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13. ABSTRACT (Maximum 200 words)

This report analyzes the problem of pedestrian crashes in the United States to support the development and assessment of effective pedestrian crash avoidance systems as part of the U.S. Department of Transportation's Intelligent Vehicle Initiative. In 1998, about 70,000 pedestrian crashes, or 1.1% of all police-reported crashes, occurred in the United States, resulting in 5,294 fatal crashes, or 14.3% of all fatal motor vehicle crashes that year. This report identifies prevalent pre-crash scenarios, describes their physical setting, and provides statistics on driver/pedestrian age and pedestrian injury severity per scenario based on GES and FARS data from 1995 through 1998. The analysis of crash contributing factors for 10 specific scenarios revealed that a high percentage of drivers reported vision obscurity in pre-crash scenarios where the pedestrian darted onto the roadway. Alcohol involvement was particularly high for drivers in scenarios where the pedestrian was walking along the roadway at a non-junction. Conversely, a high percentage of drunken pedestrians were reported in scenarios where a pedestrian was struck either crossing or walking along the roadway. Almost 60% of pedestrian crashes in which the pedestrian was walking along the roadway at a non-junction occurred at nighttime. Younger pedestrians, especially those aged from 5 to 9 years old, were the most susceptible to vehicle-pedestrian crashes, accounting for nearly 14% of all pedestrians involved. Pedestrian injuries tended to be more severe away from junctions due to higher speeds involved.

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PREFACE

The National Highway Traffic Safety Administration (NHTSA), in conjunction with the Research and Special Programs Administration Volpe National Transportation Systems Center (Volpe Center), is conducting an analysis of pedestrian crashes in support of the Intelligent Vehicle Initiative (IVI). The IVI focuses on solving traffic safety problems through the development and deployment of vehicle-based and vehicle-infrastructure cooperative crash countermeasures that address rear-end, roadway departure, lane change, crossing paths, driver impairment, reduced visibility, vehicle instability, pedestrian, and pedalcyclist crashes.

This report presents the results obtained for the analysis of pedestrian crashes using a 4-year data set from the 1995-1998 National Automotive Sampling System/General Estimates System (NASS/GES) and Fatality Analysis Reporting System crash databases. In 1998, there were about 70,000 pedestrian crashes or 1.1% of all police-reported crashes in the United States.

The authors of this report are Marco P. daSilva, John D. Smith, and Wassim G. Najm of the Volpe Center.

The authors acknowledge the technical contribution of Dr. David L. Smith of NHTSA. Also acknowledged are Peter Martin and Esther Wagner of NHTSA, and Dan Cohen of Mitretek for reviewing the report and providing valuable comments. Brittany Campbell of the Volpe Center and Kate Klotz of Planners Collaborative edited the report.

METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC	METRIC TO ENGLISH
LENGTH (APPROXIMATE)	**LENGTH** (APPROXIMATE)
1 inch (in) = 2.5 centimeters (cm)	1 millimeter (mm) = 0.04 inch (in)
1 foot (ft) = 30 centimeters (cm)	1 centimeter (cm) = 0.4 inch (in)
1 yard (yd) = 0.9 meter (m)	1 meter (m) = 3.3 feet (ft)
1 mile (mi) = 1.6 kilometers (km)	1 meter (m) = 1.1 yards (yd)
	1 kilometer (km) = 0.6 mile (mi)
AREA (APPROXIMATE)	**AREA** (APPROXIMATE)
1 square inch (sq in, in^2) = 6.5 square centimeters (cm^2)	1 square centimeter (cm^2) = 0.16 square inch (sq in, in^2)
1 square foot (sq ft, ft^2) = 0.09 square meter (m^2)	1 square meter (m^2) = 1.2 square yards (sq yd, yd^2)
1 square yard (sq yd, yd^2) = 0.8 square meter (m^2)	1 square kilometer (km^2) = 0.4 square mile (sq mi, mi^2)
1 square mile (sq mi, mi^2) = 2.6 square kilometers (km^2)	10,000 square meters (m^2) = 1 hectare (ha) = 2.5 acres
1 acre = 0.4 hectare (he) = 4,000 square meters (m^2)	
MASS - WEIGHT (APPROXIMATE)	**MASS - WEIGHT** (APPROXIMATE)
1 ounce (oz) = 28 grams (gm)	1 gram (gm) = 0.036 ounce (oz)
1 pound (lb) = 0.45 kilogram (kg)	1 kilogram (kg) = 2.2 pounds (lb)
1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)	1 tonne (t) = 1,000 kilograms (kg)
	= 1.1 short tons
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1 teaspoon (tsp) = 5 milliliters (ml)	1 milliliter (ml) = 0.03 fluid ounce (fl oz)
1 tablespoon (tbsp) = 15 milliliters (ml)	1 liter (l) = 2.1 pints (pt)
1 fluid ounce (fl oz) = 30 milliliters (ml)	1 liter (l) = 1.06 quarts (qt)
1 cup (c) = 0.24 liter (l)	1 liter (l) = 0.26 gallon (gal)
1 pint (pt) = 0.47 liter (l)	
1 quart (qt) = 0.96 liter (l)	
1 gallon (gal) = 3.8 liters (l)	
1 cubic foot (cu ft, ft^3) = 0.03 cubic meter (m^3)	1 cubic meter (m^3) = 36 cubic feet (cu ft, ft^3)
1 cubic yard (cu yd, yd^3) = 0.76 cubic meter (m^3)	1 cubic meter (m^3) = 1.3 cubic yards (cu yd, yd^3)
TEMPERATURE (EXACT)	**TEMPERATURE** (EXACT)
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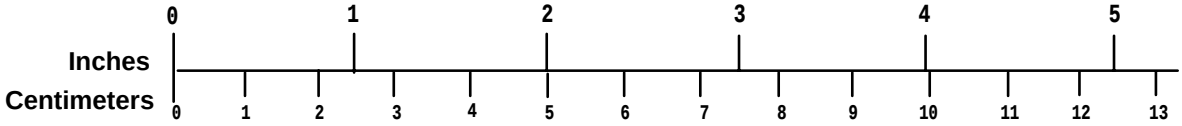

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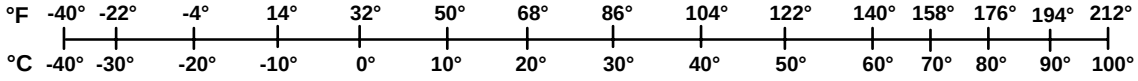

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EXECUTIVE SUMMARY

This report analyzes the problem of pedestrian crashes in the United States (U.S.) to support the development and assessment of effective pedestrian crash avoidance systems as part of the *Intelligent Vehicle Initiative*. Pedestrian crashes are defined as those involving one moving vehicle striking a pedestrian. In 1998, about 70,000 such crashes or 1.1% of all police-reported crashes occurred in the U.S. These crashes resulted in 5,294 fatal crashes or 14.3% of all fatal motor vehicle crashes during that year. This analysis identifies and counts these crashes by their pre-crash scenarios that represent vehicle maneuvers and pedestrian actions immediately prior to impact. Moreover, these pre-crash scenarios are individually described in terms of their physical setting, crash contributing factors, and crash characteristics such as the age of people involved and maximum injury severity. The analysis was conducted using a four-year data set from the 1995-1998 *National Automotive Sampling System/General Estimates System* (NASS/GES) and *Fatality Analysis Reporting System* (FARS) crash databases of the *National Highway Traffic Safety Administration*.

