pedestrian Facility	3
Construction	1

The tertiary contributing roadway factors in fatal intersection crashes are shown in Table 9.30. As with the secondary contributing roadway factors, sight distance issues are the leading tertiary contributing roadway factor. Overall, whether primary, secondary or tertiary, sight distance issues are factors in almost 8% of the total fatal intersection crashes, and as such is a cause of concern for improving the safety of intersections in Florida.

Table 9.30: Various Tertiary Contributing Roadway Factors in Fatal Intersection Crashes

Roadway Contributing Factor	Tertiary Factor
Sight Distance	27
Traffic Operations	14
Signage / Signalization	16
Roadway Geometry	14
Access Management	10
Pedestrian Facility	8
Construction	1

9.8 Fatal Intersection Crashes by Driver Characteristics

The distribution of fatal intersection crashes by driver error issues, as mentioned earlier in this chapter, is shown in Table 9.31. Again, the number of crashes does not add up to the total fatal intersection crashes as there may be multiple driver errors in a single crash. Inattention is the most prevalent driver error issue in the fatal intersection crashes followed by misjudging of the gap, which include around 60% and 40% of the total fatal intersection crashes, respectively. Table 9.31 also shows that DUI and speeding are also highly dominant driver issues in fatal intersection crashes. Almost 10% of the crashes involved a driver making an improper turn and another almost 20% of them involved red light running. Around 14 crashes had no error involved on part of either driver and typically involved vehicle or signal malfunctions.

Table 9.31: Fatal Intersection Crashes by Driver Error

Driver Error	Number	Percent
DUI	182	26.0%
Speeding	176	25.2%
Inattention	428	61.2%
Improper Turn	60	8.6%
Ran Red Light	118	16.9%
Ran Stop Sign	74	10.6%
Rear End	62	8.9%
Misjudged Gap	259	37.1%
No Error	14	2.0%
Total	699	100.0%

Figure 9.26 shows the distribution of fatal intersection crashes by driver error issue with and without involvement of DUI. It is seen that speeding is almost equally likely with DUI as it is without DUI. Other driver error issues are under represented when alcohol is involved, as compared to without DUI coupled with the issue.

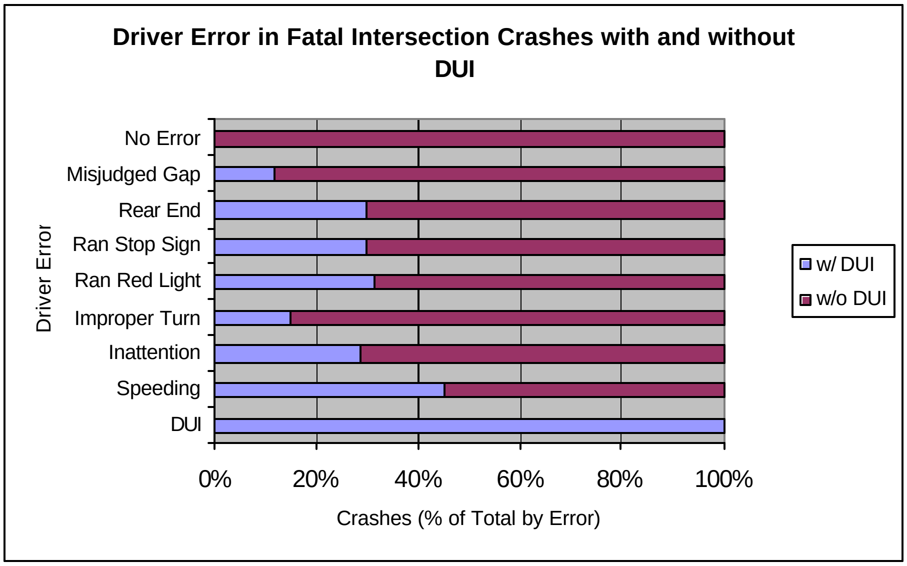

Figure 9.26: Driver Error in Fatal Intersection Crashes with DUI Involvement

Table 9.32 shows the distribution of drivers involved in fatal intersection crashes by the driver action as defined for general terms of the report. The table shows 25 instances of hit and run drivers involved in fatal intersection crashes and 13 instances of a phantom driver having contributed to the fatal intersection crash.

Table 9.32: Fatal Intersection Crashes by Driver Action

Driver Action	Number
Phantom	13
Hit And Run	25
N/A	1423

Table 9.33 shows the distribution of fatal intersection crashes according to driver age groups. Older drivers (above 65 years) are involved in almost 40 percent of the fatal intersection crashes, whereas the total number of drivers driving on roads in older driver group is far smaller than that, around 18 percent. (*Traffic* 2003). A similar relationship is seen for young drivers (under 25 years). The licensed drivers under the age of 25 are just about 13% of total licensed drivers in the state of Florida while, according to the data studied, more than 18% of them are involved in fatal intersection crashes (*Traffic* 2003).

Table 9.33: Drivers by Driver Age Groups in Fatal Intersection Crashes

Age Group	Number	Percent
5 – 14	2	0.14%
15 – 24	262	17.92%
25 – 34	275	18.81%
35 – 44	291	19.90%
45 – 54	214	14.64%
55 – 64	116	7.93%
65 – 74	109	7.46%
75 – 84	114	7.80%
85 – 94	46	3.15%
95+	2	0.14%
Unknown	31	2.12%

Figure 9.27 and Figure 9.28 show the driver fault distribution within the age group for fatal intersection crashes. As seen from Figure 9.27 and Figure 9.28, the likelihood that a driver who was involved in a fatal intersection crash was at fault in that crash varies according to age of the driver. Drivers above 65 are much more likely to be at fault in a fatal intersection crash than not at fault, and as the ages increase the likelihood of them being at fault in a fatal intersection crash increases. Young drivers are almost equally likely to be at fault as they are not at fault when involved in a fatal intersection crash, and middle-aged drivers are less likely to be at fault.

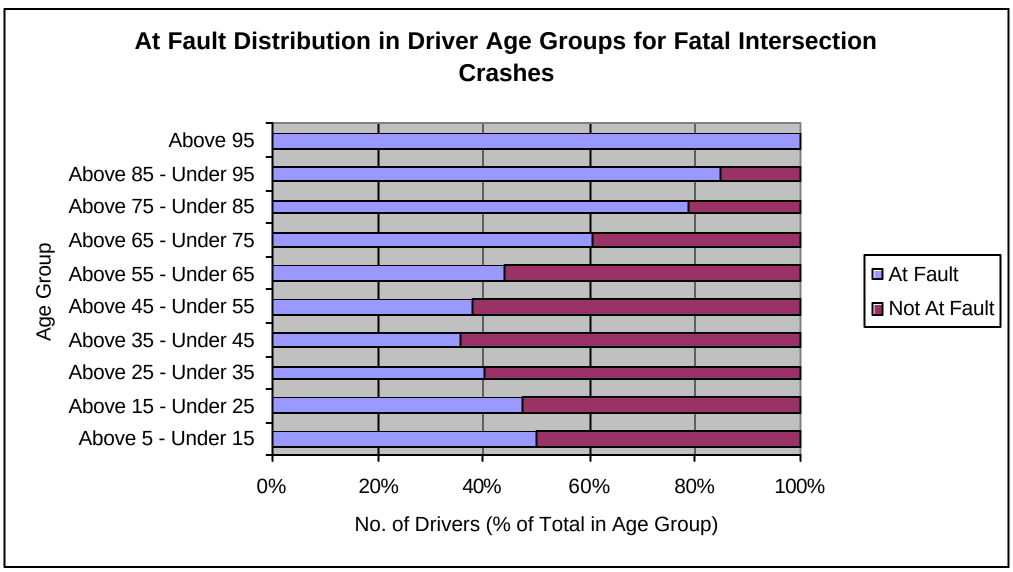

Figure 9.27: At Fault Distribution in Driver Age Groups for Fatal Intersection Crashes

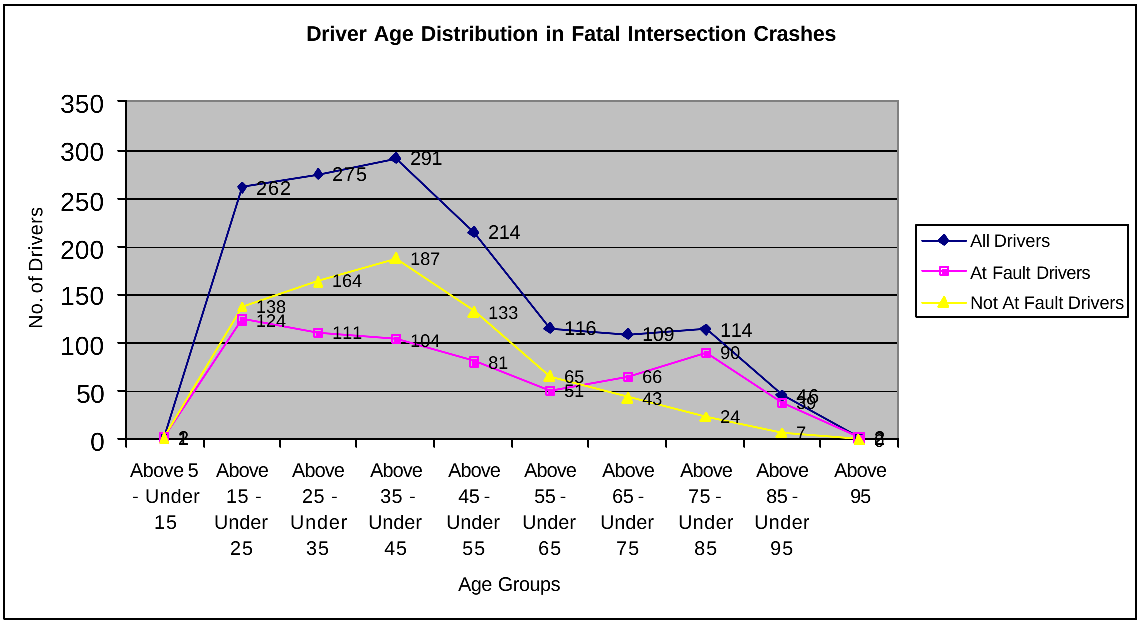

Figure 9.28: Driver Age Distribution in Fatal Intersection Crashes

Figure 9.29 shows the distribution of drivers by driver sex in fatal intersection crashes. Note that males account for almost three-quarters of the drivers involved in fatal intersection crashes. However, Figure 9.30 shows that a female driver, if involved in a fatal intersection crash, is equally likely to be at fault as she is likely to be not at fault while a male driver, if involved in a fatal intersection crash, is slightly less likely to be at fault than not at fault.

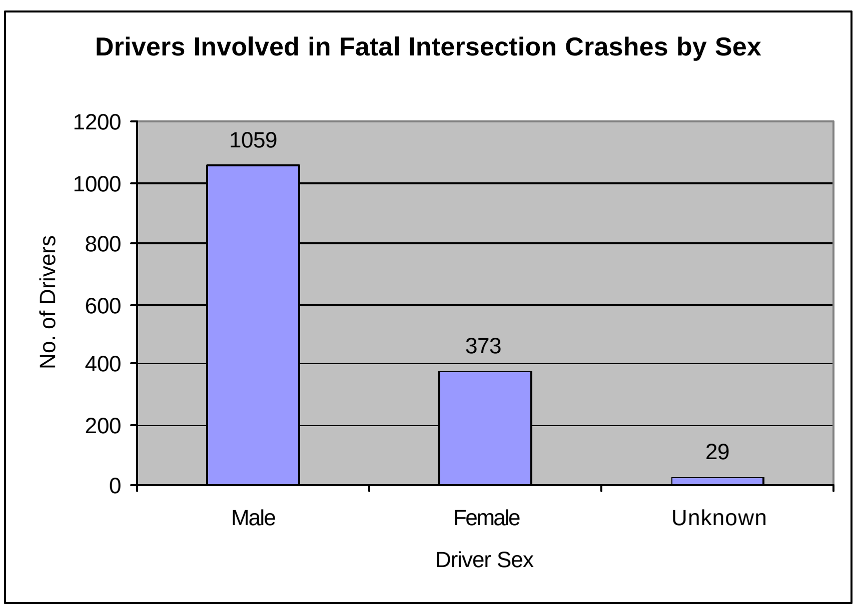

Figure 9.29: Drivers Involved in Fatal Intersection Crashes by Driver Sex

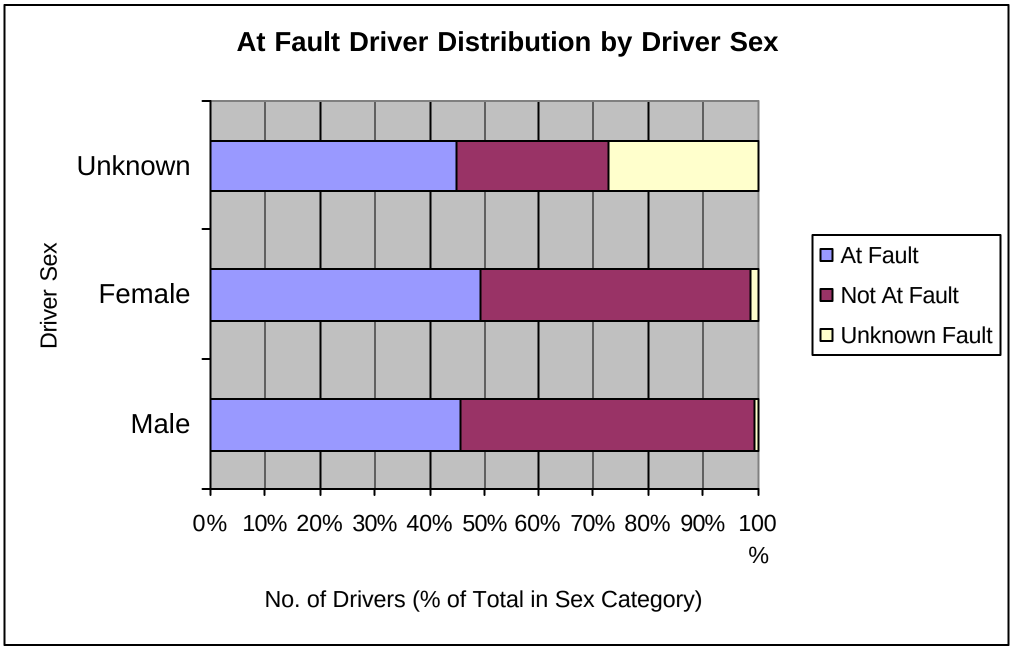

Figure 9.30: At Fault Driver Distribution by Driver Sex in Fatal Intersection Crashes

Table 9.34 and Figure 9.31 show the distribution of drivers involved in fatal intersection crashes by driver race with At Fault and Not at Fault classification within the race.

Table 9.34: Distribution of At Fault Drivers within Driver Race for Drivers Involved in Fatal Intersection Crashes

Race	At Fault		Not At Fault		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
White	511	75.04%	556	73.35%	**1.023**	0.963	1.087	Unsure
Black	82	12.04%	109	14.38%	**0.837**	0.642	1.094	Unsure
Hispanic	70	10.28%	79	10.42%	**0.986**	0.729	1.337	Unsure
Other	5	0.73%	6	0.79%	**0.928**	0.287	3.026	Unsure
Unknown	13	1.91%	8	1.06%	**1.809**	0.758	4.337	Unsure

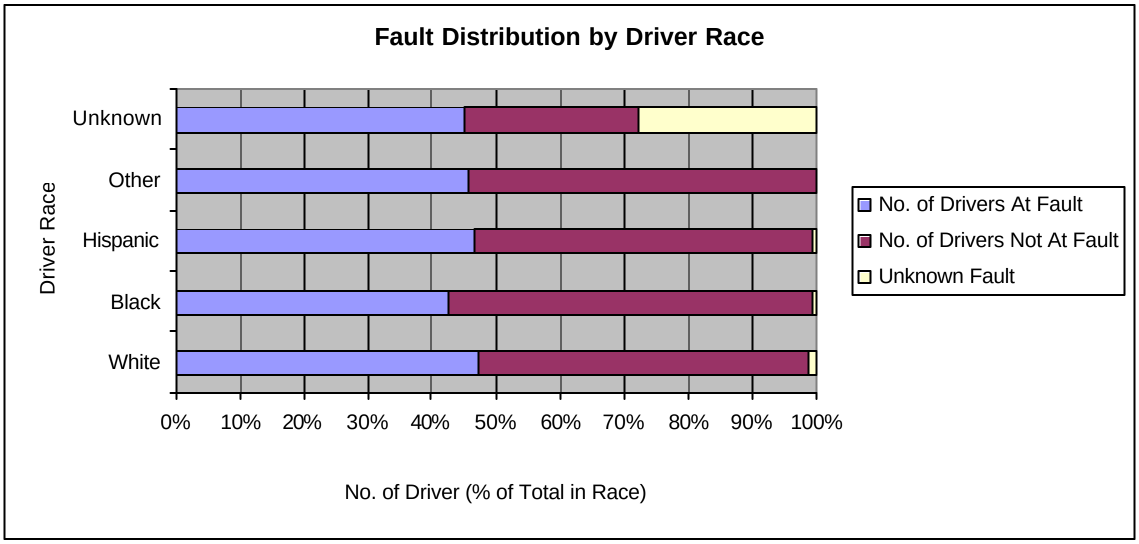

Figure 9.31: Distribution of At Fault Drivers within Driver Race for Drivers Involved in Fatal Intersection Crashes

Table 9.35 and Figure 9.32 show the distribution of drivers involved in fatal intersection crashes according to the residence of the driver and the fault involvement of the driver. The data shows that a driver residing elsewhere in state is more likely to be at fault than not at fault if the driver is involved in a fatal intersection crash Similar is the case for foreign drivers, which is quite as expected due to the unfamiliarity of the roadway to the driver. For other driver residence categories it is the other way round.

Table 9.35: Driver Distribution by Driver Residence of Drivers Involved in Fatal Intersection Crashes

Residence	At Fault		Not At Fault		ORF	Min CI	Max CI	Level
	Num.	Per.	Num.	Per.				
County of Crash	511	75.0%	532	70.2%	**1.069**	1.004	1.139	Over
Elsewhere in State	104	15.3%	169	22.3%	**0.685**	0.550	0.855	Under
Non Resident of State	47	6.9%	41	5.4%	**1.276**	0.852	1.915	Unsure
Foreign	5	0.7%	5	0.7%	**1.113**	0.326	3.828	Unsure
Unknown	14	2.1%	11	1.5%	**1.417**	0.650	3.099	Unsure

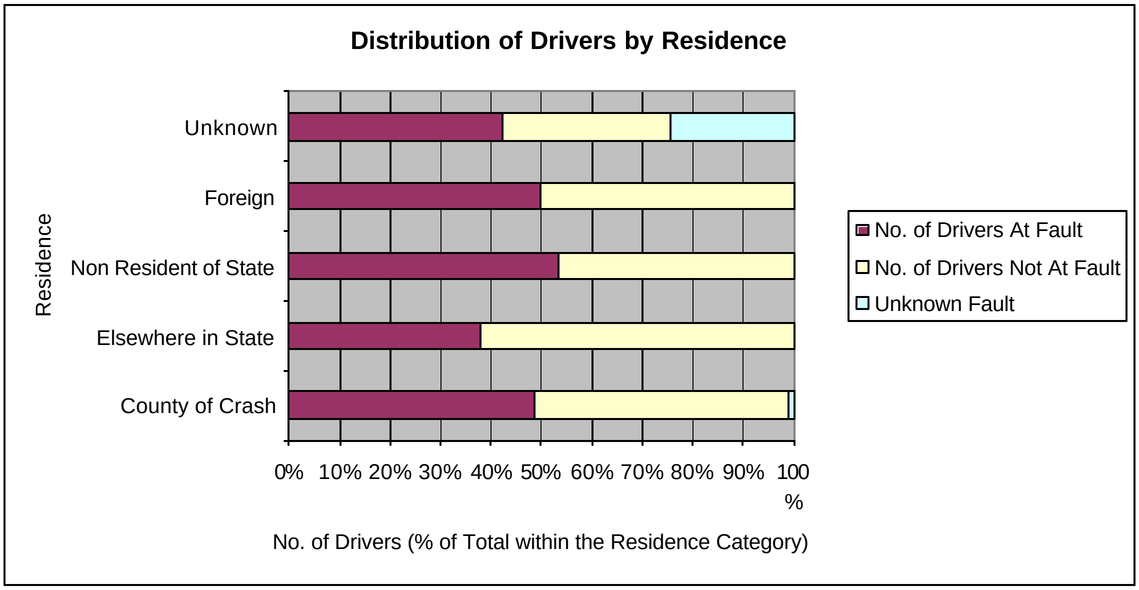

Figure 9.32: Distribution of Drivers in Fatal Intersection Crashes by Residence with Fault

Table 9.36 and Figure 9.33 show the distribution of drivers involved in fatal intersection crashes according to the injury severity and the fault involvement. The data shows that almost 30% of the time a driver not at fault in a fatal intersection crash suffered fatal injuries as a result of the crash.

Table 9.36: Injury Severity to Drivers Involved in Fatal Intersection Crashes

Injury Severity	Total		At Fault		Not At Fault		Unknown	
	Num.	Per.	Num.	Per.	Num.	Per.	Num.	Per.
None	453	31.0%	150	22.0%	302	39.8%	1	4.6%
Possible	123	8.4%	35	5.1%	84	11.1%	4	18.2%
Non Incapacitating	198	13.6%	72	10.6%	126	16.6%	0	0.0%
Incapacitating	160	11.0%	71	10.4%	83	10.9%	6	27.3%
Fatal (Within 90 Days)	503	34.4%	345	50.7%	155	20.4%	3	13.6%
Unknown	24	1.6%	8	1.2%	8	1.1%	8	36.4%
Total	1461	100.0%	681	100.0%	758	100.0%	22	100.0%

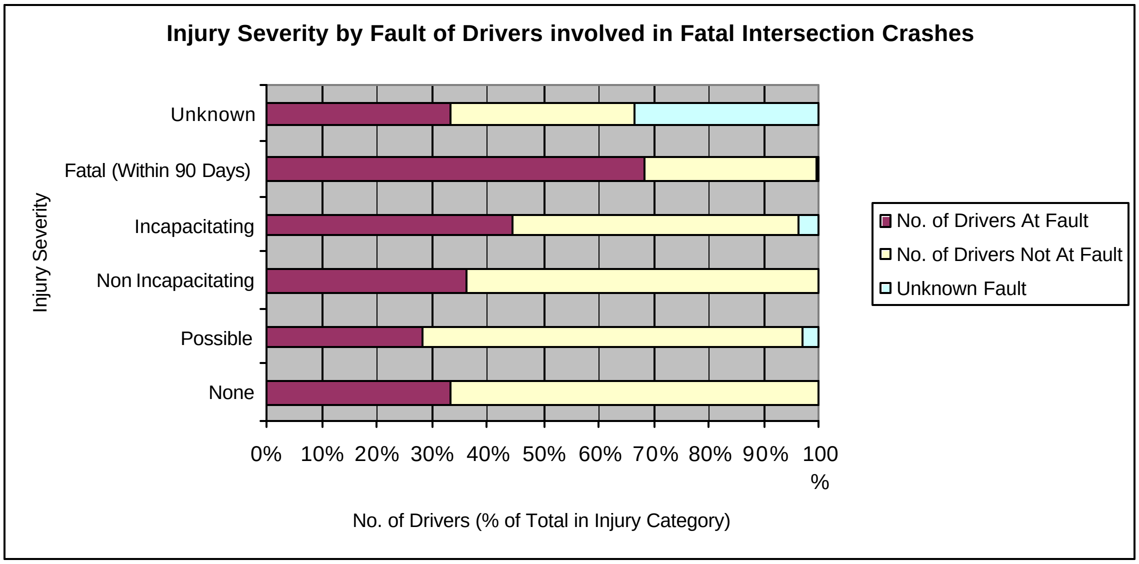

Figure 9.33: Injury Severity by Fault of Drivers Involved in Fatal Intersection Crashes

9.9 Left Turning Fatal Intersection Crashes

As seen earlier, left turning is involved in more than 50% of the fatal intersection crashes. Hence, a closer look at the various contributing factors involved in fatal intersection crashes involving a left turning movement by one of the vehicles is offered in this section. Figure 9.34 illustrates the distribution of primary and secondary contributing factors for fatal intersection crashes involving both left turning and oncoming vehicle movements. As the figure shows, the crashes are primarily caused due to human contributing factors sometimes coupled with a secondary contributing factor due to a roadway issue or a vehicle defect or may be an environment issue.

As seen in Figure 9.34 human factors are the primary contributing factor in left turn-oncoming fatal intersection crashes. Figure 9.35 below shows the distribution of various human factors that primarily and secondarily contribute towards the left turn-oncoming fatal intersection crashes. As can be seen clearly from the bar graphs, while inattention on the part of driver is the most significant primary human error, a decision error is the most significant secondary human factor that contributes towards left turn-oncoming fatal intersection crashes. Speeding is shown as the secondary human factor in more than 10% of the left turn oncoming fatal intersection crashes. This may lead to the implication that the judgment error on the part of the left turning driver may be coupled with unexpected speeding on the part of the oncoming driver.

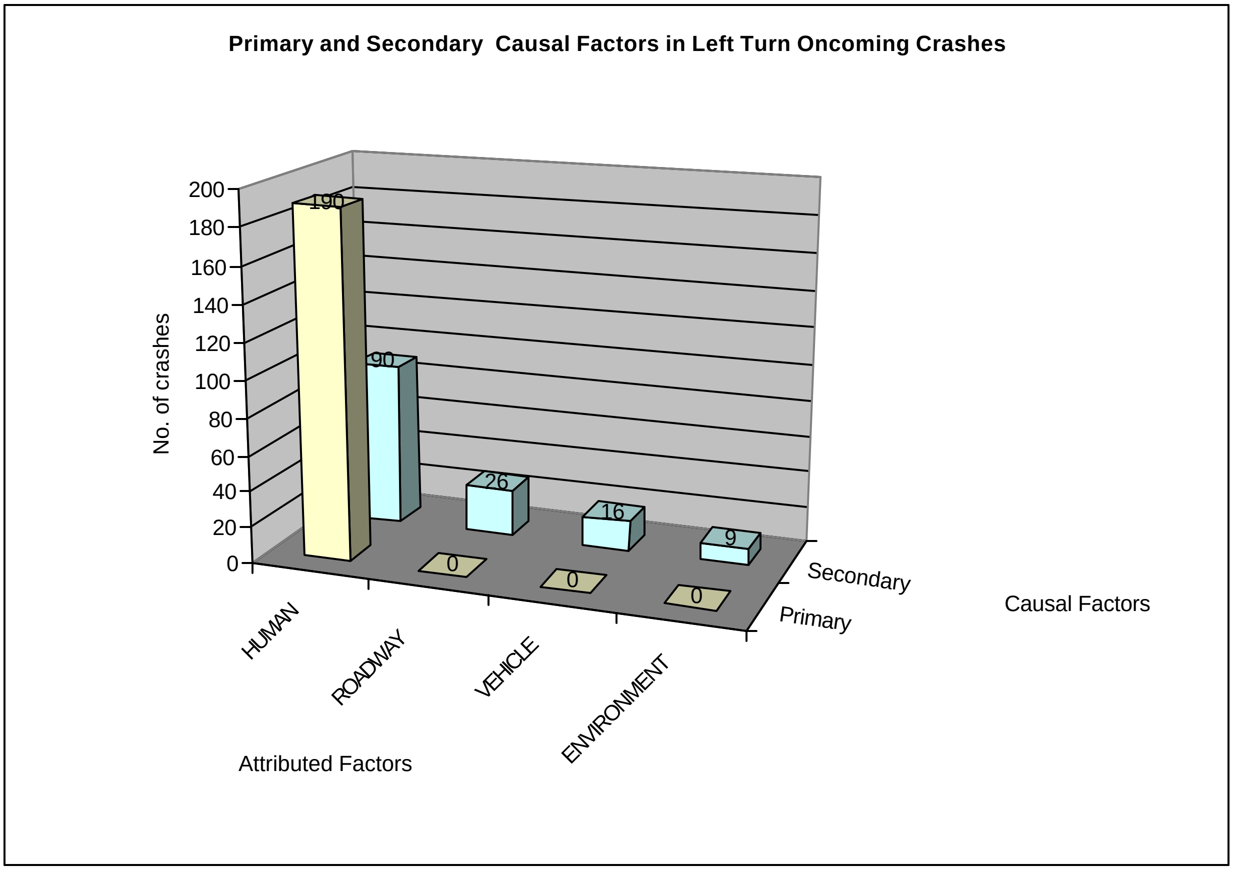

Figure 9.34: Distribution of Primary and Secondary Contributing Causes for Left Turn-Oncoming Fatal Intersection Crashes

For left turn vs. oncoming vehicle movements, the distribution of fatal intersection crashes according to median width is shown in Table 9.37. It can be seen that the left turn oncoming crashes are significantly over represented for low and higher median widths except for very wide medians with width more than 50 feet. A narrow median may lead to perception error by the turning driver leading into a crash while a wider median may increase the turning time and thereby the probability of misjudging the safe available gap to cross the intersection.

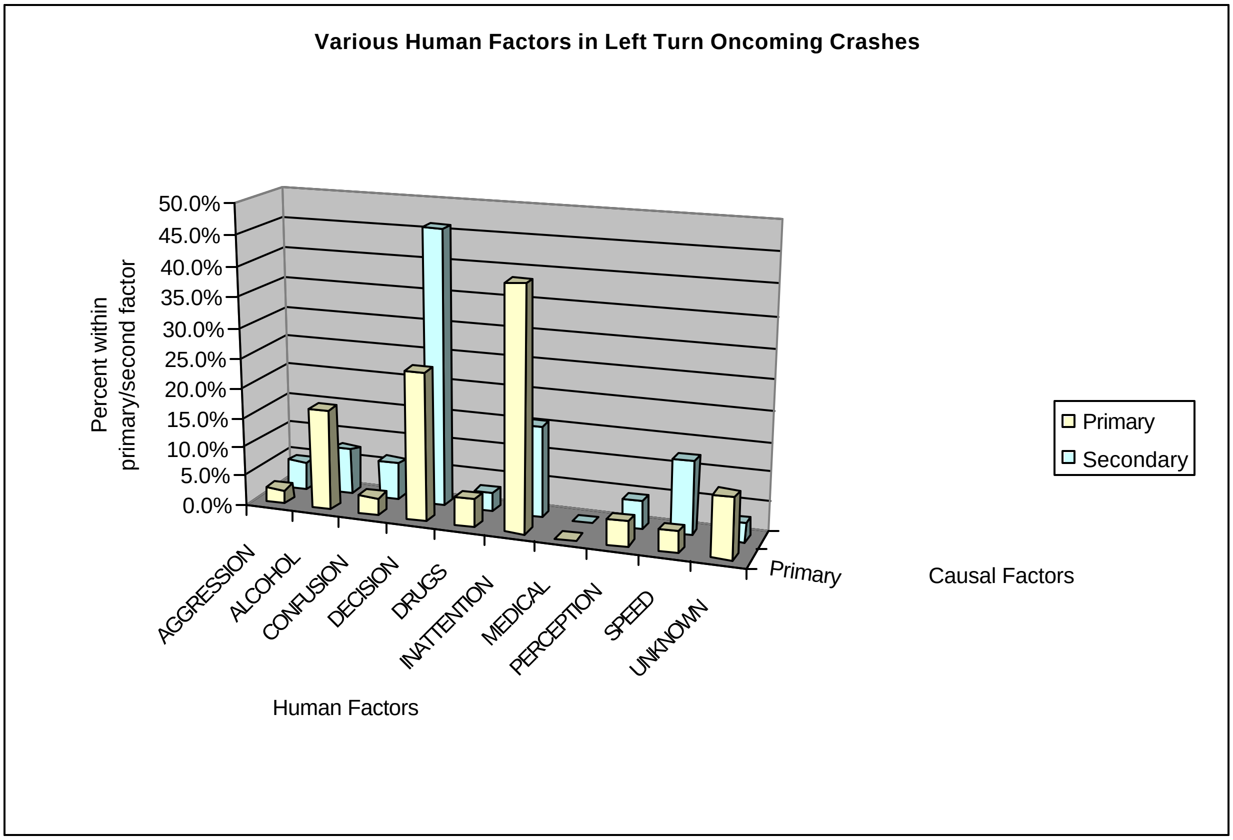

Figure 9.35: Distribution of Various Human Factors Involved in Left Turn Oncoming Fatal Intersection Crashes

Table 9.37: Distribution of Left Turn Vs. Oncoming Fatal Intersection Crashes by Median Width

Median Width	Total Crashes	Left Turn Vs. Oncoming Crashes	% Left Turn Vs. Oncoming
Undivided – 5 Feet	103	9	8.74%
5 - 10 Feet	31	12	38.71%
10 - 20 Feet	211	55	26.07%
20 - 30 Feet	114	42	36.84%
30 - 40 Feet	140	42	30.00%
40 - 50 Feet	60	22	36.67%
> 50 Feet	40	8	20.00%
Total	699	190	27.18%

Table 9.38 below shows the driver age distribution of the at fault drivers in left turn-oncoming crashes on divided roadways, compared with the total drivers involved in fatal crashes

in the state of Florida. While studying the driver age distribution, all those crashes where red light running was involved were eliminated in order to get the trend of judgment errors made by drivers while making a left turn in front of oncoming traffic on a divided roadway. The primary purpose of this table is to look for a trend in age of the at-fault drivers where the driver is required to make a judgment decision to turn in front of oncoming traffic on a divided roadway. It is notable that about one-third of the at-fault drivers in left turn-oncoming crashes are older drivers of more than 65 years of age, which leads us to understand that older drivers are much more likely to make a judgmental error while making a left turn in front of oncoming traffic. In addition, almost 15% of the drivers above 65 years of age that were involved in fatal crashes, were at-fault in a left turn-oncoming crash on a divided roadway, whereas the drivers between the ages 25 – 65 years form just about 3 % of this group.

Table 9.38: Driver Age Distribution of At Fault Drivers for Left Turn Oncoming Crashes on Divided Roadways

Age Group	At-Fault Drivers		Not-At-Fault Drivers		ORF
	Number	Percent	Number	Percent	
5 – 14	0	0%	2	0%	**0.000**
15 – 24	33	17%	647	18%	**0.956**
25 – 34	22	12%	736	20%	**0.593**
35 – 44	38	20%	753	21%	**0.966**
45 – 54	23	12%	586	16%	**0.745**
55 – 64	13	7%	334	9%	**0.762**
65 – 74	22	12%	210	6%	**2.078**
75 – 84	26	14%	155	4%	**3.285**
85 – 94	12	6%	47	1%	**4.643**
95+	2	1%	0	0%	**N/A**
Unknown	0	0%	167	5%	**0.000**

As seen previously for left turn-oncoming crashes, Figure 9.36 shows that human error is the primary contributing factor for left turn crossing fatal intersection crashes, coupled with a secondary roadway or environment or vehicle factor. From Figure 9.36, almost 20% of left turn-crossing fatal intersection crashes have a roadway factor making a secondary contribution towards the crash.

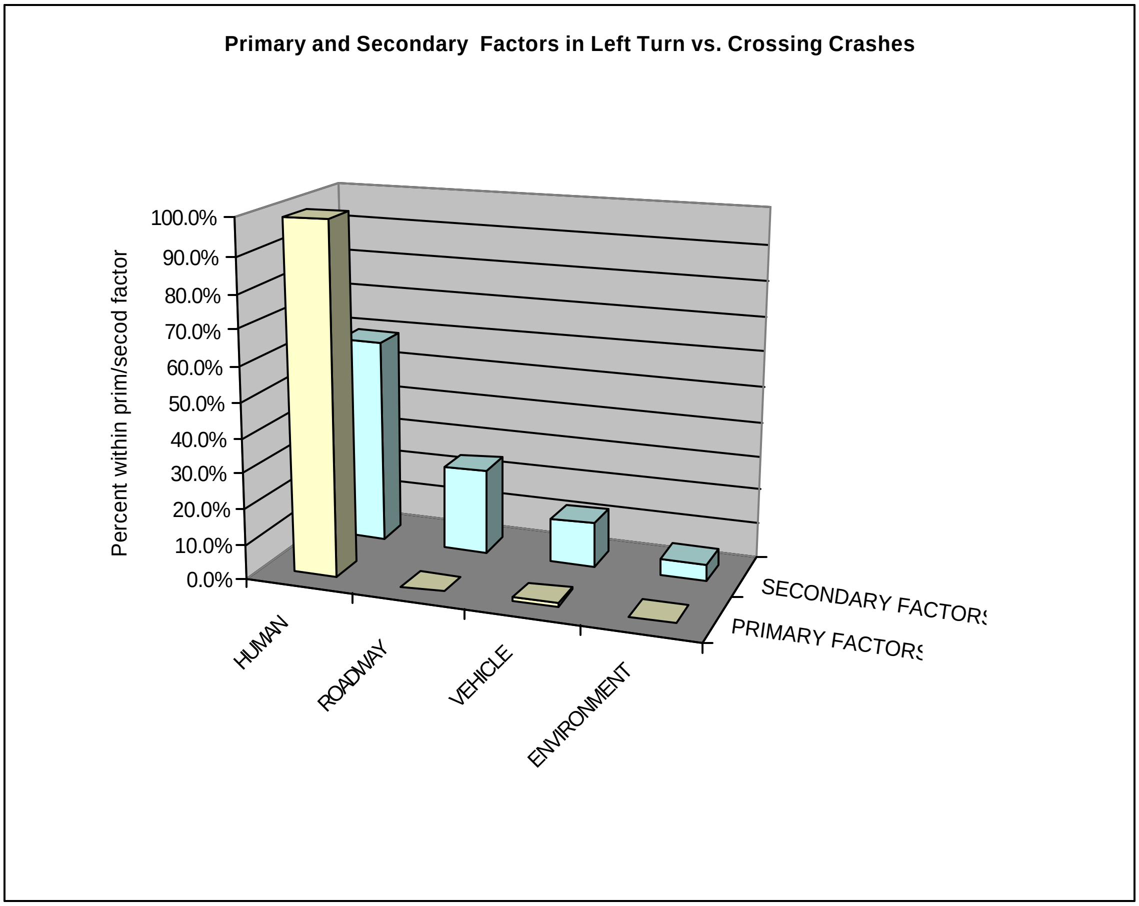

Figure 9.36: Distribution of Primary and Secondary Contributing Causes for Left Turn vs. Crossing Fatal Intersection Crashes

Figure 9.37 shows the distribution of various human factors that primarily and secondarily contribute towards the left turn crossing fatal intersection crashes. It can be seen that in secondary human contributing factors, perception decision and speeding show up prominently in the figure. Perception and decision plays an important role in fatal intersection crashes involving left turn crossing vehicle movements due to the different travel speeds on the intersecting roads. Also inattention shows up as the most significant primary human factor in the chart as for most of the fatal intersection crashes.

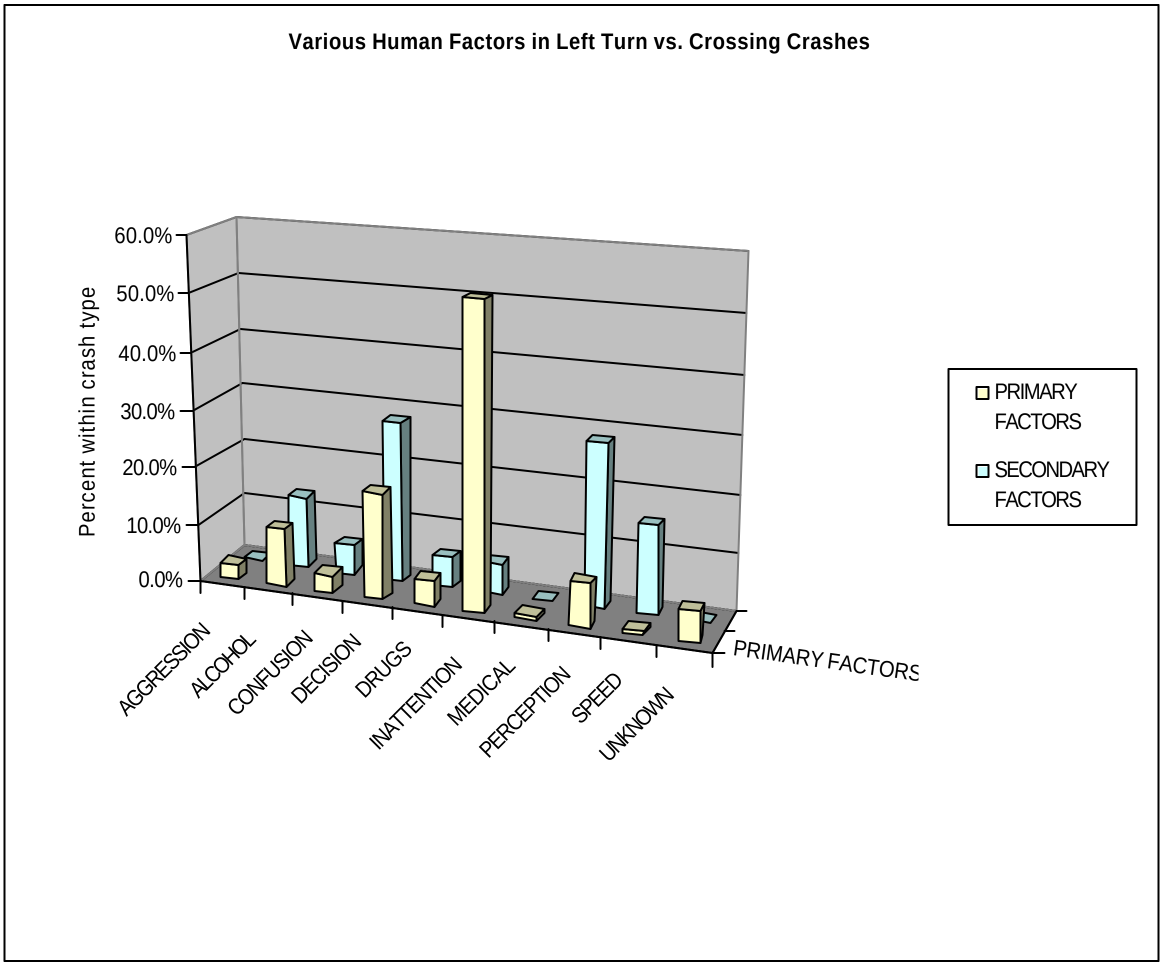

Figure 9.37: Distribution of Various Human Factors Involved in Left Turn Crossing Fatal Intersection Crashes

Table 9.39 below shows the distribution of median widths for fatal intersection crashes involving left turn vs. crossing vehicle movements. It can be seen that, as the median width increases, the percentage of fatal intersection crashes with left turn vs. crossing movement increases except for very wide medians of more than 50 feet. As the median width increases, the time required to negotiate the left turn increases, and as such the chances of the driver misjudging the gap increases. Also, the sight triangle is greatly affected by median width.

9.10 Fatal Intersection Crashes at Signalized Intersections

Almost 35% of the total fatal intersection crashes occurred at signalized intersections and as such a separate analysis of the fatal intersection crashes at signalized intersections is demanded. Table 9.40 shows the distribution of fatal intersection crashes at signalized intersections according to the crash type. The left turn-oncoming crashes form almost 40% of the fatal intersection crashes at signalized intersections. These are mostly crashes with a right of way violation by the driver with a permissive green at a signalized intersection. Pedestrian crashes with pedestrian crossing in a crosswalk add almost 10% of the fatal intersection crashes at signalized intersections, which is a issue that needs to addressed and is looked much in-depth in the chapter of the report dealing with exclusively pedestrian crashes. Rear end crashes are also quite prominent in fatal intersection crashes at signalized intersections.

Table 9.39: Distribution of Left Turn Vs. Crossing Fatal Intersection Crashes by Median Width

Median Width Range	Total Crashes	Left Turn Vs. Crossing Crashes	% Left Turn Vs. Crossing
Undivided – 5 Feet	103	16	15.53%
5 - 10 Feet	31	4	12.90%
10 - 20 Feet	211	51	24.17%
20 - 30 Feet	114	15	13.16%
30 - 40 Feet	140	32	22.86%
40 - 50 Feet	60	15	25.00%
More Than 50 Feet	40	5	12.50%
Total	699	138	19.74%

Table 9.40: Fatal Intersection Crashes by Crash Type at Signalized Intersections

Crash Type Group	Crash Type	Number	Percent
Pedestrian	Pedestrian Crash At or Influenced by Intersection	30	12.1%
Run Off Road / Single Vehicle	Right Roadside Departure	1	0.4%
	Right Roadside Departure With Control Loss	4	1.6%
	Left Roadside Departure With Control Loss	1	0.4%
	Forward Impact	1	0.4%
Same Direction	Rear End	21	8.5%
	Rear End With Avoid Impact	1	0.4%
	Sideswipe Angle	1	0.4%
Change Traffic Way / Turning	Initial Opposite Directions/Oncoming Traffic	94	38.1%
	Initial Same Direction	3	1.2%
	Turn/Merge Into Same Direction	3	1.2%
	Turn Into Opposite Directions/Cross Traffic	17	6.9%
Intersecting Paths	Not At Fault Approaching From Left	25	10.1%
	Not At Fault Approaching From Right	40	16.2%
	Not At Fault Unknown Approach Direction	5	2.0%
Total		247	100.0%

The distribution of fatal crashes at signalized intersections is shown in Table 9.41. Note that red light running accounts for almost 50 percent of the fatal crashes at signalized intersections. Also misjudging of the gap is underrepresented in fatal crashes at signalized intersections as compared to total fatal intersection crashes: misjudging of gap occurs in around 20% of the total fatal intersection crashes at signalized intersections, which is as expected since a requirement of a decision on part of driver is significantly reduced at a well signal controlled intersection. Figure 9.38 shows the DUI involvement within a driver error issue.

Table 9.41: Fatal Intersection Crashes by Driver Error at Signalized Intersections

Driver Error	Number	Percent
DUI	69	27.9%
Speeding	68	27.5%
Inattention	163	66.0%
Improper Turn	18	7.3%
Ran Red Light	118	47.8%
Ran Stop Sign	0	0.0%
Rear End	21	8.5%
Misjudged Gap	49	19.8%
No Error	7	2.8%
Total	247	100.0%

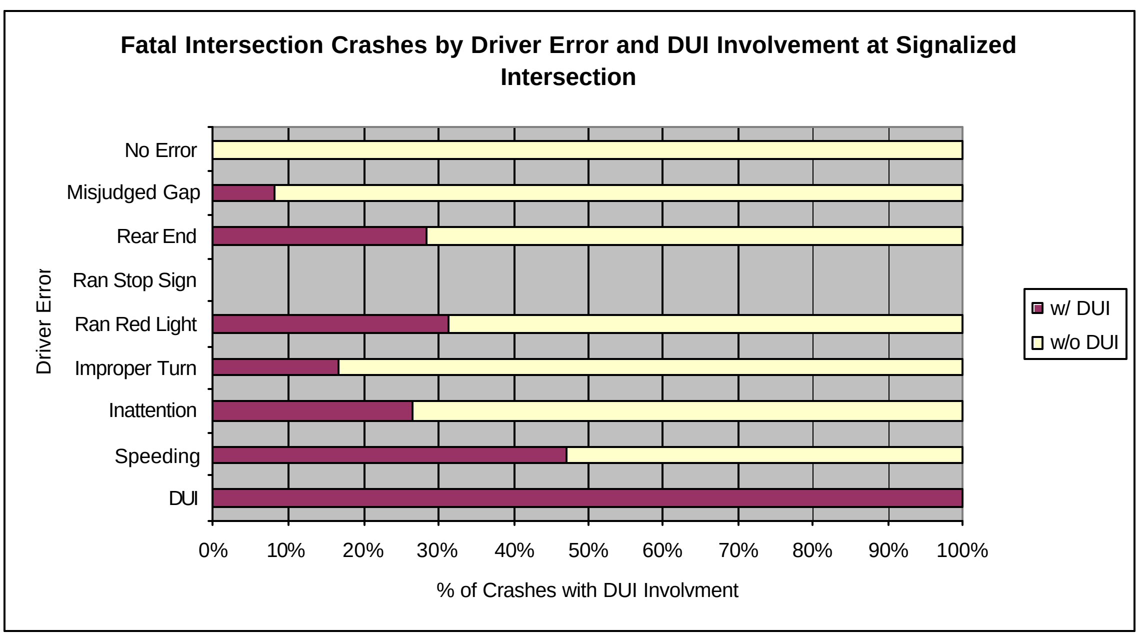

Figure 9.38: Fatal Intersection Crashes by Driver Error and DUI Involvement at Signalized Intersection

The numbers of Table 9.42, which shows the distribution of fatal intersection crashes at signalized intersections, are consistent with the numbers of Table 9.21, which shows the distribution of total fatal intersection crashes. The number of fatal intersection crashes at signalized intersections at roadways with two lanes is underrepresented as compared to the total number of fatal intersection crashes, since the number of two lane roadways that are signalized is smaller than those that are not. Table 9.43 and Figure 9.39 show the distribution of fatal intersection crashes at signalized intersections by number of lanes and roadway type as in divided or undivided.

Table 9.42: Fatal Intersection Crashes by No. of Lanes at Signalized Intersection

No. of Lanes	Number	Percent
4	111	44.9%
6	84	34.0%
2	18	7.3%
3	13	5.3%
5	10	4.0%
8	5	2.0%
7	4	1.6%
1	1	0.4%
12	1	0.4%
Total	247	100.0%

Table 9.43: Fatal Intersection Crashes by Road Type and Number of Lanes at Signalized Intersections

Number of Lanes	Number of Crashes			
	Divided	Undivided	Unknown	Total
4	75	23	13	111
6	66	4	14	84
2	6	11	1	18
3	6	7	0	13
5	5	2	3	10
8	4	0	1	5
7	4	0	0	4
1	1	0	0	1
12	1	0	0	1

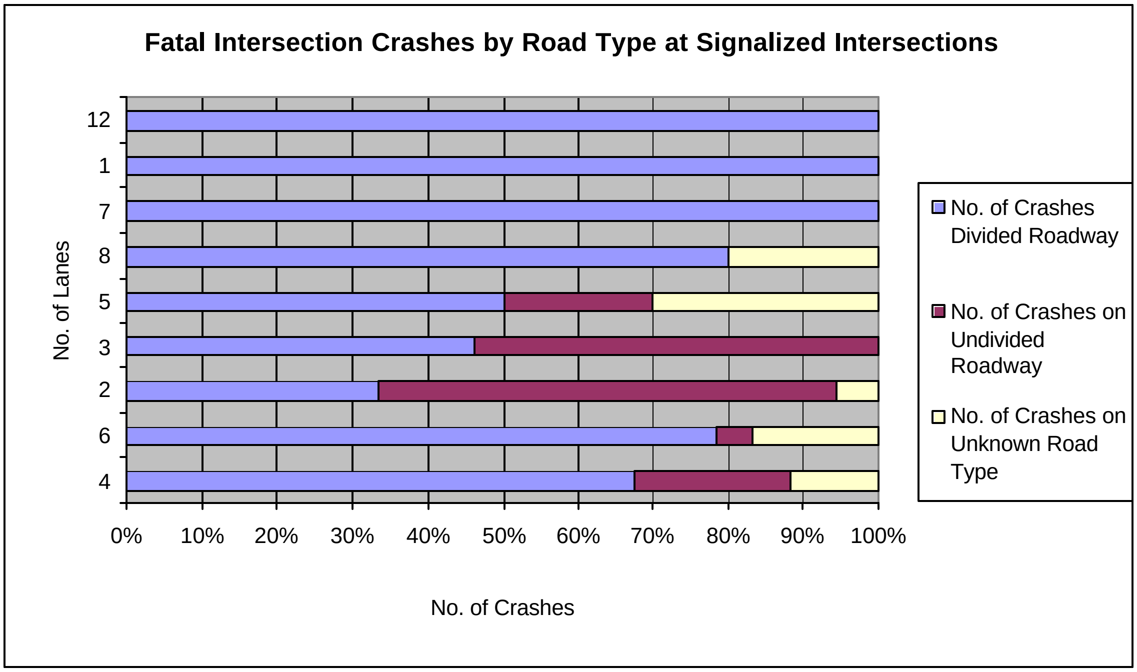

Figure 9.39: Fatal Intersection Crashes by Road Type and No. of Lanes at Signalized Intersections

The driver age distribution with fault involvement in fatal intersection crashes at signalized intersections as shown in Table 9.44 and Figure 9.40 is consistent with the overall fatal intersection crash study of driver age distribution, which is studied earlier in this chapter (Table 9.33, Figure 9.27 and Figure 9.28).

Table 9.44: Drivers by Age Groups in Fatal Intersection Crashes at Signalized Intersections

Age Group	At Fault Drivers		Not At Fault Drivers		ORF
	Number	Percent	Number	Percent	
5 – 14	1	0.4%	0	0.0%	**N/A**
15 – 24	52	22.9%	48	16.6%	**1.379**
25 – 34	37	16.3%	63	21.8%	**0.748**
35 – 44	40	17.6%	75	26.0%	**0.679**
45 – 54	22	9.7%	54	18.7%	**0.519**
55 – 64	19	8.4%	16	5.5%	**1.512**
65 – 74	20	8.8%	21	7.3%	**1.213**
75 – 84	28	12.3%	10	3.5%	**3.565**
85 – 94	8	3.5%	2	0.7%	**5.093**
95+	0	0.0%	0	0.0%	**N/A**
Total	227	100.0%	289	100.0%	**1.000**

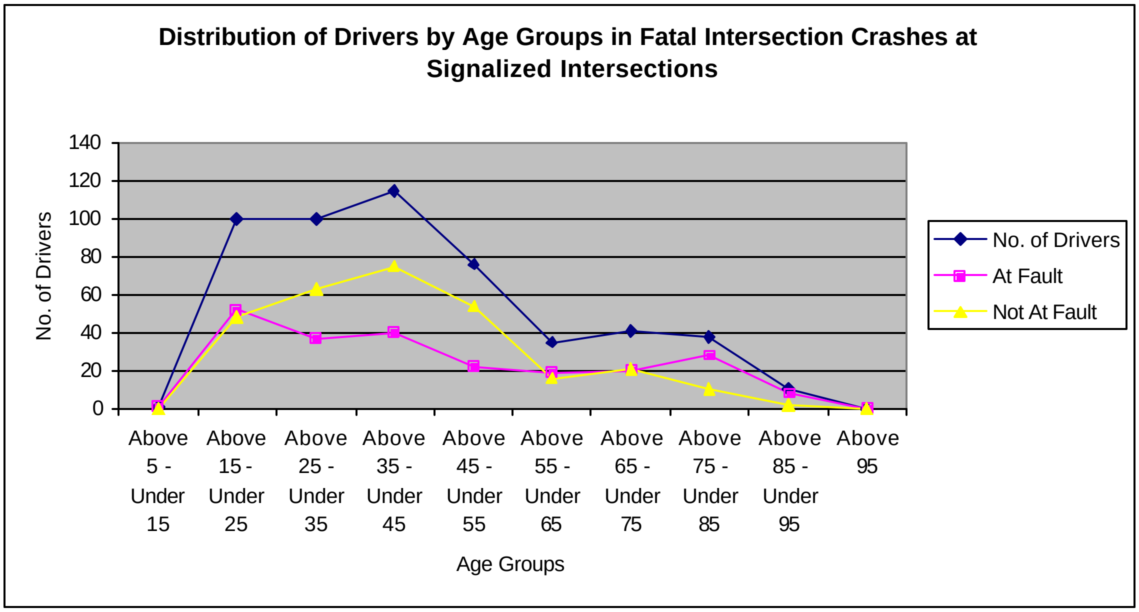

Figure 9.40: Distribution of Drivers by Age Groups in Fatal Intersection Crashes at Signalized Intersections

Table 9.45 shows the distribution of drivers by vehicle movement according to the major driver age groups. Young drivers are the drivers in the age group 5 – 24 years of age; middle age drivers are in the age group 25 – 64 years of age, and older drivers are over age 65. The highlight from this table is the number of older drivers turning left at signalized intersection being involved in a fatal intersection crash. Around 30% of the total drivers involved in fatal intersection crashes making a left turn belong to the older age group while the total percentage of older drivers driving on roads is far less than 30% of the total number of drivers driving on roadways.

Table 9.45: Vehicle Movements by Major Driver Age Groups at Signalized Intersections

Vehicle Movement	Total Drivers	Young	Middle Age	Older	Unknown
Straight Ahead	322	78	199	41	4
Slowing/Stopped/Stalled	61	5	46	9	1
Making Left Turn	120	16	66	36	2
Making Right Turn	7	1	5	1	0
Changing Lanes	1	0	0	1	0
Properly Parked	1	0	0	0	1
Making U-Turn	1	0	1	0	0
Passing	1	0	0	0	1
All Other	11	1	8	2	0
Unknown	1	0	0	0	1

Table 9.46 below shows the fatal intersection crashes at signalized intersection according to the movements of vehicles involved in a crash. It can be seen that more than 50% of the total left turn vs. oncoming vehicle crashes in fatal intersection crashes occur at signalized intersections. It should be noted that most of the left turn oncoming crashes on signalized intersections occur while the vehicle is trying to turn in a permissive left turn phase and as such a driver judgment of available gap is involved. About 10% of left turn-oncoming crashes at signalized intersection occur due to the red light running by turning or straight vehicle.

Table 9.46: Distribution of Fatal Intersection Crashes by Vehicle Movements at Signalized Intersections

Vehicle Movements in Crash	Total At Intersections	No. at Signalized Intersection	% At Signalized Intersections
Left Turning Vs Cross	138	14	10.14%
Left Turning Vs Oncoming	190	98	51.58%
Straight Vs Straight	238	93	39.08%
Rear End	62	23	37.10%
Other Movements	69	17	24.64%

Table 9.47 below shows the driver age distribution for the left turn oncoming crashes at signalized intersections with the fault involvements. The table shows a trend in congruence with the earlier driver age distribution trends with fault involvement. The older drivers are much more likely to be at fault if involved in a fatal intersection crash at a signalized intersection than their younger counterparts. Almost 90% of the older drivers (above 65 years of age) involved in fatal intersection crashes at signalized intersections are at fault.

Table 9.47: Driver Age Distribution for Left Turn-Oncoming Crashes at Signalized Intersections

Age Group	No. of Drivers		% At Fault by Age Group
	At Fault	Not At Fault	
5 – 14	15	24	38.46%
15 – 24	13	31	29.55%
25 – 34	23	35	39.66%
35 – 44	6	20	23.08%
45 – 54	8	6	57.14%
55 – 64	12	3	80.00%
65 – 74	16	1	94.12%
75+	7	1	87.50%

9.11 Fatal Intersection Crashes on Stop-Controlled Movements

Fatal intersection crashes on stop-controlled movements constitute around 30% of the total fatal intersection crashes. Table 9.48 below shows the distribution of the fatal intersection crashes at stop-controlled movements by crash type. Unlike the signalized intersections, the left turn-oncoming crashes are significantly underrepresented at stop-controlled movements, whereas the Turn into Opposite Direction/Cross Traffic type (left turn-crossing) crashes are highly overrepresented. Also the rear end crashes are underrepresented in Table 9.48 as compared to Table 9.40. This further leads us to understand that rear end crashes at uncontrolled intersections are significantly over represented within the rear end crash category for fatal intersection crashes. The straight vs. straight crash types are almost equally distributed within the crash group for known approach direction in Table 9.48.

Table 9.48: Fatal Intersection Crashes at Stop-Controlled Movements by Crash Type

Crash Group	Crash Type	Number	Percent
Pedestrian	Pedestrian Crash At or Influenced by Intersection	8	3.9%
Run off Road / Single Vehicle	Right Roadside Departure	1	0.5%
	Right Roadside Departure With Control Loss	1	0.5%
	Forward Impact	3	1.5%
Same Direction	Rear End	2	1.0%
Opposite Direction	Head-On	1	0.5%
	Forward Impact With Control Loss	1	0.5%
Change Traffic Way / Turning	Initial Opposite Directions/Oncoming Traffic	16	7.8%
	Initial Same Direction	1	0.5%
	Turn/Merge Into Same Direction	3	1.5%
	Turn Into Opposite Directions/Cross Traffic	96	46.8%
Intersecting Paths	Not At Fault Approaching From Left	40	19.5%
	Not At Fault Approaching From Right	32	15.6%
Total		205	100.0%

Table 9.49 below shows the distribution of fatal intersection crashes at stop-controlled movements according to the movements of vehicles involved in a crash. As can be seen from the table the stop-controlled movements principally differ from signal-controlled intersections when it comes to crashes involving turning movement of vehicles. Signalized intersections while facing maximum number of left turn-oncoming crashes, stop-controlled movements suffer with maximum number of left turn-crossing crashes. The left turn-oncoming crashes in fatal intersection crashes at stop-controlled movements are minimal. Also, the rear end crashes at stop-controlled movements seem negligible as compared to signalized or uncontrolled movements. Straight vs. straight moving vehicles are more likely to get into a fatal intersection crash at a stop-controlled movement, with almost 35% of total straight vs. straight fatal intersection crashes occurring at stop-controlled movements.

Table 9.49: Distribution of Fatal Intersection Crashes at Stop-Controlled Movements by Movements of Vehicles Involved in a Crash

Vehicle Movements in Crash	Total At Intersections	No. at Stop-Controlled Movements	% At Stop Controlled Movements
Left Turning Vs Cross	138	91	65.94%
Left Turning Vs Oncoming	190	7	3.68%
Straight Vs Straight	238	88	36.97%
Rear End	62	4	6.45%
Other Movements	69	13	18.84%

Table 9.50 below shows the driver age distribution for fatal intersection crashes at stop-controlled intersection with the driver fault distribution within the age group. Following the previously mentioned general trends for the driver age groups, drivers above 65 years of age are highly overrepresented in the at-fault category. Likewise, the drivers above 65 years of age are more likely to be in fatal intersection crashes at stop-controlled movements with almost 25% of the total drivers in fatal intersection crashes at stop-controlled movements being 65 years or older, which should be supplemented with the fact mentioned earlier that only about 18% of the total drivers on the roads are older than 65 years of age in Florida.

Table 9.50: Driver Age Distribution for Fatal Intersection Crashes at Stop-Controlled Movements

Age Group	% Crash Involvement	No. of Drivers		% At Fault by Age Group
		At Fault	Not At Fault	
5 – 14	18.53%	39	39	50.00%
15 – 24	16.39%	29	40	42.03%
25 – 34	19.24%	25	56	30.86%
35 – 44	12.83%	22	32	40.74%
45 – 54	9.74%	18	23	43.90%
55 – 64	7.84%	22	11	66.67%
65 – 74	10.69%	37	8	82.22%
85+	4.75%	17	3	85.00%
Total	100.0%	209	212	49.64%

9.12 Fatal Intersection Crashes – Rear End Crashes

Table 9.51 shows the distribution of the rear end crashes in fatal intersection crashes by the traffic control. Primarily, the rear end crashes occur on uncontrolled movements, with a little over 40% of the fatal rear end crash class occurring on unsignalized movements. Rear end crashes are also predominant on signalized intersections as noted earlier. Table 9.52 shows the distribution of rear end crashes by driver age groups. It appears that younger to middle age drivers are overrepresented within the fatal rear end crashes occurring at intersections.

Table 9.51: Rear End Crashes in Fatal Intersection Crashes by Traffic Control

Traffic Control	Number	Percent
Traffic Signal	21	36.8%
Stop Sign	2	3.5%
Other	10	17.5%
No Control	24	42.1%
Total	57	100.0%

Table 9.52: Rear End Crashes in Fatal Intersection Crashes by Driver Age Groups

Age Group	Number	Percent
15 – 24	12	21.1%
25 – 34	16	28.1%
35 – 44	9	15.8%
45 – 54	5	8.8%
55 – 64	4	7.0%
65 – 74	4	7.0%
75 – 84	5	8.8%
85+	2	3.5%
Total	57	100.0%

Figure 9.41 shows the distribution of contributing causes primarily and secondarily affecting the fatal rear end intersection crashes. Although primarily human factors contribute towards the fatal rear end intersection crashes, it can be seen that a significant number, almost 30%, of crashes in this group have a secondary roadway issue contributing towards the crash. The most common were traffic operations issues, involving insufficient storage, turn lanes, or u-turn lanes, contributing to the rear-end crash. Figure 9.42 shows the distribution of various human factors primarily and secondarily contributing towards the occurrence of rear end fatal intersection crashes. It shows that primarily inattention coupled with a secondary human factor of perception and speeding contributes to the causation of rear end fatal intersection crashes.

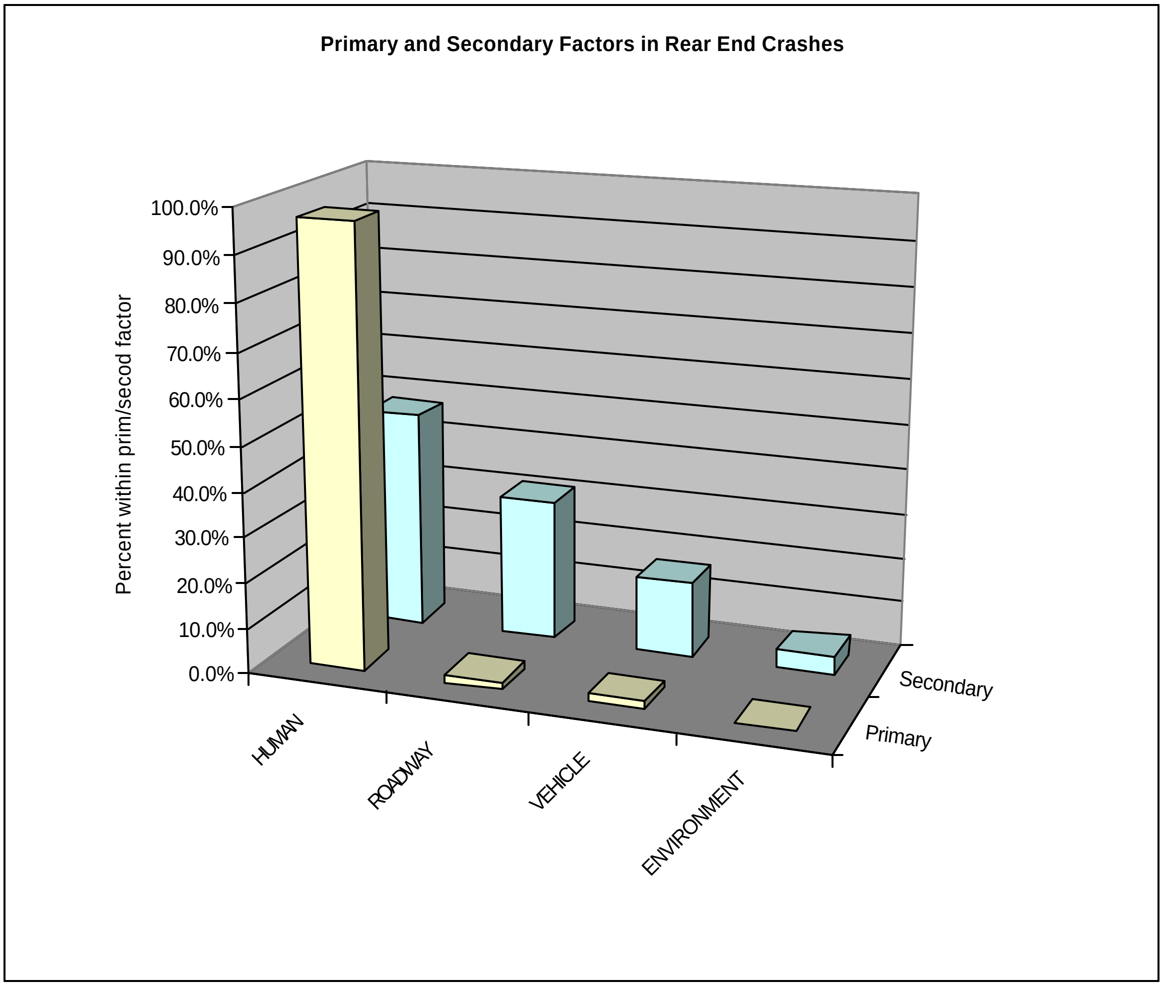

Figure 9.41: Distribution of Primary and Secondary Contributing Causes for Rear End Fatal Intersection Crashes

Table 9.53 below shows the secondary contributing factors in fatal rear end intersection crashes. As seen above, more than 50% of the crashes had a human factor as a secondary contribution, but the remaining 50% of fatal rear end intersection crashes were caused due to the secondary contribution of roadway, environment of vehicle factors. Thirty percent of the fatal rear end intersection crashes were caused due to a secondary contribution of roadway factors, such as inadequate or inappropriate u-turn facilities for CMV's, access management issues, absence of turning storage lanes, etc. Poor lighting on slowing or turning CMV's is seen as a secondary contributing factor in almost 10% of rear end fatal intersection crashes that involve a secondary factor.

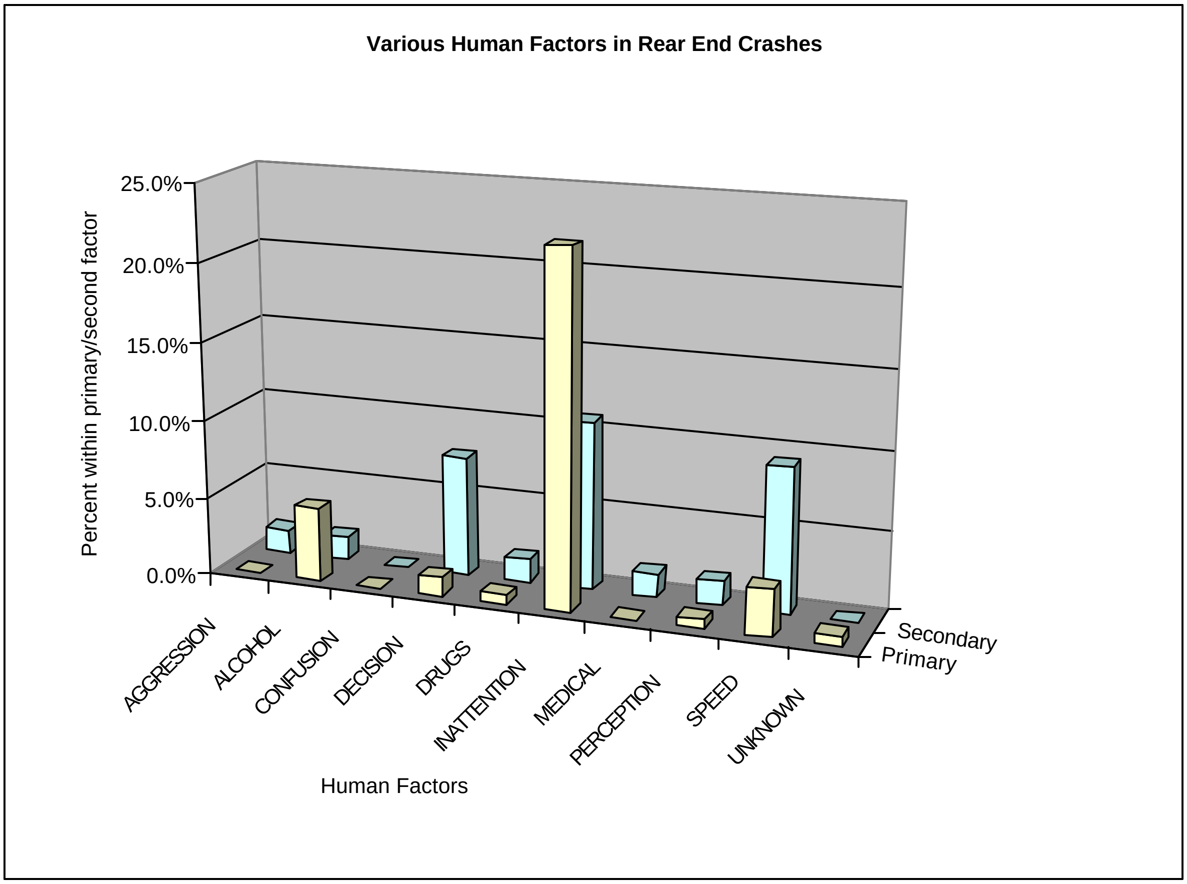

Figure 9.42: Distribution of Various Human Factors Involved in Rear End Fatal Intersection Crashes

Table 9.53: Secondary Contributing Factors in Rear End Crashes

Contributing Factor Class	Contributing Factor Detail	Number	Percent
Human	Aggression	1	55%
	Alcohol	1	
	Decision	5	
	Drugs	2	
	Inattention	7	
	Medical	1	
	Perception	1	
	Speeding	6	

Table 9.53: Secondary Contributing Factors in Rear End Crashes, continued

Contributing Factor Class	Contributing Factor Detail	Number	Percent
Roadway	CMV U-turn	4	30%
	Construction	1	
	Access Management	3	
	No turn lane/storage	3	
	Speed limit above 65 (non-limited access)	2	
Environment	Smoke/fog	1	5%
	Wet/slippery	1	
Vehicle	Acceleration rate	1	11%
	Emergency	1	
	Lighting	3	

Table 9.54 below shows the distribution of tertiary contributing factors in fatal rear end intersection crashes. As seen from table, more than 25% of rear end crashes having a tertiary contributing factor to the crash have a roadway factor, which not surprisingly are factors similar to the secondary contributing factors. Also, vehicle contributing factors figure in about four cases.

Table 9.54: Tertiary Contributing Factors to Rear End Fatal Intersection Crashes

Contributing Factor Class	Contributing Factor Detail	Number	Percent
Human	Age	1	41%
	Drugs	1	
	Inattention	5	
	Speeding	2	
Roadway	CMV U-turn	2	27%
	Construction	1	
	No turn lane/storage	2	
	Speed limit above 65 (non-limited access)	1	
Environment	Dark	1	14%
	Wet/slippery	2	
Vehicle	Acceleration rate	1	18%
	Tires	2	
	Lighting	1	

9.13 Conclusions

About one-third of the total fatal crashes studied in the data set as described previously are fatal intersection crashes. Within the year, fatal intersection crashes are higher in early spring months than any other month except in August, when the number of fatal intersection crashes is higher than the average 58 fatal intersection crashes in each month of the year for the data. Within the week, fatal intersection crashes are highly over represented on Fridays when 115 fatal intersection crashes occurred as against the average 100 fatal intersection crashes within a day of the week for the data. Within the day, fatal intersection crashes are highly over represented within the evening hour of 6 pm to 7 pm when 53 fatal intersection crashes occurred as against the average of 29 fatal intersection crashes within each hour of the day for the data.

About 10% of the fatal intersection crashes involved a pedestrian or bicycle in the crash. Almost 60 percent of fatal intersection crashes occur during daylight hours. Pedestrian crashes and those at or influenced by intersections occur more frequently during hours of darkness. Though there is no correlation between geographical location and dark/daylight, but there is correlation between geographical location and presence of streetlights.

Driver age significantly bears a correlation on the number of fatal intersection crashes. Younger drivers under 25 years are the most likely to be involved in fatal intersection crashes followed by older drivers above 65 years of age. Except for about ten cases, all fatal intersection crashes were judged to have been primarily caused by human factors. Inattention, for example, "failed to observe crossing vehicle," "failed to see bicycle," etc., is the chief primary contributing factor to the fatal intersection crashes, with almost 40% of fatal intersection crashes having inattention as the primary contributing factor. Driving under the influence (alcohol or drugs or both) is also the primary contributing factor towards the crash for more than 20% of the fatal intersection crashes. The third most prevalent human factor is a decision error, with almost 20% of fatal intersection crashes having a human decision error as the primary contributing factor. Aggression, confusion, medical, and other factors contributed to limited numbers of intersection crashes.

Almost 20% of the fatal intersection crashes had roadway issues involved that had a direct bearing on the occurrence of the crash, mostly as secondary and tertiary issues. Sight distance issue was the concern in the majority of the crashes wherein a roadway issue is involved. Overall, 68 or about 10% of intersection crashes were judged to have sight distance-related problems, but only as a primary cause of the crash in two cases. It was also observed during site visits and video log reviews that many sight distance issues occurred in the category of left-turn crashes at signalized intersections. Here, most of the cases involved the driver's line of sight being blocked by opposite queued vehicles waiting to make left or right turns. In other cases, the curvature in road, or the presence of trees, shrubs, or other fixed objects, or a combination of both, contributed towards limiting the sight distance on roadways or obstructing the clear line of sight.

Signalized intersections have the highest number of fatal intersection crashes: slightly over one-third of the fatal intersection crashes studied in the data occurred at signalized intersections, followed by around 28% on uncontrolled movements and 27% on stop-controlled movements. Signalized intersections are most likely to suffer from a fatal intersection crash involving a left turning and an oncoming vehicle. More than 50% of the total left turn oncoming crashes in fatal intersection crashes occurred at signalized intersections. Crash records and analyses for the two types of crashes indicate that 12 cases of the left-turn versus crossing crash types, and 25 cases of the left-turn versus crossing crash types, involved drivers running red light at the intersections. After review, all these running red light cases were found to be primarily caused by human factors. Also, for the left-turn versus oncoming type of crash, 66 cases or 70% were classified as “permissive left” type of crash, in which the left-turning vehicle has a right-of way issue with the oncoming vehicles. All of these cases were reviewed and found to be primarily due to human factors, speeding, decision errors, age, etc. Overall, for left turn crashes (signalized or unsignalized), roadway factors as a secondary causes of crashes, were found in about 15% (51 of 327) of crashes.

Of the 68 crashes at signalized intersections involving straight versus straight vehicle movements, 57 cases or 84% were observed to be running-red-light cases. One case, after review, indicated that the signal lights were out at the intersections, implying a roadway factor as the primary cause of crash. Other than this example, all other cases have human factors as the primary case of crash, including alcohol, inattention, aggression, age, etc. There were only two cases where the roadway geometry (skewed intersection) may have contributed to the crash, as secondary factors; in several of the cases, the at-fault driver was trying to beat the yellow light.

Left turning vehicle movements are the most likely to cause a fatal intersection crash. Almost one half of the fatal intersection crashes involve a left turn by one of the drivers involved in the crash. About 30% of the total fatal intersection crashes involve left turn versus oncoming vehicle movements. Around 20% of the total fatal intersection crashes involve left turn versus crossing traffic vehicle movement. Rear end crashes within the fatal intersection crashes are most prevalent at uncontrolled intersections, with a little under half of total rear ends in fatal intersection crashes occurring at uncontrolled intersections, followed by little over one-third of total rear ends in fatal intersection crashes occurring at signalized intersections.

Stop sign controlled intersections as opposed to signalized intersections are very unlikely to suffer from a left turn oncoming fatal intersection crash. Left turn versus crossing movement crashes are most likely on stop-controlled movements. Almost one-third of the total fatal intersection crashes involving left turn crossing movements of vehicles occur on stop controlled movements.

Medians wider than 30 feet affect the perception and judgment of driver at an intersection thereby contributing towards the fatal intersection crashes. Compared to undivided roads, and those with narrow (<10’) medians, it can be seen that the left turn oncoming crashes are significantly over represented for higher median widths except for very wide medians. A wider median may increase the turning time and thereby the probability of misjudging the safe available gap to cross the intersection. Sight distance issues also occurred when the driver’s line of sight was blocked by opposite queued vehicles waiting to make left or right turns.

Most these cases were reviewed and found to be primarily caused by human factors. Exceptions included one case where it was dark and a vehicle ran into another a stalled vehicle on the roadway. In this case, the roadway was judged to be a contributing factor (lack of roadway lighting). The only other roadway factor was a secondary cause of crash, where a vehicle failed to stop for a stopped vehicle making a left turn; the stopped vehicle was encroaching on a through lane because of an ongoing median construction on the roadway. A significant number of crashes in this group, almost 30%, have a secondary roadway issue contributing towards the crash. The most common were traffic operations issues, involving insufficient storage, turn lanes, or u-turn lanes, contributing to the rear-end crash.

9.14 Recommendations and Countermeasures

Intersections are highly prone to crashes due to the conflicting movements of vehicles. The contributing factors towards a crash in addition to driver errors may also be certain roadway or traffic operation issues, poor physical design of both the intersections and their approach roadways. Restricted sight distances or obscured lines of sight are some of the primary aspects compromising the safety of an intersection. Restricted sight distances do not offer enough time to drivers to stop or avoid hitting a pedestrian or another vehicle. Inappropriately posted traffic control devices, such as stop signs or other warning or regulatory signs, in terms of location, size, reflectivity or information contribute towards making the intersection unsafe or less forgiving to the drivers. Improving the engineering of intersections is the first step toward reducing crashes because vehicle conflicts, combined with flawed highway or street design and poor signage, often result in collisions of vehicles with roadside objects, pedestrians and other vehicles. Driver errors are also primarily responsible for crashes at intersections. Some crashes are solely due to the blatant disregard of traffic control devices and some others due to driver inattention or distraction due to cell phone use, eating in vehicle while driving or DUI etc. Also, sometimes the traffic operation issues need to be addressed with due regard to the changing traffic volumes and patterns at certain intersections.

An engineering review was used to identify the safety problems at the fatal intersection crash sites. A very crucial factor to remember when implementing countermeasures that improve safety at intersections and the vehicle traffic flow or reduce vehicle crashes, is that they do not compromise the safety of pedestrians. The strategic decisions that need to be considered when improving operation and safety at intersection are discussed below:

- Make the intersections more forgiving to the drivers, so that even in the event of a crash on account of driver error it is not as serious.
- Eliminate the pedestrian and vehicle conflict wherever possible.
- At intersections where this conflict elimination is not possible, reduce the unavoidable pedestrian and vehicle conflict to lower the chances of crashes.

Traffic engineering strategies to improve movement of vehicles and pedestrians are crucial to improving intersection safety. These strategies vary according to the critical issue that needs to be addressed at an intersection and care needs to be taken that while addressing the critical issue, other non-critical issues are not compromised; otherwise reducing one particular type of crash can increase another type, thereby not actually improving the safety of the intersection.

Basic countermeasures suggested for the fatal intersection crashes include driver education (about roadway information, traffic operations, and special education for the elderly drivers); stricter enforcement for driving violations, including DUI; and incorporation of driver demographic-specific criteria into roadway design. For example, the perception-reaction times for elderly drivers in those areas should be taken into account in determining signal warrants in areas with a large elderly population. In the following sections, countermeasures are presented, with emphasis on signalized intersections, categorized by types of vehicle movement.

Although the roadway has not been judged as the contributing factor in many crashes, the following feasible countermeasures are suggested at signalized intersections to alleviate left-turn crashes:

1. Improve Signal Timing (General), considered a low cost improvement.
2. Use Green Arrow/Protected Left Turns/Movement Signal Phasing, considered low cost, with expected 98% crash reduction.
3. Use Split Phases, considered a low cost improvement.
4. Upgrade Signal Controller, considered a medium cost.
5. Stripe for Left-Turn Lane Within Existing Roadway, considered a low cost, with expected crash reduction of 66%.
6. Construct Left-Turn Lanes with Signal Upgrades, considered a high cost improvement.
7. Left-Turn Lane, Signal and No Turn Phase, considered high cost, with an expected reduction in crash of 46 to 54%.
8. Left-Turn Lane, Signal and PLUS Turn Phase, considered high cost, with an expected reduction in crash of 43 to 45%.
9. Add Left-Turn Phasing AND Turn Lanes to An Existing Signal, considered a high cost improvement.

In addition to stricter law enforcement and driver education to address red-light running, the following feasible countermeasures are suggested:

1. Interconnect/Coordinate Traffic Signal and Optimization, considered a medium cost improvement.
2. Increase/Modify Clearance Intervals, considered a low cost improvement.
3. Improve Signal Timing (General), considered a low cost improvement.
4. Provide Green Extension (Advance Detection), considered a variable cost improvement.
5. Provide Advance Warning of Signal Changes at Rural Signalized Intersections, considered a medium cost improvement.
6. Install Flashing beacons at Intersection, considered as medium cost.
7. Install Flashing beacons at Advance of Intersection, considered as medium cost.
8. Install Backplates on Existing Signals, considered low cost.
9. Provide Louvers, Visors, and Special Lenses so Drivers are able to View Signals only for Their Approach, considered as low cost.
10. Install Additional Signal Heads, considered as medium cost.

11. Install More Overhead Traffic Signals, considered as high cost.
12. Provide Two Red-Signal Displays within each Signal head to Increase Conspicuity of the Red Display, considered as medium cost.
13. Use LED Traffic Signal Module, considered as medium cost.

As mentioned earlier and in various sections of this report, human factors were observed to be the primary causes of fatal intersection crashes. Age is one of these human factors, and is very significant for left-turn intersection crashes. About one in three of drivers involved in left-turn crashes are elderly drivers, i.e. drivers 65 years or older. Some of the following feasible countermeasures are suggested at signalized intersections, to alleviate older driver-related crashes:

1. Use Green Arrow/Protected Left Turns/Movement Signal Phasing, considered low cost, with expected 98% crash reduction.
2. Assume Slower Walking Speeds for Pedestrian Signal Timing, considered low cost.
3. Install Backplates on Existing Signals, considered low cost.
4. Install Additional Signal Heads, considered as medium cost.
5. Install More Overhead Traffic Signals, considered as high cost.

The following additional countermeasures are suggested relative to the fatal intersection crashes seen in Florida.

1. **Improve drivers' sight distance:** A large number of crashes involved straight or left turn movements versus cross traffic. To improve the sight distance for such movements, restrict parking near intersections and move stop lines towards intersections so that the driver can establish a proper line of sight before entering the intersection. The corners at intersections should be cleared of any such objects that might obstruct the line of sight of the driver. Also, on roadways with planted shrubbery in the medians, the shrubbery should be cleared near the intersections so that the driver on the intersecting road has adequate sight triangle. To address the problem of other stopped vehicles blocking or obstructing the line of sight in left-turn crashes, offset the stop bars at intersections for turning and straight vehicles. Because many of the sight distance issues involved the left-turning driver's line of sight being blocked by opposite queued vehicles waiting to make left or right turns, a suitable countermeasure is to provide offset left-and-right-turn lanes so that vehicles are not positioned to block the view of other drivers. The turning stop bars should be pushed back from the intersection so that the vehicles stopped in the turn lanes do not block the line of sight to the straight oncoming vehicles stopped at the other end of intersection. AASHTO recommends that the intersection sight distance in both directions should be equal to the distance traveled at the design speed of the major road during a period of time equal to the time gap.
2. **Upgrade signs/signals:** Especially in areas with a high elderly population, the provisions of the Florida Elder Road User program should be carefully followed,

along with other efforts to improve clarity and visibility at intersections. This includes increasing the size of signal heads to increase their visibility, providing separate signals over each lane, and installing higher intensity signal lenses. Larger street signs, overhead mounted street signs, and advance mounted street signs all reduce confusion and help users make earlier decisions. Roadside signs should be retro reflective, in good condition, and prominently visible. In sections of roadways where foggy conditions are known to occur, flashing warning signage should be considered. Speeding on the part of drivers of through vehicles was often coupled with poor gap judgment by left-turning vehicles; and speeding was often seen in conjunction with red light running. The consistency of speed limits approaching intersections should be evaluated, as well as the prominence of reduced speed limit signs. Additional research should be directed toward use of dynamic signage with the intervention of Intelligent Transportation Systems (ITS), so as to give the current traffic conditions to the drivers on the intersecting roadway, or to alert turning traffic as to unsafe gap distances.

3. **Combat red-light running:** At signalized intersections, almost 50 percent of the fatal crashes were related to red-light running. This accounts for almost 17 percent of all fatal intersection crashes. In areas where red-light running is a problem, the length of signal cycles should be evaluated, including the yellow clearance interval and the all-red phases. Experiment with the use of longer all red phase rather than a longer amber phase at high crash prone intersections. Enforcing laws that prohibit dangerous intersection driving is a necessity to even well designed and regulated intersections. Enforcement must be consistent because motorists who tend to violate traffic control are aware that the chances of receiving a citation are low. Sustained enforcement efforts can reduce both intersection violations and crash rates, sometimes to a dramatic extent. Red-light running can be curbed by strict enforcement and use of red-light running cameras. Automated speed detecting systems should be considered on roadways with red-light running problems so that a patrol officer can be dispatched to intercept speeding vehicles, which were often associated with red-light running, because of the vehicle's inability to stop in time.

4. **Facilitate left-turn traffic, especially on divided highways:** A large number of crashes involved left turning vehicles, especially involving cross traffic from stop signs, and oncoming traffic with either permissive signal phasing or an unsignalized movement. Since more than 30 % of the at-fault drivers in left turn oncoming crashes were older drivers of more than 65 years of age, using only protected green signals for left-turning in front of oncoming traffic on a divided roadway be given consideration in regions with significant populations of older drivers. Obviously, speed limits, number of lanes to be crossed, and traffic volumes should be considered in making such decisions.

   Non-traditional signage, such as the example in Figure 9.43 should be considered as appropriate. This sign, which depicts the number of oncoming lanes, can be placed in the opposing median to better inform left-turning drivers and thereby assist them in making a decision about turning across the oncoming lanes. Consideration should also be given to non-traditional intersection designs such as roundabouts or jughandle intersections, which do not rely on driver gap judgment to execute a left-turn and eliminate conflict points. According to the New Jersey Roadway Design Guide, "a 'jughandle' is an at-grade ramp provided at or between intersections to permit the motorists to make indirect left turns and/or U-turns… These ramps exit from the right lane of the highway in advance of the intersection, or past the intersection and convey traffic across the main highway under traffic signal control. This movement eliminates all turns within active traffic lanes and, in addition to providing greater safety, reduces delays to the through traffic that left turning vehicles usually create." (*Roadway*, 2004).

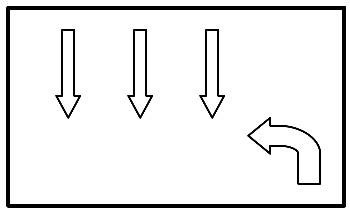

Figure 9.43: Sample Informative Sign

5. **Add turn lanes at intersections:** Turn lanes are used to separate turning traffic from through traffic. Turn lanes were not present in a number of rear-end crashes, especially on low-volume undivided roadways. Turn lanes can safely remove turning vehicles that are slowing down in through traffic lanes. By adding separate turn lanes at intersections, the delay experienced by drivers on an approach can also be reduced. Turn lanes at major driveways can also improve safety, especially on high-volume or high-speed roadways.
6. **Support in-vehicle countermeasures:** Equipping vehicles with special in-vehicle warning or messaging systems to assist the older drivers in executing time consuming or time gap judgment involving maneuvers may be thought of in advanced stages while implementing ITS technologies.
7. **Provide driver education regarding defensive driving:** Extensive driver education campaigns and public notices can be resorted to educate the drivers of the crash facts and the importance of safe driving and the property and life damage to innocent victims due to careless driving. It is important to know that taking traffic control for granted can be fatal and that more than 30% of fatalities in fatal intersection crashes are of not-at-fault drivers. Drivers should be educated about defensive driving. They should be educated to be alert at intersections and watch out for stop sign running or red light running drivers. Drivers should be encouraged to report rash driving on the road and near miss situations at intersections due to careless driving on part of other drivers. In addition, speeding on the part of drivers of through vehicles was often coupled with poor gap judgment by left-turning vehicles, even though they were often determined to be not at fault in the crash. Educational and enforcement campaigns should be directed toward such motorists.

10 PEDESTRIAN CRASHES

Overall, pedestrian crashes make up a fairly significant portion of the fatal traffic crashes, accounting for 17 percent of the total number of crashes. Further, because Florida ranks high in number of pedestrian deaths among the fifty states, and because again, there are a number of measures that can be taken to reduce pedestrian crashes, a separate study is undertaken here.

10.1 Background and Literature Review

In addition to the overall literature review provided in Chapter 3, this section provides additional background information on conditions specific to pedestrian crashes, as well as a review of relevant literature.

10.1.1 Marked and Unmarked Crosswalks

The principal pedestrian facilities provided to ensure pedestrian safety on the roadways are crosswalks. Florida statutes reference both marked and unmarked crosswalks, and are quoted below:

316.003 Definitions

(6) CROSSWALK.--

(a) That part of a roadway at an intersection included within the connections of the lateral lines of the sidewalks on opposite sides of the highway, measured from the curbs or, in the absence of curbs, from the edges of the traversable roadway.

(b) Any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface.

316.130 Pedestrian obedience to traffic control devices and traffic regulations.

(10) Every pedestrian crossing a roadway at any point other than within a marked crosswalk or within an unmarked crosswalk at an intersection shall yield the right-of-way to all vehicles upon the roadway.

(11) Between adjacent intersections at which traffic control signals are in operation, pedestrians shall not cross at any place except in a marked crosswalk.

(12) No pedestrian shall, except in a marked crosswalk, cross a roadway at any other place

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than by a route at right angles to the curb or by
the shortest route to the opposite curb.
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Neither the Manual on Uniform Traffic Control Devices (*Manual* 2004) nor the Florida Pedestrian Facilities Planning and Design Handbook (*Florida* 1999) provide further guidance concerning unmarked crossings. By strict interpretation of Florida law, the presence of a sidewalk (or "path," according to the Florida Pedestrian Handbook), is necessary for an unmarked crosswalk to exist at an intersection. Oregon law further specifies that, when crosswalks are marked across the road at (certain legs of) an intersection, they are the only legal crosswalks across the road at that intersection[1]. While not exclusively applicable to T-intersections, such a law can help clarify right-of-way issues at such intersections where a minor street ends at a junction with a major street, often stop-controlled. If a marked crosswalk is painted across the minor street, but none is painted across the major thoroughfare, then by Oregon law, no other legal crosswalks, marked or unmarked exist at that intersection.

10.1.2 Pedestrian Crash Reconstruction

Pedestrian and bicycle crashes are one of the most frequent types of injurious crashes in urban areas. Because of their unique nature, special techniques are needed to investigate and reconstruct these incidents. For crash reconstruction an investigator should have a technical understanding of pedestrian dynamics and behavior and be able to recognize, interpret and prepare physical evidence for identifying vehicle, driver and pedestrian behavior during collisions. A pedestrian crash investigation may include:

- Objective, subjective and performance data
- Pedestrian conspicuity
- Reaction time/human factors
- Reconstruction
- Pedestrian impact dynamics
- Speed analysis
- Hit and run investigation

The following list contains the types of information (or copies) that a crash reconstruction would start with, in addition to a request for an inspection of both the vehicles and crash site:

- Photographs taken at the scene by law enforcement, other agencies or interested parties such as families or witnesses.
- Photographs of the vehicles taken at the scene or at a later date
- Crash reports and homicide investigation reports and notes

[1] ORS 801.220

- Witness statements
- Chemical or toxicology reports
- Driving records and driver history
- Reports and diagrams that include calculations, and data used to produce calculations
- Depositions
- Medical data, primarily those of the emergency responders, and hospital emergency room personnel
- Autopsy reports
- Reports or fire department visits to the scene
- Crash simulation computer programs used to determine the direction, speed, and angle of approach and departure from the collision including data that were inputted into the computer programs
- TV station footage, or independent video taken at the scene or at a later time concerning the crash victims, scenes, or others involved
- Newspaper clippings that were written about the crash, people, scene, or vehicles
- Weather reports at the time of the crash from the local National Oceanic and Atmospheric Administration (NOAA) office or state department of agriculture

In addition the following list of information would be collected in a pedestrian case

- Clothes worn by the victims at the time of the crash
- Trip details, including origin and destination
- Available pedestrian facilities at the crash site or in the nearby vicinity (within 500 feet)

The details of a pedestrian crash are important, and can even be more critical than cases that involve only vehicles. The collision of a pedestrian and a vehicle leaves the pedestrian at a great disadvantage in terms of potential for injury. This is not surprising given the physical disproportions between vehicles and pedestrians. Car occupants have several tons of metal surrounding them, and safety belts and airbags buffer them from crash forces. In contrast, pedestrians are unprotected and only weigh a small fraction of any vehicle that would strike them, thus making them extremely vulnerable. In almost all motor vehicle versus pedestrian cases, the pedestrian is the one injured, many times fatally.

10.1.2.1 Vehicle Assessment

Several features give an indication to the details of the pedestrian collision. The disturbance of dust on the outside surface of a vehicle is the likely path that a pedestrian took during travel over the vehicle. Dents, other depressions, scratches, and cracks indicate points of contact between the pedestrian and the vehicle, and sometimes there are left imprint patterns or other distinctive markings left from pedestrian clothing.