Eight "basic" pre-crash scenarios were found to be the most common in pedestrian crashes, accounting for nearly 90% of all police-reported pedestrian crashes over the 1995-1998 time period. These scenarios combine vehicle maneuvers such as going straight, turning right or left, and backing up, with pedestrian actions such as crossing, darting onto, walking along, playing, and working in the roadway. The majority or 55% of all pedestrian crashes happened away from junctions, a junction being the area formed by the connection of two roadways. About 40% of pedestrian crashes were associated with intersections. The following ten "specific" pedestrian pre-crash scenarios were obtained by correlating the eight basic pre-crash scenarios with information about the crash relation to junction (percentages shown below refer to the frequency of each scenario relative to the size of all pedestrian crashes):

1. Vehicle is going straight and pedestrian is crossing the roadway at non-junction (25.9%).
2. Vehicle is going straight and pedestrian is crossing the roadway at intersection (18.5%).
3. Vehicle is going straight and pedestrian is darting onto the roadway at non-junction (16.0%).
4. Vehicle is turning left and pedestrian is crossing the roadway at intersection (8.6%).
5. Vehicle is turning right and pedestrian is crossing the roadway at intersection (6.2%).
6. Vehicle is going straight and pedestrian is walking along the roadway at non-junction (3.7%).
7. Vehicle is going straight and pedestrian is darting onto the roadway at intersection (2.5%).
8. Vehicle is backing up (2.5%).

9. Vehicle is going straight and pedestrian is not in the roadway at non-junction (1.2%).
10. Vehicle is going straight and pedestrian is playing or working in the roadway at non-junction (1.2%).

The crash statistical description provided in this report focuses on the above ten specific pre-crash scenarios that account for 86.4% of all police-reported pedestrian crashes. The majority of these pre-crash scenarios at non-junctions occurred on straight, non-hillcrest roadways with posted speed limits between 25 mph and 35 mph. The 3-color signal was reported as the traffic control device present in 45% of these scenarios at intersections, while "no controls" were coded in 36% of these crashes. It should be noted that "no controls" coding in the GES refers only to the direction of the road the vehicle is traveling on. About 17% of all pedestrians involved in the 10 pre-crash scenarios were in the crosswalk at the time of impact.

The analysis of crash contributing factors in the ten specific scenarios revealed that a very high percentage of drivers reported vision obscurity in pre-crash scenarios where the pedestrian darted onto the roadway (scenarios 3 and 7). Alcohol involvement was particularly high for drivers in scenarios where the pedestrian was either walking along the roadway at non-junctions or simply not in the roadway (scenarios 6 and 9). On the other hand, a high percentage of drunken pedestrians was observed in scenarios 1, 2, and 6 where the pedestrian was either crossing the roadway or walking along the roadway. Almost 60% of pedestrian crashes in which the pedestrian was walking along the roadway at a non-junction occurred at nighttime (scenario 6). Hit and run cases were prevalent in 15% to 19% of pedestrian crashes across the ten scenarios.

Younger pedestrians, especially those aged from 5 to 9 years old, were the most susceptible to vehicle-pedestrian crashes, accounting for nearly 14% of all pedestrians involved. This age group had about the same relative frequency in the two pre-crash scenarios where pedestrians darted onto the roadway, 35% in scenario 3 and 37% in scenario 7. The pedestrian age group of 5-24 years old composed about 46% of the pedestrian crashes and was the only age group over-represented in terms of the U.S. population. It should be noted that the focus of this analysis is on crashes, not injuries and fatalities, and that different age groups may emerge as over-represented if injuries or fatalities were the focus of the analysis. Roughly 43% of pedestrians in the pre-crash scenario where the pedestrian was walking along the roadway at a non-junction were aged from 10 to 24 years old. About 22% were in the 15 to 19 years old age group. The age group of 30-34 years old had the greatest frequency of drivers involved in pedestrian crashes, accounting for about 14% of all drivers involved in pedestrian crashes. Relative to the licensed driver population, drivers under the age of 20 years old were most likely to be involved in pedestrian crashes. Such drivers comprised about 5.3% of the total licensed driver population and yet were involved in more than 11% of pedestrian-related crashes.

Pedestrian injuries tended to be more severe away from junctions. At intersections, injuries were much more severe in the scenario where the vehicle was turning left versus

the scenario in which the vehicle was turning right. The analysis of FARS data indicated that 25% of fatalities occurred in pre-crash scenarios where the vehicle is going straight and the pedestrian is walking along, playing, or working in the roadway.

1. INTRODUCTION

This report defines the problem of pedestrian crashes and provides a basis for related future research in the United States Department of Transportation's (U.S. DOT's) *Intelligent Vehicle Initiative* (IVI). The IVI is focused on solving traffic safety problems through the development and deployment of vehicle-based and vehicle-infrastructure cooperative countermeasure systems using advanced technologies. Pedestrian crashes are defined as those involving one moving vehicle striking a pedestrian. In 1998 alone, about 70,000 such crashes occurred in the U.S. based on estimates from the *National Automotive Sampling System/General Estimates System* (NASS/GES) crash database of the *National Highway Traffic Safety Administration* (NHTSA). This accounted for 1.1% of all police-reported crashes for that year. An aggregate of four years of data from the GES database (1995-1998) is used in this report due to the relatively low frequency of this crash problem. This report identifies and counts these pedestrian crashes by vehicle and pedestrian pre-crash movements.

This report analyzes pedestrian crashes to enable the development of concepts, functional requirements, performance guidelines, and test procedures as well as the safety assessment of potential pedestrian crash avoidance systems. This analysis began with the breakdown of pedestrian crashes into common pre-crash scenarios that represented vehicle dynamics and pedestrian actions immediately prior to impact. These scenarios then formed the foundation to statistically describe the physical setting of these crashes, the factors that might have contributed to the cause of the crash, and crash consequences such as pedestrian age, number of pedestrians struck per crash, and maximum injury severity. The combination of causal factors and pre-crash scenarios allows the development of crash countermeasure concepts and essential functional requirements. Information on pre-crash scenarios and their physical setting helps to develop performance guidelines and objective test procedures, including test scenarios, for crash avoidance systems. Such information also guides researchers to collect the appropriate data on driver and pedestrian performance with and without the assistance of crash avoidance systems. Such data are essential to the design of effective warning algorithms and driver-vehicle interfaces, and estimation of safety benefits for crash avoidance systems. The age, number of pedestrians struck, and injury severity statistics support the projection of safety benefits in terms of injury severity reduction that might be accrued by the use of pedestrian crash avoidance systems.

The beginning of this report entails a review of previous work, domestic as well as international, which addressed the pedestrian crash problem area. This is followed by a discussion of possible data sources for this study.

1.1. Previous Work

A study of pedestrian crash types was performed by the University of North Carolina under the direction of the Federal Highway Administration (FHWA) using crash data from six States [1]. That work identified and coded 5,000 pedestrian crashes taken from

1991-1992 crash files from the States of California, Florida, Maryland, Minnesota, North Carolina, and Utah. The report provides a wealth of details on vehicle and pedestrian movements and conditions at the instant of pedestrian crashes using detailed crash reports with crash schematics. The crash sample, however, was evenly distributed among the six States and no effort was made to portray a national representation.

Another U.S. study conducted between 1994 and 1996 collected detailed crash reconstruction data on 292 pedestrian crashes and reported on their analysis [2]. The study was focused on pedestrian injury severity and the factors in the crash that contributed to such injury severities such as impact speed and pedestrian to vehicle interaction. The major findings were that pickup trucks were over-represented in causing serious injury, and certain parts of the vehicles, when being the first impact point for the pedestrian, caused greater injuries than others.

Yet another U.S. study aimed at quantifying the pedestrian crash problem analyzed hospital emergency department data collected at eight hospitals over a one-year period to more accurately describe pedestrian and pedalcyclist crashes [3]. The report indicated that 64% of the reported pedestrian injury events and 70% of the reported bicycle injury events did not involve a motor vehicle. It also concluded that fewer cases were reported in police-based files when official road crash statistics were compared to hospital databases.

A foreign study conducted in The Netherlands also confirmed that police-reported crash statistics underestimate injuries to pedestrians and bicyclists [4]. This is attributed to underreporting by the police of non-vehicle crash events, crashes occurring off the roadway, and crashes resulting in less serious injuries.

1.2. Possible Data Sources - Analysis Databases

A host of State and national vehicle crash databases are kept in the U.S. to aid researchers in the study of the motor vehicle crash problem. A wide selection of these databases was looked at in detail in order to determine the best data source suited for the research presented herein.

The most encompassing data source, and most widely used in crash problem analyses, is the NASS. The NASS is based upon a large sample of Police Accident Reports (PAR's) that are sorted into two systems: the *Crashworthiness Data System* (CDS) and the GES. The CDS is a nationally representative sample of about 5,000 police reported crashes. For inclusion in the CDS, at least one vehicle in the crash must have been towed away from the scene due to damage. This database is used primarily for vehicle crashworthiness studies, as the database title suggests. The GES is a nationally representative sample of police reported crashes involving all vehicle types and all severities, and codes about 55,000 cases each year. It includes about ninety data elements, known as variables, collected from police reports which describe the vehicle, physical settings, and all of the people involved in a crash. The GES is limited by the

content and accuracy of police reports and, since it is a national estimate of crashes, it has inherent potential sampling errors.

The Fatality Analysis Reporting System (FARS) is another national crash database. It contains data on all fatal crashes that occurred on U.S. public roads. To be included in the FARS, a crash must involve a motor vehicle traveling on a traffic way and result in the death of a person, either a vehicle-occupant or a non-motorist, within thirty days of the crash. This database includes over one hundred attributes of the crash, vehicle, and people involved. It gives an accurate national description of fatal crashes since it includes data on all fatal crashes, not just a representative sample.

Yet another crash database system is the *Highway Safety Information System* (HSIS) funded by FHWA and kept by the University of North Carolina. This system is a multi-State collection of crash databases. Presently, it contains crash data from California, Illinois, Maine, Michigan, Minnesota, North Carolina, Utah, and Washington. Other States also have crash databases but only these were selected for inclusion into the HSIS based on the quality of available data. Since States keep different kinds of data, not all data from each State database is included in the HSIS. Only a selection of common data available from the participating States is included in the HSIS. The system contains data only on the State-maintained highway systems from the participating States since the individual State databases only keep records of crashes on State-maintained roadways. Thus, State crash databases are not proportional to the crash size of the State. Overall, the HSIS is not a nationally representative sample of crashes.

Some individual State crash databases that are members of the HSIS were also reviewed to determine if they could provide some useful information for the analysis of the pedestrian crash problem. The databases reviewed were obtained from the following States: Michigan, California, Washington, and North Carolina. This examination was performed because the actual State-maintained crash databases contain more information than what is supplied to the HSIS. Again, the big drawback is that these State databases do not portray a national representation of vehicle crashes and reporting practices vary from State to State. Some do, however, provide more detailed information than the GES for some variables.

The GES was selected for the analysis presented herein due to its characteristic of being a broader, more populated sample of crashes than the CDS and being a nationally representative sample of crashes, of which the HSIS and the individual State crash databases are not. Also, the CDS depicts an under-representation of crashes involving pedestrians since most of those crashes do not result in property damage serious enough to warrant the towing of the striking vehicle, which is a pre-requisite for inclusion in the CDS. The combination of 1995 through 1998 GES databases was utilized for pedestrian crash count estimates due to the relative low frequency of the pedestrian crash problem. The GES vehicle-pedestrian pre-crash maneuver breakdowns, as well as the fatality demographics, were compared to statistics from the 1995-1998 FARS databases. The FARS contains data on all fatal traffic crashes within the U.S. and therefore contains a more accurate national description of fatal crashes. This selection also took into account

previous crash analysis work performed by the U.S. DOT's Bureau of Transportation Statistics, which determined that the "FARS and GES have proven to be useful databases for tracking trends and for national studies of crash characteristics, causes, and potential countermeasures" [5].