10.1.2.2 Pattern of Pedestrian Injury

To determine impact points on the vehicle that correspond to points of impact on the pedestrian, the pedestrian needs to be examined carefully. For example, pedestrians generally wear rubber or leather soled shoes that provide friction between the shoe and the walking surface as the weight of the person acts down on the shoes. If a pedestrian is walking across the street and has been struck on their left side, their knee may buckle in such a manner as to conform to the shape of the bumper.

The friction force between the pedestrian’s shoe and the street partially hold the shoe in place at the bottom of their foot while the vehicle is pushing forward at the knee level. This causes a fracture of the lower leg bones and causes the pedestrian to rotate about their center of gravity to their left on top of the hood or father up on the vehicle depending on the velocity of impact. There is a weight transfer from the right foot to the left foot preventing, in most cases, a fracture of the right foot, which is farther forward of the vehicle bumper and is behind the initial impact. The manner in which the pedestrian rotates onto and over the vehicle and lands on the ground or roadway surface requires detailed analysis.

A dented hood may correspond to injuries or bruising of the pedestrian’s upper body, such as a shoulder or elbow, as well as the hips and knees. The vehicle bumper causes impact to a pedestrian’s lower leg. Matching the height of the leg facture above the bottom of the bumper with the known height of that particular bumper can verify the impact point.

10.1.2.3 Pedestrian Rotation

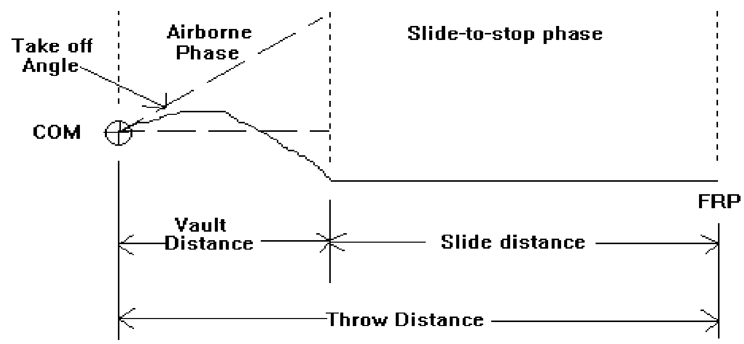
Many vehicles today have been designed aerodynamically, with rounded corners and tapered surfaces, especially in the front end, whereby manufacturers have desired to reduce wind drag and increase fuel efficiency. The shape of the front end of a vehicle affects the trajectory of the pedestrian after impact. The higher the front end of a vehicle, the less likelihood the pedestrian will be rotated on top of the hood. Conversely, a vehicle with a low front end will likely rotate a pedestrian rearward, and onto the hood or top of the vehicle instead of impact the pedestrian with the blunt front end of the vehicle.

Most vehicle hoods are sloped from the center to the left and right sides of the vehicle. This sloping affects the motion of the pedestrian as it rotates from a standing position to a somewhat horizontal position and lands either to the right of to the left depending on the initial point of contact between the vehicle and the pedestrian. The higher the speeds at impact, the farther rearward the pedestrian may land on the upper surface of the vehicle.

Several papers have been published by the Society of Automotive Engineers (SAE) indicating that, at approximately 40 mph, the pedestrian may land near the base of the windshield or into the windshield itself. This is usually the first contact point. Depending on the type of clothing worn by the pedestrian, it is possible that they may stay in that position, roll over the top of the vehicle, or slide off to one side. Leather coats or other fabrics that have a sticky-type surface may hinder the pedestrian from sliding very far across the surface of the hood. The new smoother type surfaces such as ski jackets allow the pedestrians to slide more easily off the vehicle surface.

10.1.2.4 Pedestrian Throw Distance and Impact Velocity

The center of gravity of a standing individual can be approximated, the impact point on a vehicle can be measured, and from a traffic homicide investigation report the final resting point of the pedestrian can be determined. The maximum height the center of gravity of the individual reaches at impact with the vehicle can be extracted. Knowing the distance the pedestrian landed at impact and the height or apogee of the trajectory, the velocity of the vehicle at the point of impact can be calculated (see Figure 10.1). The system is accurate within a few miles per hour; however, several theories exist and different methods have been devised.



Legend:

COM = Center of Mass

FRP = Final Resting Point

Figure 10.1: Pedestrian Throw Distance

Eubanks (1994) formalized a method for pedestrian versus vehicular crashes that considers the throw distance of the pedestrian and includes not only the point of impact but also the time and distance the pedestrian may be sliding on the upper surfaces of the vehicle; hood, windshield, or roof. The trajectory itself includes the time and distance that the pedestrian leaves the vehicle until contact with the ground and until coming to rest by sliding or rolling along the surface of the ground. In this manner the entire movement of the pedestrian is accounted for, which can give a more accurate analysis and calculation of the vehicle impact velocity. A limitation of this method is the need for the coefficient of friction of the pedestrian sliding or rolling on the surface of the vehicle as well as landing or rolling on the ground, see Table 10.1 for commonly assumed values.

Table 10.1: Pedestrian Slide Coefficients of Friction

Surface of Pedestrian Traverse	Coefficient of Friction
Vehicle; shows light to no scratches, absence of dents	0.1 – 0.3
Vehicle; shows large dents, and/or fractured windshield with glass pushed inward a few inches	0.7 – 0.8
Ground; highway or grassy surface	0.7 – 1.2

10.1.3 Literature Review

About 70,000 pedestrians are injured in motor vehicle crashes annually in the United States, and during the past decade, on average about 5,200 pedestrians have died each year. Pedestrians have represented 11-17 percent of all U.S. motor vehicle deaths since 1975. In 2002, pedestrian deaths made up almost one-fourth of traffic deaths among 5-9 year-olds and 17 percent among people age 70 and older. Pedestrian deaths are a major problem in large urban areas and mostly occur at non-intersection locations (*Insurance* 2003, *National* 2002).

However, the recent trend shows promising signs. Pedestrian death rates have declined 51 percent since 1975 (from 3.5 to 1.7 per 100,000 people in 2002). During the same years, the pedestrian death rate among 0-9 year-olds decreased 84 percent -- 60 percent among 10-19 year-olds and 61 percent among people 65 and older (*Insurance* 2003). Reasons for these steep declines aren't fully known, but they probably in part reflect changes in the amount and type of pedestrian exposure.

Based on population, children younger than age 16 are most likely to be struck by motor vehicles. Pedestrians ages 5-9 have the highest nonfatal injury rates. Elderly pedestrians, though less frequently struck than children, are more likely to die after being struck. The pedestrian death rate per capita among people age 65 and older has decreased since 1950, but this age group still has the highest pedestrian death rates. Starting at age 70, the rate is nearly twice as high as it is for people younger than 70 (2000 data). Males are more likely than females to be in pedestrian collisions. In 2002, males made up about 68 percent of pedestrian deaths (*Insurance* 2003).

Alcohol impairment plays a major role in adult pedestrian deaths, just as it does in passenger vehicle occupant deaths. According to NHTSA, in 2002 36 percent of fatally injured adult pedestrians had high blood alcohol concentrations (BAC's of 0.08 percent or higher) (*National* 2002). The percentage of fatally injured adult pedestrians with high blood alcohol concentrations decreased slightly from 39 to 36 percent during 1992-2002. During the same time, the percentage of all fatally injured motor vehicle drivers with BAC's this high decreased from 37 to 32 percent. In 2002, more than 50 percent of fatally injured pedestrians 16 and older had high blood alcohol concentrations in nighttime crashes (9 pm-5 am). The extent to which alcohol-impaired drivers collide with pedestrians hasn't been established.

The likelihood of a pedestrian crash is greatest in urban areas where pedestrian activity is concentrated. In 2002, 70 percent of pedestrian deaths occurred in urban settings, although there was a higher ratio of deaths to injuries in rural areas because of higher impact speeds on rural roads. Fatal pedestrian/motor vehicle collisions occur most often between 6 and 9 pm. Pedestrian deaths are more likely on Friday and Saturday (*Insurance* 2003).

A large number of pedestrian injuries occur at intersections. Forty-three percent of all pedestrian injuries and 22 percent of fatal injuries to pedestrians occur in collisions with motor vehicles at intersections. In urban areas, the proportion of pedestrian injuries at intersections is greater than in non-urban areas. A 1993 Insurance Institute study of fatal pedestrian crashes (occurring between 1986-1990) in four U.S. cities found 40 percent of those involving vehicles other than large trucks happened at intersections, and 51 percent of fatal pedestrian crashes involving large trucks occurred at intersections (Retting 1993). A substantial number of urban pedestrian crashes involve turning vehicles, particularly left-turning vehicles.

However, the majority of pedestrian crashes occur at locations other than intersections, where vehicle speeds are higher and drivers do not expect to have to stop. One common type of collision can be characterized as a dart-out because a pedestrian appears suddenly from the roadside allowing the driver little time to react. A good example of this is a child running out from between cars parked on a residential street.

People 65 and older have a higher proportion of fatal crashes at intersections. In 2002, 20 percent of deaths of pedestrians younger than 65 occurred at intersections, but 36 percent of pedestrians age 65 and older occurred there. Older pedestrians also are over-represented in crashes involving turning vehicles. This occurs partly because the elderly are more likely than younger people to cross at intersections, and in general, their slower walking speed and diminished vision, hearing, and reaction time put them more at risk (*Insurance* 2003).

Traditional approaches have emphasized the need to understand and modify pedestrian behavior. A 2002 Institute-sponsored study of pedestrian deaths in Baltimore and Washington, DC revealed that nearly 40 percent of the collisions involved driver negligence (Preusser et al 2002). Pedestrians were almost always judged culpable in mid-block and intersection dash crashes, the kind involving a pedestrian who appears suddenly in the path of a vehicle. Drivers were usually at fault among other crash types such as turning vehicle, vehicle backing up, and pedestrian not in road. Despite the great physical disadvantages of pedestrians in encounters with motor vehicles, a disproportionate share of attention has been focused on the pedestrian rather than on drivers and needed changes in vehicles and highways.

Most pedestrians are struck by the front of a passenger vehicle. What happens next depends on a number of factors, including vehicle speed and the relative heights of the pedestrian, vehicle front end, and bumper, but pedestrians usually are not “run over” by motor vehicles. The bumper usually strikes a child’s upper leg, and the front edge of the hood strikes the torso. An adult may be struck in the lower leg by the bumper and in the upper leg by the front edge of the hood. At impact speeds slower than 10-12 mph, these may be the only contacts between the pedestrian and the vehicle but, at higher speeds, pedestrians usually slide over the front edge of the hood before their upper bodies strike the vehicle. More than half of serious pedestrian injuries result from impacts with vehicles, not roads, and given the dynamics of pedestrian impacts, people’s heads and legs are the body parts most frequently injured (Ashton et al 1978).

Laboratory evidence suggests vehicle design does influence the type and severity of crash injuries sustained by pedestrians. For example, research has shown that altering a car’s hood/fender design can reduce the severity of forces on the heads of test dummies. A 1984 National Highway Traffic Safety Administration (NHTSA) study found adult pedestrian head injuries could be significantly decreased if there were at least 2 to 3 inches clearance distance between the hood and the engine (Pritz 1984). The study also found aluminum hoods may be more flexible and therefore able to absorb more pedestrian impact energy than steel hoods. NHTSA in the early 1990’s decided not to proceed with regulatory action that would require vehicles to be modified to lessen pedestrian injuries.

Another study of pedestrian injuries found that virtually all leg and pelvic trauma or fractures were caused by contact with the vehicle (Ashton et al 1978). Bumper contact caused 55 percent of such injuries, and contact with the front structure above the bumper caused 42 percent. Researchers also found that knee injuries are more likely to occur when vehicle bumper height rises to one-quarter or one-third the relative height of the pedestrian. Vehicles with bumpers located at a height of approximately 20-21 inches caused the highest incidence of knee injury. Pelvic injuries were more likely when the hood rose to a pedestrian's midline. According to the data, lower bumpers on automobiles with square front-end designs appeared to reduce the likelihood of pelvic and leg fractures among pedestrians. Soft-faced bumpers produce significantly fewer knee and leg injuries in laboratory experiments, a 1979 study found (Pritz 1979).

The European Union is planning new regulations requiring carmakers to build vehicles with higher hoods and flatter bumpers to reduce the severity of pedestrian injuries. The draft European rules call on carmakers to put more room between the hood and the engine to soften head impacts; bumpers would have to be built with more give to spread out the impact on a pedestrian's legs.

Improving roadway design is one way to improve pedestrian safety. A recent Insurance Institute for Highway Safety review of traffic engineering measures to reduce pedestrian-motor vehicle crashes identified several effective approaches (Retting 2003). Engineering modifications generally can be classified into three broad categories – separation of pedestrians from vehicles by time or space, measures that increase the visibility and conspicuity of pedestrians, and reduction of vehicle speeds. Separation countermeasures reduce the exposure of pedestrians to potential harm both on the roadside and when crossing. Because in many pedestrian crashes the driver reportedly does not see the pedestrian prior to the crash, measures are needed to increase the visibility and conspicuity of pedestrians. Higher vehicle speeds are strongly associated with both a greater likelihood of pedestrian crash occurrence and more serious pedestrian injury.

Effective measures to separate pedestrians from vehicles include construction of refuge islands in the median of busy two-way streets, sidewalks, overpasses and underpasses, and exclusive traffic signal phasings, which stop all vehicle traffic for part or the entire pedestrian crossing signal. One study found that providing pedestrians a three-second head start through the use of a leading pedestrian interval (a signal that allows pedestrians to begin crossing prior to the release of turning vehicles) reduces conflicts between pedestrians and turning vehicles as well as the incidence of pedestrians yielding the right-of-way to turning vehicles. Effective measures to increase the visibility and conspicuity of pedestrians include increased intensity of roadway lighting, diagonal parking, and re-location of bus stops at traffic signals from the near-side to the far-side of the intersection. Effective measures to reduce vehicle speeds in urban areas include construction of modern roundabouts in place of stop signs and traffic signals, traffic calming devices such as speed humps, and multi-way stop sign control.

Allowing right turns at red lights has been shown to increase pedestrian collisions at intersections, especially in urban areas, so curbing this practice in areas of high pedestrian activity would likely reduce pedestrian collisions (Zador 1984). Other improvements at intersections with signals include extending the time available for pedestrians, especially elderly ones, to cross with a green light. Special warning signs and pavement markings designed to encourage or prompt pedestrians to look for turning vehicles as they cross the street may help lower the frequency of pedestrian collisions at signalized intersections. Another study found the use of sign prompts and crosswalk warning messages increased the percentage of pedestrians looking for threats from turning vehicles and decreased the number of conflicts between pedestrians and turning vehicles (Retting 1996). The signs and pavement markings used in this study were relatively inexpensive and could be widely applied by traffic engineers where conflicts between pedestrians and turning vehicles are a problem. Speed limits should be strictly enforced in areas of pedestrian activity. The faster a vehicle is traveling, the less likely it is that a driver can stop in time to avoid hitting a pedestrian. When collisions do occur, the ratio of deaths to injuries is higher where speed limits are higher.

Other studies have shown that extending daylight saving time year-round can help prevent pedestrian deaths and injuries (Ferguson et al 1995). Adding an hour of light to the afternoon increases the visibility of both vehicles and pedestrians. Analyzing 1987-91 data from the federal Fatality Analysis Reporting System, researchers estimated that about 900 fatal crashes, 727 involving pedestrians and 174 involving vehicle occupants could have been avoided during the study period if daylight saving time had been in effect throughout the year.

In general, public education programs haven't worked well to reduce motor vehicle injuries and other health problems. However, educational messages that instruct children on street crossings have reduced mid-block crashes involving youths darting out into the street. In particular, the federal "Willy Whistle" program to teach youngsters how to cross between intersections was associated with a 12 percent reduction in overall child pedestrian collisions and a 21 percent decline in the incidence of motorists striking children who dashed out mid-block or from between parked cars (Preusser 1988). Tested in Los Angeles, Milwaukee, and Columbus, Ohio, during 1976-78, the program included a film, posters, and media advertisements. A similar program for older children, "And Keep on Looking," also reduced pedestrian crashes. The Federal Motor Carrier Safety Administration has developed outreach materials and safety tips for pedestrians to support their "Share the Road Safely" program – materials they make available online (http://www.nozone.org/index.asp).

10.2 Methodology

The approach for reviewing pedestrian crashes was based on the general approach presented in Chapter 4. Following a review of related literature and studies that sought to categorize pedestrian traffic fatalities, pedestrian crash types were tailored for this project based on the types of activities pedestrians and drivers were engaged in prior to collision. Additional crash type categories were developed to reflect the specific characteristics of the fatal pedestrian crashes in the state of Florida. For instance, due to the high incidence of pedestrians crossing the roadway at locations other than intersections, pedestrians crossing the road were classified as either those who had not yet crossed the first half of the road (one travel direction) or those that had and were attempting to cross the second half of the road (second travel direction). Pedestrian crashes in this study are categorized by ten crash type categories as follows:

1. **Crossing Not at Intersection (1st Half):** Mid-block or not within marked intersection crosswalk. Pedestrian failed to cross nearest lanes of traffic (traveling in one direction). Although a number of mid-block crossings appeared to occur at or near T-intersections, few such crossings met the statutory definitions of crossing in unmarked crosswalks (see Florida Statute 316.003(a) above) because of the lack of connecting sidewalks or because of the angle or position of the crossing. Thus, they are included within the set of non-intersection crossings. Nonetheless, the rate of such crossings are discussed subsequently, along with other trip generators.

2. **Crossing Not at Intersection (2nd Half):** Same as above, except pedestrian gets at least across the lanes of the traffic in the first direction before being struck. Includes pedestrians struck while in a center two way left turn lane, and applies regardless of median width.
3. **Crossing at Intersection:** Within the crosswalk or designated crossing area of an intersection that breaks traffic for the pedestrian route.
4. **In Road:** Pedestrian standing, working, playing, laying or sitting in the road. This category applies to attempted suicides (pedestrian is not attempting to cross the road). Usually there is sudden pedestrian appearance and short time exposure (driver does not have time to react).
5. **Walking Along Roadway With Traffic:** Pedestrian struck while walking in the same direction as vehicular traffic along the edge of the highway or on the shoulder or within the right hand sidewalk. In the case of divided highways, includes pedestrians walking in or along the inside edge or median shoulder.
6. **Walking Along Roadway Against Traffic:** Same as above except pedestrian is walking in the opposite direction of vehicular traffic.
7. **Exit Vehicle:** The pedestrian had been the driver or passenger in the events preceding the crash. Circumstances of this category include a disabled vehicle, working on or next to a disabled or stopped vehicle, involved in prior vehicle crash, exited a bus, and ejected passengers who have stabilized (pedestrian action, even if limited, is possible).
8. **Vehicle Turn / Merge:** Vehicle is turning or merging into traffic. Includes driver attending to traffic in one direction and hits pedestrian from a different direction.
9. **Unique:** Unique or unusual circumstances which are not likely to occur again and are not countermeasure corrective. For example, pedestrian standing outside of a car at gas station hit by debris from overturned truck on the nearby state road.
10. **Other:** All other pedestrian crashes. Includes those where circumstances of the crash are unknown. For example, unidentified pedestrian struck by a unknown hit and run vehicle with no witnesses and little to no evidence.

The focus of efforts to discover contributing factors in pedestrian cases was determining the factors that contributed to a crash, and not the factors that contributed to the fatality. The disproportionate mass and velocities of vehicles and pedestrians, and the specialization of this study on fatal crashes, almost assured that the factors contributing to the fatality centered around a vehicle hitting a pedestrian (commonly a blunt force injury). Although the ways in which pedestrians were hit and the types and nature of pedestrian throw were valuable pieces of information for preparing pedestrian reconstructions, they were not focus of the pursuit for crash contributing factors. Contributing factors in crashes are known to fall within three main categories; human, vehicle, and environment. To meet the objectives of this study the human factors were split into pedestrian and driver behaviors, while the roadway factors were separated from other environmental conditions. An additional category, “Other / Unknown”, was introduced to adequately address cases were very little information was available (such as certain hit and run cases). Investigating causes and contributing factors of crashes was complicated by the fact that a crash did not did not always have a single unambiguous cause and crash causes are often a sequence of causes. In much the same way that crash types were tailored for this project, the contributing factors of the pedestrian crashes were a customized product of the case based review approach taken. The list of crash contributing factors assigned in the review of pedestrian crashes follows:

1. **Pedestrian Behavior**
    a. Inattention / Distraction (emotional stress, headphones, working)
    b. Perceptual Error (inadequate surveillance, looked but didn't see)
    c. Decision Error (misjudged gap/speeds, not heed signal, dart out into road)
    d. Alcohol/Drug Impairment
    e. Other (standing/playing in roadway, suicide, Alzheimer's disease, medical condition)
    f. Unknown (pedestrian know to contributed to crash but exact details unknown)
2. **Driver Behavior**
    a. Inattention / Distraction (emotional stress, external/internal distraction)
    b. Perceptual Error (inadequate surveillance, looked but didn't see)
    c. Decision Error (misjudged gap/speed, following too closely, aggressive driving, improper lane change)
    d. Over correction (abrupt steering input, loss of control)
    e. Vehicle Speed (too fast, too slow – contributing to crash)
    f. Alcohol/Drug Impairment
    g. Incapacitation (asleep, blackout, seizure)
3. **Vehicle Condition** (defective brakes, etc.)
4. **Environmental Condition** (dense fog, smoke, heavy rain, wind blowing trailer, etc.)
5. **Roadway Condition**
    a. View Obstructions, Sight Distance
    b. Roadway Curvature
    c. Sign / Signal Issue
    d. Maintenance Problem (potholes, water in road)
    e. Construction, Surveying
    f. Other
6. **Other / Unknown** (emergency vehicle, crash details unknown, etc.)

The approach taken in this study assigned a primary and, if applicable, a secondary contributing factor. For example, the initial contributing factor of a pedestrian crash may be a poor decision by the pedestrian as manifest by darting out into the road. If the vehicle driver was distracted at the same time, failing to see the pedestrian and safely stop the vehicle or maneuver around the pedestrian, both the pedestrian decision error (primary) and the driver inattention (secondary) would be contributing factors. In this example, the pedestrian would have been assigned the primary contributing factor because had the pedestrian not made a poor decision the fatality would have been avoided. The driver inattention is considered a secondary factor, because even if the driver had been attentive there would have been no guarantee that the event would have been avoided, however the inattention was still judged to contribute to the crash. To complicate matters even more, there may be circumstances well in advance of the crash that may have contributed to its occurrence. For instance, the pedestrian may have been distraught, an emotional condition that could have led to lack of care and diminished observational awareness of surroundings, while the driver of the vehicle may have had defective brakes which in turn reflects on poor vehicle maintenance. In cases with multiple contributing factors, only the two factors considered to contribute most to the crash and fatality were coded primary and secondary, while the other factors were noted elsewhere.

10.3 Pedestrian Data Set

10.3.1 Summary Statistics

The data set for this research was comprised of all pedestrian fatal crashes in the state of Florida in the year 2000, and only those involving pedestrians and heavy trucks in the years 1999 and 1998. The scope of this project, and a limitation of data available from the Florida Department of Transportation, restricted the project to cases on state roadways. The details of the study data set are shown in Tables 10.2 and 10.3.

Table 10.2: Pedestrian Data Set – State Roadways

	1998 (Heavy Trucks)	1999 (Heavy Trucks)	2000 (All Cases)	Total
Cases	20	13	320	353
Pedestrians	23	13	346	382
Pedestrian Fatalities	20	10	320	350

Table 10.3: Distribution of Multiple Pedestrian Cases

	Number of Pedestrians					Total
	1	2	3	4	5	
Cases	333	14	4	1	1	353
%	94%	4%	1%	0%	0%	

The source, quality, availability, and detail of the information available for the pedestrian cases varied significantly depending on the investigating agency (see Table 10.4). The most consistent and accessible information was from the Florida Highway Patrol traffic homicide investigative reports (FHP – THI reports). Although the majority of Police Departments and

Sheriffs Offices conduct detailed traffic homicide investigations of pedestrian traffic fatalities, attempts to acquire the investigation reports were usually ineffective with only a handful of agencies sending the requested detailed reports. Table 10.5 depicts the distribution of pedestrian crashes by county. As expected, the majority of counties with high pedestrian crash frequencies are those with the largest urban populations. It is not surprising that Dade county tops the list in Table 10.5, where population demographics and other factors favor high pedestrian traffic volumes.

Table 10.4: Investigating Agency in Pedestrian Cases

Investigating Agency	No.	%
Florida Highway Patrol	166	47%
City Police Department	139	39%
Sheriffs Office	48	14%

Table 10.5: Distribution of Pedestrian Cases by County

County	Pedestrian Crashes		Non-Ped Crashes		Ped OR Factor
	Number	Percent	Number	Percent	
Alachua	5	1%	34	2%	**0.719**
Baker	2	1%	7	0%	**1.398**
Bay	4	1%	16	1%	**1.223**
Bradford	3	1%	10	1%	**1.468**
Brevard	9	3%	53	3%	**0.831**
Broward	32	9%	142	8%	**1.103**
Calhoun	0	0%	7	0%	**0.000**
Charlotte	1	0%	27	2%	**0.181**
Citrus	1	0%	15	1%	**0.326**
Clay	2	1%	10	1%	**0.978**
Collier	1	0%	40	2%	**0.122**
Columbia	3	1%	15	1%	**0.978**
Dade	50	14%	133	8%	**1.839**
Desoto	1	0%	9	1%	**0.544**
Dixie	2	1%	2	0%	**4.892**
Duval	18	5%	67	4%	**1.314**
Escambia	6	2%	27	2%	**1.087**
Flagler	2	1%	8	0%	**1.223**
Franklin	1	0%	4	0%	**1.223**
Gadsden	2	1%	6	0%	**1.631**
Gilchrist	0	0%	3	0%	**0.000**
Glades	1	0%	6	0%	**0.815**

Table 10.5: Distribution of Pedestrian Cases by County, continued

County	Pedestrian Crashes		Non-Ped Crashes		Ped OR Factor
	Number	Percent	Number	Percent	
Gulf	0	0%	2	0%	0.000
Hamilton	1	0%	3	0%	1.631
Hardee	0	0%	8	0%	0.000
Hendry	1	0%	2	0%	2.446
Hernando	0	0%	12	1%	0.000
Highlands	2	1%	21	1%	0.466
Hillsborough	31	8%	106	6%	1.444
Holmes	0	0%	6	0%	0.000
Indian River	2	1%	17	1%	0.576
Jackson	2	1%	13	1%	0.753
Jefferson	1	0%	9	1%	0.544
Lafayette	0	0%	2	0%	0.000
Lake	3	1%	34	2%	0.432
Lee	8	2%	48	3%	0.815
Leon	6	2%	24	1%	1.223
Levy	0	0%	16	1%	0.000
Liberty	0	0%	0	0%	N/A
Madison	0	0%	9	1%	0.000
Manatee	3	1%	38	2%	0.386
Marion	2	1%	32	2%	0.306
Martin	2	1%	28	2%	0.349
Monroe	3	1%	21	1%	0.699
Nassau	0	0%	16	1%	0.000
Okaloosa	3	1%	18	1%	0.815
Okeechobee	1	0%	11	1%	0.445
Orange	24	7%	63	4%	1.864
Osceola	4	1%	28	2%	0.699
Palm Beach	18	5%	80	5%	1.101
Pasco	15	4%	40	2%	1.835
Pinellas	29	8%	52	3%	2.728
Polk	9	3%	101	6%	0.436
Putnam	4	1%	10	1%	1.957
Santa Rosa	1	0%	12	1%	0.408
Sarasota	7	2%	31	2%	1.105
Seminole	4	1%	20	1%	0.978
St. Johns	2	1%	27	2%	0.362

Table 10.5: Distribution of Pedestrian Cases by County, continued

County	Pedestrian Crashes		Non-Ped Crashes		Ped OR Factor
	Number	Percent	Number	Percent	
St. Lucie	4	1%	13	1%	**1.398**
Sumter	0	0%	24	1%	**0.000**
Suwannee	2	1%	6	0%	**1.631**
Taylor	0	0%	11	1%	**0.000**
Union	0	0%	2	0%	**0.000**
Volusia	12	3%	45	3%	**1.305**
Wakulla	0	0%	8	0%	**0.000**
Walton	1	0%	12	1%	**0.408**
Washington	0	0%	5	0%	**0.000**

Table 10.6 is a summary of the distribution of pedestrian cases by month, and Table 10.7 shows the cases according to the day of the week. The same information is also presented in a graphical format, in Figures 10.2 and 10.3. Pedestrian crashes appear to be over represented during the cooler months of the year and on Fridays and Saturdays.

Table 10.6: Distribution of Pedestrian Cases by Month

	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ped Cases	35	30	41	20	32	23	21	35	22	36	25	33
Percent	9.9%	8.5%	11.6%	5.7%	9.1%	6.5%	5.9%	9.9%	6.2%	10.2%	7.1%	9.3%
Non-ped Cases	144	153	168	163	179	122	117	142	126	136	124	153
Percent	8.3%	8.9%	9.7%	9.4%	10.4%	7.1%	6.8%	8.2%	7.3%	7.9%	7.2%	8.9%
Ped ORF	**1.189**	**0.959**	**1.194**	**0.600**	**0.875**	**0.922**	**0.878**	**1.206**	**0.854**	**1.295**	**0.986**	**1.055**

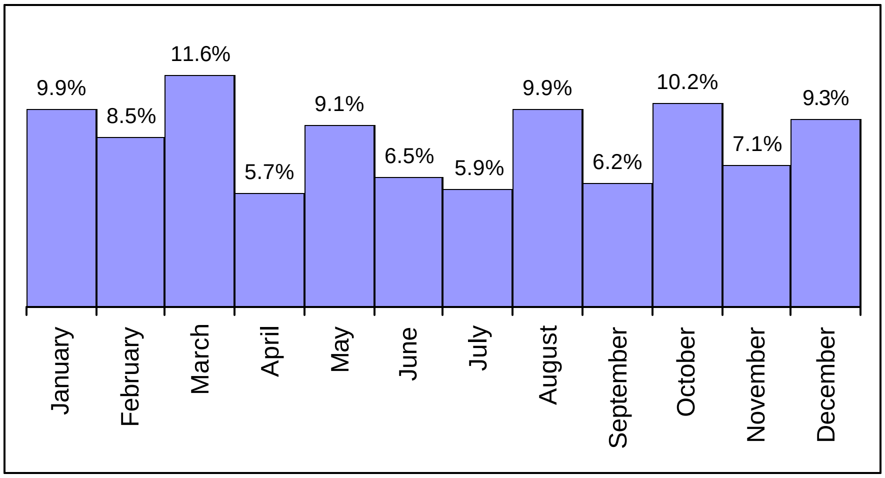


Figure 10.2: Pedestrian Cases by Month

Table 10.7: Distribution of Pedestrian Cases by Day of the Week

	Day of the Week						
	Mon	**Tue**	**Wed**	**Thu**	**Fri**	**Sat**	**Sun**
Ped Cases	50	50	39	49	57	61	47
%	14.2%	14.2%	11.0%	13.9%	16.1%	17.3%	13.3%
Non-Ped Cases	220	228	225	230	275	299	250
%	12.7%	13.2%	13.0%	13.3%	15.9%	17.3%	14.5%
ORF	**1.112**	**1.073**	**0.848**	**1.042**	**1.014**	**0.998**	**0.920**

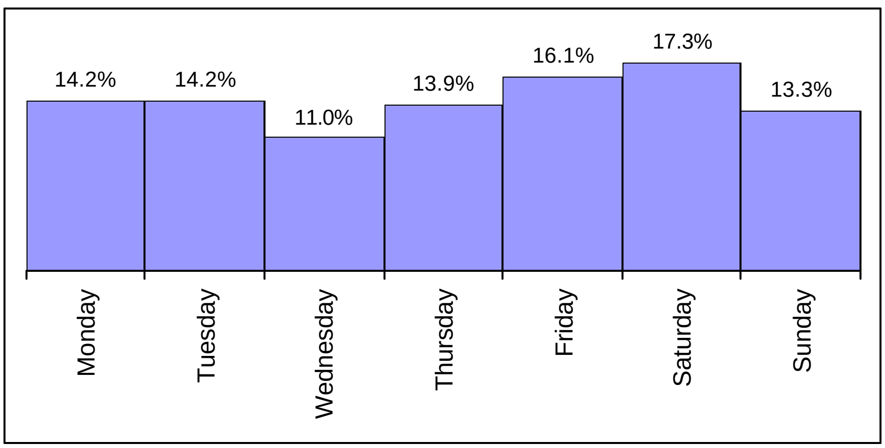


Figure 10.3: Pedestrian Cases by Day of the Week

10.3.2 Characteristics of Pedestrian Crashes by Crash Type

The frequency of crashes according to pedestrian action is given in Table 10.8. As described previously, pedestrian crash types were tailored for this project based on the types of activities pedestrians and drivers were engaged in prior to collision and come from a in depth review of the details of each case. Table 10.9 shows the distribution of crashes according to type and the FDOT district in which they occurred.

Table 10.8: Pedestrian Action Prior to Collision

Pedestrian Action	Count	%
Crossing Road not at Intersection	201	53%
Crossing Road at Intersection	38	10%
In Road	31	8%
Walking Along Road/Sidewalk	35	9%
Exit Vehicle	51	13%
All Other	26	7%
Total	382	

Table 10.9: Pedestrian Crash Types by Managing District (Counts)

Crash Type	Total	%	Managing District							
			1	2	3	4	5	6	7	8
Crossing Not at Intersection (1st Half)	76	20%	7	6	7	13	14	13	16	0
Crossing Not at Intersection (2nd Half)	125	33%	12	16	7	18	19	20	33	0
Crossing at Intersection	38	10%	3	4	2	3	6	13	7	0
In Road	31	8%	6	3	4	6	5	6	1	0
Walking Along Road With Traffic	28	7%	2	4	4	8	2	3	5	0
Walking Along Road Against Traffic	7	2%	0	2	0	0	3	2	0	0
Exit Vehicle	51	13%	3	11	3	8	12	4	8	2
Vehicle Turn / Merge	9	2%	1	0	0	4	1	3	0	0
Unique	8	2%	0	1	1	1	0	2	3	0
Other	9	2%	1	1	0	1	3	1	2	0
Total Number of Pedestrians	382		35	48	28	62	65	67	75	2
Percent			9%	13%	7%	16%	17%	18%	20%	1%

The emphasis of this project on state maintained roadways naturally leads to a higher incidence of rural pedestrian crashes than would be expected if all roadways had been included in the data set, yet the total number of rural crashes is still small and fewer than the total number of urban or suburban crashes (see Table 10.10).

Table 10.10: Pedestrian Crash Types by Urban or Rural Classification

Crash Type	Rural	Urban	Suburban	Unknown
Crossing Not at Intersection (1st Half)	4	49	23	0
Crossing Not at Intersection (2nd Half)	12	65	48	0
Crossing at Intersection	1	28	7	2
In Road	12	13	6	0
Walking Along Road With Traffic	5	14	9	0
Walking Along Road Against Traffic	2	2	3	0
Exit Vehicle	22	26	3	0
Vehicle Turn / Merge	0	8	1	0
Unique	1	5	2	0
Other	1	8	0	0
Total	60	218	102	2
Percent	16%	57%	27%	1%

Pedestrian actions and the details leading up to a fatal event are different in urban and rural pedestrian crashes. To reveal differences, the over representation of rural crashes in certain crash types is given in Table 10.11. The two types of pedestrian crashes that are more prevalent at a statistically significant level in rural areas are “In Road” and “Exit Vehicle”. The incidence of people committing suicides effects the rural over representation of “In Road” crashes. It was found that people committing suicide (cause of 8 fatalities) did so in rural areas where perhaps the impact on traffic would be less severe, vehicle speeds would be higher, and there would be a high occurrence of heavy trucks. The rural over representation in “Exit Vehicle” crashes is discussed in Section 10.5.4. Crashes in urban areas tend to involve pedestrians crossing the road whereas higher percentages of rural crashes involve a pedestrian that has exited a vehicle, or is located in or walking along a state road.

Table 10.11: Over Representation of Rural Crashes in Crash Type

Crash Type	Rural	Urban	ORF	Min CI	Max CI	Level
Crossing Not at Intersection (1st Half)	4 (7%)	49 (22%)	0.30	0.11	0.79	Under
Crossing Not at Intersection (2nd Half)	12 (20%)	65 (30%)	0.67	0.39	1.16	Unsure
Crossing at Intersection	1 (2%)	28 (13%)	0.13	0.02	0.93	Under
In Road	12 (20%)	13 (6%)	3.35	1.62	6.96	Over
Walking Along Road With Traffic	5 (8%)	14 (6%)	1.30	0.49	3.46	Unsure
Walking Along Road Against Traffic	2 (3%)	2 (1%)	3.63	0.52	25.26	Unsure
Exit Vehicle	22 (37%)	26 (12%)	3.07	1.88	5.02	Over

Table 10.11: Over Representation of Rural Crashes in Crash Type, cont.

Crash Type	Rural	Urban	ORF	Min CI	Max CI	Level
Vehicle Turn / Merge	0 (0%)	8 (4%)	0.00	0.00	0.00	Under
Unique	1 (2%)	5 (2%)	0.73	0.09	6.10	Unsure
Other	1 (2%)	8 (4%)	0.45	0.06	3.56	Unsure
Total	60 (100%)	218 (100%)				

The lighting condition at the time of pedestrian crashes plays a prominent role in the visibility of the pedestrian by the vehicle driver. Lighting conditions at the time of the crashes in this study are shown in Figure 10.4 and given in Table 10.12. On average 71% of the pedestrian crashes occurred when it was dark. For cases involving a pedestrian crossing the road not at an intersection the percentage increases to over 80%. In general it was found that a pedestrian fatality is 2 ½ times more likely when it is dark. Not all crash types are over represented at night as given by Table 10.13.

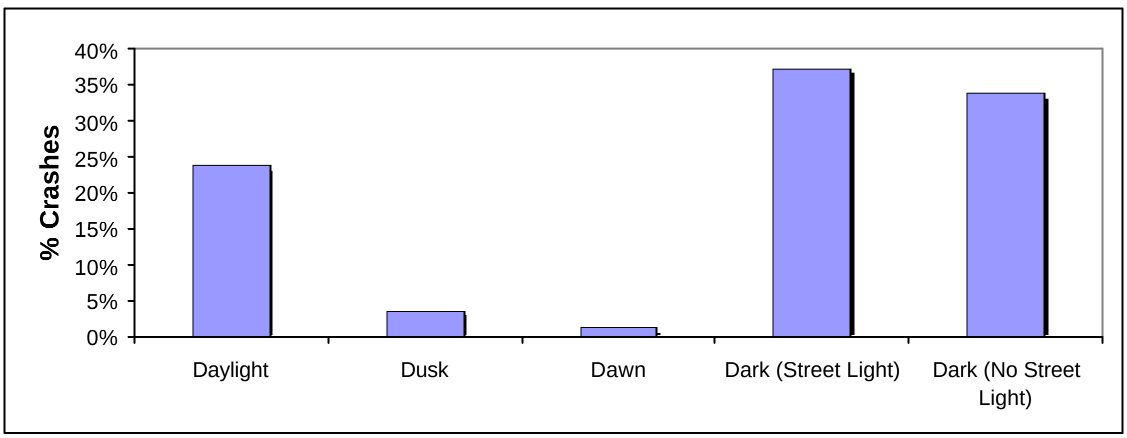


Figure 10.4: Lighting Condition is Pedestrian Crashes

More pedestrians were hit at night when there was a street light than any other lighting condition, even surpassing the number of cases when it was dark and there were no street lights. 37% of all the pedestrians in this study were crossing the street when it was dark and there were street lights. Crashes are frequently caused by pedestrians, many times pedestrians impaired by alcohol, who make poor decisions because they have a false sense of visibility at night when street lights are present. This is particularly true of pedestrians wearing dark clothing who enter the second half of a roadway thinking that drivers will see them and yield the right of way when in fact the drivers are unable to see pedestrians or do not expect pedestrians to cross their path until it is too late to avoid a collision. Although in a majority of the cases information pertaining to pedestrian clothing was unavailable, in the times when it was noted the investigator commonly stated that the pedestrian had been wearing dark clothing. When the pedestrian's dark clothing was determined to be a factor, especially in poorly lit situations at night, then human visibility was assigned as a casual factor. Public education should target both pedestrians and drivers to increase awareness of the lack of pedestrian visibility at night even when street lights are present. Pedestrians should be encouraged to make themselves visible at night by dressing to be seen or carrying flashlights. Drivers should be warned that pedestrians feel a false sense of visibility at night, especially when street lights are present and should be on the lookout for pedestrians. Drivers should be made aware of the potential for pedestrians to make unexpected decisions and enter the roadway without warning even if the pedestrian is visible to a driver. A pedestrian who appears to be drunk should warrant particular caution on behalf of passing motorists. Drivers can be warned to keep alert at first sighting of a disabled vehicle as an unnoticed pedestrian may be nearby walking along the road or crossing it directly in front of them.

Table 10.12: Lighting Condition by Crash Type

Crash Type	Daylight	Dusk	Dawn	Dark (Street Light)	Dark (No Street Light)	Un-known	% Dark
Crossing Not at Intersection (1st Half)	16	0	0	34	26	0	79%
Crossing Not at Intersection (2nd Half)	15	6	2	53	48	1	81%
Crossing at Intersection	12	2	0	18	6	0	63%
In Road	11	1	1	6	12	0	58%
Walking Along Road With Traffic	4	3	2	7	12	0	68%
Walking Along Road Against Traffic	1	0	0	0	6	0	86%
Exit Vehicle	21	1	0	12	17	0	57%
Vehicle Turn / Merge	7	0	0	2	0	0	22%
Unique	2	1	0	5	0	0	63%
Other	2	0	0	5	2	0	78%
Total	91	14	5	142	129	1	71%
Percent	24%	4%	1%	37%	34%	0%	

The overrepresentation shown in Table 10.13 is relative to the ratio of dark to light among all crashes. In this table it can be seen that "exit vehicle" and "vehicle turn/merge" have dark to light ratios that, at the 95% confidence level, are under 1.00 therefore it can be said that within these crash types dark lighting conditions are under represented. Daytime headlight use increases vehicle visibility and more quickly alerts pedestrians and other drivers to impending hazards and crashes (National Safety Council, 2004). "Lights on for safety" is a program that the National Safety Council and other safety organizations used to encouraged motorists, through public information, to drive with their low-beam headlights on during the day. Signage can also be used to encourage the use of low-beam headlights during the day, especially along roadway corridors that experience high daytime crash frequencies.

Table 10.13: Over Representation of Dark Conditions in Crash Type

Crash Type	Dark	Light	ORF	Min CI	Max CI	Level
Crossing Not at Intersection (1st Half)	60 (22%)	16 (15%)	**1.52**	0.92	2.52	Unsure
Crossing Not at Intersection (2nd Half)	101 (37%)	23 (21%)	**1.78**	1.20	2.65	Over
Crossing at Intersection	24 (9%)	14 (13%)	**0.70**	0.37	1.29	Unsure
In Road	18 (7%)	13 (12%)	**0.56**	0.29	1.11	Unsure
Walking Along Road With Traffic	19 (7%)	9 (8%)	**0.86**	0.40	1.84	Unsure
Walking Along Road Against Traffic	6 (2%)	1 (1%)	**2.44**	0.30	20.00	Unsure

Table 10.13: Over Representation of Dark Conditions in Crash Type, continued

Crash Type	Dark	Light	ORF	Min CI	Max CI	Level
Exit Vehicle	29 (11%)	22 (20%)	**0.54**	0.32	0.89	Under
Vehicle Turn / Merge	2 (1%)	7 (6%)	**0.12**	0.02	0.55	Under
Unique	5 (2%)	3 (3%)	**0.68**	0.16	2.78	Unsure
Other	7 (3%)	2 (2%)	**1.42**	0.30	6.73	Unsure
Total	271 (100%)	110 (100%)				

10.3.3 Human Profile in Pedestrian Cases

The distribution of race in pedestrian crashes follows the statewide population trend, except for a low representation of Hispanic drivers. The large number of the other and unknown driver race stems in large part from the hit-and-run cases where driver details are not obtained. The over representation of men, both as the pedestrians and the drivers who hit pedestrians is notable and points to the significance of human behaviors in contributing to crashes. Vehicle, roadway and environmental causes would not influence the gender distribution like behavioral differences between genders would. Regardless of age, men were almost three times more likely to be fatally injured in a pedestrian crash than women. This does not prove that men are more likely to engage in risky behavior and may only signify that men have a higher rate of exposure as pedestrians. However by looking at the raw numbers in Table 10.15, countermeasures aimed at effecting changes in human behavior, both in pedestrians and drivers, would do best to target males.

Table 10.14: Race and Pedestrian Crash Type

Crash Type	Pedestrian Race				Driver Race			
	White	Black	Hisp.	Other	White	Black	Hisp.	Other/UK
Crossing Not at Intersection (1st Half)	57	13	5	1	56	10	4	6
Crossing Not at Intersection (2nd Half)	83	23	19	0	94	18	7	6
Crossing at Intersection	26	6	5	1	23	10	2	3
In Road	22	7	2	0	21	4	1	5
Walking Along Road With Traffic	18	6	3	1	19	2	4	3
Walking Along Road Against Traffic	5	1	1	0	6	0	0	1
Exit Vehicle	36	6	9	0	24	15	7	5
Vehicle Turn / Merge	6	2	1	0	7	1	1	0
Unique	4	3	1	0	3	5	0	0
Other	4	2	3	0	3	1	0	5
Total	261	69	49	3	256	66	26	34
Percent	68%	18%	13%	1%	67%	17%	7%	9%
Population (FL 1998-2000)	66%	15%	16%	2%				

Table 10.15: Gender and Pedestrian Crash Type

Crash Type	Pedestrian		Driver		
	Male	Female	Male	Female	Unknown
Crossing Not at Intersection (1st Half)	56	20	55	17	4
Crossing Not at Intersection (2nd Half)	92	33	84	35	6
Crossing at Intersection	27	11	22	13	3
In Road	20	11	22	4	5
Walking Along Road With Traffic	20	8	19	5	4
Walking Along Road Against Traffic	7	0	5	1	1
Exit Vehicle	38	13	36	12	3
Vehicle Turn / Merge	5	4	8	1	0
Unique	8	0	5	3	0
Other	8	1	2	2	5
Total	281	101	258	93	31
Percent	74%	26%	68%	24%	8%
FL Population (1998-2000)	50.4%	49.6%			

Various studies by the National Highway Traffic Safety Administration indicate that particular groups of pedestrians are more likely to be involved in traffic crashes than other groups and that certain age groups are more likely to be fatally injured once they are involved in a crash. Results of this study support these findings. Other studies have found that women, pedestrians in groups, and the elderly tend to cross streets more slowly than men, pedestrians walking alone, and the young. In addition, it has been suggested that women and older pedestrians also tend to engage in less unlawful roadway crossings than do men and younger pedestrians.

The difference in the distribution of age among the pedestrians and vehicle drivers who hit pedestrians is shown in Figure 10.5. Basic statistics for age in pedestrian cases revealed that among pedestrians the median age was 44, the mean age 45.4, with a standard deviation of 19.6, and range from infant to 97 years of age. For drivers the median age was 36, the mean age 38.3, with a standard deviation of 16.2, and a range of 16 to 88 years of age. The difference between the driver age and pedestrian age was found to be around 7.1 years and was significant at the 0.05 level (95% confidence), however this is likely due to the absence of 0-14 year olds in the driver age distribution thereby changing the lower bound.

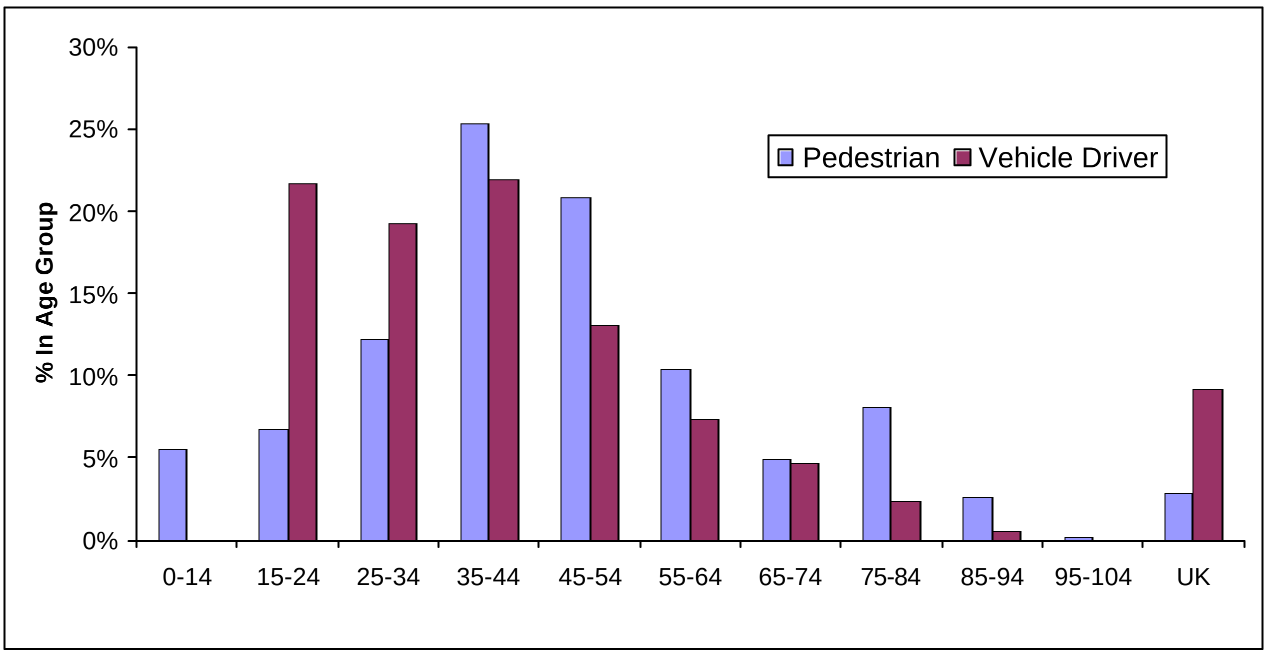


Figure 10.5: Age Distribution in Pedestrian Crashes

Categorical representation of pedestrian age and driver age, grouped by crash type, as given in Tables 10.16 and 10.17 may give a clearer picture of age distributions. The unknowns in the driver age are largely due to hit and run cases.

Table 10.16: Pedestrian Age Counts by Pedestrian Crash Type

Crash Type	Pedestrian Age										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95+	UK
Crossing Not at Intersection (1st Half)	0	7	7	21	19	8	1	9	2	0	2
Crossing Not at Intersection (2nd Half)	9	4	10	34	23	17	11	12	3	1	1
Crossing at Intersection	3	0	1	7	8	6	1	6	4	0	2
In Road	3	2	4	13	5	3	0	0	0	0	1
Walking Along Road With Traffic	2	2	4	8	7	1	2	0	0	0	2
Walking Along Road Against Traffic	0	0	3	1	1	1	0	0	0	0	1
Exit Vehicle	3	9	13	9	10	3	1	2	1	0	
Vehicle Turn / Merge	0	0	0	1	4	1	1	1	0	0	1
Unique	1	2	2	2	0	0		1	0	0	
Other	0	0	2	1	3	0	2	0	0	0	1
Total	21	26	46	97	80	40	19	31	10	1	11
Percent	5%	7%	12%	25%	21%	10%	5%	8%	3%	0%	3%

Table 10.17: Driver Age Counts by Pedestrian Crash Type

Crash Type	Driver Age										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95+	UK
Crossing Not at Intersection (1st Half)	0	20	18	17	4	6	1	4	2	0	4
Crossing Not at Intersection (2nd Half)	0	28	19	28	24	6	9	3	0	0	8
Crossing at Intersection	0	12	9	6	5	1	1	1	0	0	3
In Road	0	2	2	10	7	4	1	0	0	0	5
Walking Along Road With Traffic	0	7	5	4	1	1	4	0	0	0	6
Walking Along Road Against Traffic	0	3	2	0	1	0	0	0	0	0	1
Exit Vehicle	0	9	11	14	4	8	2	0	0	0	3
Vehicle Turn / Merge	0	2	1	4	0	1	0	1	0	0	0
Unique	0	0	5	1	2	0	0	0	0	0	0
Other	0	0	2	0	1	1	0	0	0	0	5
Total	0	83	74	84	49	28	18	9	2	0	35
Percent	0%	22%	19%	22%	13%	7%	5%	2%	1%	0%	9%

A look at the older pedestrian categories reveals that 88% of the fatally injured pedestrians 75 and older in this study were crossing the street, and the highest number of these had already crossed half the street and were hit while attempting the second half of the roadway.

These crashes involving older pedestrians were due to slower pedestrian walking speeds (thus a longer length of exposure to the danger and less ability to quickly evade), and a decrease in the perceptual acuity of the older pedestrians.

10.4 Fault in Pedestrian Crashes

Fault in pedestrian cases was determined following case study reviews wherein all the circumstances surrounding each crash were evaluated prior to assessment of fault. The most notable circumstances that illuminated fault were driver and pedestrians actions, alcohol and or drug impairment, and vehicle speeds (in some cases reconstructed speeds). Results are summarized in Table 10.18. In over 1 out of 8 cases both the driver and pedestrian were found to be at-fault. Although rare, there were a limited number of cases where neither the driver or the pedestrian was judged to be at-fault. Fault determination did not rely on the vehicle or pedestrian section number, or the existing fault classification in the FDOT CAR database, which was found to differ notably from the fault determinations ascertained in this study. There were a limited number of cases where the details necessary to establish fault were not available. The pedestrian was found to be at-fault in the majority (77.7%) of the pedestrian crashes.

Table 10.18: Fault in Pedestrian Crashes

Pedestrian At-Fault	Driver At-Fault			Total
	Yes	No	Unknown	
Yes	12.8%	64.7%	0.3%	77.7%
No	16.8%	3.9%	0.0%	20.7%
Unknown	1.0%	0.3%	0.3%	1.6%
Total	30.6%	68.8%	0.5%	

10.4.1 Pedestrian Crash Type and Fault

Crash type, revealing pedestrian and driver action, affects fault as shown in Table 10.19. It is not surprising that the types of crashes with the highest percentages of driver fault were those performing a turning or merging operation (100%), hit a pedestrian that was walking along the road with traffic (57%), or struck a pedestrian that had exited a vehicle (59%). The crash types with the highest percentages of pedestrian fault were crossing crashes (84% at intersection, 97% otherwise) and crashes where a pedestrian was in the road (74%). In crash types that involve high percentages of drivers at-fault – vehicle turn/merge, walking along the road, and exit vehicle – the pedestrians engaged in those activities have to rely more heavily on drivers for their safety. Unfortunately, the consequences of faulty driver behavior almost always proves fatal for the pedestrian. The roles are somewhat reversed in crash types with high pedestrian faults where drivers are impacted by poor pedestrian behaviors. However, regardless of who is at-fault, the fatal consequences of faulty behavior were always suffered by pedestrians in this study.

Table 10.19: Pedestrian and Driver Fault by Crash Type

Crash Type	Pedestrian At-Fault				Driver At-Fault			
	Yes	No	UK	% Yes	Yes	No	UK	% Yes
Crossing Not at Intersection (1st Half)	74	2	0	97%	17	59	0	22%
Crossing Not at Intersection (2nd Half)	121	4	0	97%	23	101	1	18%
Crossing at Intersection	32	6	0	84%	7	31	0	18%
In Road	23	6	2	74%	8	23	0	26%
Walking Along Road With Traffic	14	14	0	50%	16	12	0	57%
Walking Along Road Against Traffic	4	3	0	57%	2	5	0	29%
Exit Vehicle	18	32	1	35%	30	21	0	59%
Vehicle Turn / Merge	2	7	0	22%	9	0	0	100%
Unique	3	5	0	38%	3	5	0	38%
Other	6	0	3	67%	2	6	1	22%
Total	297	79	6		117	263	2	
%	78%	21%	2%		31%	69%	1%	

Educational efforts aimed at pedestrians should stress that regardless of who is at-fault the pedestrian is always going to lose. Drivers should not trust pedestrians to behave safely, and should take necessary precaution when near a pedestrian. The same is true of pedestrians, who should not trust drivers, or in some cases even their own abilities for their personal safety. For example, at non-signalized locations pedestrians should not expect drivers to yield right-of-way, or trust that drivers will see them, and should definitely not trust themselves to “make-it” across busy roadways. In cases where pedestrians were walking along the roadway, even if in a legal manner, it was shown that pedestrians can not always trust drivers to stay off the shoulder or the sidewalk. Pedestrians should be warned to always be on their guard.

From Table 10.20 the over representation of pedestrian fault in the different crash types relative to the fault proportions of the totals can be seen. Although pedestrians crossing the road at locations other than intersections were almost always in violation state statutes (Florida Statute 316.130(8, 10-12)), the pedestrians were assigned fault due to the behavioral factors contributing to the crash, instead of disobedience to traffic laws. Nevertheless, almost all of the pedestrians crossing the road not at intersections were found to be at-fault (97%), and were over represented compared to the overall ratio of pedestrians to drivers who were at fault. The few cases where the pedestrian was not found to be at fault involved circumstances such as young pedestrians being carried or led by another pedestrian across the road, in which case the older pedestrian was assigned fault. Even when pedestrians were crossing at intersections they were still found to be at fault 84% of the time mainly due to not heeding signals, and/or intoxication.

Table 10.20: Over Representation of Pedestrian Fault in Crash Type

Crash Type	Ped At-Fault	Driver At-Fault	ORF	Min CI	Max CI	Level
Crossing Not at Intersection (1st Half)	74	17	**1.71**	1.06	2.78	Over
Crossing Not at Intersection (2nd Half)	121	23	**2.07**	1.40	3.06	Over
Crossing at Intersection	32	7	**1.80**	0.82	3.97	Unsure
In Road	23	8	**1.13**	0.52	2.46	Unsure
Walking Along Road With Traffic	14	16	**0.34**	0.17	0.68	Under
Walking Along Road Against Traffic	4	2	**0.79**	0.15	4.24	Unsure
Exit Vehicle	18	30	**0.24**	0.14	0.41	Under
Vehicle Turn / Merge	2	9	**0.09**	0.02	0.40	Under
Unique	3	3	**0.39**	0.08	1.92	Unsure
Other	6	2	**1.18**	0.24	5.77	Unsure
Total	297	117				

10.4.2 Alcohol Use in Pedestrian Crashes

Alcohol use, and the consequent impairments to human perception, decision, attention, and physical ability was very significant in pedestrian crashes. Alcohol involvement, either by the driver or pedestrian, is presented in Table 10.21 and was determined based on a case by case review of all the obtainable information in each pedestrian case. The distinction between "no" and "yes" in regard to alcohol involved is a little misleading, therefore another term "other" is employed. "No" refers to cases where (i) the alcohol use was tested and known to be none (reported as 0.00% BAC), or (ii) the alcohol use was presumed to be no (an infant, police officer on duty, etc.). "Yes" refers to cases where a person's use of alcohol could be definitively determined or quantified. "Other" refers to cases where (i) the person was not tested (driver not suspected of alcohol, delayed fatality, etc.), (ii) and cases were the alcohol use is truly unknown (information missing, tested and not reported, hit and run, etc.).

Table 10.21: Alcohol Use In Pedestrian Crashes

Pedestrian Alcohol Involved	Driver Alcohol Involved			Total
	No	Yes	Other	
No	7.6%	1.6%	13.6%	22.8%
Yes	6.5%	3.1%	27.5%	37.2%
Other	5.5%	4.2%	30.4%	40.1%
Total	19.6%	8.9%	71.5%	

Information regarding alcohol use, when available, was gathered from the crash reports, crash report narratives, traffic homicide investigation narratives, chemical test information reports, medical examiner records, and records within state databases. Depending on the source of information, various levels of detail existed, from exact alcohol test results, to more qualitative measures such as a homicide investigators statement that "pedestrian had been drinking heavily". Since details of alcohol involvement were not always qualitative, the specifics of alcohol use in pedestrian crashes were grouped into different categories based on the type of information known as presented in Table 10.22. Under and over the limit is in reference to the legal limit of 0.08% BAC (blood alcohol content) for drivers and is used to classify pedestrians even though the limit may not be particularly applicable in a legal sense.

Table 10.22: Alcohol Use Specifics in Pedestrian Crashes

Pedestrian Alcohol Use	Driver Alcohol Use						Total	% Total
	None	Under Limit	Over Limit	Had Been Drinking	Un-known	Not Tested		
None	29	1	5	0	9	43	87	23%
Under Limit	1	1	1	0	1	8	12	3%
Over Limit	18	1	5	0	9	78	111	29%
Had Been Drinking	6	0	3	1	4	5	19	5%
Unknown	14	1	9	1	41	60	126	33%
Not Tested	7	0	5	0	1	14	27	7%
Total	75	4	28	2	65	208	382	
% Total	20%	1%	7%	1%	17%	54%		

The problem of alcohol use among drivers is probably underrepresented in the data, with these results only giving the lower threshold of actual prevalence. The lack of driver alcohol test results in over half the pedestrian cases clearly signals the need of vigilance on behalf of law enforcement to test, or at the very least report, alcohol use among drivers at the time of the crash. The percentage of unknowns in Table 10.22, 17% among drivers, and 33% among pedestrians, is high enough to alter results significantly in regards to alcohol involvement, especially since the distribution of alcohol use among the unknown cases could vary greatly. The potential impact of the "unknown" and "not tested" categories on the distribution of alcohol use among crash types is well presented in Figure 10.6 and Figure 10.7.

The relationship between alcohol use and pedestrian or driver fault follows what would be expected as given in

Table 10.23. When a driver had a blood alcohol level over the legal limit the driver was determined to be at-fault unless the driver alcohol use was clearly incidental and did not cause the crash. Whenever alcohol use was more than twice the legal limit a person was at-fault. A high percentage of drivers who were found to be at-fault were not tested for alcohol usage by law enforcement (36%). More drivers may have been found to be at-fault if a larger percentage of drivers had been tested for alcohol use. It is recommended that law enforcement be encouraged to test all drivers for alcohol in cases involving a traffic fatality.

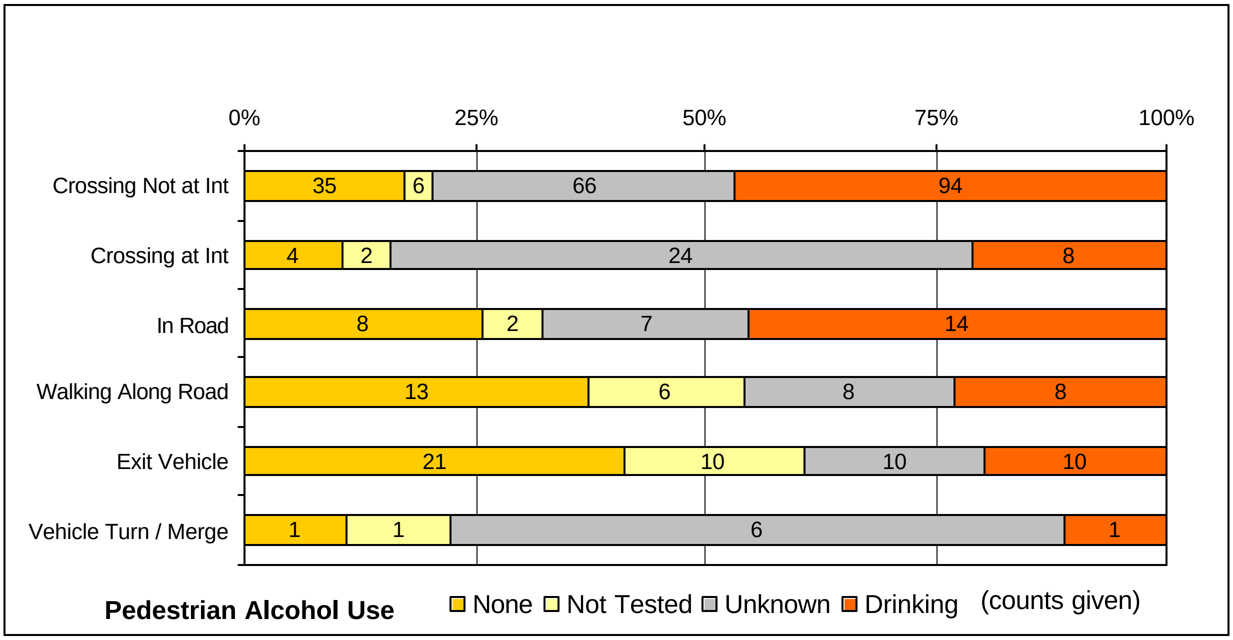


Figure 10.6: Pedestrian Alcohol Use by Crash Type

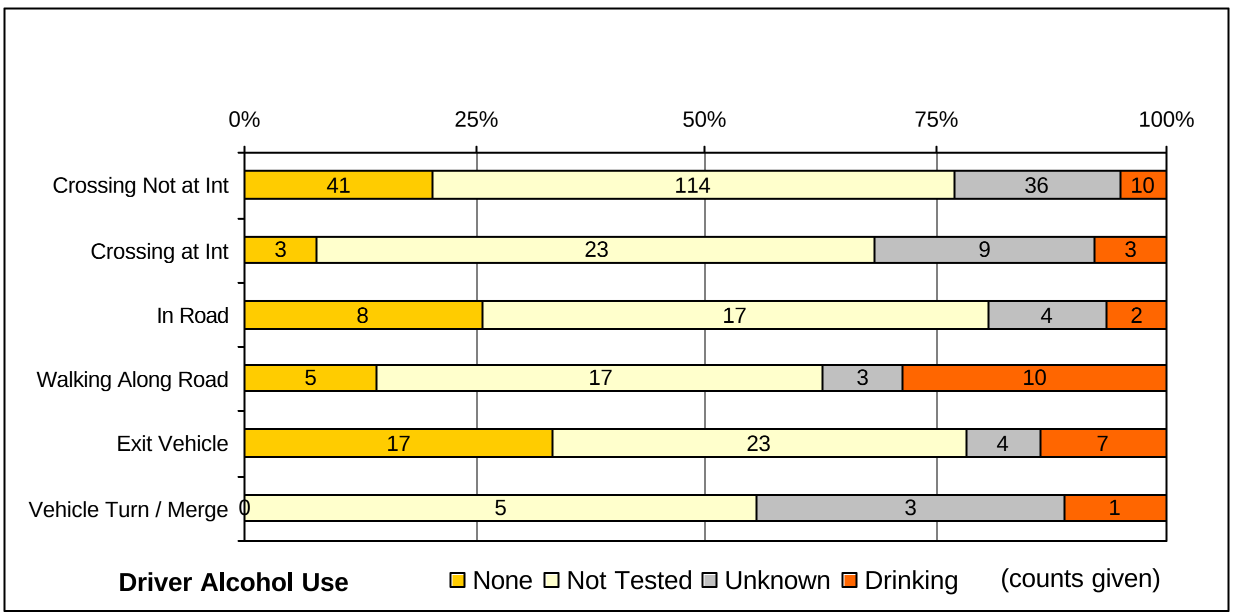


Figure 10.7: Driver Alcohol Use by Crash Type

Table 10.23: Alcohol Use and Fault in Pedestrian Crashes

Alcohol Use	Pedestrian At-Fault		Driver At-Fault	
	Yes (% Total)	No (% Total)	Yes (% Total)	No (% Total)
None	59 (20%)	27 (34%)	34 (29%)	41 (16%)
Under Limit	8 (3%)	2 (3%)	0 (0%)	4 (2%)
Over Limit (< 0.16% BAC)	15 (5%)	2 (3%)	15 (13%)	4 (2%)
Over Limit (> 0.16% BAC)	95 (32%)	0 (0%)	9 (8%)	0 (0%)
Had Been Drinking	17 (6%)	2 (3%)	2 (2%)	0 (0%)
Unknown	96 (32%)	28 (35%)	15 (13%)	44 (17%)
Not Tested	7 (2%)	18 (23%)	43 (36%)	169 (65%)
Total	297 (100%)	79 (100%)	118 (100%)	262 (100%)

The tactic used in reporting pedestrian and driver alcohol use in pedestrian crashes is to provide the percentage of alcohol involved both with and without consideration of the unknowns (see Table 10.24 and Table 10.25). Removing the unknowns, and its bias on the results, likely gives a more realistic picture of the distribution of alcohol use (or at least one that is true to the cases with reportable outcomes). Among the most alarming of the results in Table 10.24 is the high percentage of alcohol related cases among pedestrians crossing not at an intersection. With the unknown cases removed, alcohol is involved at least 69% of the time by the pedestrian, and only 6% of the time by the driver of the vehicle striking the pedestrian.

Table 10.24: Pedestrian Alcohol Use by Crash Type

Crash Type	Pedestrian Alcohol Use						% Alcohol Involved (w/o UK)	% Alcohol Inv (includes all categories)
	None	Under Limit	Over Limit	Had Been Drinking	Un-known	Not Tested		
Crossing Not at Int (1st Half)	14	1	27	4	28	2	67%	42%
Crossing Not at Int (2nd Half)	21	8	45	9	38	4	71%	50%
Crossing at Intersection	4	0	7	1	24	2	57%	21%
In Road	8	0	13	1	7	2	58%	45%
Walking Along Road With Traffic	11	1	4	1	6	5	27%	21%
Walking Along Rd Against Traffic	2	0	2	0	2	1	40%	29%
Exit Vehicle	21	1	7	2	10	10	24%	20%
Vehicle Turn / Merge	1	0	0	1	6	1	33%	11%
Unique	2	1	2	0	3	0	60%	38%
Other	3	0	4	0	2	0	57%	44%

Table 10.25: Driver Alcohol Use by Crash Type

Crash Type	Driver Alcohol Use						% Alcohol Involved (w/o UK)	% Alcohol Inv (includes all categories)
	None	Under Limit	Over Limit	Had Been Drinking	Un-known	Not Tested		
Crossing Not at Int (1st Half)	17	0	3	0	16	40	5%	4%
Crossing Not at Int (2nd Half)	24	2	5	0	20	74	7%	6%
Crossing at Intersection	3	1	2	0	9	23	10%	8%
In Road	8	1	1	0	4	17	7%	6%
Walking Along Road With Traffic	5	0	7	1	3	12	32%	29%
Walking Along Rd Against Traffic	0	0	2	0	0	5	29%	29%
Exit Vehicle	17	0	7	0	4	23	15%	14%
Vehicle Turn / Merge	0	0	0	1	3	5	17%	11%
Unique	1	0	1	0	5	1	33%	13%
Other	0	0	0	0	1	8	0%	0%

Drunk pedestrians cause crashes as they attempt to cross roads at locations other than intersections. The intoxicated pedestrians do not realize the risks they are taking, make poor decisions, fail to look or do not perceive vehicles, take erratic and unexpected actions, and do not feel inhibited in their ability to safely cross a roadway. Most times unfortunately, a sober driver is faced with an unexpected drunk pedestrian directly in their path without enough time to respond or take evasive action. Not surprisingly, the highest percentage of alcohol use among drivers was found in cases where pedestrians were struck while walking along the road. Pedestrians walking along the road are killed by drunk drivers in at least a third of the walking along the road cases. Drunk drivers swerving into the path of pedestrians is a significant cause of fatality among pedestrians walking along state roads regardless of whether the pedestrians are walking with or against traffic. As shown in Table 10.26, pedestrian drinking was found to be statistically over represented in cases where pedestrians were crossing not at an intersection. The over representation of 9:1 is in regard to the overall ratio of 5:1 between pedestrian who were drinking and drivers who were drinking. Supporting the results found above, pedestrian drinking was found to be under represented (meaning an over representation by drivers) in cases of pedestrians walking along the road.

Table 10.26: Over Representation of Pedestrian Drinking in Crash Type

Crash Type	Ped Drinking	Driver Drinking	ORF	Min CI	Max CI	Level
Crossing Not at Intersection	94	10	2.25	1.32	3.84	Over
Crossing at Intersection	8	3	0.64	0.18	2.28	Unsure
In Road	14	2	1.68	0.40	7.03	Unsure
Walking Along Road	8	10	0.19	0.08	0.45	Under
Exit Vehicle	10	7	0.34	0.14	0.83	Under
All Pedestrian Crashes	142	34				

Further insight into the particulars of the alcohol problem in pedestrian cases was found by examining driver and pedestrian age distributions relative to their alcohol usage as given in Tables 10.27 and 10.28. Highlighting within the tables is used to emphasize, using darker shades, the highest concentrations of alcohol use.

Table 10.27: Pedestrian Alcohol Use by Pedestrian Age

Ped Alcohol Use	Pedestrian Age										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	UK
None	3	9	9	21	14	8	7	11	4	0	2
Under Limit	0	1	1	5	3	1	0	1	0	0	0
Over Limit	0	8	15	42	28	13	2	1	0	0	2
Had Been Drinking	0	1	4	4	6	3	1	0	0	0	0
Unknown	13	6	12	21	24	13	9	18	6	1	3
Not Tested	5	1	5	4	5	2	0	0	0	0	4
Total	21	26	46	97	80	40	19	31	10	1	11
% of Tot Alc involved	0%	7%	14%	36%	26%	12%	2%	1%	0%	0%	1%

The highest concentration of alcohol use is among 35-44 year olds in both drivers and pedestrians. Of the pedestrians who had clear alcohol use, 36% were between the ages of 35 and 44 while only 7% were between the ages of 15-24, and only 3% were over age 65. The over representation of alcohol in middle age pedestrians (between the age of 35-44) with respect to all the pedestrians is given in Table 10.29. Among drivers the percentage who had clear alcohol use was 26% for both the 35-44 year olds and the 15-24 year olds. Thus, among the younger drivers alcohol use is in greater prevalence than among the same aged pedestrians who are involved in fatal pedestrian crashes. It is interesting to note that the highest number of drivers who are not tested for alcohol are between the ages of 15-24. This fact may point to the need for increased awareness among law enforcement to test people within this age group, especially given the fact that this age group makes up one of the prominent groups with respect to alcohol use.

Table 10.28: Driver Alcohol Use by Driver Age

Driver Alcohol Use	Driver Age										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	UK
None	0	18	14	20	9	8	4	2	0	0	0
Under Limit	0	2	0	0	2	0	0	0	0	0	0
Over Limit	0	7	6	8	2	0	3	1	0	0	1
Had Been Drinking	0	0	1	1	0	0	0	0	0	0	0
Unknown	0	10	19	16	8	5	1	1	0	0	5
Not Tested	0	46	34	39	28	15	10	5	2	0	29
Total	0	83	74	84	49	28	18	9	2	0	35
% of Tot Alc involved	0%	26%	21%	26%	12%	0%	9%	3%	0%	0%	3%

Table 10.29: Over Representation of Middle Age Pedestrians in Alcohol Use

Pedestrian Alcohol Use	Pedestrian Age		ORF	Min CI	Max CI	Level
	35-44	>74				
None	21	22	0.60	0.36	0.99	Under
Under Limit	5	1	3.14	0.38	26.28	Unsure
Over Limit	42	3	8.80	2.85	27.16	Over
Had Been Drinking	4	1	2.52	0.29	21.98	Unsure
Unknown	21	34	0.39	0.25	0.60	Under
Not Tested	4	0				
Total	97	61				

Over 10% of the fatal pedestrian crashes involved a 35-45 year old who had an alcohol level above the driving legal limit. Perhaps many of these pedestrians had the opportunity to drive but opted not to, yet their level of intoxication still proved to be a hazardous. Public awareness and education appears to be the best way to encourage pedestrians to seek alternate modes of transportation when drinking. Middle aged persons, particularly males, would be the best target of such efforts. The message to be communicated to the public is that intoxicated pedestrians on (or crossing) public roads present a hazard to law-abiding motorists as well as to themselves. Many people do not fully understand the risks of walking while intoxicated. Gender also plays a role in alcohol usage among Florida pedestrians, as shown in Table 10.30. At least 20% of the male pedestrian fatalites in this study had BAC's over 3 times the legal driving limit, while only 5% of female pedestrians reached this level of intoxication. Male pedestrians are over-represented when it comes to high intoxication levels when compared to females, who are over-represented in BAC's under the limit.

Table 10.30: Over Representation of Male Pedestrians in Alcohol Use

Pedestrian Alcohol Use	Pedestrian Gender		ORF	Min CI	Max CI	Level
	Male	Female				
None	57 (20%)	32 (32%)	0.64	0.44	0.93	Under
Under Limit	6 (2%)	4 (4%)	0.54	0.16	1.87	Unsure
Over Limit (<0.24% BAC)	38 (14%)	14 (14%)	0.98	0.55	1.72	Unsure
Over Limit (>0.24% BAC)	55 (20%)	5 (5%)	3.95	1.63	9.60	Over
Had Been Drinking	17 (6%)	2 (2%)	3.06	0.72	12.99	Unsure
Unknown	91 (32%)	35 (35%)	0.93	0.68	1.28	Unsure
Not Tested	17 (6%)	9 (9%)	0.68	0.31	1.47	Unsure
Total	281 (100%)	101 (100%)				

High intoxication levels among pedestrians (over 0.24% BAC), predominantly middle aged males, contributes to their diminished capacities and ultimately causes fatal crashes with motor vehicles. In this study it was found that for the intoxicated pedestrians physical and mental capacity was diminished as evidenced by erratic and unsafe actions. Intoxicated pedestrians attempted to cross the road at non-intersection locations without looking or looked but failed to notice or recognize the danger of approaching motor vehicles. They also stepped and/or stumbled into the path of vehicles either accidentally or willingly, and exercised poor judgment in all pedestrian related activities.

Enact State legislation or take other actions to reduce incidents involving those who repeatedly drink large amounts of alcohol and walk into state roadways. Hard core drinking pedestrians (with a blood alcohol concentration of 0.24 percent or greater) pose an increased risk of crashes, and fatalities. Hard core drinking pedestrians were involved in at least a fourth of the pedestrian fatalities. It is not enough to keep severely intoxicated people from driving, they also need to be kept from walking across or along state roadways where they endanger themselves and motorists.

10.4.3 Drug Use in Pedestrian Crashes

Drug involvement, either by the driver or pedestrian, is presented in Table 10.31 and was determined based on a case by case review of all the obtainable information in each pedestrian case. Information regarding drug use, when available, was gathered from the crash reports, crash report narratives, traffic homicide investigation narratives, chemical test information reports, and medical examiner records. The distinction between “no” and “yes” in regard to drug involvement and drug use is a little over simplified, mainly due to the difficulty in determining if a pedestrian or driver was “under the influence,” and the difficulty in substantiating nature of the impairment. The approach taken in this study was to record whether a drug substance showed up in the results of a chemical test information report, was reported on the medical examiner records, or if a testified statement (including homicide investigation narrative) indicated drug impairment at the time of the crash. Drug use information was then used in fault assessment. Drug use was broken down into the following categories:

- Drug presence was tested and reported to be none (includes cases presumed to be no, such as an infant, etc.)
- Illegal drug/s
- Prescription narcotics or other sedatives, legal in most cases but impairment may be significant (i.e. Valium, Oxycontin, etc.)
- Other prescription or non-prescription drugs
- The person was not tested (driver not suspected of drug use, delayed fatality, etc.)
- Cases where the drug use is unknown (information missing, tested and not reported, hit and run, etc.)

Table 10.31: Drug Use In Pedestrian Crashes

Pedestrian Drug Use	Driver Drug Use				Total	% Total
	None	Illegal Drugs	Un-known	Not Tested		
None	10	2	5	71	88	23%
Illegal Drugs	3	0	2	23	28	7%
Prescription Narcotics	1	0	1	9	11	3%
Non/Pres Drugs	0	0	0	2	2	1%
Unknown	4	1	86	80	171	45%
Not Tested	7	3	10	62	82	21%
Total	25	6	104	247	382	
% Total	7%	2%	27%	65%		

The percentage of unknowns and not tested in Table 10.31, 66% among pedestrians, is high enough to alter results significantly in regards to drug involvement, especially since the distribution of drug use among these cases could vary greatly. Drivers who hit pedestrians are usually not tested for drugs, or even asked about drug use, however that does not necessarily suggest that drug use, especially over the counter or prescription drug use, among these drivers is low. Pedestrians were more likely to be tested due to fatality and therefore a higher percentage of reported results were obtained. Table 10.32 presents the results of drug use among pedestrians with the unknowns and not tested cases removed to give a picture of the distribution of drug use among the cases with reportable outcomes.

Table 10.32: Drug Use Among Pedestrians

Pedestrian Drug Use	Count	%
None	88	68.2%
Illegal Drugs	28	21.7%
Prescription Narcotics	11	8.5%
Non/Pres Drugs	2	1.6%
Total	129	100.0%

Of pedestrians tested for drugs (33% of all pedestrians), nearly a third of them were found to be using drugs, however a third of the drug users were using legal drugs. The distribution of drug use among pedestrians by age, as shown in Table 10.33, shows that 48% of the drug use is concentrated among 35-44 year olds, almost twice the percentage this age group comprises within the pedestrian cases in this study, however without considering the “unknown” and “not tested” cases this result may be misleading. For instance, in almost half of the cases involving a 35-44 year old the drug usage was determinable, however for 75-84 year olds, determinable drug usage drops to only a third of the cases. It can be seen in Table 10.33 that among drivers striking pedestrians the percent "not tested" and the percent "unknown" are fairly uniformly distributed between the age groups.

Table 10.33: Pedestrian Drug Use by Pedestrian Age

Pedestrian Drug Use	Pedestrian Age										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	UK
None	1	6	8	28	18	10	5	8	2	0	2
Illegal Drugs	0	3	8	14	3	0	0	0	0	0	0
Prescription Narcotics	0	1	1	5	1	1	0	2	0	0	0
Non/Pres Drugs	0	0	1	0	1	0	0	0	0	0	0
Unknown	13	10	15	36	33	20	12	17	7	1	7
Not Tested	7	6	13	14	24	9	2	4	1	0	2
Total	21	26	46	97	80	40	19	31	10	1	11
% of Drug Use from cat.	0%	10%	24%	46%	12%	2%	0%	5%	0%	0%	0%

Table 10.34 clearly reveals the insufficiency of drug use reporting among drivers. In fact, solely relying on the data from the traffic crash report (ALC/DRUG reporting) would have only yielded 2 drivers as positive for drug use (coded 3 or 4). Further study is needed into the use of prescription, over the counter drugs and other "legal" drugs by drivers involved in fatal pedestrian crashes. It is also recommended that research be conducted to determine the link between "legal" drugs and crash causation.

Table 10.34: Driver Drug Use by Driver Age

Driver Drug Use	Driver Age										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	UK
None	0	1	8	6	6	3	0	0	0	0	1
Illegal Drugs	0	4	0	2	0	0	0	0	0	0	
Unknown	0	25	24	24	11	6	5	4	0	0	5
Not Tested	0	53	42	52	32	19	13	5	2	0	29
Total	0	83	74	84	49	28	18	9	2	0	35
% of Drug Use from cat.	0%	67%	0%	33%	0%	0%	0%	0%	0%	0%	0%

10.4.4 Vehicle Speed in Pedestrian Crashes

Generally speaking, vehicle speed was not found to be a contributing factor in pedestrian crashes, however in questionable cases speeds were reconstructed and used as part of the fault assessment. The vast majority of vehicles who struck pedestrians were traveling within a few mph of the speed limit as shown in Figure 10.8. The relationship between vehicle speed and posted speed limits is shown in Table 10.35. Speeds below 25 mph are either uncommon on state roadways, or do not prove to be fatal with regard to pedestrians. Pedestrian fatalities appear to be over represented roads with a posted speed limit of 45 mph, and under represented in roads with a posted speed limit of 55 mph. The highest percentage of pedestrian fatalities on state roads, 33%, occurs where the posted speed limit is 45 mph, yet only about 19% of the miles on state highway system have a posted speed limit of 45 mph. On the other hand, 12% of the pedestrian crashes occur within 55 mph speed limit zones, while around 27% of the state highway system falls within this speed limit.

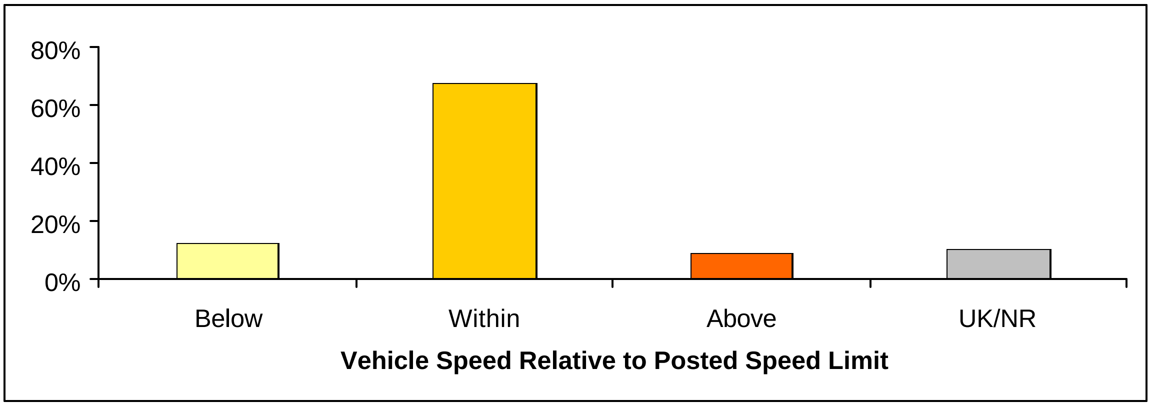


Figure 10.8: Vehicle Speed in Pedestrian Crashes

Table 10.35: Vehicle Speed vs. Posted Speed

Posted Speed	Approx % of SHS Miles	Vehicle Speed in Pedestrian Crashes										Total	%
		0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	UK/NR		
25	1%	1	1	0	1	0	0	0	0	0	1	4	1%
30	4%	1	1	10	1	0	0	0	0	0	6	19	5%
35	9%	3	3	8	25	1	3	1	0	0	11	55	14%
40	7%	1	4	6	30	4	1	0	0	0	6	52	14%
45	19%	1	0	11	28	69	7	1	0	0	10	127	33%
50	4%	0	0	0	3	11	1	1	0	0	2	18	5%
55	27%	0	0	0	1	13	25	2	1	0	3	45	12%
60	13%	0	0	0	0	0	4	1	0	0	0	5	1%
65	6%	0	0	0	0	2	9	11	0	1	1	24	6%
70	8%	0	0	0	0	1	11	18	3	0	0	33	9%
Total		7	9	35	89	101	61	35	4	1	40	382	
%		2%	2%	9%	23%	26%	16%	9%	1%	0%	10%		

The relationship between vehicle speed and driver fault follows what would be expected as given in Table 10.36. When a driver was traveling over the speed limit the percentage of time the driver was determined to be at fault was over represented relative to the regular ratio of driver fault to non-fault in all cases by over 9 times. Plainly put, drivers who were speeding were also found to be at-fault. When the driver was traveling at or under the speed limit the driver fault was under represented.

Table 10.36: Over Representation of Driver Fault in Vehicle Speed Classes

Vehicle Speed vs. Posted Speed	Driver At-Fault	Driver Not At-Fault	Total	ORF	Min CI	Max CI	Level
10 mph or more under speed limit	26	46	72	**1.28**	0.83	1.97	Unsure
Speed limit or less than 10 mph under	38	167	205	**0.52**	0.39	0.68	Under
Up to 10 mph over speed limit	19	21	40	**2.05**	1.15	3.66	Over
10 mph or more over speed limit	20	5	25	**9.06**	3.48	23.56	Over
Vehicle speed Unknown	14	26	40	**1.22**	0.66	2.25	Unsure
Total	117	265	382				

10.5 Causative Factors in Pedestrian Crashes

Table 10.37 summarizes the grouped percent distribution of primary and secondary factors which were found to cause pedestrian crashes.

Table 10.37: Causative Factors in Pedestrian Crashes

Causative Factors			Secondary						Total
			Ped	Driver	Veh	Env	Road	Other	
Primary	Pedestrian	53.1%	7.3%	11.0%	0.0%	2.1%	2.1%	0.3%	75.9%
	Driver	9.2%	2.4%	2.6%	0.0%	0.8%	1.6%	0.3%	16.8%
	Vehicle	0.5%	0.0%	0.0%	0.0%	0.0%	0.3%	0.0%	0.8%
	Environment	0.5%	0.8%	0.3%	0.0%	0.0%	0.0%	0.0%	1.6%
	Roadway	0.0%	0.3%	0.8%	0.`0%	0.0%	0.0%	0.0%	1.0%
	Other	2.9%	0.8%	0.0%	0.0%	0.3%	0.0%	0.0%	3.9%
Total		66.2%	11.5%	14.7%	0.0%	3.1%	3.9%	0.5%	

Pedestrian behavior is the cause of 80.1% of the pedestrian crashes in this study, being the primary factor in almost 76% of these cases. In 7.3% of the cases a pedestrian behavior was both the primary and secondary factor in the crash (different behaviors), and in 2.6% of the cases the driver behavior was both the primary and secondary factor in the crash. Human behavior could be both the primary and secondary factor for instance, in cases when a secondary behavior contributing to the crash was clearly manifest, and worthy of noting. The high percentage of cases, 53.1%, where the pedestrian behavior is the only factor (no secondary factor) is better understood by looking at the listing of contributing factors broken down into greater detail, as given in Table 10.38. Pedestrian alcohol/drug impairment is clearly seen to be a substantial contributing factor in fatal pedestrian crashes. Many times when the pedestrian has an alcohol/drug impairment, secondary contributing factors are not clearly discernable.

Of the contributing factors assigned to pedestrian cases, pedestrian alcohol/drug impairment was most common, either as primary or secondary factor. This is different than with the driver behaviors where speeding was the most common driver related factor contributing to pedestrian crashes, followed by driver alcohol/drug impairment and driver perception errors. Both alcohol and vehicle speed are discussed in greater detail in subsequent sections of this report. Pedestrian perception errors are associated with the elderly, as are cases that involve a roadway sign or signal issue. All four cases with a roadway sign/signal issue involved elderly pedestrians (average age 79.8) crossing at an intersection. The signal issue was an inadequate pedestrian phase to accommodate pedestrians (such as elderly) with slower walking speeds.

Table 10.38: Primary and Secondary Crash Causes and Age

Crash Cause	Prim	Sec	Total	Mean Ped Age	Mean Driver Age
Pedestrian Inattention/Distraction	18	13	31	40.3	39.6
Pedestrian Perception Error	36	7	43	70.2	43
Pedestrian Decision Error	50	7	57	49.1	37.8
Pedestrian Alcohol/Drug Impairment	138	15	153	41.3	37.1
Pedestrian Other	37	2	39	38.1	39.5
Pedestrian Unknown	11	0	11	41.5	51.6
Driver Inattention/Distraction	4	2	6	53.3	49.2
Driver Perception Error	11	17	28	48.6	39.4
Driver Decision Error	9	11	20	36.7	37.3
Driver Over-correction	2	0	2	38.5	32.5
Driver Speeding	16	18	34	40	36.7
Driver Alcohol/Drug Impairment	20	8	28	40.3	32
Driver Incapacitation	2	0	2	39	34.5
Vehicle Condition	3	0	3	49	24.3
Environmental Condition	6	12	18	45.7	33.2
Roadway View Obstruction or Sight Distance	0	1	1	24	47
Roadway Curvature	0	3	3	38.7	28
Roadway Sign / Signal Issue	2	2	4	79.8	43.3
Roadway Construction / Surveying	1	7	8	43.5	42.3
Roadway Other	1	2	3	53.3	52
Other / Unknown	15	2	17	46.5	39.8
Total	382	129	511	45.4	38.3

Contributing factors for each of the major crash types is given in Table 10.39. The most significant crash causes in the pedestrian crashes is identified by darker shading in the table. Pedestrian behavioral factors predominate in cases involving crossing the road or where a pedestrian was in the road. Driver behavioral factors are more common and appear in greater frequency in cases involving walking along the road or cases where a pedestrian has exited a vehicle. Alcohol impairment by either the pedestrian or the driver appears in every type of crash.

Table 10.39: Crash Causes by Crash Type

Crash Cause (Primary, Secondary, or Tertiary)		**Crash Type**					
		Crossing Not At Int	**Crossing At Int**	**In Road**	**Walking Along Road**	**Exit Vehicle**	**Vehicle Turn / Merge**
Human	Age	7%	11%	4%		<1%	8%
	Alcohol	19%	9%	13%	14%	11%	4%
	Alcohol & Drugs	2%	2%	5%	5%	<1%	
	Decision	10%	19%	4%	4%	4%	13%
	Drugs	1%	2%	3%	1%	4%	
	Fatigue/Asleep					1%	
	Inattention	4%	1%	11%	2%	11%	
	Medical			3%		<1%	
	Mental/Emotional	1%		10%		2%	
	Mobility	1%	3%			<1%	13%
	Other	<1%		5%	6%	1%	
	Perception	10%	11%	4%	2%	3%	29%
	Physical Defect	<1%		1%			
	Speed	2%	3%	3%	10%	5%	
	Steering Input	<1%		3%	3%	1%	4%
	Unknown	1%	1%		1%	<1%	
	Visibility	1%		3%	3%	<1%	
Vehicle	Defect					2%	
	Disabled					22%	
	Emergency					<1%	
	Load Shift/Fall					<1%	
	Maneuverability					<1%	4%
	Stability					<1%	
	Tires					<1%	
	View Obstruction	<1%	3%			<1%	13%
	Visibility	<1%			1%	1%	
Environment	Dark	17%	13%	8%	6%	3%	4%
	Dawn/Dusk	2%	1%	1%	4%	<1%	
	Heavy Rain		1%				
	Smoke/Fog	<1%				2%	
	Wet/Slippery	1%	6%	1%	1%	5%	
	Wind					<1%	

Table 10.39: Crash Causes by Crash Type, continued

Crash Cause (Primary, Secondary, or Tertiary)		Crash Type					
		Crossing Not At Int	Crossing At Int	In Road	Walking Along Road	Exit Vehicle	Vehicle Turn/Merge
Roadway	Construction	<1%		6%		<1%	4%
	Curvature	<1%			1%	1%	4%
	Lighting	14%	7%	11%	17%	5%	
	Maintenance	<1%					
Roadway	No Sidewalk				16%		
	Obstruction			1%		6%	
	Other				1%		
	Ped Facilities	<1%					
	Sight Distance	<1%					
	Sign/Signal		3%				
Other/Unknown	Unknown	1%	1%	1%	1%	<1%	
Totals		100%	100%	100%	100%	100%	100%

10.5.1 Causes of Crashes Involving a Pedestrian Crossing the Road

Nearly 63% of the fatal pedestrian crashes occurred as a result of a pedestrian attempting to cross a roadway. Only 10% of the fatal pedestrian crashes occurred within the designated crossing areas of intersections. To better understand the factors that contribute to road-crossing crashes, crash factors for select age groups of pedestrians and drivers were examined in Table 10.40. Age groups were chosen to compare trends among young, middle aged, and older (loose definitions) pedestrians and drivers, and to show groups with the highest numbers.

Pedestrian behaviors, specifically alcohol/drug impairments top the list of factors contributing to cross the road crashes among pedestrians age 35-44. Among pedestrians over 74 years old the primary cause of pedestrian crashes when crossing the road is a perception error, such as inadequate surveillance, and looking but not being able to see the danger. The next highest cause among both the middle age pedestrians and elderly pedestrians is a decision error, in the form of misjudging the gaps or speeds in a roadway, not heeding signals, or darting out into the road. Among drivers, of all ages, the leading cause of pedestrian crashes in crossing crashes is hitting pedestrians that are impaired by alcohol and or drugs who are trying to cross the road. Drivers over the age of 54, relatively speaking, also tend to a have higher percentage of perception and decision errors.