No other databases were used in this study because they were deemed to hold no significant "added value" to the crash databases used in this analysis of the pedestrian crash problem. One exception is the Washington State Department of Transportation's crash database. This database, not used in this study, contains an attribute about the color of pedestrian clothes, which is divided into five categories: "Dark," "Light," "Mixed," "Retro-Reflective," and "Other Reflective Apparel." As will be shown in this report, a significant number of crashes occur at nighttime. Information on what types of clothes the pedestrians are wearing could provide further insight into the development of vehicle-based and vehicle-infrastructure cooperative countermeasure systems.

2. PROBLEM SIZE

2.1. Frequency of Pedestrian Crashes

Pedestrian crashes involve a moving vehicle that strikes one or more pedestrians. The GES crash database identifies such crashes by the code "5" in the *Person Type* variable from the "Person File" [6]. Each individual involved in a crash has his/her own "Person File" in the GES (e.g., driver and pedestrian). Some GES crash cases contain multiple "Person Files" coded as a "pedestrian," meaning that more than one pedestrian was involved in the crash. This report provides frequency estimates of pedestrian crashes based on a four-year aggregate sample from the 1995-1998 GES.

Pedestrian crashes accounted for an average of 81,000 police-reported collisions per year or 1.2% of the total average of 6,615,000 crashes reported in the U.S. based on 1995-1998 GES statistics. Table 1 lists the annual frequency of pedestrian crashes and the yearly number of pedestrians involved in these crashes over this four-year period from 1995 through 1998. As an average, approximately 85,000 pedestrians were struck by moving vehicles per year with a ratio of 1.05 pedestrians per crash. Pedestrian crashes dropped 21% from a high of 89,000 in 1995 to 70,000 in 1998 even though overall crashes dropped about 5.5% during this four-year period.

A cumulative 324,000 pedestrian crashes occurred in the U.S. over the four-year period from 1995 through 1998, involving 339,000 pedestrians. It should be noted that the national estimates extracted from GES data might differ from the true values because they are based on a probability sample of crashes and not a nationwide census of all crashes. Generalized standard errors for GES estimates of totals are provided in [6]. By accounting for the GES sampling standard error, the drop in pedestrian crashes as observed from Table 1 is not statistically significant based on the 95% confidence intervals of these estimates. Figure 1 shows the lower and upper bounds of annual pedestrian crash estimates, which indicate no change in the annual frequency of pedestrian crashes from 1995 through 1998 due to the overlap among all 95% confidence intervals.

Table 1. Pedestrian Crash Problem Size (Based on 1995-1998 GES)

Year	Total Crashes	Pedestrian Crashes	# of Pedestrians Involved
1995	6,690,000	89,000	92,000
1996	6,834,000	86,000	90,000
1997	6,612,000	79,000	83,000
1998	6,325,000	70,000	74,000
4-yr Total	26,461,000	324,000	339,000
4-yr Average	6,615,000	81,000	85,000

- Numbers in cells were rounded to the nearest 1,000.

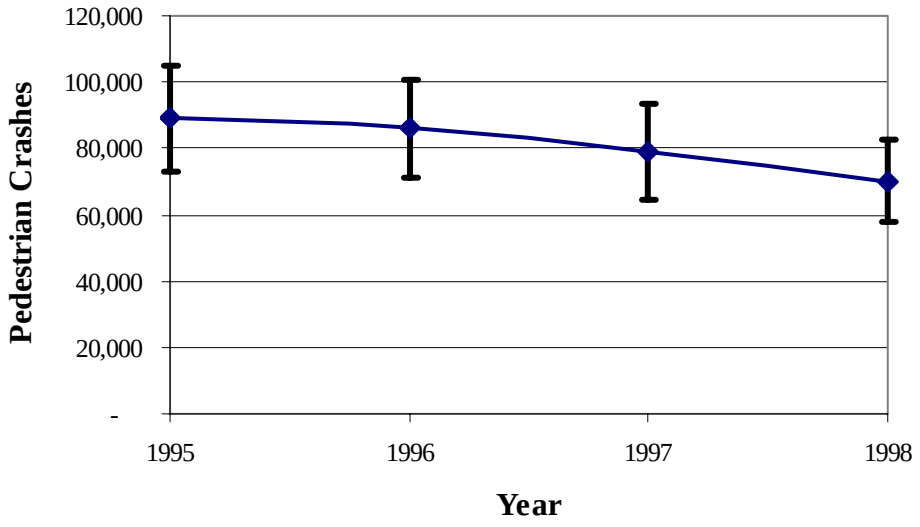

Figure 1. Pedestrian Crash Estimates and Concomitant 95% Confidence Intervals

2.2. Frequency of Fatal Pedestrian Crashes

A four-year data set from the 1995-1998 FARS databases was queried to obtain counts of fatal pedestrian crashes. The FARS provides an accurate count of crashes that result in at least one fatality. Table 2 shows the distribution of the total number of fatal crashes, the number of fatal pedestrian crashes, and the number of pedestrians killed in the U.S. from 1995 to 1998 based on FARS data. Over this four-year period, about 37,000 fatal crashes occurred on the nation's roads per year. It should be noted that a fatal crash sometimes results in multiple fatalities. Fatal pedestrian crashes accounted for 14.6% of all fatal crashes. In contrast, only 1.2% of all crashes (fatal and non-fatal combined) involved pedestrians by GES estimates. Moreover, the average number of pedestrians killed per fatal pedestrian crash amounted to 1.1 based on FARS data while the number of pedestrians involved per pedestrian crash averaged about 1.05 based on GES statistics.

Based on frequency data in Tables 1 and 2, about 6.7% of all pedestrian crashes from 1995 through 1998 resulted in at least one fatality. In addition, about 7.1% of all pedestrians involved in motor vehicle crashes were killed over this four-year period.

Table 2. Fatal Pedestrian Crash Problem Size (Based on 1995-1998 FARS)

Year	Total Crashes	Pedestrian Crashes	# of Pedestrians Involved
1995	37,241	5,613	6,249
1996	37,494	5,520	6,019
1997	37,324	5,357	5,922
1998	37,107	5,294	5,769
4-yr Total	149,166	21,784	23,959
4-yr Average	37,292	5,446	5,990

3. PRE-CRASH SCENARIOS

3.1. Pedestrian Pre-Crash Scenarios

Pre-crash scenarios denote vehicle maneuvers and pedestrian actions immediately prior to a pedestrian crash. The GES enables the definition of such scenarios by combining codes from the *Univariate Imputed Movement Prior to Critical Event* variable from the "Vehicle/Driver File," *Pedestrian/Cyclist Crash Type* variable from the "Accident File," and *Non-Motorist Action* variable from the "Person File."