Table 10.40: Causes of Crossing the Road Crashes for Select Age Groups (Counts)

Crash Cause	Pedestrian Age			Driver Age		
	<25	35-44	>74	<25	35-44	>54
Pedestrian Inattention/Distraction	4	6	2	3	4	1
Pedestrian Perception Error	3	3	26	6	11	9
Pedestrian Decision Error	5	10	8	16	8	10
Pedestrian Alcohol/Drug Impairment	6	17	1	29	24	11
Pedestrian Other	6	7	1	5	2	2
Pedestrian Unknown	0	1	0	0	1	3
Driver Inattention/Distraction	0	0	1	0	0	0
Driver Perception Error	4	7	3	7	2	3
Driver Decision Error	0	1	3	0	6	0
Driver Abrupt Steering Input	0	0	0	1	0	0
Driver Speeding	1	3	3	5	6	1
Driver Alcohol/Drug Impairment	1	1	1	2	5	0
Environmental Condition	0	1	1	3	4	0
Roadway View Obstruction or Sight Distance	1	1	0	0	0	0
Roadway Sign / Signal Issue	0	0	2	0	0	0
Roadway Construction / Surveying	1	1	0	1	1	0
Roadway Other	0	0	1	0	0	1
Other / Unknown	2	2	1	1	3	1
Total	34	61	54	79	77	42

10.5.2 Causes of "Crossing Not At Intersection" Type Pedestrian Crashes

Pedestrians crossing at locations other than intersections comprise 53% of the fatal pedestrian crashes in this study; therefore, a detailed look at these crashes is necessary. A total of 201 crashes were classified as non-intersection crashes. As stated previously, pedestrian crossings of a major roadway at or in the vicinity of a T-intersection involving a minor side street, were classified as non-intersection crashes. This decision was made for the following reasons:

1. Most of the minor roads lacked sidewalks, which are required by Florida statute to indicate the legal presence of an unmarked crosswalk across the major street.
2. The crossing angle or starting position of the pedestrian rarely fit within the extended lines of the likely placement of such a sidewalk, meaning that even if an unmarked crosswalk had been present, the pedestrian would likely not have started and completed the crossing within its confines.
3. In all such cases, no traffic control devices (stop signs or traffic signals) were provided to stop the traffic on the major street to facilitate such a crossing. Drivers, pedestrians, and investigating officers tend to treat such a crossing as a non-intersection, unprotected street crossing.

Nonetheless, on reviewing the individual cases, street crossings at such unprotected T-intersections accounted for approximately 20 percent of all mid-block crossings. When business driveways and crossings near (within 100’) of unprotected crossing are included, almost 40 percent of such crossings are accounted for. This indicates that the presence of minor side street and business driveways are significant trip generators for pedestrian street crossings. Business noted as trip generators included bars, restaurants, grocery stores, and gas stations/convenience stores, which are often located on major roads at the corners of either major or minor side streets. Given the number of non-intersection crossings, especially those that occurred near unprotected T-intersections, it was important to examine the distance of the crossing point from the nearest protected (signalized) intersection. Table 10.41 examines the distance from the point of collision to the nearest traffic signal, according to the number of lanes attempted. Highlighting within the tables is used to emphasize, using darker shades, the highest concentrations of events.

Table 10.41: No. Lanes Attempted by Ped Versus Distance to Nearest Traffic Signal

Traffic Signal	Lanes Attempted					Total	%
	< 3	3 - 4	5 - 6	7 - 8	> 8		
Within 200 ft	1	1	19	4	1	26	13%
Between 200 ft and 600 ft	1	14	30	19	4	68	34%
Between 600 ft and 0.25 mi	2	19	21	14	0	56	28%
Between 0.25 mi and 0.5 mi	5	5	9	2	0	21	10%
Between 0.5 mi and 1 mi	2	7	1	1	0	11	5%
Greater than 1 mi	6	6	7	0	0	19	9%
Total	17	52	87	40	5	201	
Percent	8%	26%	43%	20%	2%		

One of the main goals in looking at the distance to nearest traffic signal from the location of pedestrian crossing was to evaluate the adequacy of pedestrian facilitates. In about a fourth of the cases, the distance to the nearest intersection is over a quarter mile, which is likely farther than any pedestrian would be willing to travel to get to a safe crossing location. In 28% of the cases, the distance is over 600 ft but less than a quarter mile. However, almost half of all pedestrians in this study not crossing in a crosswalk were crossing within 600 ft of a signalized intersection, or overpass in the case of a limited access facility. In many cases, the nearest signal would be visible at this distance or less, especially at night. This phenomenon of pedestrians crossing near signals is particularly revealing of the problem given the rural nature of many portions of the state highway system. Using a pedestrian walking speed of 5 fps, the time it would take such a pedestrian to reach an intersection 600’ away would be 2 minutes, the time to walk back to the crossing location on the other side would be an additional 2 minutes. Estimating the additional waiting time at the signal at 1 to 2 minutes means that, in total, crossing at the signal would probably add 5 to 6 min to the trip. Ninety-four pedestrians in this study decided not to take the extra time and effort it would take to cross at the traffic signal.

Significant causes of crashes where a pedestrian crossed not at an intersection are summarized in Table 10.42 and reveal the predominance of human factors, especially as primary causative factors. Ninety-six percent of the primary factors in cases involving a pedestrian crossing not at an intersection were attributed to the human. Crossing not at an intersection is in essence a poor decision when considering that in this study it was almost always done in violation of state statutes (Florida Statute 316.130(8, 10-12)).

Roadway characteristics were studied more closely in this subset of pedestrian crashes to determine if there were any roadway factors that contribute to these crashes but were otherwise obscured due to the high prevalence of human factors. For each of the cases involving a pedestrian crossing a roadway the number of lanes the pedestrian attempted to cross and the number of lanes actually crossed were documented. The number of lanes attempted included turn lanes, two way left turn lanes, or any other lanes expected to have regular vehicular traffic. The relationship between the number of lanes attempted and the number of lanes crossed is shown in Table 10.43.

Table 10.42: Significant Causes of "Crossing Not At Intersection" Type Pedestrian Crashes

Class	Factor	Primary Ped + Driver (% Cases)	Secondary Ped + Driver (% Cases)	Tertiary Ped + Driver (% Cases)	Total Ped + Driver (% Cases)
Human	Age	0 + 0 (0%)	7 + 2 (4%)	7 + 16 (11%)	14 + 18 (16%)
	Alcohol	85 + 3 (43%)	1 + 0 (<1%)	0 + 2 (1%)	86 + 5 (45%)
	Decision	37 + 1 (19%)	5 + 6 (5%)	0 + 0 (0%)	42 + 7 (24%)
	Perception	32 + 0 (16%)	3 + 13 (8%)	1 + 0 (<1%)	36 + 13 (24%)
Environment	Dark	0 (0%)	60 (29%)	21 (10%)	81 (40%)
Roadway	Lighting	1 (<1%)	49 (24%)	18 (9%)	68 (33%)

Table 10.43: Number of Lanes Pedestrian Attempted Versus Number of Lanes Crossed

Lanes Attempted	Lanes Crossed								Total	%
	0	1	2	3	4	5	6	7		
< 3	2	15	0	0	0	0	0	0	17	8%
3 - 4	7	14	13	18	0	0	0	0	52	26%
5 - 6	3	18	10	18	28	10	0	0	87	43%
7 - 8	0	2	8	5	10	4	8	3	40	20%
> 8	0	0	0	2	0	2	1	0	5	2%
Total	12	49	31	43	38	16	9	3	201	
Percent	6%	24%	15%	21%	19%	8%	4%	1%		

It was found that 43% of the cases occurred at locations where the pedestrians were attempting to cross 5-6 lanes, and two thirds of the time they made it successfully across the first half of the lanes only to be struck in the opposing lanes. In many of the cases where the number of lanes attempted were 5 to 6 lanes, there was a center two way left turn lane, or a median break with median turn lanes. Many times, median breaks at T-intersections and driveway entrances are points that generate pedestrian crossings, particularly if a pedestrian crossing facility is not available within a few hundred feet. The presence of the turn lane/s may give the pedestrians a false sense of refuge and security and thus the pedestrian will take a chance at a risky crossing because of lack of awareness of the danger. A drunk pedestrian with diminished perceptual and decision making capabilities would be particularly vulnerable. It is shocking that over 22% of the cases involve pedestrians attempting to cross over 7 lanes of traffic without the aid of a pedestrian crossing facility. Of the cases where a pedestrian was attempting to cross 7 or more lanes of traffic, a signal was located within 600 ft nearly two thirds of the time (11% where traffic signal within 200 ft, 51% where traffic signal between 200 and 600 ft).

The number of lanes attempted, or crossed relative to the posted speed limit on the roadway are given in Table 10.44 and 10.45. Roadways with posted speed limits of 45 mph prove to be the most hazardous with regard to pedestrian crossing crashes. Clearly pedestrians do not perceive the danger at this speed or their actions, or have great confidence in their ability to cross than is actually the case.

Table 10.44: Number of Lanes Pedestrian Attempted to Cross Versus Posted Speed

Lanes Attempted	Posted Speed										Total	%
	25	30	35	40	45	50	55	60	65	70		
< 3	0	0	2	1	4	1	6	3	0	0	17	8%
3 - 4	1	3	6	11	15	2	8	1	3	2	52	26%
5 - 6	0	6	12	18	33	4	8	0	6	0	87	43%
7 - 8	0	5	1	7	19	5	3	0	0	0	40	20%
> 8	0	0	0	0	5	0	0	0	0	0	5	2%
Total	1	14	21	37	76	12	25	4	9	2	201	
Percent	0%	7%	10%	18%	38%	6%	12%	2%	4%	1%		

Table 10.45: Number of Lanes Pedestrian Crossed Versus Posted Speed

Lanes Crossed	Posted Speed										Total	%
	25	30	35	40	45	50	55	60	65	70		
< 2	1	5	8	11	19	3	10	3	1	0	61	30%
2 - 3	0	2	6	14	29	3	10	1	7	2	74	37%
4 – 5	0	7	7	9	22	3	5	0	1	0	54	27%
6 – 7	0	0	0	3	6	3	0	0	0	0	12	6%
Total	1	14	21	37	76	12	25	4	9	2	201	
Percent	0%	7%	10%	18%	38%	6%	12%	2%	4%	1%		

The age distribution among pedestrians and drivers in relation to the number of lanes the pedestrian attempted is presented in Table 10.46 and Table 10.47. The large number of pedestrians over age 65 attempting to cross 5 or more lanes (14%) emphasizes the need for counteractive measures addressed at this ever increasing age group in Florida. Increases in pedestrian age also lead to decreases in pedestrian walking speeds and physical dexterity putting older pedestrians who choose to cross the road at a higher risk for a longer periods time and with diminished capacities to respond to hazards – a fatal combination.

Table 10.46: Number of Lanes Pedestrian Attempted to Cross Versus Pedestrian Age

Lanes Ped Attempted	Pedestrian Age										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	UK
< 3	1	2	5	2	0	2	1	2	2	0	0
3 - 4	0	5	2	17	12	7	4	3	0	0	2
5 - 6	4	2	6	24	19	12	6	9	3	1	1
7 - 8	4	2	4	9	9	4	1	7	0	0	0
> 8	0	0	0	3	2	0	0	0	0	0	0
Total	9	11	17	55	42	25	12	21	5	1	3
Percent	4%	5%	8%	27%	21%	12%	6%	10%	2%	0%	1%

Table 10.47: Number of Lanes Pedestrian Attempted to Cross Versus Driver Age

Lanes Ped Attempted	Driver Age										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	UK
< 3	0	4	1	6	2	1	3	0	0	0	0
3 - 4	0	14	6	11	3	4	4	2	1	0	7
5 - 6	0	22	19	20	14	5	3	2	0	0	2
7 - 8	0	8	10	8	9	0	0	1	1	0	3
> 8	0	0	1	0	0	2	0	2	0	0	0
Total	0	48	37	45	28	12	10	7	2	0	12
Percent	0%	24%	18%	22%	14%	6%	5%	3%	1%	0%	6%

As with all other pedestrian cases drivers tend to be younger on average than the pedestrians they strike. The 35 to 44 year olds have the highest frequencies in Table 10.47, and not surprisingly, this is the same age group that had the highest concentration of alcohol use. Herein the lack of perception, and sound decision making ability caused by alcohol use, combined with a false sense of aptitude and dexterity likely takes its greatest toll. When the number of lanes the pedestrians were actually able to cross is examined relative to alcohol use, given in Table 10.48, the diminished capability of the pedestrians is evident by the distribution of number of successful lanes for pedestrians with an alcohol concentration over the legal limit.

In about half of the non-intersection crossings, the distance to the nearest protected intersection is over 600'. Unfortunately, not only are the number of lanes to be crossed at these locations high, the average daily traffic (ADT), a measure of traffic density, tends to be higher as the number of lanes increases. Table 10.49 compares the number of lanes attempted to the ADT of the roadway in these non-intersection crossing pedestrian crashes.

Table 10.48: Number of Lanes Crossed by Pedestrian and Alcohol Use

Pedestrian Alcohol Use	Lanes Crossed								Total	%
	0	1	2	3	4	5	6	7		
None	2	8	7	6	6	4	2	0	35	17%
Under Limit	0	3	0	2	4	0	0	0	9	4%
Over Limit	3	22	9	15	11	6	4	2	72	36%
Had Been Drinking	1	1	4	1	4	1	1	0	13	6%
Unknown	6	15	10	18	10	4	2	1	66	33%
Not Tested	0		1	1	3	1	0	0	6	3%
Total	12	49	31	43	38	16	9	3	201	
Percent	6%	24%	15%	21%	19%	8%	4%	1%		

Table 10.49: Number of Lanes Attempted by Pedestrian Versus ADT

ADT	Lanes Attempted					Total	%
	< 3	3 - 4	5 - 6	7 - 8	> 8		
0 – 9,999	8	2	1	0	0	11	5%
10,000 - 19,999	7	15	8	0	0	30	15%
20,000 - 29,999	1	18	24	8	0	51	25%
30,000 - 39,999	1	9	21	7	0	38	19%
40,000 - 49,999	0	4	17	8	0	29	14%
50,000 - 59,999	0	3	6	8	3	20	10%
60,000 - 69,999	0	0	7	3	2	12	6%
> 70,000	0	1	3	6	0	10	5%
Total	17	52	87	40	5	201	
Percent	8%	26%	43%	20%	2%		

The most critical combination for pedestrians crossing the road at locations other than in an intersection tended to be for 35-44 year old, male, alcohol impaired pedestrians attempting to cross a 5 or 6 lane roadway with an ADT between 20,000 to 29,000, at night, within 200 to 600 ft of an intersection. Pedestrian behavior was the single greatest contributing factor in the non intersection crossing crashes.

10.5.3 Causes of "Walking Along Road" Type Pedestrian Crashes

Pedestrians classified as walking along the road, either with traffic or against traffic, only comprise 9% of the fatal pedestrian crashes in this study, however a closer look is warranted to report the adequacy of pedestrian facilities in these cases. For each case where a pedestrian was walking along the road the presence of a sidewalk, and the use thereof by the pedestrian, were documented. Table 10.50 shows the presence and use of pedestrian facilities grouped by the type of roadway in which the crash occurred.

Table 10.50: Pedestrian Facilities Versus Roadway Details

Roadway	Pedestrian Facilities			Total
	No Sidewalk	Sidewalk Present, Ped not using	Ped in Sidewalk	
Interstate Urban	1	0	0	1
Interstate Rural	1	0	0	1
Suburban 2-3Ln 2Wy Divd Pavd	3	0	0	3
Suburban 2-3Ln 2Wy Undivd	0	1	0	1
Rural 2-3Ln 2Wy Undivd	4	1	0	5
Urban 4-5Ln 2Wy Divd Rasd	1	2	5	8
Urban 4-5Ln 2Wy Divd Pavd	0	1	3	4
Suburban 4-5Ln 2Wy Divd Rasd	7	0	0	7
Rural 4-5Ln 2Wy Divd Rasd	1	0	0	1
Urban 6+Ln 2Wy Divd Rasd	2	0	0	2
Urban 6+Ln 2Wy Divd Pavd	0	0	1	1
Suburban 6+Ln 2Wy Divd Rasd	0	1	0	1
Total	20	6	9	35
% of Total	57%	17%	26%	
% Urban	20%	50%	100%	
% Suburban	50%	33%	0%	
% Rural	30%	17%	0%	

In 57% of the cases, there was not a sidewalk for the pedestrian to use. Of these cases, 20% were in urban areas where pedestrian traffic is most likely. Suburban roadways accounted for the highest percentage of crashes lacking a sidewalk (50%), which reveals the inadequacy of pedestrian facilities in these areas. The use of alcohol among pedestrians walking along the roadway, and drivers of striking vehicles is given in Table 10.51 and Table 10.52.

Table 10.51: Pedestrian Facilities Versus Pedestrian Alcohol Use

Pedestrian Alcohol Use	Pedestrian Facilities			Total	%
	No Sidewalk	Sidewalk Present, Ped not using	Ped in Sidewalk		
None	11	1	1	13	37%
Under Limit	1	0	0	1	3%
Over Limit	1	5	0	6	17%
Had Been Drinking	1	0	0	1	3%
Unknown	5	0	3	8	23%
Not Tested	1	0	5	6	17%
Total	20	6	9	35	
% of Total Alc Involved	15%	83%	0%	23%	

Table 10.52: Pedestrian Facilities Versus Driver Alcohol Use

Driver Alcohol Use	Pedestrian Facilities			Total	%
	No Sidewalk	Sidewalk Present, Ped not using	Ped in Sidewalk		
None	5	0	0	5	14%
Under Limit	0	0	0	0	0%
Over Limit	4	0	0	9	26%
Had Been Drinking	1	0	0	1	3%
Unknown	3	0	0	3	9%
Not Tested	7	6	4	17	49%
Total	20	6	9	35	
% of Total Alc Involved	25%	0%	56%	29%	

Pedestrian alcohol impairment largely explains why pedestrians were not using the sidewalk when one was present, and were killed walking along the road. In the cases where a pedestrian was hit while walking where they should have been, in the sidewalk, the driver was intoxicated or was not tested for alcohol use. In most cases, the lack of sidewalks led pedestrians, who were primarily not under the influence of alcohol, to walk along the roadway or shoulder where they were stuck and killed by motor vehicles whose drivers, at least 25% of the time, were under the influence of alcohol. The problem of alcohol use among drivers is probably underrepresented in the data, with these results only giving the lower threshold of possible levels. The lack of driver alcohol test results in nearly half the cases clearly signals the need of vigilance on behalf of law enforcement to test and report alcohol use among drivers.

10.5.4 Causes of "Exit Vehicle" Type Pedestrian Crashes

In a previous section it was shown that "Exit Vehicle" type pedestrian crashes are overrepresented in rural areas (see Table 10.11). In this study, 37% of rural pedestrian crashes involved a pedestrian that has exited a vehicle, compared to 12% of urban crashes. In rural areas, the root causes of these crashes is the lack of a safe place to harbor a disabled vehicle (parking lot, side street) and the higher reliance on the shoulder to park a vehicle. The width of a shoulder affects the safety of pedestrians who have exited a disabled vehicle. In one case in particular, the investigator noted the narrow shoulder as a prominent factor contributing to the crash. Even when shoulders are adequate, pedestrians who exit disabled vehicles do not perceive the danger of passing traffic and do not take adequate precaution thereby contributing to their own death.

Of the 35 factors found to contribute to the 51 "Exit Vehicle" pedestrian fatalities, nine factors were found to be significant (each occurring in over 10% of the cases). The causes listed in Table 10.53 collectively reflect over 71% of the 152 individual causes identified in the "Exit Vehicle" cases. The most frequent cause of this type of crash was a pedestrian exiting a disabled vehicle (65% of the time); however, it was always found to be of a secondary or tertiary nature. Human factors predominate the list of primary causes and show that drivers, followed by pedestrians, cause these crashes. The leading driver-related causes were: inattention; intoxication; and speeding. Drivers were inattentive or drunk, did not anticipate pedestrians, and therefore did not see the pedestrians or react until too late. Examples that reflect poor pedestrian judgment and behavior include: pedestrians intoxicated and stumbling along the edge of travel lanes, pedestrians working on their vehicles inches from (or even partially within) travel lanes; refueling shoulder parked vehicles while standing in travel lanes; standing in or near travel lanes hand at night flagging traffic; and others who were distraught by circumstances regarding their disabled vehicle and were not paying attention as they walked (attempting to cross the road, or walking along the road). Roadway lighting was noted in cases where poor roadway lighting or the lack of street lights contributed to the crash, but like most other roadway, vehicle, and environment conditions, when causes were prioritized it was found to follow human causes.

Table 10.53: Significant Causes of "Exit Vehicle" Type Pedestrian Crashes

Class	Factor	Primary Ped + Driver (% Cases)	Secondary Ped + Driver (% Cases)	Tertiary Ped + Driver (% Cases)	Total Ped + Driver (% Cases)
Human	Alcohol	6 + 6 (24%)	0 + 2 (4%)	0 + 2 (4%)	6 + 10 (31%)
	Decision	2 + 3 (10%)	1 + 0 (2%)	0 + 0 (0%)	3 + 3 (12%)
	Drugs	3 + 0 (6%)	0 + 3 (6%)	0 + 0 (0%)	3 + 3 (12%)
	Inattention	2 + 10 (24%)	1 + 1 (4%)	0 + 2 (4%)	3 + 13 (31%)
	Speed	0 + 3 (6%)	0 + 5 (10%)	0 + 0 (0%)	0 + 8 (16%)
Vehicle	Disabled	0 (0)%	22 (43%)	11 (22%)	32 (65%)
Environment	Wet/Slippery	0 (0)%	1 (2%)	6 (12%)	7 (14%)
Roadway	Lighting	0 (0)%	0 (0)%	7 (14%)	7 (14%)
	Obstruction	0 (0)%	6 (12%)	3 (6%)	9 (18%)

Recent ad campaigns by American vehicle manufactures have highlighted the safety benefits of the OnStar communications hardware system as a post incident safety feature. Gary Cowger, president of GM's North American operations, claims that the technology along with electronic stability control is second only to seat belts in terms of saving lives (Butters, 2005). Even if the claims have yet to been proven, the advantages of current communications technology is tangible when it comes to disabled vehicles. Using cellular technology, occupants of disabled vehicles in the shoulder do not need to exit their vehicles to solicit aid. The public should be taught as drivers how to respond safely when approaching or passing a disabled vehicle, they should be warned of the dangers of exiting a vehicle, especially in rural areas and on high speed state roadways, and they should be educated on the safety precautions that pedestrians who must exit vehicles should take. Of the human related causal factors, 71% are attributed to the drivers who strike pedestrians, therefore education efforts should target drivers. It is recommended that future research be conducted to establish the benefits of communications hardware to Floridians involved in crashes. Shoulder widening should be considered when shoulders are narrow, other pedestrian facilities are not provided, and crash history indicates incidents involving pedestrians or disabled vehicles.

10.5.5 Causes of Pedestrian Crashes on Limited Access Facilities

A total of 15% of the pedestrian crashes occurred on limited access facilities (interstate, toll road, other limited access facility, or ramp) resulting in 58 pedestrian fatalities. 27 factors were found to contribute to pedestrian crashes on limited access facilities but eight factors were found to be significant – that is that the factor contributed in at least 10% of the cases. Table 10.54 summarizes the most significant contributing factors. Of the 26 factors found to contribute to the 58 pedestrian fatalities on limited access facilities, eight factors were found to be significant (each occurring in over 10% of the cases). The causes listed in Table 10.54 collectively reflect over 75% of the 158 individual causes determined for the limited access cases. The most frequent cause of this type of crash was a pedestrian exiting a disabled vehicle (50% of the time), however it was always found to be of a secondary or tertiary nature. Human factors predominate the complete list of primary causes and show that drivers (61%), followed by pedestrians (39%) cause these crashes.

In general, pedestrians do not belong on or near limited access highways. State statutes reinforce this notion by stating “No pedestrian shall walk upon a limited access facility or a ramp connecting a limited access facility to any other street or highway” (Florida § 316.130(18)). State statutes explicitly prohibit pedestrian traffic on limited access facilities, however half of the pedestrian crashes on limited access facilities were caused as a result of a disabled vehicle. This raises the question of whether or not the pedestrian presence is legitimate in cases involving a disabled vehicle – in many cases it seemed to be. However, in some of these same cases the pedestrian is intoxicated or is not paying attention. This is further aggravated by darkness, poor or no roadway lighting, and rain – environmental and roadway conditions that were found to contribute to these crashes. It is worth clarifying that when a factor such as Environment-Dark is listed, as shown in Table 10.54, it does not simply reiterate the facts regarding the crashes. For example, 64% of the limited access cases occurred at night, yet darkness was determined to be a causative factor in only 16% of the cases. That means that not only was it dark, but poor lighting conditions contributed to the crash obscuring the pedestrian and no other human or other deliberate and clear causes contributed to the crash – a prioritization scheme adopted in this study and described in the methodology. Additionally, in 24% of the cases the absence of roadway lighting at night contributed to the crash at least in a secondary or tertiary way.

Table 10.54: Significant Causes of Pedestrian Crashes on Limited Access Facilities

Class	Factor	Primary Ped , Driver (% Cases)	Secondary Ped , Driver (% Cases)	Tertiary Ped , Driver (% Cases)	Total Ped , Driver (% Cases)
Human	Alcohol	14 + 7 (36%)	0 + 2 (3%)	0 + 2 (3%)	14 + 11 (43%)
	Inattention	2 + 9 (19%)	3 + 2 (9%)	1 + 2 (5%)	6 + 13 (33%)
	Speed	0 + 3 (5%)	0 + 4 (7%)	0 + 0 (0%)	0 + 7 (12%)
Vehicle	Disabled	0 (0%)	20 (34%)	9 (16%)	29 (50%)
Environment	Dark	0 (0%)	3 (5%)	6 (10%)	9 (16%)
	Wet/Slippery	0 + 0 (0%)	1 (2%)	6 (10%)	7 (12%)
Roadway	Lighting	0 + 0 (0%)	5 (9%)	9 (16%)	14 (24%)
	Obstruction	0 (0%)	5 (9%)	3 (5%)	8 (14%)

The use of incident management patrols that look for disabled vehicles and provide highway assistance can be valuable in countering pedestrian fatalities on limited access facilities. At present, the Road Rangers program (funded by FDOT and partners) consists of roving vehicles that provide free highway assistance services in certain parts of Florida to reduce delay and improve safety for the motoring public and emergency responders. The successful program is helping many motorists who may have otherwise become pedestrians; however, the focus has been congested areas and high incident locations of urban freeways. It is recommended to expand coverage areas, and to increase the hours of service in other areas.

Keeping pedestrians off limited access facilities is clearly a way to address the 50% of the cases where a disabled vehicle was not involved. Law enforcement must play a significant effort in enforcing state statues. It is recommended that FDOT review the use and effectiveness of signage prohibiting pedestrians on limited access facilities. Perhaps the message is not being clearly conveyed to the public. In addition, a program like the Road Rangers can be expanded to include the notification law enforcement of pedestrian presence, or may even be used to assist or remove pedestrians from roadways. Although the benefits of incident management patrols to motorists may be clear, future research is needed to evaluate the exact safety benefits to pedestrians.

10.6 Pedestrian Crashes Conclusions and Recommendations

1. The principal issues seen in the fatal pedestrian crashes were, in general, alcohol use by pedestrians, non-use of pedestrian facilities, especially crosswalks, followed by environment and pedestrian facility issues. The most common types of pedestrian crashes among the 382 pedestrians in this study were pedestrians crossing a roadway not in an intersection (53%), pedestrians that had exited a vehicle prior to the fatal event (13%), followed by pedestrians who were crossing at intersections (10%). The most critical combination found in this study was male pedestrians crossing the road at night at locations other than at intersections, between 35-44 years old, alcohol impaired, attempting to cross a 5 or 6 lane roadway with an ADT between 20,000 to 29,000, within 200 to 600 ft of an intersection.

2. Pedestrian behavior is the first contributing cause of 80.1% of the pedestrian crashes in this study. The greatest indicators of fault (indicative of pedestrian or driver action) were found to be the crash type, alcohol involvement, and vehicle speed relative to the posted speed limit. The pedestrian was found to be at fault in 77.8% of the cases. Because of the prevalence of risk-taking pedestrian behavior, educational campaigns directed specifically at this group are recommended. Appendix C contains a sample script for a televised media campaign that builds upon known safe driving behaviors to encourage safe pedestrian actions.

3. Alcohol use was determined to be the most significant contributing factor in pedestrian crashes, with at least 43% of the crashes involving alcohol use by either the driver or pedestrian. The effect of alcohol among pedestrians crossing at non-intersection locations was the most profound, with a rate of 69% in cases where alcohol use was determinable. Among drivers, the most common contributing factor was speeding followed by alcohol/drug impairment. The highest concentration of alcohol use among pedestrians and drivers alike were in people aged 35 to 44.

4. The lack of driver alcohol test results in over half the pedestrian cases (54% not tested) indicates the need for vigilance on behalf of law enforcement to test, or at least report, alcohol use among drivers at the time of the crash. In contrast, only 7% of pedestrians were not tested for alcohol use. This is likely due to the fact the toxicology results are commonly completed on all fatalities, regardless of whether alcohol use was anticipated.

5. Males were found to be more likely to be involved in pedestrian crashes, and accounted for 74% of the pedestrians, and 68% of the striking vehicle drivers. This is consistent with previous research indicating that males are more likely to engage in risk taking behavior, such as excessive alcohol use, or crossing at non-intersection locations. Sixteen percent of pedestrian fatalities were age 65 and older, and five percent were under age 15.

6. Pedestrians crossing at locations other than in marked or unmarked crosswalks at intersections comprise 53% of the fatal pedestrian crashes in this study. Motorists normally expect pedestrians to cross a road at an intersection. The most common trip generator was crossing near a minor side street ending in a T-intersection with no facilities for pedestrian crossing the major roadway. Restaurants, bars, grocery stores, and gas stations/convenience stores, which are often located on street corners,

were mentioned as trip generators. In many cases, it was unknown why a pedestrian crossed at a particular non-intersection location. Pedestrians who were attempting to cross at non-intersection locations were most often trying to cross in a 45 mph segment (38%), and were attempting to cross 5 or more lanes (65%).

7. In nearly half of the roadway crossing cases, pedestrians were attempting to cross the road within 600 ft of a crossing location with a traffic signal or within 600 ft of an under/overpass. Measures aimed at directing pedestrians to intersections and discouraging pedestrian crossings elsewhere should be very actively pursued. Establishment of “pedestrian no cross zones,” marked, signed, fenced, barricaded or otherwise delineated within a certain distance of intersections, along with public awareness and enforcement campaigns, are just a few of the types of measures that can be considered. See Figure 10.9 for an example of a public awareness message that could be generated from the results of this study. Among the many options the following countermeasures are listed that can make crossing the road safer: high visibility crosswalk striping, incorporating curb extensions, adding signing, removing street side parking, adding or widening crossing islands, establishing raised medians, and installing pedestrian signals. Some of these measures could be used at locations where the distance to the nearest signal is greater than any pedestrian would be anticipated to travel. As with any improvement, the costs and potential benefits of any changes would have to be evaluated on nearly a case by case basis.

8. Over half of non-intersection crossings were over 600’ from an intersection protected by a traffic signal. These tend to be crossings of limited access facilities, countermeasures of which are discussed subsequently, and on multi-lane divided highways where traffic from side streets is primarily controlled by stop signs. Because of this, there are often long stretches without adequate crosswalks protected by traffic signals. Where such roadways are located in areas of high pedestrian traffic, sufficient crosswalks should be provided. As an alternative to adding signals to side street intersections, mid-block crosswalks protected by pedestrian activated traffic signals can be used to provide safe pedestrian crossings without increasing vehicular traffic on side streets.

9. Fourteen percent of pedestrians crossing at non-intersection locations were over age 65 and attempting to cross 5 or more lanes. This indicates that there is a need for counteractive measures addressed at this ever-increasing age group of pedestrians in Florida. Many elderly are active, mobile citizens. The facts of lessened perceptual ability, decreasing agility, hearing and vision inadequacies cannot be ignored. In areas where large elderly populations reside, general separation or other alternatives should be sought even if the elderly do not take an active role in insisting that accommodating pedestrian facilities be provided. It is recommended that a leadership role be taken at the state level.

10. Lighting condition plays a major role in pedestrian cases, as evidenced by 71% of the pedestrians being hit at night, 37% of which occurred in locations where there were streetlights. The presence of streetlights may give pedestrians a false sense of visibility, where in fact it is insufficient for the driver to observe and react to the problem thus avoiding the collision. Public education aimed at both pedestrians and drivers is recommended. Pedestrians need to be aware that drivers may not see them,

especially at night, even if streetlights are present and they think the driver should be able to see them. Drivers should be reminded of potential for pedestrians in or along the road, and prompted to be mindful that pedestrians behave unexpectedly. Signage can be used to alert drivers of areas with pedestrian traffic. Review of the current standards for, and usage of, roadway signage is recommended — specifically in relation to informing drivers of the dangers of nighttime pedestrian traffic.

11. For cases where pedestrians were crossing the road, not at intersections, the number of nighttime pedestrian crashes where highway lighting was present is considerably higher than the number of daytime crashes at similar locations. Among other factors, the lighting level was likely insufficient for drivers to see pedestrians. Increasing the level of highway lighting to improve visibility is recommended in areas where pedestrian traffic or pedestrian activity at night is anticipated, or is known to be significant. Improved lighting is recommended for intersections, sidewalks, and mid-block locations with high pedestrian traffic or history of nighttime pedestrian crashes. However, the effect of mid-block lighting on the rate of non-intersection street crossings should be studied.

12. For pedestrians over 74 years old, the primary cause of pedestrian crashes when crossing the road was determined to be a perception error, such as inadequate surveillance, and looking but not being able to see and perceive the danger. Inadequate pedestrian phase to accommodate pedestrians (such as elderly) with slower walking speeds were seen in a small number of intersection cases. Although the recommended design pedestrian walking speed may be used in signal timing design, elderly pedestrians do not always travel at the design pace. The state should consider amending the design walking speed for elderly pedestrians and require its usage in signal timing design where elderly pedestrian traffic is expected, or in locations near elderly pedestrian trip generators.

13. Many times drivers leave most of the responsibility for avoiding crashes to pedestrian, even when the pedestrian is an elderly person. The high number of older pedestrians killed when crossing the road, especially those hit in the second half of the road, indicates that perception errors coupled with decreased mobility make older pedestrians especially vulnerable in such situations. Measures aimed at both educating drivers and increasing their responsibility for avoiding these crashes are recommended, given the growing elderly population in Florida. Reduced speed limits, or other measures to reduce operating speeds in areas of high elderly pedestrian exposure, might also improve driver reaction time to avoid collisions with pedestrians crossing at non-intersection locations.

14. A total of 15% of the pedestrian crashes occurred on limited access facilities (interstate, toll road, other limited access facility, or ramps). In general, pedestrians do not belong on or near limited access highways, a notion reinforced by state statutes. However half of the pedestrian crashes on limited access facilities were caused as a result of a disabled vehicle. The use of incident management patrols that look for disabled vehicles and provide highway assistance can be valuable in countering pedestrian fatalities on limited access facilities. It is recommended that FDOT also review the use and effectiveness of signage prohibiting pedestrians on limited access facilities.

15. It is recommended that intersection sites with the following characteristics be strongly considered for design review: sites where the number of lanes to be crossed is high (inclusive of turn lanes), a pedestrian median refuge is not provided, and where crash history reveals incidents (not only fatal) involving the elderly, or young, being struck in the second half of the crossing. Potential countermeasures may include (i) a signal timing scheme that would accommodate slower walking speeds (below 5 fps), (ii) inclusion of an all red phase specifically to allow pedestrians a chance to get a head start in crossing, and (iii) installation of countdown pedestrian signals to deter slower walking pedestrians from attempting the crossing late in the phase.

16. Sidewalks should be considered for divided suburban roadways, especially as the number of travel lanes increases and where pedestrian traffic is anticipated. In 57% of the cases where a pedestrian was walking along the roadway, there was not a sidewalk for the pedestrian to use. Of these cases, multilane divided suburban roadways accounted for the highest percentage (50%). The following countermeasures can improve pedestrian safety along roadways (walking along the road crashes): sidewalks, roadway narrowing, improved street lighting.

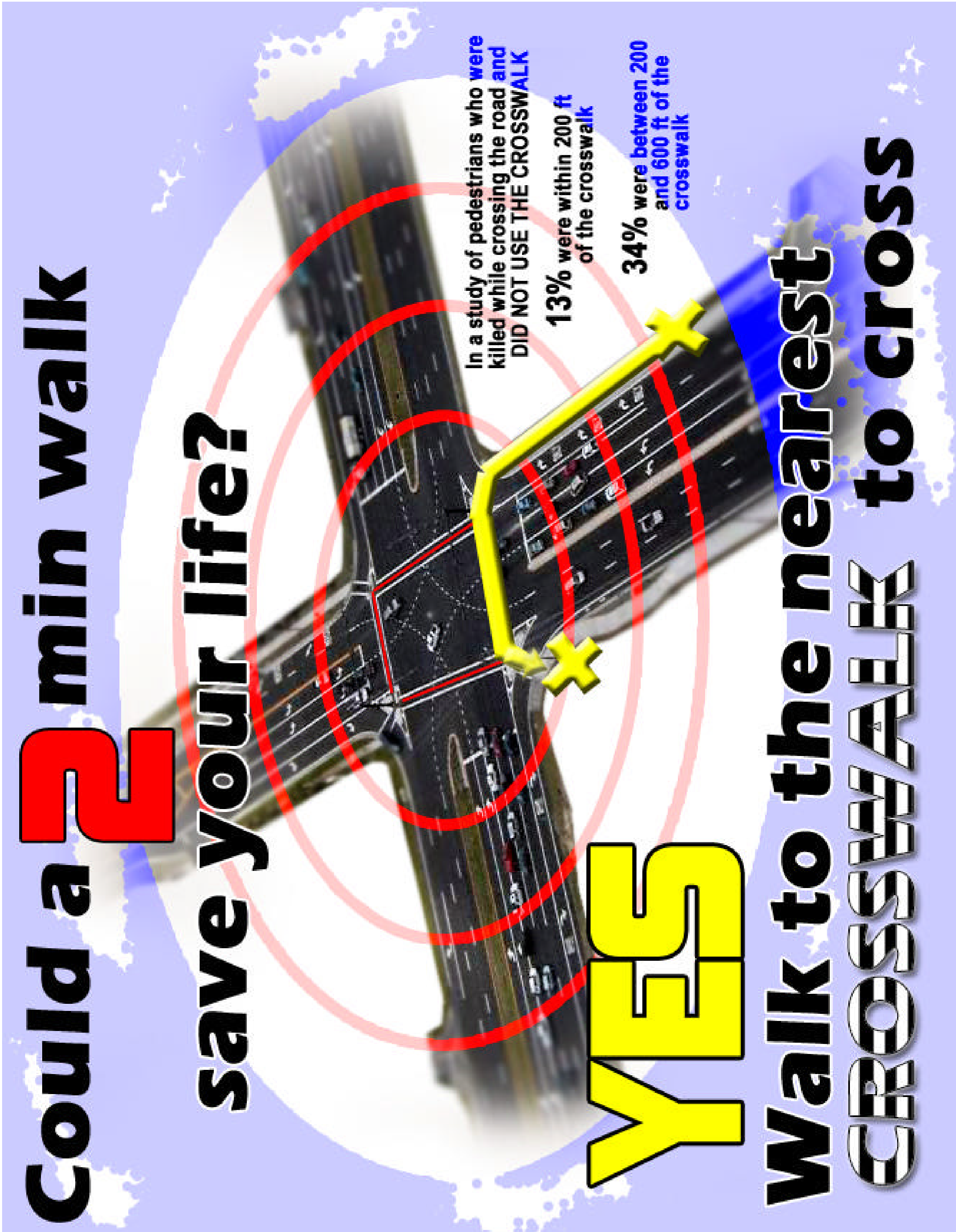


Figure 10.9: Example Public Awareness Message Utilizing Study Results

11 BICYCLE CRASHES

While bicycle crashes make up only a small fraction of the fatal crashes, about three percent, researchers undertook a study of the bicycle crashes in an effort to identify contributing factors and potential countermeasures. This chapter summarizes crash-subtype and contributing factors for crashes involving bicycles. A brief review of literature relating to bicycle crashes is presented, followed by details of the methodology that are pertinent to bicycle crashes.

11.1 Background and Literature Review

The importance of providing a safe transportation network for bicyclists has been recognized in recent years. In the year 2000, the Institute of Transportation Engineers (ITE) formed a task force to focus primarily on improving the facilities for non-motorized travel modes such as pedestrians and bicyclists. Called the Pedestrian and Bicycle Task Force, its main responsibilities include identifying issues and needs that are not being addressed by existing ITE Councils. The initial focus areas of the task force included problems such as inadequate funding, regionalism, and safety (*ITE* 2000). The state of Pennsylvania has established a statewide master plan for bicycle and pedestrian transportation, which has the goal of doubling the percentage of trips made by foot and/or bicycle (Diec 2003). It was found that, since the Clean Air Act was established in 1970, Pennsylvania has provided funding for bicycle paths and related facilities and incorporated such facilities into its comprehensive transportation plan.

Some studies have shown that separating bicycle and motor vehicle traffic through the use of bike lanes is the safest way to accommodate both modes of transportation. Huang et al (2002) looked at the effect of "road diets," conversions of four-lane undivided roads into three lanes (two through lanes plus a center turn lane) on crash rates. While the study examined all crashes, not just vehicle-bicycle crashes, converting the four vehicle lanes into three vehicle lanes often provides additional paved right-of-way for bicycle lanes. Alternate uses are additional space for sidewalks or on-street parking. Road diets are sometimes implemented with the objective of reducing vehicle speeds as well as the number of motor vehicle crashes and injuries. A before and after analysis using a "yoked comparison" study design found that the crash rate after conversion was about 6% lower than that of the matched comparison sites. However, a separate analysis in which a negative binomial model was used to control for possible differential changes in average daily traffic, study period, and other factors indicated no significant treatment effect.

Other studies suggest that the use of separate bicycle paths do not improve overall safety. Leden et al (2000) state that bicycle-vehicle interaction seems to be optimal when both groups share the roadway. Forester (2001) also concludes that separate bikeways do not reduce crash rates in comparison with the cycling on the roadway.

A number of studies have found that intersections account for the majority of vehicle-bicycle collisions. Wang and Nihan (2004) classified intersection crashes into three categories:

- Through motor vehicle related collisions
- Left-turn motor vehicle related collisions
- Right-turn motor vehicle related collisions

The researchers related the risk of each type of crash to its related flows. The methodology was demonstrated using four years worth of crash data from 115 signalized intersections in the Tokyo Metropolitan area.

Danish studies of intersection crashes involving bicycles and motor vehicles found a high rate of crashes in which the motorist failed to yield right-of-way to the bicyclist (Herslund 2003). It was determined that the motorists in many cases looked in the direction of the approaching bicyclist but failed to see (i.e. perceive the presence of) the bicycle. The researchers studied self-reported near crashes that involved this phenomenon, and also examined the gap acceptance of motorists with respect to approaching bicycles. It was found that the gap acceptance varied depending on whether or not another car was present in the intersection.

Various countermeasures have been proposed for reducing vehicle-bicycle crashes at intersections. Koike (2003) examines the effect of uneven pavements on vehicle and bicycle speeds. It was found that uneven surfaces can reduce speeds at intersections with limited sight distances, but that uneven surfaces might interfere with pedestrian crossings, especially those using wheelchairs. The Federal Highway Administration studied the effect of colored markings to delineate bicycle crossings, as is commonly done in many European cities (Hunter et al, 2000). Ten sites in Portland, Oregon were marked with paint, blue thermoplastic, and an accompanying "Yield to Cyclist" signs. All of the crossings were all at locations where the cyclist travels straight and the motorist crosses the bicycle lane by way of an entrance or exit ramp or to enter a right-turn lane. Analysis of videotape of the sites showed that significantly higher numbers of motorists yielded to cyclists, and more cyclists followed the colored bike-lane path. However, when using the colored path, fewer cyclists turned their heads to scan for traffic or used hand signals, possibly because of an increased comfort level. Most cyclists and about half of the motorists felt the blue areas enhanced safety.

Leden et al (2000) present a risk index model to assess the safety effect of potential countermeasures to reduce bicycle crashes. The model estimates risk in a multiplicative way, which makes it possible to analyze the impact of different factors separately. Expert judgments are incorporated through a Bayesian error model. The variance of the risk estimate is determined by Monte-Carlo simulation. When tested on the design of a new bicycle crossing, the safety per bicyclist was improved by approximately 20%. The new design resulted in decreases in automobile speeds but increases in bicycle speeds. It also resulted in increased bicyclist flow, probably because the bicyclists perceived that the new crosswalks increased safety and decreased delays.

A number of studies have shown that use of bike helmets reduces injury severity in bicycle crashes. Legislation in California mandating helmet use for bicyclists under age 18 was found to be associated with a reduction in traumatic brain injuries of over 18% among youth bicyclists (Lee 2005). The proportions of other head, face, and neck injuries were not significantly changed. An overall increase of 9% was seen in all other injuries, and there was no statistically significant change in the proportions of injury outcomes for adult bicyclists over the same time period. Curnow et al (2003), on the other hand, examine a meta-analysis on helmet use and injury severity, concluding that the meta-analysis does not provide scientific evidence that such helmets reduce serious injury to the brain. The authors further suggest that the Australian policy of compulsory wearing "lacks a basis of verified efficacy against brain injury."

11.2 Methodology

Bicycle crashes were reviewed using similar techniques to those presented in Chapter 4. To help in understanding the interaction of the bicycle and other vehicles in the crash, a number of bicycle-specific crash types and subtypes were developed. Most are categorized according to the bicycle action, with the exception of a vehicle running off the road and hitting a bicycle. The categories include only actions addressed within the study set. For instance, no cases involving bicycles turning at intersections were present in this study, so no separate sub-categories were developed. Following is a list of crash types and subtypes, with brief definitions.

- **Bicycle Crossing Road at Intersection:** Bicycle crossing a public road (not including driveways) under various signalization states. Includes bicycles using an adjacent sidewalk or bike trail. Includes other vehicles either turning or proceeding straight. Sub-types applicable to this data set include:
    - Bicycle Crossing Road at Signalized Intersection
    - Bicycle Crossing Road at Signalized Intersection (On Sidewalk)
    - Bicycle Crossing Road at Signalized Intersection (On Adjacent Bike Trail Crosswalk)
    - Bicycle Crossing Road at Unsignalized Movement (On Sidewalk)
    - Bicycle Crossing Road at Stop Sign
    - Bicycle Crossing Road at Signalized Intersection (Diagonally)
    - Bicycle Crossing Driveway (On Sidewalk)
- **Bicycle Crossing Road Not at Intersection:** Bicycle crossing a road where no public road intersects it. This type of crossing offers no protective facilities (crosswalks, stop control, etc.), but is often generated by a private drive intersecting the road. This category also includes crossings that were near or influenced by an intersection, but did not occur within the boundaries of the intersection, as defined either by edge of crosswalks the edge of the intersecting road's pavement or sidewalk, as appropriate. However, it includes only complete crossings, from shoulder to shoulder: lane changing/veering maneuvers conducting by a bicyclist initially traveling along the mainline road are included in the next category. Includes the following subtypes:
    - Bicycle Crossing Road Near Intersection
    - Bicycle Crossing Road at Mid-Block
    - Bicycle Crossing Road at Mid-Block (Median Break)
    - Bicycle Crossing Road at Mid-Block (From Driveway)
    - Bicycle Crossing Road at Mid-Block (Toward Driveway)
- **Bicycle Veer Into Road:** Bicycle making angled movement toward center of roadway, including movements from bike lanes and sidewalks. Includes bicycle

veering into the road in an attempt to conduct non-intersection left-turning/lane changing maneuvers, as well as veering due to loss of control. Subtypes include

- Bicycle Traveling in Direction of Traffic Veers Left
- Bicycle Traveling In Direction Of Traffic Veers Left (From Bike Lane)
- Bicycle Traveling Against Traffic Veers Right
- Bicycle Entered Roadway From Sidewalk

- **Bicycle Traveling in Direction of Traffic/Bicycle Rear End:** Bicycle traveling along the mainline road in the prevailing direction of traffic (i.e. with driver's back to vehicular traffic in the same lane), with no change of course or veering toward the center. Includes bicycles traveling at any distance from the edge of pavement, other than on a paved shoulder to the outside of a solid white line marking the edge of the outermost vehicle travel lane.
- **Bicycle Traveling Against Traffic/Bicycle Wrong Way:** Bicycle traveling along the mainline road, against the prevailing direction of traffic (i.e. with driver facing oncoming vehicular traffic in the same lane), with no change of course or veering toward the center. Includes bicycles traveling at any distance from the edge of pavement, other than on a paved shoulder to the outside of a solid white line marking the edge of the outermost vehicle travel lane.
- **Ran off Road, Hit Bicycle on Shoulder:** Bicycle on paved shoulder, outside of the solid white line marking the edge of the outermost vehicle travel lane. Includes bicycles traveling either with or against traffic.
- No Crash Report Image/Unknown

11.3 Data Set

A total of 62 fatal bicycle crashes occurred in the study set, for which 61 crash reports were available. The remaining crash was left out of this portion of the study. Each crash involved a single bicycle that was impacted by a single vehicle, even though many involved a secondary vehicle that subsequently hit either the bicyclist or the other vehicle. In each case, however, the other vehicle/driver characteristics that are provided are those of the initial contacting vehicle. In 61 of the 62 considered cases, the bicyclist was the fatality. In the remaining case, a motorized vehicle made an evasive move in a failed attempt to avoid a bicycle that pulled into its path, and lost control into the path of a third vehicle, resulting in the fatality of two occupants in vehicle two.

Tables 11.1 and 11.2 summarize the bicycle crashes into types and more detailed subtypes. As shown in Table 11.2, which groups the crashes into larger categories, most of the bicycle crashes involved an attempt on the part of the bicyclist to cross the road. Even the categories that involve "bicycle veers left" into road typically involve the bicyclist attempting to change lanes or make a left turn without appropriate attention to the trailing or oncoming vehicles. None of the intersection cases involved turning bicycles and four involved turning vehicles, three of which were turning right. All four of these vehicles were heavy trucks. Failure to observe the bicyclist was mentioned directly in three of the cases, indicating that the design of the trucks limited the driver's view, especially to the front right corner. However, it is certainly possible that many passenger vehicles struck bicyclists during similar right-turning maneuvers, only the crashes were not fatal due to the lower vehicle weight.

In addition to the crashes involving a bicycle attempting to cross the road, an additional nine crashes involved rear-ending of a bicycle that was traveling in a straight line with no turning or veering. Bicyclists traveling in the direction of traffic were killed more frequently than those facing traffic; however, without information on the rates at which bicyclists travel with or against traffic, it is impossible to say that the latter is the safer choice, although it is the legally mandated choice. In five cases, the motorized vehicle ran off the road, hitting a bicyclist on the paved shoulder of the road. Note that no bicyclists were killed while traveling in bike lanes, although two were killed veering from a bike lane into the path of a trailing vehicle, and a third was killed where a bike trail crossed a public road. The latter case involved an 87 year old bicyclist who failed to yield at the street crossing and was subsequently hit by a turning cement mixer whose driver saw the bicyclist, but was unable to stop in time. The street crossing actually involved a county road, although the heavy truck was on a U.S. highway that ran parallel to the bike trail.

Table 11.1: Crashes According to Bicycle Crash Subtypes

Crash Subtype	Number	Percent
Bicycle Traveling In Direction Of Traffic	9	15%
Bicycle Traveling In Direction Of Traffic Veers Left	9	15%
Bicycle Crossing Road At Signalized Intersection	7	11%
Bicycle Crossing Road At Stop Sign	6	10%
Ran Off Road, Hit Bicycle On Shoulder	5	8%
Bicycle Crossing Road At Mid-Block	4	6%
Bicycle Crossing Road At Mid-Block (From Driveway)	3	5%
Bicycle Traveling Against Traffic	3	5%
Bicycle Crossing Road Near Intersection	3	5%
Bicycle Crossing Road At Mid-Block (Toward Driveway)	2	3%
Bicycle Traveling In Direction Of Traffic Veers Left (From Bike Lane)	2	3%
Bicycle Crossing Driveway (On Sidewalk)	1	2%
Bicycle Crossing Road Near Intersection, Exited Vehicle	1	2%
Bicycle Entered Roadway From Sidewalk	1	2%
Bicycle Crossing Road At Unsignalized Intersection (On Sidewalk)	1	2%
Bicycle Crossing Road At Mid-Block (Median Break), Exited Vehicle	1	2%
Bicycle Crossing Road At Signalized Intersection (Diagonally)	1	2%
Bicycle Crossing Road At Signalized Intersection (On Adjacent Bike Trail Crosswalk)	1	2%
Bicycle Crossing Road At Signalized Intersection (On Sidewalk)	1	2%
No Crash Report Image	1	2%
Total	62	100%

Table 11.2: Crashes According to Bicycle Crash Types

Crash Type	Number	Percent
Bicycle Crossing At Intersection	18	30%
Bicycle Crossing Not At Intersection	14	23%
Bicycle Veer Into Road	13	21%
Bicycle Rear Ended	9	15%
Run Off Road/Bicycle On Shoulder	5	8%
Bicycle Wrong Way	2	3%
Total	61	100%

Table 11.3 shows the primary, secondary, and tertiary contributing factors in the set of bicycle crashes. As with most crash types, human factors are the most prominent contributing factors. Alcohol use and inattention appear most often as primary factors. Roadway, vehicle, and environmental factors were rarely the primary cause, although vehicle lighting, decision errors, and darkness are the most common secondary and tertiary factors. Vehicle lighting is cited more frequently than darkness because of the scheme used to prioritize contributing factors: had the vehicle had sufficient lighting, it would have been more visible despite the darkness. Likewise, inadequate bicycle facilities (e.g. bike lanes) are rarely cited as contributing factors because in many of the cases (e.g. bicycle veering into traffic), it was judged that causes such as inattention, poor driver decisions, alcohol use, and/or other factors led to the crash and that bicycle facilities would not have prevented the collision. On the other hand, adequate vehicle lighting might have made the bicycle more visible and allowed the vehicle driver to react more quickly.

In three cases, it was determined that increased bicycle-vehicle separation, through either a bike lane or a wider paved shoulder, might have prevented the crash; therefore, inadequate bike facilities was cited as a contributing factor. Two of these cases were bicycle rear-end cases on narrow medium to high speed roads (45 and 55 mph) with no paved shoulders, and the third involved a bicyclist who attempted to move right for the trailing motor vehicle, hit the curb and was redirected into the path of the vehicle. In the first and second cases, alcohol and drug use on the part of motorist and bicyclist, respectively, also contributed to the crash. It should be noted that, in about half of the bicycle rear-end cases, the bicyclist, being under the influence of alcohol, was not keeping as close to the right edge of pavement as possible, possibly out of concern for driving off the edge or into the curb and losing control. In these cases, a wider road could have allowed for more vehicle-bicycle separation. However, in several cases, the bicyclist was in the travel lane despite the provision of a paved shoulder. Regardless, other contributory factors were deemed more important in these crashes; therefore inadequate bike facilities were not labeled as primary, secondary, and tertiary factors.

Table 11.3: Primary, Secondary and Tertiary Contributing Factors

Factor Class	Factor	Primary	Secondary	Tertiary
Human	Confusion	0	1	0
	Decision	7	10	0
	Drugs	1	0	0
	Fatigue/Asleep	2	0	0
	Perception	1	1	0
	Speed	2	1	0
	Alcohol	23	4	1
	Age/Inexperience	0	0	1
	Unknown	1	0	1
	Age/Mobility	0	0	2
	Inattention	24	8	2
Environment	Visibility/Rain	0	1	0
	Wet Slippery	0	0	2
	Dark	1	8	6
Roadway	Design	1	0	0
	Bike Facilities	0	0	3
Vehicle	View Obstructions/Blind Spots	0	5	0
	Stability	0	1	1
	Lighting	0	10	10
Other	Other	1	3	0

Tables 11.4 and 11.5 assign the vehicle and driver factors to either the bicycle or the vehicle. From Table 11.4, it is evident that, when a crash had a human factor as a primary cause, it belonged to the bicyclist approximately four out of five times. Alcohol use was strongly overrepresented in bicyclists, and inattention was somewhat overrepresented. Fatigue and speeding belong exclusively to vehicle drivers, although they were overall not very common. Lack of vehicle lighting was the most common secondary factor, cited in approximately one-third of the bicycle crashes. Decision errors occurred in one-sixth of the cases, exclusively on the part of the bicyclist. Inattention errors occur as frequently as decision errors, however they are underrepresented in bicyclists. Bicycle stability issues involved loss of control or falling from the bicycle upon impacting curbs; the motor stability case involved an automobile that was blown slightly off course due to a gust of wind off a passing semi-trailer.

Table 11.4: Primary Factors According to Vehicle Type

Factor Class	Factor	Bicycle	Vehicle	Total	Bicycle ORF
Human	Alcohol	20	1	21	**4.490**
	Decision	7	0	7	**N/A**
	Drugs	0	1	1	**0.000**
	Fatigue/Asleep	0	2	2	**0.000**
	Inattention	20	4	24	**1.122**
	Other	1	0	1	**N/A**
	Perception	1	0	1	**N/A**
	Speeding	0	2	2	**0.000**
	Unknown	0	1	1	**0.000**
	Total	49	11	60	

Table 11.5: Secondary and Tertiary Factors According to Vehicle Type

Factor Class	Factor	Bicycle	Vehicle	Total	Bicycle ORF
Human	Alcohol	3	0	3	**N/A**
	Confusion	1	0	1	**N/A**
	Decision	10	0	10	**N/A**
	Inattention	5	6	11	**0.305**
	Inexperience	0	1	1	**0.000**
	Speeding	0	3	3	**0.000**
	Unknown	0	1	1	**0.000**
Vehicle	Lighting	19	0	19	**N/A**
	Unknown	1	0	1	**N/A**
	View Obstruction	0	3	3	**0.000**
	Stability	2	1	1	**0.732**
	Total	40	15	55	

Table 11.6 looks at fault in the fatal bicycle crashes. In 80 percent of the crashes, the bicyclist was found to be at fault, typically involving either failure to yield right-of-way and/or bicycling under the influence. Dual fault was assigned in a total of six cases, implying that the bicyclist and the driver both had a primary factor that caused the crash. For instance, in one case, a bicyclist under the influence of alcohol was crossing the street near but not at an intersection. A vehicle pulled from behind stopped traffic into a painted safety zone (i.e. a paved gore area not meant for vehicular travel) in an attempt to pass the stopped traffic and move ahead into a turn lane. Both driver actions violated traffic laws, and both drivers were found to be at-fault in the crash. Another common example is a bicyclist crossing, not at an intersection, who is hit by a vehicle traveling significantly over the speed limit. Overall, bicyclists were found to be at fault in 80 percent of the crashes and the other vehicle was found to be at fault in 28 percent of

the cases. Within most of the crash types, fault is assigned almost entirely to either the bicyclists or the other drivers, with bicyclists being at fault most frequently in the most common types of crashes. However, fault in bicycle rear-end collisions is almost even divided between bicyclists and other drivers. As expanded upon in the next few tables, this is due to high numbers of bicyclists under the influence in this type of crash, coupled with a high rate of improper bicycle lighting during nighttime hours.

Table 11.6: Fault in Fatal Bicycle Crashes

	Bicyclist				Other Driver			
	Yes	No	UK	Fault (%)	Yes	No	UK	Fault (%)
Bicycle Crossing At Intersection*	17	2	0	89%	4	15	0	21%
Bicycle Crossing Not At Intersection**	13	0	0	100%	4	9	0	31%
Bicycle Veer Into Road	13	0	0	100%	0	13	0	0%
Bicycle Rear Ended	4	4	1	44%	4	4	1	44%
Run Off Road/Bicycle On Shoulder	0	5	0	0%	5	0	0	100%
Bicycle Wrong Way	2	0	0	100%	0	2	0	0%
Total	49	11	1		17	43	1	
Percent	80%	18%	2%		28%	70%	2%	

* Two Cases Of Dual Fault

** Four Cases Of Dual Fault

Table 11.7 looks at alcohol use on the part of bicycle and other drivers. In this table, no alcohol use includes those cases where the officer saw no reason to conduct a BAC test. Percent driving under the influence includes all drivers with a blood alcohol content greater than zero, and are calculated as a percent of those with known BAC values, i.e. excluding unknown's. It is evident from this table that alcohol use on the part of the bicyclists is a key contributing factor in the crashes. Overall, 36 percent of the bicyclists were under the influence of alcohol, while only five percent of the other vehicle drivers were known to be under the influence. Note that BAC values are not known for approximately one third of the drivers, including bicyclists. As noted in Chapter 5, a large number of the bicycle cases were not investigated by FHP, which limited our ability to obtain THI reports and BAC data.

Table 11.8 and Figure 11.1 look at age of the bicyclists and other drivers. As a general trend, the bicyclists tended to be older than the other vehicle drivers. Only two of the bicyclists were below age 15, the youngest being nine. The oldest bicyclist was 92 years old, and the average age of bicyclists in the fatal crashes was 42.85. The youngest driver hitting a bicyclist was 16 and the oldest was 75. The average age of drivers hitting bicyclists was 37.54. Over 45 percent of the other vehicle drivers were in the 15-34 year old age groups, while over 45 percent of the bicycle drivers were in the 35-54 year old age groups. The younger bicyclists were more likely to cross not at an intersection and veer into the road, while the younger drivers were more likely to hit bicyclists crossing at intersections. The oldest bicyclists were more likely to be hit crossing at an intersection or while riding on the shoulder.

Table 11.7: Alcohol Use in Bicycle Crashes

Crash Type \ Alcohol Use	Bicyclist					Other Driver				
	0.00	<0.08	>0.08	UK	DUI (%)	0.00	<0.08	>0.08	UK	DUI (%)
Bicycle Crossing At Intersection	3	1	5	10	67%	12	0	0	7	0%
Bicycle Crossing Not At Intersection	3	0	5	5	63%	8	0	0	5	0%
Bicycle Veer Into Road	4	2	3	4	56%	8	0	2	3	20%
Bicycle Rear Ended	4	0	4	1	50%	6	0	1	2	14%
Run Off Road/Bicycle On Shoulder	3	0	1	1	25%	4	0	0	1	0%
Bicycle Wrong Way	0	0	1	1	100%	1	0	0	1	0%
Total	17	3	19	22	56%	39	0	3	19	7%
Percent	28%	5%	31%	36%		64%	0%	5%	31%	

Table 11.8: Age of Bicyclists and Other Drivers in Bicycle Crashes

Age Group	Bicyclist									
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	UK
Bicycle Crossing At Intersection	2	0	2	5	4	1	2	0	2	1
Bicycle Crossing Not At Intersection	0	3	2	4	2	2	0	0	0	0
Bicycle Veer Into Road	0	3	1	4	2	2	0	0	0	1
Bicycle Rear Ended	0	0	3	2	2	2	0	0	0	0
Run Off Road/Bicycle On Shoulder	0	0	1	1	0	1	0	2	0	0
Bicycle Wrong Way	0	0	0	1	1	0	0	0	0	0
Total	2	6	9	17	11	8	2	2	2	2
Cumulative Total	2	8	17	34	45	53	55	57	59	61
Percent	3%	10%	15%	28%	18%	13%	3%	3%	3%	3%
	Other Driver									
Bicycle Crossing At Intersection	0	5	5	2	5	0	1	0	0	1
Bicycle Crossing Not At Intersection	0	2	5	0	3	1	0	0	0	2
Bicycle Veer Into Road	0	1	4	3	3	0	1	1	0	0
Bicycle Rear Ended	0	2	2	2	1	1	0	0	0	1
Run Off Road/Bicycle On Shoulder	0	1	1	1	0	0	1	0	0	1
Bicycle Wrong Way	0	0	0	1	1	0	0	0	0	0
Total	0	11	17	9	13	2	3	1	0	5
Cumulative Total	0	11	28	37	50	52	55	56	56	61
Percent	0%	18%	28%	15%	21%	3%	5%	2%	0%	8%

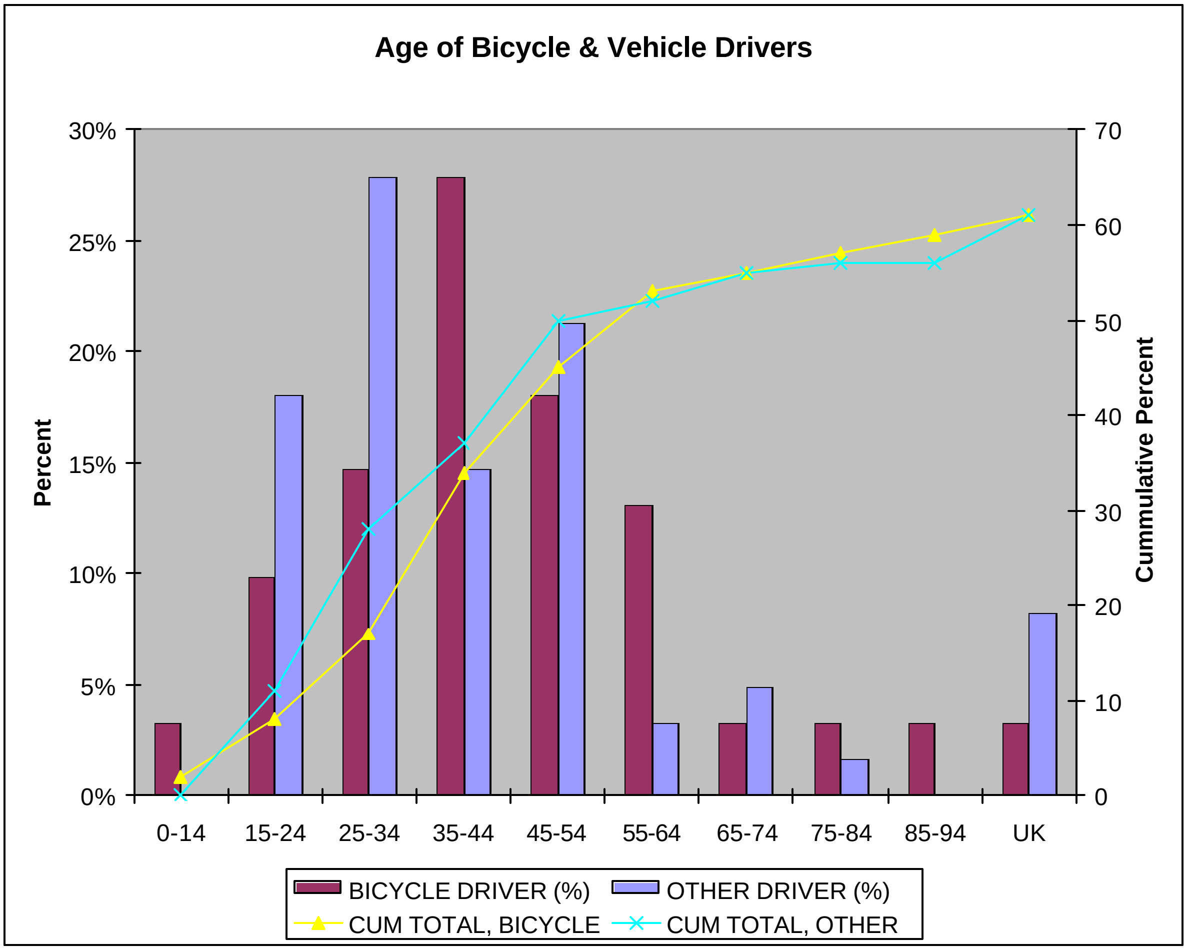


Figure 11.1: Distribution of Driver Age in Bicycle Crashes

Table 11.9 and Figure 11.2 compare driver age and alcohol use. While there are very few known BAC values for the other vehicle drivers, alcohol use is seen on the part of the bicyclists ranging from 25 to 74 years old. For each of those age groups, at least 50 percent of the bicyclists with known BAC values were under the influence of alcohol. For the drivers of other vehicles, alcohol use is only seen on the part of 25-34 year olds, where 21 percent of those with known BAC's were under the influence. This is shown graphically in Figure 11.2.

Table 11.9: Age Versus Alcohol Use in Bicycle Crashes

Bicyclist										
Age Group	**0-14**	**15-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**	**75-84**	**85-94**	**UK**
0.00	1	2	2	3	4	3	0	1	0	0
<0.08	0	0	0	2	1	0	0	0	0	0
>0.08	0	0	2	7	5	5	1	0	0	0
Unknown	1	4	5	5	1	0	1	1	2	2
Total	2	6	9	17	11	8	2	2	2	2
Percent DUI	0%	0%	50%	75%	60%	63%	100%	0%	N/A	N/A
Other Driver										
Age Group	**0-14**	**15-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65-74**	**75-84**	**85-94**	**UK**
0.00	0	8	11	8	8	1	2	1	0	0
<0.08	0	0	0	0	0	0	0	0	0	0
>0.08	0	0	3	0	0	0	0	0	0	0
Unknown	0	3	3	1	5	1	1	0	0	5
Total	0	11	17	9	13	2	3	1	0	5
Percent DUI	N/A	0%	21%	0%	0%	0%	0%	0%	N/A	N/A

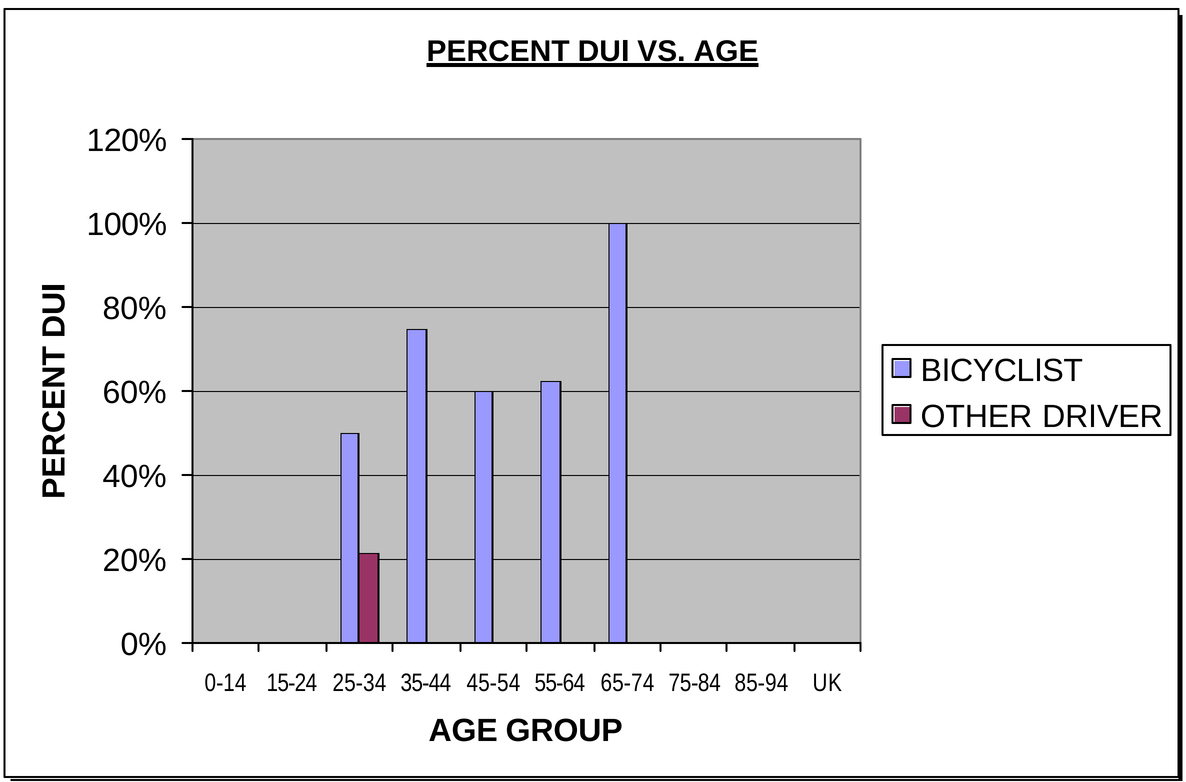


Figure 11.2: Distribution of Age and Alcohol Use in Bicycle Crashes

Table 11.10 looks at lighting conditions at the time of the bicycle crashes. Fifty-nine percent of the bicycle crashes occurred during hours other than darkness. Checking the THI reports revealed that low light and poor visibility was typically an issue in crashes coded as dawn or dusk also. Cases where the bicycle and motorized vehicle were following parallel tracks (e.g. rear-end and wrong way/head-on collision) had the highest percent occurrence during non-daytime hours; limited visibility was a key causative factor in most of these crashes. On the other hand, only forty percent of the vehicle run off the road crashes occurred during darkness, indicating that visibility of the bicyclist was less important in these crashes. In the non-intersection street crossings, the suddenness of the maneuver (i.e. decision error by the bicyclist, followed by inattention by the other driver) seemed to be a more important contributory factor. However, note that all of the nighttime street crossing happened in areas with street lighting, as did many of the bicycle rear-end cases. On the other hand, most of the nighttime bicycle veering cases involved areas with no street lights.

Table 11.10: Bicycle Crashes by Lighting Condition

Crash Type	Daylight	Dawn	Dusk	Dark-Street Lights	Dark-No Street Lights	Percent Non-Daylight
Bicycle Crossing At Intersection	10	0	1	8	0	47%
Bicycle Crossing Not At Intersection	5	0	1	3	2	55%
Bicycle Veer Into Road	6	0	1	1	6	57%
Bicycle Rear Ended	1	1	0	5	3	90%
Run Off Road/Bicycle On Shoulder	3	0	0	0	2	40%
Bicycle Wrong Way	0	0	0	1	1	100%
Total	25	1	3	18	14	59%
Percent	41%	2%	5%	30%	23%	

As noted previously, lack of adequate bicycle lighting seemed to be a major contributing factor in many of the nighttime traffic crashes. State law requires bicycles to be equipped with front and rear lighting visible from 500’ when driven in hours after sunset and before sunrise. Table 11.11 summarizes the status of bicycle lighting, bicycle reflectors, and street lighting in the non-daytime crashes, including those occurring during dawn and dusk hours. In over fifty percent of the non-daylight crashes, the road had some level of artificial lighting. However, less than 20 percent of the bicycles in nighttime crashes were known to have some lighting, and over 45 percent were known to have no lighting. Note that complete information was lacking in a number of cases, especially where no THI report was available. When in use, lighting was typically inadequate, frequently consisting of hand-held flashlights, or lighting in only one direction. Only three bicycles had fully operational front and rear mounted lights, as required by Florida statutes. One bicyclist had flashing lights mounted on his cap and arm rather than on the bicycle itself. Very few bicycles also had adequate reflectors, defined as having reflectors mounted so as to be visible from the front, rear and side, e.g. handlebar-, seat-, and wheel-mounted reflectors. (The presence of bicycle reflectors was used as a surrogate for adequacy, as the actual reflectivity of the reflectors was rarely addressed in the homicide report.) Note that the adequacy of street lighting was known in 97% of the cases, but adequacy of bike reflectors was known in only 44% of the cases.

Table 11.11: Bicycle and Street Lighting During Nighttime Crashes

	Bicycle Lighting		Bicycle Reflectors		Street Lighting	
	Number	Percent	Number	Percent	Number	Percent
None	17	47%	0	0%	16	44%
Partial/Inadequate	4	11%	14	39%	2	6%
Full/Adequate	3	8%	2	6%	17	47%
Unknown	12	33%	20	56%	1	3%
Total	36	100%	36	100%	36	100%

11.4 Contributing Factors to Fatalities

Because this section of the report deals with bicycle crashes, the most important safety measure on the part of the bicyclist is the use of a bike helmet. (As noted previously, one bicyclist was uninjured in the crash; the fatality was on the part of an occupant of a vehicle hit by another vehicle attempting to avoid the bicyclist.) As summarized in Table 11.12, only five percent of the bicyclists were wearing helmets at the time of the crash. Head injuries were explicitly cited in 12 of the bicyclist fatalities. Of the three bicyclists under age 16, who are legally required by wear helmets according to Florida statutes, none was wearing a helmet.

Table 11.12: Safety Equipment Used by Bicyclists

Safety Equipment	Number	Percent
No safety equipment	55	90%
Helmet	3	5%
Eye Protection	2	3%
Unknown	1	2%

Other factors potentially contributing to bicyclist fatalities are as follows. Twelve of the fatally injured bicyclists (approximately 20 percent) were hit by heavy trucks. Seven were above age 65, considered as evidence of increased frailty and susceptibility to fatal injury in any collision event. Finally, six (approximately 10 percent) were run over by one or more vehicles after making initial contact with the impacting vehicle.

11.5 Conclusions and Recommendations

Examining all of the fatal crashes in which bicycles were involved, one gets a picture of middle aged and older bicyclists, who are on the road at night, with poor bicycle lighting, and often either under the influence of alcohol, impairing their judgment as to the safe operation of their bicycle, or inattentive to surrounding traffic conditions. A small number of bicyclists were youths, who were involved more frequently in intersection related road crossings, and who sometimes showed judgment errors due to their youth and inexperience. While there was more variability among the drivers of other vehicles, in general, they were younger, less likely to be under the influence of alcohol, but frequently inattentive, and sometimes fatigued or traveling at excessive speeds. Although bike riders were more likely to be found at fault overall, the highest fault rates (sole or shared fault) among motorized vehicle drivers were in running off the road, rear ending, and bicycle non-intersection crossing cases. In intersection crossings, the bicyclist was much less likely to have yielded right-of-way as required: motorists failed to yield right-of-way in only 21 percent of these crashes.

Vehicle factors included the lack of visibility, sometimes coupled with blind spots, especially in heavy truck performing turning maneuvers. In a few cases, instability or condition of the bicycle potentially played a role in the crash. The only environmental condition that played a significant role in the crashes is darkness, sometimes coupled with poor street lighting and more frequently coupled with poor bicycle lighting. Nighttime bicycle crossing and rear-ending cases tended to occur most frequently on segments with street lights (16 out of 21 cases), while bicycle veering cases tended to occur on unlit segments (6 out of 7 cases).

Inadequate separation of bicycles and motorized vehicles, e.g. by bike lanes, did not appear to be a contributor as frequently as failure to yield right-of-way at street crossings, and other instances of bicycles veering into the road. It could be surmised from the lack of rear end crashes where the bicyclist was in a bike lane that providing bike lanes prevents fatal crashes, i.e. non-appearance of these crash types is evidence that bike lanes work. However, the fact that so few of the fatal crashes involved bicyclists proceeding straight in the mainline direction without veering into or attempting to cross a street indicates that other countermeasures might be more productive. On the other hand, a tendency by bicyclists under the influence of alcohol to maintain a greater distance from the edge of the pavement might indicate a potential benefit from wider roads and increased vehicle-bicycle separation, despite the fact that other factors tended to be named as more important contributors to the crashes.

Trends in bicyclist age, bicycle condition, alcohol use, and other information gained from the case reviews paints a picture of many bicyclists who use that mode of transportation by necessity (loss of driver's license or economic necessity) rather than choice. In several cases, it was explicitly noted by the officer that the bicyclist had a history of DUI's or had a suspended or revoked license. In most of the cases, however, the license status was not addressed or coded as "not applicable" on the crash report, because a license is not required to operate a bicycle. In other cases where the bicyclist was under the influence of alcohol, the scenario is potentially consistent with a person who had access to both a bicycle and a motorized vehicle, and possibly being aware of the illegality and dangers of drinking and driving a motorized vehicle under the influence of alcohol, instead chose the bicycle as an alternate means of transportation. However, without more information on the license status of the bicyclists, it is difficult to draw conclusions in this matter. Improved reporting in this area would provide a clearer picture of bicyclist demographics. Given the second scenario, of impaired individuals choosing to operate a bicycle rather than a motorized vehicle, a potential countermeasure is improved education on the illegality and dangers of alcohol-impaired bicycling. A concept for a public service announcement addressing the issue of impaired pedestrians, with an alternative approach addressing impaired bicycling, is presented in Appendix C.

Given these factors, the following countermeasures are recommended to reduce bicycle fatalities. The ordering of the list reflects the general prioritization of these efforts as measured by potential for reducing the number of fatal collisions.

- Educational campaigns directed at improving bicycle lighting and safety helmet use.
- Increased enforcement of laws requiring bicycle lighting and youth safety helmet use.
- Educational campaigns directed at the dangers of inattentive and impaired bicycling.
- Improved data collection on driver license status of bicyclists.
- Evaluation of lighting standards, especially at intersections in areas of high nighttime bicycle use.
- Installation of street lighting on non-intersection segments with high nighttime bicycle use, especially where narrow roadways increase the chance of vehicle-bicycle collisions.
- Widening of roads or installation of bicycle lanes on roadway segments with high bicycle usage.

12 ROLLOVER CRASHES

Because of the high number of crashes involving overturning vehicles, it was decided to study vehicle rollovers. A number of results were obtained to see which type and size of vehicles are more prone to rollovers and fatalities, and whether human factors such as age, experience level and gender have any effect on rollovers. These results are summarized in this chapter.

12.1 Background and Literature Review

Several studies have tried to identify the main factors that influence rollover crashes. However, search of the relevant literature revealed that there were not many research studies on sports utility vehicles and/or rollovers in multi-vehicle crashes. This may have been due to the fact that many state databases do not differentiate the SUV's from other vehicle categories, nor do they separate out harmful event (i.e. rollover) as a vehicle-level attribute. This makes it difficult to identify which vehicle rolled over without a detailed review of each case.

Viner (1995) examined the importance of the problem of run-off-road vehicles that rollover on slopes and ditches by analyzing Fatality Analysis Reporting System (FARS) data and New Mexico crash data. Rollover on slopes and ditches was identified as the leading cause of driver fatalities in run-off-the-road, accounting for about one-fourth of the driver fatalities. On rural roads, slope rollovers account for more driver fatalities than any specific object struck, whereas on urban roads, both tree and utility pole impacts account for more fatalities than slope rollovers. This paper also found that about half of fatal rollovers occur on curves.

Richardson et al (1996) developed a statistical description of patterns of motor-vehicle crash types among drivers of different age and sex in order to identify underlying differences in behavior and ability. The data source used was the Hawaii Motor Vehicle Accident file. They examined the interactions between driver age and sex, crash type and vehicle type. They also suggested that young drivers have much higher frequency of rollovers, which pick-up trucks have much higher frequency of rollover and that young male drivers more frequently drove these vehicles. Head-on, rollovers, and rear-enders indicate reckless behavior and poor judgment commonly attributed to the young driver.

Farmer et al (2002) studied the association of characteristics of the driver, roadway environment, and vehicle with the likelihood of rollover. Light truck injury and fatal crashes involved rollover more often than car crashes, and this was true for a variety of crash circumstances. Rollover risk was highest on rural curves, but even urban curves were risky for young drivers of the smaller light trucks. Larger vehicles tended to roll over less often than smaller vehicles of the same type, but specific vehicle comparisons point out the need for more information. Fatality Analysis Reporting System (FARS) and the National Center for Statistics and Analysis (NCSA) datasets were used for the study.

Donelson et al (1999) focused their study on rollovers in single-vehicle crashes involving light-duty trucks. Statistical models of fatality risk were developed with multivariate logistic regression applied to data on single-vehicle rollovers of any severity. Their study was based on the data from the Fatality Analysis Reporting System. Differences in rates for light trucks decreased greatly and, in general, became statistically insignificant. Studies comparing fatality-based rates among vehicles need careful, statistical control of factors that increase the risk of fatal injury. Researches suggest that fatal crashes are rare and have special attributes. Rollover research specific to vehicles would do well to concentrate on crashes of any severity, which, for vehicles grouped by make and model, demands reference to large-volume files maintained by states.

McGinnis et al (2000) studied the run-off-road (ROR) fatal crashes and analyzed the data to see how driver characteristics such as gender, age, and alcohol usage relate to ROR crashes. The data used for this analysis was from Fatality Analysis Reporting System and the National Personal Transportation Studies. In their report they inferred that young drivers, male drivers, drivers over 70, sports utility vehicles (SUV's), rollovers, and alcohol pose special challenges for roadside safety improvements efforts. Males 20 to 24 years of age have ROR crash rates 3.3 times females of the same age. The number of sports utility vehicles involved in ROR crashes increased nearly 600%. Seventy percent of fatal ROR crashes with utility vehicles involve a rollover. Rollovers rates for vans and pickups involved in fatal ROR crashes are nearly 5 times those for non-ROR crashes.

Kindelberger et al (2003) studied the younger driver in the age group of 16-24 involved in SUV rollover crashes in the years 1992 through 2001. The data from the Fatality Analysis Reporting System was used in this study. This study the addresses the topics of younger driver in SUV crashes, relative risk of rollover among differing age groups, rollovers in aging SUV's and age groups that are at high risk. To test the significance of relative risks and odds ratio under the National Automotive Sampling System's General Estimates System (GES) sample design, the SUDAAN (Survey Data Analysis Software for Statistical Analysis of Correlated Data) software package was utilized. The study revealed that the drivers of ages 16-24 were more likely to rollover SUV than older drivers above age 25. Among younger drivers of SUV's that crashes, males were more likely to rollover SUV's than females. They found that older SUV's in crashes were more likely to rollover than the newer SUV's. The limitations of this study was restricted to more general characteristics and does not address behavior-based variables such as alcohol, speeding and safety belt usage.

12.2 Methodology

Because of limitations of the Florida Traffic Crash Report, two important steps had to be conducted during case study reviews of rollover crashes. The fist involved determining the vehicle model and assigning the vehicle subtype to vehicles. The FTCR does not include a separate category for SUV's, even though many of the vehicles on the road are SUV's. Hence, when the officers fill out the crash report, they code SUV's from the available vehicle type codes, typically as an automobile (01) but often as a light truck (03). Sometimes SUV's were also coded as seventy-seven, which are "Other Vehicles." To calculate the number of SUV's involved in crashes, it was very important to know the vehicle model or vehicle type since just the vehicle make does not tell anything about the vehicle type. The vehicle model data was obtained from the THI reports when available. In case of missing THI reports, the vehicle model was retrieved using VIN (Vehicle Identification Number) decoding software. VIN's from the FDOT database were used where possible; VIN's that could not be decoded were verified against the paper crash reports and the errors in reporting were noted.

Another important problem was in identifying rollover cases. The Department of Transportation uses the first harmful event and second harmful event, which are the attributes of the crash to indicate whether there was a rollover involved. It does not state which vehicle rolled over. In investigating the rollover crashes it is important to know which vehicle type rolled over and what factors influenced the rollover, like whether it was high center of gravity, which is definitely a vehicle characteristic. Another point is, if the vehicle rolled over as the consequence of other crash events, it would likely not be indicated as a harmful event, since only the first two harmful events are maintained at the crash level. A careful review of all events and circumstances around the crash was necessary to identify all rollover cases. It is important to note that the rollover is the main cause of fatalities in most vehicles that overturn, even in low energy rollover events.

The data set for this research was comprised of all rollover crashes involving vehicles of type 01 to 06, that is, four-wheeled passenger vehicles, medium, and heavy trucks. Vehicles such as bicycles, motorcycles, trains, buses, and motor homes were excluded from this portion of the analysis. These vehicle types are not considered in this analysis for two main reasons. First, two-wheelers roll over in almost all crash circumstances, i.e. they fall on their side almost every time they are involved in a crash. In addition, the driver getting ejected on two-wheelers is more likely than the driver getting ejected from a passenger car. These vehicle types are considered separately in other chapters of this report. Regarding the set of trains, buses and motor home, there were very few of these vehicles involved in the fatal crashes overall (42), and rollovers were a very minor aspect of their behavior (only two rollovers, one involving a motor home and a second involving a bus). Further, the lack of seat belts in most seating positions on buses skews the data on seat belt use and crash survivability. Thus these vehicle types are not considered in the analysis.

12.3 Data Set

The distribution of rollover cases by year is shown in Table 12.1. As can be seen from Table 12.1, the percentage of rollover crashes in the year 1998, which involved heavy truck crashes only, was approximately the same as the percentage of rollover crashes for the year 2000, while the percentage of rollover crashes in the year 1999 was somewhat lower. Overall, however, the additional data does not greatly affect the overall rollover rate in the data set, which was around 29%.

Table 12.1: Fatal Rollover Cases

Crash Types	Crash Year			Total
	Heavy Trucks		All Crashes	
	1998	1999	2000	
Rollover Cases	57	48	484	589
Non-Rollover Cases	142	150	1133	1425
Total Cases	199	198	1617	2014
Percent Rollover	29%	24%	30%	29%

As the concentration of this project is on rollover crashes, the county wise distribution of fatal rollover and non-rollover crashes is shown in Figure 12.1. As can be seen from the above Figure 12.1, the highest non-rollover crashes occurred in Dade County while highest number of rollover crashes occurred in Broward County.

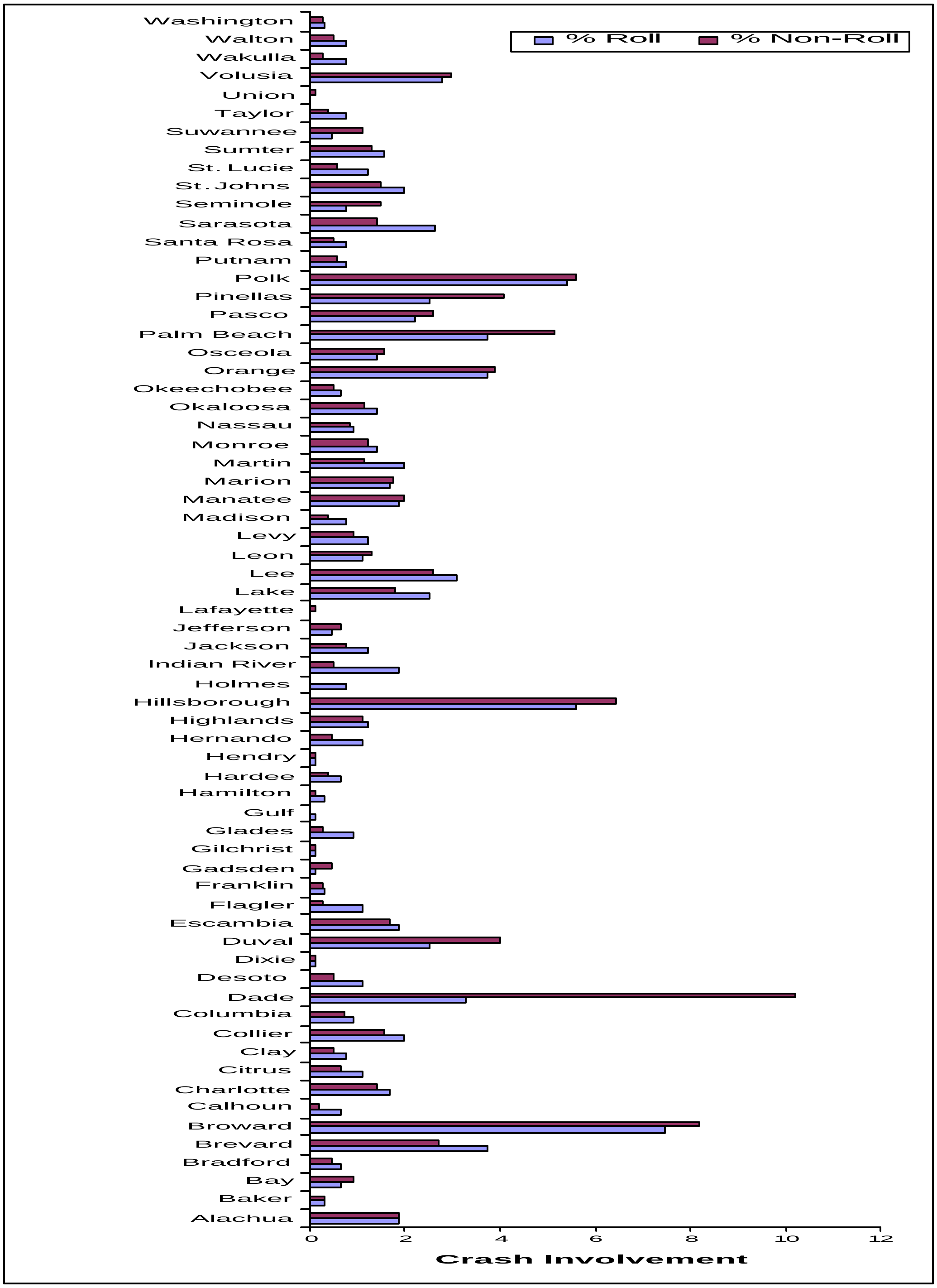


Figure 12.1: County-wise Distribution of Fatal Crashes

12.4 Characteristics of Rollover Crashes

Table 12.2 shows the correlation between rollover and fatalities. As can been seen from the table, rollover vehicles are overrepresented in fatalities compared to the non-rollover vehicles. In other words, vehicles that rolled over had at least one fatality more frequently than the non-rollover vehicles.

Table 12.2: Fatalities in Vehicle Rollovers

Crashes	Roll	Non-Roll	ORF	Min CI	Max CI	Level
Non-Fatal	92	1870	**0.29**	0.24	0.35	Under
Fatal	421	1124	**2.19**	2.06	2.32	Over
Total	513	2994				

Table 12.3 and Figure 12.2 show the primary crash types of the rollover crashes. Rollover is highly associated with run off the road crashes, and negatively associated with pedestrian crashes, intersection crashes involving a turning movement, and other/unknown crash types. Rollover has a positive association with intersection crashes involving only straight movements (intersecting paths), but this is not statistically significant.

Table 12.3: Crash Types in Rollover Crashes

Crash Type	Rollover	Not	ORF	Min CI	Max CI	Level
Pedestrian	7	307	**0.055**	0.026	0.115	Under
Run off Road	338	307	**2.644**	2.343	2.983	Over
Rear End/Side Impact	88	214	**0.988**	0.785	1.241	Unsure
Head-on/Forward Impact	40	140	**0.686**	0.489	0.962	Under
Intersection-Turn	49	298	**0.395**	0.296	0.525	Under
Intersection-Straight	61	118	**1.242**	0.925	1.665	Unsure
Other	2	21	**0.229**	0.053	0.972	Under
Total	585	1405				

Because of the prevalence of rollover in run off the road (ROR) crashes, Table 12.4 examines the various subtypes of ROR crashes. With respect to other ROR crashes, overturning is overrepresented in both left side departures where the vehicle had lost control prior to leaving the roadway and in ramp departures, although not to a statistically significant degree in the latter. Rollovers were underrepresented in right side departures where there was no control loss.

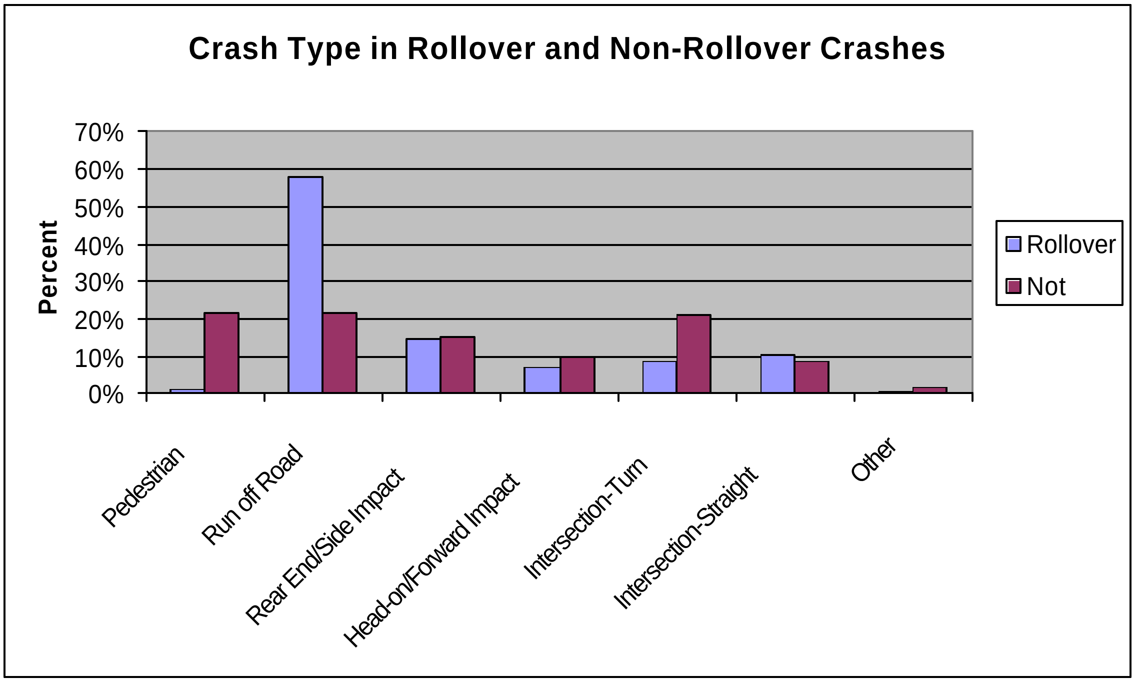


Figure 12.2: Crash Types in Rollover Crashes

Table 12.4: Run off the Road Crash Subtypes in Rollover Crashes

ROR Crash Subtype	Roll	Not	ORF	Min CI	Max CI	Level
Right side departure	63	91	**0.629**	0.474	0.833	Under
Right side w/control loss	87	83	**0.952**	0.736	1.232	Unsure
Left side departure	62	52	**1.083**	0.775	1.413	Unsure
Left side w/control loss	109	68	**1.456**	1.122	1.889	Over
Forward impact/end of pavement	4	6	**0.606**	0.172	2.126	Unsure
Ramp departure	13	7	**1.687**	0.682	4.173	Unsure
Total	338	307				

Table 12.5 looks at the primary contributing factor in the rollover crashes. The most common factor class is human, meaning that the crashes were primarily initiated by human factors. Alcohol and drug use, inattention, steering input, and speed are the most common contributing factors. Steering input refers to excessive turning of the steering wheel, as in overcorrection or sudden evasive action. Distraction, speed, excess steering input, and fatigue are significantly overrepresented in rollover crashes. The first three factors correlate to loss of lateral stability, which in turn correlates to rollover, while fatigue correlates with running off the road and subsequent tripping. A number of other factors appear only a few times, meaning that, even though they are highly under- or overrepresented, the results are not statistically significant.

Table 12.5: Primary Contributing Factor in Rollover Crashes

Class	Factor	Roll	Not	ORF	Min CI	Max CI	Level
Environment	Dark	1	1	**2.400**	0.150	38.300	Unsure
	Smoke/Fog	2	1	**4.799**	0.436	52.826	Unsure
	Wet/Slippery	1	14	**0.171**	0.023	1.300	Unsure
	Wind	0	1	**0.000**	N/A	N/A	N/A
Human	Aggression	7	28	**0.600**	0.264	1.366	Unsure
	Alcohol/Drugs	200	435	**1.103**	0.846	1.186	Unsure
	Confusion	1	13	**0.185**	0.024	1.408	Unsure
	Decision	30	159	**0.453**	0.310	0.661	Under
	Distraction	9	5	**4.319**	1.454	12.834	Over
	Fatigue/Asleep	25	20	**3.000**	1.679	5.358	Over
	Inattention	129	318	**0.973**	0.813	1.166	Unsure
	Inexperience	1	0	**N/A**	N/A	N/A	N/A
	Medical	8	24	**0.800**	0.361	1.770	Unsure
	Mental/Emotional	1	16	**0.150**	0.020	1.128	Unsure
	Perception	5	67	**0.179**	0.073	0.442	Under
	Police Pursuit	1	2	**1.200**	0.109	13.206	Unsure
	Speed	58	86	**1.618**	1.177	2.226	Over
	Steering Input	34	37	**2.205**	1.398	3.478	Over
	Unknown	27	120	**0.540**	0.360	0.811	Under
Roadway	Access Point	1	9	**0.267**	0.034	2.100	Unsure
	Congestion	0	2	**0.000**	N/A	N/A	N/A
	Construction	0	2	**0.000**	N/A	N/A	N/A
	Curvature	2	2	**2.400**	0.339	16.995	Unsure
	Obstruction	4	5	**1.920**	0.517	7.124	Unsure
	Sight Distance	1	0	**N/A**	N/A	N/A	N/A
	Sign/Signal	0	2	**0.000**	N/A	N/A	N/A
	Standing Water	0	6	**0.000**	N/A	N/A	N/A
Vehicle	Brakes	2	0	**N/A**	N/A	N/A	N/A
	Defect	4	3	**3.200**	0.718	14.251	Unsure
	Load Shift/Fall	0	3	**0.000**	N/A	N/A	N/A
	Over height	1	0	**N/A**	N/A	N/A	N/A
	Tires	31	12	**6.199**	3.206	11.987	Over
	Trailer	0	2	**0.000**	N/A	N/A	N/A
	Unsecured Wheelchair	0	1	**0.000**	N/A	N/A	N/A
	Visibility	0	1	**0.000**	N/A	N/A	N/A
	Other	0	3	**0.000**	N/A	N/A	N/A
Other	Other	2	13	**0.369**	0.084	1.631	Unsure

Table 12.6 shows the crash involvement of different vehicle types in rollover crashes. Although each of these vehicles rolled over in the context of a fatal traffic crash, this chart doesn't consider whether fatalities occurred in these vehicles, just whether a rollover occurred. As can be seen from the table, automobiles and CMV's are underrepresented in rollovers. This means that automobiles and heavy trucks do not roll over as frequently in fatal crashes as other vehicles in the data set. Sports utility vehicles are over three times as likely to rollover in the fatal crashes compared to other vehicle types, and light trucks are 1.66 times as likely to roll over. Medium trucks are underrepresented in the data set, however this cannot be stated with 95 percent confidence as the upper limit of the confidence interval is above one. Figure 12.3 shows the crash involvement in rollovers by vehicle type.

Table 12.6: Rollovers by Vehicle Involved in Fatal Crashes

Vehicle Type	Rollover	Non-Rollover	Total	ORF	Min CI	Max CI	Level
Automobile	154	1316	1470	**0.55**	0.48	0.63	Under
Passenger Van	58	143	201	**1.91**	1.43	2.56	Over
Pickup/Light Truck	100	284	384	**1.66**	1.35	2.04	Over
Sports Utility Vehicles	126	180	306	**3.30**	2.69	4.06	Over
Medium Trucks	11	57	68	**0.91**	0.48	1.72	Unsure
Commercial Motor Vehicles	74	488	562	**0.72**	0.57	0.90	Under
Total	523	2468	2991				

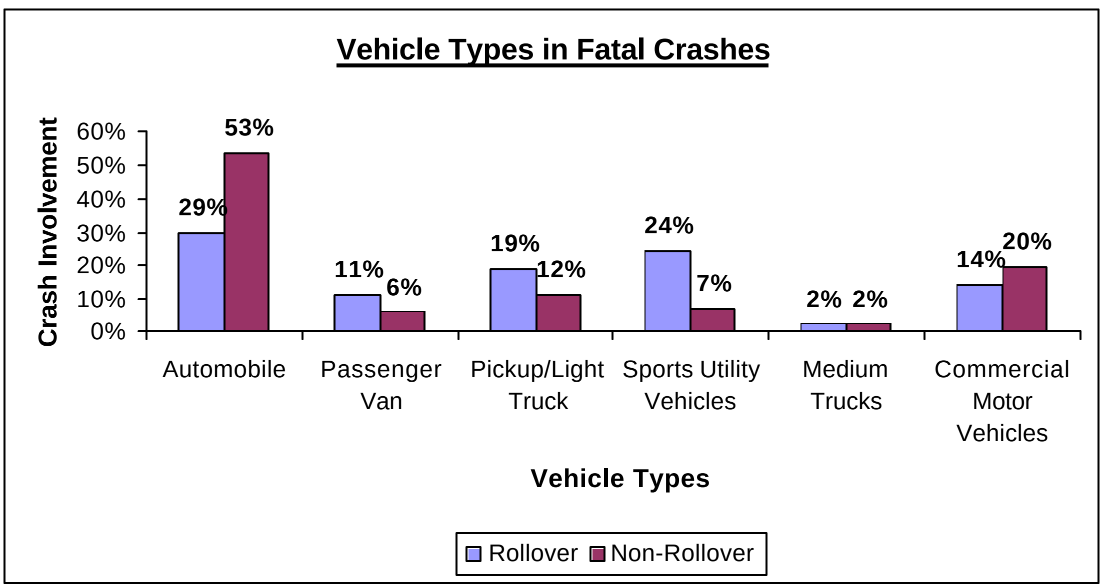


Figure 12.3: Rollovers by Vehicle Type

Vehicle size plays an important role in rollover. Table 12.7 looks at the rollover rates of different vehicles by their subtypes. In this comparison, all the three SUV subtypes are highly overrepresented in rollovers compared to other vehicle subtypes. It is observed that large vans are also rolling over frequently, followed by the compact pickups. On the other hand, heavy trucks and most sizes of automobiles roll over less frequently and are underrepresented in the group.

Table 12.7: Rollover Rates by Vehicle Subtypes

Vehicle Subtype	Number of Vehicles		Percent of Vehicles		ORF	Min CI	Max CI	Level
	Rolled	Non-Rolled	Rolled	Non-Rolled				
Subcompact Auto	28	326	5.85	12.41	**0.47**	0.32	0.68	Under
Compact Auto	50	297	10.44	11.31	**0.92**	0.70	1.23	Unsure
Midsize Auto	38	440	7.93	16.76	**0.47**	0.34	0.65	Under
Full Size Auto	15	254	3.13	9.67	**0.32**	0.19	0.54	Under
Minivan	39	155	8.14	5.90	**1.38**	0.98	1.93	Unsure
Large Van	18	44	3.76	1.68	**2.24**	1.31	3.85	Over
Compact Pickup	54	189	11.27	7.20	**1.57**	1.18	2.09	Over
Large Pickup	42	206	8.77	7.84	**1.12**	0.81	1.54	Unsure
Compact SUV	12	15	2.51	0.57	**4.39**	2.07	9.31	Over
Midsize SUV	95	117	19.83	4.46	**4.45**	3.46	5.73	Over
Large SUV	13	29	2.71	1.10	**2.46**	1.29	4.69	Over
Other Light Truck	0	10	0.00	0.38	**0.00**	N/A	N/A	N/A
Other Medium Truck	16	66	3.34	2.51	**1.33**	0.78	2.27	Unsure
Heavy Truck	59	478	12.32	18.20	**0.68**	0.53	0.87	Under
Total	479	2626						

Table 12.8 examines the rollover fatality rates by the vehicle subtypes. It can be observed that vans, pickups, SUV's and CMV's are overrepresented in rollover fatality rates. The automobiles are comparatively safer vehicles when it comes to rollovers and rollover fatalities in the group. Thus it can be stated with 95 percent confidence that automobiles are underrepresented both in rollovers and rollover fatality rates. It was seen that CMV's are less likely to rollover, but in an event of rollover they are highly overrepresented in the fatality rate. This can be attributed to the fact that the sheer size and weight of these vehicles proves fatal in rollovers. In non-rollover crashes, CMV's are the safest in the group. Refer to Table 12.9 to look at the fatality rates in general for the data set. The fatality rates for automobiles, compact pickups and SUV's (compact and midsize) are higher than the other vehicle subtypes. A person is more likely to die in a smaller vehicle than in larger one.

Table 12.8: Rollover Fatalities by Vehicle Subtype

Vehicle Subtype	Vehicles with Fatalities		Percent Vehicles with Fatalities		ORF	Min CI	Max CI	Level
	Rolled	Non-Rolled	Rolled	Non-Rolled				
Subcompact Auto	23	186	6.05	18.67	**0.32**	0.21	0.49	Under
Compact Auto	47	142	12.37	14.26	**0.87**	0.64	1.18	Unsure
Midsize Auto	33	244	8.68	24.50	**0.35**	0.25	0.50	Under
Full Size Auto	13	134	3.42	13.45	**0.25**	0.15	0.44	Under
Minivan	28	50	7.37	5.02	**1.47**	0.94	2.30	Unsure
Large Van	15	15	3.95	1.51	**2.62**	1.29	5.31	Over
Compact Pickup	50	74	13.16	7.43	**1.77**	1.26	2.49	Over
Large Pickup	34	61	8.95	6.12	**1.46**	0.98	2.18	Unsure
Compact SUV	9	6	2.37	0.60	**3.93**	1.41	10.97	Over
Midsize SUV	80	39	21.05	3.92	**5.38**	3.74	7.74	Over
Large SUV	13	8	3.42	0.80	**4.26**	1.78	10.19	Over
Other Light Truck	0	1	0.00	0.10	**0.00**	N/A	N/A	N/A
Other Medium Truck	6	7	1.58	0.70	**2.25**	0.76	6.64	Unsure
Heavy Truck	29	29	7.63	2.91	**2.62**	1.59	4.33	Over
Total	380	996						

Table 12.9: All Fatalities by Vehicle Subtype

Vehicle Subtype	Number of Vehicles		Percent of Vehicles		ORF	Min CI	Max CI	Level
	With Fatal	With No Fatality	With Fatal	With No Fatality				
Subcompact Auto	211	145	15.27	8.35	**1.83**	1.50	2.23	Over
Compact Auto	191	159	13.82	9.15	**1.51**	1.24	1.84	Over
Midsize Auto	277	203	20.04	11.69	**1.72**	1.45	2.03	Over
Full Size Auto	147	123	10.64	7.08	**1.50**	1.19	1.89	Over
Minivan	78	116	5.64	6.68	**0.85**	0.64	1.12	Unsure
Large Van	30	32	2.17	1.84	**1.18**	0.72	1.93	Unsure
Compact Pickup	125	120	9.04	6.91	**1.31**	1.03	1.66	Over
Large Pickup	96	153	6.95	8.81	**0.79**	0.62	1.01	Unsure
Compact SUV	15	12	1.09	0.69	**1.57**	0.74	3.35	Unsure
Midsize SUV	119	96	8.61	5.53	**1.56**	1.20	2.02	Over
Large SUV	21	21	1.52	1.21	**1.26**	0.69	2.29	Unsure
Other Light Truck	1	`9	0.07	0.52	**0.14**	0.02	1.10	Unsure
Other Medium Truck	13	69	0.94	3.97	**0.24**	0.13	0.43	Under
Heavy Truck	58	479	4.20	27.58	**0.15**	0.12	0.20	Under
Total	1382	1737						

Table 12.10 shows the distribution of overturned vehicles according to driver age. As can be seen from the table, the age group 15-24 is overrepresented in rollovers. This means the younger drivers rollover the vehicles more frequently as compared to the other age groups in the dataset. The age group 85-94 is highly underrepresented in the dataset, since there is only one driver in that age group that rolled over the vehicle. For the other age groups no definite conclusion can be drawn as to whether they are over or under represented as the 95% confidence interval contains one. Drivers of unknown age are also underrepresented in rollover, since this is a group composed primarily of hit and run drivers.

Table 12.10: Age Group in Vehicle Rollovers

Age Group	Roll	Non-Roll	% Roll	% Non-Roll	ORF	Min CI	Max CI	Level
15-24	133	478	25.93	15.97	**1.62**	1.37	1.92	Over
25-34	110	552	21.44	18.44	**1.16**	0.97	1.40	Unsure
35-44	102	569	19.88	19.00	**1.05**	0.87	1.26	Unsure
45-54	78	441	15.20	14.73	**1.03**	0.83	1.29	Unsure
55-64	41	266	7.99	8.88	**0.90**	0.66	1.23	Unsure
65-74	23	190	4.48	6.35	**0.71**	0.46	1.08	Unsure
75-84	18	156	3.51	5.21	**0.67**	0.42	1.09	Unsure
85-94+	1	58	0.19	1.94	**0.10**	0.01	0.72	Under
Unknown	7	284	1.36	9.49	**0.14**	0.07	0.30	Under
Total	513	2994						

To determine whether gender of the driver influences the rate of rollovers, a comparison was done. As can be seen from Table 12.11, there is no such difference, as males and females are only slightly more likely to rollover a vehicle. Again, drivers of unknown gender, including hit and run drivers, are much less likely to have rolled over the vehicle.

Table 12.11: Driver Gender in Vehicle Rollovers

Driver Sex	Roll	Non-Roll	% Roll	% Non-Roll	ORF	Min CI	Max CI	Level
Male	386	2146	75.24	71.68	**1.05**	0.99	1.11	Unsure
Female	123	751	23.98	25.08	**0.96**	0.81	1.13	Unsure
Unknown	4	97	0.78	3.24	**0.24**	0.09	0.65	Under
Total	513	2994						

Table 12.12 provides a detailed distribution of speed of rollover vehicles with respect to the posted speed. The color ranges describe the vehicles well below posted speed, approximately within the posted speed and well above the posted speed or speeding. It was found that about 27

percent of vehicles were traveling above the posted speed, and about 13 percent were below the speed limit. About 60 percent of all vehicles that rolled over were traveling approximately at the limit.

Table 12.13 depicts the vehicle speed of *at-fault* drivers who rolled over the vehicle. It can be seen that almost 86 percent of the at-fault drivers were speeding, as opposed to only 60 percent of all drivers. Speeding was found to be a primary contributing cause for rollovers. At high speed the drivers were not able to keep the vehicle in control, and a slight decision error such as jerking the steering and overcorrection led to loss of lateral stability and overturning, either with or without running off the road. Speeding, overcorrection, loss of control and abrupt maneuvers were mainly associated with younger drivers. There were only 14 percent of at-fault drivers who were traveling approximately at the limit and rolled over.

Table 12.12: Speed of Rollover Vehicles

Posted Speed	Vehicle Speed in Rollover Crashes										
	0-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	>105
25	20.00	40.00	0.00	0.00	0.00	20.00	20.00	0.00	0.00	0.00	0.00
30	16.67	33.33	0.00	16.67	33.33	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	0.00	12.50	37.50	12.50	25.00	0.00	0.00	12.50	0.00	0.00
40	0.00	0.00	0.00	28.57	28.57	0.00	14.29	14.29	0.00	14.29	0.00
45	2.00	6.00	4.00	18.00	42.00	16.00	10.00	2.00	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	60.00	20.00	20.00	0.00	0.00	0.00	0.00
55	7.94	0.79	0.00	1.59	8.73	57.14	15.08	6.35	0.00	1.59	0.79
60	7.14	2.38	2.38	0.00	2.38	61.90	7.14	11.90	2.38	2.38	0.00
65	2.90	1.45	1.45	1.45	1.45	17.39	56.52	11.59	5.80	0.00	0.00
70	6.72	0.00	0.00	0.75	1.49	5.22	52.24	25.37	3.73	3.73	0.75

Table 12.13: At Fault Speed in Rollover Vehicles

Posted Speed	At Fault Vehicle Speed in Rollover Crashes								
	25-34	35-44	45-54	55-64	65-74	75-84	85-94	95-104	105+
25	0.00	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
30	0.00	33.33	66.67	0.00	0.00	0.00	0.00	0.00	0.00
35		0.00	25.00	50.00	0.00	0.00	25.00	0.00	0.00
40		0.00	25.00	0.00	25.00	25.00	0.00	25.00	0.00
45			23.53	41.18	29.41	5.88	0.00	0.00	0.00
50			0.00	50.00	50.00	0.00	0.00	0.00	0.00
55				21.05	50.00	21.05	0.00	5.26	2.63
60				0.00	30.00	50.00	10.00	10.00	0.00
65					33.33	44.44	22.22	0.00	0.00
70					0.00	71.43	14.29	11.90	2.38

12.5 SUV Rollover Characteristics

As demonstrated in the previous section, SUV's tend to rollover often than non-SUV's. Because SUV's have higher rollover rates, a study of rollover crashes with a focus on SUV's was done. Table 12.14 shows the number of SUV's and non-SUV's involved in rollover crashes and those involved in non-rollover fatal crashes for comparison. There were 523 vehicles that rolled over in vehicle types one through six. Note that there are just 10 percent of SUV's involved in fatal crashes, but approximately 41 percent of them rolled. This is a significant number as compared to non-SUV rollovers, which were only 14 percent. Thus it can be said SUV's are three times more likely to rollover than the non-SUV's. Conversely, the non-SUV's are much less likely to be in a rollover than the SUV's.

Table 12.14: Number of SUV and Non-SUV Rollovers

Rollover	SUVs	Non-SUV's	Total	ORF	Min CI	Max CI	Level
Yes	126	397	523	2.78	2.37	3.27	Over
No	180	2288	2468	0.69	0.63	0.76	Under
Total	306	2685	2991				

Table 12.15 shows the number of fatalities that occurred in SUV's that rolled as compared to SUV's that did not. The average number of fatalities in SUV rollover crashes is 0.93; in other words there are 93 fatalities every 100 rollovers. For the non-rollover SUV crashes there are 35 fatalities per 100 rollovers. From the table, it can be seen that though there were fewer SUV rollovers than non-rollovers, there were almost twice as many fatalities in these crashes.

Table 12.15: Number of Fatalities in SUV Rollover Crashes

SUV	Rolled	Non-Rolled	ORF	Min CI	Max CI	Level
Non-Fatal	17	123	0.43	0.27	0.68	Under
Fatal	109	57	5.95	4.75	7.45	Over
Total	126	180				

Table 12.16 examines the contributing factors for rollover crashes. There is not much difference in the crash types of SUV and non-SUV rollover crashes with a few exceptions: SUV's are overrepresented in crashes with driver distraction, excess steering input, and tire tread separation. All of these types correspond to events with rotation about the yaw axis (z-axis), potential loss of lateral stability and/or sudden weight shift. These phenomenon are associated with rollover in SUV's because of their high centers of gravity. Rollover resulting from tire tread separation in SUV's has been highly publicized in the news media.

Table 12.16: SUV Rollovers by Primary Contributing Factor

Class	Factor	Rolled	Not	ORF	Min CI	Max CI	Level
Environment	Smoke/Fog	1	2	1.729	0.158	18.938	Unsure
	Wet/Slippery	0	1	0.000	N/A	N/A	N/A
	Dark	0	1	0.000	N/A	N/A	N/A
Human	Aggression	0	7	0.000	N/A	N/A	N/A
	Alcohol/Drugs	40	176	0.786	0.588	1.050	Unsure
	Decision	8	28	0.988	0.460	2.121	Unsure
	Distraction	5	5	3.459	1.015	11.784	Over
	Fatigue/Asleep	8	17	1.628	0.717	3.695	Unsure
	Inattention	26	124	0.725	0.496	1.061	Unsure
	Medical	1	7	0.494	0.061	3.984	Unsure
	Mental/Emotional	1	1	3.459	0.218	54.961	Unsure
	Perception	2	4	1.729	0.320	9.348	Unsure
	Police Pursuit	1	0	N/A	N/A	N/A	N/A
	Speed	16	49	1.129	0.663	1.925	Unsure
	Steering Input	14	24	2.018	1.072	3.799	Over
	Unknown	4	25	0.553	0.196	1.565	Unsure
	Other	0	2	0.000	N/A	N/A	N/A
Other	Other	0	2	0.000	N/A	N/A	N/A
Roadway	Curvature	1	1	3.459	0.218	54.961	Unsure
	Obstruction	1	4	0.865	0.097	7.677	Unsure
	Other	0	3	0.000	N/A	N/A	N/A
Vehicle	Other defect	1	6	0.576	0.070	4.750	Unsure
	Tires	16	16	3.459	1.773	6.746	Over

Owing to severity of rollover crashes, it is very important to understand how and why these rollovers occur. There are two primary types of rollovers, namely tripped and untripped. A tripped rollover occurs when the vehicle is tripped by a fixed object, another vehicle, or soft soil. The relative height of the resistive or frictional force, coupled with the higher center of gravity of the vehicle, causes the vehicle to rollover. Untripped rollovers occur solely due to weight shift on the tires or loss of lateral stability of the vehicle. During the weight shift, the load of the entire vehicle comes of two tires and the vehicle topples over. Sudden abrupt steering or evasive maneuvers cause this type of rollover.

Table 12.17 examines the rollover mechanism for the vehicles in the dataset that rolled over. As can be seen in the table, the rollover in both SUV's and non-SUV's occurred due to tripping approximately 95 percent of the time. SUV's were overrepresented in untripped rollovers; however, the factor was not statistically significant due to overall low numbers. The distribution of tripping mechanisms for SUV's and non-SUV's is given in Table 12.18. Of the tripped rollovers in both SUV's and non-SUV's, about 58 percent of occurred on grass and 30 percent after colliding with point fixed objects such as utility poles, tress etc. About 12 percent of rollovers occurred after tripping over guardrails. SUV's are overrepresented in tripping on grass and underrepresented in tripping on trees and poles.

Table 12.17: Rollover Mechanism in Vehicles

Rollover	SUV	Non-SUV	ORF	Min CI	Max CI	Level
Tripped	113	368	**0.97**	0.91	1.03	Unsure
Untripped	13	29	**1.41**	0.76	2.63	Unsure
Total	126	397				

Table 12.18: Types of Tripping in Rollover Vehicles

Tripped by	SUV	Non-SUV	ORF	Min CI	Max CI	Level
Grass	66	170	**1.26**	1.04	1.53	Over
Vehicle	28	100	**0.91**	0.63	1.31	Unsure
Wall	3	16	**0.61**	0.18	2.06	Unsure
Ditch	2	7	**0.93**	0.20	4.42	Unsure
Guardrail	7	24	**0.95**	0.42	2.15	Unsure
Trees/Poles	2	29	**0.22**	0.05	0.93	Under
Others	5	22	**0.74**	0.29	1.91	Unsure
Total	113	368				

Table 12.19 shows the number of drivers involved in SUV and Non-SUV rollover crashes by gender. This table compares whether driver sex influences the rollovers in SUV and Non-SUV crashes. As can be seen from the figure, females roll over SUV's more frequently than non-SUV's. It cannot be concluded from the available data whether males are over or under represented in the dataset. It can be stated with 95 percent confidence that female drivers rollover SUV's more often than the male population. This might indicate a tendency by female drivers, when faced with a need to respond to a driving stimulus (e.g. a stopped vehicle or an obstruction in the road) to engage in a sudden evasive maneuver or abrupt steering input, initiating rollover of the vehicle.

Table 12.19: Rollover Crashes by Driver Gender

Driver Sex	SUV	Non-SUV	ORF	Min CI	Max CI	Level
Male	88	309	**0.89**	0.78	1.01	Unsure
Female	38	84	**1.41**	1.02	1.96	Over
Total	126	393				

Table 12.20 and Figure 12.4 present the distribution of driver age in rollover crashes. There are no significant differences. The age group from 15-24 is more frequently involved in

rolling over SUV. At the same time the age group 75-84 is highly overrepresented in SUV rollovers. The overrepresentation of young age drivers is due to inexperience, speeding and driving under influence. In older drivers, reasons such as failing to negotiate curves and decision-making problems seem to be predominant.

Table 12.20: Rollover Crashes by Driver Age

Age Group	SUV	Non-SUV	ORF	Min CI	Max CI	Level
15-24	35	101	**1.09**	0.79	1.52	Unsure
25-34	30	83	**1.14**	0.79	1.64	Unsure
35-44	24	80	**0.95**	0.63	1.42	Unsure
45-54	19	60	**1.00**	0.62	1.61	Unsure
55-64	6	36	**0.53**	0.23	1.22	Unsure
65-74	5	18	**0.88**	0.33	2.31	Unsure
75-84+	6	12	**1.58**	0.60	4.11	Unsure
Unknown	1	7	**0.45**	0.06	3.62	Unsure
Total	126	397				

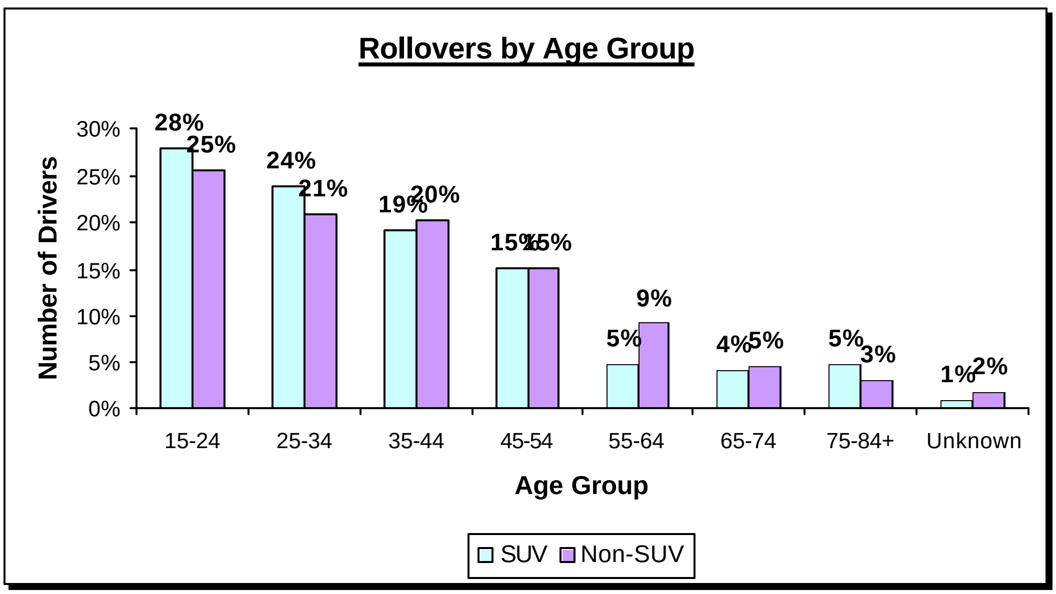


Figure 12.4: Age Group in Rollovers

12.6 Fatality Causative Factors

Fatality contributing factors are measured in terms of safety equipment in use, such as airbag and seatbelt, ejection rates of the occupants and severity of the crash in terms of number of overturns. Table 12.21 and Figure 12.5 show the total safety equipment in use by the occupants of the vehicles that rolled over. Total safety equipment means the safety features that were in use during the time of crash. Overall, 62 percent of the rollover occupants died. This shows that rollovers are one of the most severe crash events. However, when there was only airbag present and seatbelt was not in use, the fatality rate was highest, at 82 percent. Only 34 percent of the occupants with a seat belt and no airbag died. The addition of airbags appears to worsen outcomes, both with and without seatbelts; however, upon review of the THI's, this appears to be an issue with interpretation of "safety equipment *in use*." In a number of cases where an airbag was present and did not deploy, the officer did not mark the FTCR with the code for airbags in use. Presumably, the officer either did not know that the vehicle had an airbag, because it didn't deploy, or he assumed that the airbag was not *in use* because it did not deploy,

Table 12.21: Injury Severity by Safety Equipment

Safety Equipment Used	Injury Severity					Total
	None	Possible	Non-incapacitating	Incapacitating	Fatal	
Airbag	0	1	0	12	59	72
Seatbelt	11	8	33	31	42	125
Airbag & Seatbelt	2	3	16	16	29	66
Not in Use	4	6	13	35	184	242
Unknown	1	0	3	5	9	18
Total	18	18	65	99	323	523

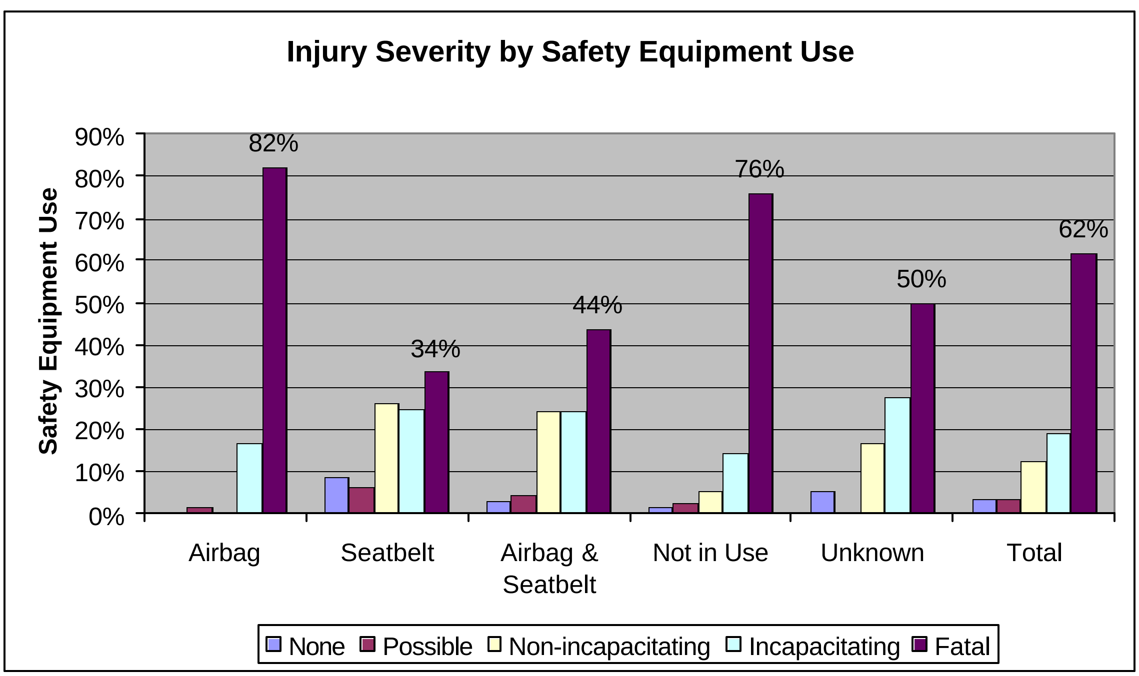


Figure 12.5: Injury Severity by Safety Equipment Use

Airbags are provided in vehicles to reduce the injury severity in case of crashes. Airbags are helpful for planar crashes such as head-on collisions. They deploy in case of frontal impact. Rollovers are complex phenomenon; they are the non-planar in nature. Thus airbags often do not deploy and do not help in reducing injuries. While the pre-2002 FTCR doesn't have information as to whether the airbag deployed, the THI typically did. Unfortunately, that data was inconsistent with what was given on the crash report in approximately 20 percent of the rollover cases. Further, the issue was sometimes not addressed in the THI, or the THI was not available, meaning that we had no information as to whether the airbag deployed.

Given all of that, Table 12.22 and Figure 12.6 show the available information on airbags as contained in the homicide reports. Where the homicide report indicated that an airbag was presented, it is noted to have deployed approximately 55 percent of the time. However, it is difficult to draw conclusions on the effect of the airbag on injury status for a number of reasons, including the large amount of missing data, the high rates of severe and fatal injuries, and the low number of cases where the vehicle was known to have an airbag. Looking only at those cases, deployment of the airbag correlates with slightly lower rates of severe injuries, and somewhat higher fatality rates. This could indicate that the airbags are not helpful in preventing deaths in rollover crashes.

Table 12.22: Airbag Status from Homicide Report

Injury	Deployed	Not Deployed	No airbag	Unknown
None	2	0	6	3
Possible	4	1	4	4
Non-Incapacitating	5	10	13	17
Incapacitating	12	18	26	15
Fatal	55	36	100	66
Total	78	65	149	105

Table 12.23 and Figure 12.7 show the ejection rate according to the seatbelt use. As can be seen from the figures, the ejection rate is extremely low for the people who were using seatbelt. On the other hand, almost two-thirds of the occupants not wearing seatbelt were ejected from the vehicle.

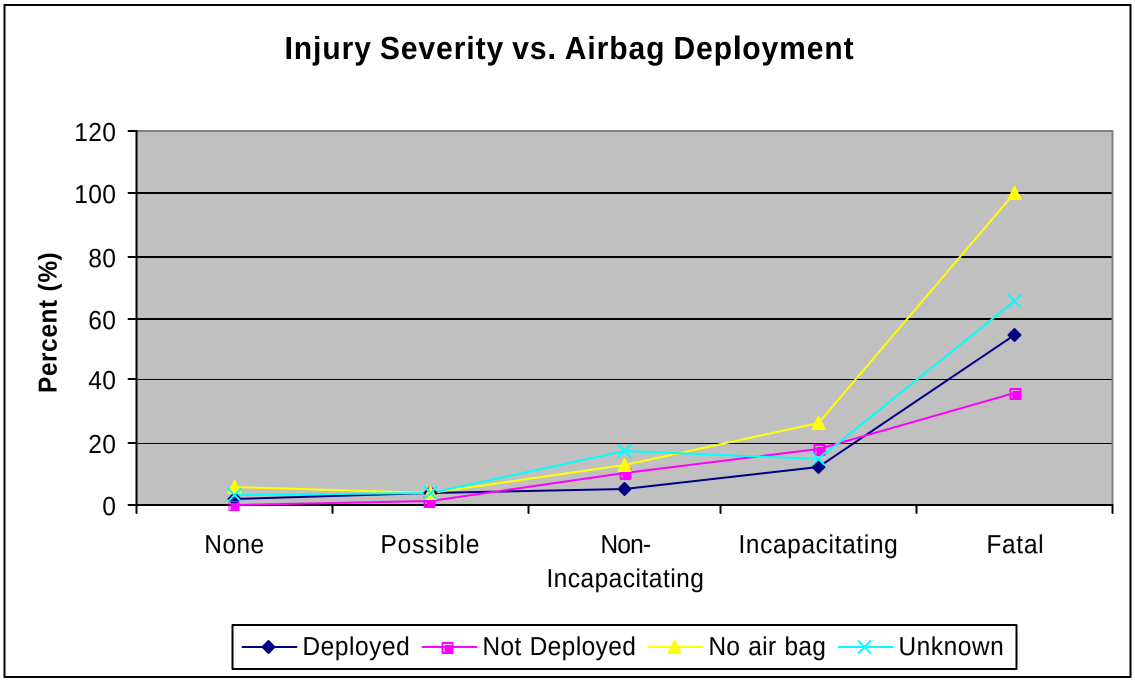


Figure 12.6: Airbag Status from Homicide Report

Table 12.23: Ejection by Seatbelt Use

Ejected	Seatbelt		ORF	Min CI	Max CI	Level
	In Use	Not in Use				
No	178	99	2.951	2.36	3.48	Over
Yes	7	188	0.061	0.02	0.14	Under
Partial	5	19	0.432	0.19	1.38	Unsure
Unknown	8	19	0.691	0.3	1.96	Unsure
Total	198	325				

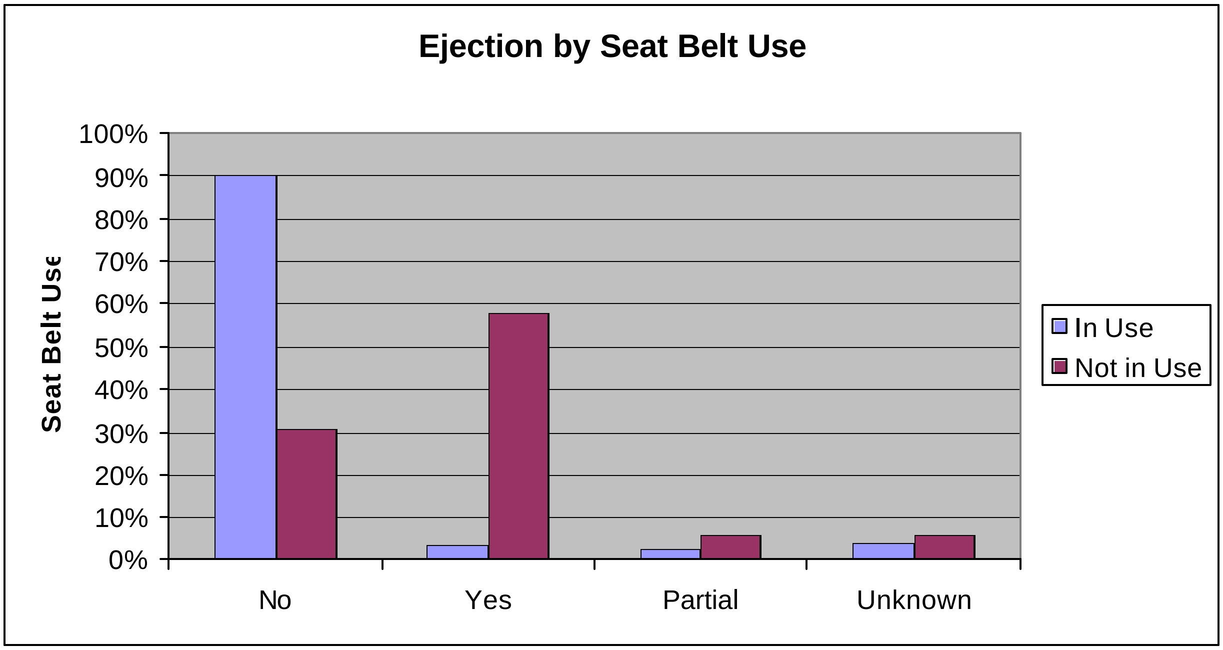


Figure 12.7: Ejection by Seatbelt Use

Putting together information from the last two tables, Table 12.24 and Figure 12.8 observe the injury severity of the occupants by ejection. As can be seen from the chart, the level of severity was highest for the occupants that were either completely or partially ejected during the rollover. The occupants who were not ejected fared better than the occupants who were ejected. There were less severe injuries and fatalities amongst this group: 84 percent of the occupants who were ejected or partially ejected died during the rollover, while only 45 percent of those who remained in the vehicle during the rollover died. Based on previous research, the unbelted occupant is the most vulnerable to ejection and fatality; however, even the belted occupant is at risk because some seatbelts are primarily designed to withstand the forces of the planar crash. The outward motion of the occupants during the rollover, a motion which is not as well resisted by seatbelts, as well as passenger compartment intrusion and crushing during rollover help to explain the relatively high fatality rate, even among non-ejected occupants. However, because seat belt use is inversely correlated with ejection, and ejection is highly correlated with fatality, it is understandable that seat belt use improves survivability in rollover crashes.

Table 12.24: Injury Severity by Ejection in SUV's

Ejection	Injury Severity						Total
	None	Possible	Non-incapacitating	Incapacitating	Fatal	Unknown	
No	15	18	62	62	131	1	289
Yes	0	0	2	30	167	0	199
Partial	0	0	1	3	20	0	24
Unknown	3	0	0	0	3	5	11
Total	18	18	65	95	321	6	523

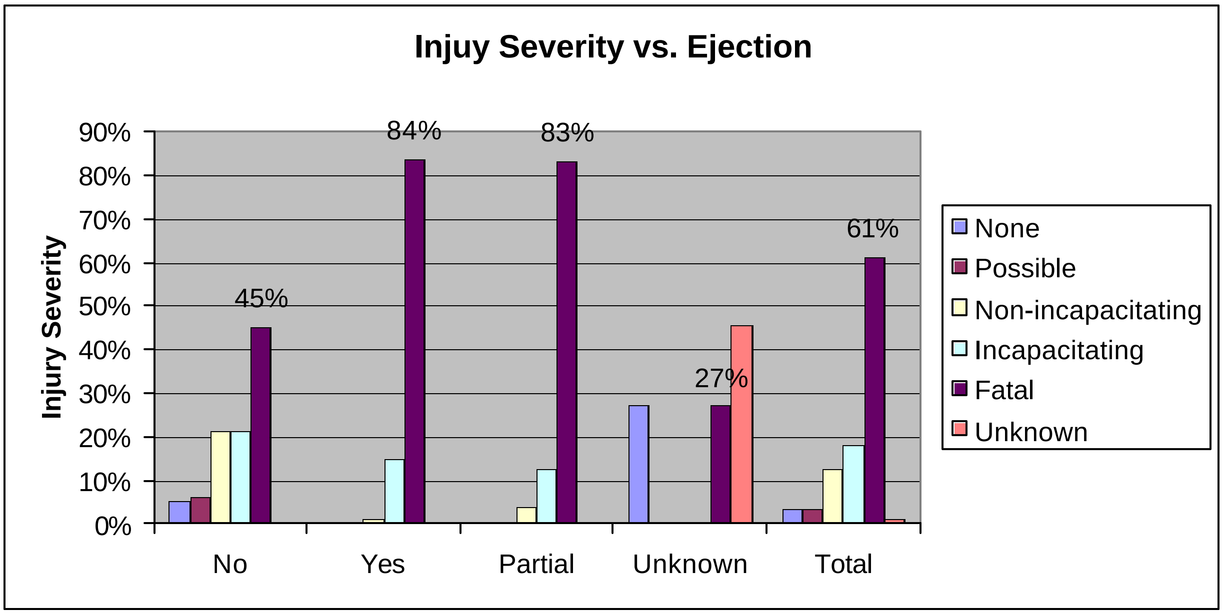


Figure 12.8: Injury Severity by Ejection

To find out the association between ejection and fatality rates, an odds ratio was computed as shown.

Fatality	Ejection	
	Yes	No
Yes	187	134
No	36	166

$$\text{Odds of Death by Ejection} = \frac{187}{36} = 5.19$$

Odds of Death with No Ejection = $\frac{134}{166}$ = 0.81

Odds Ratio = 6.45

The odds ratio is much greater than one. This indicates that the odds of death by ejection are much higher than the odds of death with no ejection. In other words, there is strong association between dying and ejection.

It has been suggested that occupants of SUV's are more vulnerable to fatality in the event of a rollover than non-SUV's because the roofs are subject to severe deformation and passenger compartment intrusion in rollovers. To find out the association between vehicle type and fatality rates, odds ratios were computed for all vehicle occupants as shown.

Fatality	SUV	
	Yes	No
Yes	75	246
No	51	145

Odds of Death in SUV = $\frac{75}{51}$ = 1.47

Odds of Death in non-SUV = $\frac{246}{145}$ = 1.70

Odds Ratio = 0.877

Because the odds ratio is less than one, this indicates that the odds of death in an SUV rollover are actually lower than the odds of death in a rollover in another type of vehicle. Repeating the calculation for only non-ejected occupants, the results are as follows.

Fatality	SUV	
	Yes	No
Yes	30	101
No	41	116

Odds of Death in SUV = $\frac{30}{41}$ = 0.732

Odds of Death in non-SUV = $\frac{101}{116}$ = 0.871

Odds Ratio = 0.840

Again, the odds ratio of less than one shows that SUV occupants who remain in the vehicle are also less likely to die than occupants who remain inside a non-SUV during a rollover event.

Table 12.25 shows the number of overturns the vehicle undergoes during the rollover for both SUV's and non-SUV's. In most of the cases, 56 percent, the vehicle overturned more than once. SUV's tended to fully overturn more frequently than not SUV's, by a factor of 1.48.

Table 12.25: Number of Overturns in Rollover Vehicles

Number of Overturns	SUV	NON-SUV	ORF	Min CI	Max CI	Level
1	10	79	**0.40**	0.21	0.75	Under
2	10	72	**0.44**	0.23	0.82	Under
3	2	10	**0.63**	0.14	2.84	Unsure
4	9	34	**0.83**	0.41	1.69	Unsure
>4	95	202	**1.48**	1.29	1.70	Over
Total	126	397				

Table 12.26 and Figure12.9 show the injury severity by the number of overturns in SUV and non-SUV rollover crashes. Sixty four percent of occupants were killed in rollover when the vehicle overturned three or more quarter turns, while only 43 percent died when the vehicle turned only one quarter-turn. In general the trend for two quarter turns is very close to that of three or more quarter turns. As can be seen from the chart, the rate of fatalities is high for the rollover, especially when there are at least two quarter turns.

Table 12.26: Number of Quarter Turns by Injury Severity in Rollovers

Quarter Turns	None	Possible	Non Incapacitating	Incapacitating	Fatal	Total
1	5	9	17	25	42	98
2	3	4	8	14	59	88
3+	4	8	44	68	222	346
Total	12	21	69	107	323	532

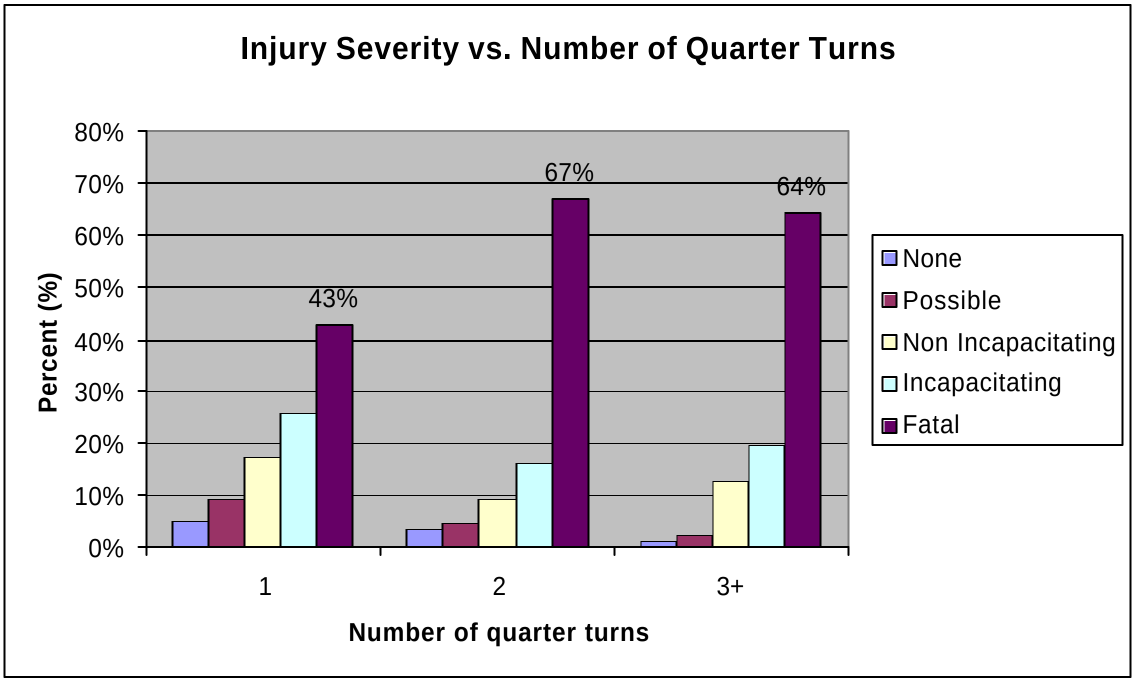


Figure 12.9: Injury Severity by Number of Quarter Turns

12.7 Conclusions and Recommendations

This section provides a summary of major conclusions regarding rollover crashes, including factors contributing to both the rollover crashes and fatalities in rollover crashes. A number of countermeasures are recommended as well.

12.7.1 Crash Contributing Factors

As discussed in Chapter 5.3, the proportion of SUV's involved in fatal crashes was less than the rate at which they were driven. This indicates that SUV's are not inherently more dangerous than other vehicles. However, sports utility vehicles were found to have the highest rollover rates compared to other vehicle types. Compact, midsize and large SUV's had highest rollover propensity as compared to other vehicle subtypes. These vehicle subtypes were followed by large vans and compact pickup trucks.

The fatality rates due to rollovers were found to be higher in large vans; compact pickups; compact, midsize and large SUV's; and CMV's respectively. However, subcompact, midsize and large automobiles were underrepresented in rollover fatalities. After examining fatality rates in general, i.e. irrespective of rollovers, occupants in passenger cars, compact pickups and midsize SUV's were more likely to incur severe or fatal injuries when involved in a severe crash.

Driver errors were the most significant contributing factors in the rollover crashes. From the case reviews of single and multi vehicle crashes, driver factors that accounted for rollovers were incapacitation followed by driver inattention. Incapacitation includes cases where the driver did not control the vehicle because he/she was either under the influence of alcohol or drugs or fatigued or asleep. Driver inattention refers to driver actions such as improper lane change, failing to slow for stopped traffic, incorrect passing and so on. The cases of drivers with medical problems were significantly high for non-SUVs rollovers.

It was found that there were more males driving both SUV's and non-SUV's in the fatal crashes. However, females were overrepresented in rolling over SUV's when compared to the non-SUV's. The age of the drivers was found to have significant effect in rollover crashes of both SUV's and non-SUV's. It was found that younger drivers rolled over vehicles more frequently than older drivers. However, enough evidence was not established to prove any significant differences between rollovers and age in comparison of SUV's with non-SUV's. It was also determined that younger drivers were driving over the speed limit more often than the older drivers and they were more prone to reckless driving. The drivers who were at-fault and rolled over the vehicle were found to be driving over the speed limit more frequently than the not at-fault drivers.

Differences in rollover rates among various vehicle types were discussed previously. It was determined that several factors contributed to rollover in the vehicles. Considering only vehicle defects, tire tread separation and tire blowouts were found to be the causative factors in SUV rollovers more frequently than in non-SUV rollovers. All rollovers were mainly caused by tripping of the vehicle over grass shoulder or median. Neither the vehicle movement prior to the crash nor any vehicle defects significantly contributed to the crash. Over 50% of the rollover crashes involved run off road as the primary event. However, many rollovers occurred when the vehicle left the pavement subsequent to another collision event, e.g. a collision with another vehicle. Over 90% of all rollover crashes were tripped, of which 25% were tripped by an impact with another vehicle. This leaves 75% of the tripped vehicles that were initiated by grass or another roadside object. Overall approximately 45% of the rollovers were tripped by grass or soft soil. This type of rollover was overrepresented in SUV's. The most common fixed objects that tripped vehicles were guardrails, followed by trees/poles, each of which were responsible for about 30 rollover cases.

The geographical area had an effect on the fatality rates in rollover crashes. Over seventy percent of the rollovers occurred on rural roads, when fewer than 60 percent of the state roads are rural (measured in terms of centerline miles). This is likely due to higher speeds on those roads, coupled with decreases in driver performance resulting from longer trips. Rollovers were not more likely to occur on curves or in construction zones than other crash types. Rollover crashes occurred more frequently on roads with lower traffic volumes, and non-SUV rollovers were overrepresented on roads with average daily traffic less than 10,000.

Environmental factors were not found to be significant contributing factors in this dataset. Approximately equal numbers of crashes occurred during daylight and dark hours. Very few crashes occurred in severe weather and these crashes did not form a significant part of the database. Thus, the environmental factors are underrepresented in all rollover crashes.

12.7.2 Fatality Contributing Factors

Ejection was found to be the main cause of fatality in rollover crashes. This was due to the low safety belt usage among drivers and passengers. Also, considering the fact that the safety belts are not designed for non-planar rollover crashes, they were not very helpful in restraining the outward movement of the occupants. It was observed that the airbag deployed in a small number of cases. Most of the rollovers occurred sideways and deployment of frontal airbags had little or no effect on the injuries sustained by the occupants. It was found that the severity of the crash increased by the number of overturns the vehicle makes before coming to rest. Overall a higher percentage of non-SUV occupants died in rollovers of at least 2 quarter turns while SUV occupants had a higher fatality rate when there was only single quarter turn. It was observed that the main cause of fatalities in rollover crashes was dominated by injuries mostly in upper part of the body. Head injuries and blunt force trauma injuries to head & neck were most common followed by chest trauma and skull fracture.

12.7.3 Crash Reduction Countermeasures

An overall goal of the study was to find countermeasures to reduce the number of rollover crashes and fatalities in the state. Based on the seen characteristics the rollover crashes, countermeasures are recommended in these areas as follows.

Engineering: Not many roadway issues were found to contribute to the rollover crashes; however, most rollover crashes involved running off the road onto the roadside. Of these, the most significant tripping mechanism was grass or soft soil, responsible for over 40 percent of the rollovers. Potential countermeasures such as widening paved shoulders and improving side slopes and soil condition should be considered.

Education: Driver actions were the most common contributing factor in rollover crashes. Alcohol & drug use, inattention and speeding contributed to large number of rollover crashes. Excess steering input, fatigue and distraction were also overrepresented in rollover crashes. Each of these can be addressed by educational as well as enforcement measures. Improper vehicle and tire maintenance also contributed to a significant number of rollovers, especially with SUV's. Younger drivers were highly overrepresented in rollover crashes, and while males were not overrepresented, they accounted for 75 of the rollover crashes. Educational campaigns directed toward these demographics would be most useful. However, females were overrepresented in SUV rollovers when compared to non-SUV rollovers, therefore educational campaigns could also be directed towards this demographic. A number of non tripped rollovers were associated with loss of control due to over correction or other abrupt evasive maneuvers or steering inputs. Although vehicle design issues affect stability and roll propensity, this is another issue that could be addressed through educational campaigns focusing on correct behavior upon drifting off the road or encountering an obstacle or other sudden unexpected condition.

Enforcement: Speeding and driving under influence are two areas where increased enforcement should be implemented. In 70 mph speed zones, approximately one-third of the rollover vehicles were traveling at least 5 miles over the limit, while speeding was seen at most speed limits.

13 AGE AS A CONTRIBUTING FACTOR

Because of the high rate of fatal crashes involving both older and younger drivers, age is considered separately as a driver contributing factor. First, relevant literature considering age as a factor is presented, followed by details of the methodology that are specific to this portion of the study.

13.1 Background and Literature Review

The elderly constitute nearly thirteen percent of the population of the United States and this group of people, ages 65 and above, is an increasing percent of the population every year (United States, 2002). The U.S. society has experienced a tremendous demographic transition in recent decades, and trends toward an increasing number of older drivers have been well documented. By 2030, more than one in five Americans will be over age 65. The size of the elderly population reached 34.5 million people (12.7 percent of the total population) in the United States in 1999. The U.S. Census Bureau estimates that there will be about 70 million older persons (20 percent of the entire population) by 2030, more than twice the number in 1999. Senior citizens now constitute the fastest growing segment of the United States population.

13.1.1 Roadway Issues Affecting Older Drivers

A rapidly increasing number of older people may require the urban landscape and transportation systems to be reinvented to cope with the demographic transition of society. How to design more accessible living environments and to help the elderly maintain mobility in the wave of their growing number are significant challenges to society. In 1995, the average older American made 3.4 trips per day, totaling 24.4 miles per day, which works out to be about 7.2 miles per trip (Hu, 1999). An increasing number of older adults will continue to travel, both as drivers and as pedestrians, as they age. Age related changes can be relevant to safe driving performance. From an older traveler's perspective, highway signs and other traffic control devices are frequently not large enough, not bright enough or not properly located. Complex intersections can be too confusing and required walking speeds can be too fast for many older pedestrians. A number of these issues are discussed in more detail below.

Decrements in cognitive and psychomotor functions associated with the aging process increases the distance at which a sign must be visible for older drivers to have sufficient time and distance to find a sign, comprehend its massage and respond appropriately. Careful sign placement ensures that a driver has plenty of time to detect the sign and take necessary action. Studies have shown that signs should be located within 10 degrees of an older driver's line of sight for maximum visibility. All signs displaying right-of-way rules at intersections should be placed on the far side of the intersection approach whenever possible. In this way drivers stopped at the stop bar will be able to find and read signs displaying left turn protected / permitted rules and right-turn-on-red status without the need to make large head and neck movements.

A number of factors can affect a driver's ability to recognize and understand the information being conveyed on a road sign. Chief among these is the choice of text and symbols on the sign. Research has shown that the legibility distance of symbols is approximately twice that of alphanumeric signs (*Synthesis*, 1997). Symbols, however, require a different kind of comprehension than words. Symbol meaning is either understood intuitively or learned. Research has shown that what is intuitive to designers is not always intuitive to drivers, and that teaching observers the meaning of more abstract symbols is frequently successful. Care should be taken when selecting to display information in a symbolic format; the target audience should readily understand the symbol's meaning. When words are used instead of symbols, a synthesis by Johnston (1974) found that, when capital letter height is equal, uppercase words have a 20 percent greater legibility distance than mixed-case words, but that when mixed-case loop height is equal to uppercase letter height, lowercase words are more legible than uppercase words.

Internal contrast is the difference between the luminance of the sign copy and its background. Nighttime traffic sign legibility and recognition heavily depend on the traffic sign background luminance, which has a strong causal link to the retro-reflectivity of the traffic sign sheeting material. Designers of modern traffic sign sheeting materials have almost full control over how intensely the incident headlight flux is to be returned to the observer. Therefore, it is imperative to know the luminance requirements of observers to design traffic sign materials that will effectively perform in the field. The FHWA synthesis report on older drivers (Synthesis 1997) provides conclusions dealing with daytime and nighttime luminance requirements from a number of studies, standards, and codes.

Sayed et al (2005) found that the addition of yellow retro-reflective sheeting to traffic signal backboards at signalized intersections can provide cost-effective road safety benefits. The results of this study indicated that the visibility improvements to the traffic signal backboards could reduce collisions by about fifteen percent. The cost of applying this improvement is minimal, especially when combined with regular signal construction or maintenance activities. The installation requires four strips of tape per backboard and only a few minutes of staff time to install. The cost to retrofit a backboard with retro reflective sheeting is approximately $35 (CDN). Therefore, for very large intersections that may have backboards for the two through movements and one protected left turn per approach, there are a total of 12 backboards and thus, the cost of retrofitting the intersection is less than $500. Figure 13.1 shows signals treated with the reflective sheeting at day and at night.

Figure 13.1: Signals with Retro-Reflective Sheeting, Shown at Day and Night

The factors which effect visual complexity include the number and overall density of the noise in the driver's visual field and the density of items immediately adjacent to the sign. External contrast is the difference between the luminance of the sign and that of the area immediately surrounding the sign. As the sign's external contrast ratio increases, so does the sign's conspicuity. Figures 13.2 and 13.3 depict scenarios in which a pedestrian warning sign is placed in a busy urban area and in a bare rural area (Shnell et al 2004). The ease with which the sign can be seen and recognized is much decreased in the scene with the visual clutter in the background.

Figure 13.2: Nighttime Visibility of Pedestrian Warning Sign on Simulated Urban Environment

Figure 13.3: Nighttime Visibility of Pedestrian Warning Sign on Simulated Rural Environment

Improved delineation can be accomplished through higher placement standard for retro reflective pavements markings, more frequent repainting of edges and center lines, and the use of raised pavements markers (RPM's) and other marking treatments, especially in areas of alignment changes or lane drops. Sometimes improper or fainted marking results in crashes as older drivers got confused with the markings. Staplin et al (1990) found that older drivers need pavement markings anywhere from 30 to 300 percent more retro reflective than younger drivers.

The angle at which intersecting roads meet is an important consideration in the design of new facilities. Intersections at an angle other than 90 degrees may require greater head movement to provide the necessary sight distance. This is practically troublesome for older drivers (Staplin et al 1997). FHWA guidelines for highway designs accommodating older drivers recommend that skew at intersections be limited to angles no greater than 75 degrees, and eliminated if right-of-way is not a concern (*Older* 1998).

The left turn maneuver from minor road onto the major road at a stop-controlled intersection is complex and requires a minimum sufficient sight distance. Because at-grade intersections define locations with the highest probability of conflict between vehicles, adequate intersection sight distance is particularly important. A number of related studies had shown that sight distance problems at intersections usually result in a higher crash rate (Hanna 1976, David 1979) During the unprotected left-turn green phase at four-leg intersections on divided highways, left turning drivers from the major road need to accept proper gaps or lags to cross the opposing through traffic into the minor road. However, vehicles in the opposing left-turn lane often block the left-turner's view. For that situation, available sight distance for left-turners is a very important geometric design factor. Inadequate visibility of opposing through traffic can cause not only a serious safety problem due to driver's misjudging the gap, but also increase intersection delay for the left-turn traffic. McCoy et al (1992) reported that, in California, signalized intersections with opposing left-turn lanes were found to have significantly more crashes than intersections without opposing left-turn lanes, which were attributed primarily to sight distance obstructions caused by opposing left-turn vehicles. For 90° intersections on level tangent sections of four-lane divided roadways with 3.6-m (12-ft) left-turn lanes in 4.9-m (16-ft) medians with 1.2-m (4-ft) medial separators,, the researchers state that: 1) a 0.6-m (2-ft) positive offset provides unrestricted sight distance when the opposite left-turn vehicle is a passenger car, and (2) a 1.06-m (3.5-ft) positive offset provides unrestricted sight distance when the opposite left-turn vehicle is a truck, for design speeds up to 113 km/h (70 mi/h).

One way to avoid some confusion regarding protected versus unprotected turns status is to avoid the use of both on the same approach if this could be accomplished without causing excessive delay on any approach.

A closer look at the freeway driving experience identifies several aspects that can be especially stressful for older drivers: merging into traffic flow from on-ramps, changing lanes, reading and interpreting road signs, and responding quickly to road hazards. Failure to yield and lane changes are the maneuvers more often associated with crashes involving older drivers (Harkey et al 1995).

In the United States, pedestrian fatalities account for nearly 12% of all traffic fatalities. Nearly two thirds of pedestrian fatalities occur at night, and insufficient pedestrian conspicuity is suspected to be a major causal factor. Collisions between vehicles and pedestrians are both common and devastating. In the year 2001, 4882 pedestrians were killed (11.6% of all traffic fatalities) and 78,000 pedestrians were injured (2.6% of all traffic injuries) in the United States alone (9). Older pedestrian can be expected to walk more slowly that younger pedestrian have trouble judging the speed of oncoming vehicles, and have difficulty with uneven pavement and sidewalk surfaces. Older pedestrian who misjudge the speed and /or the distance of an approaching vehicle and cannot traverse the entire width of the roadway are especially vulnerable. To avoid such crashes, pedestrian refuge island should be provided at wide crossings with high-speed traffic. In addition, the condition of the roadway at and around the crosswalk should be maintained and curb cuts should be provided when possible to minimize the chance of slip and fall accidents.

13.1.2 Recent Research on Older Drivers

Given both the expected growth in the number of older drivers and their over-involvement in fatal and serious injury crashes, there has been a world-wide call for improved licensing procedures to manage older driver safety (Langford et al 2004). In particular, licensing authorities have been urged to move from mandatory assessment of all older drivers to assessment practices targeting only those at higher crash risk. The current study examined older driver fatal and serious injury crash involvement rates across all Australian states to determine a possible association with the different licensing procedures. In particular, older driver crash involvement rates in Victoria (where there is no age-based assessment program) have been compared with rates in other jurisdictions with assessment programs. Crash involvement rates have been calculated using two denominators: per population and per number of licensed drivers. Some data limitations notwithstanding, older drivers in jurisdictions with age-based mandatory assessment programs could not be shown to be safer than drivers in Victoria. Further, there is some indicative evidence that older drivers in Victoria may have a significantly safer record regarding overall involvement in serious casualty crashes.

Owsley et al (2004) find that the older drivers (licensed drivers aged 60 years and older) have among the highest rates of motor vehicle collision involvement per mile driven of all age groups. Educational programs that promote safe driving strategies among seniors are a popular approach for addressing this problem, but their safety benefit has yet to be demonstrated. The objective of this study was to determine whether an individualized educational program that promoted strategies to enhance driver safety reduces the crash rate of high-risk older drivers.

Owsley et al (2003) argue that visual processing impairment increases crash risk among older drivers. He claims that many older drivers meet the legal requirements for licensing despite having vision impairments that elevate crash risk. The research used 365 older drivers who were licensed, visually impaired, and crash-involved in the prior year were randomly assigned to an intervention group or usual-eye-care control group to evaluate the efficacy of an educational intervention that promoted the performance of self-regulatory practices. The researchers designed educational curriculum to change self-perceptions about vision impairment and how it can impact driver safety and to promote the avoidance of challenging driving situations through self-regulation, leading to reductions in driving exposure. The study used pre and posttest control group methodology. The study finds that at post-test, drivers who had received the educational intervention were more likely to acknowledge that the quality of their eyesight was less than excellent, report a higher frequency of avoiding challenging driving situations (e.g. left-turns) and report performing more self-regulatory practices (e.g. three right-turns) as compared to controls. Additionally, drivers in the educational intervention group reported significantly fewer days, fewer places and fewer trips made per week as compared to those not receiving the educational intervention. Hence, the researchers argue that visually impaired older drivers at higher risk for crash involvement may benefit from educational interventions by reducing their driving exposure and increasing their avoidance of visually challenging driving situations.

Austin et al (2003) argue that the expected substantial increase in people aged 65 or older is important for those concerned about transportation injuries. They explore the differences across age groups using two nationwide travel surveys, crash involvement, fatalities, and injuries from crash databases and an ordered probit model of injury severity. The researchers identify two differences to explain injury risk, which are 1) older people are more likely to travel in passenger cars than younger people, who frequently use light trucks, and 2) that seriously injured older occupants are more likely to be involved in side-impact crashes than their younger counterparts (Austin et al 2003). The research further argues that increased attention to vehicle engagement in side-impact crashes and to vehicle technologies help drivers avoid side collisions, and hence helpful for older occupants.

Daigneault et al (2002) explore the relationships between the previous convictions or crashes and the risk of subsequent crashes of older drivers in Quebec, Canada. The first objective of the study was to describe the most common types of crashes in the elderly population of drivers living in Quebec (=65 years of age). The second objective of the study was to analyze the relationship between previous crashes or convictions and the risk of subsequent crashes. The major finding of the study is that the old drivers are characterized by error crashes involving more than one car, especially at intersections. It further explores that prior crashes are a better predictor for crash risk than prior convictions. The study concludes that these trends steadily increase with each age group (drivers 65 years old to 80 years or more).

Guerrier et al (1999) conduct research on the role of working memory, field dependence, visual search, and reaction time in the left turn performance of older female drivers. They argue that the older drivers have difficulties at intersections, especially in their performance of left turns. The study argues that the older females are especially at risk in intersection maneuvers. The research examines the relationship of field dependence, visual search skills, and working memory to the decision to make a left turn at an intersection as well as to gap choice. The research included respondents who were thirty-three women ranging in age from 61 to 84 years. The results show that working memory plays a very important role in left-turn performance. Implications for appropriate interventions are discussed.

Li et al (2003) estimated the roles of fragility (susceptibility to injury) versus excessive crash involvement in the increased fatality risk of older drivers per vehicle-mile of travel (VMT) using multiple national data systems. They computed the deaths per driver involved in a crash (a marker of fragility) and drivers involved in crashes per VMT (a marker of excessive crash involvement) for each age and gender group. The study finds that the drivers younger than 20 and older than 74 both had much higher driver death rates per VMT compared with drivers' ages 30–59. The research observed highest death rates per mile driven, 13-fold increases among drivers age 80 or older, who also had the highest death rates per crash. The study further finds that fragility begins to increase between ages 60–64 and increase steadily with advancing age, accounting for about 60–95% of the excess death rates per VMT in older drivers, depending on age group and gender. Among older drivers, the researchers argue that the observed excesses in crash involvement did not begin until age 75, but explained no more than about 30–45% of the elevated risk in this group of drivers; excessive crashes explained less of the risk among drivers ages 60–74. In contrast, the study argues that the crash over-involvement was the major factor contributing to the high risk of death among drivers younger than 20, accounting for more than 95% of their elevated death rates per VMT. The study concludes that although both fragility and crash over-involvement contributed to the excess death rates among older drivers per VMT, fragility appeared to be of over-riding importance. These outcomes suggest that measures to improve the protection of older vehicle occupants in crashes should be vigorously pursued.

Zhang et al (2000) conducted a population-based cross-sectional study to examine factors affecting the severity of motor vehicle traffic crashes (MVTC's) involving elderly drivers in Ontario. The study population included drivers aged 65 and over involved in injury-producing MVTC's between 1988 and 1993 on Ontario public roads. The study used data from the Canadian Traffic Accident Information Databank (TRAID) compiled from police reports. The study classified the severity of MVTC as fatal, major, minor or minimal. It compared fatal-, major-, minor- and minimal-injury crashes. It also examined the percentage distributions of crashes at each level of severity involving elderly drivers and tested using the Chi-squared test. The multivariate unconditional logistic regression was used to calculate the estimated relative risk as odds ratios while controlling for confounding factors. A number of factors were significantly related to the increased risk of fatal-injury in crashes compared with a reference category for each variable. These included age, sex, failing to yield right-of-way/disobeying traffic signs, non-use of seat belts, ejection from vehicle, intersection without traffic controls, roads with higher speed limits, snowy weather, head-on collisions, two-vehicle turning collisions, overtaking, and changing lanes. The study finds that the physical disabilities increased the risk of fatality by a factor of 5 for drivers 75–79 years of age and a factor of 3.5 for those 80 years and over. However, in the age group 65–74, medical/physical condition did not appear to be related to risk of fatality. The study found similar but weaker associations between these factors and risk of major- and minor-injury in crashes were also observed. The study concludes that strategies could target specific factors such as head-on collisions, single-vehicle collisions, and traffic controls at intersections to reduce the fatality of crashes, especially for the older drivers. The study recommends further study for driver conditions such as medical/physical conditions and driver actions such as failing to yield right-of-way/disobeying traffic signs.

13.1.3 Recent Research on Younger Drivers

Lam (2003) conducts an exploratory study to investigate factors associated with car crash injury among learner drivers across difference ages by using data routinely collected by the NSW police. The results obtained indicated that some factors are commonly associated with car crash injury across nearly all ages. On the other hand, some others are more age specific. On the whole, female learner drivers were more at risk of being killed or injured as compared to males. The drivers of 16 years old had an increased risk of crash injury due to environmental factors, such as special road feature, and distraction outside the vehicle. The increased risk of crash injury for older drivers (=25 years) was associated with distractions from both inside and outside vehicle. Nighttime driving posed a special risk to learner drivers aged 20–24 years old, but not other age groups. Speeding was a common factor for the increased risk of crash injury across all age groups. The implication of the results and limitations of the study were discussed.

Mayhew et al (2003) deal with the issue of changes in collision rates among novice drivers during the first months of driving. They argue that as a group, young drivers have crash rates that far exceed those of older, experienced drivers. They further claim that even among teenagers there are age-related differences; crash rates decline consistently and dramatically with each yearly increase in age. They researcher also studies the month-to-month changes in collisions among new drivers and finds that crash rates drop most dramatically during the first 6 months of driving. The research also explores that involvement in certain types of crashes, e.g. run-off-the-road, single-vehicle, night, weekend declines more rapidly. Hence the researchers argue that novices improve their driving in a relatively short period of time (Mayhew et al 2003).

Preusser et al (1998) conduct research on the effects of teenage passengers on the fatal crash risk of teenage drivers. They identified the fatal crash-involved drivers of passenger vehicles in the Fatality Analysis Reporting System for the period 1990 through 1995. Each driver was then categorized as being alone in the vehicle at the time of the crash or with one or more passengers. The at-fault drivers were defined as all drivers involved in a single-vehicle crash, or drivers in multiple-vehicle crashes who were coded in the Fatality Analysis Reporting System as committing one or more driver errors. The study finds that the passenger presence was associated with proportionately more at-fault fatal crashes for drivers aged 24 and younger, were a neutral factor for drivers aged 25–29, and were associated with fewer at-fault involvements for drivers aged 30 and older. The research further finds that the relative risk of fatal crash involvement was particularly high for teenage drivers traveling, day or night, with two or more teenage passengers.

Ulmer et al (2001) conduct research on Connecticut fatal crashes. The study explores the effects of implementing the first phase of graduated licensing requiring 16- and 17-year-olds to hold a learner's permit for 6 months (4 months with driver's education) prior to licensure. The research compared the crash rates for 16- to 18-year-olds in Connecticut before and after the change with crash rates in nearby counties in New York State. It finds that fatal/injury crash involvements of Connecticut 16-year-old drivers declined by 22% during the first full year following the law change. However, the study did not find significant differences between the males and females or as a function of the income level of the city/town in which the crash occurred. Also the fatal/injury crash involvements for 17- and 18-year-olds in Connecticut and 16-, 17-, and 18-year-olds in New York did not change significantly. The study concludes that delaying teenage licensure in Connecticut during which a teen could engage in more practice driving, was associated with a 22% reduction in fatal/injury crash involvements for 16-year-old drivers.

Keall et al (2004) collected breath alcohol measurements and other data at randomly selected roadside sites were combined with data on fatally injured drivers in crashes occurring on the same weekdays and times (Friday and Saturday nights) at locations matched by the size of the nearest town. A logistic model was fitted to these data for the years 1995–2000 to estimate the effects of alcohol, driver's age and the influence of passengers carried on the risk of driver fatal injury in New Zealand. The estimated risks increased steeply with increasing blood alcohol concentration (BAC), closely following an exponential curve at levels below about 200 mg/dl (i.e. 0.2%) and increasing less than exponentially thereon. The model fitted to data for drivers under 200 mg/dl showed that risks at all BAC levels were statistically significantly higher for drivers aged under 20 (over five times) and for drivers aged 20–29 (three times) than for drivers aged 30 and over. Further, controlling for age and BAC level, driving with a single passenger was associated with approximately half the nighttime risk of driver fatal injury relative to driving either solo or with two or more passengers. According to a recent travel survey, the types of passengers carried at the times of night and days of week studied appear to differ significantly from the types of passengers carried generally, which may lead to different passenger effects on driver behavior. The high relative risk of teenage drivers means that they reach high risk levels commonly regarded as unacceptable in the field of road safety even at their current legal limit of 30 mg/dl, particularly when more than one passenger is carried in the car.

13.1.4 Other Research on Driver Age

Williams et al (2003) argues that motor-vehicle crash rate comparisons by age and gender usually are based on the extent to which drivers in a particular age/gender category are themselves injured or involved in crashes (e.g., the number of 20-year-old females in crashes). Basing comparisons instead on the extent to which drivers in various age/gender groups are responsible for deaths (including themselves) in their crashes is more revealing of their overall contribution to the problem. Data from the Fatality Analysis Reporting System (FARS, 1996–2000) were used in the analysis, which was based on crashes that involved one or two vehicles only. Drivers in fatal single-vehicle crashes were assumed to have responsibility for the crash. In fatal two-vehicle crashes, driver operator errors reported by police were used to assign crash responsibility. When all crashes were considered, both the youngest and oldest drivers were most likely to be responsible for deaths in their crashes. In two-vehicle crashes, the oldest drivers were more likely than young drivers to be responsible. Young males were more likely than young females to be responsible for crash deaths, whereas females in their 50s and older were more likely than same-age males to be responsible. In terms of responsibility for deaths per licensed driver, young drivers, especially males, had the highest rates because of their high involvement rates and high responsibility rates. The majority of deaths for which young drivers were responsible occurred to people other than themselves, especially passengers in their vehicles, whereas the bulk of the deaths for which older drivers were responsible were their own. The results highlight the contribution of young drivers to the motor-vehicle crash problem, the need for measures such as passenger restrictions in graduated licensing systems, and the need for vehicle modifications to better protect older occupants.

Ferrante et al (2001) investigated the relationships between the novice drink drivers, recidivism and crash involvement. For this purpose, they selected a group of drink drivers with no prior arrest for drink driving from drink driving arrest records originating in Western Australia between 1987 and 1995. The drinking-driving records were linked to road crash records for the same period. The researchers focused on the sequence of driving events (i.e., arrests, crashes and arrests resulting from crashes) and the present article explores the relationship in time between known drink driving incidents and crash involvement to analysis the combined records. The study used multivariate survival analysis and finds that if a driver's first drink driving offence resulted from a road crash, especially if this occurred at a younger age, he/she was significantly more likely to drink, drive and crash again.

13.2 Methodology

While the case studies were conducted in a similar manner as was done elsewhere in the report, a number of additional statistical methods were used to analyze the data on older and younger drivers. Different statistical techniques including Chi-squared tests, adjusted residuals, and risk factors were used to analyze the data. The chi-square tests were conducted to investigate the impacts of ages of the at-fault drivers on a potential contributing factor. Because the chi-square test only indicates whether a dependency exists, confidence level tests in the form of adjusted residuals were conducted to investigate the cause of the dependence regarding the relationships between each individual age category and each individual category of other contributing factors. The risk factors are used to explore the likelihood of younger and older drivers being involved in different types of crashes as a function of number of driving hours. Each of these approaches is discussed in more detail below.

13.2.1 Chi-Square Test and Adjusted Residuals

The chi-square test is a statistical test most commonly used for evaluating whether two sets of data are independent or whether there is an association between them. It provides a method for testing the association between the row and column variables in a two-way table, and summarizes how close the expected frequencies fall to the observed frequencies. The null hypothesis H_0 assumes that there is no association between the variables (in other words, one variable does not vary according to the other variable), while the alternative hypothesis H_a claims that some association does exist. The alternative hypothesis does not specify the type of association; so close attention to the data is required to interpret the information provided by the test. From the chi-square value the p-value is determined, which concludes whether to accept or reject the null hypothesis. The p-value is nothing but the probability of obtaining data as extreme or more extreme than the current data assuming null hypothesis is true.

The symbol χ^2 is called the chi-square statistic. It is the oldest test statistic in use today, having been introduced by the British statistician Karl Pearson (Washington et al, 2003). It can be defined as follows.

$$c^{2} = \sum_{i=1}^{m} \sum_{j=1}^{n} \frac{\left(f_a(i,j) - f_e(i,j)\right)^2}{f_e(i,j)}$$

Where:

f_a = Actual or observed frequency in cell i,j

f_e = Expected frequency in cell i,j, and f_e is defined as follows:

$$f_e(i,j) = \frac{\sum_{n} f_a(i,n) * \sum_{m} f_a(m,j)}{\sum_{m} \sum_{n} f_a(m,n)}$$

The summation is taken over all cells in the contingency table. For each cell, we square the difference between the observed and expected frequencies and then divide that square by the expected frequency. After calculating this term for every cell, we sum the terms to construct the χ^2 statistic. When H_0 is true, f_o and f_e tend to be close for each cell, and χ^2 is relatively small. If

H_0 is false, at least some of the f_o and f_e values tend not to be close, leading to large $(f_o - f_e)^2$ values and a large test statistic. The larger the χ^2 value, the greater the evidence against the null hypothesis of independence.

A test statistic and its P-value summarize the strength of evidence against the null hypothesis. If χ^2 is large for testing independence, then somewhere in the contingency table the data depart from what independence predicts. The test statistic does not indicate, however, whether all cells deviate greatly from independence or perhaps only one or two of the cells do so.

A cell-by-cell comparison of observed and expected frequencies reveals the nature of the evidence. The difference $(f_o - f_e)$ between an observed and expected cell frequency is called a residual. The residual is positive when the observed frequency f_o exceeds the value f_e that independence predicts; it is negative when the observed frequency is smaller than independence predicts. To know whether a residual is large enough to indicate a significant departure from independence, we use an adjusted form of the residual that behaves like a z-score.

$$AR(i, j) = \frac{f_a(i, j) - f_e(i, j)}{\sqrt{\left(1 - \sum_n f_a(i,n)\right)\left(1 - \sum_m f_a(m, j)\right)}}$$

The denominator is the standard error of the difference $(f_o - f_e)$, when the variables are truly independent. It uses the marginal proportions for the row and column in which the cell falls. Suppose the null hypothesis of independence is true. Then an adjusted residual reports the number of standard errors that the observed count falls from the expected count, and it has a large-sample standard normal distribution. In that case, the adjusted residuals fluctuate around a mean of 0.0, with a standard deviation of 1.0. Because the Z-statistic and the adjusted residuals provide same information, the adjusted residuals are interpreted in the same way as Z-statistics. For example, the adjusted residual value of 1.96 (≈ 2) or more, which is same as the Z-statistic for 95% confidence, indicates the significance of a statistical relationship at 95% confidence level. Thus, there is only about a five percent chance that any particular adjusted residual exceeds 2.0 in absolute value. As a result, a large adjusted residual provides evidence against independence in that cell; a value exceeding 3.0 provides strong evidence.

13.2.2 Risk Factors

While Chi-square tests and adjusted residuals measure the association between two categories of variables, the risk factors (RF) show the weight of one specific group of object compared to the "average" group. Risk factors have been used in this research to find out the vulnerability of different age groups for fatal crashes caused by different contributing factors compared to the vulnerability of an "average" driver in the state of Florida. The RF's are different than Odds Ratios (OR) and Relative Risks (RR) in that the OR's and RR's are exposure-less measures for calculating the odds or risk of a specific crash type or contributing factor, while the risk factors account for the number of drivers within an age group and the average number of hours driven by those drivers. The risk factors are calculated using the following formulas.

$$VMT_{F,i} = \frac{VMT_{D,i} \times L_{F,i}}{1,000,000}$$

$$VMT_F = \sum_i VMT_{F,i}$$

$$VMT\_P_i = \frac{VMT_{F,i}}{VMT_F} \times 100$$

$$N = \sum_i A_i$$

$$A\_P_i = \frac{A_i}{N} \times 100$$

$$RF_i = \frac{A\_P_i}{VMT\_P_i}$$

where:

$VMT_{F,,i}$ = Million Vehicle Miles Traveled in Florida by i^{th} Age Group

$VMT_{D,i}$ = Vehicle Miles Traveled per Driver per Year by i^{th} Age Group

$L_{F,i}$ = Number of Licensed Drivers in Florida in the i^{th} Age Group

VMT_F = Total Vehicle Miles Traveled in Florida

VMT_P_i = Percent of Total Vehicle Miles Traveled in Florida by i^{th} Age Group

$A_{,i}$ = Number of Crashes involving Contributing Factor within the i^{th} Age Group

N = Number of Crashes involving Contributing Factor

$A\_P_{,i}$ = Percent of Crashes within the i^{th} Age Group involving Contributing Factor

$RF_{,i}$ = Risk Factor for Contributing Factor within the i^{th} Age Group

13.3 Data Set

Table 13.1 provides descriptive statistics for the ages of the at-fault drivers. There were a total of 1,874 at-fault drivers in the database. This is fewer than the total number of crashes because some crashes had only at-fault pedestrians, and no at-fault drivers. Among the at-fault drivers, the ages of 67 drivers were not known, primarily in the case of hit and run crashes. Because age is the key variable for this aspect of the research, those drivers with unknown age are not considered in this chapter, resulting in a total of 1,807 at-fault drivers of known age. The mean age of the at-fault drivers fall in the middle age group indicating the central tendency of the ages. The median age is 38 years meaning that half of the at-fault drivers are aged 38 or younger and the rest half are aged 38 or older. The mode of the ages is 19 years indicating that most of the at-fault drivers are very young. The standard deviation and variance are self-explanatory. The skewness is positive, which means that the data of the ages of the at-fault drivers are skewed to the right. The kurtosis value is negative, which indicates that the age data has flat distribution with short tails, which is also called platykurtic.

Table 13.1: Descriptive Statistics of the Ages of the At-Fault Drivers in 2000

N	1807
Missing	0
Mean	42.41228556
Std. Error of Mean	0.465613138
Median	38
Mode	19
Std. Deviation	19.79266628
Variance	391.7496386
Skewness	0.706340655
Kurtosis	-0.47127288
Range	84
Minimum	13
Maximum	97

Figure 13.4 shows that more than one fifth of the at-fault drivers in Florida in 2000 were from the age groups of 15 to 24 years. Only one at-fault driver, a bicyclist was from the youngest age group (≤14 years). One out of every five at-fault drivers belong to each of the early-middle (25-34 years) and middle-middle (35-44 years) age groups. Then the percent of at-fault drivers drops as the age increases, until drivers of age 65-74 are at-fault in less than seven percent of the crashes. Altogether, drivers aged 65 or older are at-fault in over 15 percent of the crashes with 6.6%, 6.9%, and 3.2% in the age groups 65-74, 75-84, and ≥85 years.

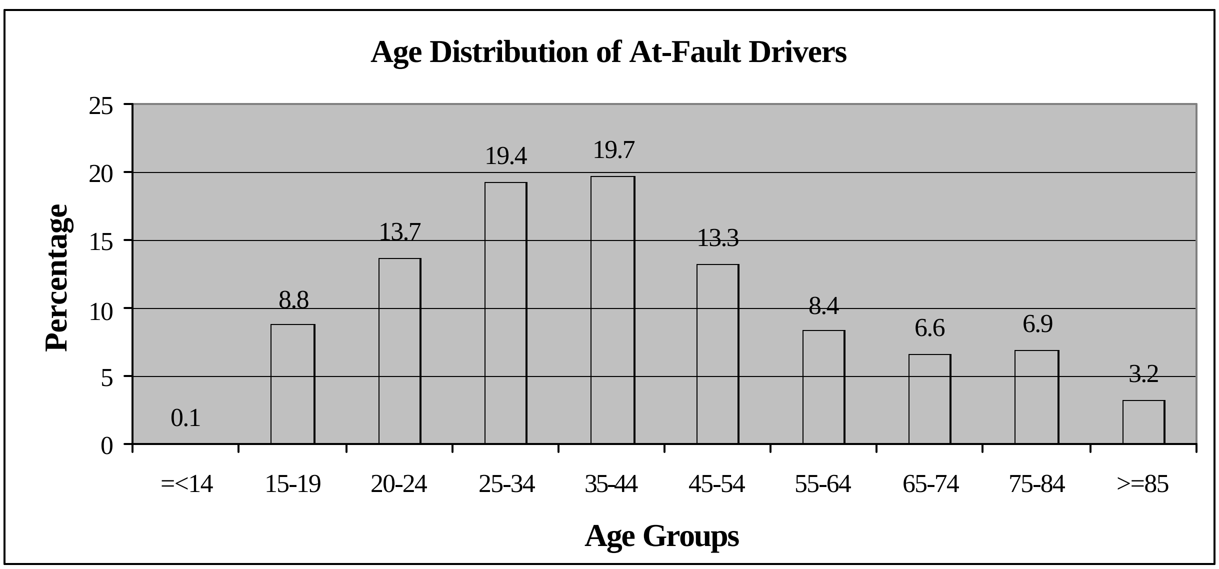


Figure 13.4: Age Distribution of At-Fault Drivers Involved in Fatal Crashes by Percentages

On the other hand, Figure 13.5 shows the number of at-fault drivers normalized by the population in different age groups. This figure explores that, compared to the total number of population in each group, the proportion of at-fault drivers is highest in the 20-24 years age group followed by the extreme older drivers (≥85 years). The rate steadily decreases from the 20-24 age group as the age group year increases until there is a sizeable increase in the 75-84 years age group. Overall, those in the youngest (≤24 years) and oldest (≥65 years) age groups are involved as at-fault drivers in more crashes than the middle age drivers in comparison to the population in each age group. The figure further indicates that the distribution of age of at-fault drivers normalized by population takes a "U" shape, especially if the 15-24 year olds are added together to create uniform sized age cohorts. It means that the younger and the older drivers' driving behaviors need close attention and detail research, which is the objective of this study.

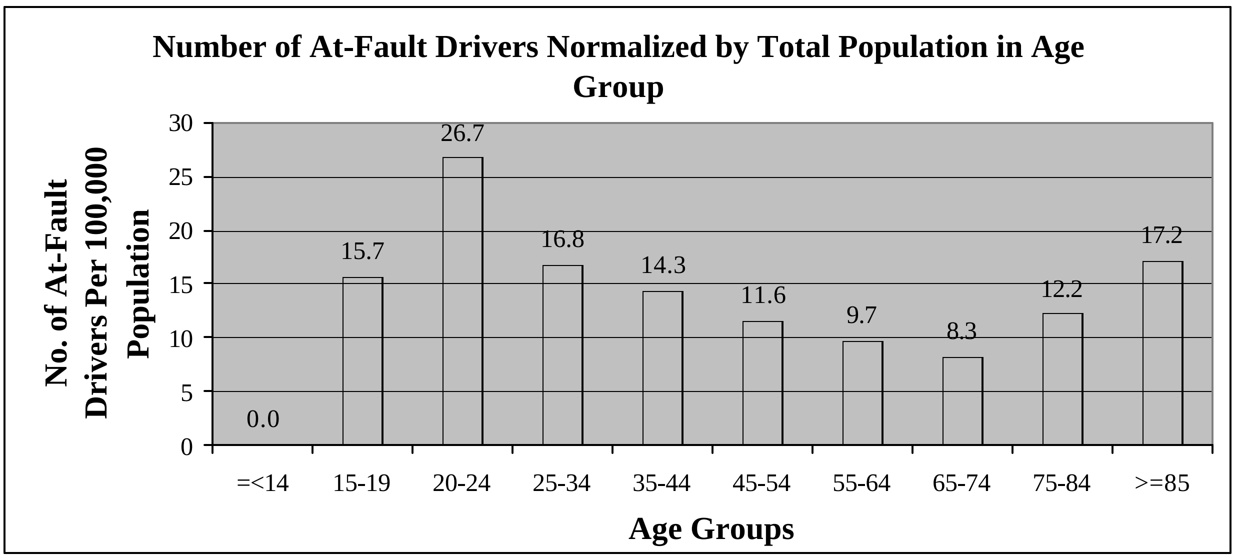


Figure 13.5: Age Distribution of At-Fault Drivers Normalized by Total Population in Age Group

Figures 13.6 and 13.7 repeat the calculations for the not-at-fault drivers. The un-normalized data shows that 35-44 year olds are involved most frequently in fatal traffic crashes followed by the 25-34 and 45-54 years age groups. The proportion of fatal crashes in which the young and older drivers are involved as not-at-fault drivers is very low. The figure shows that the distribution of not-at-fault drivers follows approximately a normal curve. When normalized by population, the bell-shaped curve flattens out slightly, so that drivers aged 25-54 are involved in crashes at approximately equal rates. The youngest and oldest drivers are involved in fatal crashes at the lowest rates. It is important to note here that while the figure of normalized at-fault drivers took a "U" shape the same figure for the not-at-fault drivers take an approximately normal curve.

It has been observed so far that the proportion of the at-fault and not-at-fault drivers in the age group ≤14 years is very small. On the other hand, the behavioral characteristics of the drivers belonging to 15-19 and 20-24 do not differ substantially as both of these groups are very young. So the data of age groups ≤14 years, 15-19 years, and 20-24 years are combined hereafter and considered as one age group of ≤24 years. Similarly the previous studies indicate that the driving behavior of 75-84 years and ≥85 years are not remarkably different. So, the data of these two age groups are also added together to make a single oldest group of ≥75 years. This also provides an age cohort of approximately the same population size as that of the 65-74 year old group.

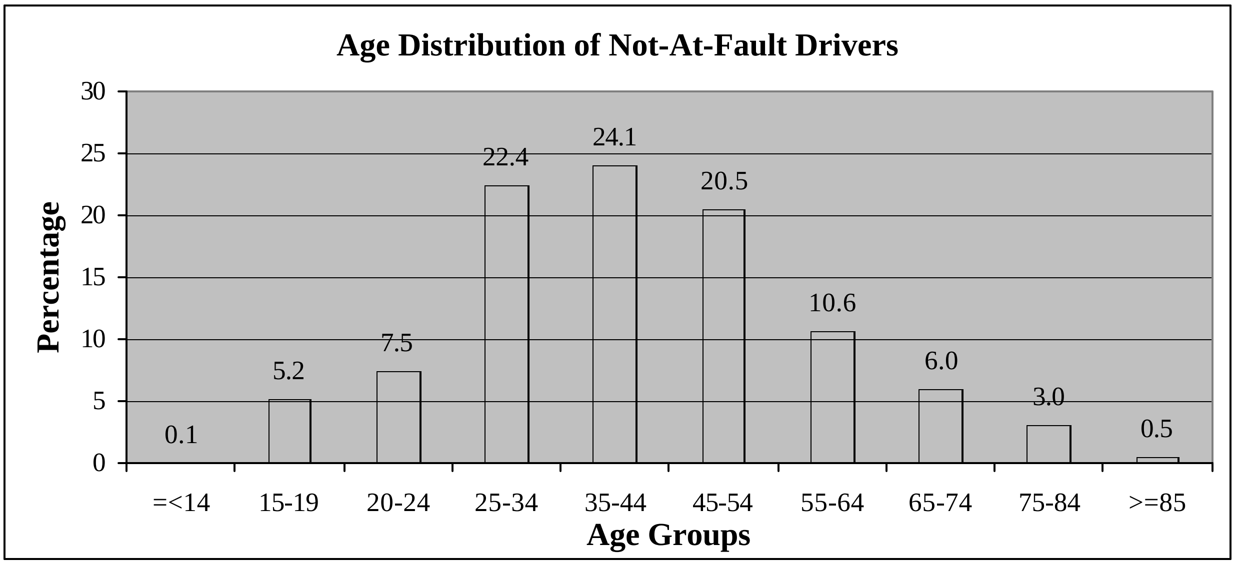


Figure 13.6: Age Distribution of Not-At-Fault Drivers Involved in Fatal Crashes

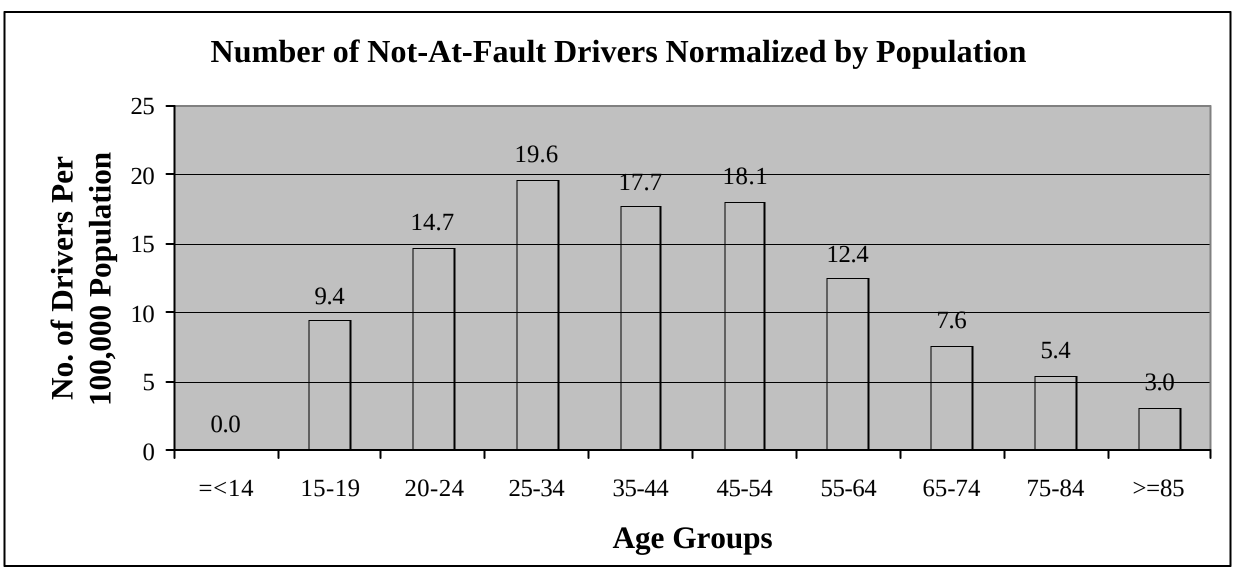


Figure 13.7: Age Distribution of Not-At-Fault Drivers Normalized by Total Population in Age Group

Table 13.2 and Figure 13.8 show the distribution of at-fault drivers in the eight FDOT districts, including the turnpike (District 8), categorized by seven age groups. Overall, one out of every five fatal crashes occurred in District 1 followed by Districts 5 and 4. Figure 13.8 shows younger drivers are involved in the highest percentage of crashes in most of the districts. The figure further explores that the distribution of crashes in different districts among the age groups is however fairly uniform except that the oldest drivers are involved in more crashes in Districts 1 and 7 compared to other districts, and middle-aged drivers in District 8. Table 13.2 explores that the young drivers are underrepresented in Districts 1, 6, and 8. Similarly, the oldest drivers are overrepresented in Districts 1 and 7 while they are under represented in other districts. The very low under-representation factors for the older and young drivers in District 8 (0.58 and 0.49, respectively) indicate that the older and young drivers drive less on the turnpikes. On the other hand, the overrepresentation of the older drivers in Districts 1 and 7 reflect the reality that many older people migrate to and live in the counties of these two districts in southwestern Florida.