Figure 2 and Table 3 show respectively the distribution of vehicle maneuvers and the distribution of pedestrian actions that precede pedestrian crashes based on 1995-1998 GES statistics. The vehicle was going straight (traveling at constant speed) and the pedestrian was simply crossing the roadway in about 76% and 63% of all pedestrian crashes, respectively. The vehicle was making a turn in only 15% of these crashes. "Other" pre-crash maneuvers in Figure 2 refer to vehicles starting in the traffic lane, passing, changing lanes, or parking. Table 3 indicates that "darting onto roadway" ranked as the second most prevalent pedestrian action. The remaining known pedestrian actions each accounted for less than 5% of all pedestrian crashes.

The combination of vehicle maneuvers and pedestrian actions outlines basic pre-crash scenarios leading to pedestrian crashes. Table 4 breaks down the pedestrian crash problem into 10 basic pre-crash scenarios and ranks them by the frequency of occurrence in a descending order. Section 4 of this report describes the physical setting of these basic scenarios. Two pre-crash scenarios dominate pedestrian crashes with individual

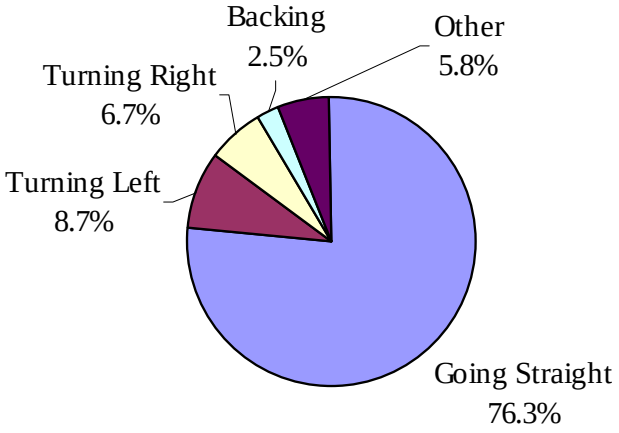

Figure 2. Distribution of Vehicle Maneuvers in Pedestrian Crashes (Based on 1995-1998 GES)

Table 3. Distribution of Pedestrian Actions in Pedestrian Crashes
(Based on 1995-1998 GES)

Pedestrian Actions	Freq.
Crossing roadway	62.8%
Darting onto roadway	18.5%
Unknown/Other	9.3%
Walking along roadway	4.5%
Not in roadway	3.6%
Working in roadway	0.8%
Playing in roadway	0.6%

Table 4. Pre-Crash Scenario Breakdown of Pedestrian Crashes
(Based on 1995-1998 GES)

Rank	Basic Scenario	Frequency		
		(4-yr total)	(Avg)	%
1	Vehicle is going straight and pedestrian crossing the roadway	147,000	37,000	45.5%
2	Vehicle is going straight and pedestrian darting onto the roadway	60,000	15,000	18.5%
3	Vehicle is turning left and pedestrian crossing the roadway	28,000	7,000	8.6%
4	Vehicle is turning right and pedestrian crossing the roadway	22,000	6,000	6.8%
5	Vehicle is going straight and pedestrian is walking along the roadway	14,000	4,000	4.3%
6	Vehicle is going straight and pedestrian is doing "unknown/other"	14,000	4,000	4.3%
7	Vehicle is going straight and pedestrian is not in the roadway	9,000	2,000	2.8%
8	Vehicle is backing	8,000	2,000	2.5%
9	Vehicle is going straight and pedestrian is playing/working in roadway	4,000	1,000	1.2%
10	Other	19,000	5,000	5.9%
	Totals:	324,000	81,000	100.0%

- Numbers in cells were rounded to the nearest 1,000.

relative frequency greater than 15%. Each of the remaining eight scenarios had an individual relative frequency below 9%. It is noteworthy that the top four pre-crash scenarios in Table 4 accounted for 79.3% of all pedestrian crashes. Scenarios 6 and 10 contain "unknown" or "other" information and were associated with about 10% of all pedestrian crashes.

3.2. Fatal Pedestrian Pre-Crash Scenarios

The 1995-1998 FARS databases were utilized to characterize vehicle maneuvers and pedestrian actions immediately before a fatal pedestrian crash. The *VEH_MAN* variable in the FARS "Vehicle File" discerns the vehicle maneuver. This variable describes the maneuver that the driver was executing just prior to entering a crash situation, and does not describe the avoidance maneuver as that information is described by a different variable. The *P_CF1*, *P_CF2*, and *P_CF3* variables in the FARS "Person File" identify

the actions taken by pedestrians as well as the person-level contributing factors in the crash.

Figure 3 presents the distribution of vehicle maneuvers just prior to the crash for the fatal pedestrian crashes as included in the 1995-1998 FARS databases. Going straight just prior to striking a pedestrian was reported in most fatal pedestrian crashes and accounted for about 89.2% of all vehicle maneuvers. The relative frequency of this vehicle maneuver was higher in fatal pedestrian crashes than in all pedestrian crashes reported by the GES. On the other hand, the turning maneuver was indicated in only 4.1% of fatal pedestrian crashes and was much lower than in all police-reported pedestrian crashes (15.4%). Turning maneuvers resulted in lower pedestrian fatality rates than going straight because vehicles generally make turns at low travel speeds.

Figure 4 illustrates the distribution of pedestrian actions just prior to the crash for the fatal pedestrian crashes as included in the 1995-1998 FARS databases. It is clearly seen that the pedestrian action categories in the FARS differ from those in the GES. The GES coding scheme offers a more distinct breakdown of pedestrian actions than the FARS. As observed in Figure 4, the FARS combines multiple actions such as walk, play, or work in roadway into one category. Moreover, the "impaired" code refers to the pedestrian condition instead of action and the "improper crossing" code merges the pedestrian action (crossing) with pedestrian culpability (improper). In addition, there were many cases coded as "Other/Unknown" for the pedestrian action in the FARS, accounting for about one-third of all fatal pedestrian crashes. Conversely, the pedestrian action was coded as "Other/ Unknown" in only 9.3% of all pedestrian crashes in the

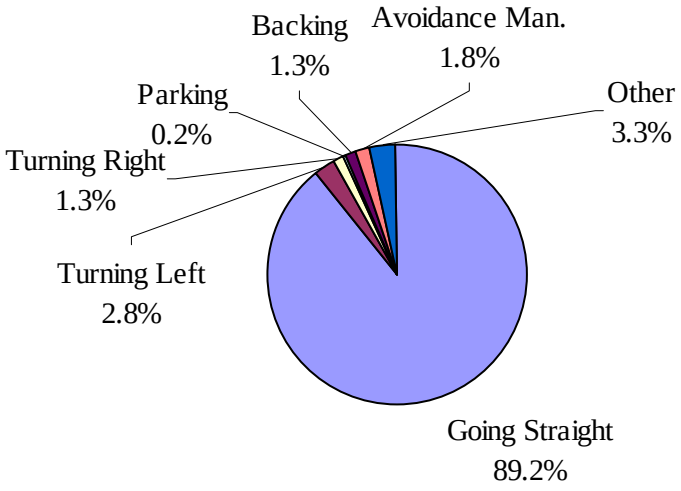

Figure 3. Distribution of Vehicle Maneuvers in Fatal Pedestrian Crashes (Based on 1995-1998 FARS)

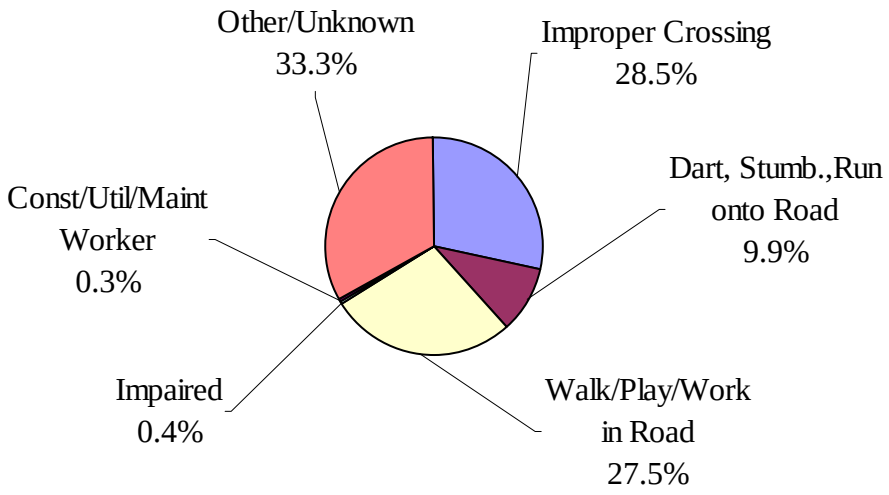

Figure 4. Distribution of Pedestrian Actions in Fatal Pedestrian Crashes
(Based on 1995-1998 FARS)

GES. The relatively high frequency of "Other/Unknown" pedestrian actions in the FARS might be explained by the fact that the pedestrian was killed and no eyewitnesses were present to report the pedestrian action immediately prior to the crash. "Improper Crossing" was the most dominant action and accounted for about 29% of all fatal pedestrian crashes. This action was closely followed by the labeled "Walk/Play/ Work in Road" action at about 28% of all fatal pedestrian crashes. By comparison, the combined "Walking along Roadway," "Working in Roadway," and "Playing in Roadway" actions were associated with about 6% of all pedestrian crashes based on GES statistics.

Table 5 identifies fatal pedestrian pre-crash scenarios by correlating vehicle maneuvers with pedestrian actions. About 38% of all fatal pedestrian crashes contained "Other/Unknown" information for the vehicle maneuver or the pedestrian action. Unfortunately, the different codes for the pedestrian action between the GES and FARS don't allow for a direct comparison between the two sets of pre-crash scenarios.

Table 5. Pre-Crash Scenario Breakdown of Fatal Pedestrian Crashes
(Based on 1995-1998 FARS)

Rank	Basic Scenario	Frequency		
		(4-yr total)	(Avg)	%
1	Vehicle is going straight and pedestrian improperly crossing	6,518	1,630	27.2%
2	Vehicle is going straight and pedestrian performs other/unknown	6,384	1,596	26.6%
3	Vehicle is going straight and pedestrian walk/play/working in roadway	6,043	1,511	25.2%
4	Vehicle is going straight and pedestrian dart/stumbles/runs onto roadway	2,280	6,043	9.5%
5	Vehicle is turning left and pedestrian performs other/unknown	471	46	2.0%
6	Other	2,263	40	9.4%
	Totals:	23,959	5,990	100.0%

4. PHYSICAL SETTING

This section presents statistics on the physical setting of pedestrian crashes so as to paint a more precise picture of the pre-crash scenarios. The physical setting of pre-crash scenarios was first described in terms of their relation to junction. After, pre-crash scenarios occurring away from junctions were delineated in terms of roadway alignment, roadway profile, and posted speed limit. Pre-crash scenarios at intersections were later characterized by the type of traffic control device present at these crash locations. In addition, pre-crash scenario statistics were reported about the crash relation to roadway and pedestrian location in crosswalk.

4.1. Relation to Junction

The *Relation to Junction* variable in the GES "Accident File" indicates whether or not the location of the first harmful event occurred within or outside the boundaries of an interchange [6]. An interchange is a connection between two roadways involving a change in grade. Table 6 correlates pedestrian pre-crash scenarios with their relation to a junction. Approximately 55% and 40% of the 81,000 pedestrian crashes occurred at non-junctions and at intersections (including intersection-related locations), respectively. The remaining 5% happened at driveways or alleyways and at other locations. Based on these results, this study subsequently focused on the "Non-Junction" and "Intersection" categories to further analyze the pedestrian crashes. The "Intersection" category combines intersections and intersection-related locations.

Table 7 presents statistics on the distribution of crash locations for each pre-crash scenario independently. These statistics show that the majority of pedestrian crashes belonging to pre-crash scenarios 3 and 4 in which the vehicle was making a turn happened at intersections (> 97%). On the other hand, the non-junction was the dominant location for over two-third (> 68%) of the pedestrian crashes belonging to pre-crash scenarios 2, 5, 7, 8, and 9 in which the vehicle was backing up or the pedestrian was darting onto the roadway, walking along the roadway, not in the roadway, and playing/working in the roadway.