Table 13.2: Cross Tabulation of Age Distribution of At-Fault Drivers by DOT District

Age Distribution		DOT District								Total
		1	2	3	4	5	6	7	8	
≤24	Count	72	61	41	70	70	31	55	8	408
	Row %	17.6%	15.0%	10.0%	17.2%	17.2%	7.6%	13.5%	2.0%	100.0%
	Column %	20.4%	23.6%	23.6%	25.8%	23.3%	21.4%	22.6%	13.1%	22.6%
25-34	Count	62	50	40	46	59	35	41	17	350
	Row %	17.7%	14.3%	11.4%	13.1%	16.9%	10.0%	11.7%	4.9%	100.0%
	Column %	17.6%	19.4%	23.0%	17.0%	19.6%	24.1%	16.9%	27.9%	19.4%
35-44	Count	67	49	28	50	59	38	45	20	356
	Row %	18.8%	13.8%	7.9%	14.0%	16.6%	10.7%	12.6%	5.6%	100.0%
	Column %	19.0%	19.0%	16.1%	18.5%	19.6%	26.2%	18.5%	32.8%	19.7%
45-54	Count	54	27	24	38	42	21	26	8	240
	Row %	22.5%	11.3%	10.0%	15.8%	17.5%	8.8%	10.8%	3.3%	100.0%
	Column %	15.3%	10.5%	13.8%	14.0%	14.0%	14.5%	10.7%	13.1%	13.3%
55-64	Count	29	30	16	24	17	7	24	3	150
	Row %	19.3%	20.0%	10.7%	16.0%	11.3%	4.7%	16.0%	2.0%	100.0%
	Column %	8.2%	11.6%	9.2%	8.9%	5.6%	4.8%	9.9%	4.9%	8.3%
65-74	Count	23	16	11	20	27	3	18	2	120
	Row %	19.2%	13.3%	9.2%	16.7%	22.5%	2.5%	15.0%	1.7%	100.0%
	Column %	6.5%	6.2%	6.3%	7.4%	9.0%	2.1%	7.4%	3.3%	6.6%
≥75	Count	46	25	14	23	27	10	34	3	182
	Row %	25.3%	13.7%	7.7%	12.6%	14.8%	5.5%	18.7%	1.6%	100.0%
	Column %	13.0%	9.7%	8.0%	8.5%	9.0%	6.9%	14.0%	4.9%	10.1%
Total	Count	353	258	174	271	301	145	243	61	1806
	Row %	19.5%	14.3%	9.6%	15.0%	16.7%	8.0%	13.5%	3.4%	100.0%
	Column %	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

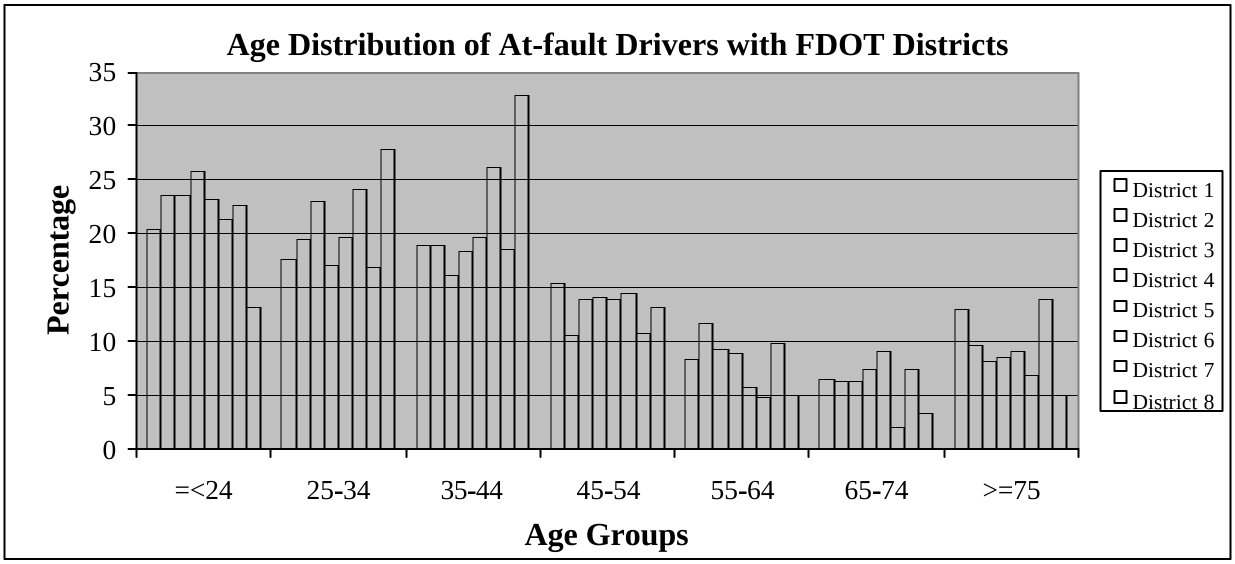


Figure 13.8: Age Distribution of At-Fault Drivers by DOT Districts

Figure 13.9 shows that pedestrians were involved in one out of every 25 fatal crashes (4%). In case of distribution of crashes among different age groups, Table 13.3 and Figure 13.10 explore that the middle-age drivers are involved in more pedestrian related crashes than any other age groups. The case-by-case analysis of the pedestrian involved crashes of the middle age drivers reveals that mostly two reasons are responsible for such crashes, viz. failure to stop/slow by the driver and attempting to cross/staying/lying on the street by the pedestrians not at designated locations. Although the middle age drivers are involved in more pedestrian related crashes, the investigation of individual crashes does not hint that the drivers of this age category are more susceptible to pedestrian involved crashes for any scientific reasons. Figure 13.10 reveals that the drivers of the age group ≤24 years are also involved in more pedestrian related crashes than the older drivers.

However, in case of crashes without pedestrian involvement, Figure 13.10 and Table 13.4 show that the younger drivers are involved in more crashes while the trend goes down with the increase of the age groups until the ≥75 years older when it goes up. The interesting feature to note here that the drivers of age group 65-74 are involved in the least number of crashes whether including pedestrians or not. On the other hand, the oldest drivers are involved in least proportion of pedestrian related crashes among all age groups. This is because the older drivers can avoid hitting pedestrians as they often do not drive at high speeds.

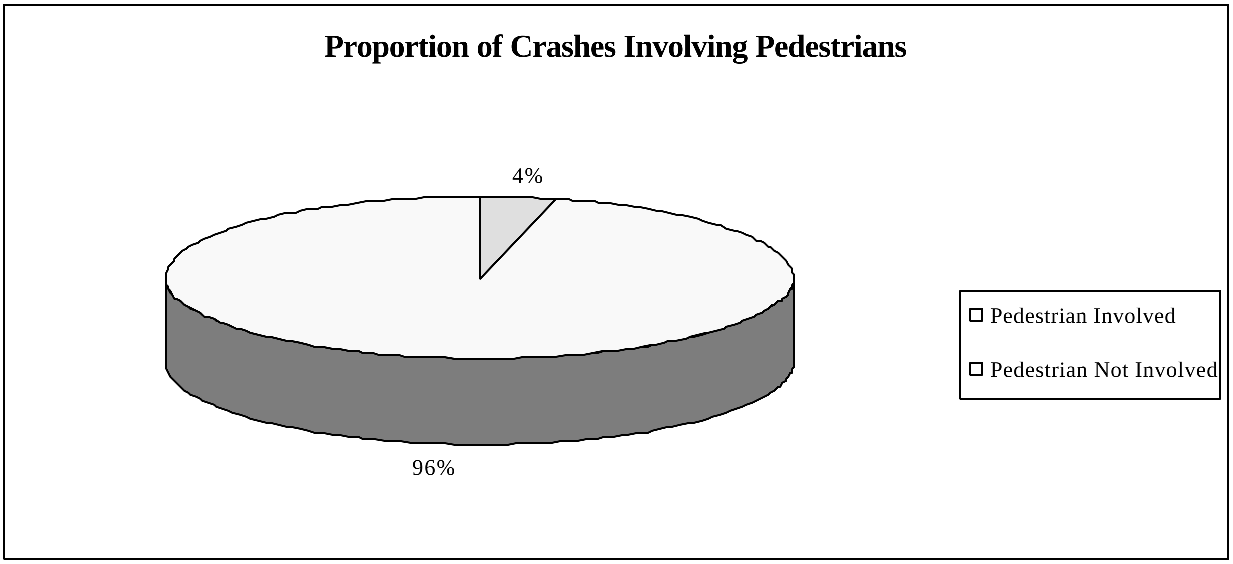


Figure 13.9: Proportion of Crashes Involving Pedestrians

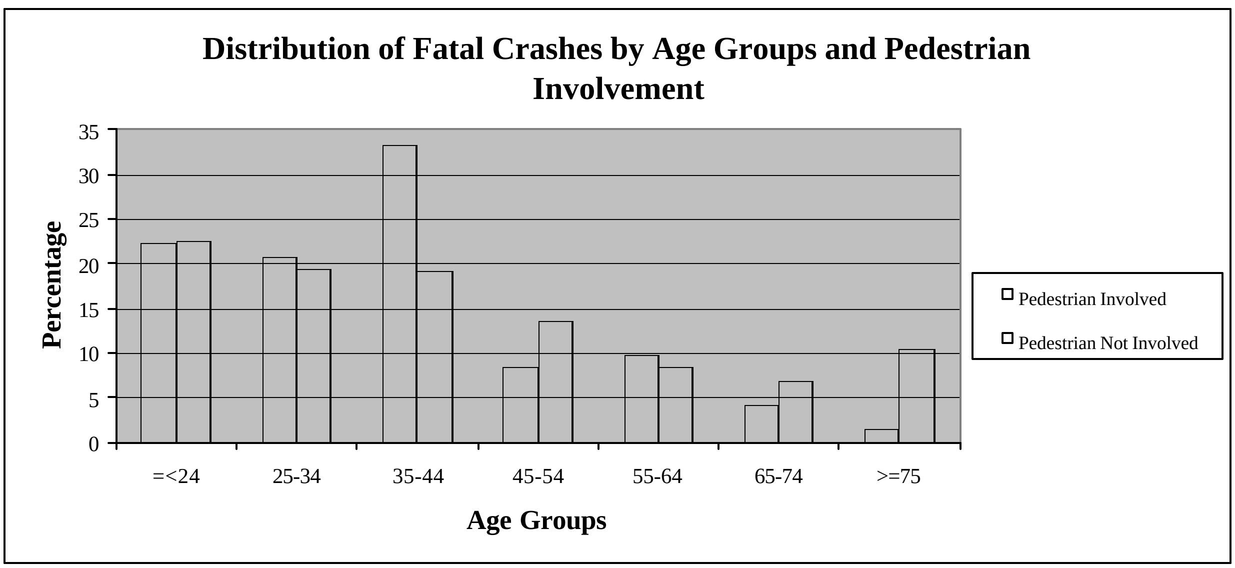


Figure 13.10: Distribution of Percentage of Pedestrian Involvement by Age Groups

Table 13.4 and Figure 13.11 depict the risk factors for pedestrian involved crashes by age categories. They show that young drivers are twice as likely as the "average" drivers to cause pedestrian related crashes followed by the drivers of 35-44 years old. None of the other age categories is more likely to cause pedestrian related crashes compared to the "average" drivers. Specifically, the two groups apart from the young drivers that are of interest to this study, the 65-74 years and ≥75 year older drivers are far less likely to cause pedestrian related fatal crashes.

The reason behind more likely by the young and less likely by the older drivers is that most of the crashes caused by older drivers at intersection with low speed while many crashes by the young drivers at non-intersection locations with high speeds. Because of the high speeds by the young drivers it becomes very difficult for them to stop vehicles after seeing a pedestrian crossing at location not designated for pedestrian crossing. On the other hand the older drivers can avoid pedestrian related crashes as most of their crashes are at low speeds.

Table 13.3: Cross Tabulation of Age Distribution and Pedestrian Involvement

Age Distribution	Data	Pedestrian Involved?		Total
		Yes	No	
≤24	Count	16	392	408
	% within Age Distribution	3.9%	96.1%	100.0%
	% within Pedestrian Involved?	22.2%	22.6%	22.6%
25-34	Count	15	335	350
	% within Age Distribution	4.3%	95.7%	100.0%
	% within Pedestrian Involved?	20.8%	19.3%	19.4%
35-44	Count	24	332	356
	% within Age Distribution	6.7%	93.3%	100.0%
	% within Pedestrian Involved?	33.3%	19.1%	19.7%
45-54	Count	6	234	240
	% within Age Distribution	2.5%	97.5%	100.0%
	% within Pedestrian Involved?	8.3%	13.5%	13.3%
55-64	Count	7	144	151
	% within Age Distribution	4.6%	95.4%	100.0%
	% within Pedestrian Involved?	9.7%	8.3%	8.4%
65-74	Count	3	117	120
	% within Age Distribution	2.5%	97.5%	100.0%
	% within Pedestrian Involved?	4.2%	6.7%	6.6%
≥75	Count	1	181	182
	% within Age Distribution	.5%	99.5%	100.0%
	% within Pedestrian Involved?	1.4%	10.4%	10.1%
Total	Count	72	1735	1807
	% within Age Distribution	4.0%	96.0%	100.0%
	% within Pedestrian Involved?	100.0%	100.0%	100.0%

Table 13.4: Risk Factors for Pedestrian Involved Crashes

A	B	C	D	E = B*C	G = E/F	H	I = H/N1	RF1 = I/G
Age Group	US-VMT Per Year Per Driver	Licensed Drivers of Florida	% of Total Drivers	Florida VMT Per Million	Florida VMT Percent of Total	# of Pedestrian Involved Crashes	% of Pedestrian Involved Crashes	Risk Factors for Pedestrian Involved Crashes
≤24	22,950	1,859,606	13.24	42,678	11.35	16	22.22	2.0
25-34	32,400	2,681,209	19.09	86,871	23.11	15	20.83	0.9
35-44	31,100	2,927,153	20.85	91,034	24.22	24	33.33	1.4
45-54	30,100	2,374,937	16.91	71,486	19.02	6	8.33	0.4
55-64	25,200	1,658,581	11.81	41,796	11.12	7	9.72	0.9
65-74	16,700	1,365,502	9.72	22,804	6.07	3	4.17	0.7
≥75	16,400	1,174,859	8.37	19,268	5.13	1	1.39	0.3
		14,041,847	100.00	375,937	100.00	72		
				F = 375937		N_1 = 72		

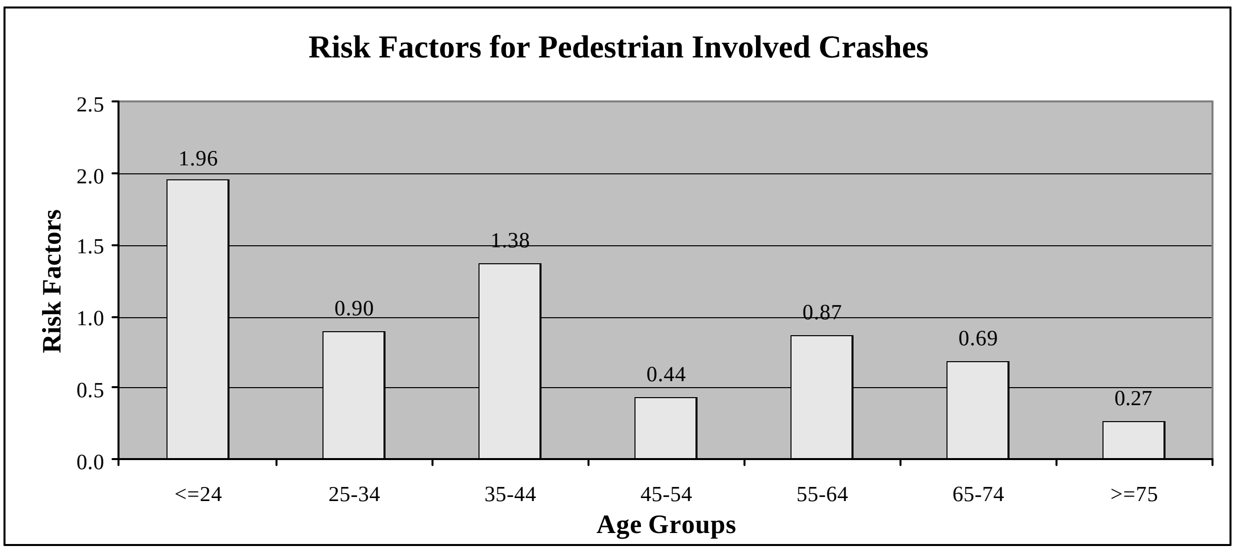


Figure 13.11: Risk Factors for Pedestrian Involved Crashes

Figure 13.12 explores that bicycles were involved in only 3% of the fatal crashes that occurred in Florida in the year 2000. In case of distribution of crashes among different age groups, Table 13.5 and Figure 13.13 explore that the involvement of bicycles in fatal crashes decreases with the increase of age groups. The drivers of the age group ≤24 years and 25-34 years are involved in 15.1% and 22.6% crashes related to bicycle involvement. These are followed by the drivers of middle age with 28.3% for 35-44 years, 20.8% for 45-54 years, and 5.7% for 55-64 years. In contrast the older and the oldest drivers make a total of little more than seven percent of bicycle related crashes with 3.8% in each of 65-74 years and ≥75 years.

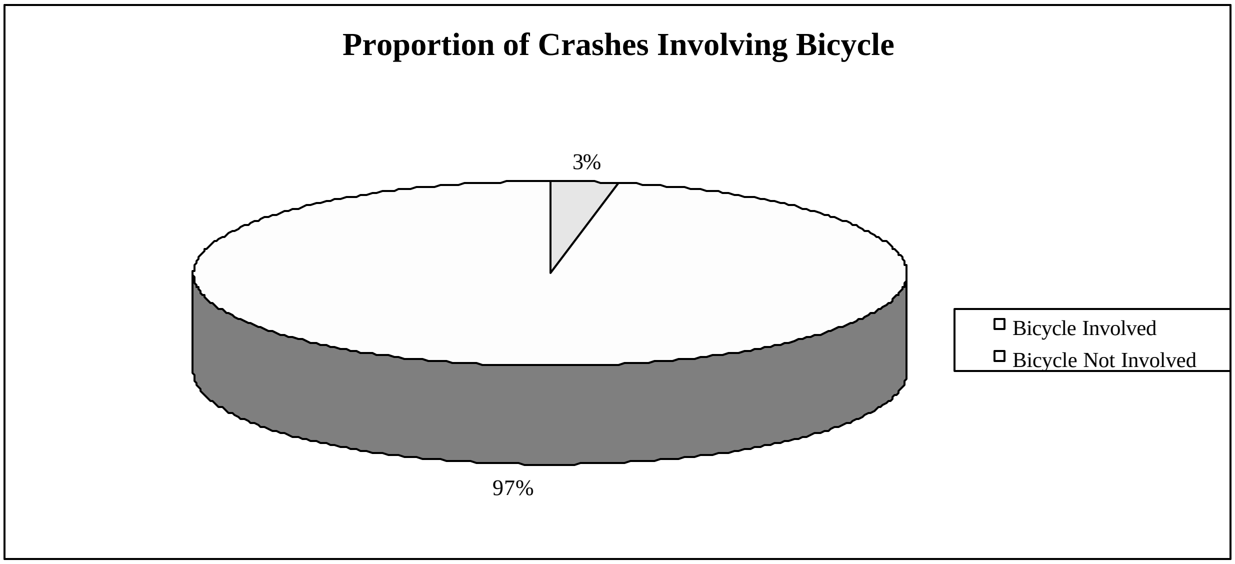


Figure 13.12: Proportion of Crashes Involving Bicycles

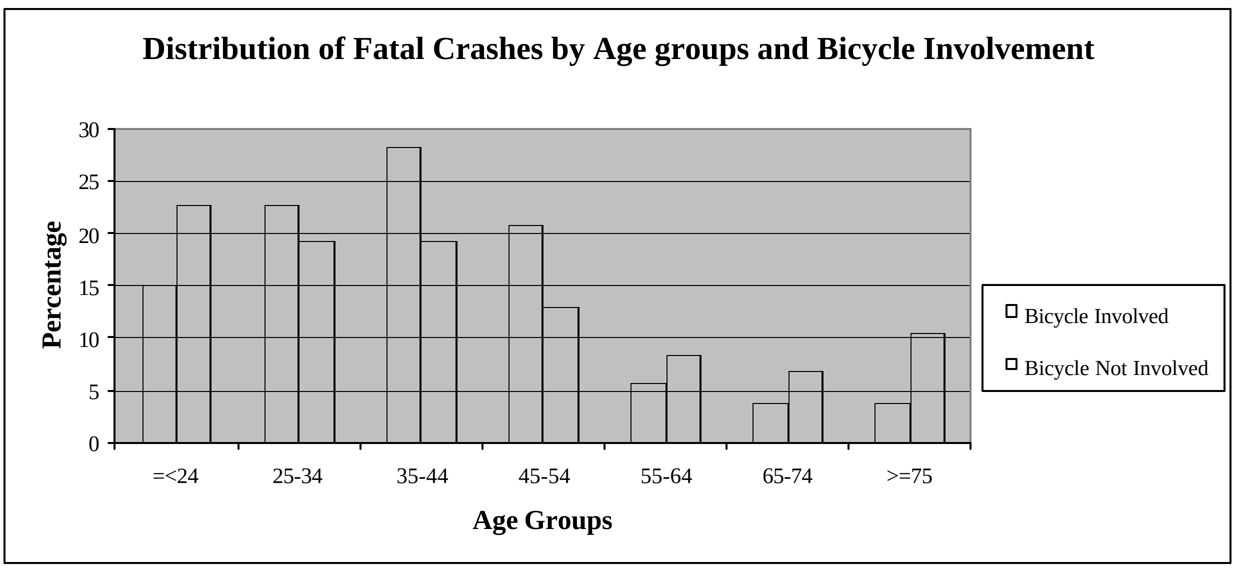


Figure 13.13: Age Distribution and Percentage of Bicycle Involvement

Table 13.5: Cross Tabulation of Age Distribution and Bicycle Involvement

Age Distribution	Data	Yes	No
≤24	Count	8	384
	% within Age Distribution	2.0%	97.2%
	% within Bicycle Involved?	15.1%	22.7%
25-34	Count	12	327
	% within Age Distribution	3.5%	96.2%
	% within Bicycle Involved?	22.6%	19.3%
35-44	Count	15	327
	% within Age Distribution	4.3%	94.8%
	% within Bicycle Involved?	28.3%	19.3%
45-54	Count	11	220
	% within Age Distribution	4.8%	95.2%
	% within Bicycle Involved?	20.8%	13.0%
55-64	Count	3	142
	% within Age Distribution	2.1%	97.9%
	% within Bicycle Involved?	5.7%	8.4%
65-74	Count	2	114
	% within Age Distribution	1.7%	97.4%
	% within Bicycle Involved?	3.8%	6.7%
≥75	Count	2	176
	% within Age Distribution	1.1%	98.9%
	% within Bicycle Involved?	3.8%	10.4%
Total	Count	53	1690
	% within Age Distribution	3.0%	96.5%
	% within Bicycle Involved?	100.0%	100.0%

The case investigation of bicycle involved crashes of age group 35-44 years older drivers (the tallest bar in Figure 13.13) show that both the bicyclists and the drivers are responsible for such crashes. The bicyclists' errors include crossing the roadway at not designated areas, riding bicycle inside the highway lanes, suddenly coming in front of the high-speed vehicle, etc. while the drivers' errors include driving at high speeds, could/did not see the bicyclist, unable to stop the vehicle, and driving onto the bicyclists on the shoulders are important.

Table 13.6 and Figure 13.14 show the risk factors of different age groups to be involved in bicycle related fatal crashes. They show similar results as those of pedestrian related crashes except that the drivers of 45-54 years age group are also more likely to cause fatal crashes along with the drivers of 35-44 years and the young drivers compared to the "average" drivers of the state. As the characteristics of pedestrians and bicyclists do not differ substantially, further discussion is not provided here.

Table 13.6: Risk Factors for Bicycle Related Crashes

A	B	C	D	E = B*C	G = E/F	H	I = H/N_1	RF_1 = I/G
Age Group	US-VMT Per Year Per Driver	Licensed Drivers of Florida	% of Total Drivers	Florida VMT Per Million	Florida VMT Percent of Total	# of Bicycle Involved Crashes	% of Bicycle Involved Crashes	Risk Factors for Bicycle Involved Crashes
≤24	22,950	1,859,606	13.24	42,678	11.35	8	15.09	1.3
25-34	32,400	2,681,209	19.09	86,871	23.11	12	22.64	1.0
35-44	31,100	2,927,153	20.85	91,034	24.22	15	28.30	1.2
45-54	30,100	2,374,937	16.91	71,486	19.02	11	20.75	1.1
55-64	25,200	1,658,581	11.81	41,796	11.12	3	5.66	0.5
65-74	16,700	1,365,502	9.72	22,804	6.07	2	3.77	0.6
≥75	16,400	1,174,859	8.37	19,268	5.13	2	3.77	0.7
		14,041,847	100.00	375,937	100.00	53		
				F = 375937		N_1 = 53		

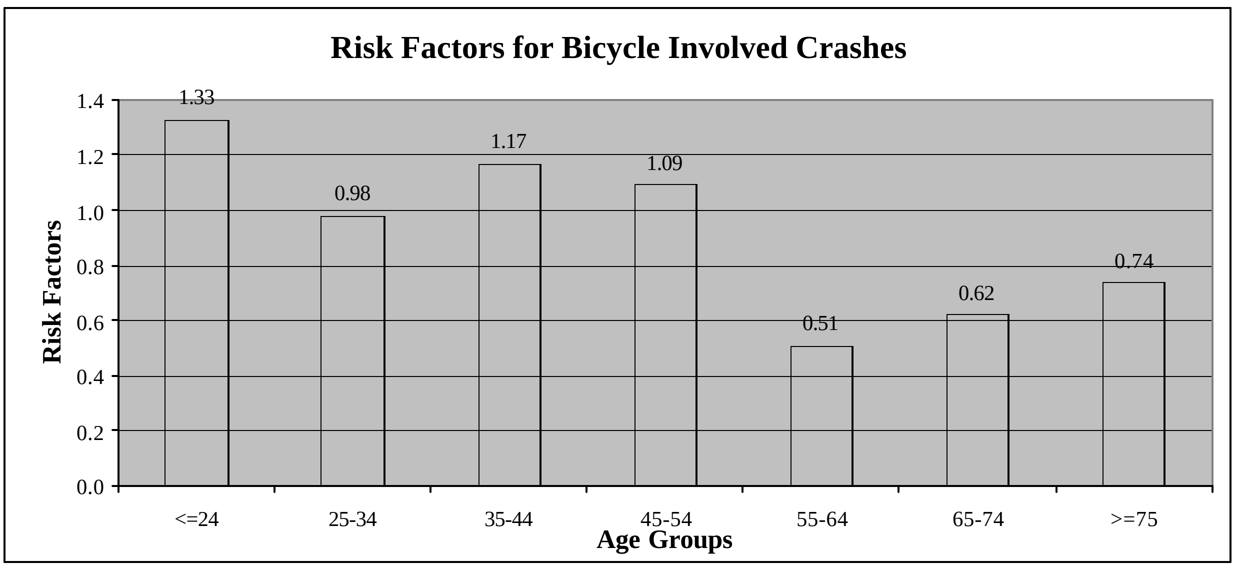


Figure 13.14: Risk Factors for Bicycle Related Crashes

Figure 13.15 shows that about three out of each ten crashes in the year 2000 have heavy truck involvement with 31%. However, the Table 13.7 and Figure 13.16 explore that the highest number of crashes related to heavy trucks involved middle age drivers suppressing the younger and the older drivers. The drivers of age 35-44 years were involved in 122 heavy truck related crashes making 22.4% contribution for this group alone while the 25-34 years older drivers are involved in 23.3% heavy truck related crashes. Apart from these age groups, the young drivers are also found susceptible to heavy truck related crashes with 16.3%. The proportion of involvement in heavy truck related crashes decreases with the increase of age groups until it slightly increases for the oldest drivers. The reason behind this trend is the fact that the older drivers are more cautious of the heavy vehicles like trucks while the middle age and younger drivers take more risks and drive carelessly even after seeing the heavy trucks, which causes less involvement of older drivers in the heavy truck related crashes, and vice versa for the young drivers. Figure 13.16 shows that the crashes are apparently smoothly distributed among different age groups without having any peak/tall bar. It indicates that none of the age groups need case-by-case investigation.

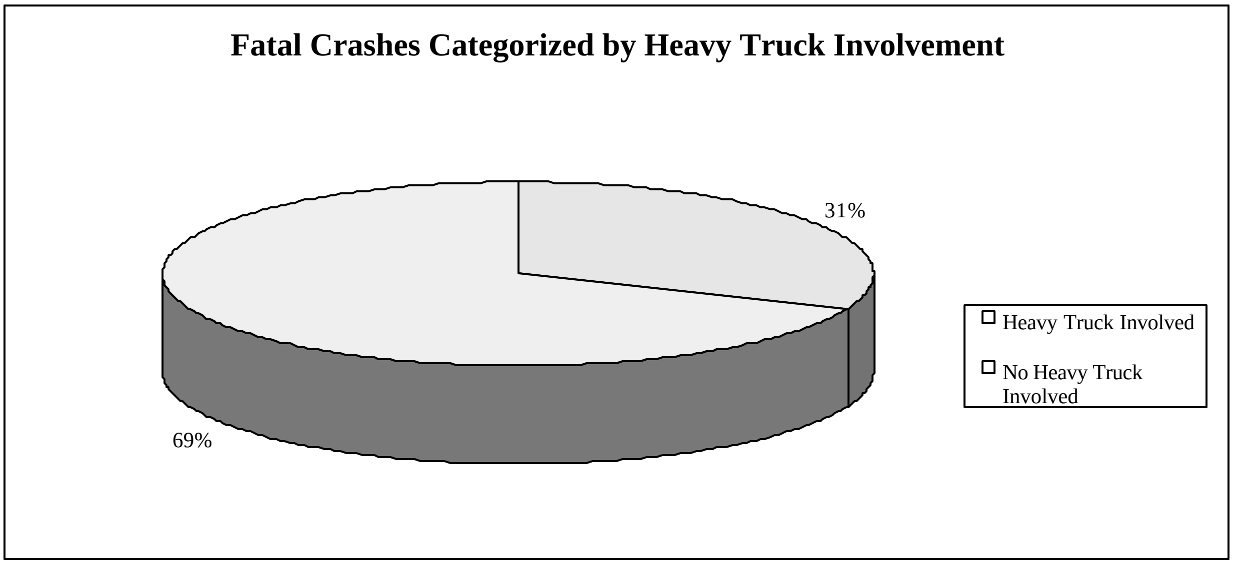


Figure 13.15: Proportion of Crashes Involving Heavy Trucks

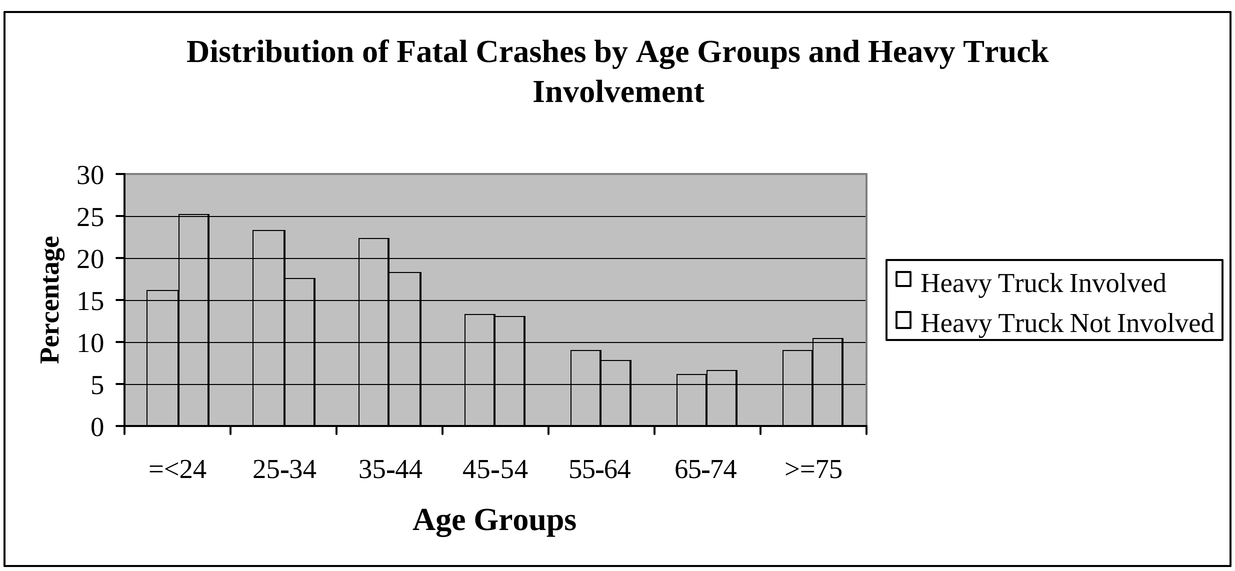


Figure 13.16: Age Distribution and Percentage of Heavy Trucks Involvement

Table 13.7: Cross Tabulation of Age Distribution and Heavy Truck Involved

Age Distribution	Data	Yes	No
≤24	Count	89	305
	% within Age Distribution	22.5%	77.2%
	% within Heavy Truck Involved?	16.3%	25.4%
25-34	Count	127	212
	% within Age Distribution	37.4%	62.4%
	% within Heavy Truck Involved?	23.3%	17.7%
35-44	Count	122	221
	% within Age Distribution	35.4%	64.1%
	% within Heavy Truck Involved?	22.4%	18.4%
45-54	Count	73	158
	% within Age Distribution	31.6%	68.4%
	% within Heavy Truck Involved?	13.4%	13.2%
55-64	Count	50	95
	% within Age Distribution	34.5%	65.5%
	% within Heavy Truck Involved?	9.2%	7.9%
65-74	Count	34	82
	% within Age Distribution	29.1%	70.1%
	% within Heavy Truck Involved?	6.2%	6.8%
≥75	Count	50	128
	% within Age Distribution	28.1%	71.9%
	% within Heavy Truck Involved?	9.2%	10.7%
Total	Count	545	1201
	% within Age Distribution	31.1%	68.6%
	% within Heavy Truck Involved?	100.0%	100.0%

Table 13.8 and Figure 13.17 present the risk factors of different age categories to cause are heavy truck related fatal crashes. The figure and table explore that the young and oldest drivers more likely to cause heavy truck related crashes compared to an “average” driver. On the other hand, the early middle-age drivers and older drivers of 65-74 years are just as likely as the “average” drivers to be involved in heavy truck related crashes. The main reasons for the young drivers to be involved in such crashes are driving at high speeds making contacts with the heavy truck due to lack of control over the vehicle, improper lane change, and loss of control. On the other hand, the oldest drivers feel shaky when a heavy truck runs parallel to them, causing loss of control of their vehicles. The oldest drivers are also involved many intersection crashes involving heavy truck approaching from the other directions. The reasons for intersection crashes by the oldest drivers apply here which are misjudgment of the speeds of the oncoming vehicles (23%), complicated intersection with too much of traffic and billboard signals (6.9%), failure to observe all sides before approaching the intersection (20.7%), disregarded traffic control (16.9%), disregarded stop signs (9.2%), etc.

Table 13.8: Risk Factors for Heavy Truck Related Crashes

A	B	C	D	E = B*C	G = E/F	H	I = H/N1	RF1 = I/G
Age Group	US-VMT Per Year Per Driver	Licensed Drivers of Florida	% of Total Drivers	Florida VMT Per Million	Florida VMT Percent of Total	# of Heavy Truck Involved Crashes	% of Heavy Truck Involved Crashes	Risk Factors for Heavy Truck Involved Crashes
≤24	22,950	1,859,606	13.24	42,678	11.35	89	16.33	1.4
25-34	32,400	2,681,209	19.09	86,871	23.11	127	23.30	1.0
35-44	31,100	2,927,153	20.85	91,034	24.22	122	22.39	0.9
45-54	30,100	2,374,937	16.91	71,486	19.02	73	13.39	0.7
55-64	25,200	1,658,581	11.81	41,796	11.12	50	9.17	0.8
65-74	16,700	1,365,502	9.72	22,804	6.07	34	6.24	1.0
≥75	16,400	1,174,859	8.37	19,268	5.13	50	9.17	1.8
		14,041,847	100.00	375,937	100.00	545		
				F = 375937		N_1 = 545		

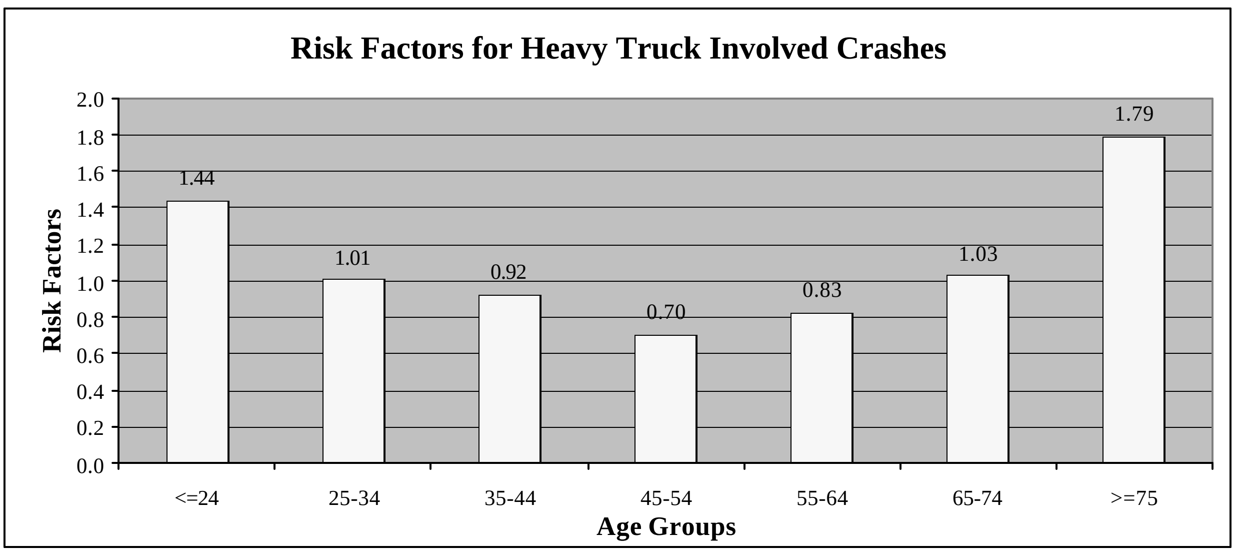


Figure 13.17: Risk Factors for Heavy Truck Related Crashes

The number of vehicles involved in fatal crashes is a very important phenomenon that needs careful investigation and analysis. Figure 13.18 shows that the distribution of numbers of vehicles involved in fatal crashes are generally equally distributed within different age groups. Figure 13.18 further explores that the youngest drivers are involved in more than one-fourth one-vehicle fatal crashes followed by the drivers of 25-34 years with about approximately one-fourth of such crashes. On the other hand, the drivers of 35-44 years age group are more susceptible to

3-vehicle and 4 or more vehicle crashes. However, all these data needs to be checked whether the drivers of any age groups are more likely to be involved in any types of fatal crashes than the average drivers.

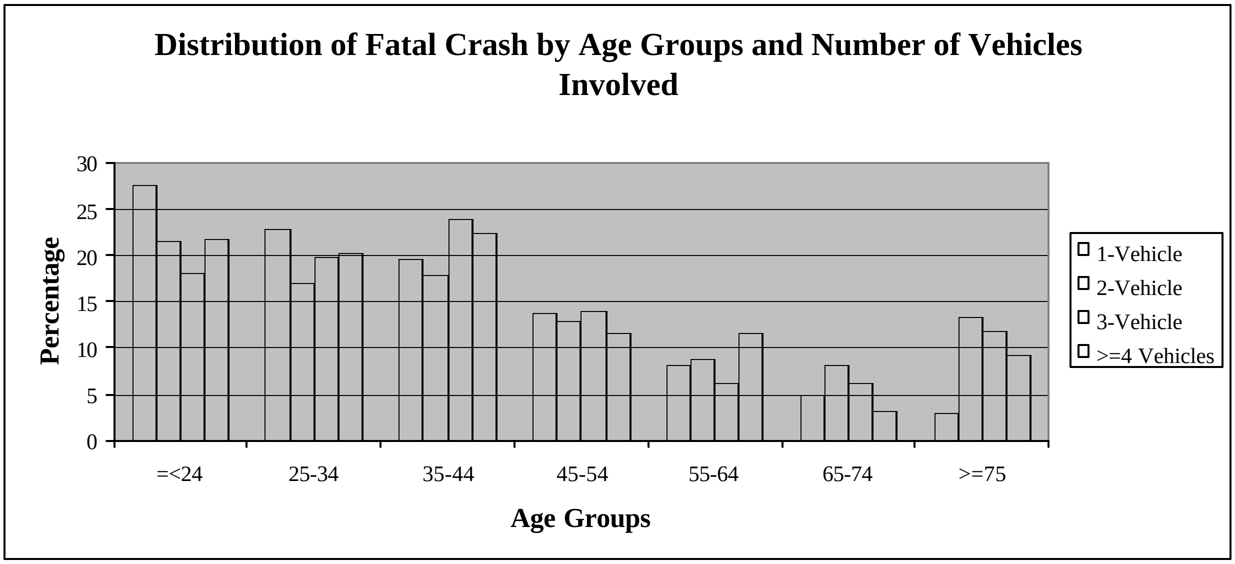


Figure 13.18: Age Distribution of Fatal Crashes by Number of Vehicles Involved

Table 13.9 shows the detail calculations of risk factors for drivers of different age categories to be involved in 1-vehicle, 2-vehicle, 3-vehcle, and ≥4 vehicle crashes. Figure 13.19 confirms that the youngest drivers are 2.4 times more likely to cause 1-vehicle crashes as compared to the "average" drivers. All the age groups starting from 35 years older are less likely to cause 1-vehicle crashes compared to the "average" drivers. Similarly, the Figure 13.20, Figure 13.21, and Figure 13.22 show that the oldest drivers (≥75 years) are 2.6, 2.3, and 1.8 times more likely to cause the 2-vehicle, 3-vehicle, and ≥4-vehicle crashes than the "average" drivers in Florida. The figures also tell similar stories for young drivers with values of 1.9, 1.6, and 1.9 times for respective vehicle types. However, the drivers of 65-74 years older are only more likely to be involved in 2-vehicle crashes compared to the "average" drivers. The impact of age of the at-fault drivers on number of vehicle involvement in the crashes is statistically significant at 0.000 significant level with a Chi-square value of 139.829 for 72 degrees of freedom.

Table 13.9: Calculation of Risk Factors for Involvement in Types of Vehicles

A	E = B*C	G = E/F	H	I = H/N1	RF1 = I/G	J	K = J/N2	RF2 = K/G	L	M = L/N3	RF3 = M/G	P	Q = P/N4	RF4 = Q/G
Age Group	Florida VMT Per Million	Florida VMT Percent of Total	# of Drivers Involved in 1-Vehicle Crashes	Percentage of Crash Involvement in 1-Vehicle Crash	Risk Factor for 1-Vehicle Crashes	# of Drivers Involved in 2-Vehicle Crashes	Percentage of Crash Involvement in 2-Vehicle Crash	Risk Factor for 2-Vehicle Crashes	# of Drivers Involved in 3-Vehicle Crashes	Percentage of Crash Involvement in 3-Vehicle Crash	Risk Factor for 3-Vehicle Crashes	# of Drivers Involved in ³ 4-Vehicle Crashes	Percentage of Crash Involvement in ³ 4-Vehicle Crash	Risk Factor for 3-Vehicle Crashes
≤24	42,678	11.35	134	27.57202	2.4	188.0	21.6092	1.9	58	18.01242	1.6	28	21.70543	1.912
25-34	86,871	23.11	111	22.83951	1.0	149.0	17.12644	0.7	64	19.87578	0.9	26	20.15504	0.872
35-44	91,034	24.22	95	19.54733	0.8	155.0	17.81609	0.7	77	23.91304	1.0	29	22.48062	0.928
45-54	71,486	19.02	67	13.78601	0.7	113.0	12.98851	0.7	45	13.97516	0.7	15	11.62791	0.612
55-64	41,796	11.12	40	8.230453	0.7	76.0	8.735632	0.8	20	6.21118	0.6	15	11.62791	1.046
65-74	22,804	6.07	24	4.938272	0.8	72.0	8.275862	1.4	20	6.21118	1.0	4	3.100775	0.5112
≥75	19,268	5.13	15	3.08642	0.6	117.0	13.44828	2.6	38	11.80124	2.3	12	9.302326	1.815
		100.0	486	100		870.0	100		322	100		129	100	
	F = 2455217		N1 = 486			N2 = 870			N3 = 322			N4 = 129		

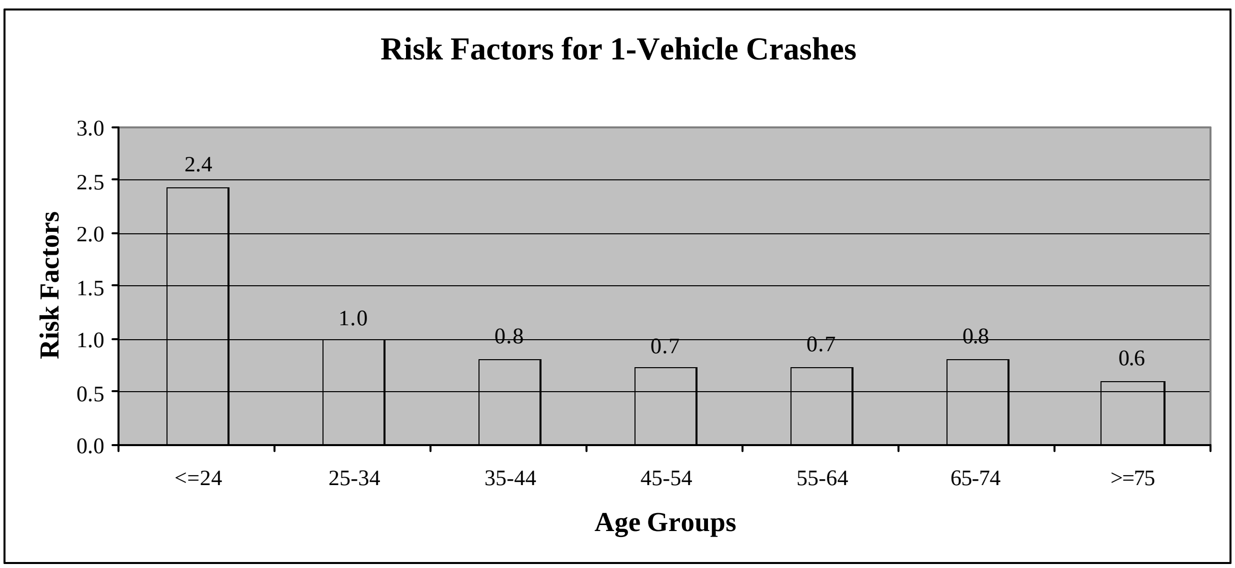


Figure 13.19: Risk Factors of Different Age Categories for 1-Vehicle Crashes

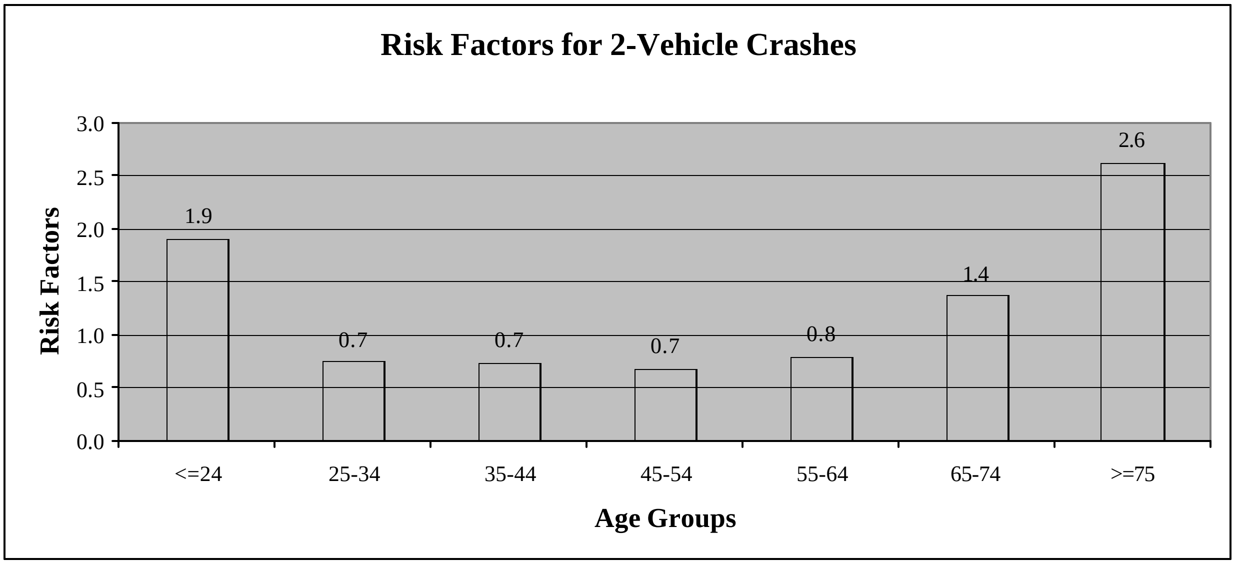


Figure 13.20: Risk Factors of Different Age Categories for 2-Vehicle Crashes

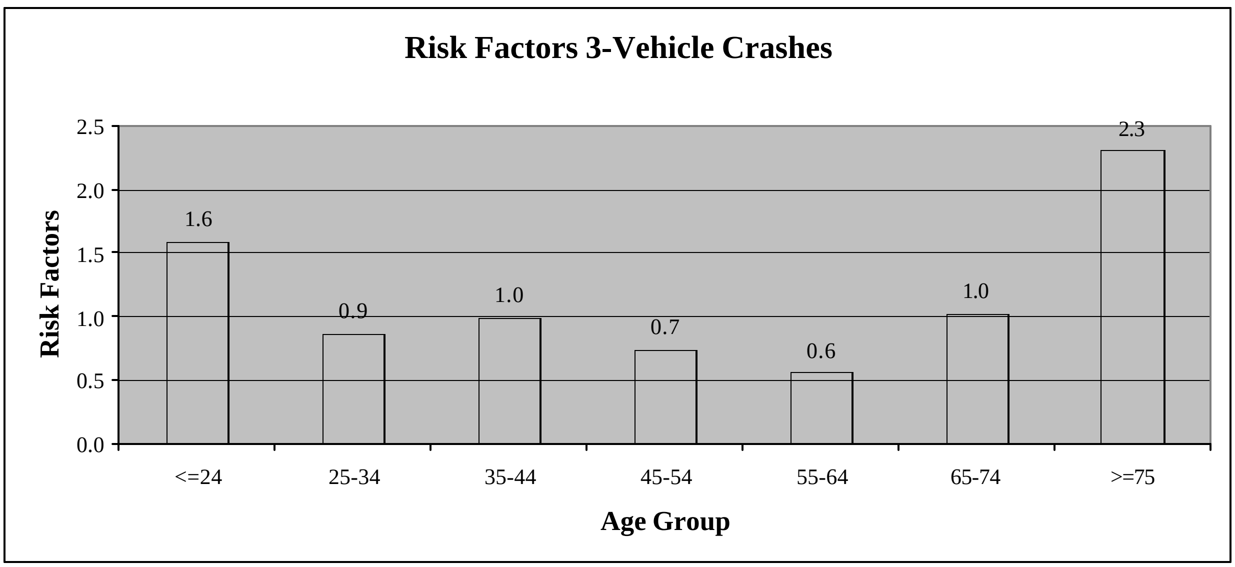


Figure 13.21: Risk Factors of Different Age Categories for 3-Vehicle Crashes

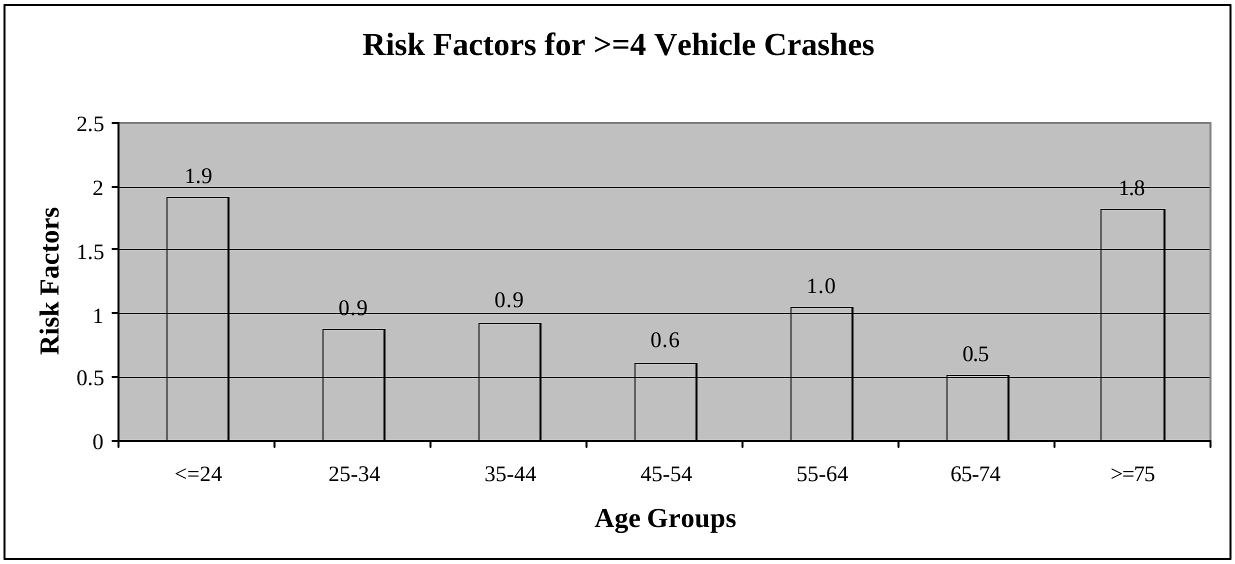


Figure 13.22: Risk Factors of Different Age Categories for ≥4-Vehicle Crashes

13.4 Environmental Contributing Factors

Figure 13.23 depicts the hourly distribution of fatal crashes clustered by age distribution. The figure indicates that a high proportion of young and early middle-age drivers (≤24 and 25-34 years) and a very low portion of older drivers are involved in the crashes during the time period from midnight to 4:00am. It is evident that every three out of five crashes occurred during the midnight to dawn period is caused by the drivers 34 years and younger. This is justifiable in the sense that very few older drivers are on the state highways during nighttime. A similar picture is observed during 8:01pm-midnight because of same reason. However, a high proportion of older drivers are involved in the fatal crashes during the day and evening time, i.e., from 8:01am-12:00noon, 12:01pm-4:00pm, and from 4:01pm-8:00pm. These are the times when the older drivers are on the streets for various purposes including social and shopping activities. The figure further depicts that the drivers of active workforce age groups contribute to remarkable proportions of fatal crashes during the early morning (4:01am-8:00am), and late afternoon and evening period. The reason behind this is that many of the working drivers drive to the offices in a hurried manner in the morning while many working drivers return home in the late afternoon from work that are stressed. Social and shopping trips are also made during the late afternoon.

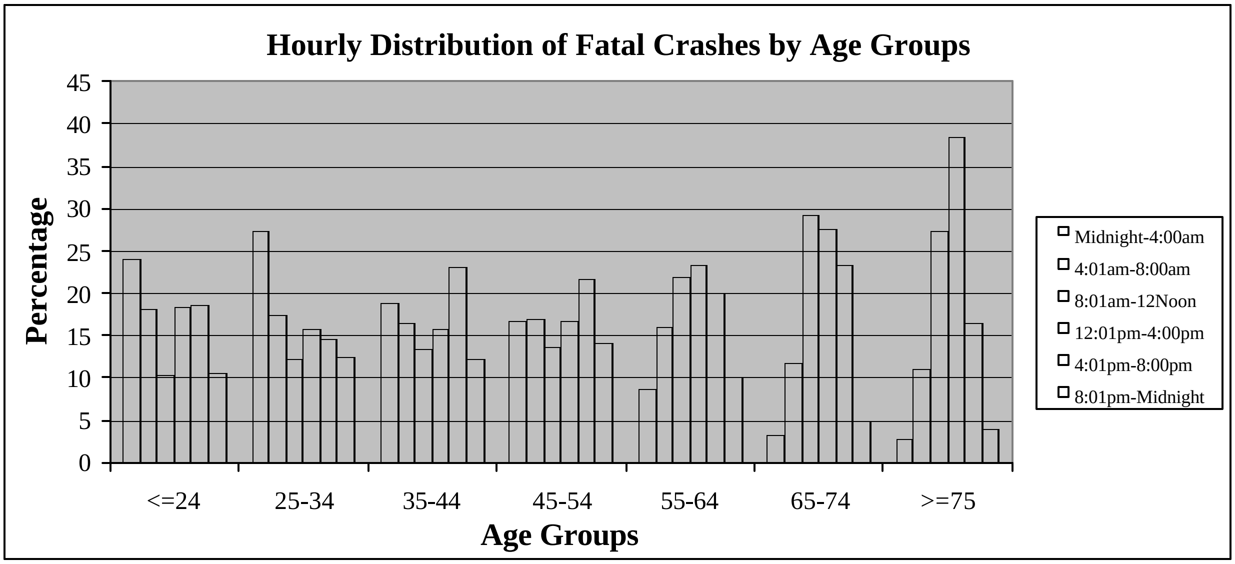


Figure 13.23: Hourly Distribution of Fatal Crashes in Florida

However, the impact of age on the probability of occurring fatal crashes needs to be tested statistically. The Chi-square test is performed for this purpose. The following null and alternative hypotheses are constructed.

H_0 = Age of the aft-fault drivers does not have significant impacts on the crash hour distribution.

H_a = Age of the aft-fault drivers has significant impacts on the crash hour distribution.

Table 13.10 shows the observed and expected frequencies and the adjusted residuals in each category of age groups and crash hour distribution. The Chi-square value is 191.842 with 30 degrees of freedom at a 0.000 significance level. This Chi-square value is greater than the table Chi-square value for 30 degrees of freedom, which is 59.7 for 0.001 significance level. So the null hypothesis is rejected. Thus the Chi-square test proves that age of the at-fault drivers has significant impacts on the occurrence of fatal crashes during different hours of the day.

Table 13.10: Cross Tabulation of Age Distribution and Crash Hour Distribution

Age Distribution	Data	Crash Hour Distribution						Data
		Midnight - 4:00am	4:01am-8:00am	8:01am-12Noon	12:01pm - 4:00pm	4:01pm-8:00pm	8:01pm-Midnight	
≤24	Count	98	74	42	75	76	43	408
	Expected Count	73.0	66.2	64.2	82.2	78.8	43.6	408.0
	Adjusted Residual	3.7	1.2	-3.4	-1.0	-.4	-.1	
25-34	Count	96	61	43	55	51	44	350
	Expected Count	62.6	56.8	55.0	70.5	67.6	37.4	350.0
	Adjusted Residual	5.2	.7	-2.0	-2.3	-2.5	1.3	

Table 13.10: Cross Tabulation of Age Distribution and Crash Hour Distribution, continued

Age Distribution	Data	Crash Hour Distribution						Data
		Midnight - 4:00am	4:01am-8:00am	8:01am-12Noon	12:01pm - 4:00pm	4:01pm-8:00pm	8:01pm-Midnight	
35-44	Count	67	59	48	56	82	44	356
	Expected Count	63.7	57.8	56.0	71.8	68.8	38.0	356.0
	Adjusted Residual	.5	.2	-1.3	-2.3	2.0	1.1	
45-54	Count	40	41	33	40	52	34	240
	Expected Count	42.9	38.9	37.7	48.4	46.4	25.6	240.0
	Adjusted Residual	-.5	.4	-.9	-1.4	1.0	1.9	
55-64	Count	13	24	33	35	30	15	150
	Expected Count	26.8	24.3	23.6	30.2	29.0	16.0	150.0
	Adjusted Residual	-3.1	-.1	2.2	1.0	.2	-.3	
65-74	Count	4	14	35	33	28	6	120
	Expected Count	21.5	19.5	18.9	24.2	23.2	12.8	120.0
	Adjusted Residual	-4.3	-1.4	4.2	2.1	1.2	-2.1	
≥75	Count	5	20	50	70	30	7	182
	Expected Count	32.6	29.5	28.6	36.7	35.2	19.4	182.0
	Adjusted Residual	-5.6	-2.0	4.6	6.5	-1.0	-3.1	
Total	Count	323	293	284	364	349	193	1806
	Expected Count	323.0	293.0	284.0	364.0	349.0	193.0	1806.0

In contrast to the Chi-square results, the adjusted residuals show the statistical relationships and their significance between each row cell and column cell. The adjusted residuals are interpreted similar to Z-statistics. For example, the adjusted residual values of –3.1, -4.3, and –5.6 between the age groups 55-64, 65-74, and ≥75 with crash hour group midnight-4:00 AM shows that within each of these age groups one year increase in age decreases the probability of causing fatal crashes by 3.1, 4.3, and 5.6 numbers. This is highly justifiable as the older drivers usually do not drive during the middle of night. Similarly, the probability of causing fatal crashes during midnight-4:00AM are statistically significant for youngest (≤24 years) and early middle-age drivers (25-34 years) with adjusted residual values +3.7 and +5.2. However, for the drivers of other middle-age groups these values are not statistically significant (<1.96 at 5% significant level) although the signs show convincing results. The table further shows that the presence of the young and early middle-age drivers on the highways during the morning until noon time decreases the probability of fatal crashes while it is increased by the presence of the older drivers (65-74, and ≥75 years) during the same time period. This is because of the reason that more older drivers are on the highways during this time period that causes more crashes by them. The adjusted residual values of other groups of age and crash hour distribution are similarly evident from Table 13.10.

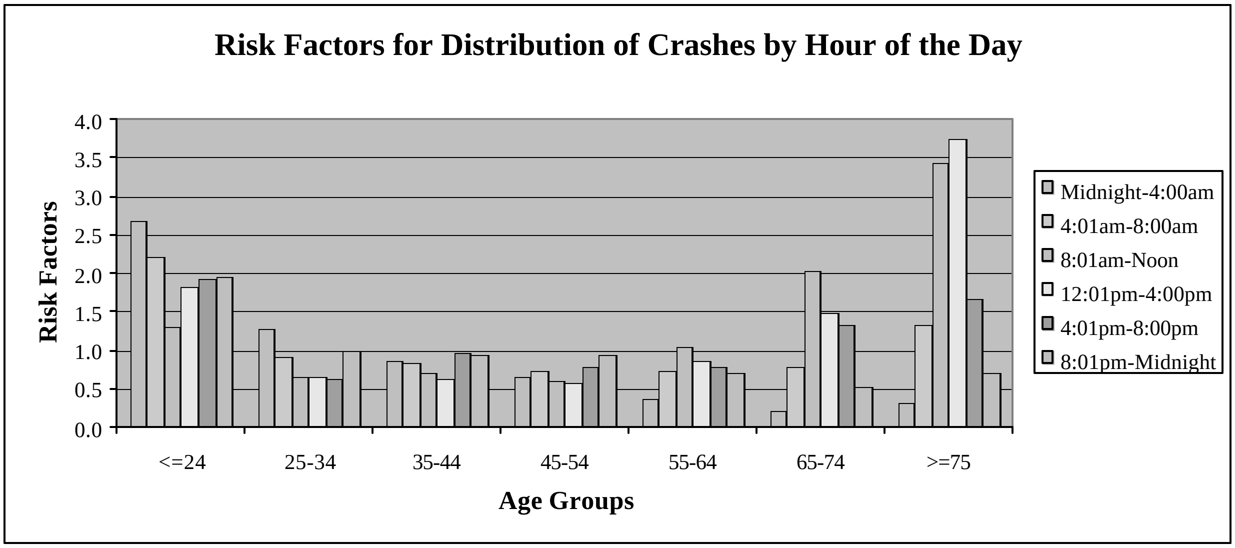


Figure 13.24: Hourly Distribution of Risk Factors of Fatal Crashes by Hour of Day

In contrast to Figure 13.23 and Table 13.10, Figure 13.24 shows the likeliness of the fatal crashes by the drivers of different age groups. It shows that young drivers are more likely to cause fatal crashes compared to the "average" drivers at any time of the day. On the other hand, the oldest drivers (≥75 years) are more likely to cause such crashes all the times except from 8:01pm-4:00am. Similarly, the drivers of age 65-74 years are also less likely to cause fatal crashes during the night and early morning time, but are more likely to cause such crashes during the daytime. The reason behind this is the presence of very few older drivers on the highways during nighttime and many older drivers during the daytime.

Similar surprising results are seen in case of lighting conditions at the time and place of the crash. Figure 13.25 reveals that although darkness is one very important factor for the occurrence of fatal crashes, more than half of fatal crashes occurred during daylight. Darkness is divided in two categories: dark (street light) and dark (no street light). Figure 13.25 reveals that about one out of each five crashes occur in dark, but with streetlights available. However, one in every four fatal crashes in Florida occurred on streets in the dark with no streetlights. In total, about 44% of the crashes happened in dark, 51% during daylight, and the rest are in dusk and dawn. The lighting conditions for the remaining eight crashes are unknown or unreported.

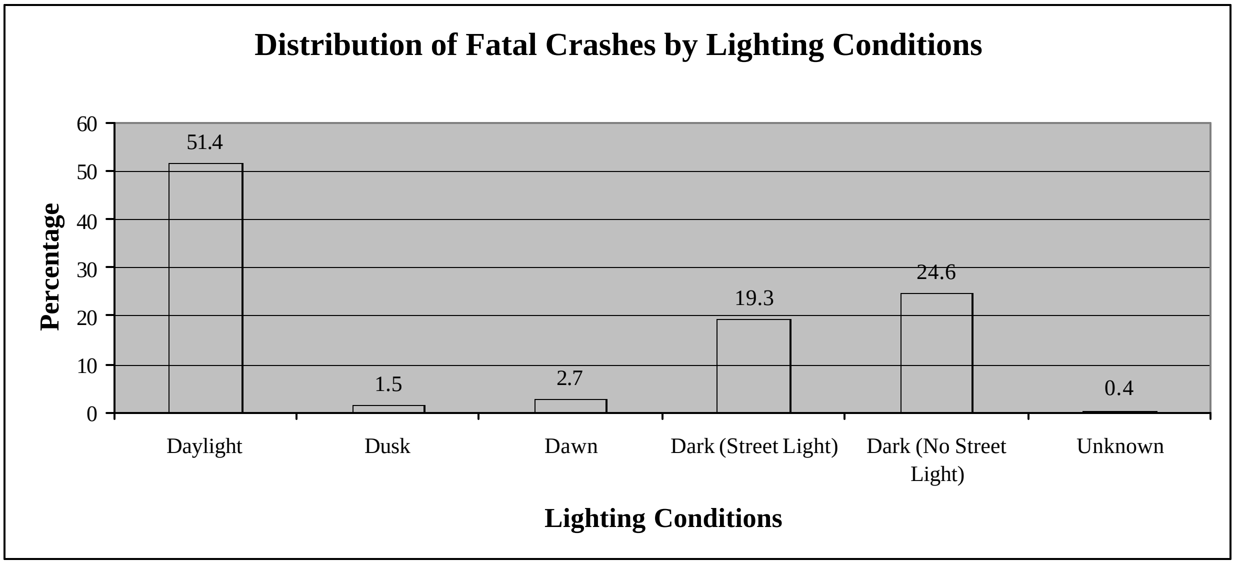


Figure 13.25: Distribution of Fatal Crashes in Florida Based on Lighting Condition

Figure 13.26 shows that the older drivers are susceptible to fatal crashes during daylight, dusk and dawn while they are not susceptible in crashes during dark period. The investigation of the individual cases indicates that this is because the older drivers drive minimum on the state roads in dark when their visibility is reduced. On the other hand the crashes during daylight are attributed to the high number of older drivers on the streets at this time. Although the heights of the bars in Figure 13.26 do not differ substantially, there is a tall bar for the youngest drivers during the dawn time. All the dawn time crashes for the ≤24 years were investigated to see why the young drivers cause fatal crashes at this time. The investigation shows that among 19 such crashes the vision was obscured in only three cases (15.78%). The remaining 16 crashes (82.22%) occurred in good roadway conditions and in good environmental condition.

The three cases mentioned above were due to inclement weather conditions including low visibility and fog. The reasons for remaining 16 crashes includes failed to yield right of way, careless driving, disregarded traffic signals, and disregarded stop signals. The case-by-case investigation of the dawn time crashes by the drivers of 25-34 years were also investigated which shows similar findings as that of age group ≤24 years. So it becomes evident from the cases that the relatively un-congested streets cause the careless driving at dawn by the young and early middle-age drivers. However, the proportion of drivers involved in crashes in dark (with street light) and dark (without street light) are roughly equal among the drivers of 54 years and younger while it is lower in the age groups 55-64, 65-74, and ≥75. The reason behind this is that very few older drivers come out on the streets in darkness. However, the older drivers are at-fault in relatively higher proportion of crashes during dusk time as their own visibility goes down at this time. There are only eight crashes with unknown lighting conditions for which they have been excluded from Figure 13.26. The investigation of these eight crashes indicates that although the lighting conditions are not known, the crashes were happened for similar reasons outlined for young drivers' dawn time crashes.

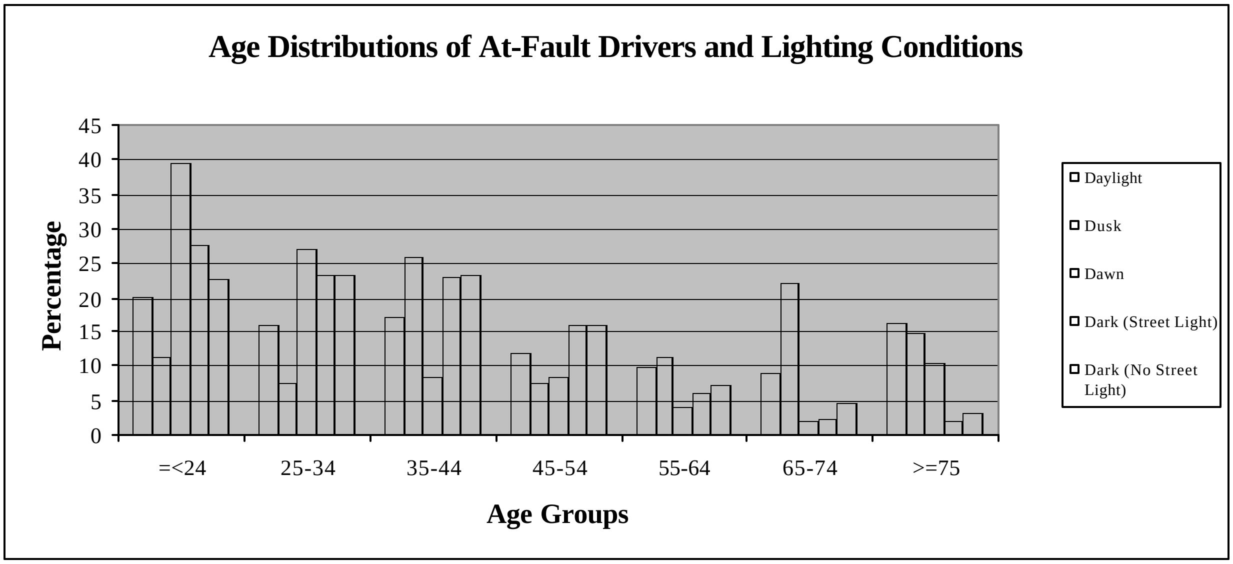


Figure 13.26: Distribution of Fatal Crashes Based on Lighting Condition by Age Group

To test the significance of the impacts of age on the probability of crashes during different lighting conditions following null and alternative hypotheses are constructed.

H_0 = Age of the aft-fault drivers does not significantly contribute to the probability of crash occurrence based on lighting conditions.

H_a = Ages of the at-fault drivers significantly cause to the occurrence of fatal crashes based on lighting conditions.

Table 13.11 shows the observed and expected values of the frequencies in each lighting condition group. The calculated Chi-square value of the test is 170.320 while the table value for degree of freedom 30 is 59.7 at 0.001 significance level. It means that the null hypothesis is rejected, and in general, age of at-fault drivers significantly causes the probability of occurrence of fatal crashes based on lighting conditions. Table 13.11 also shows the significance of relationships between each row cell and column cell of two categories, viz. age distribution and lighting conditions. The table shows that none of the crashes of unknown lighting conditions are statistically significant. However, the table shows several significant relationships between different age groups and lighting conditions. For example, the daylight crashes are significant with all age groups. In general, the adjusted residuals tell us that the presence of 65-74 years older drivers on state highways increases the probability of occurring fatal crashes during daylight and dusk while it decreases in dark (both with and without street lights). On the other hand, the probability of fatal crashes increases by the presence of young drivers during the dark (street lights) and dawn while it decreases in daylight. The reasons for all these have already been discussed above based on case review. It is also true for the drivers of ≥75 years except dusk time, which is not statistically significant.

Table 13.11: Cross tabulation Age Distribution and Lighting Condition

Age Distribution	Data	Lighting Condition						Total
		Daylight	Dusk	Dawn	Dark (Street Light)	Dark (No Street Light)	Unknown	
≤24	Count	187	3	19	96	101	1	407
	Expected Count	209.5	6.1	10.8	78.5	100.3	1.8	407.0
	Adjusted Residual	-2.5	-1.4	2.9	2.5	.1	-.7	
25-34	Count	148	2	13	81	104	2	350
	Expected Count	180.1	5.2	9.3	67.5	86.3	1.6	350.0
	Adjusted Residual	-3.8	-1.6	1.4	2.0	2.4	.4	
35-44	Count	159	7	4	80	104	2	356
	Expected Count	183.2	5.3	9.5	68.6	87.8	1.6	356.0
	Adjusted Residual	-2.9	.8	-2.0	1.7	2.2	.4	
45-54	Count	109	2	4	55	70	0	240
	Expected Count	123.5	3.6	6.4	46.3	59.2	1.1	240.0
	Adjusted Residual	-2.0	-.9	-1.0	1.5	1.7	-1.1	
55-64	Count	92	3	2	21	32	0	150
	Expected Count	77.2	2.2	4.0	28.9	37.0	.7	150.0
	Adjusted Residual	2.5	.5	-1.1	-1.7	-1.0	-.9	
65-74	Count	84	6	1	8	20	1	120
	Expected Count	61.8	1.8	3.2	23.1	29.6	.5	120.0
	Adjusted Residual	4.2	3.3	-1.3	-3.6	-2.1	.7	
≥75	Count	150	4	5	7	14	2	182
	Expected Count	93.7	2.7	4.8	35.1	44.9	.8	182.0
	Adjusted Residual	8.8	.8	.1	-5.6	-5.6	1.4	
Total	Count	929	27	48	348	445	8	1805
	Expected Count	929.0	27.0	48.0	348.0	445.0	8.0	1805.0

Figure 13.27 and Table 13.12 explore the likeliness of the occurrence of fatal crashes by different age groups in different lighting conditions compared to the “average” drivers. It shows that the young drivers, among all who drive on the highways are more vulnerable to fatal crashes in all five lighting conditions. On the other hand, the oldest drivers are more susceptible to cause fatal crashes in daylight, dusk, and dawn while the drivers of age groups 65-74 years are in daylight and dusk. The reason behind the less likeliness of the older drivers to cause fatal crashes during dark time is simply that they do not come out on to the streets at this time.

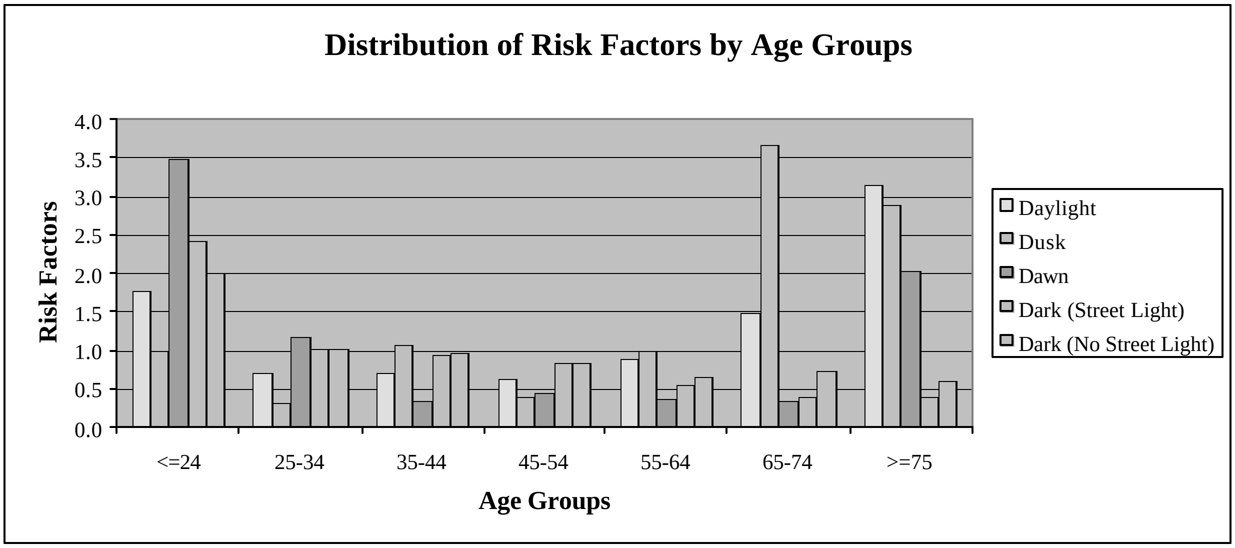


Figure 13.27: Risk Factors of Fatal Crashes by Lighting Conditions

Table 13.12: Calculation of Risk Factors for Age Groups and Lighting Condition

A	E = B*C	G = E/F	I	RF1 = I/G	K	RF2 = K/G	M	RF3 = M/G	Q	RF4 = Q/G		
Age Group	Florida VMT Per Million	Florida VMT Percent of Total	% of Crashes during Daylight	Risk Factor for Daylight Crashes	% of Crashes during Dusk	Risk Factor for Dusk Crashes	% of Crashes during Dawn	Risk Factor for Dawn Crashes	% of Crashes during Dark (Street Light)	Risk Factors for Crashes during Dark (Street Light)	% of Crashes during Dark (No Street Light)	Risk Factors for Crashes during Dark (No Street Light)
≤24	42,678	11.35	20.13	1.8	11.11	1.0	39.58	3.5	27.59	2.43	22.70	2.0
25-34	86,871	23.11	15.93	0.7	7.41	0.3	27.08	1.2	23.28	1.01	23.37	1.0
35-44	91,034	24.22	17.12	0.7	25.93	1.1	8.33	0.3	22.99	0.95	23.37	1.0
45-54	71,486	19.02	11.73	0.6	7.41	0.4	8.33	0.4	15.80	0.83	15.73	0.8
55-64	41,796	11.12	9.90	0.9	11.11	1.0	4.17	0.4	6.03	0.54	7.19	0.6
65-74	22,804	6.07	9.04	1.5	22.22	3.7	2.08	0.3	2.30	0.38	4.49	0.7
≥75	19,268	5.13	16.15	3.2	14.81	2.9	10.42	2.0	2.01	0.39	3.15	0.6
	375,937	100.00	100.00		100.00		100.00		100.00		100.00	
	F = 375937											

13.5 Roadway Contributing Factors

Figure 13.28 shows the distribution of fatal crashes based on site location. From the figure, it is evident that more than one-third of the fatal crashes occur at intersections. This total includes crashes that occur on the intersections of driveways, which frequently involve vehicles turning into the driveway in the same way that a turning maneuver is accomplished at an intersection. Similarly, ramp crashes that involve traffic control devices as vehicles exited or entered the ramp are included in intersection crashes; ramp crashes are considered to be those that happened within the confines of the ramp, e.g. failure to negotiate curves, and those that involve merging onto or off of ramps. Crashes involving signalized or stop-sign controlled intersections at the ends of ramps are grouped with intersection crashes.

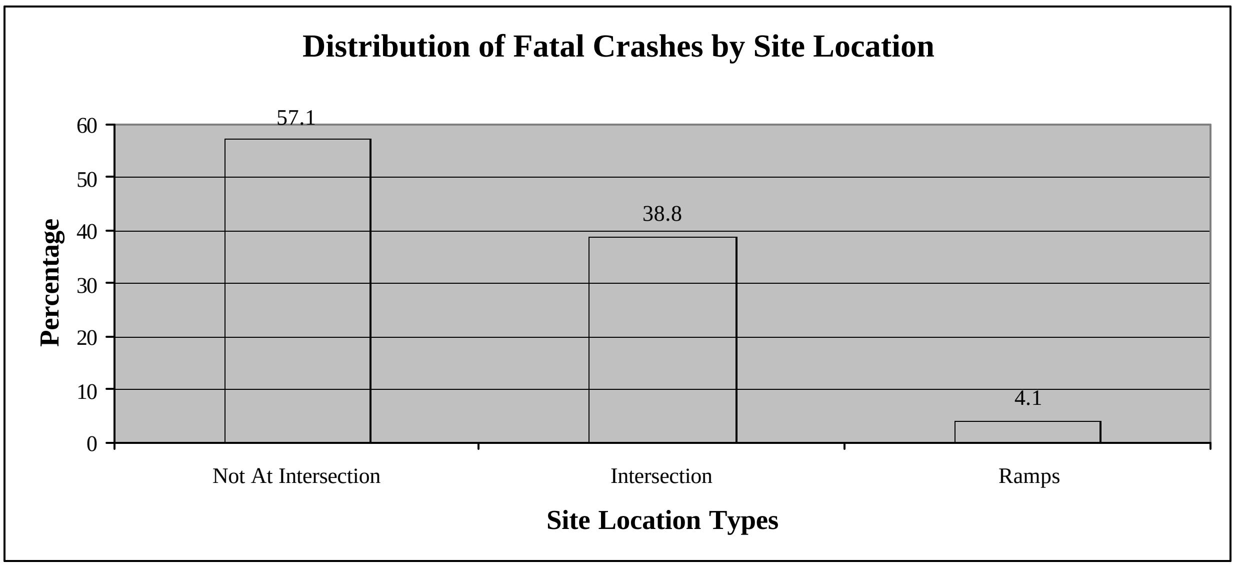


Figure 13.28: Distribution of Fatal Crashes Based on Site Location

When contrasted by age, it seems from Figure 13.29 that site location is not closely linked with driver age for most age groups. However, it explores that the oldest drivers are susceptible to the intersection crashes as are young drivers. As expected, the young drivers are involved in non-intersection crashes too with a value of one out of every four such crashes. The Chi-square test based on the observed and expected frequencies in Table 13.13 shows that as a whole age has significant impacts on the probability of occurrence of fatal crashes on different site locations. The null hypothesis is rejected at 0.000 significance level with Chi-square value of 139.348 for 12 degrees of freedom.

Table 13.13 also shows the significance of the relationships between different age groups and different site locations. It explores that the young drivers have significant statistical relationships with non-intersection fatal crashes with a value of +2.0. It means that more the young drivers drive on the highways with no intersection, the more the probability of fatal crashes will be. Statistically, the young drivers do not cause significant proportion of intersection and ramp crashes. On the other hand, the older (65-74 years) drivers have significantly negative relationships with non-intersection fatal crashes and significantly positive relationships with intersection crashes. It is also true for the oldest (≥75 years) drivers with more weight (-9.8 for non-intersection and +10.5 for intersection crashes). These mean that the older and oldest drivers cause less probability of non-intersection fatal crashes while they cause more probability of intersection fatal crashes. It is worthwhile to mention here that the tallest bar in Figure 13.29 that represents the relationship between the age group 35-44 years and ramp crashes is not statistically significant even at 95% confidence level.

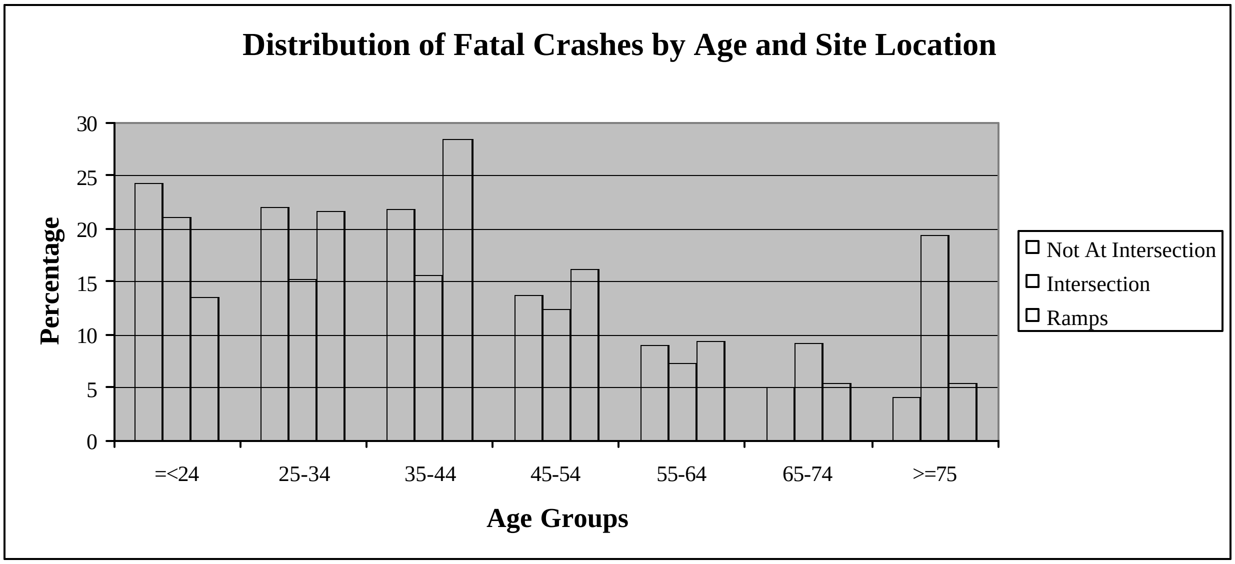


Figure 13.29: Distribution of Fatal Crashes Based on Site Location Contrasted by Age Group

Table 13.13: Cross Tabulation of Age Distribution and Site Location

Age Distribution	Data	Site Location			Total
		Not At Intersection	Intersection	Ramps	
≤24	Count	250	147	10	407
	Expected Count	232.6	157.8	16.7	407.0
	Adjusted Residual	2.0	-1.2	-1.9	
25-34	Count	228	106	16	350
	Expected Count	200.0	135.7	14.3	350.0
	Adjusted Residual	3.4	-3.6	.5	
35-44	Count	226	109	21	356
	Expected Count	203.4	138.0	14.6	356.0
	Adjusted Residual	2.7	-3.5	1.9	
45-54	Count	141	87	12	240
	Expected Count	137.1	93.0	9.8	240.0
	Adjusted Residual	.5	-.9	.8	

Table 13.13: Cross Tabulation of Age Distribution and Site Location, continued

Age Distribution	Data	Site Location			Total
		Not At Intersection	Intersection	Ramps	
55-64	Count	93	51	7	151
	Expected Count	86.3	58.5	6.2	151.0
	Adjusted Residual	1.2	-1.3	.3	
65-74	Count	52	64	4	120
	Expected Count	68.6	46.5	4.9	120.0
	Adjusted Residual	-3.2	3.4	-.4	
≥75	Count	42	136	4	182
	Expected Count	104.0	70.5	7.5	182.0
	Adjusted Residual	-9.8	10.5	-1.4	
Total	Count	1032	700	74	1806
	Expected Count	1032.0	700.0	74.0	1806.0

Table 13.14 and Figure 13.30 represent the risk factors and their graphical distribution by age groups. These explore that the young drivers are more likely to cause fatal crashes on all three site locations compared to the "average" drivers while the older (65-74 years) and oldest (≥75 years) are both likely to cause more intersection crashes at 1.5 and 3.8 times, respectively, and less likely to cause the non-intersection crashes compared to the "average" drivers. The oldest drivers, however, are also slightly more likely to cause ramp crashes.

The individual investigations of the intersection crashes reveal that the officers overuse the term "failure to yield right of way." Only one driver crossed the median and came in front of oncoming vehicle near the driveway access. Two major causes of "failure to yield right of way" are misjudgment of the speed and failure to observe the oncoming vehicles by the older drivers. However, there are individual cases that did not look at both sides of the streets before approaching the intersection and few others who could not see the oncoming vehicle. The individual case analysis reveals that too much of traffic and billboard sign also caused the intersection crashes. Too much of signs also distract the mind of the drivers and confuse them, specifically the older drivers. The intersection crashes are further analyzed contrasted by age groups in the following paragraphs.

Table 13.14: Risk Factors for Site Location

A	E = B*C	G = E/F	H	I = H/N1	RF1 = I/G	J	K = J/N2	RF2 = K/G	L	M = L/N3	RF3 = M/G
Age Group	Florida VMT Per Million	Florida VMT Percent of Total	# of Drivers Involved in Non-Intersection Crashes	% of Drivers Involved in Non-Intersection Crashes	Risk Factor for Non-Intersection Crashes	# of Drivers Involved in Intersection Crashes	% of Drivers Involved in Intersection Crashes	Risk Factor for Intersection Crashes	# of Drivers Involved in Ramp Crashes	% of Drivers Involved in Ramp Crashes	Risk Factor for Ramp Crashes
≤24	42,678	11.35	250.00	24.22	2.1	147	21	1.8	10	13.5135	1.2
25-34	86,871	23.11	228.00	22.09	1.0	106	15.143	0.7	16	21.6216	0.9
35-44	91,034	24.22	226.00	21.9	0.9	109	15.571	0.6	21	28.3784	1.2
45-54	71,486	19.02	141.00	13.66	0.7	87	12.429	0.7	12	16.2162	0.9
55-64	41,796	11.12	93.00	9.012	0.8	51	7.2857	0.7	7	9.45946	0.9
65-74	22,804	6.07	52.00	5.039	0.8	64	9.1429	1.5	4	5.40541	0.9
≥75	19,268	5.13	42.00	4.07	0.8	136	19.429	3.8	4	5.40541	1.1
	375,937	100.00	1032			700.00			74		
	F = 375937		N_1 = 1032			N_2 = 700			N_3 = 74		

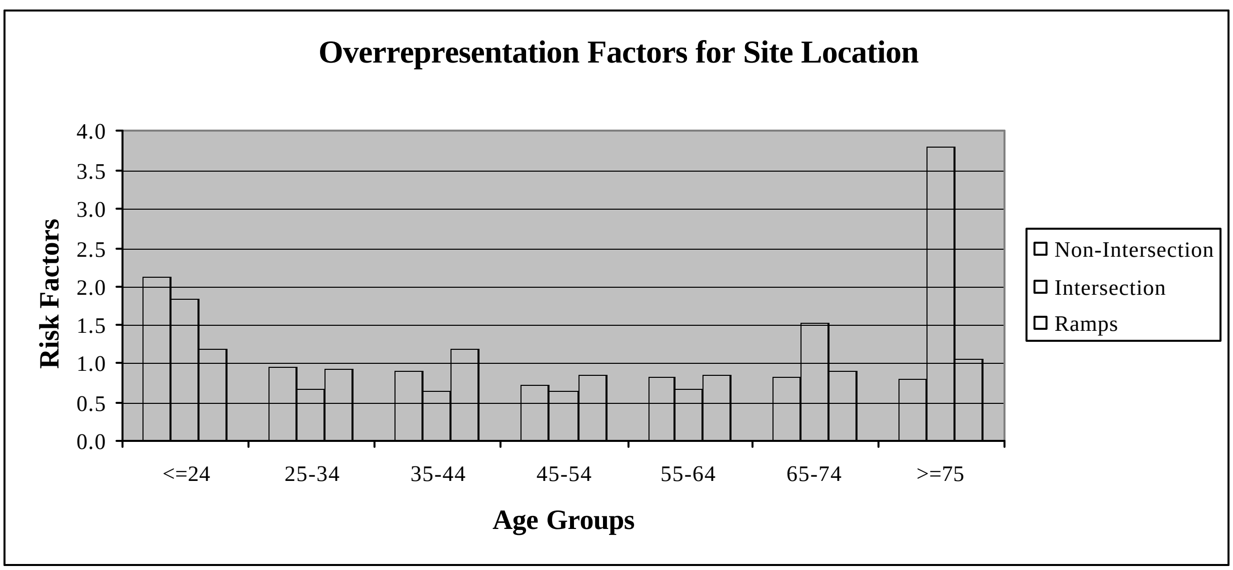


Figure 13.30: Distribution of Risk Factors of Crashes at Different Site Locations

Figure 13.31 shows that one out of three fatal intersection crashes occurs at stop light while more than one-fourth occur at stop sign traffic controls. Another one-third occurs at intersection with no control followed by other traffic control and flashing lights. The calculated Chi-squared value for overall impacts of age on intersection crashes is 25.185 with 24 degrees of freedom at the 0.344 significance level while the table values are 51.2 and 36.4 at 99% and 95% confidence level. It means that as a whole the age of at-fault drivers does not have significant impacts on the occurrence of intersection crashes. Table 13.15 shows the observed and expected frequencies, and the adjusted residuals of the distribution of traffic control systems at the intersection. It explores that none of the age groups has statistically significant relationships to any of the traffic control systems, except between oldest drivers and stop sign. The positive value of the adjusted residual means that the probability of stop sign intersection crashes increases by the presence of oldest drivers at this type of traffic control. This claim is significant at 95% confidence level.

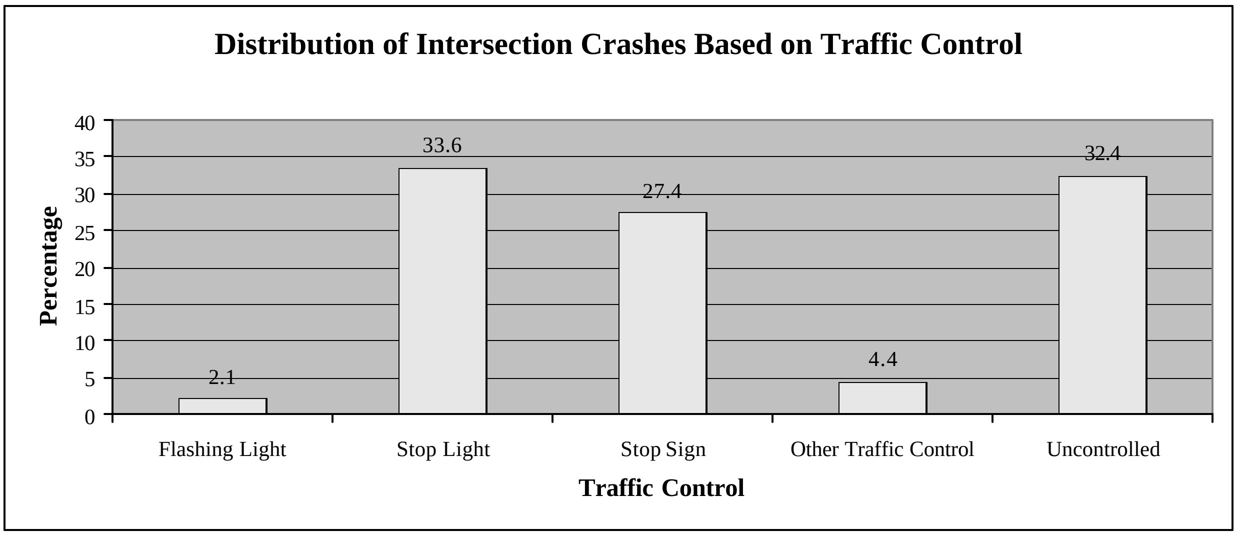


Figure 13.31: Distribution of Fatal Intersection Crashes Based on Traffic Control at Intersection

Table 13.15: Cross Tabulation of Age Distribution and Traffic Control

Age Distribution	Data	Crash Type					Total
		Flashing Light	Stop Light	Stop Sign	Other Traffic Control	Uncontrolled	
≤24	Count	3	55	35	6	45	144
	Expected Count	3.1	48.3	39.5	6.4	46.7	144.0
	Adjusted Residual	-.1	1.3	-.9	-.2	-.3	
25-34	Count	3	38	26	4	38	109
	Expected Count	2.3	36.6	29.9	4.8	35.3	109.0
	Adjusted Residual	.5	.3	-.9	-.4	.6	

Table 13.15: Cross Tabulation of Age Distribution and Traffic Control, continued

Age Distribution	Data	Crash Type					Total
		Flashing Light	Stop Light	Stop Sign	Other Traffic Control	Uncontrolled	
35-44	Count	1	43	23	8	38	113
	Expected Count	2.4	37.9	31.0	5.0	36.6	113.0
	Adjusted Residual	-1.0	1.1	-1.8	1.5	.3	
45-54	Count	3	26	19	4	29	81
	Expected Count	1.7	27.2	22.2	3.6	26.3	81.0
	Adjusted Residual	1.0	-.3	-.9	.2	.7	
55-64	Count	1	17	17	2	14	51
	Expected Count	1.1	17.1	14.0	2.3	16.5	51.0
	Adjusted Residual	-.1	.0	1.0	-.2	-.8	
65-74	Count	3	19	18	1	25	66
	Expected Count	1.4	22.2	18.1	2.9	21.4	66.0
	Adjusted Residual	1.4	-.9	.0	-1.2	1.0	
≥75	Count	1	37	54	6	38	136
	Expected Count	2.9	45.7	37.3	6.0	44.1	136.0
	Adjusted Residual	-1.3	-1.8	3.6	.0	-1.2	
Total	Count	15	235	192	31	227	700
	Expected Count	15.0	235.0	192.0	31.0	227.0	700.0

Figure 13.32 shows that each of the age groups has roughly equal proportion of each type of intersection crashes except the stop sign crashes by the oldest drivers. More than one out of every four stop sign crashes are caused by oldest drivers that makes the tallest bar in Figure 13.32 in age group ≥75 years. The investigation of each of the individual intersection crashes reveals that about one-fourth (23%) of the older drivers misjudged the speeds of the oncoming vehicle(s) and started approaching the intersection leading to a crash. Other reasons are failed to observe (20.7%), disregarded traffic control (16.9%), improper left turn (10.8%), disregarded stop sign (9.2%), confused by traffic and billboard signs plus wide intersection (6.9%), loss of control (4.6%), and exceeded safe/stated speed limits (3%). The other insignificant causes are drove wrong direction (1.5%), driving under the influence, (0.77%), improper lane change (0.77%), and failure to stop to avoid hitting from the back (0.77%). The rest 1.09% are unknown. However, more than 73% of these crashes were coded by the investigation officers as the failure to yield the right of way to the next vehicle. Further investigation of these crashes reveal that 29.6% older drivers misjudged the speeds of the oncoming vehicles while 24.4% failed to observe the oncoming vehicles, 15.3% disregarded traffic control, 13.3% attempted improper left turn, 9.2% were confused by the intersection environment, and 8.2% disregarded stop signs. As the investigation reveals that the complicated intersection and too much of signs confused the older drivers in about ten percent of the crashes, it can be inferred that it is not only the drivers' own error that caused these crashes, but also the roadway and traffic characteristics that helped occur these crashes.

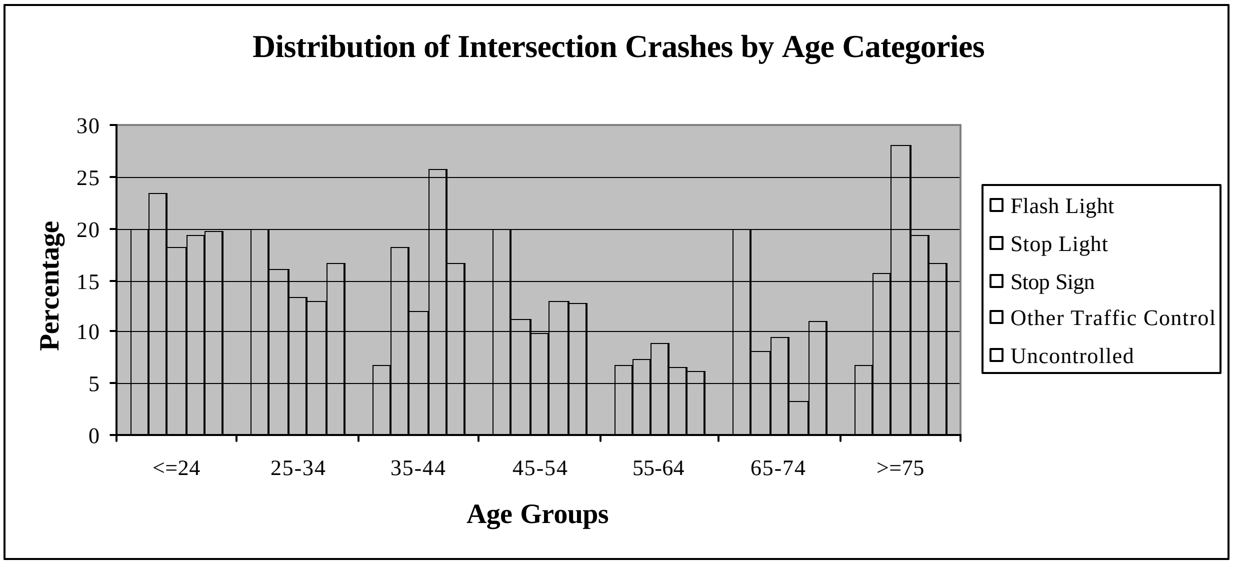


Figure 13.32: Age Distribution of Fatal Intersection Crashes by Major Traffic Controls

Table 13.16 and Figure 13.33 display the risk factors of the major traffic control systems by age groups. The flashlight and other traffic control have been kept out of these figure and table as they constitute small proportion of intersection crashes. The table and figure reveal that all the three important age groups of this study viz. young (≤24 years), older (65-74 years), and oldest (≥75 years) drivers are more likely to cause all three types of fatal crashes compared to the "average" drivers. Specifically, the oldest drivers are 5.5 times more likely to cause "stop sign" crashes than the "average" drivers in the state, which is statistically significant at 95% confidence level (shown in Table 13.16). Although these three age groups are more likely to cause all the above-mentioned three types of crashes, they do not cause statistically significant fatal crashes, except "stop sign" crashes by the oldest drivers.

Table 13.16: Risk Factors for Major Intersection Types

A	E = B*C	G = E/F	H	I = H/N1	RF1 = I/G	J	K = J/N2	RF2 = K/G	L	M = L/N3	RF3 = M/G
Age Group	Florida VMT Per Million	Florida VMT Percent of Total	# of Drivers Involved in Stop Light Crashes	% of Drivers Involved in Stop Light Crashes	Risk Factor for Stop Light Crashes	# of Drivers Involved in Stop Sign Crashes	% of Drivers Involved in Stop Sign Crashes	Risk Factor for Stop Sign Crashes	# of Drivers Involved in Uncontrolled Crashes	% of Drivers Involved in Uncontrolled Crashes	Risk Factor for Uncontrolled Crashes
≤24	42,678	11.35	55	23.4	2.1	35	18.229	1.6	45	19.8238	1.7
25-34	86,871	23.11	38	16.17	0.7	26	13.542	0.6	38	16.7401	0.7

Table 13.16: Risk Factors for Major Intersection Types, continued

A	E = B*C	G = E/F	H	I = H/N1	RF1 = I/G	J	K = J/N2	RF2 = K/G	L	M = L/N3	RF3 = M/G
Age Group	Florida VMT Per Million	Florida VMT Percent of Total	# of Drivers Involved in Stop Light Crashes	% of Drivers Involved in Stop Light Crashes	Risk Factor for Stop Light Crashes	# of Drivers Involved in Stop Sign Crashes	% of Drivers Involved in Stop Sign Crashes	Risk Factor for Stop Sign Crashes	# of Drivers Involved in Uncontrolled Crashes	% of Drivers Involved in Uncontrolled Crashes	Risk Factor for Uncontrolled Crashes
35-44	91,034	24.22	43	18.3	0.8	23	11.979	0.5	38	16.7401	0.7
45-54	71,486	19.02	26	11.06	0.6	19	9.8958	0.5	29	12.7753	0.7
55-64	41,796	11.12	17	7.234	0.7	17	8.8542	0.8	14	6.1674	0.6
65-74	22,804	6.07	19	8.085	1.3	18	9.375	1.5	25	11.0132	1.8
≥75	19,268	5.13	37	15.74	3.1	54	28.125	5.5	38	16.7401	3.3
	375,937	100.00	235			192			227		
	F = 375937		N_1 = 235			N_2 = 192			N_3 = 227		

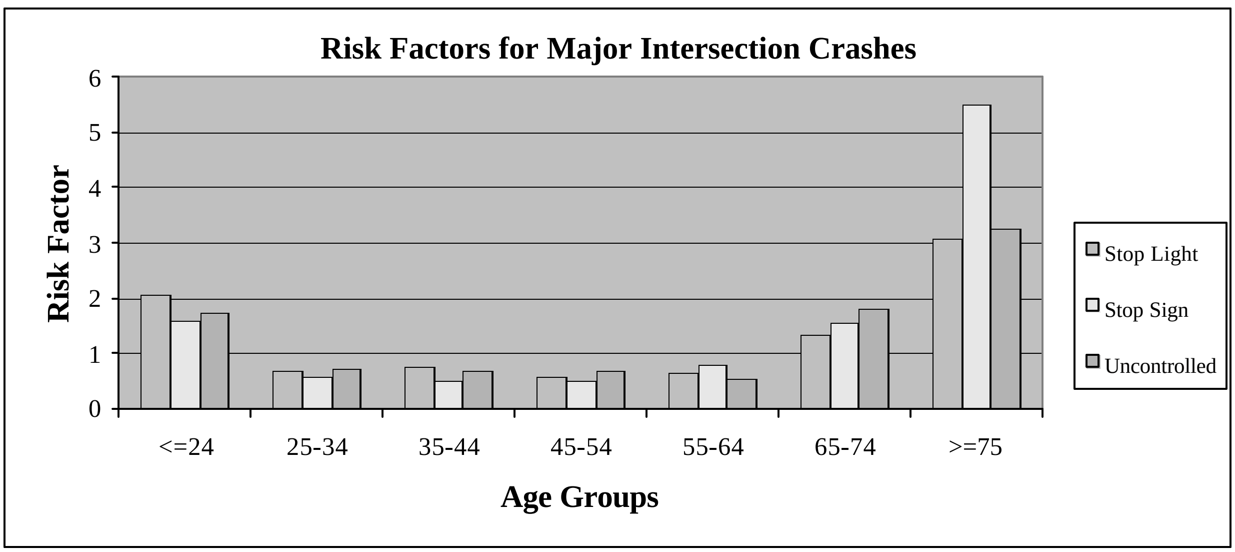


Figure 13.33: Risk Factors for Major Intersection Type Crashes

There is relationship between the ADT and the fatal crashes. Figure 13.34 shows that about one-third of the fatal crashes occurs in the streets with ADT 25,001-50,000 followed by approximately three out of every ten crashes with ADT 10,001-25,000. However, it is remarkable that one in every five crashes occurred on roads with less traffic with ADT equal to or less than 10,000. Only about five percent of the crashes occur on high ADT roads.

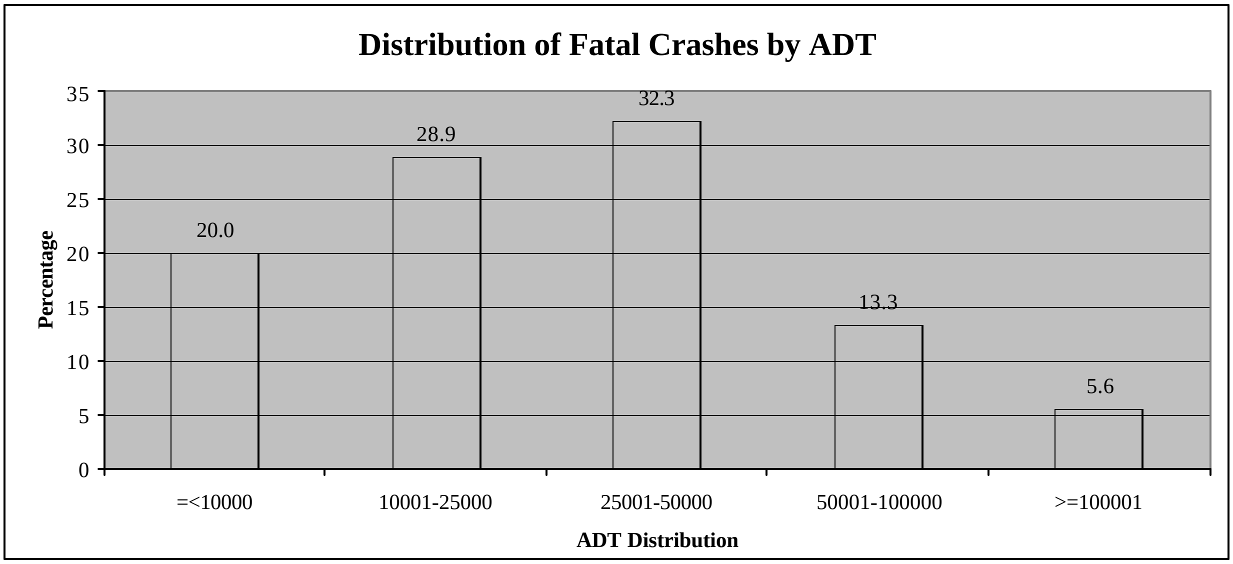


Figure 13.34: Distribution of Fatal Crashes by ADT

Figure 13.35 shows that older drivers cause a smaller proportion of fatal crashes on the streets with high ADT's while young drivers cause fatal crashes approximately at equal proportion on streets with all categories of ADT. However, drivers aged 25-34 contribute to approximately 35% of the crashes occurring on streets with ADT of 100,001 or greater. For other age groups and ADT categories, the proportions are downward from younger age group to the oldest age group which is expected as the total number of drivers in younger age groups is higher than that of the older age groups.

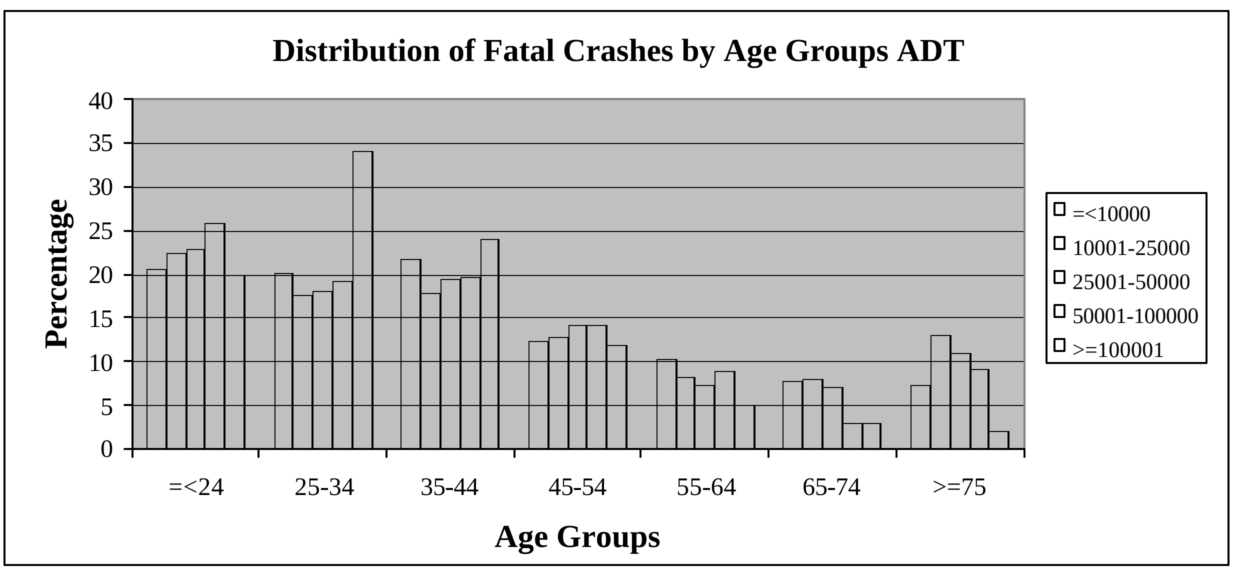


Figure 13.35: Age Distribution of ADT's

The tallest bar in Figure 13.35 was investigated further; the investigation showed that there are only 100 crashes with ADT ≥100,101 of which 34 were caused by drivers aged 25-34. The small number of crashes on such high volume roads made the tall bar for this age group although this age group has far higher numbers of crashes in other ADT categories. The Chi-square value of 45.565 for 24 degrees of freedom is greater than the table Chi-square value of 32 at 99% confidence level. It means that age plays significant roles in the occurrence of fatal crashes based on ADT distribution at the 0.01 significance level, but not at 0.001 significance level. Table 13.17 shows that the oldest drivers have statistical relationships with ADT's ≤10,000 (negative), 10,001-25,000 (positive), and ≥100,001 (negative). The first negative relationship is due to the fact that the oldest drivers feel comfortable on roads with less traffic where they can watch carefully with more time, and make decisions. On the other hand, the second negative relationship indicates the very low number of oldest drivers on the high ADT streets that makes very less crashes by this group of drivers on such roads. It is worthwhile to mention here that the relationships between the youngest drivers and any of the ADT categories are statistically significant.

Table 13.17: Cross Tabulation of Age Distribution and ADT Distribution

Age Distribution	Data	ADT Distribution					Total
		£10000	10001-25000	25001-50000	50001-100000	³ 100001	
≤24	Count	74	116	133	62	20	405
	Expected Count	80.9	117.0	130.7	53.9	22.5	405.0
	Adjusted Residual	-1.0	-.1	.3	1.4	-.6	
25-34	Count	72	91	105	46	34	348
	Expected Count	69.5	100.5	112.3	46.3	19.4	348.0
	Adjusted Residual	.4	-1.3	-.9	.0	3.8	
35-44	Count	78	93	112	47	24	354
	Expected Count	70.7	102.2	114.3	47.1	19.7	354.0
	Adjusted Residual	1.1	-1.2	-.3	.0	1.1	
45-54	Count	44	67	82	34	12	239
	Expected Count	47.7	69.0	77.1	31.8	13.3	239.0
	Adjusted Residual	-.7	-.3	.7	.5	-.4	
55-64	Count	37	43	43	21	5	149
	Expected Count	29.8	43.0	48.1	19.8	8.3	149.0
	Adjusted Residual	1.5	.0	-.9	.3	-1.2	
65-74	Count	28	41	41	7	3	120
	Expected Count	24.0	34.7	38.7	16.0	6.7	120.0
	Adjusted Residual	1.0	1.3	.5	-2.5	-1.5	
≥75	Count	26	68	64	22	2	182
	Expected Count	36.4	52.6	58.7	24.2	10.1	182.0
	Adjusted Residual	-2.0	2.7	.9	-.5	-2.8	
Total	Count	359	519	580	239	100	1797
	Expected Count	359.0	519.0	580.0	239.0	100.0	1797.0

13.6 Driver Contributing Factors

As mentioned in the objectives of this research, this study concentrates mainly on the older and young drivers although the drivers of other ages have also been evaluated. For this purpose, the researchers have investigated the drivers' errors of each of the young and older at-fault driver's case to find out further reasoning of the fatal crashes. These case-by-case investigations are complement to the results discussed in other chapters.

Overall, three-fourth of the at-fault drivers in the fatal traffic crashes under study were male while the rest were female. Figure 13.36 shows the distribution of fatal crashes by age categories and sex. It shows that the distribution of at-fault drivers by sex is fairly uniform among the different age categories. However, the figure shows that there are little more male young drivers compared to young female drivers while little more female older drivers compared to older male drivers. The Chi-square test was conducted to check the significance of the relationships between age groups and sex. The result shows that the relationship is not statistically significant even at 90% confidence level (the calculated Chi-square value is 18.340 while the table Chi-square value is 18.5 for 12 degrees of freedom).

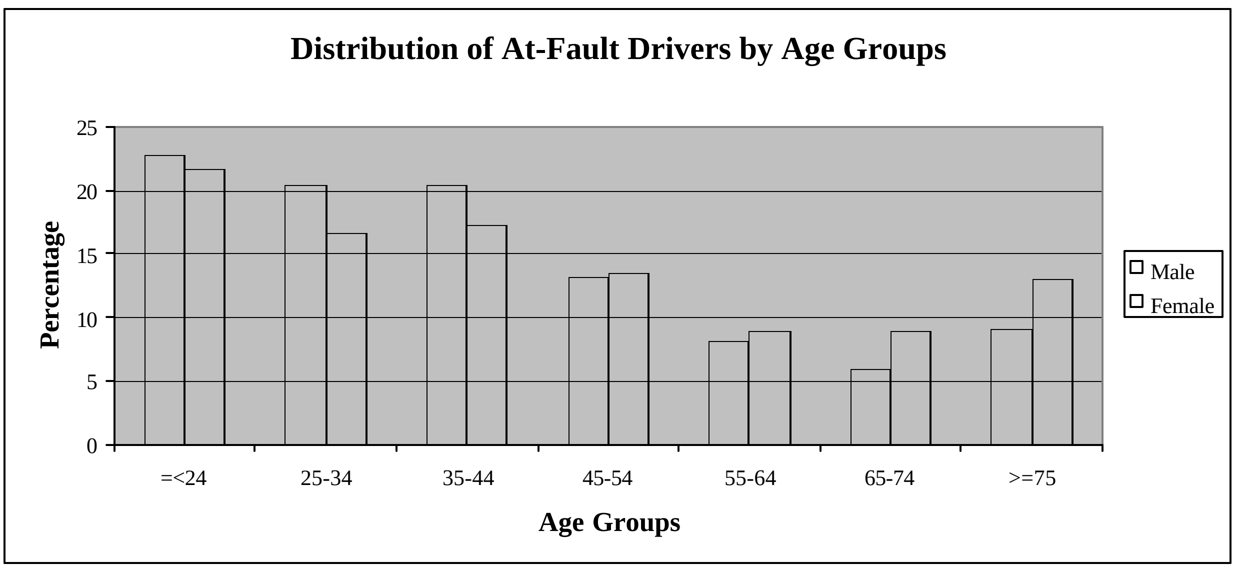


Figure 13.36: Distribution of Crashes by Sex and Age Categories

Table 13.18 and Figure 13.37 show the risk factors of the at-fault drivers based on sex. They explore that the both young and older drivers of both sexes are overrepresented in the data sets with 2.0 and 1.8 for male drivers of ≤24 and ≥75 years while with 1.9, 1.5, and 2.6, respectively, for female drivers of age groups ≤24 years, 65-74 years, and ≥75 years. These are shown by the "U" shaped curves for both the males and females. These table and figure tell us that the young and older drivers are cause fatal crashes in Florida highways compared to the "average" drivers irrespective of the gender of the drivers. Scrutinizing more, the figure and table explore that the young male drivers are little more likely (2.0 vs. 1.9) to cause fatal crashes compared to young female drivers while the older female drivers are more vulnerable to cause fatal crashes compared to older male drivers with 1.5 vs. 1.0 for 65-74 age group, and 2.6 vs. 1.8, for age group ≥75 years.

Table 13.18: Calculation of Risk Factors for Sexes of Driver

A	B	C	D	E = B*C	G = E/F	H	I = H/N1	RF1 = I/G	J	K = J/N2	RF2 = K/G
Age Group	US-VMT Per Year Per Driver	Licensed Drivers of Florida	% of Total Drivers	Florida VMT Per Million	Florida VMT Percent of Total	# of Male Drivers	% of Crash by Male Drivers	Risk Factor for Male Drivers	# of Female Drivers	% of Crash by Female Drivers	Risk Factor for Female Drivers
≤24	22,950	1,859,606	13.24	42,678	11.35	308	22.80	2.0	98	21.73	1.9
25-34	32,400	2,681,209	19.09	86,871	23.11	275	20.36	0.9	75	16.63	0.7
35-44	31,100	2,927,153	20.85	91,034	24.22	276	20.43	0.8	78	17.29	0.7
45-54	30,100	2,374,937	16.91	71,486	19.02	178	13.18	0.7	61	13.53	0.7
55-64	25,200	1,658,581	11.81	41,796	11.12	111	8.22	0.7	40	8.87	0.8
65-74	16,700	1,365,502	9.72	22,804	6.07	80	5.92	1.0	40	8.87	1.5
≥75	16,400	1,174,859	8.37	19,268	5.13	123	9.10	1.8	59	13.08	2.6
		14,041,847	100.00	375,937	100.00	1351	100.00		451	100.00	
				F = 375937		N_1 =1351			N_2 = 451		

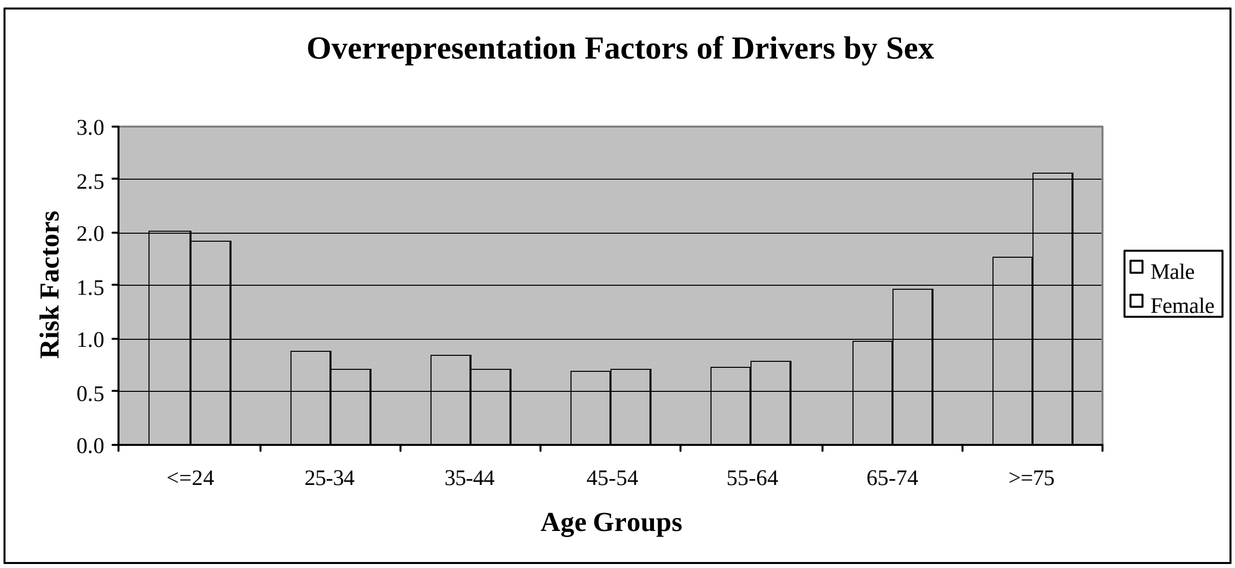


Figure 13.37: Risk Factors of Different Age Categories for Driver Sex

Figure 13.38 shows the distribution of crashes based on maximum-posted speed limit distribution. It explores that more than one-fourth of the crashes in 2000 were high-speed zones that occurred in the speed category of 71 miles or higher. However, the highest proportion of fatal crashes occurred in the speed category 61-70 mph with approximately three out of every ten crashes. Medium speed category constitutes one-fourth of all fatal crashes. As we perceive, the figure shows that very small proportion of the crashes occurred at low and medium speed limits of 50 mph or less. The most important feature of this figure is that only little more than two percent of the crashes occurred in the speed zones 30 miles or less. The figure confirms that there is a positive relationship between the maximum posted speed and the occurrence of fatal crashes.

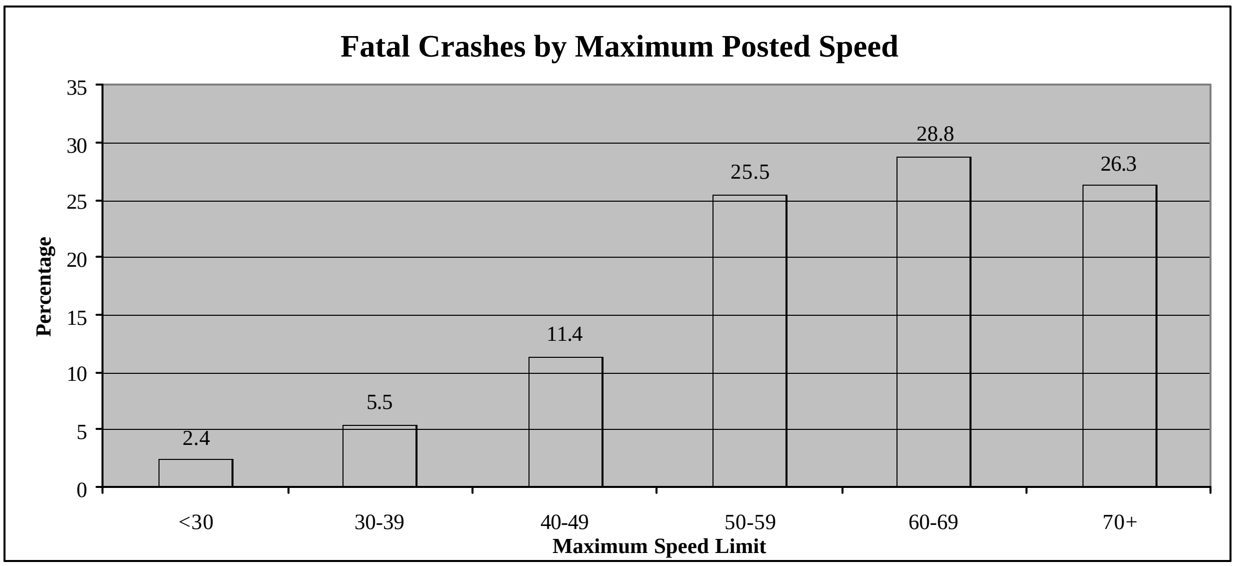


Figure 13.38: Proportion of Fatal Crashes by Maximum Posted Speed Limits

In contrast to Figure 13.38, Figure 13.39 shows the distribution of fatal crashes by actual vehicle speeds at the time of crashes. It is worthwhile to mention here that the vehicle speeds of a large number (281 vehicles) of at-fault vehicles are unknown. So, Figure 13.39 represents the available data of 1,526 at-fault vehicles' speeds instead of all the vehicles of at-fault drivers. The comparison of Figure 13.38 and Figure 13.39 shows that although only 2.4 percent of fatal crashes occurred in the <30 mph zones, in reality more than one-fourth fatal crashes occurred with actual vehicle speeds of less than 30 mph. It means that these low-speed crashes occurred at higher-speed zones. Figure 13.39 also shows that the highest proportion of crashes was high-speed crashes with 70 miles or higher vehicle speeds.

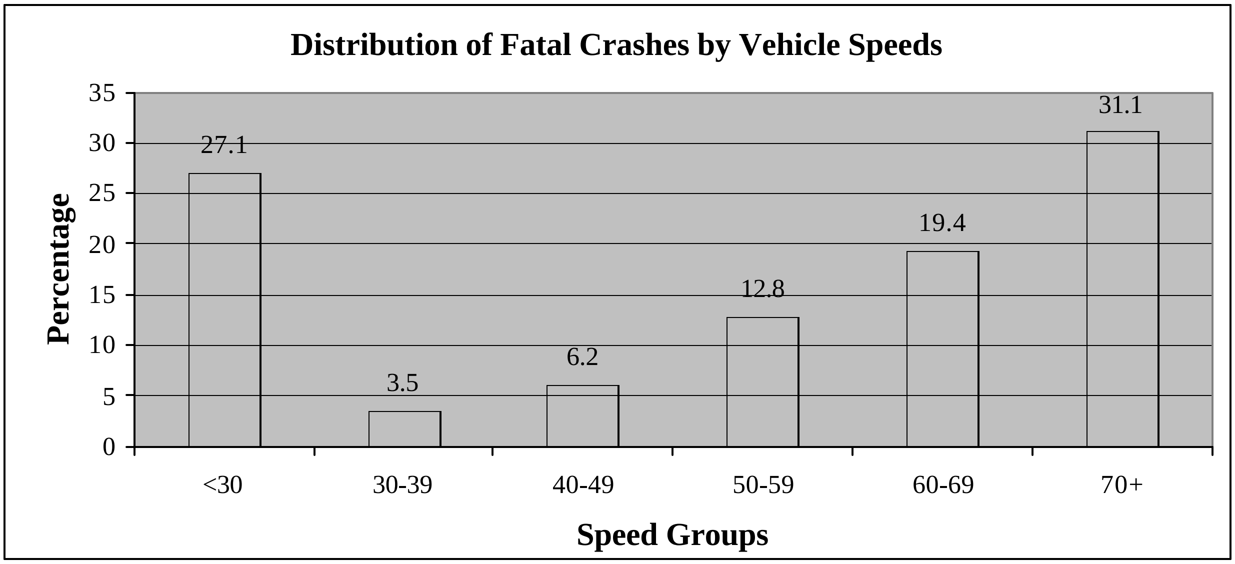


Figure 13.39: Proportion of Fatal Crashes Categorized by Actual Vehicle Speeds at Crash

Figure 13.40 shows that the young drivers cause approximately three out of every ten high-speed fatal crashes in Florida while they contribute to smaller proportions of low and medium speed crashes. The trend for high-speed crashes gradually decreases with the increase of age groups. Not surprisingly, the figure explores that the older drivers contribute to higher proportions of low-speed crashes (50 mph or less) while their contribution to medium and high-speed crashes are low.

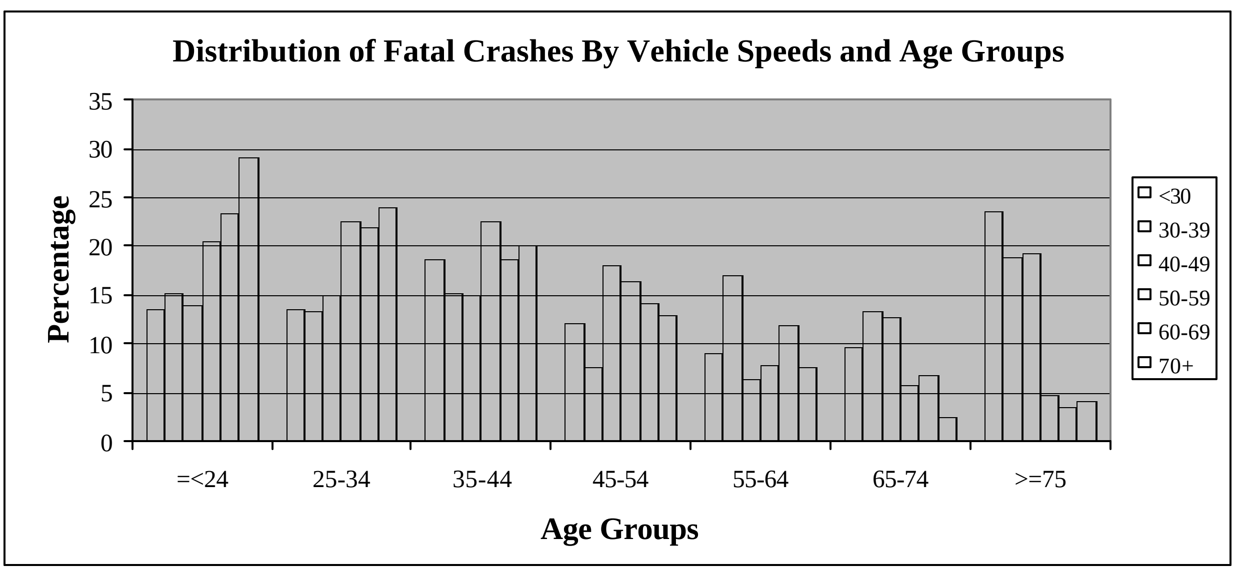


Figure 13.40: Distribution of Crashes by Age Groups and Actual Vehicle Speeds

The high-speed crashes by the young drivers have been investigated case-wise. The investigation shows that the proportions of young drivers driving at high-speeds are higher (42.6% of the young drivers) than the older (11.76% of the older drivers) and oldest (11.65% of oldest drivers) age groups. Most of the high-speed crashes involving younger drivers resulted in loss of control due to the high speed. Some of younger drivers also could not stop the vehicles when they saw pedestrians or bicyclists in front of them due to their high speed. Many of the younger drivers were driving at high speed under the influence of drugs/alcohol. In brief, after investigations of the young drivers with high-speed crashes it can be inferred that there is a relationship between the age of the driver and the speed related crashes. However, it needs to be tested statistically. Hence the null and alternative hypotheses for the general relationship between age and crash type are formulated as below.

H_0 = Ages of the at-fault drivers does not significantly cause the occurrence of fatal crashes in different vehicle speeds.

H_a = Ages of the at-fault drivers significantly cause on the fatal crashes in different speeds.

The calculated Chi-square value of 202.711 for 24 degrees of freedom is greater than the table value of Chi-square value of 51.2 at the 0.001 significance level. It means that overall, ages of the at-fault drivers play significant roles on the occurrence of fatal crashes at different vehicle speeds. Apart from the overall relationships, the age specific hypotheses are also tested from the adjusted residuals presented in Table 13.19. The table shows that there is a direct relationship between the age of the young drivers and the speeds at which they cause fatal crashes. However, the relationships are significant only for low-speed (30 mph lo less) and high-speed (≥71 mph) crashes. The table tells us that for one-year increase in age of the youngest drivers the probability of low-speed crashes decreases by 4.5 numbers while it increases the probability of high-speed crashes by 5 numbers. Similarly, the table further explores that there is an inverse relationship between the age of the oldest (≥75 years) drivers and the speeds at which they cause fatal crashes. The relationships are significant for all speed crashes. It is evident from the table that an increase of one year age of the oldest drivers increases the probability of low-speed crashes by 9.9, 2, and 2.7 of the crashes of ≤30 mph, 31-40 mph, and 41-50 mph, respectively. On the other hand, an increase of one year age of the oldest drivers decreases the probability of high-speed crashes by 2.9, 4.5, and 5.7 of the categories 51-60 mph, 61-70 mph, and ≥71 mph, respectively.

Figure 13.41 depicts the risk factors of the drivers of different age categories to cause fatal crashes at different speeds. The figure shows that the young drivers are more likely to cause fatal crashes at all speed categories compared to an “average” driver while the oldest drivers are more likely to cause fatal crashes at low speeds of 50 mph or less. The reasons for such driving behavior by the young and older drivers have already been discussed in previous paragraphs. It is evident that older drivers of age 65-74 years are also more likely to cause low and medium-speed crashes while they are as likely to cause such crashes as the “average” drivers at speed range 51-70 mph. The middle-age drivers are not more likely to cause fatal crashes for any of the speed categories except that the drivers of age 55-64 years are more likely at speeds between 31-40 mph. In addition to the figures and tables mentioned in section 5.4.1 above, Figure 13.41 reconfirms that older drivers are more susceptible to cause fatal crashes at low speeds as they usually do not drive at high speeds.

Table 13.19: Cross Tabulation of Age Distribution and Vehicle Speed Distribution

Age Distribution	Data	Vehicle Speed Distribution						Total
		£30	31-40	41-50	51-60	61-70	³71	
≤24	Count	56	8	13	40	69	138	324
	Expected Count	87.7	11.3	20.0	41.4	62.8	100.9	324.0
	Adjusted Residual	-4.5	-1.1	-1.8	-.3	1.0	5.0	
25-34	Count	56	7	14	44	65	114	300
	Expected Count	81.2	10.4	18.5	38.3	58.2	93.4	300.0
	Adjusted Residual	-3.7	-1.2	-1.2	1.1	1.1	2.9	
35-44	Count	77	8	14	44	55	95	293
	Expected Count	79.3	10.2	18.0	37.4	56.8	91.2	293.0
	Adjusted Residual	-.3	-.8	-1.1	1.3	-.3	.5	
45-54	Count	50	4	17	32	42	61	206
	Expected Count	55.8	7.2	12.7	26.3	40.0	64.1	206.0
	Adjusted Residual	-1.0	-1.3	1.3	1.3	.4	-.5	
55-64	Count	37	9	6	15	35	36	138
	Expected Count	37.3	4.8	8.5	17.6	26.8	43.0	138.0
	Adjusted Residual	-.1	2.1	-.9	-.7	1.9	-1.3	
65-74	Count	40	7	12	11	20	12	102
	Expected Count	27.6	3.5	6.3	13.0	19.8	31.7	102.0
	Adjusted Residual	2.9	1.9	2.4	-.6	.1	-4.4	
≥75	Count	97	10	18	9	10	19	163
	Expected Count	44.1	5.7	10.0	20.8	31.6	50.7	163.0
	Adjusted Residual	9.9	2.0	2.7	-2.9	-4.5	-5.7	
Total	Count	413	53	94	195	296	475	1526
	Expected Count	413.0	53.0	94.0	195.0	296.0	475.0	1526.0

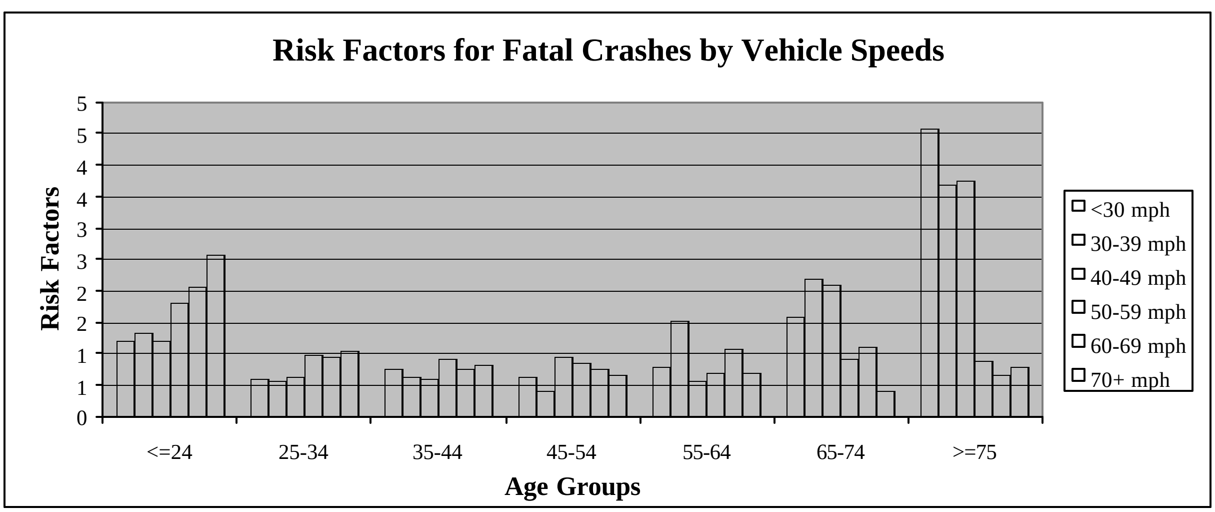


Figure 13.41: Risk Factors for Speed Related Crashes

Table 13.20 shows the first harmful events in all fatal crashes, along with percentages and cumulative percentages. Figure 13.42 shows the distribution of fatal crashes by age groups and major first harmful events for the five most common harmful events, which account for two-thirds of the fatal crashes. It shows that the young drivers are involved in more head-on and overturn crashes while the older drivers are involved in left turn and angle crashes.

Table 13.20: Proportion of Fatal Crashes by First Harmful Events

First Harmful Event	Frequency	Percent	Cumulative
Collision With MV in Transport (Angle)	469	26.0%	26.0%
Collision With MV in Transport (Rear End)	243	13.4%	39.4%
Collision With MV in Transport (Left Turn)	207	11.5%	50.9%
Overturned	157	8.7%	59.5%
Collision With MV in Transport (Head-On)	130	7.2%	66.7%
All Other	70	3.9%	70.6%
MV Hit Tree/Shrubbery	67	3.7%	74.3%
Collision With MV in Transport (Sideswipe)	61	3.4%	77.7%
MV Hit Guardrail	60	3.3%	81.0%
MV Ran Into Ditch/Culvert	55	3.0%	84.1%
Collision With Pedestrian	47	2.6%	86.7%
Collision With Bicycle	47	2.6%	89.3%
MV Hit Utility Pole/Light Pole	32	1.8%	91.0%
MV Hit Concrete Barrier Wall	21	1.2%	92.2%
Collision With Parked Car	20	1.1%	93.3%
MV Hit Sign/Sign Post	16	0.9%	94.2%
MV Hit Fence	16	0.9%	95.1%
MV Hit Other Fixed Object	16	0.9%	96.0%
MV Hit Bridge/Pier/Abutment/Rail	15	0.8%	96.8%
Ran Off Road Into Water	14	0.8%	97.6%
Collision With Fixed Object Above Road	8	0.4%	98.0%
Collision With MV in Transport (Right Turn)	6	0.3%	98.3%
Collision With Construction Barricade/Sign	5	0.3%	98.6%
Tractor/Trailer Jackknifed	5	0.3%	98.9%
Collision With Moped	3	0.2%	99.1%
Collision With Train	4	0.2%	99.3%
Collision With Animal	4	0.2%	99.5%
Occupant Fell From Vehicle	4	0.2%	99.7%
Collision With MV on Other Roadway	1	0.1%	99.8%
Collision With Traffic Gate	1	0.1%	99.8%
Collision With Crash Attenuators	1	0.1%	99.9%
Collision With Moveable Object on Road	1	0.1%	99.9%
Unknown	1	0.1%	100.0%
Total	1807	100.0%	100.0%

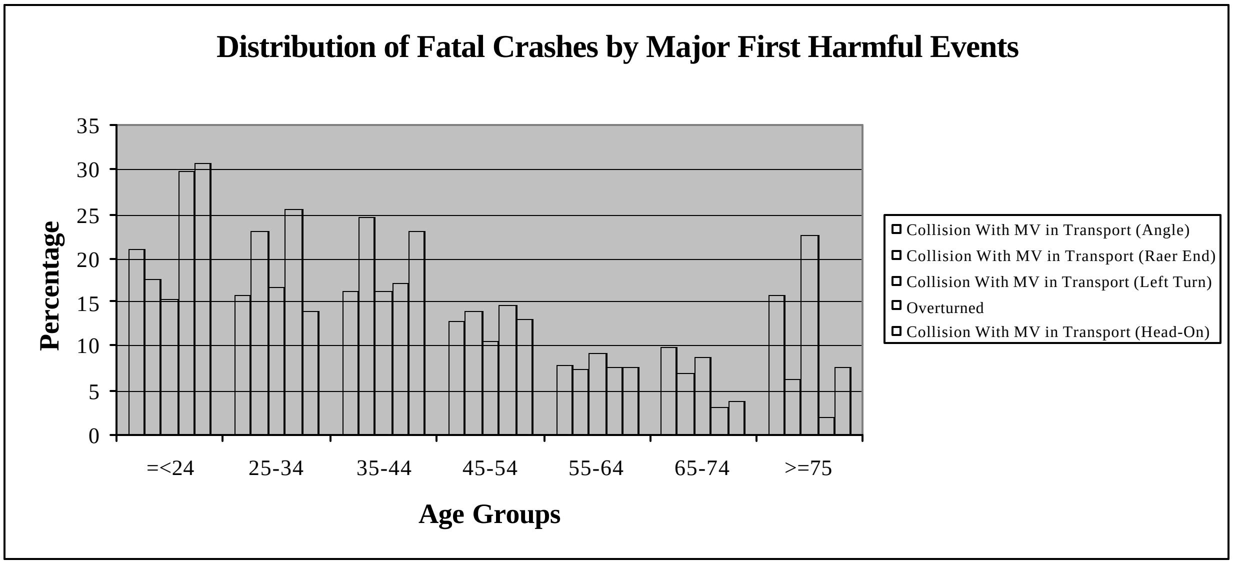


Figure 13.42: Distribution of Fatal Crashes by Major First Harmful Events

On the other hand, the investigation of the older drivers indicates that misjudgment (23%), failure to observe the oncoming vehicles from the other directions (20.7%), and confusion (6.9%) regarding the intersection are major causes that lead them to be involved in left-turn and angular crashes. However, the misjudgment and confusion are created by several other reasons. In case of angular collision with other motor vehicles it is found that the older drivers are unable to judge the angle properly they should make to avoid a crash. However, these drivers are involved in more left-turn crashes than any other age groups at low speeds. As mentioned above, the reasons behind this are confusion and misjudgment which are further caused by being unable to judge the speed of the oncoming vehicle, failure to observe the oncoming vehicles, too much of signs at the intersection, and complicated nature of many intersections. The Chi-square results show that the ages of the at-fault drivers have significant effects on the fatal crashes based on first harmful events. This claim is statistically significant at 0.000 significant level where the calculated Chi-square value is 292.271 for 186 degrees of freedom while the table Chi-square value is 149.

13.6.1 Contributing Factors in Fatal Crashes Caused by Young Drivers

There were 682 young (under age 25) drivers in the database, of which 420 were found to be at fault. Table 13.21 shows the crash types of the crashes in which those drivers were involved. Younger drivers were highly overrepresented in fault in forward impacts with control loss, that is, collisions with oncoming vehicles in which the driver lost control prior to the impact. Younger drivers were also overrepresented in fault in left roadside departure crashes. These two crash types generally involve high speeds and abrupt steering input and potentially indicate inattention and/or an inability to use sound judgment and make quick decisions. Other crash types that were common although not overrepresented among young at-fault drivers were left roadside departures with control loss, rear end collisions, head-on collisions without control loss, and turning in front of oncoming traffic. Younger drivers were underrepresented in fault in crashes involving turning in front of cross traffic and turning in front of oncoming traffic.

Table 13.21: Crash Types of Crashes Caused by Younger Drivers

Type	Sub-Type	Older At-Fault		Other At-Fault		ORF	Min CI	Max CI	Level
		No.	Per.	No.	Per.				
Change Trafficway/Turning	Initial Same Direction	0	0.0%	20	1.5%	**0.000**	N/A	N/A	N/A
	Single Vehicle Control Loss While Turning	0	0.0%	2	0.1%	**0.000**	N/A	N/A	N/A
	Turn Into Opposite Directions/Cross Traffic	19	4.5%	121	9.0%	**0.506**	0.316	0.810	Under
	Turn/Merge Into Same Direction	5	1.2%	18	1.3%	**0.895**	0.334	2.396	Unsure
	Evasive Action To Avoid Turning/Merging Vehicle	1	0.2%	2	0.1%	**1.611**	0.146	17.722	Unsure
	Initial Opposite Directions/Oncoming Traffic	35	8.4%	160	11.9%	**0.705**	0.497	0.999	Under
Intersecting Paths	Backing	1	0.2%	4	0.3%	**0.805**	0.090	7.187	Unsure
	Not At Fault From Left	20	4.8%	65	4.8%	**0.991**	0.608	1.617	Unsure
	Not At Fault From Right	28	6.7%	63	4.7%	**1.432**	0.930	2.205	Unsure
	Not At Fault Unknown Direction	0	0.0%	4	0.3%	**0.000**	N/A	N/A	N/A
Opposite Direction	Forward Impact With Control Loss	16	3.8%	22	1.6%	**2.343**	1.242	4.420	Over
	Sideswipe Angle	0	0.0%	3	0.2%	**0.000**	N/A	N/A	N/A
	Head-On	36	8.6%	101	7.5%	**1.148**	0.798	1.653	Unsure
Pedestrian	Exit Vehicle	0	0.0%	10	0.7%	**0.000**	N/A	N/A	N/A
	Unique	0	0.0%	1	0.1%	**0.000**	N/A	N/A	N/A
	Walking Along Road Against Traffic	1	0.2%	0	0.0%	**N/A**	N/A	N/A	N/A
	Crossing At Intersection In Crosswalk	2	0.5%	4	0.3%	**1.611**	0.296	8.764	Unsure
	Crossing Not At Intersection--First Half	4	1.0%	9	0.7%	**1.432**	0.443	4.626	Unsure
	Crossing Not At Intersection--Second Half	4	1.0%	14	1.0%	**0.921**	0.305	2.782	Unsure
	Other In Road	0	0.0%	6	0.4%	**0.000**	N/A	N/A	N/A
	Vehicle Turn/Merge	1	0.2%	7	0.5%	**0.460**	0.057	3.730	Unsure
	Walking Along Road With Traffic	1	0.2%	3	0.2%	**1.074**	0.112	10.297	Unsure

Table 13.21: Crash Types of Crashes Caused by Younger Drivers, continued

Type	Sub-Type	Older At-Fault		Other At-Fault		ORF	Min CI	Max CI	Level
		No.	Per.	No.	Per.				
Run Off Road/Single Vehicle	Ramp Departure	9	2.1%	22	1.6%	**1.318**	0.612	2.840	Unsure
	Forward Impact	2	0.5%	9	0.7%	**0.716**	0.155	3.301	Unsure
	Left Roadside Departure	53	12.6%	85	6.3%	**2.009**	1.451	2.781	Over
	Left Roadside Departure With Control Loss	46	11.0%	109	8.1%	**1.360**	0.981	1.885	Unsure
	Other	1	0.2%	1	0.1%	**N/A**	0.202	51.39 9	Unsure
	Right Roadside Departure	50	11.9%	171	12.7%	**0.942**	0.701	1.266	Unsure
	Right Roadside Departure With Control Loss	28	6.7%	73	5.4%	**1.236**	0.811	1.884	Unsure
Same Direction	Sideswipe Angle With Control Loss	3	0.7%	12	0.9%	**0.805**	0.228	2.841	Unsure
	Rear End	38	9.1%	159	11.8%	**0.770**	0.550	1.078	Unsure
	Rear End With Avoid Impact	7	1.7%	29	2.1%	**0.778**	0.343	1.762	Unsure
	Sideswipe Angle	6	1.4%	31	2.3%	**0.624**	0.262	1.484	Unsure
Other/Unknown		2	0.5%	10	0.7%	**0.644**	0.142	2.929	
Total		419	100%	1350	100%	**1.000**			

Table 13.22 looks at contributing factors in crashes where a younger driver was found to be at fault. Ninety-four percent of the primary factors were human factors, with alcohol and/or drug use accounting for almost 30 percent of the cases. Inattention and speed each accounted for almost twenty percent of the primary contributing factors in crashes with a young at-fault driver. Abrupt steering input, decision errors, aggression, and fatigue each were primary contributors to at least four percent of the crashes. The most common non-human factor was tire blowouts/tread separation, which was the primary contributor to about three percent of the crashes involving younger drivers. Wet or slippery conditions and curvature were the most common overall non-human factors, indicating that the younger drivers, who tended to drive at higher speeds and have less experience behind the wheel, had more difficulty negotiating curves and driving in inclement weather.

Table 13.22: Contributing Factors in Crashes Where a Younger Driver Was At Fault

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.	Num.	Num.	Num.	Per.
Environment	Wet/Slippery	4	1.0%	12	22	38	4.1%
	Dark	0	0.0%	14	12	26	2.8%
	Smoke/Fog	0	0.0%	5	2	7	0.8%
	Dawn/Dusk	0	0.0%	0	1	1	0.1%
	Heavy Rain	0	0.0%	1	0	1	0.1%

Table 13.22: Contributing Factors in Crashes Where a Younger Driver Was At Fault, continued

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.	Num.	Num.	Num.	Per.
Human	Alcohol	90	21.5%	8	4	102	11.1%
	Inattention	82	19.6%	29	9	120	13.0%
	Speed	70	16.7%	60	9	139	15.1%
	Unknown	25	6.0%	0	0	25	2.7%
	Steering Input	21	5.0%	45	22	88	9.5%
	Decision	20	4.8%	28	3	51	5.5%
	Drugs	20	4.8%	3	2	25	2.7%
	Aggression	19	4.5%	9	1	29	3.1%
	Fatigue	16	3.8%	6	1	23	2.5%
	Alcohol & Drugs	12	2.9%	1	1	14	1.5%
	Medical	5	1.2%	1	0	6	0.7%
	Perception	4	1.0%	3	0	7	0.8%
	Distraction	3	0.7%	1	2	6	0.7%
	Inexperience	2	0.5%	19	4	25	2.7%
	Police Pursuit	2	0.5%	2	0	4	0.4%
	Mental/Emotional	1	0.2%	3	1	5	0.5%
	Confusion	1	0.2%	1	2	4	0.4%
	History	0	0.0%	2	6	8	0.9%
	Age	0	0.0%	2	1	3	0.3%
	Unfamiliar w/Vehicle	0	0.0%	2	0	2	0.2%
	Low Speed	0	0.0%	1	0	1	0.1%
	Other	0	0.0%	0	1	1	0.1%
	Physical Defect	0	0.0%	0	1	1	0.1%
	Unfamiliar w/Area	0	0.0%	0	1	1	0.1%
Roadway	Access Point	3	0.7%	3	4	10	1.1%
	Obstruction	1	0.2%	5	3	9	1.0%
	Standing Water	1	0.2%	0	0	1	0.1%
	Curvature	0	0.0%	4	19	23	2.5%
	Lighting	0	0.0%	1	14	15	1.6%
	Construction	0	0.0%	8	2	10	1.1%
	Sight Distance	0	0.0%	6	4	10	1.1%
	Bike Facilities	0	0.0%	4	1	5	0.5%
	Congestion	0	0.0%	4	1	5	0.5%
	Traffic Operation	0	0.0%	2	3	5	0.5%
	Design/Geometry	0	0.0%	2	2	4	0.4%
	Sign/Signal	0	0.0%	2	2	4	0.4%
	Speed Limit	0	0.0%	0	3	3	0.3%
	Shoulder Design	0	0.0%	0	2	2	0.2%

Table 13.22: Contributing Factors in Crashes Where a Younger Driver Was At Fault, continued

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.	Num.	Num.	Num.	Per.
Vehicle	Tires	13	3.1%	3	5	21	2.3%
	Defect	2	0.5%	3	2	7	0.8%
	Other	1	0.2%	0	0	1	0.1%
	Visibility	0	0.0%	7	5	12	1.3%
	Emergency	0	0.0%	2	1	3	0.3%
	Lighting	0	0.0%	1	2	3	0.3%
	Overweight	0	0.0%	1	1	2	0.2%
	Jackknife	0	0.0%	0	1	1	0.1%
	Low Speed	0	0.0%	0	1	1	0.1%
	Trailer	0	0.0%	1	0	1	0.1%
	View Obstruction	0	0.0%	0	1	1	0.1%
Other/Unknown		1	0.2%	0	0	1	0.1%
Total		419	100.0%	317	187	923	100.0%

The types of drivers' errors of the young at-fault drivers are shown in Table 13.23; these errors are typically the critical reason for the crash. Table 13.23 shows that each of last seven types of errors contribute to less than 1% of fatal crashes caused by young drivers. Those are added together, labeled as "others," and the data are presented in Figure 13.43.

Table 13.23: Drivers' Errors of Young At-Fault Drivers

Drivers' Errors/Critical Reasons	Frequency	Percentage
Exceeded Safe Speed Limit	109	28.5
Loss of Control	101	26.4
Disregarded Traffic Control	32	8.4
Failed to Stop	26	6.8
Driving Under the Influence	19	5.0
Disregarded Stop Sign	18	4.7
Failed to Observe	14	3.7
Driving Wrong Direction	12	3.1
Improper Lane Change	11	2.9
Improper Left Turn	10	2.6
Failed to Negotiate Curve	10	2.6
Improper Road Crossing	6	1.6
Fell Asleep	6	1.6
Misjudgment of Speed	4	1.0
Improper U-Turn	2	0.5

Table 13.23: Drivers’ Errors of Young At-Fault Drivers, continued

Drivers’ Errors/Critical Reasons	Frequency	Percentage
Disabled Vehicle	1	0.3
Entered and Crossed Median	1	0.3
Followed too Closely	1	0.3
Hit Roadside Fixed Object	1	0.3
Illegally Parked on the Street	1	0.3
Improper Passing	1	0.3
Violated Pedestrian ROW	1	0.3
	387	100.0

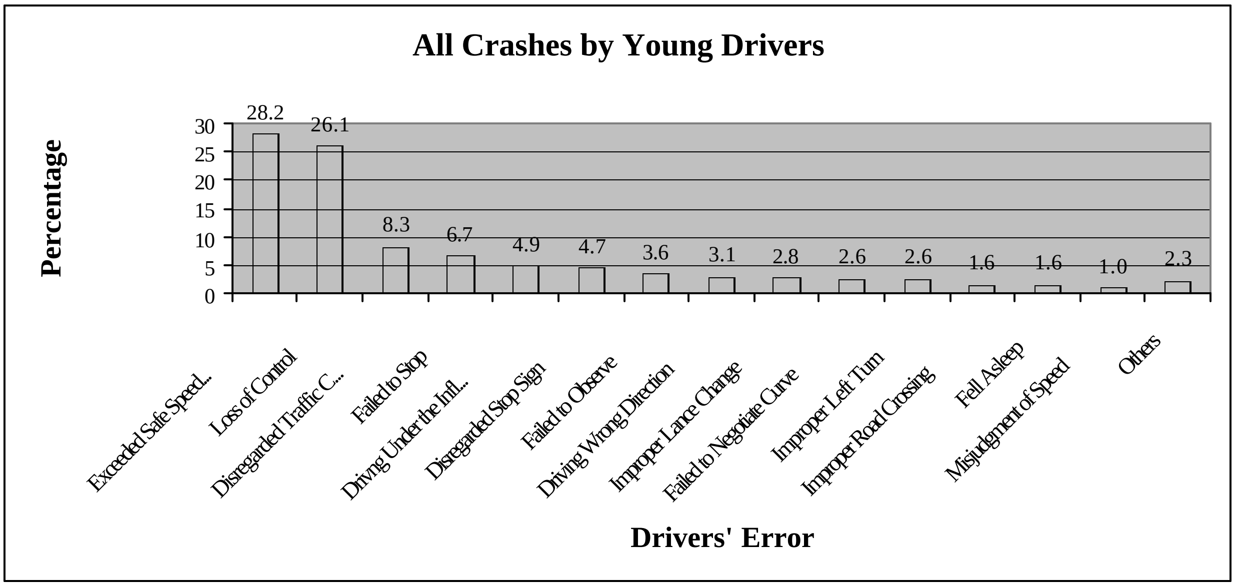


Figure 13.43: Drivers’ Errors of Young At-Fault Drivers

Table 13.23 and Figure 13.43 show that about three out of every ten fatal crashes caused by the young drivers are due to exceeding safe speed limits while little more than one-fourth are due to loss of control of the vehicle. The loss of control of the vehicle are those crashes in which the drivers were driving within the safe speed limits, but lost control of the vehicle followed by subsequent events such as ran off the roadway, entered into the median, etc. The figure and table also indicate that disregarding traffic control, failure to stop vehicle to avoid hitting the front vehicle from the back, driving under the influence of alcohol/drug, disregarding stop signs, failure to observe the oncoming vehicle/surrounding conditions, driving wrong direction, failure to negotiate curvature, and improper left turns are important factors for the young drivers. However, the drivers’ errors of these young drivers are further categorized in two types of crashes viz. intersection crashes and non-intersection crashes.

Out of 387 fatal crashes by the young drivers, a total of 145 crashes or 37 percent occurred at intersections, of which the causes of ten crashes are unknown. The contributing factors for remaining 135 crashes are shown in Table 13.9 and the charts are shown in Figure 13.44.

Table 13.24: Drivers' Errors of Young At-Fault Drivers in Intersection Crashes

Drivers' Errors/Critical Reasons	Frequency	Percentage
Disregarded Traffic Control	31	23.0
Exceeded Safe Speed Limit	24	17.8
Disregarded Stop Sign	18	13.3
Failed to Observe	11	8.1
Failed to Stop	10	7.4
Improper Left Turn	9	6.7
Loss of Control	8	5.9
Driving Under the Influence	6	4.4
Driving Wrong Direction	6	4.4
Improper Road Crossing	4	3.0
Misjudgment of Speed	4	3.0
Others	4	3.0
Total	135	100.0

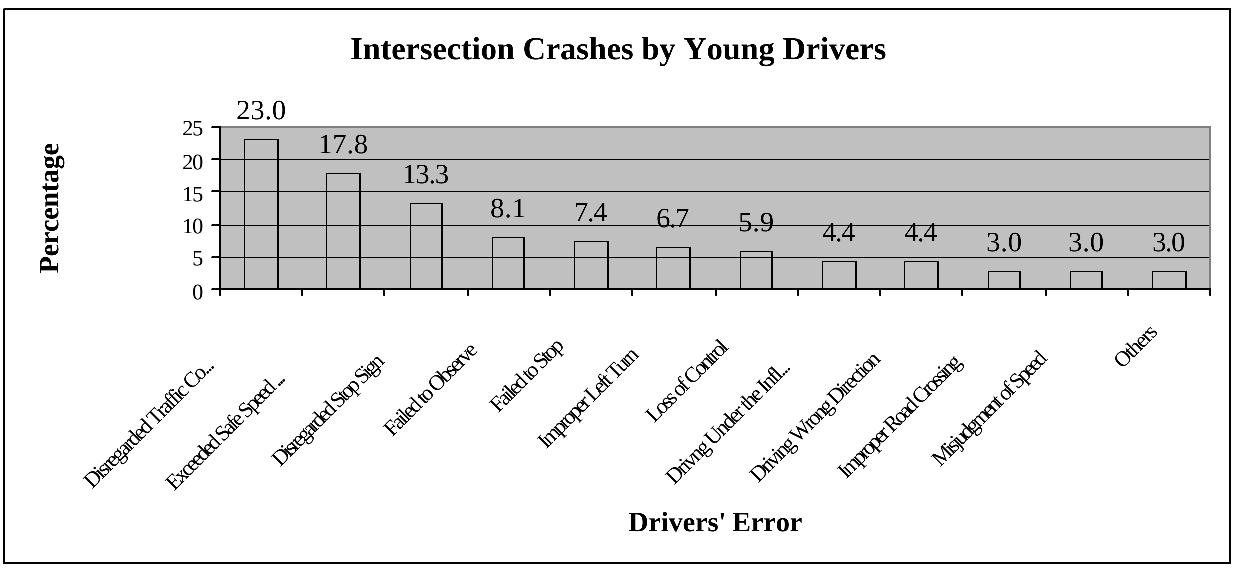


Figure 13.44: Drivers' Errors of Young At-Fault Drivers in Intersection Crashes

Table 13.24 and Figure 13.44 depict that disregarding traffic control is the major cause of intersection crashes by the young drivers although the exceeding safe speed limits and loss of control were two major causes for overall (intersection plus non-intersection) fatal crashes by the young drivers. These two tables and figure also explore that exceeding safe speed limit and disregarding stop signs are two other significant contributing factors for fatal intersection crashes by the young drivers. Combining the disregarding traffic control and disregarding stop signs, it is evident that more than 35% of the intersection crashes by the young drivers are caused by disregarding the traffic rule, whether traffic lights or stop signs. It means that the young drivers are more susceptible to violate the laws that cause significant proportion (36.3%) of fatal crashes. These crashes are those in which the drivers disregarded the traffic lights or stop signs while driving within the safe speed limits. Thus these crashes are separate from those crashes, which are caused explicitly due to exceeding safe speed limits at the intersection. Approximately one out of every five (17.8%) intersection crashes by the young drivers is caused by exceeding safe speed limits at the intersections.

Table 13.25 and Figure 13.45 explore the frequencies and charts of different types of drivers' errors for non-intersection fatal crashes by the young drivers. While the table and figure are self-explanatory they warrant further discussion. The table and figure show that nearly two out of every five (36.9%) non-intersection fatal crashes caused by the young drivers are due to loss of control of the vehicle. The loss of control is defined as the cause not prior influenced by any other factors such as driving under the influence of drug/alcohol, tire blew up, exceeding speed limits, etc. It means that the loss of control is that event in which an at-fault driver losses the control of the vehicle at the first instance and then involve in a crash. There might be follow up errors by the drivers such as drove left of center, ran off the roadway, entered into the median, hit roadside fixed objects, etc. But, the first contributing cause by the drivers is "loss of control." It is noticeable that the second major contributing cause by the driver is the exceeding safe speed limits on the state roads by the young drivers. Together, these two factors cause more than 70% of the non-intersection fatal crashes caused by the young drivers. These are reasonable as the young drivers frequently exceed the safe speed limits and they drive carelessly on the streets that cause them to loss control of the vehicles. The third major type is failure to stop vehicle to avoid hitting the front vehicle. This factor does not include those drivers who were exceeding safe speed limit, but those who were driving within the speed limit but failed to stop the vehicle to avoid the crash.

The data reported by the investigation officers show that the crashes caused by the young drivers drive carelessly in a high proportion (37%) of crashes fatal. However, it has been noticed that the reporting officers have tendency of using "careless driving" over other types of causes available to them. So, the "careless driving" by the young drivers was further categorized in different contributing causes. These were done by case based analysis. When carelessness is narrowed down, factors such as loss of control of the vehicle, exceeding safe speed limits, and failure to stop vehicle to avoid rear-end collision come up as the major contributing causes. Other causes for young careless driving crashes are driving under the influence, improper lane change, failure to negotiate curvature, falling asleep, disregarding traffic control, driving wrong direction, and failure to observe. Table 13.26 shows the proportions of the contributing causes of fatal crashes by the young drivers that were recorded as "careless driving."

Table 13.25: Drivers' Errors of Young At-Fault Drivers in Non-Intersection Crashes

Drivers' Errors/Critical Reasons	Frequency	Percentage
Loss of Control	93	36.9
Exceeded Safe Speed Limit	85	33.7
Failed to Stop	16	6.3
Driving Under the Influence	13	5.2
Improper Lane Change	11	4.4
Failed to Negotiate Curve	9	3.6
Driving Wrong Direction	6	2.4
Fell Asleep	6	2.4
Failed to Observe	3	1.2
Improper Road Crossing	2	0.8
Others	8	3.2
Total	252	100.0

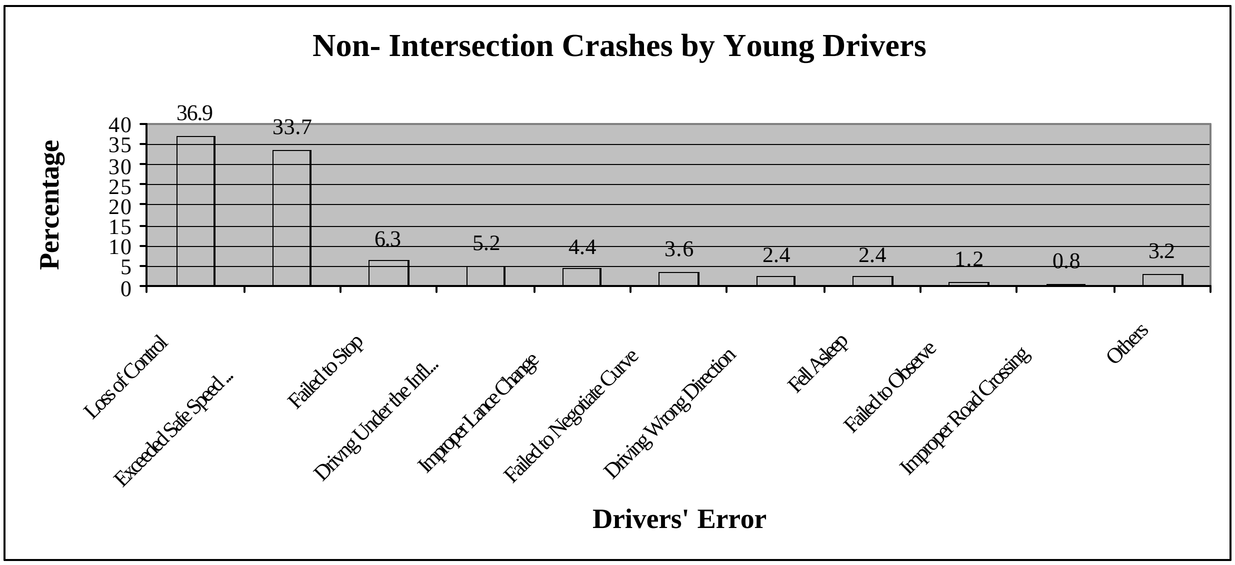


Figure 13.45: Drivers' Errors of Young At-Fault Drivers in Non-Intersection Crashes

Table 13.26 and Figure 13.46 confirm the results of Table 13.23 and Figure 13.45 that loss of control and exceeding safe speed limits are two major contributing causes for fatal crashes by the young drivers. Similarly, failure to stop to avoid rear-end collision, improper lane change, driving under the influence of alcohol/drug, etc. also play important roles in fatal crashes by the young drivers. All these are recorded as "careless driving" by the investigation officers, a category that is too broad to understand the actual situation and contributing cause of a crash.

Table 13.26: Breakdown of Overused Term "Careless Driving"

	Loss of control	Exceeding safe speed limits	Failure to stop vehicle	Improper lane change	Driving under the influence	Failure to negotiate curvature	Fell asleep	Disregarding traffic control	Others	Total
No.	54	51	14	6	5	5	4	3	7	149
%	36.2	34.2	9.4	4.0	3.4	3.4	2.7	2.0	4.7	100

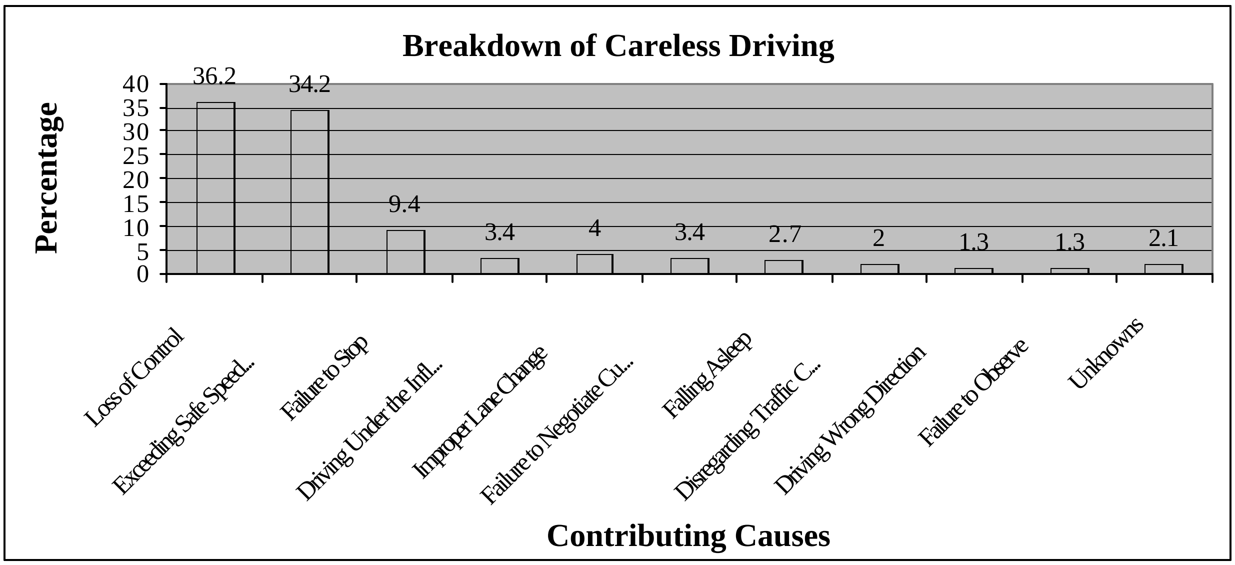


Figure 13.46: Breakdown of Contributing Cause "Careless Driving"

13.6.2 Contributing Factors in Fatal Crashes Caused by Older Drivers

Overall, older drivers (defined as those aged 65 or older) were involved in 474 fatal crashes and were responsible for about 301 fatal crashes (64 percent). This is approximately three-fourths as many crashes as the youngest drivers, profiled in the previous section. Table 13.27 looks at crash types and sub-types of the crashes in which older drivers, defined as those age 65 and older, were found to be at fault. Older drivers were significantly overrepresented in fault in three crash types, all of which involved turning movements at intersections. The types involved vehicles heading initially in opposite directions (oncoming traffic), initially in the same direction, and turning into opposite directions (cross traffic). These crash types are consistent with the data presented elsewhere in this report, indicating that older drivers have difficulty judging gaps in crossing and oncoming traffic, especially at busy intersections on stop-sign controlled movements, uncontrolled movements, or signalized movements with permissive phasing. The "initial same direction" crashes tend to involve confusion and/or late decisions by the driver, including turns from the wrong lane. Adding advance street name signs and increasing the size and visibility of street name signs could help alleviate this crash type. Older drivers were highly underrepresented in fault in most other crash types.

Table 13.27: Crash Types of Crashes Caused by Older Drivers

Type	Sub-Type	Older At-Fault		Other At-Fault		ORF	Min CI	Max CI	Level
		No.	Per.	No.	Per.				
Change Trafficway/Turning	Initial Same Direction	9	3.0%	13	0.9%	3.365	1.452	7.801	Over
	Single Vehicle Control Loss While Turning	0	0.0%	2	0.1%	0.000	N/A	N/A	N/A
	Turn Into Opposite Directions/Cross Traffic	66	21.9%	72	4.9%	4.455	3.267	6.075	Over
	Turn/Merge Into Same Direction	5	1.7%	18	1.2%	1.350	0.505	3.608	Unsure
	Evasive Action To Avoid Turning/Merging Vehicle	0	0.0%	2	0.1%	0.000	N/A	N/A	N/A
	Initial Opposite Directions/Oncoming Traffic	62	20.6%	130	8.9%	2.318	1.759	3.055	Over
Intersecting Paths	Backing	1	0.3%	3	0.2%	1.620	0.169	15.52	Unsure
	Not At Fault From Left	21	7.0%	64	4.4%	1.595	0.990	2.570	Unsure
	Not At Fault From Right	20	6.6%	71	4.9%	1.369	0.847	2.214	Unsure
	Not At Fault Unknown Direction	1	0.3%	4	0.3%	1.215	0.136	10.83	Unsure
Opposite Direction	Forward Impact With Control Loss	1	0.3%	37	2.5%	0.131	0.018	0.954	Under
	Sideswipe Angle	0	0.0%	3	0.2%	0.000	N/A	N/A	N/A
	Head-On	16	5.3%	121	8.3%	0.643	0.387	1.066	Unsure
Pedestrian	Exit Vehicle	1	0.3%	9	0.6%	0.540	0.069	4.247	Unsure
	Unique	0	0.0%	1	0.1%	0.000	N/A	N/A	N/A
	Walking Along Road Against Traffic	0	0.0%	1	0.1%	0.000	N/A	N/A	N/A
	Crossing At Intersection In Crosswalk	0	0.0%	6	0.4%	0.000	N/A	N/A	N/A
	Crossing Not At Intersection--First Half	3	1.0%	10	0.7%	1.458	0.404	5.267	Unsure
	Crossing Not At Intersection--Second Half	0	0.0%	18	1.2%	0.000	N/A	N/A	N/A
	Other In Road	0	0.0%	6	0.4%	0.000	N/A	N/A	N/A
	Vehicle Turn/Merge	1	0.3%	7	0.5%	0.694	0.086	5.623	Unsure
	Walking Along Road With Traffic	1	0.3%	3	0.2%	1.620	0.169	15.52	Unsure
Run Off Road/Single Vehicle	Ramp Departure	1	0.3%	30	2.1%	0.162	0.022	1.183	Unsure
	Forward Impact	2	0.7%	9	0.6%	1.080	0.235	4.974	Unsure
	Left Roadside Departure	11	3.7%	127	8.7%	0.421	0.230	0.770	Under
	Left Roadside Departure With Control Loss	12	4.0%	144	9.8%	0.405	0.228	0.720	Under
	Other	0	0.0%	2	0.1%	0.000	N/A	N/A	N/A
	Right Roadside Departure	26	8.6%	194	13.3%	0.651	0.441	0.962	Under
	Right Roadside Departure With Control Loss	6	2.0%	95	6.5%	0.307	0.136	0.694	Under

Table 13.27: Crash Types of Crashes Caused by Older Drivers, continued

Type	Sub-Type	Older At-Fault		Other At-Fault		ORF	Min CI	Max CI	Level
		No.	Per.	No.	Per.				
Same Direction	Sideswipe Angle With Control Loss	1	0.3%	14	1.0%	**0.347**	0.046	2.630	Unsure
	Rear End	20	6.6%	175	12.0%	**0.555**	0.356	0.867	Under
	Rear End With Avoid Impact	4	1.3%	33	2.3%	**0.589**	0.210	1.651	Unsure
	Sideswipe Angle	7	2.3%	30	2.1%	**1.134**	0.503	2.558	Unsure
Other/Unknown		3	1.0%	9	0.6%	**1.620**	0.441	5.949	Unsure
Total		301	301	100%	1463	**100%**	1.000		

Table 13.28 looks at contributing factors in crashes in which an older driver was at fault. In 96 percent of the cases, the primary contributing factor was a human factor, inattention in one-third of the cases, followed by decision errors and perception errors. Surprisingly, alcohol and/or drug use was the primary factor in almost 10 percent of the cases. Looking at all contributing factors, not just primary factors, the broad category of "age" was cited in about 15% of the cases. This factor indicates a sense on the part of the case reviewer that the age of a driver or pedestrian affected his or her ability to complete the driving task, whether because of lack of mobility, increased perception-reaction time, or general confusion or inappropriate decisions. (Where a specific cause, such as lack of mobility, was specifically identified through the case review, it is noted explicitly in the factors.) Other than those named previously, common overall crash contributing factors included confusion, typically late decisions (e.g. turn from wrong lane), illegal maneuvers (e.g. wrong way or left-turn where not permitted), or inappropriate actions (e.g. stop on interstate, drive around train crossing gates). Over two-thirds of the confusion cases were attributed to drivers over aged 74. The most common overall non-human factor was roadway design/geometry, which tended to be applied to wide, unsignalized intersections or those with complicated geometry that might be confusing to an older driver.

Table 13.28: Contributing Factors in Crashes Where an Older Driver Was At Fault

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.	Num.	Num.	Num.	Per.
Environment	Wet/Slippery	1	0.3%	3	8	12	1.8%
	Smoke/Fog	1	0.3%	5	2	8	1.2%
	Dark	0	0.0%	1	1	2	0.3%
	Dawn/Dusk	0	0.0%	0	2	2	0.3%
	Glare	0	0.0%	1	0	1	0.1%
	Heavy Rain	0	0.0%	1	0	1	0.1%
Human	Inattention	97	32.2%	9	5	111	16.2%
	Decision	67	22.3%	26	1	94	13.7%
	Perception	30	10.0%	19	0	49	7.2%

Table 13.28: Contributing Factors in Crashes Where an Older Driver Was At Fault, continued

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.	Num.	Num.	Num.	Per.
Human	Alcohol	23	7.6%	8	0	31	4.5%
	Medical	15	5.0%	3	0	18	2.6%
	Unknown	13	4.3%	1	1	15	2.2%
	Confusion	11	3.7%	21	2	34	5.0%
	Steering Input	7	2.3%	7	4	18	2.6%
	Speed	6	2.0%	18	2	26	3.8%
	Fatigue	5	1.7%	0	1	6	0.9%
	Mental/Emotional	4	1.3%	4	0	8	1.2%
	Drugs	4	1.3%	1	1	6	0.9%
	Distraction	2	0.7%	0	0	2	0.3%
	Age	1	0.3%	55	41	97	14.2%
	Low Speed	1	0.3%	1	1	3	0.4%
	Alcohol & Drugs	1	0.3%	0	0	1	0.1%
	Other	1	0.3%	0	0	1	0.1%
	Aggression	0	0.0%	1	1	2	0.3%
	Mobility	0	0.0%	1	1	2	0.3%
	Physical Defect	0	0.0%	2	0	2	0.3%
	Unfamiliar W/Area	0	0.0%	2	0	2	0.3%
	History	0	0.0%	0	1	1	0.1%
Roadway	Sign/Signal	2	0.7%	3	0	5	0.7%
	Sight Distance	1	0.3%	4	6	11	1.6%
	Obstruction	1	0.3%	4	0	5	0.7%
	Design/Geometry	0	0.0%	15	10	25	3.6%
	Traffic Operations	0	0.0%	2	7	9	1.3%
	Pavement Markings	0	0.0%	2	6	8	1.2%
	Lighting	0	0.0%	1	6	7	1.0%
	Curvature	0	0.0%	3	3	6	0.9%
	Construction	0	0.0%	4	1	5	0.7%
	Access Point	0	0.0%	1	3	4	0.6%
	Congestion	0	0.0%	2	2	4	0.6%
	Access Management	0	0.0%	0	3	3	0.4%
	Speed Limit	0	0.0%	2	0	2	0.3%
	No Sidewalk	0	0.0%	0	1	1	0.1%
Vehicle	Tires	3	1.0%	0	0	3	0.4%
	Disabled	1	0.3%	2	1	4	0.6%
	Other	1	0.3%	0	0	1	0.1%
	Visibility	0	0.0%	8	3	11	1.6%

Table 13.28: Contributing Factors in Crashes Where an Older Driver Was At Fault, continued

Factor Class	Factor	Primary		Secondary	Tertiary	Total	
		Num.	Per.	Num.	Num.	Num.	Per.
Vehicle	Blind Spot	0	0.0%	1	3	4	0.6%
	Lighting	0	0.0%	0	3	3	0.4%
	Trailer	0	0.0%	0	2	2	0.3%
	View Obstruction	0	0.0%	0	2	2	0.3%
	Bus	0	0.0%	1	0	1	0.1%
	Emergency	0	0.0%	1	0	1	0.1%
	Jackknife	0	0.0%	0	1	1	0.1%
Other/Unknown		2	0.7%	0	0	2	0.3%
Total		301	100.0%	246	138	685	100.0%

Table 13.29 and Figure 13.47 look at specific driver errors by the older drivers. The case-based study finds that about one-sixth (14.8%) of the older drivers lost control of the vehicles, one-eighth of them were driving under the influence of alcohol/drugs, and one-eighth of them misjudged the speeds of the vehicle(s), leading them to start into an intersection without sufficient clearance, leading to a crash. Other reasons for crashes (both intersection and non-intersection) by the older drivers are failure to observe all sides and the vehicle, disregarding traffic signals, improper left turn, and disregarding a stop sign, with more than 5% of the fatal crashes caused by each factor. The factors such as exceeding safe speed limits, failure to stop to avoid rear-end collision, confused by complicated intersection/too much of sign, driving wrong direction, improper road crossing, and improper passing contribute to 1% to 5% of such crashes, while others constitute about seven percent of such crashes.

It is worthwhile to mention here that the three major drivers' errors in crashes by older drivers were loss of control (14.8%), driving under the influence (12%), and misjudgment of speeds of the vehicles (12%) while the first three contributing factors for crashes by younger drivers were driving under the influence (28.4%), exceeding safe speed limits (19.7%), and loss of control of the vehicles (19.7%). It means that the driving under the influence and loss of control are common contributing factors that are common to both the younger and older drivers. However, the younger drivers more frequently exceed the safe speed limits, indicating their tendency to violate traffic rules, while the older drivers frequently misjudge the speeds of the vehicles, indicating the reduction in the ability to perceive by the older drivers. Overall, the older drivers' crashes are more evenly distributed among the various contributing factors, while the younger drivers' crashes are highly concentrated among driving under the influence, loss of control, and exceeding stated speed limits.

Table 13.29: Drivers' Errors of Older At-Fault Drivers

Drivers' Errors/Critical Reasons	Frequency	Percentage
Loss of Control	43	14.8
Driving Under the Influence	35	12.0
Misjudgment of Speed	35	12.0
Failed to Observe	33	11.3
Disregarded Traffic Signals	28	9.6
Improper Left Turn	25	8.6
Disregarded Stop Sign	18	6.2
Exceeded Safe Speed Limit	13	4.5
Failed to Stop	11	3.8
Confused (due to complicated intersection, too much traffic and/or billboard signs	9	3.1
Improper Lane Change	9	3.1
Driving Wrong Direction	6	2.1
Improper Road Crossing	3	1.0
Improper Passing	3	1.0
Others	20	6.9
Total	291	100.0

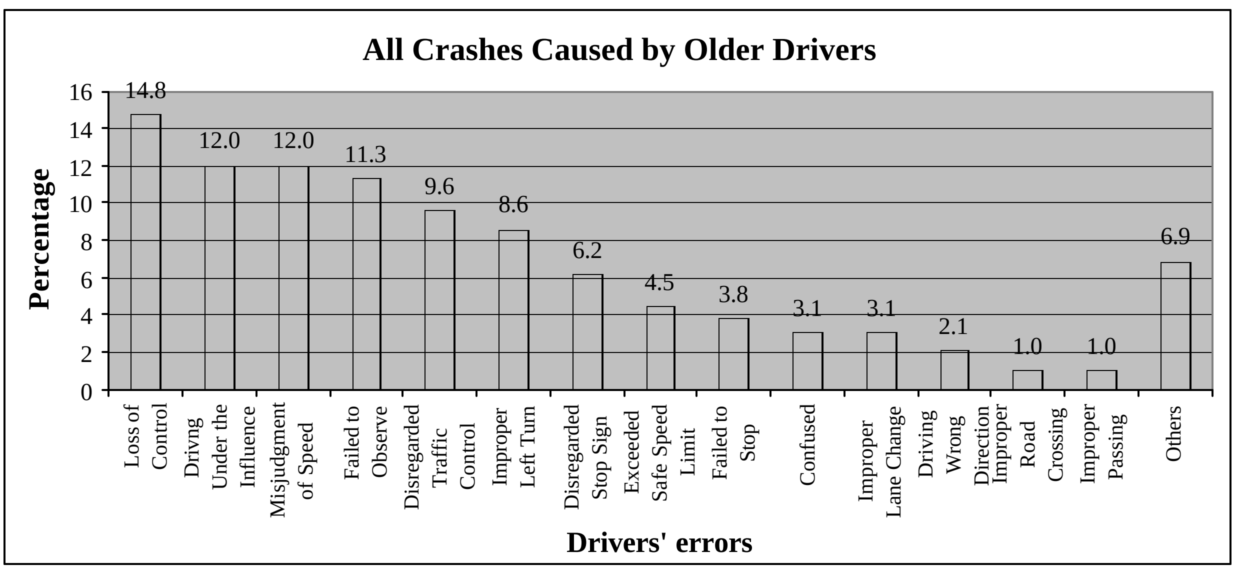


Figure 13.47: Drivers' Errors of Older At-Fault Drivers

There were a total of 203 intersection crashes by the older drivers, out of which the causes of nine crashes are unknown. This represents 70 percent of the crashes in which an older driver was at fault, a much higher percent than was seen with the younger drivers. The remaining 194 crashes with known causes are used to explore the intersection crashes caused by the older drivers. Figure 13.48 and Table 13.30 depict the major contributing factors of intersection crashes caused by the older drivers. This table and figure explore that misjudgment of speeds of the vehicles, failure to observe the vehicle/all sides before approaching the intersection, disregarding traffic signals, and improper left turn are four major contributing factors each of which contributes to more than 10 percent of the intersection crashes caused by the older drivers.

"Misjudgment of speeds of the vehicles" is the term used for the crashes in which the investigation officers clearly stated or gave any hint that the at-fault driver failed to judge the speeds of the vehicles from the other directions properly. This also includes those crashes in which the vehicles were coming at a speed higher than the posted maximum speed which the older drivers could not judge properly. These crashes were identified based on the detail investigation of the photographs of the intersection, posted speed limit at the intersection, actual speed of the vehicle, etc. On the other hand, the "failure to observe vehicles" are those crashes in which the investigation officers reported that the at-fault driver failed to see the vehicle, did not look at all sides before approaching the intersection, or could not see the vehicles. These crashes also include those in which the investigation officers did not explicitly mention about "failure to observe the vehicle," but the total reporting gave hint to the researcher that the at-fault driver failed to observe the vehicle or all sides before approaching the intersection.

For this research, the "improper left turn" category includes those crashes in which the at-fault driver attempted a left turn although s/he did not have permission to make a left turn. Examples include turning from an incorrect lane and turning where no left turns are allowed. The "improper left turn" category does not include "misjudgment of speed of the vehicle" and "failure to observe the vehicle/all sides before approaching the intersection." Other important factors are disregarding stop signs, driving under the influence of alcohol/drugs, confusion caused by the complexity of the intersection and traffic/billboard signs, loss of control, failure to stop, exceeding safe speed limits, and improper road crossing that contribute to less than one percent of such crashes. The term "others" in these two tables and figures include those factors that contribute to less than one percent of the crashes. These include did not see, improper U-turn, stopped improperly on the road, technical problems, unconsciousness, improper passing, improper lane change, etc. It is important here that driving under the influence of alcohol (8.8%) is not one of major five factors for the older drivers' intersection crashes, although it was the most important factor for younger drivers' intersection crashes, contributing to 23.9% of such crashes.

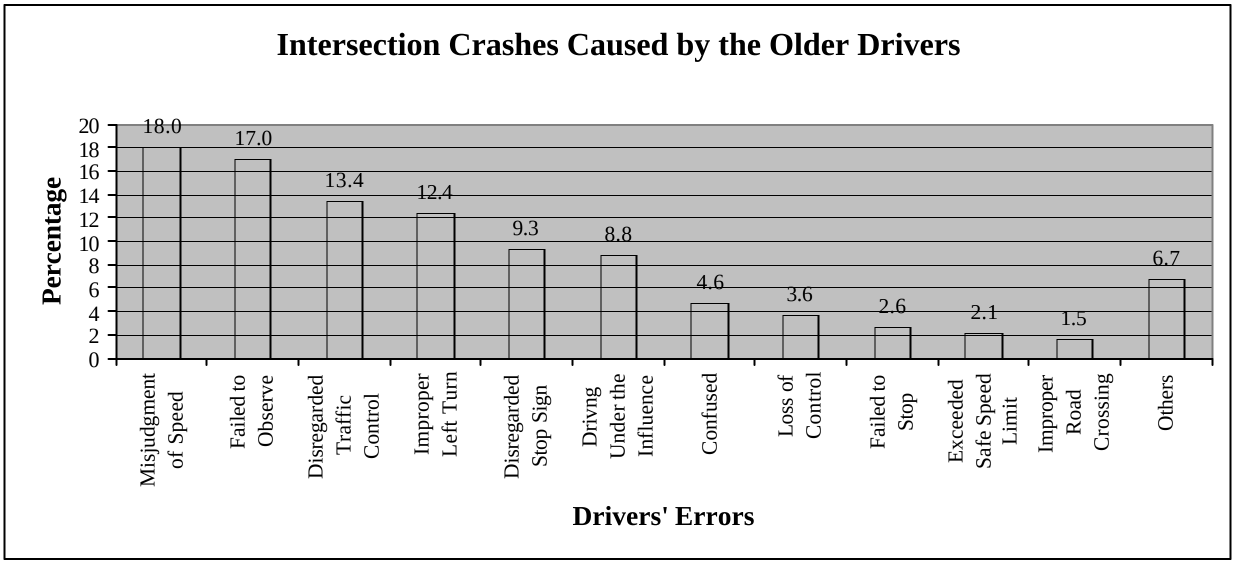


Figure 13.48: Drivers' Errors of Older At-Fault Drivers for Intersection Crashes

Table 13.30: Drivers' Errors of Older At-Fault Drivers for Intersection Crashes

Drivers' Errors/Critical Reasons	Frequency	Percentage
Misjudgment of Speed	35	18.0
Failure to Observe Vehicles	33	17.0
Disregarded Traffic Signals	26	13.4
Improper Left Turn	24	12.4
Disregarded Stop Sign	18	9.3
Driving Under the Influence	17	8.8
Confused	9	4.6
Loss of Control	7	3.6
Failed to Stop	5	2.6
Exceeded Safe Speed Limit	4	2.1
Improper Road Crossing	3	1.5
Others	13	6.7
Total	194	100.0

There were a total of 98 non-intersection crashes by the older drivers out of which the cause of one crash is unknown. The remaining 97 crashes are used to explore the non-intersection crashes caused by the older drivers. Figure 13.49 and Table 13.31 depict the major contributing factors of non-intersection crashes caused by the older drivers. This table and figure explore that loss of control contributes to more than one-third of the crashes, while driving under the influence of alcohol contributes to almost one-fifth of such crashes. Exceeding safe speed limits, improper lane change, failure to stop the vehicle to avoid rear-end collisions, driving wrong direction, and stopped on the roadway for some reason are the third to seventh most important contributing factors, respectively each of which contributes to more than 4 percent of crashes. The term “others” in these tables and figures include those factors that contribute to less than two percent of the crashes. These include this failure to observe, improper U-turn, technical problems, improper passing, improper left turn, ran of road, lack of visibility, failure to negotiate curves, etc. It is important here that driving under the influence of alcohol (18.4%) is the second major factor for the older drivers’ non-intersection crashes, although it was not one of five major causes for intersection crashes.