Table 6. Distribution of Pedestrian Pre-Crash Scenarios by Relation to Junction (Based on 1995-1998 GES)

Rank No.	Basic Scenario Description	Non-Junction	Inters.	Inters. Related	Driveway / Alley	Other	Scen. Freq.
1	Vehicle is going straight and pedestrian crossing the roadway	25.4%	15.9%	3.1%	0.7%	0.3%	45.4%
2	Vehicle is going straight and pedestrian darting onto the roadway	15.5%	2.2%	0.4%	0.3%	0.0%	18.5%
3	Vehicle is turning left and pedestrian crossing the roadway	0.1%	7.6%	0.9%	0.2%	0.0%	8.6%
4	Vehicle is turning right and pedestrian crossing the roadway	0.0%	5.9%	0.7%	0.1%	0.0%	6.8%
5	Vehicle is going straight and pedestrian is walking along the roadway	4.1%	0.0%	0.0%	0.1%	0.0%	4.3%
6	Vehicle is going straight and pedestrian is doing "unknown/other"	3.6%	0.5%	0.0%	0.0%	0.1%	4.3%
7	Vehicle is going straight and pedestrian is not in the roadway	1.8%	0.3%	0.2%	0.2%	0.0%	2.8%
8	Vehicle is backing	1.9%	0.4%	0.2%	0.1%	0.0%	2.5%
9	Vehicle is going straight and pedestrian is playing/working in roadway	1.0%	0.2%	0.1%	0.0%	0.0%	1.2%
10	Other	2.0%	0.5%	0.5%	2.8%	0.0%	5.9%
	Relation to Junction Totals	55.3%	33.4%	6.3%	4.5%	0.5%	100.0%

Table 7. Distribution of Pedestrian Crashes vs. Relation to Junction by Each Pre-Crash Scenario (Based on 1995-1998 GES)

Rank No.	Basic Scenario Description	Non-Junction	Inters.	Inters. Related	Driveway / Alley	Other	Scen. Freq.
1	Vehicle is going straight and pedestrian crossing the roadway	55.9%	35.0%	6.9%	1.6%	0.7%	100.0%
2	Vehicle is going straight and pedestrian darting onto the roadway	84.0%	11.8%	2.3%	1.8%	0.1%	100.0%
3	Vehicle is turning left and pedestrian crossing the roadway	1.5%	86.4%	10.4%	1.8%	0.0%	100.0%
4	Vehicle is turning right and pedestrian crossing the roadway	0.0%	87.6%	11.1%	0.8%	0.4%	100.0%
5	Vehicle is going straight and pedestrian is walking along the roadway	96.3%	0.8%	1.0%	1.7%	0.2%	100.0%
6	Vehicle is going straight and pedestrian is doing "unknown/other"	85.6%	10.7%	1.1%	0.5%	2.0%	100.0%
7	Vehicle is going straight and pedestrian is not in the roadway	68.7%	11.8%	9.2%	9.3%	1.1%	100.0%
8	Vehicle is backing	72.8%	15.3%	6.0%	5.6%	0.3%	100.0%
9	Vehicle is going straight and pedestrian is playing/working in roadway	74.9%	15.3%	8.2%	0.7%	1.0%	100.0%
10	Other	34.0%	9.0%	8.9%	47.9%	0.3%	100.0%

The breakdown of pedestrian pre-crash scenarios by relation to junction leads to a detailed and more specific description of these scenarios. Table 8 lists the top ten specific pedestrian pre-crash scenarios and ranks them in a descending order by their frequency of occurrence. These ten specific pre-crash scenarios accounted for about 86% of all pedestrian crashes based on 1995-1998 GES. It should be noted that the relative frequency was calculated based on the average yearly pedestrian crash population of 81,000. Table 8 also indicates the upper and lower 95% confidence intervals for each pre-crash scenario as calculated from the generalized standard error estimates given in the NASS/GES *Analytical User's Manual* [6]. The upper and lower limits of the confidence interval reflect a 95% confidence that the actual crash population lies within that range. Figure 5 shows the relative size of the ten specific pre-crash scenarios along with their respective confidence intervals.

Table 8. Specific Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

Rank	Scenario	Crash Freq. (Yr Avg)	Relative Freq.	Lower 95% Conf. Int.	Upper 95% Conf. Int.
1	Going Straight and Pedestrian Crossing Roadway at Non-Junction	21,000	25.9%	15,600	25,900
2	Going Straight and Pedestrian Crossing Roadway at Intersection	15,000	18.5%	11,300	19,700
3	Going Straight and Pedestrian Darting onto Roadway at Non-Junction	13,000	16.0%	8,800	16,200
4	Turning Left and Pedestrian Crossing Roadway at Intersection	7,000	8.6%	4,300	9,200
5	Turning Right and Pedestrian Crossing Roadway at Intersection	5,000	6.2%	3,300	7,700
6	Going Straight and Pedestrian Walking Along Roadway at Non-Junction	3,000	3,7%	1,700	4,800
7	Going Straight and Pedestrian Darting onto Roadway at Intersection	2,000	2.5%	900	3,100
8	Vehicle Backing Up	2,000	2.5%	800	3,200
9	Going Straight and Pedestrian Not in Roadway at Non-Junction	1,000	1.2%	500	2,500
10	Going Straight and Pedestrian Playing/Working in Roadway at Non-Junction	1,000	1.2%	100	1,400
		70,000	86.4%		

- Crash frequency rounded to the nearest 1,000.
- Confidence intervals rounded to the nearest 100.

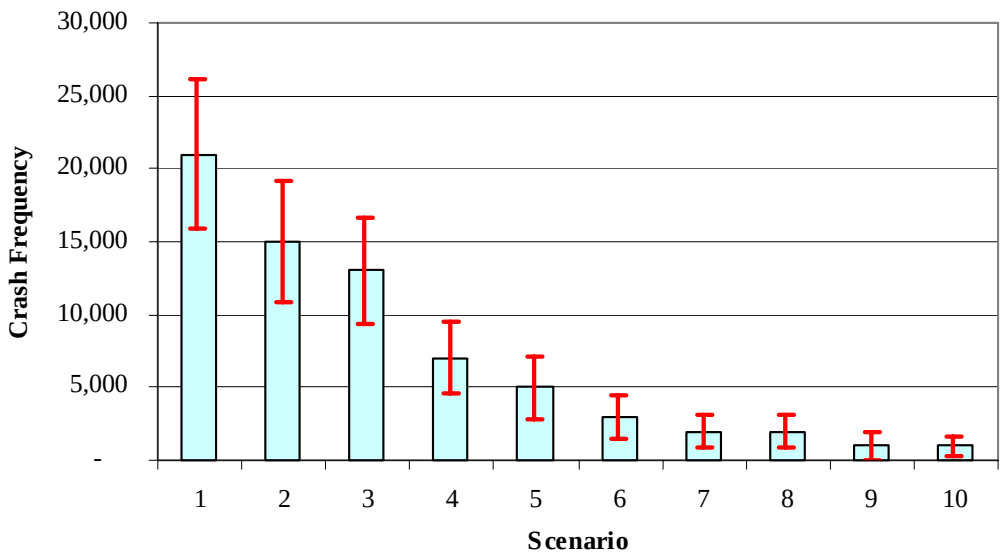

Figure 5. Top Ten Pedestrian Pre-Crash Scenario Frequency With 95% Confidence Interval Bars (Based on 1995-1998 GES)