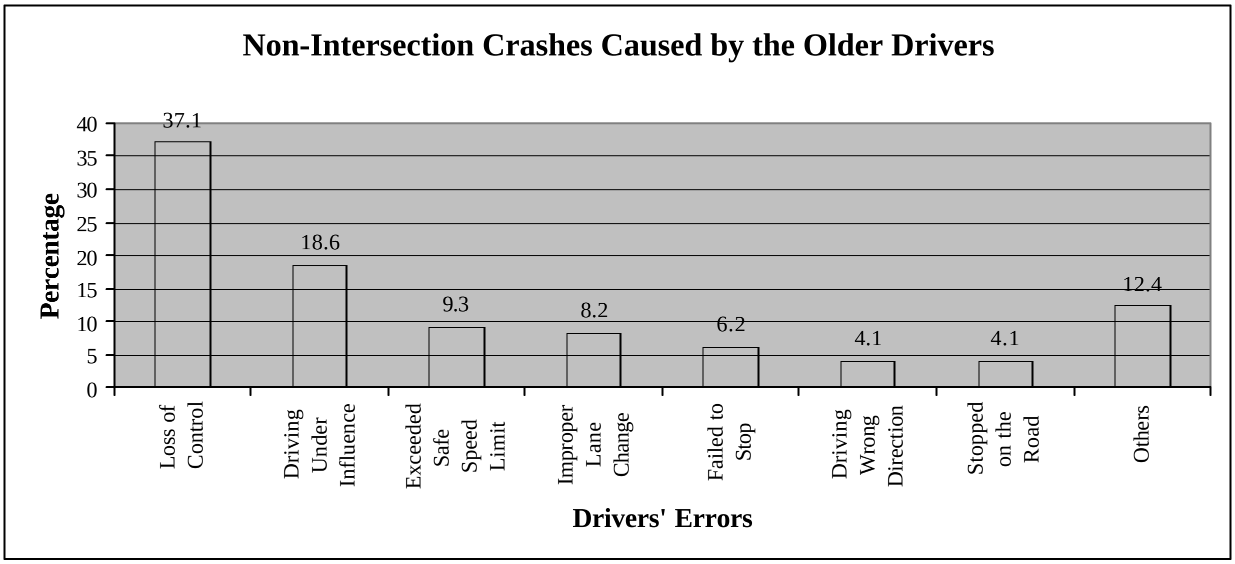


Figure 13.49: Drivers’ Errors of Older At-Fault Drivers for Non-Intersection Crashes

Table 13.31: Drivers’ Errors of Older At-Fault Drivers for Non-Intersection Crashes

Drivers' Errors/Critical Reasons	Frequency	Percentage
Loss of Control	36	37.1
Driving Under Influence	18	18.6
Exceeded Safe Speed Limit	9	9.3
Improper Lane Change	8	8.2
Failed to Stop to Avoid Rear-End Collision	6	6.2
Driving Wrong Direction	4	4.1
Stopped on the Road/Confused	4	4.1
Others	12	12.4
Total	97	100.0

It has been noticed that the investigation officers have a tendency to frequently the term “failure to yield right of way” for intersection crashes in a similar manner to the overuse of "careless driving" for the younger drivers involved in non-intersection crashes. A total of more than 73% of the above-mentioned crashes were recorded by the investigating officers as "failure to yield right of way" instead of further breaking down as shown above. The researcher has further investigated how/why the failure to yield occurred, since many of these are not mutually exclusive with failure to yield, or are not available to the officer. The characteristics of misjudgment of speed of vehicle, failure to observe the vehicle, and improper left turn have been discussed elsewhere in this chapter.

The drivers' errors disregarding traffic signals, disregarding stop signs, and driving under the influence are readily understandable. The drivers' error "confused by the complicated intersection/too much signs" are those in which the older driver appears to have become confused as to what to do because they were provided too much information by a complicated roadway, traffic and/or billboard signs. Improper road crossings are the straight lane thru crossing of the intersection in which the at-fault driver attempted to cross the road while the not-at-fault driver had the right of way and in which the not-at-fault driver did not have any unsafe driving error. When those 73% crashes were further broken down, the results come out as shown in Table 13.32 and Figure 13.50. Table 6.2.4 and Figure 13.50 show that the overused term "failure to yield right of way" constitutes other more detailed contributing factors, primarily misjudgment of speeds and failure to observe vehicles/all sides before entering the intersection, but also disregarding traffic signals and other less common causes.

Table 13.32: Representation of Overused Term "Failure to Yield Right of Way"

Drivers' Errors	Frequency	Percentage
Misjudgment of Speed of the Vehicle	32	24.6
Failed to Observe the Vehicle	28	21.5
Improper Left Turn (same as failed to yield)	21	16.3
Disregarded Traffic Signals	13	10.0
Disregarded Stop Sign	12	9.2
Driving Under the Influence	11	8.5
Confused by Complicated Intersection/Too Much Signage	9	6.9
Improper Lane Change	2	1.5
Improper Road Crossing	2	1.5
Total	130	100

Table 13.26 and Figure 13.46 (for "careless driving"), and Table 13.32 and Figure 13.50 (for "failure to yield right of way") indicate that the investigation officers either do not spend enough time and effort, or do not have enough information to identify the actual causes behind the fatal crashes. Another potential explanation is that they are unwilling to provide detailed contributing factors because of the ongoing criminal homicide investigation, especially in the case of fatal crashes. However, all necessary measures should be taken so the investigation officers cane investigate further and in more detail to find out the actual causes of fatal crashes, so that the policy makers could be benefited from the reports.

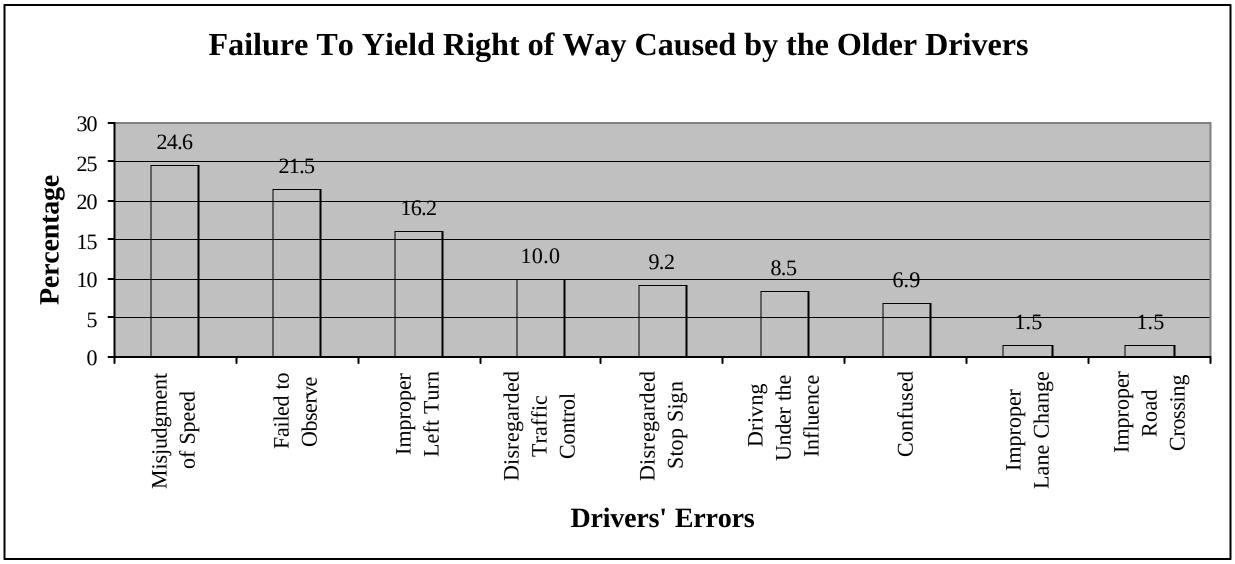


Figure 13.50: Representation of Overused Term "Failure to Yield Right of Way"

13.7 Conclusions

The study finds some interesting features that are in contrast with our general belief regarding the causes of fatal crashes. Such findings include the facts that many (51.4%) fatal crashes occur during daylight, and most occur on dry road surfaces (88.9%), in clear weather (74.5%), and on straight roads (75.5%) in contrast to our belief that most of the crashes would typically be on wet and slippery road surfaces (11.1%), during dark periods (19.3% with street lights and 24.6% without street lights) and on curvature (10.1% on level streets and 4.0% on upgrade/downgrade). The research explores that these general beliefs are not applicable in Florida. The study also reveals that over one-fourth of the crashes that occurred during the early morning hours (midnight – 4:00 AM) are caused by the younger drivers while over 35% of the crashes that occurred during the late morning hours (8:00 AM –noon) were caused by older drivers. The study reveals that the morning crashes are highly due to the high speed on relatively uncongested roadways by the younger drivers, while the crashes caused by the older drivers are attributed to loss of control due to stress, failure to observe, misjudging speeds, which are likely reflective of decreased perception/field of vision issues and slower perception-reaction times, and other factors.

Analysis of the crashes reveals that drivers aged 35 to 44 are involved in one out of every three of the pedestrian related crashes followed by the less than 25 and the 25-34 year olds, with more than one out of every five crashes each. All other age groups have less than ten percent involvement with pedestrians. The scenario for bicycle related crashes are also similar with three out of ten by 35-44 year-olds, and more than one out of every five crashes by 25-34 and 45-54 year-older drivers. The reason for this is that most of the drivers on the highways are of middle age who drive at high speeds. Hence, involvement of pedestrians is a major problem in many of the crashes analyzed in this study. It has been observed that the pedestrians have tendency to cross the roadways not at designated locations. It makes difficult for the high-speed drivers to stop the vehicles within a fraction of second, which causes crashes and fatalities. Similarly, involvement of bicyclists plays role in many of the fatal crashes in Florida in the middle of a highway, not at a pedestrian crossing. It is worthwhile to mention here that this research looks only at the at-fault drivers, and pedestrians or bicyclists even if the latter was at-fault.

Based on the statistical tests conducted for this study, the impacts of age on the fatal crashes based on different contributing factors are explored by Table 13.33. It explores that age has a significant effect on the occurrence of fatal crashes based on crash hours, lighting conditions, road grades, site locations, vehicle speeds, contributing cause-environment, and safety equipment usage, while it does not have a significant impacts where road surface condition, weather conditions, and traffic signals are concerned. It is important to note here that the age of the at-fault drivers do not have any significant impact on the fatal crashes at intersection. The reason behind this is that the drivers are controlled by the traffic signals where traffic signals play dominating role drivers' behavior than the age of the driver. Age has moderate impacts when other scenarios are considered for fatal crashes.

Table 13.33: Impacts of Age on the Occurrence of Fatal Crashes Based on Contributing Factors

Contributing Factors	Younger Drivers	Older Drivers	All Drivers
Sex	Both sexes are equally vulnerable	Females are more vulnerable	Moderate Impacts
Race	All races are equally vulnerable	Whites are more vulnerable	Moderate Impacts
Crash Hours	Significant Impacts	Significant Impacts	Significant Impacts
Road Surface Condition	Non-Significant Impacts	Non-Significant Impacts	Non-Significant Impacts
Weather Condition	Non-Significant Impacts	Non-Significant Impacts	Non-Significant Impacts
Lighting Condition	Significant Impacts	Significant Impacts	Significant Impacts
Road Grade	Non-Significant Impacts	Significant Impacts	Significant Impacts
Road Surface Type	Non-Significant Impacts	Mostly Significant Impacts	Mostly Significant Impacts
Site Location	Mostly Significant Impacts	Significant Impacts	Significant Impacts
Traffic Signals	Non-Significant Impacts	Non-Significant Impacts	Non-Significant Impacts
Lane Types	Mostly Significant Impacts	Mostly Significant Impacts	Mostly Significant Impacts
Pedestrian Involvement	Significant Impacts	Non-Significant Impacts	Mostly Significant Impacts
Bicycle Involvement	Significant Impacts	Non-Significant Impacts	Mostly Significant Impacts
Heavy Truck Involvement	Significant Impacts	Significant Impacts	Significant Impacts
Vehicle Speed	Mostly Significant Impacts	Mostly Significant Impacts	Significant Impacts
ADT	Non-Significant Impacts	Mostly Significant Impacts	Mostly Significant Impacts
Contr. Cause-Environ	Significant Impacts	Significant Impacts	Significant Impacts
No. of Vehicles Involved	All types of vehicles	Single Vehicle Crashes	Mostly Significant Impacts
Safety Equipment Usage	Significant Impacts	Significant Impacts	Significant Impacts

The case-based analysis reveals that driving under the influence of alcohol, exceeding safe speed limits, and loss of control are three major causes of fatal crashes caused by younger drivers in Florida, resulting in a large number of single-vehicle, high-speed, pedestrian/bicycle related, and loss of control type crashes. Among other factors, disregarding traffic signals and failure to stop to avoid rear-end collision contribute to less than five percent of crashes caused by younger drivers, while failure to observe vehicles/all sides, disregarding stop signs, improper left turn, and improper lane change contribute to equal to or more than two percent. In case of intersection crashes, driving under the influence of alcohol, disregarding traffic signals, and exceeding safe speed limits come out as three major contributing causes. Other important contributing factors are disregarding stop signs, failure to observe vehicles/all sides, failure to stop to avoid rear-end collision, improper left turn, and loss of control that contribute to ≥ 5% of intersection crashes. On the other hand, driving under the influence of alcohol, loss of control of the vehicle, exceeding safe speed limits, and failure to stop the vehicle to avoid rear-end collisions come out as four major contributing factors that cause ≥ 5% of the non-intersection crashes by these drivers.

The study reveals that the older drivers are involved in more intersection crashes than non-intersection crashes while the situation is opposite for the younger drivers. Misjudgment of speeds of the vehicles, failure to observe the vehicle/all sides before approaching the intersection, disregarding traffic signals, and improper left turn are four major contributing factors, each of which contributes to greater than 10% of intersection crashes by the older drivers. In case of non-intersection crashes, the study reveals that sudden loss of control contributes to more than one-third while driving under the influence of alcohol contributes to almost one-fifth of such crashes.

The case-based analysis finds that the investigation officers overuse the terms "careless driving" and "failure to yield right of way." A large percent (73%) of the intersection crashes caused by the older drivers are recorded as "failure to yield right of way." A more detailed analysis of the contributing factors of these crashes, including consistent use of the terms "failed to yield right-of-way," "disregarded traffic signal/stop sign," and "improper turn," would provide more detail about the circumstances. Further, the case-based analysis finds that the major contributing causes for intersection crashes by the older drivers are found as misjudgment of speeds, failure to observe all sides before approaching the intersection, improper left turn, disregarding traffic signals, disregarding stop signs, driving under the influence of alcohol, and confused by the situation (complicated intersection/too much of traffic and/or billboard signs).

Similarly, a total of 34% of the non-intersection crashes caused by the younger drivers are recorded as "careless driving." The case-based analysis finds that loss of control of the vehicle, driving under the influence of alcohol, and exceeding safe speed limits appear as the three major contributing causes. Other causes for younger careless driving crashes are failure to stop vehicle to avoid rear-end collision, improper lane change, failure to negotiate curvature, falling asleep, disregarding traffic signals, failure to observe, and driving wrong direction.

Based on the case analysis, the overall impacts of age of at-fault drivers on the occurrence of fatal crashes at intersection and not-at intersection by the younger and older drivers are depicted by Table 13.34. It explores that driving under the influence of alcohol is the sole important factors for fatal crashes by the younger drivers, be it intersection or non-intersection crashes. Other important factors for the younger drivers that cause fatal crashes are exceeding safe speed limits, loss of control, and disregarding traffic signals systems, which is a reflection of careless driving. The first three of these causes are also applicable for the non-intersection crashes caused by the older drivers. However, the intersection crashes by the older drivers are occurred mainly due to misjudgment of speeds, failure to observe all sides/ vehicles before approaching the intersection, and disregarding traffic signals. In brief, the four major contributing factors for both types of fatal crashes by both older and younger drivers are driving under the influence, exceeded safe speed limit, loss of control, and disregarded traffic signals.

Table 13.34: Impacts of Age on the Occurrence of Fatal Crashes – Case Based Analysis

Importance of Contributing Factors	Younger Intersection Crashes	Younger Non-Intersection Crashes	Older Intersection Crashes	Older Non-Intersection Crashes
First Contributing Factor	Driving Under the Influence	Driving Under the Influence	Misjudgment of Speed	Loss of Control
Second Contributing Factor	Disregarded Traffic Signals	Loss of Control	Failed to Observe	Driving Under Influence
Third Contributing Factor	Exceeded Safe Speed Limit	Exceeded Safe Speed Limit	Disregarded Traffic Signals	Exceeded Safe Speed Limit
Fourth Contributing Factor	Disregarded Stop Sign	Failed to Stop	Improper Left Turn	Improper Lane Change
Fifth Contributing Factor	Failed to Observe	Improper Lane Change	Disregarded Stop Sign	Failed to Stop

13.8 Recommendations

To reduce the current number of fatal crashes on state roads in Florida, the following recommendations are made.

1. The over use/misuse of the term “careless driving” and “failure to yield right of way” by the reporting officers makes it difficult for researchers to find out the exact reasons for many of the fatal crashes. In this study, researchers had access to traffic homicide reports; however, such reports are not available on all crashes. So, the study recommends appropriate training of reporting officers regarding frequent use of the terms “careless driving” and “failure to yield right of way” for driver contributing factors.
2. The younger drivers are seen to be involved in fatal crashes with, in order, driving under the influence, exceeding safe speed limits, loss of control, disregarding traffic signals, disregarding stop signs, improper lane change/overtaking, etc. These all are behavioral issues, and can be reduced by changing the personal level behaviors. So, educational programs should be initiated for the younger drivers to improve their behavior on the highways. The educational programs should also emphasize on building them as more responsible while driving on the roads.
3. Driving under the influence of alcohol is the most important contributing factor for fatal crashes by the younger drivers for both the intersection and non-intersection crashes. Increased enforcement should be directed toward laws implemented to stop drug and alcohol related crashes.

4. Older drivers cause fatal intersection crashes mainly due to misjudgment of speeds of the vehicles, failure to observe the vehicle/all sides before approaching the intersection, disregarding traffic signals, and improper left turns. Ability to negotiate confusing intersections became more of an issue with the oldest driver cohort (≥75 years). In areas of high elderly population, ideas to reduce intersection traffic crashes include increased deployment of aspects of the Florida Elder Road program such as larger street signs and more advanced signage, and intersection design and signalization that decreases reliance on judgment in making left turns (e.g. protected left turns, roundabouts, etc.). Prior to implementation of unusual designs such as roundabouts, thorough study should be conducted for the potential to confuse elderly drivers, leading to unsafe and illegal driving maneuvers.

5. Because many of the factors involved in fatal crashes among older drivers (except DUI) are behavioral issues due to the effects of age. The study also finds that the oldest drivers (≥75 years) are more likely to cause two or more-vehicle crashes and that fatal crashes among the oldest drivers often occur because these drivers become confused on what to do in a busy situation. Hence, the issuance and renewal of licenses to the older drivers might need to be based on regular physical and mental examinations so that the proportion of involvement of the older drivers can be kept low in the fatal crashes. More public transit systems may be introduced for the older drivers who cannot pass the tests every year and even for the younger drivers who cannot abide by the laws of safe driving. Other facilities like vanpooling can be more popular to these drivers. But, special education is needed to make the van pooling system popular to these drivers.

6. Both younger and older drivers are found to be involved in disregarding traffic signals and exceeding safe speed limits, among other factors that cause fatal crashes. More appropriate and effective laws and penalties should be introduced for both of these two traffic violations so these can be reduced towards reducing the number of fatal crashes.

14 CONCLUSIONS

The research project described herein used a case-study approach to identify factors contributing to both the occurrence and the outcome of fatal traffic crashes on state roads in Florida. Three years of heavy truck fatality data were combined with one year of data on all fatal crashes on state roads to provide a data set of 2,080 cases. The following brief conclusions are provided. All statements below apply to the set of fatal crashes studied in this research project. For more detailed information, refer to the conclusions sections of the previous nine chapters.

14.1 Quality and Consistency of Crash Reports

Significant inconsistencies were noted between crash reports and homicide reports. The crash report sometimes provides an unreliable estimate of alcohol and drug use, and information in either the CAR database or the TIFF image of the crash report may not be consistent or reflect the most recent updates. The driver/pedestrian in section one is often but not always at fault in the crash, particularly when a pedestrian is involved or when there are large numbers of vehicles involved: the algorithm used within the CAR database to assign fault relies information on the violations section of the crash report, which is often not correct or complete in fatal traffic crashes. Coding errors are introduced by officer misunderstanding and misinterpretation of how to complete the form. Some errors are introduced by DHSMV during the data transcription/database development phase.

The traffic homicide reports provide more detail and better accuracy than the Florida Traffic Crash Reports. However, engineering information (reconstructed speeds, driver perception-reaction times, skid mark analysis) is often lacking. It is also difficult to extract information from the narrative report. Formats and contents vary greatly from agency to agency. Reports often do not focus on the initial driver action (fatigue, speed, roadway factors) that led to the loss of control or other harmful events that might have occurred. Incorrect or incomplete information was sometimes noted when officers were required to differentiate between pedestrians and bicyclists, differentiate between heavy trucks and truck tractors, describe the presence and condition of lighting and reflectors on bicycles and truck trailers, and collect DL information on pedestrians and bicyclists where available. Complete and accurate narratives and diagrams were not always provided, and the term careless driving was overused to describe any number of driver errors, from speeding, to improper turns, to disregarding of traffic control devices.

14.2 Overall Crash Contributing Factors

Run off the road and intersection crashes were the common crash types, followed by pedestrian and rear-end/sideswipe crashes. Run off the road crashes were often associated with head-on collisions due to median cross-overs, and rear-end crashes frequently occurred at or near intersections. Overall, almost a quarter of the at-fault drivers were younger than 25, and over 13 percent were over age 64. About three-fourths of involved drivers, at-fault drivers, and pedestrians in the fatal crashes were male. This is consistent with previous research indicating that males are more likely to engage in risk taking behavior, such as excessive alcohol use, speeding, and crossing at non-intersection locations.

Human factors were the primary causative factor in 94 percent of the fatal crashes; the most common human factors were alcohol and/or drug use and driver errors, including inattention and decision errors. Around 30 percent of at-fault drivers were impaired by alcohol or drugs at the time of the crash. Having a poor driving history with multiple prior offenses and/or having a suspended or revoked license at the time of the crash correlated strongly with fault in the fatal crash.

Around 30 percent of the crash contributing factors (including secondary and tertiary factors) were roadway, environmental, and vehicle factors. Tire tread separation/blowout was the most common vehicle factor by far, accounting for 40 percent of the non-human primary factors. Other vehicle condition issues contributed to about eight percent of the fatal crashes. Obstructions (typically vehicles from previous crashes) were the most common primary roadway contributing factor. Inadequate lighting and curvature were the most common additional factors. Darkness, wet/slippery conditions, and smoke/fog contributed to around seven percent of the crashes in total.

14.3 Overall Fatality Contributing Factors

Not wearing a seat belt is the most common cause of fatality found in this study, contributing to fatality among 63% of vehicle occupants. Wearing a seat belt would reduce the likelihood of fatality most notably in crashes involving hitting a fixed object or vehicle roll-over. Most importantly, wearing a seat belt would reduce the likelihood of vehicle ejection, an event clearly linked to fatality. SUV drivers were twice as likely as automobile drivers to be ejected. In this study, nearly a third of the children passengers under the age of six did not have any safety equipment in use at the time of the accident.

Among drivers wearing seat belts, the most common contributing factors to the fatality were age, nearside impacts and vehicle-vehicle impact (as opposed to fixed object and overturning crashes, which were less frequently harmful to belted occupants). Elderly and mature persons were more likely to die in the crash, even if they were belted, because of their physical frailty.

In impacts involving both non-CMV's and CMV's, five times as many fatalities occurred in the non-CMV's. In heavy trucks, 50 percent of fatalities occurred in vehicles that rolled over, and 26 percent occurred in vehicles that caught fire. While most of the other vehicles hit the front of the CMV, trailer rear and side underrides accounted for almost 28 percent of the fatal impacts.

14.4 Heavy Truck Crashes

Heavy trucks were overrepresented in multi-vehicle and multi-fatality crashes. They were overrepresented in rear end, side swipe and turning/merging crashes. Truck crashes were more likely to occur on rural roadways, on limited access facilities and on two-three lane roads rather than on larger non-limited access facilities. Over half of the other vehicle defects (not including tire defects) in the fatal crashes belonged to heavy trucks, even though trucks only accounted for 17 percent of the vehicles in the crashes. Vehicle defects, especially brake failures, directly contributed to over ten percent of the crashes where CMV's were at fault, especially in run off the road and head-on crashes.

Trucks were at-fault in only about 30 percent of the crashes in which they were involved; they were more likely to be at-fault in rear-end, run off the road, and intersection-turning crashes. Truck drivers aged 25 to 34 were overrepresented in fault when compared to older truck drivers. Overall, the most common factor in crashes where a truck was at fault was inattention, which was a contributing factor in over 50 percent of the crashes and the primary contributing factor in almost 40 percent of the crashes. Fatigue could be a root cause of many driver behaviors that were attributed to inattentiveness as well.

In crashes where the truck driver was at fault, a tendency toward "taking" of right-of-way by the CMV was seen. This type of ROW violation, including pulling out in front of another driver without sufficient gap space to complete a maneuver, or stopping with the trailer portion of the CMV blocking one or more travel lanes, could be attributed to inattention, perception errors (looked but failed to see), or decision errors (deliberate ROW violations, expecting that the other driver will see the CMV, understand that it needs more time and space to maneuver, and yield accordingly). It is possible that, at certain levels of traffic volumes and in certain roadway configurations (divided highways, stop-controlled intersections, etc.), the truck driver simply cannot make the necessary maneuver without blocking traffic or otherwise failing to yield the right-of-way.

Obstructions (typically vehicles from previous crashes) were overrepresented in truck crashes. Congestion, construction, obstructions (primarily disabled vehicles or vehicles from previous crashes), and traffic operations issues were overrepresented as secondary or tertiary contributing factors. Traffic operations issues tended to involve lack of facilities for storage or maneuvering of large trucks, including turn lanes. Smoke/fog was overrepresented as a secondary contributing factor in truck crashes, often in combination with stopped traffic due to obstructions or congestion and inattention on the part of the driver.

14.5 Run Off the Road (ROR) Crashes

Substantial numbers of ROR crashes occurred on rural limited access facilities, involving younger (aged 15-24) drivers and those under the influence of alcohol. Alcohol, speed, and abrupt steering input (including overcorrection and evasive maneuvers) are the most common driver contributing factors in all ROR crashes, and over 25 percent of the ROR drivers had BAC's over the legal limit at the time of the crash. Inattention was cited as an important factor in about 15 percent of the crashes, and fatigue or sleep in about seven percent. Tire tread separation and tire blowouts occurred in around eight percent of the ROR crashes. Roadway curvature and access points were cited as one of the three most important contributing factors in about eight percent of the cases, respectively.

Approximately 25 percent of the ROR crashes in the study set involved subsequent overcorrection, resulting in a loss of control and a subsequent crash either with another vehicle, a fixed object on the same or opposite side of the road, or overturning because of loss of lateral stability. Overcorrection cases were strongly associated with alcohol, inattention, and fatigue/asleep, all factors that might cause the driver to drift off the roadway, and high speed, which tends to be associated with the vehicle's tires encroaching on the shoulder during aggressive passing maneuvers. Younger drivers are more prone to overcorrection crashes, and overcorrection was about 50 percent more likely to occur on road segments with rumble strips.

ROR crashes were almost evenly divided between limited access and non-limited access facilities. The highest number of ROR crashes occurred on rural interstates, and ROR crashes were highly overrepresented on all limited access facilities. ROR crashes are overrepresented on curves; however, almost 30 percent of the curvature cases involved curves with radii of at least 3500', which are relatively shallow curves. Rates of speeding among ROR drivers increased as the posted speed increased; speeding was also more common as a contributing factor on tighter curves. For roads with posted speeds of 65 and above, approximately one-third of the ROR drivers were traveling at least 10 mph over the speed limit. Younger drivers are more likely to be involved in ROR crashes on interstates and roads with more lanes.

Absence of rumble strips strongly correlated with high numbers of ROR crashes. Rumble strips were present in only about 15 percent of the fatal ROR crashes, being most common on rural toll roads and interstates. However, overcorrection was about 50 percent more likely to occur in ROR crashes on road segments with rumble strips. Alcohol and speed were more of a problem on non-limited access roads, but other human factors like inattention and fatigue/asleep made up a higher percent of the ROR crashes on limited access roads. More than one-third of the drivers on non-limited access roads were over the legal limit for blood alcohol.

The most common outcomes of ROR crashes were overturning and fixed object impacts. Hitting parked vehicles and pedestrians on the shoulder were more common than entering water. The most harmful event was overturning in 40 percent of the cases, and a fixed object impact in about 30 percent. A fixed object tripped the vehicle in about 25 percent of the cases where overturning was the most harmful event. The most common factor associated with fatalities in ROR crashes was not wearing a seat belt. Seat belts were much more effective in preventing fatalities in crashes where the most harmful event was overturning than where the most harmful event was a fixed object or vehicle-vehicle impact.

14.6 Intersection Crashes

Over one-third of the intersection crashes involved straight versus straight movements, and almost 28 percent involved left-turn versus oncoming movements. Left turn versus crossing movements accounted for one-fifth of the crashes, and rear-end crashes for approximately one-tenth. Over one-third of the crashes occurred at signalized intersections, including half of the left-turn versus oncoming crashes. Seventy percent of these were classified as "permissive left" type crashes, in which the left-turning vehicle has a right-of way issue with the oncoming vehicles. Another 30 percent of the fatal intersection occurred on stop-controlled movements, including almost two-thirds of the left-turn versus cross traffic crashes.

Left turning vehicle movements are the most likely to cause a fatal intersection crash. Almost one half of the fatal intersection crashes involve a left turn by one of the drivers involved in the crash. Overall, roadway factors as a secondary causes of crashes were found in about 15% (51 of 327) of these crashes (signalized or unsignalized). Compared to undivided roads, and those with narrow (<10' medians), it can be seen that the left turn oncoming crashes are significantly over represented for higher median widths except for very wide medians. Sight distance issues also occurred when the driver's line of sight was blocked by opposite queued vehicles waiting to make left or right turns.

Red-light running accounted for fifty percent of the crashes at signalized intersections and over 17 percent of all fatal intersection crashes. Speeding and attempting to beat the yellow signal were associated with some red-light running cases. In a small number of cases, the at-fault driver could not be determined due to lack of witnesses or conflicting witness statements.

Driver age has a significant correlation with the number of fatal intersection crashes. Younger drivers under 25 years are the most likely to be involved in fatal intersection crashes followed by older drivers above 65 years of age. Except for about ten cases, all fatal intersection crashes were judged to have been primarily caused by human factors. Inattention, for example, "failed to observe crossing vehicle," "failed to see bicycle," etc., is the chief primary contributing factor to the fatal intersection crashes, with almost 40% of fatal intersection crashes having inattention as the primary contributing factor. Driving under the influence (alcohol or drugs or both) is also the primary contributing factor towards the crash for more than 20% of the fatal intersection crashes. The third most prevalent human factor is a decision error, with almost 20% of fatal intersection crashes having a human decision error as the primary contributing factor.

Almost 20% of the fatal intersection crashes had roadway issues involved that had a direct bearing on the occurrence of the crash, mostly as secondary and tertiary issues. Sight distance issue was the concern in the majority of the crashes wherein a roadway issue is involved. Overall, 68 or about 10% of intersection crashes were judged to have sight distance-related problems, but only as a primary cause of the crash in two cases. Other roadway issues involved location of stop bars, wide or confusing design/geometry, lack of turn lanes/storage, and signal timing issues. Again, each of these occurred relatively infrequently.

14.7 Pedestrian Crashes

The principal issues seen in the fatal pedestrian crashes were alcohol use by pedestrians; non-use of pedestrian facilities, especially crosswalks; followed by environment and pedestrian facility issues. The most common types of pedestrian crashes among the 382 pedestrians in this study were pedestrians crossing a roadway not in a crosswalk (53%), pedestrians that had exited a vehicle prior to the fatal event (13%), followed by pedestrians who were crossing at intersections (10%). The most critical combination found in this study was a male pedestrian crossing the road at night at a location other than an intersection, between 35-44 years old, alcohol impaired, attempting to cross a 5 or 6 lane roadway with an ADT between 20,000 to 29,000, within 200 to 600 ft of an intersection. Sixteen percent of pedestrian fatalities were age 65 and older, and five percent were under age 15.

Pedestrian behavior is the first contributing cause of over 80% of the pedestrian crashes in this study. Where alcohol use was determinable, 69% of pedestrians crossing at non-intersection locations were under the influence. Among drivers, the most common contributing factor was speeding followed by driver alcohol/drug impairment. Over 40 percent of drivers impacting pedestrians were below age 35. Lighting condition plays a major role in pedestrian cases, as evidenced by 71% of the pedestrians being hit at night, 37% of which occurred in locations where there were streetlights.

In nearly half of the roadway crossing cases, pedestrians were attempting to cross the road within 600 ft of a crossing location with a traffic signal. However, about one-fourth of the non-intersection crossings were over one-quarter of a mile from the nearest protected crossing. The most common trip generator for a non-intersection crossing was being in the vicinity of an intersection with a driveway or minor side street. Pedestrians who were attempting to cross at non-intersection locations were most often trying to cross in a 45 mph segment (38%), and were attempting to cross 5 or more lanes (65%). Fourteen percent were over age 65 and attempting to cross 5 or more lanes. The number of nighttime non-intersection crossing crashes where highway lighting was present is considerably higher than the number of daytime crashes at similar locations. The presence of streetlights may give pedestrians a false sense of visibility, while being under the influence of alcohol may lead to sudden moves into the street, unexpected by drivers even if they saw the pedestrian on the shoulder.

In 57% of the cases where a pedestrian was walking along the roadway, there was not a sidewalk for the pedestrian to use. Of these cases, multilane divided suburban roadways accounted for the highest percentage (50%). A total of 15% of the pedestrian crashes occurred on limited access facilities (interstate, toll road, other limited access facility, or ramp). Half of these cases resulted from a disabled vehicle; however, alcohol use, inattention, poor lighting, and rain contributed to a number of such cases.

14.8 Bicycle Crashes

A large number of fatal bicycle crashes involved middle aged and older bicyclists, who are on the road at night, with poor bicycle lighting, and often either under the influence of alcohol, impairing their judgment as to the safe operation of their bicycle, or inattentive to surrounding traffic conditions. A small number of bicyclists were youths, who were involved more frequently in intersection related road crossings, and who sometimes showed judgment errors due to their youth and inexperience. Bike riders were more likely to be found at fault overall: in intersection crossings, the bicyclist was much less likely to have yielded right-of-way when required, and cases of bicyclists veering into the road, often in an attempt to change lanes or make a left turn, occurred frequently.

Vehicle factors included the lack of visibility, sometimes coupled with blind spots, especially in heavy truck performing turning maneuvers. In a few cases, instability or condition of the bicycle potentially played a role in the crash. The only environmental condition that played a significant role in the crashes is darkness, sometimes coupled with poor street lighting and more frequently coupled with poor bicycle lighting.

Trends in bicyclist age, bicycle condition, alcohol use, and other information gained from the case reviews paints a picture of many bicyclists who use that mode of transportation by necessity (loss of driver's license or economic necessity) rather than choice. In several cases, it was explicitly noted by the officer that the bicyclist had a history of DUI's or had a suspended or revoked license. In most of the cases, however, the license status was not addressed or coded as "not applicable" on the crash report, because a license is not required to operate a bicycle. Improved reporting in this area would provide a clearer picture of bicyclist demographics, to better direct enforcement and educational programs.

14.9 Rollover Crashes

SUV's were involved in fatal traffic crashes at lower rates than the rates at which they are driven. However, sports utility vehicles were found to have the highest rollover rates compared to other vehicle types. Large vans and compact pickup trucks also had higher than average rollover rates. Driver errors, including inattention and incapacitation due to either alcohol/drug use or fatigue, were the most significant contributing factors in the rollover crashes. The only significant differences in causative factors between SUV rollovers and non-SUV rollovers were high rates of tire tread separation and tire blowouts in the SUV rollovers. Over 90% of all rollover crashes were tripped, of which 25% were tripped by an impact with another vehicle. Overall approximately 45% of the rollovers were tripped by grass or soft soil. This type of rollover was overrepresented in SUV's.

14.10 Age as a Contributing Factor

Older drivers (65 and older) were at fault in 64% of the crashes in which they were involved. They were significantly overrepresented in fault in left turn crashes versus oncoming traffic and versus cross traffic; these accounted for over 42 percent of the crashes in which older drivers were at fault. Misjudgment of speeds of the vehicles, failure to observe the vehicle/all sides before approaching the intersection, disregarding traffic signals, and improper left turn were the four major contributing factors, each of which contributes to greater than 10% of intersection crashes by the older drivers. Sudden loss of control contributed to more than one-third of non-intersection crashes, while driving under the influence of alcohol contributes to almost one-fifth of such crashes. Over 35% of the crashes that occurred during the late morning hours (8:00 AM –noon) were caused by drivers aged 75 and older while over one-fourth of the crashes that occurred during the early morning hours (midnight – 4:00 AM) are caused by the younger drivers.

Younger drivers (under age 25) were at fault in 62 percent of the crashes in which they were involved, and they were highly overrepresented in fault in forward impacts with control loss and in left roadside departure crashes. These two crash types generally involved high speeds and abrupt steering input and potentially indicated inattention and/or an inability to use sound judgment and make quick decisions. The case-based analysis revealed that driving under the influence of alcohol, exceeding safe speed limits, and abrupt steering input were three major factors in fatal crashes caused by younger drivers in Florida, resulting in a large number of single-vehicle, high-speed, pedestrian/bicycle related, and loss of control type crashes. In the case of intersection crashes, driving under the influence of alcohol, disregarding traffic signals, and exceeding safe speed limits come out as three major contributing causes. Other important contributing factors were disregarding stop signs, failure to observe vehicles/all sides, failure to stop to avoid rear-end collision, improper left turn, and loss of control. On the other hand, driving under the influence of alcohol, loss of control of the vehicle, exceeding safe speed limits, and failure to stop the vehicle to avoid rear-end collision were the four major contributing factors of the non-intersection crashes by these drivers.

15 RECOMMENDATIONS

Based on the case reviews and data analysis, a number of recommendations are offered to reduce the number of fatal traffic crashes in the state of Florida. A combination of education, enforcement, engineering, and other countermeasures are suggested. In considering these suggested countermeasures, one should remember that the study looked only at causes of fatal traffic crashes. As a result, it does not include traffic volumes and other exposure measures that should be considered before implementing state-wide programs. In addition, these strategies vary according to a critical issue that was identified at a crash site and care needs to be taken that while addressing the critical issue, other issues are not compromised. Otherwise efforts taken to reduce one particular type of crash can increase another type, thereby not actually improving the safety of the site.

The results of this research can be used to develop educational, enforcement, and engineering countermeasures to address broad categories of crashes and contributing factors identified as occurring frequently on state roadways in Florida. The results can also be used to direct additional research projects into more specific areas of need identified by this research. The primary benefit to the state of Florida should be a reduction in the number of fatalities on state roadways in Florida.

The most relevant countermeasures that address the highest number of traffic fatalities are summarized here. To further prioritize the list, countermeasures are grouped according to the rough number of fatalities in the study set to which the countermeasure might potentially apply. More information on each of these recommendations is provided in the previous nine chapters. Additional countermeasures are also suggested that are not repeated here because of limited space.

15.1 Countermeasures Addressing Over 1000 Traffic Fatalities

It is recommended that primary enforcement laws be adopted in Florida. Stricter enforcement of existing seat belt laws, especially regarding minor children, is recommended. Public education campaigns should focus on high risk occupants (SUV's, light trucks, and vans), with the message that seat belts are effective in preventing occupant ejection during a crash, and the vast majority of the ejected occupants are fatally injured or incapacitated (as opposed to urban legends suggesting that being thrown from the vehicle is safest in a severe crash).

15.2 Countermeasures Addressing Between 500 and 1000 Traffic Fatalities

Countermeasures for belted occupants should focus on preventing the crash in the first place, reducing the severity of the crashes through the improvement of safety vehicle features, and improving emergency response time. It is recommended that support be given to increased usage of vehicle safety technology that prompts quick emergency response (e.g. in-vehicle wireless communications) and to assist in implementing the associated systems. Side curtain air bags and stronger body frames would prevent fatalities due to nearside impacts (a common crash type in which belted drivers die) and rollovers. Roll stability control systems, which controls braking on individual wheels when lateral acceleration thresholds are exceeded, are currently under development by a number of vehicle manufacturers.

Because of the high rates of ROR crashes on road segments without rumble strips, including a large number of crashes on limited access facilities, rumble strips should be considered on all roads with high rates of or potential for ROR crashes. To avoid increases in overcorrection-type crashes, it has been suggested that varying the position, depth, and placement method (e.g. rolled into fresh pavement rather than milled into existing pavement) can affect the sound volume resulting from driving over the rumble strips, affecting the driver's steering response to the alert signal. Additional research into this issue should be undertaken.

Alcohol and drug use were most strongly correlated with ROR crashes on non-limited access facilities. Since it is most common among 25-44 year olds, enforcement is expected to be a more effective countermeasure than education. However, alcohol was a contributing factor across the entire spectrum of crashes, including drivers of all ages and all types of crashes.

15.3 Countermeasures Addressing Between 250 and 500 Traffic Fatalities

Educational programs directed at young drivers should focus on building driving responsibility. Issues specific to younger drivers that can be addressed through educational and enforcement programs are in order, driving under the influence, exceeding safe speed limits, loss of control/abrupt steering input, disregarding traffic signals, disregarding stop signs, and improper lane change/overtaking.

Overrepresentation in fault occurs with speeding as little as five miles per hour over the posted limit, so increased enforcement and stiffer penalties for lower levels of speeding should be considered. Education and enforcement measures should be directed toward drivers on high speed segments such as on rural interstates, and on segments where ROR crashes are occurring on relatively tight (radius less than 1500') curves.

Since elderly occupants are more likely to die in traffic crashes, even if properly belted, the best countermeasure to reduce traffic fatalities among the elderly is to reduce traffic crashes among the elderly. In areas of high elderly population, ideas to reduce traffic crashes include improved transit support, basing licensing on regular re-examinations, and increased deployment of aspects of the Florida Elder Road programs such as larger street signs and more advanced signage, and intersection design and signalization that decreases reliance on judgment in making left turns (e.g. protected only phasing on left turns, roundabouts, etc.). Prior to implementation of innovative designs such as roundabouts, thorough study should be conducted for the potential to confuse elderly drivers, leading to unsafe and illegal driving maneuvers. The perception-reaction times for elderly drivers in those areas should be taken into account in determining signal warrants in areas with a large elderly population.

Because fixed object impacts are more severe than other types of ROR crashes and fatalities due to these impacts are less preventable by improved seat belt use, a comprehensive program should be developed to remove or relocate objects in hazardous locations, or provide crash cushions or other protective barriers in locations where this is impractical. FDOT should also work to educate private owners regarding the danger and potential liability of not providing a safe clear zone for the traveling public.

A variety of approaches should be considered to reduce conflicts involving left-turning vehicles. Since gap judgment seems to be a problem for left-turners facing cross traffic from stop signs, as well as oncoming traffic at unsignalized movements or with permissive signal phasing, various approaches should be considered on high volume divided roadways. Since speeding on the part of drivers of through vehicles was often coupled with poor gap judgment by left-turning vehicles, the consistency of speed limits approaching intersections should be evaluated, as well as the prominence and visibility of reduced speed limit signs. Offsetting left-turn lanes can reduce sight distance issues where queuing vehicles waiting to make left turns potentially block the view of opposing drivers. Given the fact that many of the locations might not meet warrants for signal installation, appropriate responses may include improving the availability of gaps through appropriate signal spacing and timing at nearby signalized intersections, and access management techniques and educational programs that promote right turn followed by U-turns on multilane divided highways. A systemic approach to reevaluating unsignalized intersections with high crash rates is recommended, to assure that traffic signals are installed where warranted, or scheduled for installation to keep current with anticipated growth. Research should also be directed toward safety and effectiveness of non-traditional signage (e.g. dynamic message signs alerting turning traffic to unsafe gap distances) and and non-traditional intersection designs such as roundabouts or jug-handle intersections that do not rely on driver gap judgment to execute a left-turn and eliminate conflict points.

Due to the low number of fatal crashes associated with redirection, and the high number of fatal crashes associated with median cross-over, median guardrails are should be considered on segments with high traffic volumes and narrow to medium median widths (up to 70' on limited access facilities and up to 40' on other facilities). However, guardrail designs should be evaluated regarding their potential for tripping vehicles, resulting in rollover crashes.

15.4 Countermeasures Addressing Between 100 and 250 Traffic Fatalities

Sites with soft shoulders, whether composed of grass, sand or other soft soils, should be evaluated for their potential to trip ROR vehicles. Potential countermeasures include improving the quality of the soil/grass shoulder, or providing additional paved shoulder width. (186) While a less frequent cause of tripping, designs of drainage culverts and culvert walls should be reevaluated, given the fact that when hit, they result in rollovers more frequently when compared to other types of fixed objects.

At intersections where red light running is a problem, the length of signal cycles should be evaluated, including the yellow clearance interval and the all-red phases. Experiment with the use of longer all red phase rather than a longer amber phase at high crash prone intersections. Red light running can be curbed by strict enforcement and use of red light running cameras. Drivers should be educated about defensive driving, including the importance of remaining alert at intersections and watching out for stop sign running or red light running drivers.

Increasing the level of highway lighting to improve visibility is recommended in areas where pedestrian traffic or pedestrian activity at night is anticipated, or is known to be significant. This includes potentially upgrading lighting standards for intersections with existing street lights, as well as adding lighting in mid-block locations with significant pedestrian activity. New lighting products, such as induction lighting, that could potentially reduce energy costs and improve brightness and color rendering, should be studied. Review of the current standards for, and usage of, roadway signage is recommended — specifically in relation to informing drivers of the dangers of nighttime pedestrian traffic. One idea is to use changeable message signs that are only used on nights with high pedestrian activity; intermittent use would serve to decrease extra signage during the day and improve and preserve driver attention to the sign and the message it contains.

Since many of the non-intersection crossings were over 600' from an intersection protected by a traffic signal, pedestrian facilities for such crossings need to be considered. Many of these crossings are on limited access facilities, where other countermeasures are appropriate; however, many occur on multi-lane divided highways where traffic from side streets is primarily controlled by stop signs. Because of this, there are often long stretches without adequate crosswalks protected by traffic signals. Where such roadways are located in areas of high pedestrian traffic, sufficient crosswalks should be provided. As an alternative to adding signals to side street intersections, mid-block crosswalks protected by pedestrian activated traffic signals can be used to provide safe pedestrian crossings without increasing vehicular traffic on side streets.

Increased attention needs to be paid to proper adjudication of individual driving offenses, including driving under the influence and driver without a license. Increasing penalties for serious offenses and increased enforcement of unlicensed driving should also be considered.

Educational campaigns directed at "safe walking" strategies should developed. Measures aimed at directing pedestrians to intersections and discouraging pedestrian crossings elsewhere should be actively pursued. Establishment of "pedestrian no cross zones" within a certain distance of intersections (marked, signed, barricaded or otherwise delineated), along with public awareness and enforcement campaigns, are just a few of the types of measures that can be considered. One concept for encouraging use of crosswalks is a campaign centered on "Could a two minute walk save your life?" Another concept is "When you are a pedestrian, your most important safety equipment is your brain. Use it." Drivers should be warned of high pedestrian activity with signage, and reminded through educational campaigns that pedestrians sometimes behave unexpectedly.

Increased enforcement and additional educational programs should be directed at aggressive driving by motorcyclists. Greater attention should be paid to "share the road" type public service campaign, focusing on improving driver awareness of motorcyclists and the dangers of inattentive driving, especially at intersections and other conflict points.

15.5 Countermeasures Addressing Under 100 Traffic Fatalities

Improved training of officers completing crash reports is needed, addressing issues such as differentiation of pedestrians/bicyclists, differentiation of heavy trucks/truck tractors, the need for collecting DL information on pedestrians and bicyclists where available, the need for complete and accurate narratives and diagrams, overuse of the term careless driving, etc. Procedures for updating TIFF images and the CAR database upon completion of the traffic homicide investigation are strongly recommended, especially since many investigations are inconclusive until the THI is completed. Consistency and completeness in traffic homicide reports is also needed, with focus on accurate speed reconstructions, complete roadway descriptions, and vehicle details especially concerning unusual vehicles like bicycles and heavy trucks.

To improve the sight distance on stop-controlled movements, parking should be restricted near intersections and stop lines should be moved towards intersections so that the driver can establish a proper line of sight before entering the intersection. The corners at such intersections should be cleared of any such objects that might obstruct the line of sight of the driver. Because many of the sight distance issues involved the left-turning driver's line of sight being blocked by opposite queued vehicles waiting to make left turns, a suitable countermeasure is to provide offset left-turn lanes so that vehicles are not positioned to block the view of other drivers. 37

A potential education issue regarding truck crashes addresses the problem of the truck taking right-of-way from other vehicles. Likely, the truck driver assumes that the driver of the other vehicle sees him when he pulls out onto a road and will yield right-of-way. However, CMV drivers should be trained that, if the other driver is inattentive, speeding, or under the influence of alcohol, he/she is often unable to stop in time to prevent the crash.

The suitability of various roadway and intersection designs for large trucks and tractor trailers should be considered, especially on urban arterials where trucks might need to make unprotected left-turns or u-turns to access business destinations. Given the prevalence of multi-lane divided highways in the state, careful consideration should be given to appropriate median widths, provision of left-turn and u-turn lanes with sufficient storage, and the need for sufficient gap space at intersections without traffic signals.

Driver education and increased enforcement of speeding and tailgating among CMV's, especially on high-speed limited access facilities is recommended to reduce rear-end crashes, as well as the numerous ROR and head-on collisions related to evasive steering maneuvers. Fatigue in truck drivers can be addressed by closer enforcement of regulations on maximum hours of service and possibly by legislative changes in such regulations.

Because most trucks in the study did not meet the newest standard for rear underride guards on CMV trailers, further research on the adequacy of current standards is recommended. Research on efficacy of side underride guards is also recommended.

Increased rates of inspection for out-of-service violations, coupled with stiffer penalties on owners and commercial motor carriers who operate unsafe vehicles would decrease the rate of vehicle defects among commercial motor vehicles. Improved enforcement of commercial driver license regulations and stiffer penalties for driving offenses are also recommended. Because of the high at-fault rates among young truck drivers, improved training programs for CMV drivers are also suggested.

A large percent of the ROR crashes where the vehicle entered water occurred on a single road segment, which is I-75 in Collier county, more commonly known as Alligator Alley. Specific remediation concerning this roadway segment, including relocating the canal or providing an improved barrier system, might be warranted.

Intersection sites where the number of lanes to be crossed is high (inclusive of turn lanes), a pedestrian median refuge is not provided, and the crash history reveals incidents (not only fatal) involving elderly or young pedestrians being struck in the second half of the crossing should be considered for design review. Potential countermeasures may include (i) a signal timing scheme that would accommodate slower walking speeds (below 5 fps), (ii) inclusion of an all red pedestrian-only phase, (iii) installation of countdown pedestrian signals to deter slower walking pedestrians from attempting the crossing late in the phase.

Sidewalks should be considered for divided suburban roadways, especially as the number of travel lanes increases and where high pedestrian traffic is anticipated. Improved lighting along such segments is also recommended.

The following countermeasures to reduce bicycle fatalities are recommended, in decreasing order of priority. Educational campaigns directed at 1) improving rates bicycle lighting and safety helmet use and 2) the dangers of inattentive and impaired bicycling should be developed. Increased enforcement of laws requiring bicycle lighting and youth safety helmet use should be implemented. Improved data collection on driver license status of bicyclists is needed; modifications to the crash report form or officer training should be considered. Improving lighting standards at intersections in areas of high nighttime bicycle use should be evaluated. Widening of roads or installation of bicycle lanes on narrow roadway segments with high bicycle usage should be considered.

Improved handling of traffic during conditions of stopped traffic due to previous crashes, construction, and forest fires/controlled burns is needed. Use of temporary advanced warning signage or law enforcement patrols to warn motorists of stopped traffic ahead is recommended, along with increased use of incident management patrols to assist to clear roadways and shoulders of disabled and wrecked vehicles. Increased awareness of the dangers of crossing, walking along, or standing on the shoulder of high speed roadways during an emergency situation should be promoted.

Public service campaigns regarding proper tire maintenance, proper response to tire blowout, and proper response to drifting off road should be developed and distributed. Drivers should be educated on current laws requiring crash vehicles to be moved from the travel lane, where possible, and on laws prohibiting pedestrians on limited access facilities.

Appropriate warning signs (maximum safe speed, chevrons), pavement markings (painted chevrons or other shoulder delineators), and roadside safety hardware (guardrails) should be considered for use on curves with high rates of or potential for ROR crashes. Appropriate warning or regulatory speed limit signs should be placed on exit ramps to ensure that drivers slow down sufficient prior to reaching the ramp curvature.

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APPENDIX A: PROPOSED PROCESS FOR FUTURE FDOT FATAL CRASH REVIEWS

The main objective of a case-study review of a fatal traffic crash is to identify causative factors for the traffic crash, which can lead to identification of potential countermeasures. This document proposes a process for reviewing fatal traffic crashes and provides information on available data resources that can help in conducting the review.

DATA RESOURCES

The two primary data sources for any fatal traffic crash are the Fatal Traffic Crash Report (FTCR) and the Traffic Homicide Investigation Report (THI). However, a number of additional data resources are available.

Florida Traffic Crash Reports/Crash Analysis Report (CAR) Database

Most traffic safety professionals are familiar with the Florida Traffic Crash Report (FTCR), the standard crash report form used in the state of Florida. Many of the coded fields from the FTCR are stored electronically by the FDOT in the Crash Analysis Report (CAR) database. This data is location referenced, and indexed to a number of roadway characteristics, including degree of curvature and average daily traffic (ADT). However, the electronic data does not include the narrative (sequence of events) or the diagram of the crash scene. To supplement the coded data from the CAR database, TIFF images of the original crash reports are available from the FDOT's infonet.

Issues to consider in using FTCR data from either source are the accuracy, consistency, and timeliness of the data. The TIFF images consist of the original coded form, plus any updates that are available at the time of the scanning. However, in many cases, data that was pending at the time the crash report was scanned is never updated in the image file. Examples include supplemental driver information in the event of a hit and run driver or unidentified pedestrian, or blood alcohol values generated from subsequent toxicology reports. The data in the CAR database is typically accurate; however, any transcribed data is subject to transcription errors. Errors noted in working with the CAR database included BAC data associated with an incorrect driver, and pedestrian data incorrectly assigned to a driver instead. Because the CAR database is updated to the current version of the crash report codes, care should be used in mixing data sources, especially with older versions of the crash report form.

Traffic Homicide Reports and Crash Scene Photos

For any fatal crash that occurs, two types of reports are created, namely, the Fatal Traffic Crash Report (FTCR) and the Traffic Homicide Investigation Report (THI). While the FTCR's are prepared for all crashes; in case of a fatality, a detailed THI report is prepared by specially trained officers from the agency investigating the crash. Most fatal traffic crashes in the state of Florida are investigated by the Florida Highway Patrol (FHP), although 30 to 40 percent are investigated by local law enforcement agencies.

Traffic homicide reports are significantly more detailed reports than the crash reports, prepared by specially trained officers. The detailed report includes a scaled crash scene diagram and sometimes reconstruction information. It also furnishes any available background information prior to the crash of the drivers/pedestrians. This helps in understanding the state of the mind of persons involved, such as whether he or she was under stress, had had a fight with someone, if there were alcohol/drugs involved, whether the person was fleeing from police, etc. The report also gives the detailed information of the state of roadway during the time of crash. It often describes the signage present, the speed zones posted, whether there was ongoing construction, roadway defects, etc. This is particularly useful in crashes involving roadway curvature, as the RCI data often does not match the actual curvature at the crash scene because of crashes that occur on ramps or errors in referencing the exact location of the crash.

The THI report typically provides the drivers' previous driving histories, autopsy reports and the different citations issued (information that is typically pending at the time of the crash report). The autopsy report not only tells us about any controlled substance present, but whether the death was as a result of the crash or other medical problems. The BAC data in particular is often not updated on the TIFF images of the FTCR reports or in the CAR database, so this is often the only source of this information. Most agencies will take photographs of the crash scene; these can provide information about skid mark lengths, vehicle damage, and roadway conditions.

The availability of Traffic Homicide Reports is becoming more important given an increasing trend by law enforcement officers to leave much of the information pending on crash reports for fatal crashes. While it makes sense to withhold information until the investigation is complete, the crash report is typically submitted to the Department of Highway Safety and Motor Vehicles prior to completion of the homicide investigation. If this information is not updated, the crash report often provides negligible information about the crash, because the narrative and diagram are blank, and most of the fields are coded as "unknown." For previous years, THI reports can be obtained from the State Headquarters of the Florida Highway Patrol using the following contact information:

Traffic Homicide Coordinator
Florida Highway Patrol
Neil Kirkman Building
2900 Apalachee Parkway
Tallahassee, FL 32399

Crash scene photos are also available from the FHP state headquarters by contacting the Photo Laboratory at the same location. To obtain homicide reports for more recent crashes, contacting the local troop headquarters is advised; see http://www.fhp.state.fl.us/misc/fhpstations.htm for contact information. For fatal crashes investigated by local law enforcement agencies (police departments or Sheriff's offices), contact the agency directly. Contact information for most agencies in the state of Florida is available through the Florida Department of Law Enforcement (http://www.fdle.state.fl.us/links). Note that many agencies reference crashes according to the Investigating Agency Number generated by the agency, rather than the pre-coded HSMV Crash Report Number. FHP uses the Homicide

Case Number, a number that is of the form 705-02-01 and is typically written in the narrative section of the report. In this example code, "7" is the form type, "05" is the year in which the crash occurred, "02" is the FHP county code for the county in which the crash occurred (note that the coding system is not the same as the FDOT county coding system), and the "01" is the number of fatal crashes in the county to date that year.

Roadway Characteristic Inventory (RCI)

The Florida Department of Transportation's Transportation Statistics Office (TranStat) maintains an electronic inventory of the highway system known as the Roadway Characteristics Inventory (RCI). The RCI is a computerized database of physical and administrative data related to the roadway networks that are maintained by or are of special interest to the Department. In addition to data required by the Department, the RCI contains other data as required for special Federal and State reporting obligations. The RCI is maintained by District and Central Office personnel. Features, which can be physical or administrative, may be length features (with a beginning and ending milepoint) or point features (with a single milepoint). It is important to note that the roadway data is updated as the road changes overtime, thus it is sometimes not possible to get the exact characteristics of the roadway at the time of the crash.

The RCI Re-Engineering Project (RCI2) is an improvement over the original system in that it is web-based and includes more visual representations of the data. RCI data is referenced by the roadway segment number and milepoint. RCI2 can be accessed through the FDOT's infonet via the Enterprise Application tab. Choose Web Applications, then RCI2 and the welcome screen for RCI2 will appear. Bulk reports can still be generated through the mainframe TSO application. Additional information about RCI and RCI2 can be obtained through http://www.dot.state.fl.us/planning/statistics/rci/default.htm.

Video Logs

The FDOT video log application viewer can be used in lieu of a site visit to investigate potential roadway design and traffic operations issues that might have contributed to a fatal traffic crash. The video logs are still photographs taken in both directions at regular interval from the right most lanes of the state maintained roads. Video logs can be very useful in investigating sight distances, signage, crosswalks, speed transition zones, presence of pedestrian signals and other information. Limitations of the video log viewer are the limited field of vision on wide roadways and into the right-of-way, and the lack of a cross-street view at intersections where the cross-street is not a state roadway. Currently the video log images are updated on a three-year cycle, but FDOT is considering decreasing this to a one-year cycle, as well as adding additional camera angles to address some of the other limitations. Figure A.1 shows a screen shot of the video log viewer.

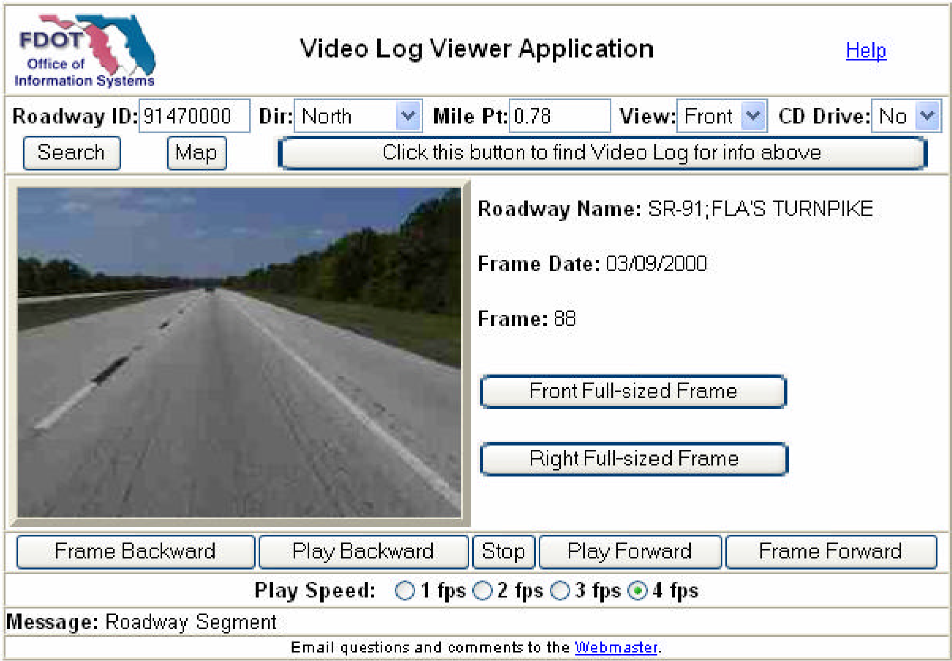


Figure A.1: Screen Shot of Video Log Viewer

Site Visits

The primary goal of a site visit to identify any roadway factors that may have contributed to the crash at each site. Site visits should also be conducted to collect various measurements and other data not available from the crash diagrams and FDOT video log. If possible, the site visitor should videotape a drive-through in the direction of both at-fault and not at-fault vehicles, as well as measuring and photographing various site features. Depending on the site, issues to be investigated during the site visits should include traffic volumes, prevailing speeds, and other related aspects; adequacy of facilities, design, and signage/signalization; and site-specific aspects such as access management and potential view obstructions. Depending on the nature of the site, special attention should be paid to the following items:

- Number and width of lanes and shoulders
- Existence, length and number of turning lanes
- Roadway alignment (vertical and horizontal curves)
- Roadway type (divided, channelized, median islands, raised curbs)
- Pavement type and condition
- Grades, cross-slopes, and superelevation
- As appropriate, roadside features, including drainage ditches, culverts, trees, crash cushions, etc. Clear zone distances as appropriate.
- Signage (type, size, visibility, location)
- Signalization (type, visibility, timing-now and historical, etc.)

- Traffic volume (observed and from data)
- Bike lanes, pedestrian crossings (type and signalization)
- For interchanges, ramp locations, signalization, turning radii, etc.

The following factors were considered as the site visits were conducted:

- Vehicle and pedestrian sight distances, taking into account vehicle/pedestrian position, size, and height, and potential obstructions.
- Visibility of traffic control devices, especially from turning lanes and accounting for sun glare. Position of signal heads with respect to travel lanes.
- Appropriateness of speed limits, given area location, roadway geometry, and traffic volumes.
- Suitability of site and features for pedestrian and bicycle traffic, as appropriate.

Prior to conducting a site visit, detailed records of construction activities since the crash should be obtained, to avoid visiting sites that have been significantly modified since the crash. Of course, sites where construction activities at the time of the crash had a significant effect on crash circumstances are also not good candidates for site visits, unless the construction is ongoing at the time of the site visit.

CASE REVIEWS

Prior to conducting a case review, both the FTCR crash report and the Traffic Homicide Report should be obtained, if possible. Read the report narratives and examine the diagrams to get a feel for what happened during the crash. As you review and read both the FTCR and the THI reports, check the reports for accuracy and consistency. Is there any information given on the crash report that is incorrect or missing according to the THI? If the reports are inconsistent, the case reviewer must use his or her judgment to determine which one is more likely to be accurate. Errors and inconsistencies should be noted for future reference. One of the largest sources of inconsistencies involved alcohol and drug use. The alcohol or drug use field on the FTCR is usually left blank/pending and often not updated after the results of the test are obtained. The traffic homicide report consists of results based on autopsy and other medical information, and is often more accurate than the crash report.

The following crash-level data should be evaluated. Determine the day of the week on which the crash occurred and whether it was on or near a holiday. Determine whether any pedestrians, bicycles, or heavy trucks/CMV's were involved in the crash. After a careful review of both crash report and homicide report, determine the crash type and make note of the sequence of events for the crash. Sometimes it is useful to distill the narrative into a series of simple statements summarizing the events. (E.g. V1 faced NB in a left-turn-only lane. V1 turned left on a permissive signal state. V2 traveling SB hit V2 on passenger side door.) Check the harmful events on the crash report for completeness and accuracy. Table A.1 includes crash types used in this research study; the codes were developed based on numerous case reviews and literature resources including (Bates 2004, Hendricks et al 1999, Thiriez et al 2002, Eskandarian 2004, *National* 2002).

Table A.1: Crash Type Codes

Pedestrian	
(10)	Crossing Not at Intersection – First Half
(11)	Crossing Not at Intersection – Second Half
(12)	Crossing at Intersection (in crosswalk)
(13)	In Road (standing, working, playing, laying, sitting, suicide)
(14)	Walking Along Road With Traffic
(15)	Walking Along Road Against Traffic
(16)	Exit Vehicle (disabled vehicle, working on vehicle, prior vehicle crash, exit bus, ejected passenger)
(17)	Vehicle Turn / Merge
(18)	Unique (not likely to occur again)
(19)	Other, Unknown
Single Vehicle Initiated	
(20)	Right Roadside Departure
(21)	Right Roadside Departure w/Control Loss
(22)	Left Roadside Departure
(23)	Left Roadside Departure w/Control Loss
(24)	Forward Impact (obstruction/end of pavement)
(25)	Ramp Departure
(26)	Other
Same Traffic way, Same Direction	
(30)	Rear-end
(31)	Rear-end w/avoid impact
(32)	Sideswipe Angle
(33)	Control Loss
Same Traffic way, Opposite Direction	
(40)	Head-on
(41)	Forward Impact (control loss or avoid impact)
(42)	Sideswipe Angle
Change Traffic way, Vehicle Turning	
(50)	Initial Opposite Directions (oncoming traffic)
(51)	Initial Same Direction
(52)	Turn/Merge Into Same Direction
(53)	Turn Into Opposite Direction (cross traffic)
Intersecting Paths	
(60)	Driver Side Impact
(61)	Passenger Side Impact
(62)	Other
(70) Other	

The following vehicle data should be collected where available. Determine the total number of occupants, injuries, and fatalities in each vehicle. Determine the vehicle model and make. If not available from the homicide report, make and model information can be obtained from Vehicle Identification Number (VIN) decoding software. Depending upon the software, additional information such as size, presence of airbags, and number of drive axles can also be obtained from the VIN number. Note the posted speed and actual speed of all vehicles involved in the crash. Where speeding is potentially an issue, note whether the speed limit changed in close proximity to the crash site.

The following driver/passenger information should be collected on all occupants. Determine whether each passenger was seated in a regular seating position, and whether they were using available safety belts. Determine which seating positions were equipped with airbags and whether the airbags deployed as a result of the collision. Make note of each occupant's injury severity, especially as it relates to the safety equipment in use. For the driver, additional information on contributing factors should be assessed. The driver history should be reviewed where available. Driver history records are typically available with THI reports, and contain records past crashes and/or citations, including adjudications issued. Where a driver history is not included, it may be obtained from the Information Systems Administration at the Department of Highway Safety and Motor Vehicles.

Determine the at-fault vehicle or pedestrian. Review the officer's determination of who was at fault in the crash, and note which drivers received citations due to the crash. If there is any evidence that the officer's assessment may be incorrect, make a note of the differences and why you disagree. It is possible for multiple drivers and/or pedestrians to share fault, although again this is sometimes a judgment issue. For instance, alcohol use by a driver who had no other contributing factors is sometimes determined by the officer to be evidence of fault. In evaluating fault, the case reviewer should therefore be aware of potential mis-assignment of fault in the CAR database. The typical practice among law enforcement officers is to use section one of the FTCR for data on the at-fault vehicle or pedestrian: this is the basic assumption of the CAR database. The CAR database relies on an algorithm that identifies the first vehicle as the at-fault vehicle unless citations are given to drivers/pedestrians in other sections. However, this practice is not done always followed by the reporting officer, especially in crashes with large number of vehicles or where a pedestrian was at-fault. Further, where a fatality is involved, the use of citations often does not detect fault on the part of a higher-numbered section because first, citations are often left pending further review by the homicide investigator, and second, citations are not given to drivers or pedestrians who die in the crash, even when they are at fault. In addition, the result of homicide investigation sometimes differs with the original assessment of fault. This new information from the THI needs to be considered along with the original report.

In determining whether a site visit is necessary, use the Table A.2 as a guide. In general, the lower priorities should be used if the crash was exclusively related to driver error. In such cases, the crash scene is likely a wide open, straight, flat, well constructed, unobstructed roadway with light to medium traffic. The crash did not occur at an intersection. The roadside features are adequate and not a hindrance. The shoulders of the road are well constructed with firm soils and a shallow slope. The mid range priorities can be used for issues that include driver error, minor roadway issues and the environment. The highest priority range should be used for crashes that have major roadway design and traffic operations issues. Be aware that Table A.2 is only a guideline and the case reviewer's experience as a driver and knowledge of roadway issues and design to help in the overall site visit assessment.

Table A.2: Site Visit Prioritization Scheme

Driver Exclusive ⟷ Driver/ Environment/ Minor Roadway Issues ⟷ Roadway Exclusive

Priority 1	Priority 2	Priority 3	Priority 4	Priority 5
Non-traffic fatality	Straight and level roadway	High speed crashes	Curvature of the roadway at the crash site	Heavy traffic volume / Congestion
Driver medical condition	Adequate signage	*Rollover crashes	Poor approach and/or warning signage	Intersections with inadequate or excessive signage
Passenger jumped/fell from vehicle	Good perception / Sight distance	*Simple Signalized Intersections	Illegal turns (with respect to access management and appropriate signage)	Poor Roadway design / **Apparent design issues
	Deliberate driver decision	Simple Non-signalized intersections (e.g. Driveways, T-intersections)	All major / busy intersections -	Access Management Issues
		Too fast for conditions / poor driving conditions	Inadequate sight distance	Complicated roadway designs
		Alcohol Induced		Complex intersections, complicated design issues, confusing

* Except obvious design issues.

Evaluate potential roadway factors using information available from RCI, video logs, and site visits. Evaluate the site for congestion, pavement quality, adequacy of signage and pavement markings, signalization (including placement and timing), shoulder design, etc. In addition to potential crash contributors, be sure to note available safety features (advanced warning signs, ped/bike facilities, guardrails/crash cushions, etc.). Determine whether the roadway was under construction at the time of the crash, and if so, whether the construction influenced the crash.

The following lists provide suggested issues to be considered in reviewing specific types of crashes. These questions should be expanded on for each case if necessary. The data collected from these questions is to be added to the contributing factors (crash and fatality) as needed. Multiple protocols may be applicable to the crash.

CMV Crashes

1. Was the CMV at-fault?
2. Is a CMV inspection report available? If so, should the vehicle have been out of service at the time of the crash?
3. Is an hours of service report available on the driver? If so, was the driver in compliance with state and federal requirements (see Appendix A.1)? Was fatigue an issue in the crash?
4. Was there adequate striping on the sides and rear of the trailer?
5. Did the rear underride guard meet current standards? Was the trailer made after January 1998?
6. What was the impact point on the truck/trailer? Was there underride of either the side or the rear of the trailer?

Run off the Road Crashes

1. What movements were the vehicles (at-fault and not-at-fault) making?
2. Any indication why the vehicle ran off the road? Abrupt maneuver, slowing, drifting, aggressive driving, traffic congestion, incursion of another vehicle into lane, etc.
3. Was there any evasive action or steering input that took place prior to running off the road?
4. Which direction did the vehicle run off the road? (Median, gore, shoulders)
5. Did the vehicle overcorrect back into the travel lanes, overcorrect into opposing travel lanes, cross into opposing lanes without overcorrection, etc.?
6. What are the roadway characteristics, such as, but not limited to ramps, rumble strips, roadway grade, curvature, super-elevation, pavement markings. Where known, indicate coefficient of friction for road surface, age of the pavement, whether the road was under construction, etc. Did roadway features affect crash (e.g. vehicle didn't follow curvature)?
7. Did the vehicle overturn? If so, Try to determine the cause of the overturn. (Hit object, tripping mechanisms, loss of lateral stability, slope, etc.)
8. Did the roadway/shoulder characteristics influence the crash? Was there a difference in grade from the roadway to the shoulder? What was the shoulder type (paved, gravel, etc)? What were the characteristics of the shoulder?
   a. How soft was the soil (if applicable)?
   b. Where there any tripping mechanisms?
   c. What was the slope of the shoulder?
   d. Where there any obstructions in the shoulder? Were the obstructions fixed or not? How far from the roadway were the obstructions? Were the obstructions in the clear zone?

Fixed Obstructions

1. Where was the object located? How far from the road?
2. What was the obstruction?
3. Was the object in the clear zone?
4. Was the object a "break-away"?

5. Was the obstruction FDOT property?
6. Were there guardrails/attenuators in place? What was their condition? Why/how did they fail?

Non-Fixed Obstructions

1. Where was the object located? On the road? If not on the road, how far from the road?
2. What was the obstruction?
3. Where did it come from?
4. Was the object large enough to be visible to the driver?
5. Was the perception/reaction an issue to avoid the object?

Signalized Intersection Crashes

1. What movements were the vehicles (at-fault and not-at-fault) making?
2. What type of intersection is it? What type of traffic control was present for each vehicle?
3. If a traffic light, was the light flashing or cycling? If the light was flashing, is it always flashing, or does it begin a flashing phase at a certain time. If so, what are the times that the light is flashing? Was the (electronic) traffic control device working properly?
   a. Are there traffic signals for the turning movement? Are the signals protected, permissive, or both? What was the condition during the crash?
4. Did the at-fault vehicle violate the signal?
   a. Was the movement legal?
5. Did the crash occur in the dilemma zone?
6. Were there pedestrians involved? If so, refer to pedestrian protocol.
7. How many lanes are present for vehicle/pedestrians to cross, including turn lanes if applicable? How many lanes did each vehicle/pedestrian cross before the impact? Are there exclusive turn lanes for turning traffic?
8. Are there crosswalks present? Medians? Channelization?
9. Are there any sight distance issues? On approach of the intersection? Stopped at the intersection? Proceeding through the intersection?
10. Are all of the traffic control devices clearly visible on approach of the intersection?
11. Was there any advisory signage on approach to the intersection?
12. What is the type (mast arm/pole & wire, mounted horizontally or vertically) and location of the signals? Were glare screens in place?
13. What are the signal times and phases like? Are the signal times and phases appropriate for the ADT at the time of the crash? Are the signal times and phases appropriate for the roadway configuration at the time of the crash? Is the number of lanes appropriate for the ADT?
14. Are the storage bays of the turn lanes long enough for the amount of traffic turning?
15. Were the roadway characteristics an influence to the crash? If so, what influences were relevant?

Non-Signalized Intersections (with/ without Traffic Control)

1. What type of intersection is it? What types of roads/driveways intersect?
2. What movements were the vehicles (at-fault and not-at-fault) making?
3. What type of traffic control was present for each vehicle (if any)?
4. Are all of the traffic control devices clearly visible on approach of the intersection (if applicable)?
5. How many lanes are present for vehicle/pedestrians to cross?
6. Are there turn lanes for turning traffic?
7. Are there crosswalks present? Medians? Channelization?
8. Are there any sight distance issues? On approach of the intersection? Stopped at the intersection? Proceeding through the intersection?
9. Was there any signage on approach to the intersection?
10. Are the storage bays of the turn lanes long enough for the amount of traffic turning?
11. For movements with stop sign, did vehicle stop? Did vehicle misjudge stopping distance or gap distance?
12. For movements with yield sign, did vehicle yield right-of way?
13. Did vehicle make a legal maneuver using the appropriate lanes?
14. Were the roadway characteristics an influence to the crash? If so, what influences were relevant?

Lane Changes/Crossing Centerline

1. Which direction was the lane change?
2. What movements were the vehicles (at-fault and not-at-fault) making?
3. Was the lane change intentional or evasive? Was the vehicle drifting?
4. What was the angle of the collision?
5. Was sight distance an issue?
6. Were there pavement markings and were they clearly visible on the roadway?
7. Was the equipment on the vehicles working properly, e.g. headlights, taillights?
8. Was either of the vehicles in its correct lane? If not, which vehicle was in the wrong lane? Why was this vehicle in the wrong lane? What action made the vehicle proceed to the wrong lane (merging from shoulder, passing, merging from entrance ramp, etc)?
9. Were there any evasive actions or steering inputs that took place prior to the lane change or after the lane change?
10. Did vehicle cross over the centerline into opposing lanes? What were the speed differences in the vehicles involved?
11. Did the vehicle leave the roadway? If so, refer to run-off the road protocols.
12. Did the vehicle overturn? If so, see overturn crashes.
13. Were the roadway characteristics an influence to the crash? If so, what influences were relevant?

Rear-End Crashes

1. What were the speed differences in the vehicles involved? (Speed is a major issue in working with rear-end crashes.) Were vehicles above/below posted speeds?

2. Was there any evasive action taken prior to impact? By which vehicle? If so, explain what actions were taken and how close to the impact were the actions taken. If not, try to determine why, such as, was the driver not paying attention, fatigue, medical conditions, defective equipment, etc.
3. Why was the lead vehicle stopped/slowing? (Stopped due to traffic, U-turning, legally/illegally parked)?
   a. Was traffic congestion an issue? If so, what was the cause of the congestion (construction, insufficient storage on turn-lanes, etc.)? Specifically look at the ADT and other traffic data to determine if the Level of Service is adequate.
   b. If any of the vehicles were parked, determine why they were parked. Were they parked legally and if so why/how did the vehicle get hit. For vehicles parked on the road side, determine why the vehicle was parked on the side of the road. Look at the shoulders/emergency-lanes and determine if they are adequate. Was the vehicle far enough off the road?
   c. Were any vehicles making a U-turn? Was it at a legal/illegal cross over? Was a left turn lane provided?
   d. If a CMV was involved, did the CMV rear-end a vehicle or did the CMV get rear-ended?
4. Who was at-fault, the driver of the vehicle in the front (that was rear-ended) or the driver of the vehicle in the rear (that sustained frontal damage)?
5. How did the roadway design affect the crash with respect to vehicle movements?

Pedestrians

1. What is the road type where the pedestrian was hit? (Intersection, Interstate, undivided, 4-lane divided, etc)
2. How many lanes were they attempting to cross?
3. What movement was the vehicle attempting? (Through movement, right turn, left turn, changing lanes, etc.)
4. What movement was the pedestrian attempting? (Walking across road, running across road, standing in road, standing on shoulder, walking with traffic, walking against traffic, etc.)
5. In which lane was the pedestrian hit? How many lanes did they successfully cross?
6. Were there crosswalks available, if applicable?
7. Were there sidewalks available, if applicable? On which sides of the road?
8. Was a median or channelization available, if applicable? Painted or raised?
9. If crossing roadway, were there any pedestrian signals available? If so, was the pedestrian crossing with or against the signal?
10. What types of signals were present at the intersection (if applicable)? Where were the signals located?
11. How close was the pedestrian to the nearest pedestrian control? (crosswalk if crossing road, sidewalk if in road, etc)
12. If the pedestrian was walking/running in roadway, were they traveling with or against traffic?
13. How fast was the vehicle traveling? Did the driver attempt any evasive action? Did the pedestrian attempt any evasive action?

14. Was the pedestrian under the influence of alcohol or drugs?
15. How old was the pedestrian? Could age have been a factor (very old/young)?

Mechanical Malfunctions

1. What type of mechanical defect caused the crash, such as tires, steering wheels, axles, etc.?
2. Was the driver aware of the defect before the crash?
3. If the defect was tire related, determine if it was a blow-out, tread separation, or a deflation. If it was a tread separation, determine the vehicle make and model and see if the tires fall under the Ford Explorer/Firestone Tire problems. Did tire fail prior to crash or as a result of/during the crash (e.g. deflation due to loss of lateral stability, vehicle movement perpendicular to rolling direction)?

Other Crashes

1. Over-correction crashes
   a. Determine what caused the driver to over-correct (overtaking vehicle, vehicle incursion into lane, sudden awareness following inattention/sleep)
   b. What type or amount of steering input caused the over-correction?
   c. If the over correction is due to a run-off the road type crash then refer to the run-off the road protocols.
2. Roll-over crashes
   a. What steering input caused the vehicle to roll over
   b. Look at the roadway geometry and determine if the roadway was a factor
   c. Was there a tripping mechanism to cause the overturn?
   d. What type of vehicle? Is this vehicle susceptible to rollover?
   e. What type of damage did the vehicle sustain?
   f. Did the vehicle leave the roadway before overturning?

Using all information available from the case review, evaluate possible factors contributing to the crash. Crash causes can typically be categorized as environmental, roadway, vehicle and person (driver/passenger/pedestrian). Factors can also be labeled as significant, moderate and minor contributors depending on the influence of the factor on the crash. In evaluating potential factors, every attempt should be made to differentiate causative factors, those factors that contributed to the crash, from conditions that merely existed at the time of the crash. The following ideas are offered as initial suggestions:

- Roadway
  - Traffic control devices
  - Roadway geometry / Alignment
  - Roadside Geometry / Structures
  - Striping / Pavement Condition
  - Signage

  - Location
  - Placement
  - Suitability
  - Traffic Congestion
  - Reference any ASHTO guidelines, or any other reference books.
  - Soil Characteristics
  - Type of shoulder (paved, grass, gravel)
- Driver/Person
  - Age (very old / very young)
  - Alcohol or drugs
  - Distracted (Inattention)
  - Aggressive driving
  - Driver errors / Violations (e.g. D1 misjudged gap on permissive left turn phase and turned into path of V2; D1 did not stop at red arrow and turned left into path of V2)
  - Familiarity with vehicle
  - Familiarity with area
  - Mental condition (state of mind)
  - Physical condition
- Environmental
  - Weather
  - Lighting
  - Vision obstructed (glare, etc)
  - Slick Roads
  - Objects in road
- Vehicle
  - Mechanical defects
  - Age / Size
  - Vehicle defects
  - Load shifting / Escaping
  - Trailer attachment failure

Table A.3 contains factor codes used in the fatal crash study.

Table A.3: Crash Contributing Factor Codes

Pedestrian Behavior	
	(10) Inattention / Distraction (emotional stress, headphones, working)
	(11) Perceptual Error (inadequate surveillance, looked but didn't see)
	(12) Decision Error (misjudged gap/speeds, not heed signal, dart out into road)
	(13) Alcohol/Drug Impairment
	(14) Other (standing/playing in roadway)
	(19) Unknown
Driver Behavior	
	(20) Inattention / Distraction (emotional stress, external/internal distraction)
	(21) Perceptual Error (inadequate surveillance, looked but didn't see)
	(22) Decision Error (misjudged gap/speed, following too closely, aggressive driving)
	(23) Abrupt Steering Input/Overcorrection/Loss of Lateral Stability
	(24) Vehicle Speed (too fast, too slow)
	(25) Alcohol/Drug Impairment
	(26) Incapacitation (asleep, medical condition)
	(29) Unknown
Vehicle Condition	
	(31) Faulty Brakes
	(32) Worn/Smooth Tires
	(33) Tire Puncture/Blowout/Tread Separation
	(34) Other Mechanical Defect
	(35) Disabled Vehicle
Environmental Condition	
	(41) Rain
	(42) Smoke/Fog
	(43) Sun Glare
Roadway Condition	
	(50) View Obstructions, Sight Distance
	(51) Roadway Curvature
	(52) Sign / Signal Issue
	(53) Maintenance Problem (potholes, standing water in road)
	(54) Construction
	(55) Wet/Slippery Road
	(59) Other
(60) Other / Unknown	

Understandably, it is a difficult task to determine which factors contributed to a crash, and the decision is often based on the judgment of the case reviewer. For instance, a BAC above 0.08% is *prima facie* evidence of impairment, and a person with that BAC is assumed to be under the influence, that is, affected by the alcohol. If the BAC is lower than 0.08%, it is more difficult to determine whether the alcohol affected the driver. Another example involves a driver who, after stopping at a stop sign, crosses wide and is hit by crossing traffic. In judging whether the at-fault driver was inattentive or made a judgment (decision) error, the case reviewer must consider factors including the speed of the crossing vehicle, its proximity to the at-fault vehicle when it pulled from the stop sign, and the state of mind of the at-fault driver. Other factors, such as visibility of a motorcycle, the effect of rain or darkness, or the reason for making a sudden lane change, are also difficult to state conclusively. However, a conscientious effort should be made to correctly identify potential causative factors and label them as primary or secondary factors.

To help judge the relative importance of various contributing factors, the prioritization scheme shown in Table A.4 was developed. The methodology is based on ideas gleaned from the literature review, particularly Campbell et al (2003) Obviously there are exceptions, and each case was considered separately; however, this list provides a general idea of how factors were prioritized. The concept behind this prioritization scheme is the driver's responsibility to adapt to prevailing conditions. So, given a scenario of a driver rounding a curve at a high speed in wet weather, the first contributing factor would be the speed of the vehicle, followed by the environmental conditions, followed by the curvature of the roadway. However, an exception might be a roadway obstruction on an interstate. Given the driver's expectation of clear, high-speed travel lanes, a sudden obstruction (e.g. object falling from a vehicle, or vehicles from a prior crash) might be given the highest priority, followed by the driver's inattention to the conditions. Had the blockage occurred on a non-limited-access facility, driver inattention would likely be given the highest priority over the obstruction.

Table A.4: Common Contributing Factors in Decreasing Order of Priority

Contributing Factor	Relative Priority
Deliberate unsafe driving act	Highest
Under influence of alcohol or drugs	
Vehicle defect	
Aggression	
Distraction	
Inattention, perception, or decision errors	
Vehicle speeding w/ or w/out control loss	
Environmental factors	
Roadway factors	Lowest

Using all information available from the case review, evaluate contributing factors to the fatality. The following factors are offered as initial ideas:

- Roadway
  - Shoulder design / location of fixed objects
- Driver/Person

  - Use of safety equipment
  - Performance of safety equipment
  - Ejection
  - Seating position versus impact point
  - Medical condition / health / age
- Vehicle
  - Size / Age / Condition
  - Modifications (e.g. removal of safety equipment, non-standard seating or roof, etc.)
  - Penetration / deformation of passenger compartment

Appendix A.1: Hours of Service Guidelines[2]

1. 72 hours on-duty time in 7 consecutive days; or

2. 84 hours on-duty time in 8 consecutive days.

3. After 24 consecutive hours of off-duty time, a new 7-day or 8-day period will begin.

These intrastate driving time limitations and on-duty time limitations do not apply to drivers of vehicles transporting unprocessed agricultural products that are subject to seasonal harvest during harvest periods, being transported from place of harvest to the first place of processing or storage, or from harvest directly to market.

IDENTIFICATION REQUIREMENTS / VEHICLE MARKING

Required markings shall be displayed on both sides of the power unit, in letters that contrast sharply in color with the background and readily visible and readable from a distance of 50'.

INTERSTATE COMMERCE

1. Name or trade name of the motor carrier,

2. The city or community and state in which the carrier maintains its principal place of business or in which the vehicle is customarily based,

3. The USDOT number or the ICC-MC number.

INTRASTATE COMMERCE

1. Name of the motor carrier,

2. The city or town or place of domicile of the vehicle owner or motor carrier,

3. The vehicle unit number.

Corporate logos containing the name and domicile of the company shall be considered to be in compliance with the requirements.

Any vehicle identified as required by the INTERSTATE regulations shall be considered to be in compliance.

[2] Hours of service extracted from the Florida Department of Transportation Office of Motor Carrier Compliance Trucking Manual.

APPENDIX B: DATABASE DESIGN

** Note: Many of the fields are filled in by a lookup menu, which references fields in a lookup table. Details of these tables are not included in this appendix to save space. Definitions are not provided for fields that are self-explanatory or that correspond to identically coded fields on the DHSMV approved Florida Traffic Crash Report (FTCR) form. References are provided where data was extracted directly from the FDOT Crash Analysis Reporting system (CAR) database.

Crash Data Table

- DHSMV Number (Number)
- Agency Number (Char): Number assigned to the crash of the investigating agency
- Investigating Agency (Char): Agency that investigated the homicide
- County ID (Number)
- Crash Hour (Number): Time of the crash with the minutes truncated
- Crash Day (Number)
- Crash Minute (Number)
- Crash Date (Number)
- Crash Month (Number)
- Crash Year (Number)
- Mile Post (Number): The milepost of the crash site indicated on the crash report or in the CAR database
- Nearest Node (Number): Nearest node of the crash site indicated on the crash report
- Multiple Event Collision (Number): Y/N - Indicates if there was more than one impact
- First Harmful Event (Number)
- Second Harmful Event (Number)
- Crash Type (VarChar2): Categorizes the type of crash as determined by the research team
- Number of Vehicles (Number)
- Number Killed (Number)
- Number Injured (Number)
- Pedestrians Involved (Number): Y/N
- Bicycle Involved (Number): Y/N
- Heavy Truck Involved (Number): Y/N

- Construction Zone (Number): Y/N – Indicates if the crash was in or influenced by a construction zone
- Effect of Construction Zone (VarChar2): Explains the effect the construction zone had on the crash
- DHSMV Report Obtained (Number): Y/N
- Homicide Report Obtained (Number): Y/N
- Photos Obtained (Number): Y/N
- Video Log Obtained (Number): Y/N
- Audio Tapes Obtained (Number): Y/N
- Site Visit Required (Number): Y/N
- Site Visit Conducted (Number): Y/N
- Data Complete (Number): Y/N
- Special Notes (VarChar2)
- Maximum Difference (Number): Maximum speed differential between any two vehicles or between any vehicle and fixed object (currently not in use)
- Site Visit Priority (Number): Prioritized need for site visit, with one being the lowest and five being the highest
- Basic Crash Type (VarChar2): Categorizes the type of crash as determined by the research team
- Critical Event (VarChar2): The event that made the crash eminent, as determined by the research team
- Critical Reason (VarChar2): The reason for the critical event, as determined by the research team
- Outcome (VarChar2): Textual description of crash outcome
- Managing District (Number): FDOT District in which the crash occurred (CAR db)
- Phantom and HitRun Code (Number): FDOT CAR phantom/hit and run code
- Alcohol Involved Code (Number): FDOT CAR alcohol involved code
- Crash Damage (Number): Total monetary damage due to crash (CAR db)
- Vehicle Damage (Number): Total monetary damage to vehicles due to crash (CAR db)
- Property Damage (Number): Total monetary damage to property due to crash (CAR db)
- Tot Persons (Number): Total persons involved in crash (CAR db)

- Tot Nontraffic Fatal (Number): Total non-traffic fatalities involved in crash (CAR db)
- Tot Pedalcyclists (Number): Total pedalcyclists involved in crash (CAR db)
- Crash Day of Week (Number): Day of week on which crash occurred, where 1 = Monday
- Tot Pedestrians (Number): Total number of pedestrians involved in crash (CAR db)
- Run Off Road (Char): Y/N/S, indicating whether any vehicle ran off the road during this crash, where S = secondary run-off-road event
- Crash Type Code 1 (Number): First crash type code, defined as indicated in Chapter 4
- Crash Type Code 2 (Number): Second crash type code, defined as indicated in Chapter 4
- Primary Factor Class (Char): Class of primary causative factor in the crash (Human, Roadway, Environment, or Vehicle)
- Primary Factor Detail (Char): Description of primary causative factor in the crash, according to definitions provided in Chapter 4
- Primary Factor Vehicle (Char): Sequence number of vehicle/driver corresponding to primary factor, or “PED” for pedestrian
- Secondary Factor Class (Char): Class of secondary causative factor in the crash (Human, Roadway, Environment, or Vehicle)
- Secondary Factor Detail (Char): Description of secondary causative factor in the crash, according to definitions provided in Chapter 4
- Secondary Factor Vehicle (Char): Sequence number of vehicle/driver corresponding to secondary factor, or “PED” for pedestrian
- Tertiary Factor Class (Char): Class of tertiary causative factor in the crash (Human, Roadway, Environment, or Vehicle)
- Tertiary Factor Detail (Char): Description of tertiary causative factor in the crash, according to definitions provided in Chapter 4
- Tertiary Factor Vehicle (Char): Sequence number of vehicle/driver corresponding to tertiary factor, or “PED” for pedestrian

Crash Road Table

- DHSMV Number (Number)
- Crash Road ID (Number): Primary Key (auto numbered field)
- Roadway Segment Number (Number): Roadway ID
- Road System (Number): interstate, US state, local, etc.

- State Road (Char)
- Common Name (Char): Other road name other than SR name
- Intersecting Road (IR) (Char): Road name referenced at or closet to crash site
- IR Common Name (Char): Other road name other than SR name
- Distance (VarChar2): Distance from IR Road taken from crash report
- Direction (Number): Direction from the IR road
- Road Type (Number): divided, not-divided, etc
- Number of Lanes (Number)
- Accident Lane (Number)
- ADT (Number)
- Traffic Control (Number): First traffic control
- Site Location (Number)
- Road Surface Type (Number)
- Road Surface Condition (Number)
- Road Defect (Number): Contributing Cause Roadway
- Traffic Character (Number)
- Shoulder Type (Number)
- Road Grade (Number)
- Rural Urban (Number): As determined by research team
- Geographical Area (Number): Inside/outside city limits/urban area, given by FDOT for 1998 and 1999 crashes
- Traffic Control 2 (Number): from CAR database
- Road Defect 2 (Number): from CAR database
- Side of Raod (Number): from CAR database
- FAHYSYS (Number): from CAR database
- Surface Width (Number): from CAR database
- Shoulder Type 1 (Number): from CAR database
- Shoulder Type 2 (Number): from CAR database
- Median Width (Number): from CAR database
- Horizontal DOC (Number): from CAR database
- Max Posted Speed (Number): from CAR database

- Type of Parking (Number): from CAR database
- Avg T Factor (Number): from CAR database
- Skid Test Results No (Number): from CAR database
- Radius of Curvature (Number): Radius of curvature in feet, as determined by research team
- Superelevation (Number): Superelevation in percent, as determined by research team
- Notes (VarChar2)

Vehicle Table

- DHSMV Number (Number)
- Vehicle ID (Number): Primary Key and ID number of the vehicle (auto numbered field)
- Vehicle Sequence Number (Number): Sequence number of the vehicle in the crash, as used by the reporting officer in completing the narrative
- Vehicle Number (Char): Vehicle Identification Number, or VIN number of vehicle
- Vehicle Type (Number)
- Vehicle Subtype (Number): Subtype of vehicle, further differentiating size and class of vehicle
- Trailer Type (Number): Type of trailer being towed primarily by the CMV
- Vehicle Year (Number)
- Vehicle Make (Char)
- Vehicle Model (Char)
- Vehicle Use (Number)
- Vehicle Movement (Number)
- Vehicle Direction (Number)
- Point of Impact (Number)
- Vehicle Defect (Number)
- Vehicle Special Function (Number)
- Posted Speed (mph) (Number)
- Vehicle Speed (mph) (Number)
- Location on Roadway (Number)
- Driver Action (Number)
- Speed Calculated By (VarChar2): Source of vehicle speed calculation

- Speed Differential (Number): Differential between vehicle and posted speed, with positive number indicating vehicle speed over limit
- Number of Occupants (Number)
- Number of Injuries (Number)
- Number of Fatalities (Number)
- Roll Over (Number): Y/N
- Form Section (Number): Accident form section number
- Ran Off Road (Char): Y/N/S, where S = secondary run-off-road
- ROR Direction (VarChar2): Direction of ROR
- ROR Overcorrect (Char): Y/N/Red, where Red = redirected back onto roadway
- ROR Fixed Object (VarChar2): Fixed object impacted after ROR event
- Tripping Mech (VarChar2): Tripping mechanism resulting in roll-over event
- Overcorrect Result (VarChar2): Result of overcorrect event
- Fixed Object Dist (Number): Lateral distance of impacted fixed object from edge line of outside travel lane
- Rumble Strips (Char): Y/N
- ROR Other Outcome (VarChar2): Other outcome of ROR event
- Most Harmful Event (VarChar2)
- Fixed Object Ownership (VarChar2)
- Notes (VarChar2)

Driver Table

- Vehicle ID (Number): ID number of the vehicle which the driver is driving
- Driver ID (Number): Primary Key (auto numbered field)
- Driver License Number (Char)
- Driver License State (Number): State by which DL was issued
- Driver Name (Char)
- Birth Month (Number)
- Birth Day (Number)
- Birth Year (Number)
- Driver Age (Number)
- Driver Sex (Number)

- Driver Race (Number)
- Driver Residence (Number)
- Physical Defect (Number)
- BAC Test (Number): Type of Blood Alcohol Test Conducted
- First Safety Equipment (Number)
- Second Safety Equipment (Number)
- Driving History (Multiple Violations) (Number): Y/N – Denotes if the driver had more that one violation their DL at the time of the crash
- Ejected (Number)
- Injury Severity (Number)
- Charges Filed (Number): Y/N/No-Deceased – Denotes if the driver was charged for the crash (no-deceased means the driver would have been charged but died due to the crash)
- Citations (Number): Y/N/No-Deceased – Denotes if the driver receive a citation(s) for the crash
- Alcohol Drug (Number): Taken from crash report to denote if there has been use of alcohol / drugs
- Alcohol Test Results (VarChar2): BAC test results taken from the homicide report
- Drug Test Results (VarChar2): Drug test results taken from the homicide report
- First Contributing Cause, Driver (Number):
- Second Contributing Cause, Driver (Number):
- At Fault Driver (Number): Y/N - Denotes if the driver was at-fault for the crash
- Total Safety Equipment (Number): Combination of first and second safety equipment fields, indicating total safety equipment in use
- License Status (Number): the DL status of the driver at the time of the crash (suspended, valid, etc)
- Airbag THI (Number): Air bag status, according to THI report
- Driver History Ranking (Number): Qualitative indictor of driving history prior to this crash, ranging from 1 = clean driving record to 5 = poor driving record
- Years in Hist (Number): Years in driving history
- Driver BAC FDOT (Number): Driver BAC according to FDOT CAR db (hundreds of mg/dl with presumed decimal point)
- Alcohol Involved FDOT (Number): Alcohol involved code (CAR db)
- Under Influence Alcohol (Char): Level of alcohol in blood, in reference to BAC limit

- Under Influence Drugs (Char): Type/category of drug found in blood
- Notes (VarChar2)

Passenger Table

- Vehicle Number (Number): ID number (Vehicle ID) of vehicle which passenger occupied
- Passenger Number (Number): Primary Key (auto numbered field)
- Location in Vehicle (Number)
- Injury Severity (Number)
- First Safety Equipment (Number)
- Second Safety Equipment (Number)
- Ejected (Number)
- At Fault (Number): Y/N - Denotes if the passenger caused the crash
- Charges Filed (Number): Y/N/No-Deceased – Denotes if the driver was charged for the crash (no-deceased means the driver would have been charged but died due to the crash)
- Alcohol Test Results (VarChar2): Results taken from the homicide report
- Drug Test Results (VarChar2): Results taken from the homicide report
- Total Safety Equipment (Number): Combination of first and second safety equipment fields, indicating total safety equipment in use
- Notes (VarChar2)

Pedestrian Table

- DHSMV Number (Number)
- Pedestrian Sequence Number (Number)
- Ped License Number (Char)
- Pedestrian Name (Char)
- Ped Birth Month (Number)
- Ped Birth Day (Number)
- Ped Birth Year (Number)
- Age (Number)
- Bicycle (Number): Denotes if the pedestrian was on a bicycle prior to becoming pedestrian

- At Fault (Number): Y/N - Denotes if the pedestrian was at fault in the crash
- Pedestrian Action (Number)
- Injury Severity (Number)
- Alcohol Drug (Number) Alcohol and/or drug use from crash report
- Physical Defect (Number)
- Residence (Number)
- Race (Number)
- Sex (Number)
- Alcohol Test Results (VarChar2): Results taken from the homicide report
- Drug Test Results (VarChar2): Results taken from the homicide report
- Charges Filed (Number): Y/N/No-Deceased – Denotes if the driver was charged for the crash (no-deceased means the driver would have been charged but died due to the crash)
- Citations (Number): Y/N/No-Deceased – Denotes if the pedestrian receive a citation(s) for the crash

  Number of Lanes Attempted (Number)
- Number of Lanes Crossed (Number)
- First Contrib Cause (Number)
- Second Contrib Cause (Number)
- ACFMSECT (Number): Accident form section number (CAR db)
- PERSEQ (Number): Person sequence number (CAR db)
- Crash Type (Number): Pedestrian specific crash type code, as defined in Chapter 4
- Crash Factor 1 (Number): First contributing factor, as defined in Chapter 4
- Crash Factor 2 (Number): Second contributing factor, as defined in Chapter 4
- Striking Vehicle (Number): ID number (Vehicle ID) of striking vehicle
- Under Influence Alcohol (Char): Level of alcohol in blood, in reference to BAC limit
- Under Influence Drugs (Char): Type/category of drug found in blood
- Notes (VarChar2)

Truck Table

- DHSMV Number (Number)
- Truck Number (Char): Primary Key (auto numbered field)

- Hazardous Material (Number): Y/N – CMV carrying hazardous material
- Hours of Service (Number): Y/N – denotes whether or not the driver had an hours of service log
- Hours of Service Violated (Number): Y/N
- Inspection Reports (Number): denotes whether or not the driver had inspection reports
- Inspection Violations Noted (Number): Y/N
- Violation Description (VarChar2): Describes the violations
- First Event (Number): Sequence of events taken from the commercial vehicle supplement report
- Second Event (Number): Sequence of events taken from the commercial vehicle supplement report
- Third Event (Number): Sequence of events taken from the commercial vehicle supplement report
- Fourth Event (Number): Sequence of events taken from the commercial vehicle supplement report
- Notes (VarChar2)

Environment Table

- DHSMV Number (Number)
- Lighting Condition (Number)
- Weather (Number)
- First Contributing Cause, Environment (Number)
- Second Contributing Cause, Environment (Number)

Sequence of Events Table

- DHSMV Number (Number)
- Event Number (Number)
- Event (VarChar2): Specific sequence of events listed in order

Contributing Factor Crash Table

- DHSMV Number (Number)
- Factor (VarChar2): Factor that contributed to the crash

- Factor Type (Number): Classified as a type determined by the research team
- Noted By (Char)
- Importance (Number): issued a level of importance – minor, moderate, significant
- Factor Number (Number): ID number of factor
- Vehicle Number (Number): sequence number of vehicle corresponding to factor
- Factor Class (Char): Class to which factor was assigned

Contributing Factor to Fatality Table

- DHSMV Number (Number)
- Factor (VarChar2): Factor that contributed to the fatality
- Factor Type (Number): Classified as a type determined by the research team
- Noted By (Char)
- Importance (Number): issued a level of importance – minor, moderate, significant
- Factor Number (Number): ID number of factor
- Vehicle Number (Number): sequence number of vehicle corresponding to factor
- Factor Class (Char): Class to which factor was assigned
- Driver ID (Number): ID number of driver to which factor was assigned
- Passenger Number (Number): ID number of passenger to which factor was assigned
- Ped Sequence Number (Number): Sequence number of pedestrian to which factor was assigned

Violations Table

- DHSMV Number (Number)
- Vehicle Number (Number)
- Violation (VarChar2): Violations given to the person taken from the homicide report

Errors on Reports Table

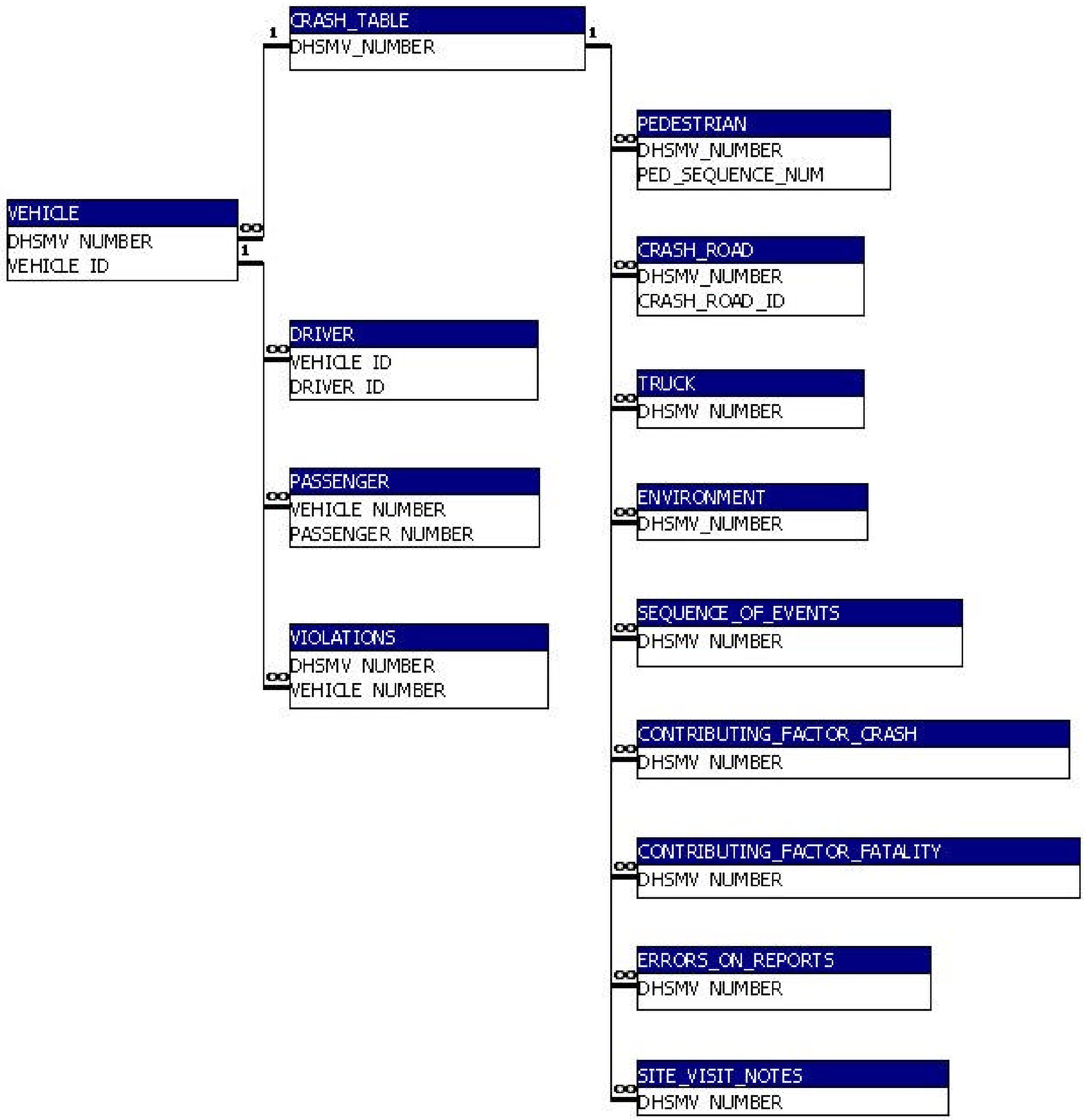
- DHSMV Number (Number)
- Field (Char)
- Incorrect Information Source (VarChar2)
- Incorrect Information (VarChar2)
- Correct Information (VarChar2)

- Reason for Correction (VarChar2)

Site Visit Notes Table

- DHSMV Number (Number)
- Note Number (Number)
- Noted By (Char)
- Type of Note (Number): Type of site visit note (e.g. Site Description, Roadway Issue, Traffic Operations Issue, etc.)
- Note (VarChar2)

Database Relationships for fatal_crash_study



CRASH_TABLE	
DHSMV_NUMBER	TOT_NONTRAFFIC_FATAL
AGENCY_NUMBER	TOT_PEDALCYCLISTS
INVESTIGATING_AGENCY	CRASH_DAY_OF_WEEK
COUNTY_ID	TOT_PEDESTRIANS
CRASH_HOUR	RUN_OFF_ROAD
CRASH_DAY	CRASH_TYPE_CODE_1
CRASH_MONTH	CRASH_TYPE_CODE_2
CRASH_YEAR	PRIMARY_FACTOR_CLASS
MILEPOST	PRIMARY_FACTOR_DETAIL
NEAREST_NODE	SECONDARY_FACTOR_CLASS
MULTIPLE_EVENT	SECONDARY_FACTOR_DETAIL
FIRST_HARMFUL_EVENT	TERTIARY_FACTOR_CLASS
SECOND_HARMFUL_EVENT	TERTIARY_FACTOR_DETAIL
CRASH_TYPE	
NUMBER_OF_VEHICLES	
NUMBER_KILLED	
NUMBER_INJURED	
PEDESTRIANS_INVOLVED	
BICYCLE	
HEAVY_TRUCK	
CONSTRUCTION_ZONE	
EFFECT_OF_CONSTRUCTION	
DHSMV_RPT_OBTAINED	
HOMICIDE_RPT_OBTAINED	
PHOTOS_OBTAINED	
VIDEO_LOG	
AUDIO_TAPES_OBTAINED	
SITE_VISIT_REQUIRED	
SITE_VISIT_CONDUCTED	
DATA_COMPLETE	
SPECIAL_NOTES	
MAXIMUM_DIFFERENCE	
SITE_VISIT_PRIORITY	
BASIC_CRASH_TYPE	
CRITICAL_EVENT	
CRITICAL_REASON	
OUTCOME	
PRIMARY_FACTOR	
THI_NUMBER	
CRASH_MINUTE	
CRASH DATE	
MANAGING DISTRICT	
PHANTOM AND HITRUN CODE	
ALCOHOL INVOLVED CODE	
CRASH DAMAGE	
VEHICLE DAMAGE	
PROPERTY DAMAGE	
TOT PERSONS	

VEHICLE
DHSMV_NUMBER
VEHICLE_ID
VEHICLE_SEQUENCE_NUMBER
VEHICLE_NUMBER
VEHICLE_TYPE
VEHICLE_SUBTYPE
TRAILER_TYPE
VEHICLE_YEAR
VEHICLE_MAKE
VEHICLE_MODEL
VEHICLE_USE
VEHICLE_MOVEMENT
VEHICLE_DIRECTION
POINT_OF_IMPACT
VEHICLE_DEFECT
VEHICLE_SPECIAL_FUNCTION
POSTED_SPEED
VEHICLE_SPEED
LOCATION_ON_ROADWAY
NOTES
DRIVER_ACTION
SPEED_CALCULATED_BY
SPEED DIFFERENTIAL
NUM OF OCCUPANTS
NUM OF INJURIES
NUM OF FATALITIES
ROLL OVER
MATCHES
TEMP YEAR
TEMP MAKE
TEMP MODEL
TEMP YEAR 2
TEMP MAKE 2
TEMP MODEL 2
TEMP SUBTYPE
TEMP SUBTYPE 2
TEMP COLUMN
FORM SECTION
RAN OFF ROAD
ROR DIRECTION
ROR OVERCORRECT
ROR FIXED OBJECT
TRIPPING MECH
OVERCORRECT RESULT
FIXED OBJECT DIST
RUMBLE STRIPS
ROR OTHER OUTCOME
MOST HARMFUL EVENT
FIXED OBJECT OWNERSHIP

DRIVER
VEHICLE_ID
DRIVER_ID
DRIVER_LICENSE_NUMBER
DRIVER_LICENSE_STATE
DRIVER_NAME
BIRTH_MONTH
BIRTH_DAY
BIRTH_YEAR
DRIVER_SEX
DRIVER_AGE
DRIVER_RACE
DRIVER_RESIDENCE
PHYSICAL_DEFECT
BAC_TEST
FIRST_SAFETY_EQUIPMENT
SECOND_SAFETY_EQUIPMENT
DRIVING_HISTORY
EJECTED
INJURY_SEVERITY
CHARGES_FILED
CITATIONS
ALCOHOL_DRUG
ALCOHOL TEST RESULT
DRUG TEST RESULT
FIRST CONTRIB CAUSE DRIVER
SECOND CONTRIB CAUSE DRIVER
AT FAULT DRIVER
NOTES
TOTAL SAFETY EQUIPMENT
LICENSE STATUS
AIRBAG THI
DRIVER HIST RANKING
YEARS IN HIST
TEMP COLUMN
DRIVER BAC FDOT
ALCOHOL INVOLVED FDOT
UNDER INFLUENCE ALCOHOL
UNDER INFLUENCE DRUGS

PASSENGER
VEHICLE_NUMBER
PASSENGER_NUMBER
LOCATION_IN_VEHICLE
INJURY_SEVERITY
FIRST_SAFETY_EQUIPMENT
SECOND_SAFETY_EQUIPMENT
EJECTED
AT_FAULT
CHARGES_FILED
ALCOHOL_TEST_RESULTS
DRUG_TEST_RESULTS
NOTES
TOTAL_SAFETY_EQUIPMENT

PEDESTRIAN
DHSMV_NUMBER
PED_SEQUENCE_NUM
PED_LICENSE_NUM
PEDESTRIAN_NAME
PED_BIRTH_MONTH
PED_BIRTH_DAY
PED_BIRTH_YEAR
AGE
BICYCLE
AT_FAULT
PEDESTRIAN_ACTION
INJURY_SEVERITY
ALCOHOL_DRUG
PHYSICAL_DEFECT
RESIDENCE
RACE
SEX
NOTES
ALCOHOL_TEST_RESULT
DRUG_TEST_RESULT
CHARGES_FILED
NUM_LANES_ATTEMPTED
CITATIONS
NUM LANES CROSSED
FIRST CONTRIB CAUSE
SECOND CONTRIB CAUSE
ACFMSECT
PERSEQ
CRASH TYPE
CRASH FACTOR 1
CRASH FACTOR 2
STRIKING VEH
UNDER INFLUENCE ALCOHOL
UNDER INFLUENCE DRUGS

CRASH_ROAD
DHSMV_NUMBER
CRASH_ROAD_ID
ROADWAY_SEGMENT_NUMBER
ROAD_SYSTEM
STATE_ROAD
COMMON_NAME
INTERSECTING_ROAD
IR_COMMON_NAME
DISTANCE
FEET_OR_MILES
DIRECTION
ROAD_TYPE
NUMBER_OF_LANES
ACCIDENT_LANE
ADT
TRAFFIC_CONTROL
SITE_LOCATION
ROAD_SURFACE_TYPE
ROAD_SURFACE_CONDITION
ROAD_DEFECT
TRAFFIC_CHARACTER
SHOULDER_TYPE
ROAD GRADE
RURAL URBAN
GEOGRAPHICAL AREA
TRAFFIC CONTROL 2
ROAD DEFECT 2
SIDE OF ROAD
FAHWYSYS
CRASH RATE CLASS CAT
ROADWAY ACCESS TYPE
CENSUS PLACE CODE
SURFACE WIDTH
SHOULDER TYPE 1
SHOULDER TYPE 2
MEDIAN WIDTH
HORIZONTAL DOC
MAX POSTED SPEED
TYPE OF PARKING
AVG T FACTOR
SKID TEST RESULTS NO
RADIUS OF CURVATURE
NOTES
SUPERELEVATION

ENVIRONMENT
DHSMV_NUMBER
LIGHTING_CONDITION
WEATHER
FIRST_CONTRIB_CAUSE
SECOND_CONTRIB_CAUSE

SEQUENCE_OF_EVENTS
DHSMV_NUMBER
EVENT_NUMBER
EVENT

CONTRIBUTING_FACTOR_CRASH
DHSMV_NUMBER
FACTOR
FACTOR_TYPE
NOTED BY
IMPORTANCE
FACTOR NUMBER
VEHICLE NUMBER
FACTOR CLASS

CONTRIBUTING_FACTOR_FATALITY
DHSMV NUMBER
FACTOR
FACTOR TYPE
NOTED BY
IMPORTANCE
FACTOR NUMBER
VEHICLE NUMBER
FACTOR CLASS
DRIVER ID
PASSENGER NUMBER
PED SEQUENCE NUM

TRUCK
DHSMV_NUMBER
TRUCK_NUMBER
HAZARDOUS_MATERIAL
HOURS_OF_SERVICE
HOURS_OF_SERVICE_VIO
INSPECTION_REPORTS
INSPECTION_VIOLATIONS
VIOLATION_DESCRIPTION
NOTES
FIRST_EVENT
SECOND_EVENT
THIRD_EVENT
FOURTH_EVENT

VIOLATIONS
DHSMV_NUMBER
VEHICLE_NUMBER
VIOLATION

ERRORS_ON_REPORTS
DHSMV_NUMBER
FIELD
INCORRECT_INFO_SOURCE
INCORRECT INFORMATION
CORRECT INFORMATION
REASON FOR CORRECTION

SITE_VISIT_NOTES
DHSMV NUMBER
NOTE NUMBER
NOTED BY
TYPE OF NOTE
NOTE

APPENDIX C: SAMPLE PUBLIC SERVICE ANNOUNCEMENT

Video: Mother bucking children into car seats, fastening her own seat belt, checking side and rear view mirrors. Audio: Children laughing, mother talking, music on radio

Audio: Silence. **Video:** Crash test, air bags deploying, crumple zones, etc. Voice-over: When you are in a car, you are protected by 3000 pounds of steel, seat belts, air bags, and a safety cage specially designed to protect you in an accident.

Video: Teenagers walking on edge on a city street, drinking from dark bottles, laughing, jostling one another, one talking on cell phone. Teenagers start crossing street at angle as car (driven by mother) approaches from behind. A teenager tells his friends that he left something in the car, and turns around to run back across the street. Brakes squeal as pedestrian and driver both realize that an impact is imminent.

Audio: Silence. **Video:** Black screen. **Voice-over:** When you are a pedestrian, your only safety equipment is your brain. Use it wisely.

Text on black screen (repeated by announcer): Highway Safety: It's not just for drivers.

Alternate text/voice-over: If you're too drunk to drive, you're too drunk to be walking in the road.

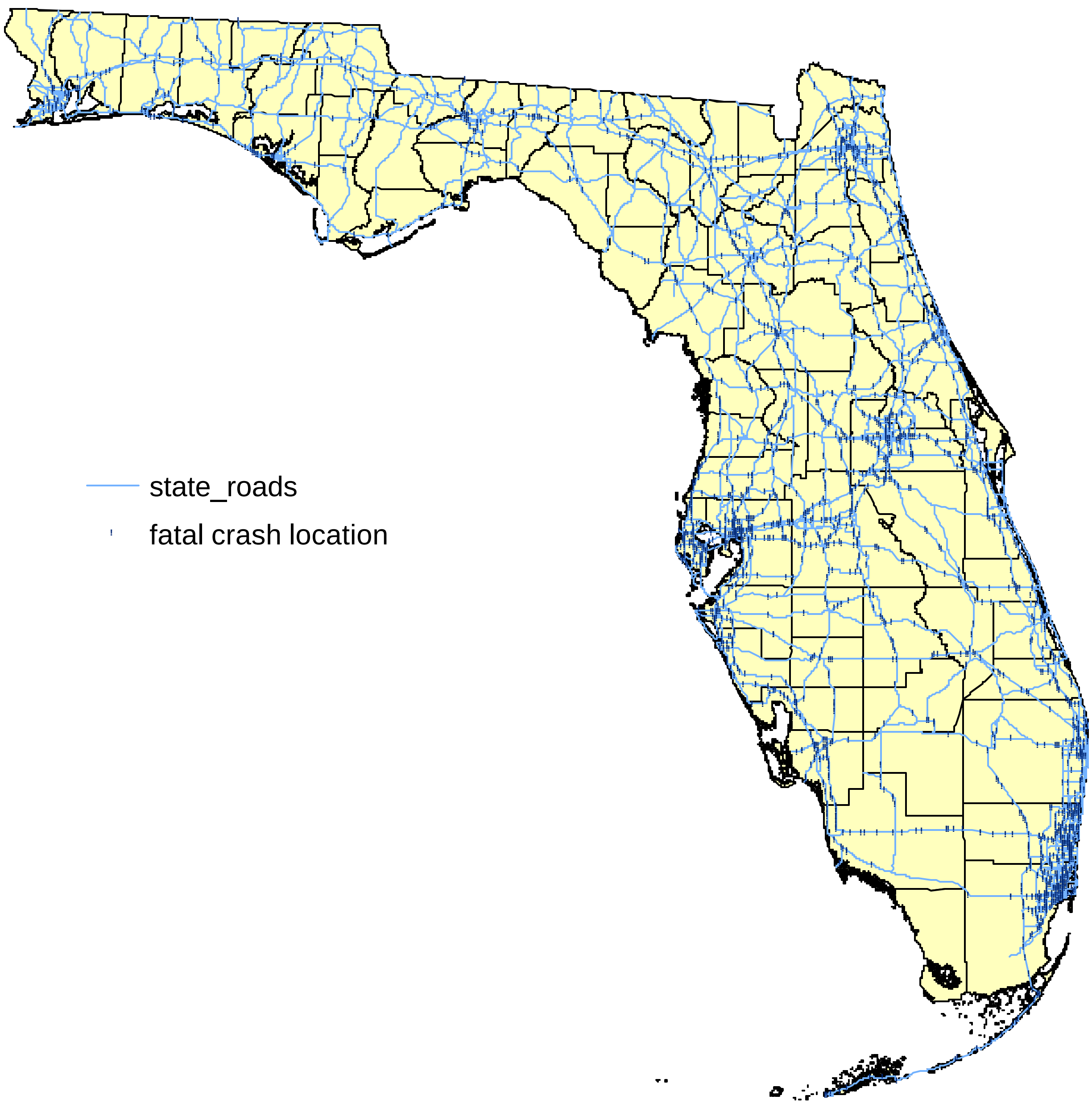
Alternate text: Safety statistics on number of pedestrian fatalities and alcohol-related pedestrian fatalities in Florida.

Variations: Bicyclist weaving, listening to headphones, trying to retrieve water bottle, veering into traffic without looking back. **Voice-over:** When you are on a bicycle, your most important piece of safety equipment is your brain.

APPENDIX D: GIS OVERVIEW OF FATAL AND NON-FATAL CRASHES IN FLORIDA

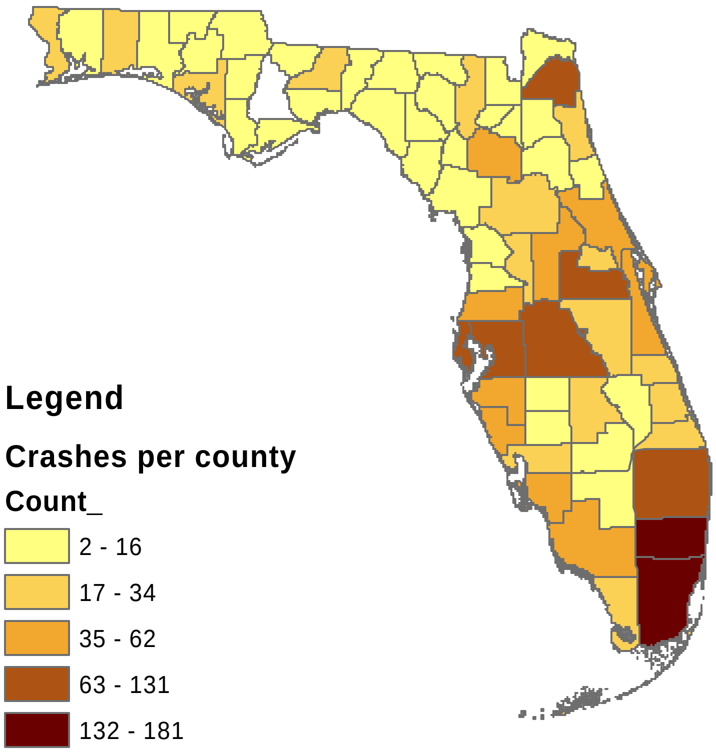
This appendix contains a graphic summary of data concerning the overall trends in fatal crashes in the state of Florida. Because of the prime emphasis on heavy truck (CMV) crashes, those crashes are considered in this chapter as well. Many of the charts are presented using the same codes that are available from the Florida Traffic Crash Report. However, in all cases, this data has been corrected using the results of the more detailed case studies of the crashes. A brief analysis is provided with each of the GIS maps. The Florida Department of Transportation GIS Data Directory (available on-line through the State Planning Office) and the Florida Geographic Data Library (FGDL) were also used as references and sources of information.

Location of Fatal Crashes in Florida



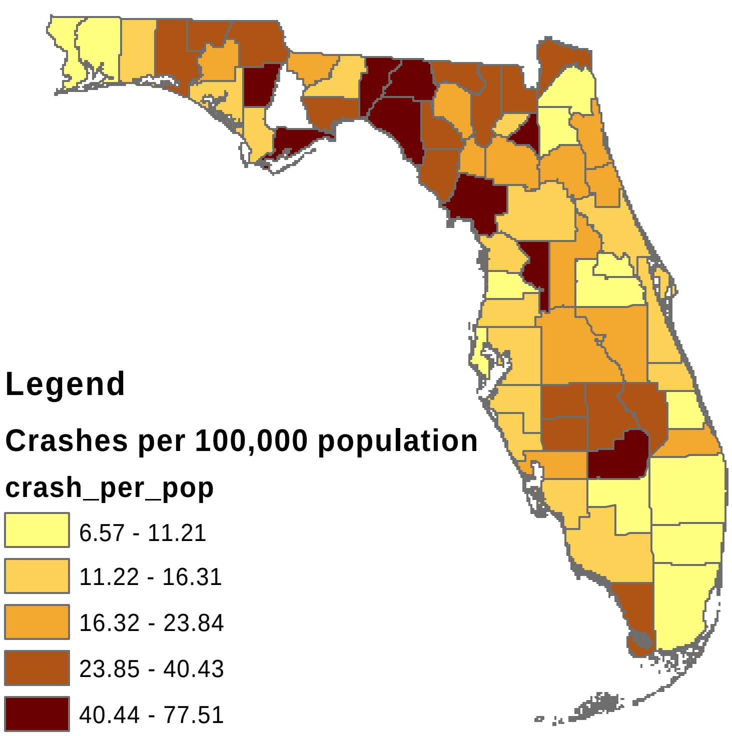
Fatal crashes are distributed throughout the State of Florida, with the highest concentrations occurring in populous urban areas and along the most heavily trafficked state roadways.

Crash Distribution by County



Crashes per County

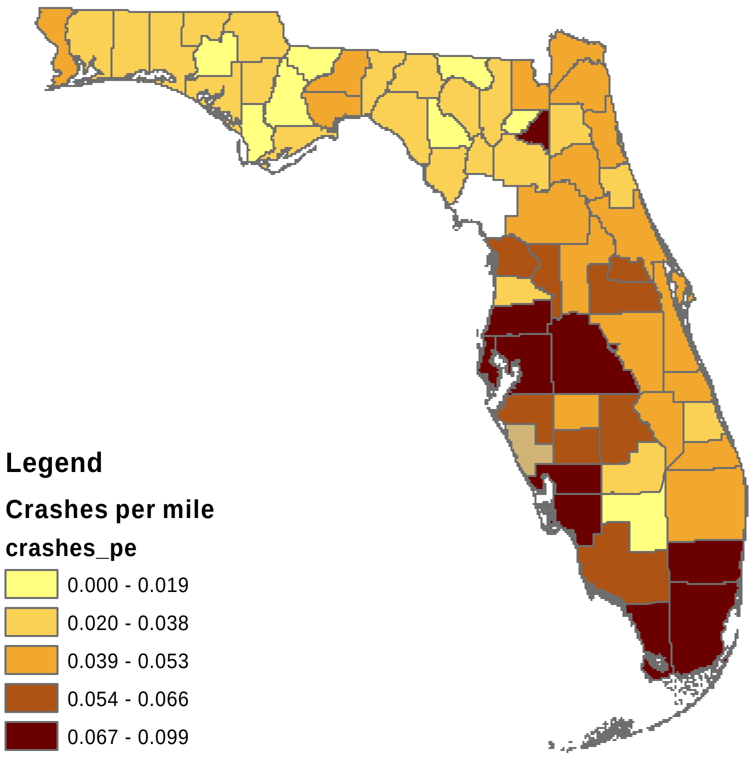
Looking only at number of crashes, the highest county crash counts are in southeast Florida in Dade, Broward, and Palm Beach counties, followed by central Florida, especially Pinellas, Hillsborough, Polk, and Orange counties.



Crashes per 100,000 County Population

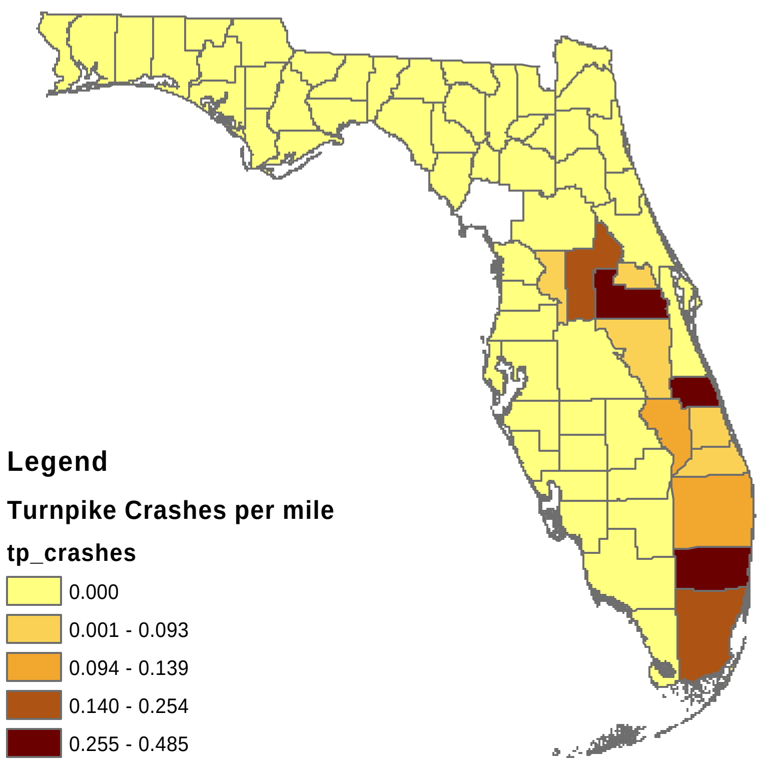
When county crash rates are normalized by population, a number of counties in northern Florida, especially in the Big Bend region, have the highest crash rates.

Crash Density by Mileage of State Roadway



Crashes per Mile of State Roadway in Each County

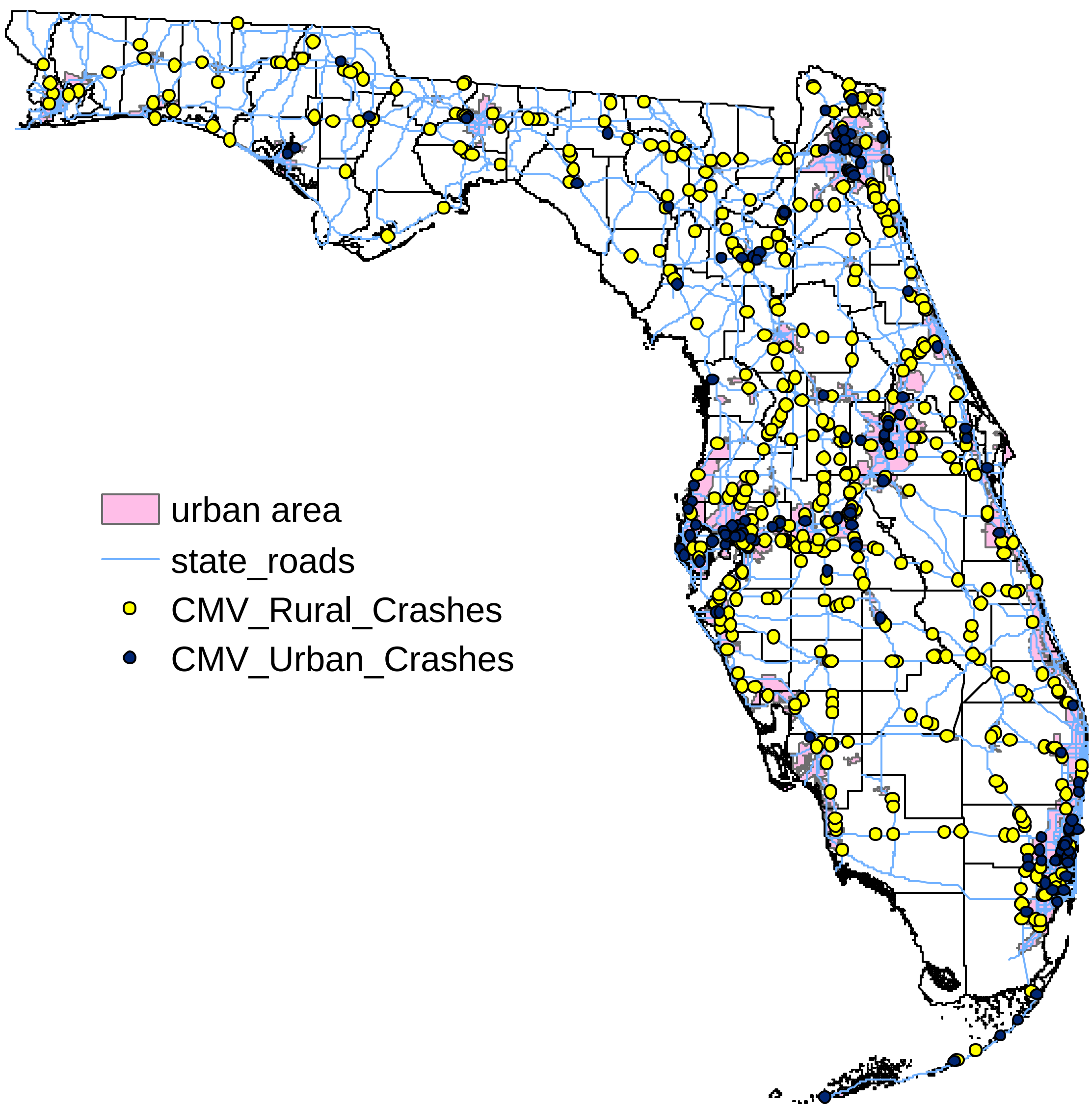
When county crash rates are normalized by the miles of state road, the highest crash rates are in the south and southwest parts of the state; Pasco county has the highest number of crashes per mile of state road, followed by Lee and Charlotte counties.



Crashes per Mile of Turnpike

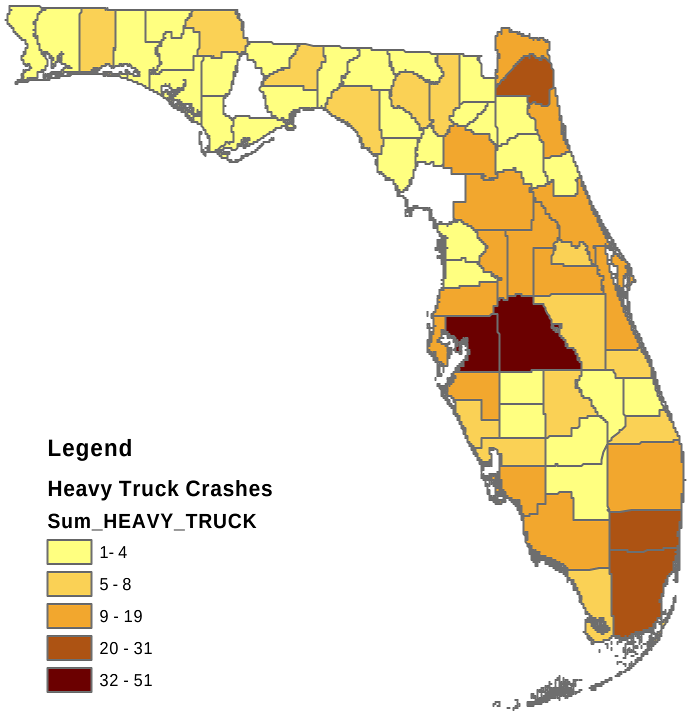
Indian River, Palm Beach and Orange counties have the highest crash rate per mile on the turnpike. Overall, the turnpike averages three times as many crashes per mile as the average state roadway.

Location of Commercial Motor Vehicle (CMV) Crashes



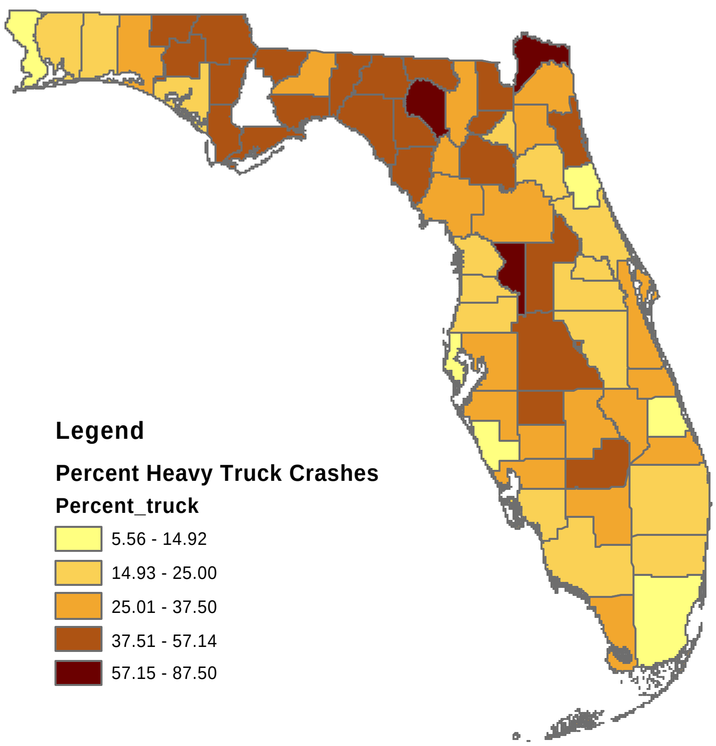
For the most part, CMV crashes are distributed in approximately the same way as non-CMV crashes. Urban areas are shown by pink shading. There were 575 CMV crashes in the study, over three quarters of which occurred in rural areas (437 rural CMV crashes).

Commercial Motor Vehicle (CMV) Crashes



CMV Crashes by County

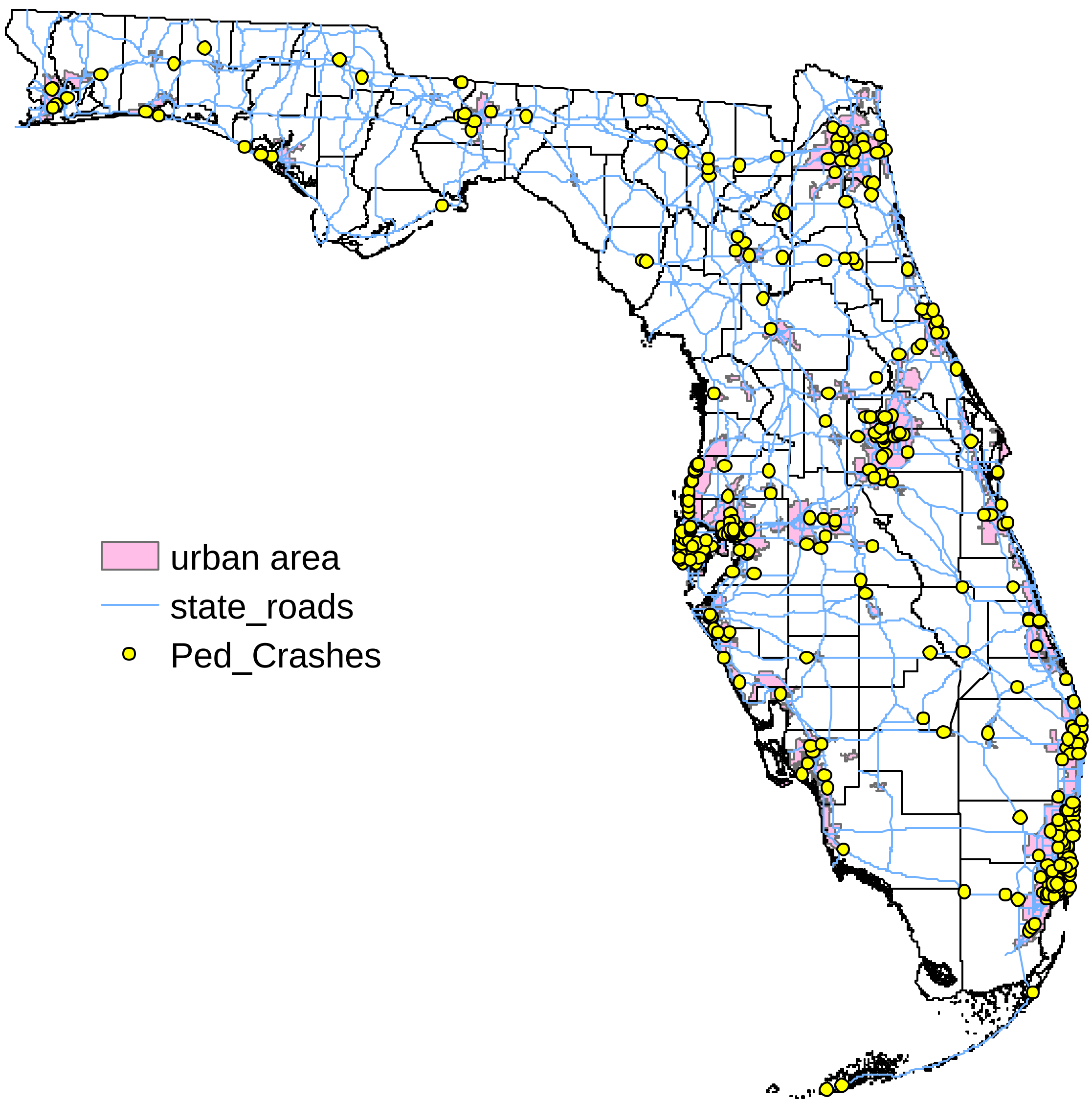
The largest number of CMV crashes is in Polk county, followed by Hillsborough county. Together, these counties account for almost seventeen percent of all CMV crashes in the state.



CMV Crashes as a Percent of the Total Crashes in a County

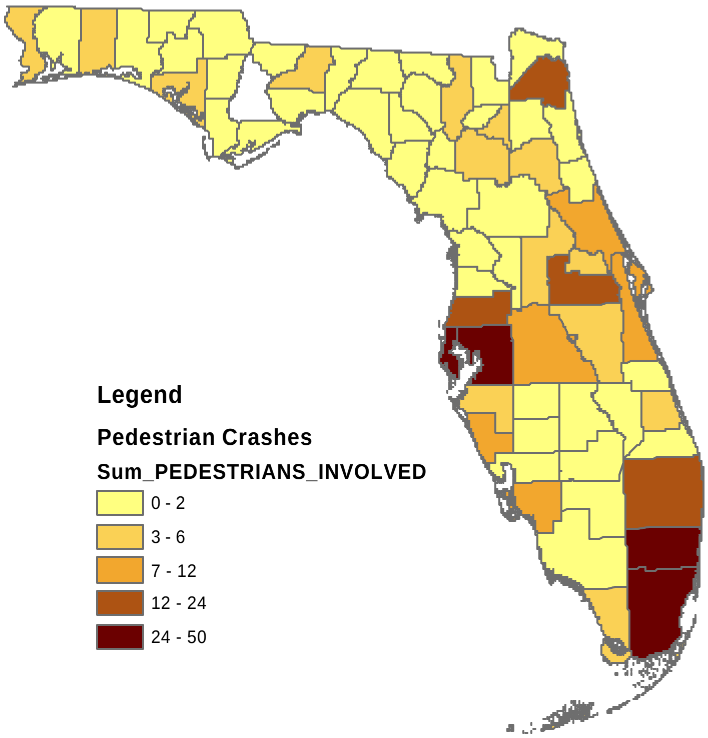
With respect to non-CMV crashes, CMV crashes are highly over-represented in Sumter, Nassau, and Suwannee counties.

Location of Pedestrian Crashes



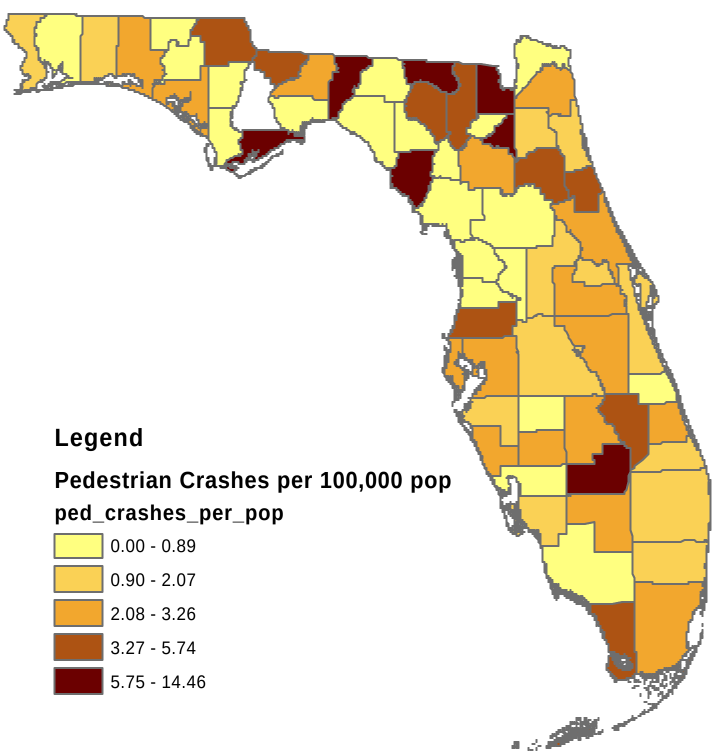
Pedestrian crashes are not evenly distributed throughout the state, instead clustering in higher population areas, as would be expected. Urban areas are shown by pink shading.

Pedestrian Crashes



Pedestrian Crashes by County

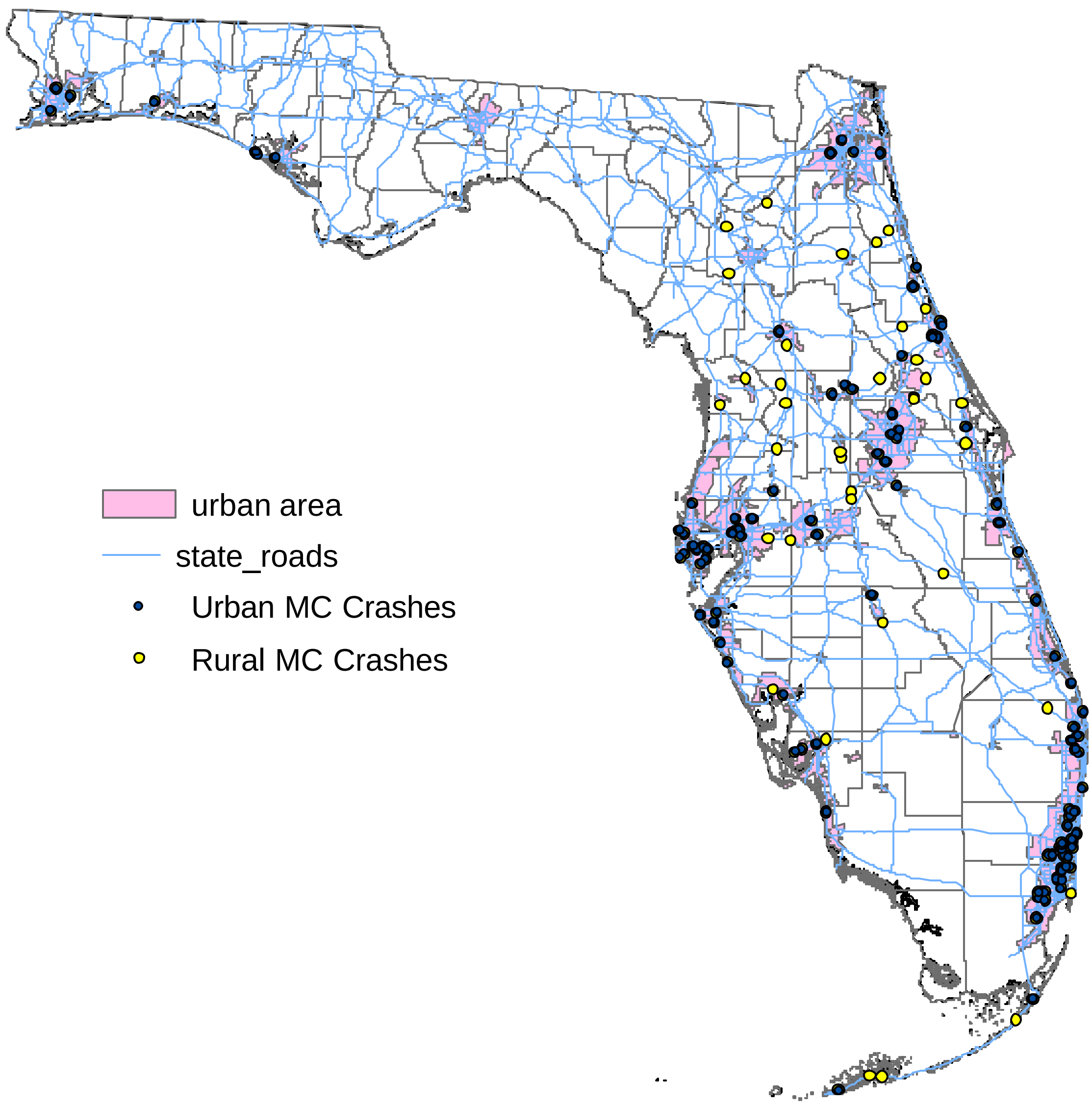
Dade and Broward counties have the highest numbers of fatal pedestrian crashes, together accounting for approximately 25 percent of the crashes. Dade, Pinellas, and Orange counties are highly over-represented in pedestrian crashes, meaning that pedestrian crashes account for a large portion of the crashes in those counties.



Pedestrian Crashes per 100,000 Population

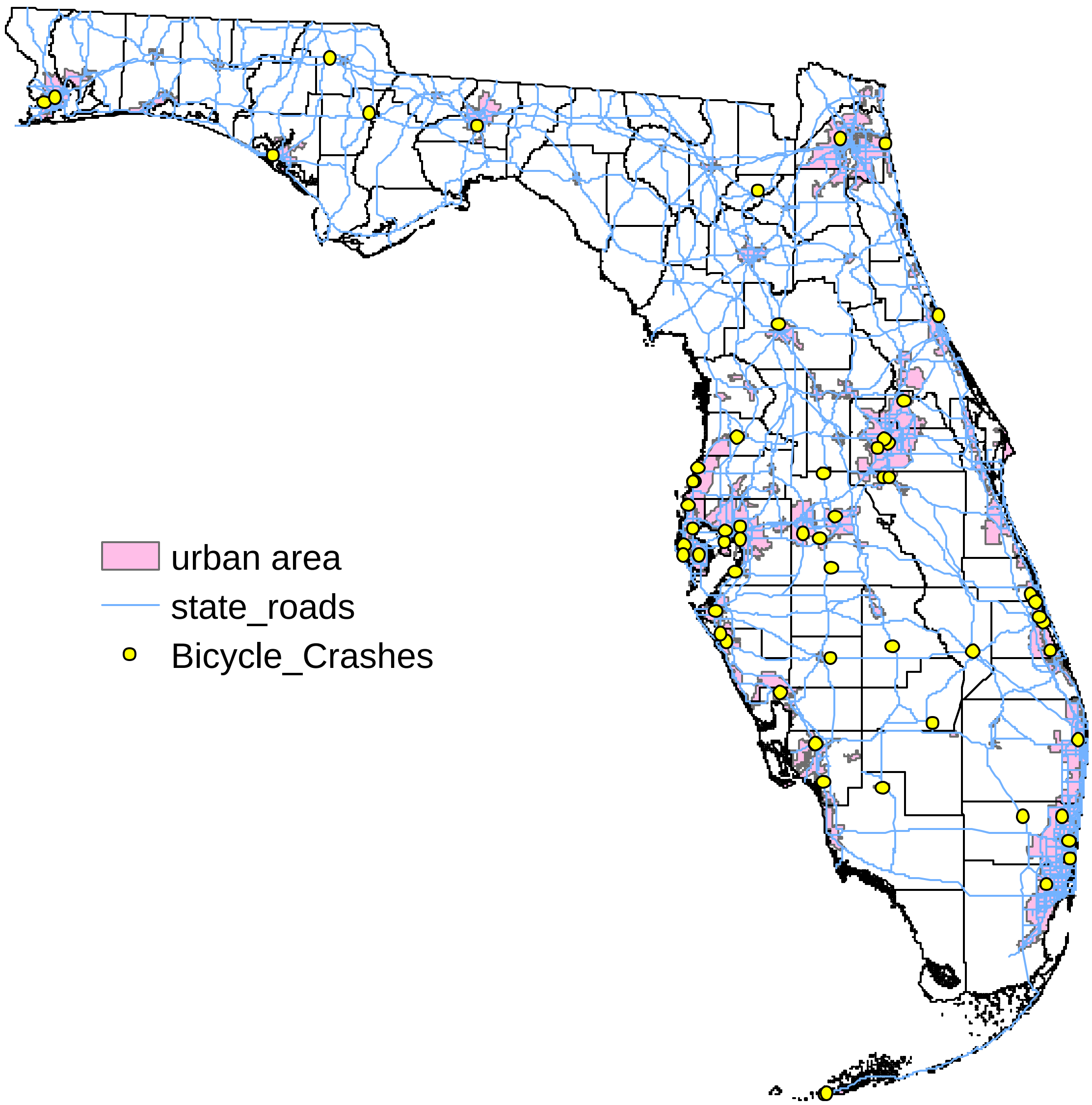
When normalized by population a number of counties in the Big Bend region of north Florida have a high pedestrian crash rate.

Location of Motorcycle Crashes



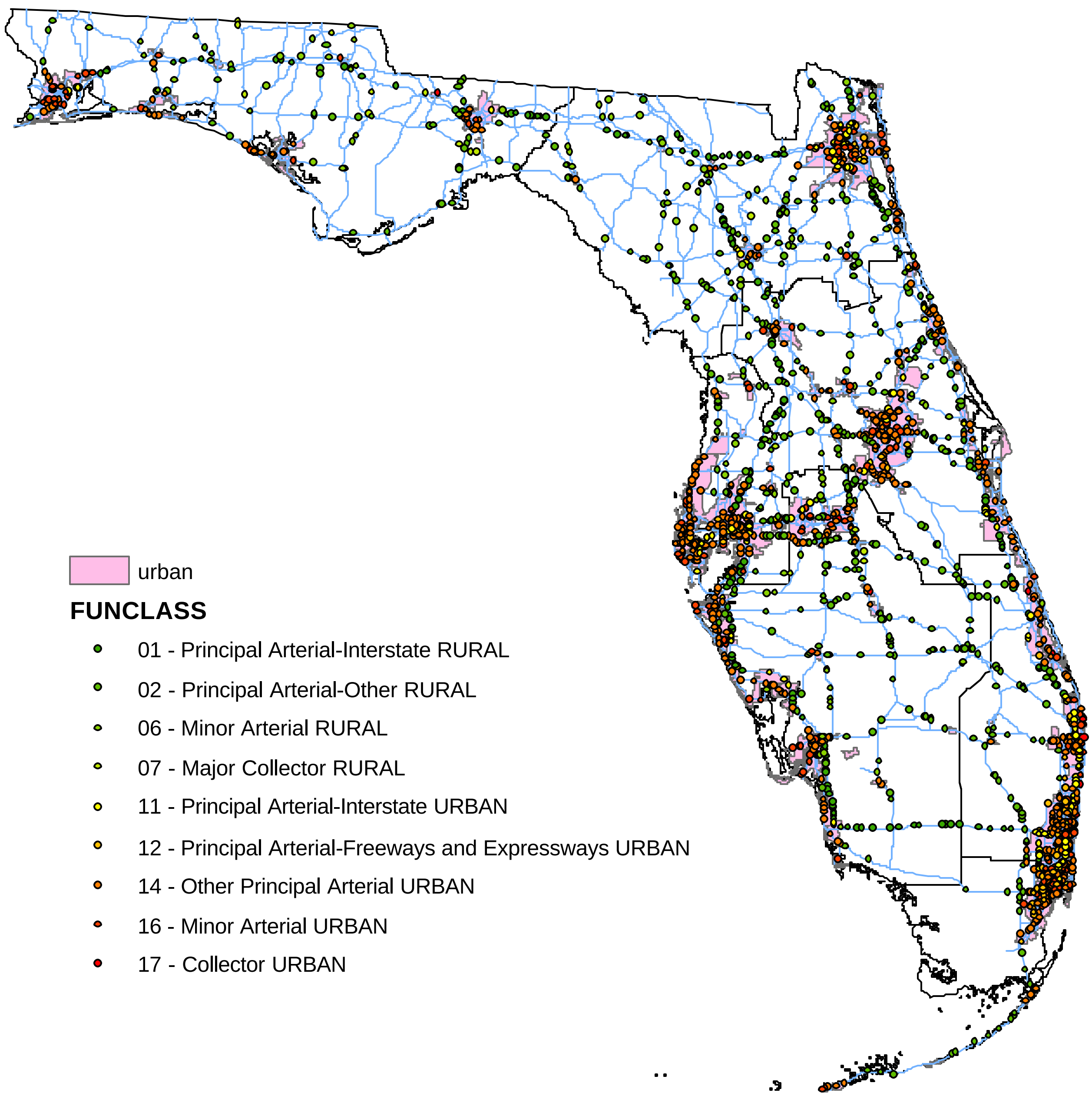
There were 151 motorcycles (4 mopeds included) involved in fatal crashed in the study. Six crashes involved multiple motorcycles. Of the 145 locations where motorcycles crashed, 110 were in urban areas.

Location of Bicycle Crashes



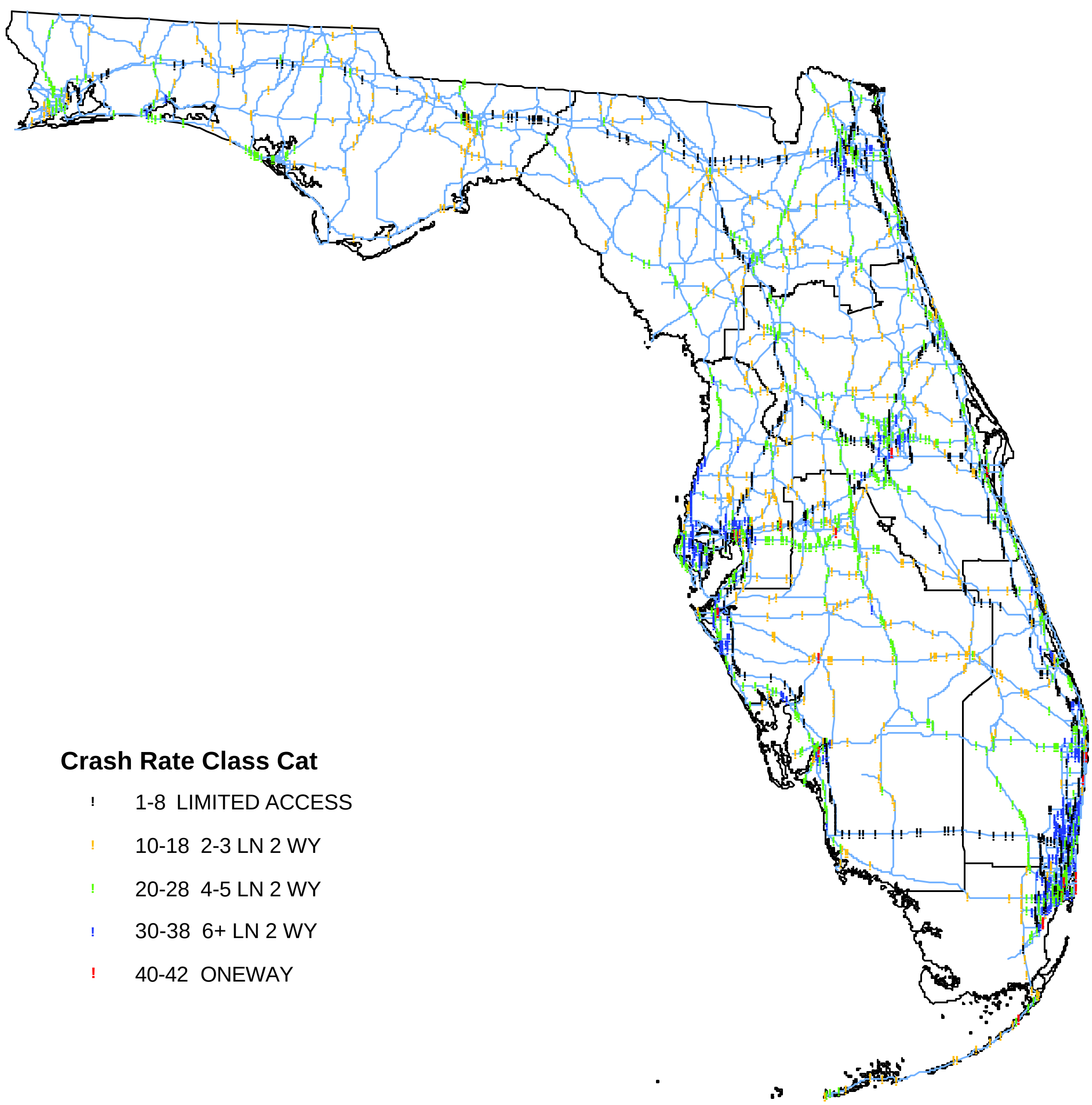
There were 62 bicycle related fatal crashes in this study. Of the locations where bicycle crashes occurred, exactly half were in urban areas.

Crashes by Functional Classification of Road



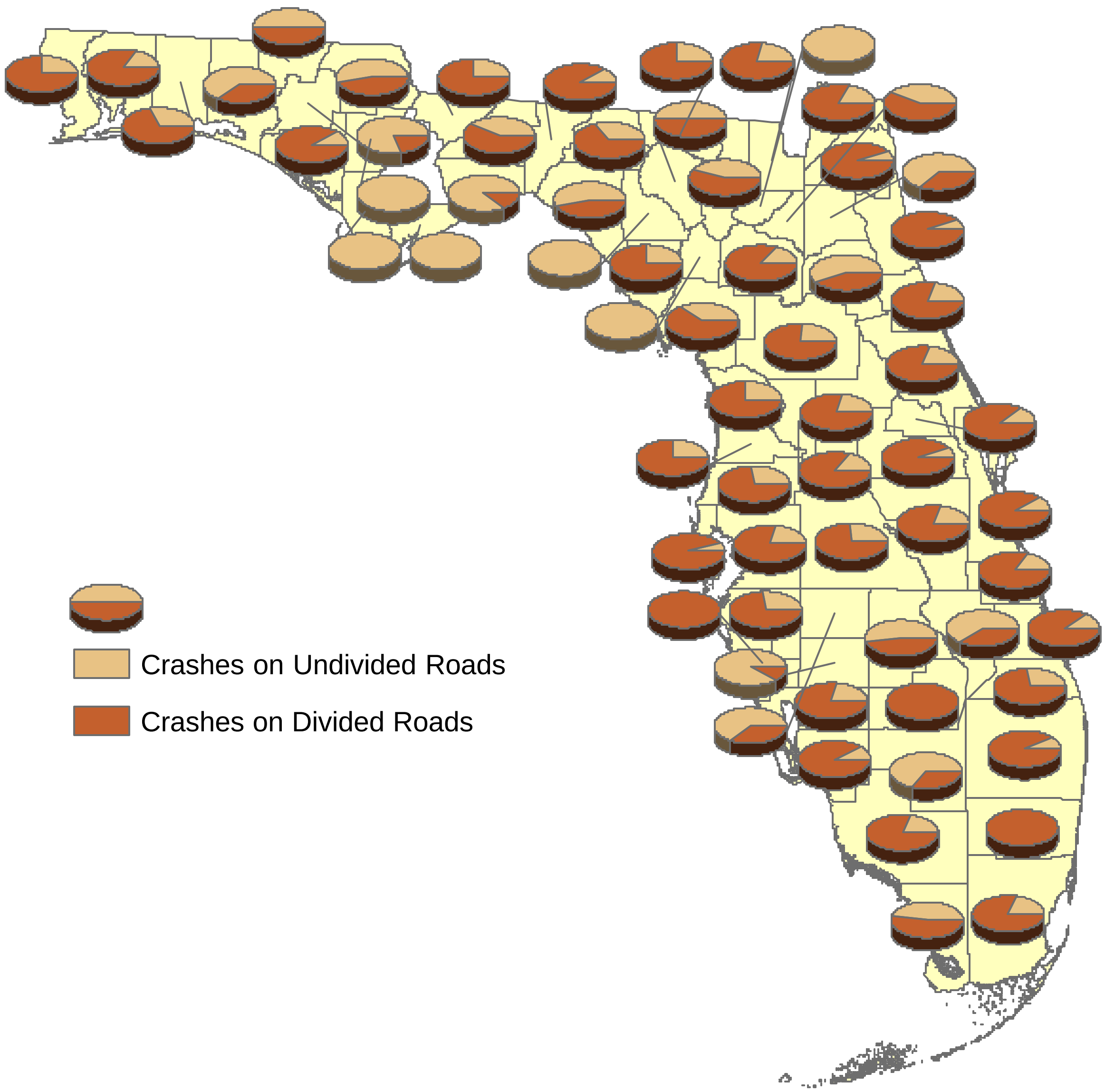
As expected the distribution of crashes based on functional classification of road follows the distribution of urban and rural areas in Florida.

Crashes by Facility Type and Size



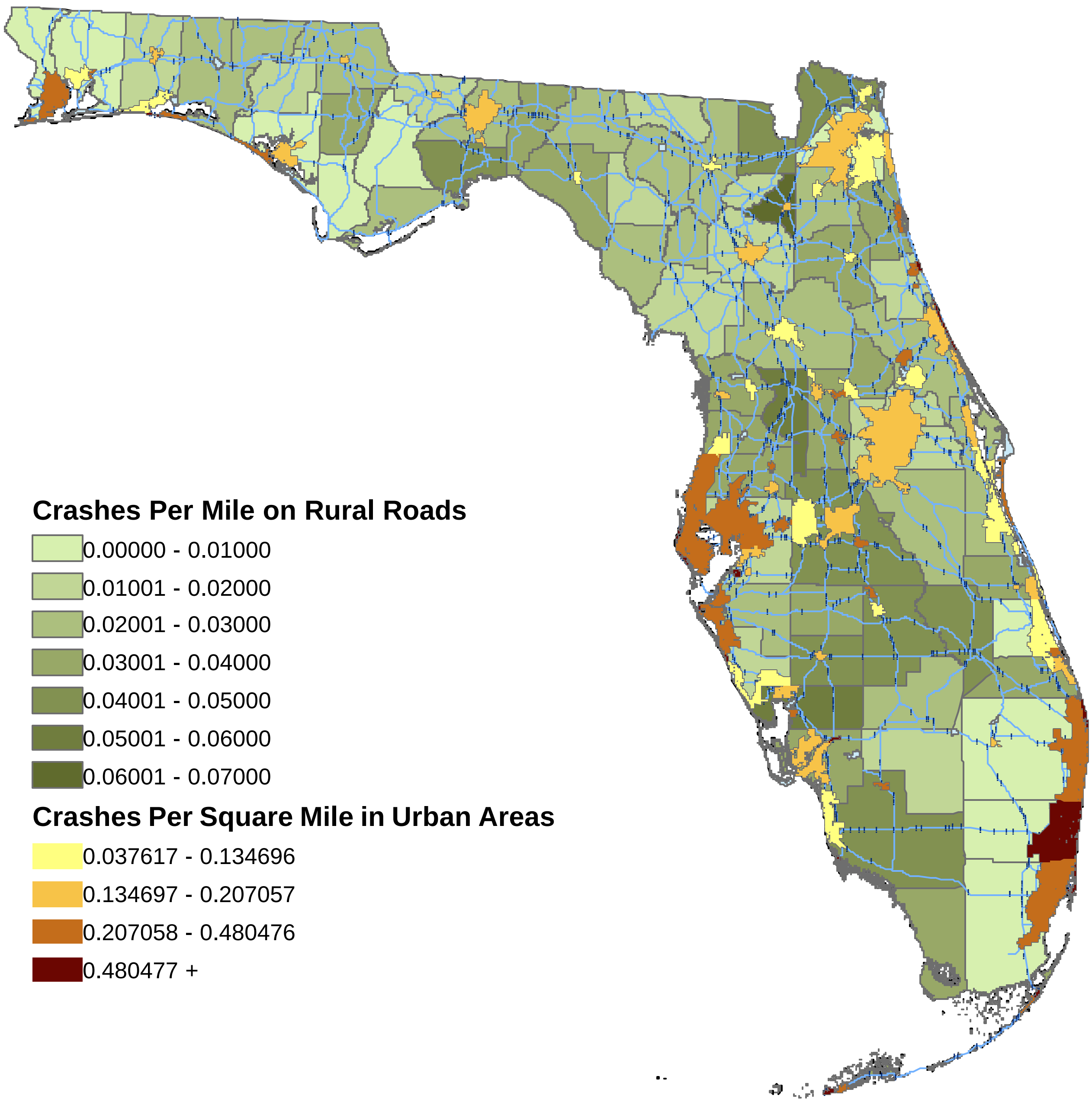
The interstates and other limited access facilities are clearly visible. The increased number of lanes corresponds to the urban areas.

Crashes by Facility Type and Size



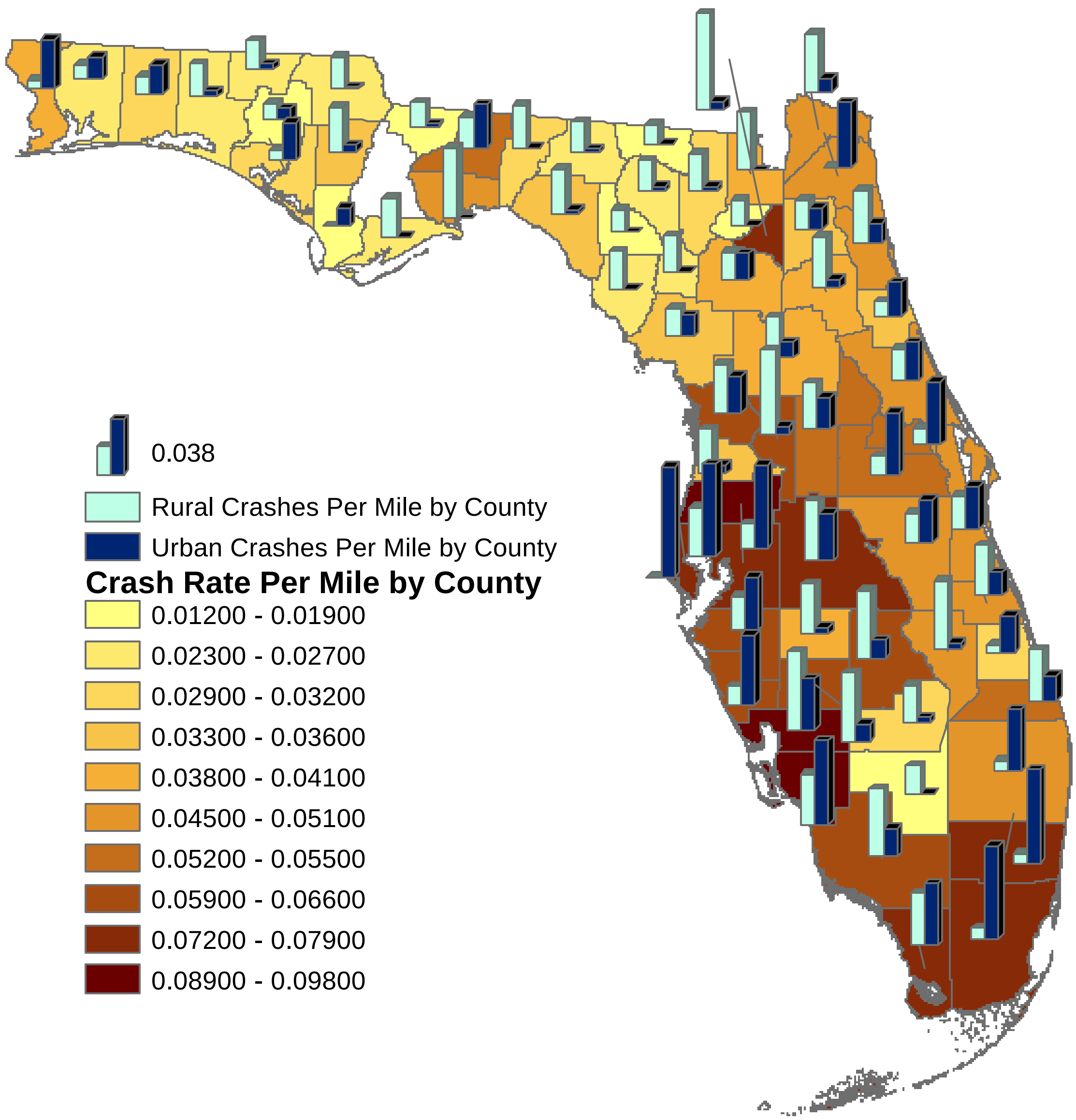
The relative proportion of crashes that occurred on undivided vs. divided highways per county.

Urban and Rural Crashes



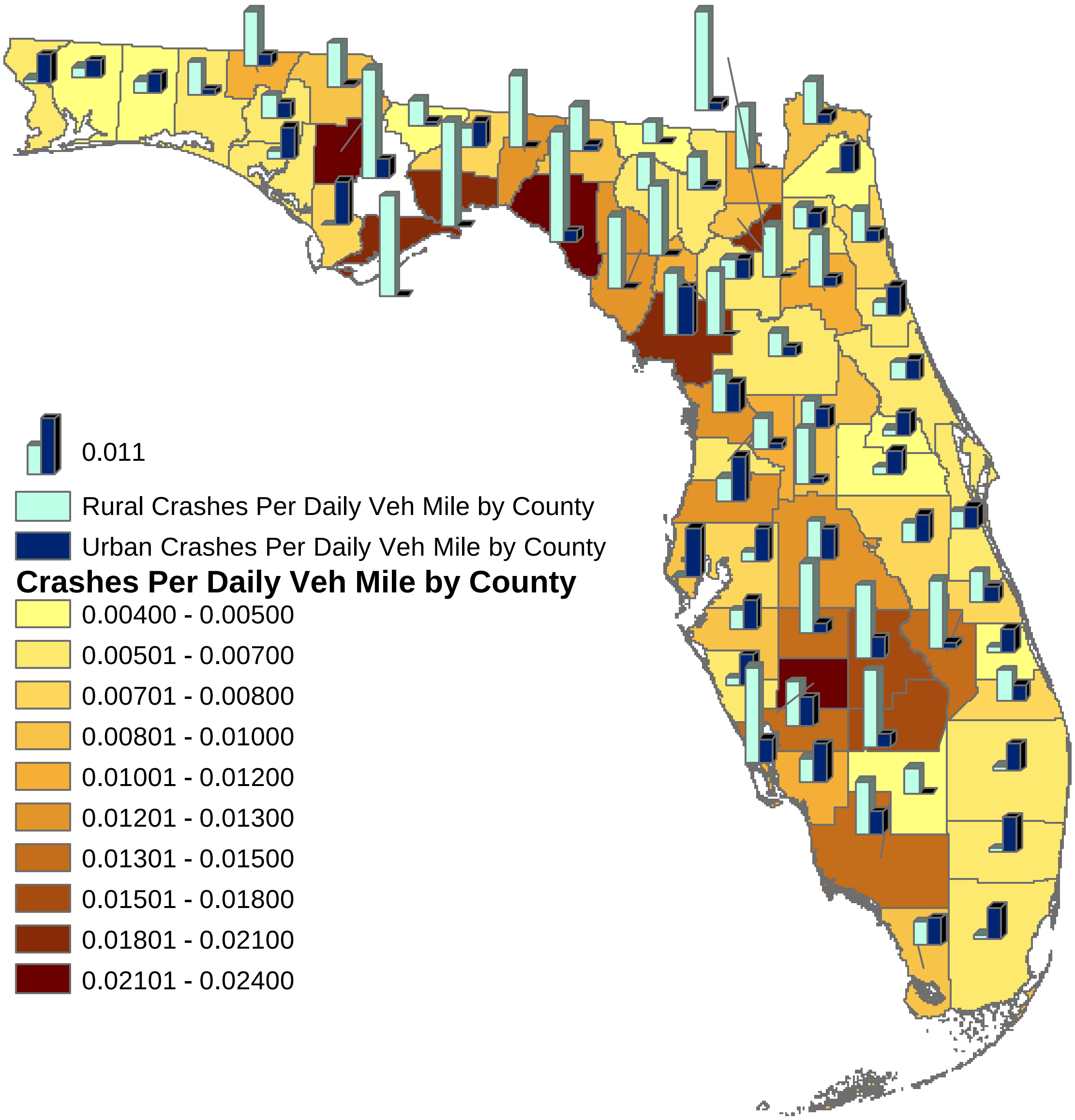
The distinction between where the highest crash densities occur in rural areas, compared to what urban areas have the highest crash densities in demonstrated in this plot. The values above represent averages, thus in rural areas it is average number of crashes per mile for the entire county, and in urban areas it is the average number of crashes per square mile within the urban boundary.

Urban and Rural Crashes



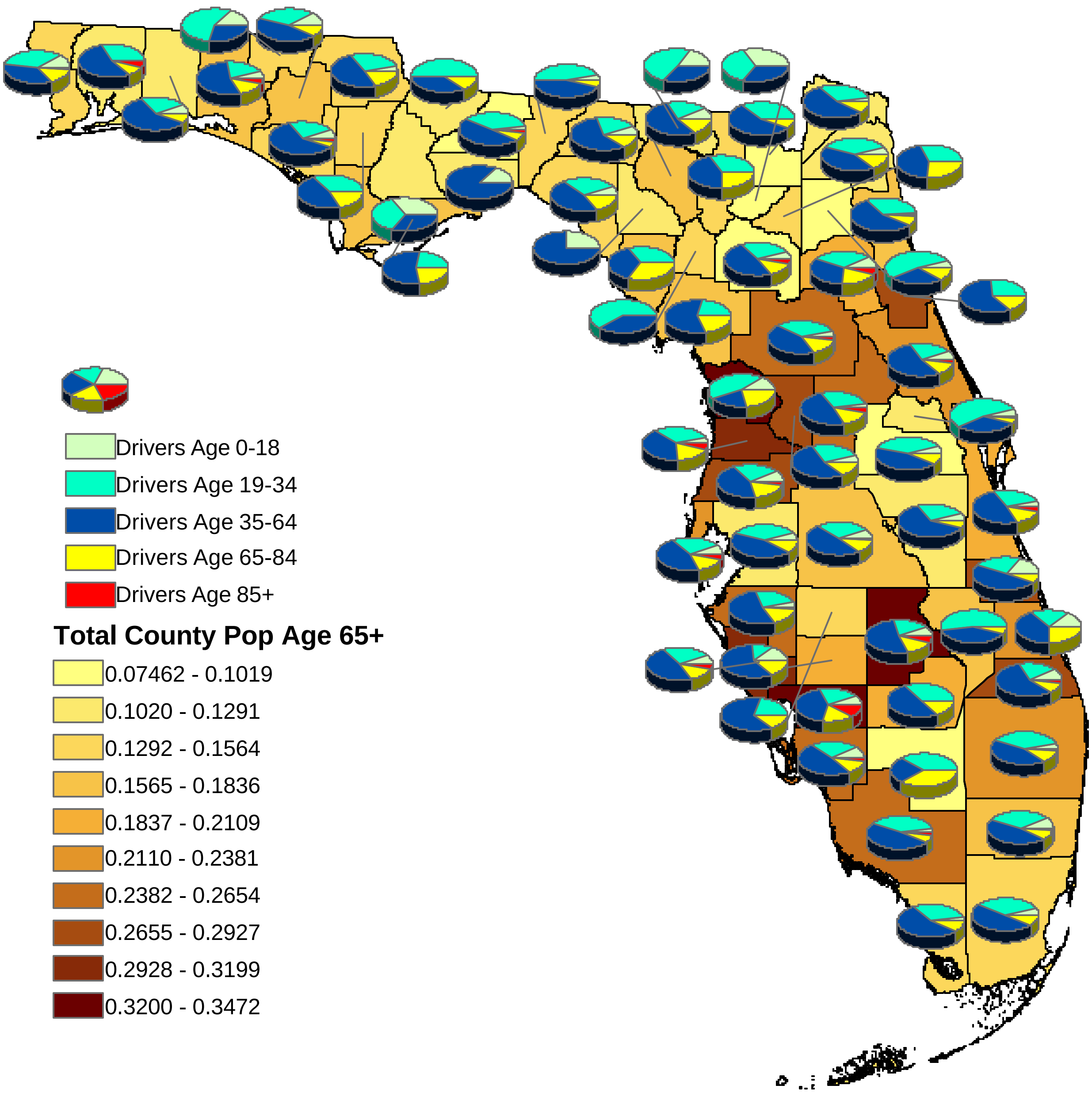
The distribution of crashes relative to the total number of miles of state road within a county are presented herein.

Urban and Rural Crashes



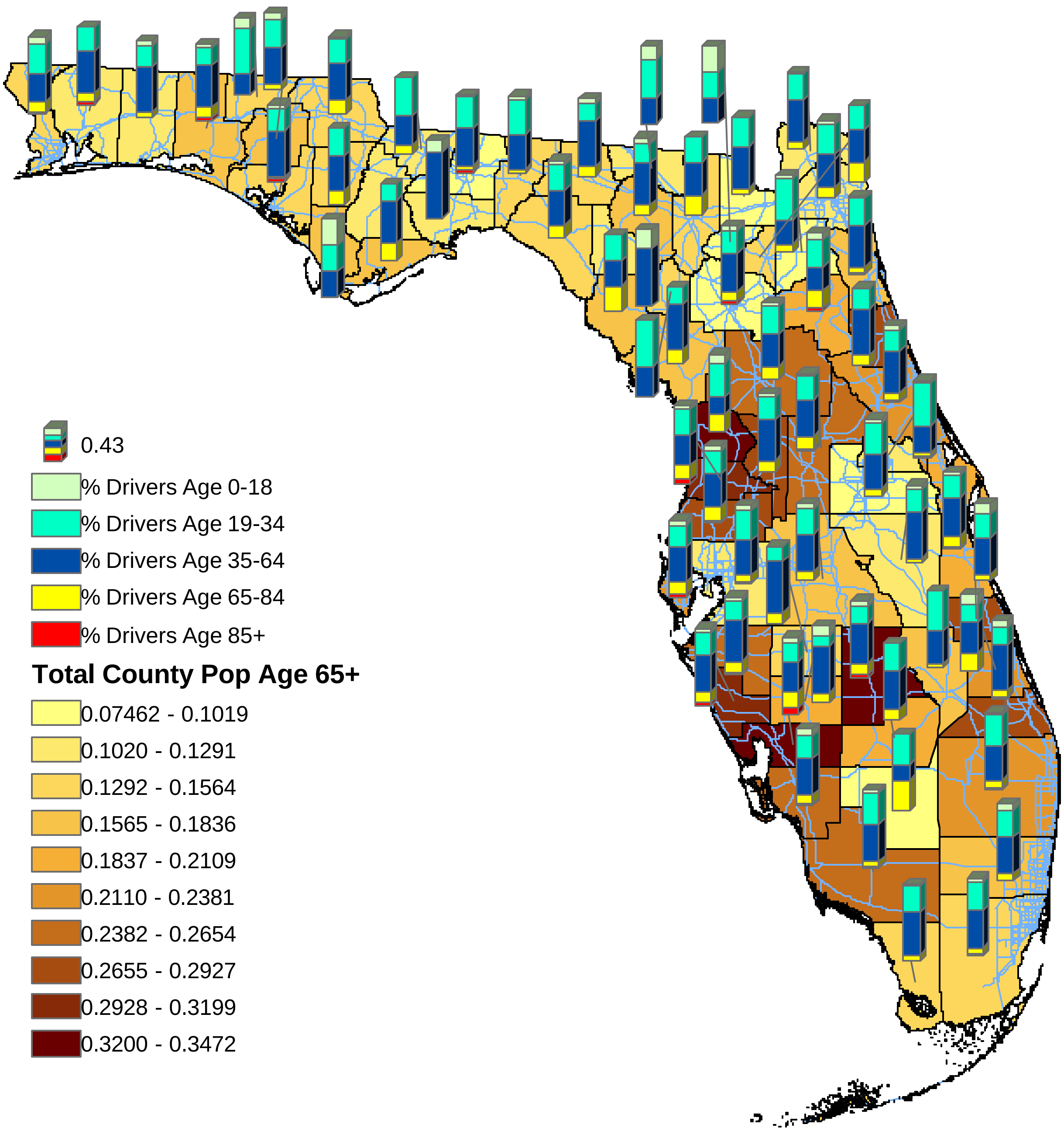
The distribution of crashes relative to the total number of miles of state road within a county are presented herein, along with a measure of exposure. Areas with the highest crash rates are rural and are likely areas that experience a high level of exposure due to the need for longer trips.

Age of Driver as a Function of Demographic Trends



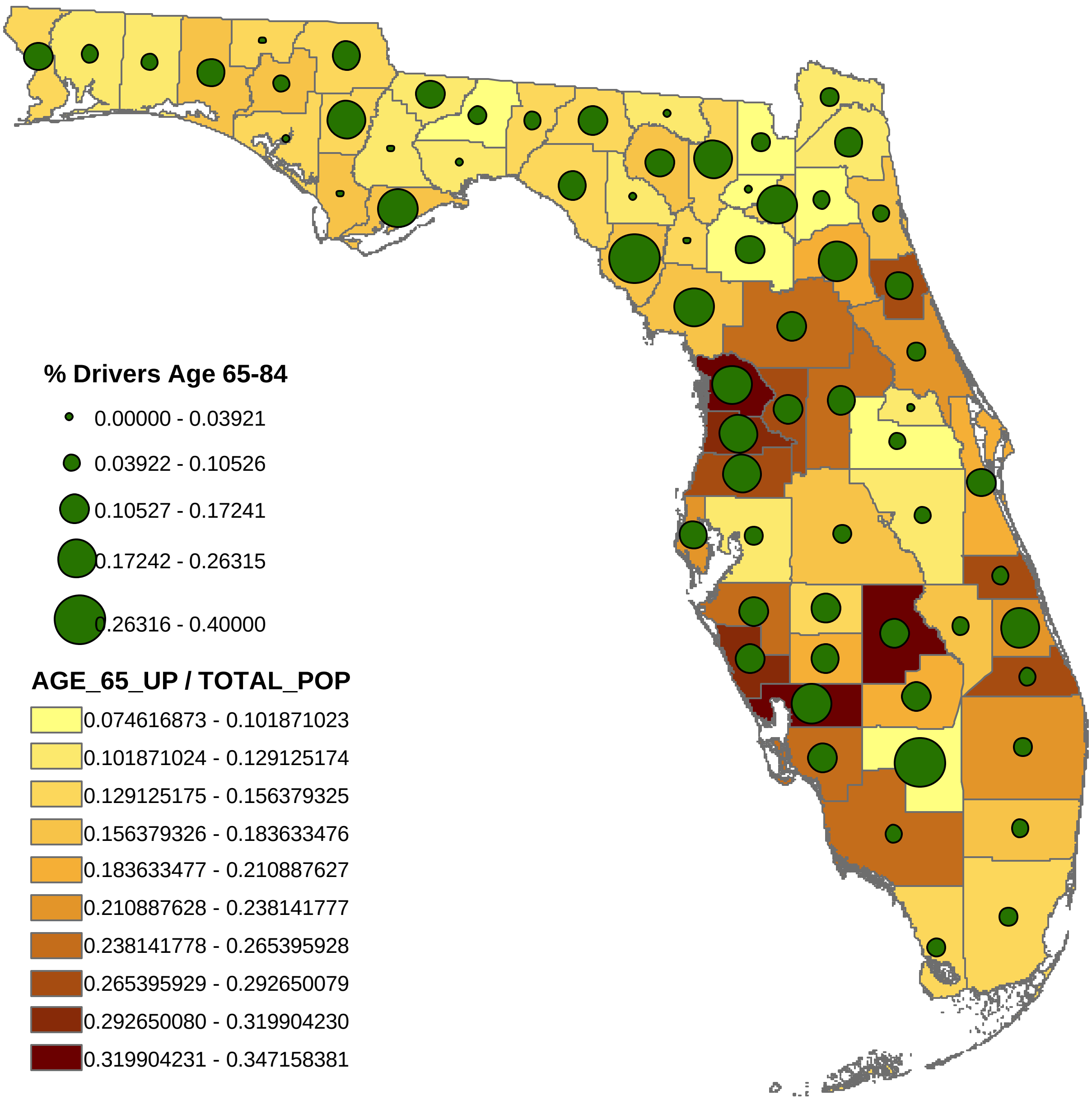
The percent elderly (Total County Pop Age 65+) in each county is shown along with the driver age distribution (drivers in this study) within each county. For the most part, in areas with higher densities of elderly, the drivers of vehicles in fatal crashes also follows the same pattern. The most notable exceptions are Alachua and Santa Rosa, counties.

Age of Driver as a Function of Demographic Trends



The percent elderly (Total County Pop Age 65+) in each county is shown along with the driver age distribution within each county. As would be expected, the highest percentages of events involving drivers age 85 and up in fatal crashes occurs in counties where there is a high elderly population. The most notable examples are Charlotte, Hernando, and Highlands counties.

Age of Driver as a Function of Demographic Trends



Age of driver as a function of elderly demographics. The larger the green dots, the larger the percentage of drivers age 65-84 involved in fatal crashes within a particular county. Dixie and Hendry counties are examples of counties where there are fewer people age 65 residing in the county, yet the percentage of drivers involved in fatal accidents that are in the 65-84 age bracket is high.