As seen in Table 8, five specific pre-crash scenarios occurred away from junctions and accounted collectively for about 48% of all pedestrian crashes. Four specific pre-crash scenarios happened at intersections and amounted jointly to about 36% of all pedestrian crashes. It should be noted that this study did not describe the "vehicle backing up" pre-crash scenario by the relation to junction because crash location was deemed unnecessary for the development of countermeasures for this particular pre-crash scenario. For the remainder of this report, crash statistics will be presented for the ten specific pedestrian pre-crash scenarios listed in Table 8.

4.2. Non-Junction Pre-Crash Scenarios

The physical setting of the five pedestrian pre-crash scenarios occurring away from junctions were further delineated in terms of the roadway alignment, roadway profile, and posted speed limit. The roadway alignment and profile describe the geometric configuration of the crash location and may indicate whether or not the roadway configuration limited the detection distance of either the vehicle or the pedestrian. The posted speed limit may imply information about the travel speed of vehicles.

4.2.1. *Roadway Alignment and Profile*

The variables *Roadway Alignment* and *Roadway Profile* from the GES "Accident File" refer respectively to the horizontal alignment and the vertical alignment of the roadway in

the immediate vicinity of the first harmful event in the crash. These two variables have the following codes:

Roadway Alignment	*Roadway Profile*
Code 01 = Straight	Code 01 = Level
Code 02 = Curve	Code 02 = Grade
	Code 03 = Hillcrest
	Code 08 = Other

Table 9 provides GES statistics about the roadway alignment and profile for each of the five non-junction pre-crash scenarios (1, 3, 6, 9, and 10) as well as the backing up scenario (8). This analysis lumped together the codes 01, 02, and 08 from the *Roadway Profile* variable into the category labeled as "Other" and distinguished the presence of a hillcrest since the latter affects visibility. The majority of pedestrian crashes belonging to pre-crash scenarios at non-junctions or about 95% of crashes associated with the six scenarios listed in Table 9 occurred on straight, non-hillcrest roads. Curves and hillcrests were reported in approximately 4% and 1% of these crashes, respectively.

Table 9. Statistics of Roadway Profile and Alignment for Non-Junction Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

	Scenario					
Alignment/Profile	**1**	**3**	**6**	**8**	**9**	**10**
Straight/Hillcrest	0.9%	0.8%	2.0%	2.8%	0.4%	0.7%
Curve/Hillcrest	0.2%		0.5%	0.0%	0.0%	
Straight/Other	94.9%	97.4%	87.7%	93.1%	90.0%	99.3%
Curve/Other	4.0%	1.8%	9.7%	4.1%	9.6%	
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

- Empty cells refer to categories that had no crashes in the 1995-1998 GES samples.

4.2.2. *Posted Speed Limit*

The variable *Speed Limit* from the GES "Accident File" indicates the posted speed limit for the roadway on which the crash took place. Table 10 provides the distribution of posted speed limit statistics for each of the five non-junction pedestrian pre-crash scenarios. It should be noted that Table 10 does not include the "backing up" scenario since the speed limit is irrelevant for vehicle backing maneuvers.

Table 10. Distribution of Posted Speed Limit Statistics for Non-Junction Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

	Scenario				
Speed Limit	**1**	**3**	**6**	**9**	**10**
No Statutory Limit	0.0%	0.1%	0.8%	0.4%	0.0%
5 mph	0.0%	0.0%	0.0%	0.5%	0.0%
10 mph	0.3%	0.1%	0.0%	0.0%	0.0%
15 mph	2.0%	2.9%	2.4%	0.0%	2.5%
20 mph	2.3%	4.2%	0.6%	0.4%	0.9%
25 mph	27.1%	37.9%	23.4%	24.6%	44.8%
30 mph	13.1%	15.6%	14.4%	13.6%	8.2%
35 mph	25.6%	20.5%	17.4%	15.6%	16.1%
40 mph	6.7%	5.5%	8.4%	4.2%	14.7%
45 mph	11.1%	7.9%	8.9%	10.5%	8.3%
50 mph	1.8%	1.1%	2.8%	1.8%	1.8%
55 mph	8.2%	3.8%	19.8%	19.3%	1.8%
60 mph	0.7%	0.1%	0.2%	1.4%	0.0%
65 mph	0.9%	0.2%	0.2%	4.4%	0.9%
70 mph	0.2%	0.0%	0.7%	3.3%	0.0%
75 mph	0.1%	0.0%	0.0%	0.0%	0.0%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	13,000	3,000	1,000	1,000

Approximately 67% of all crashes in the five non-junction pedestrian pre-crash scenarios in Table 10 occurred at speed limits of 25 MPH, 30 MPH, and 35 MPH. The 25 MPH speed limit was the most dominant in each of the five scenarios and accounted for about 31% of all crashes belonging to the five scenarios. The highest relative frequency of about 74% on roadways with speed limits between 25 MPH and 35 MPH was found in pre-crash scenario 3 where the vehicle was going straight and the pedestrian darted onto the roadway at non-junction. The highest relative frequency of about 45% on roadways with posted speed limit of 25 MPH was reported in pre-crash scenario 10 where the vehicle was going straight and the pedestrian was playing/working on roadway at non-junction. Next to 25 MPH, the 55 MPH speed limit was the second most dominant on roadways in pre-crash scenarios 6 (20%) and 9 (19%) that are characterized respectively by the pedestrian walking along the roadway and the pedestrian not in the roadway at non-junction. Figure 6 illustrates the speed limit distribution across the five non-junction pedestrian pre-crash scenarios. High peaks at 25 MPH and 35 MPH can be observed for pre-crash scenarios 1, 3, and 10 while high peaks at 25 MPH and 55 MPH can be seen in pre-crash scenarios 6 and 9.

4.3. Intersection Pre-Crash Scenarios

This study identified the type of traffic control device present in the four pedestrian pre-crash scenarios occurring at intersections. The *Traffic Control Device* variable from the GES "Accident File" indicates whether or not a traffic control device was present at the location of the crash and the type of the device. The codes of this variable were

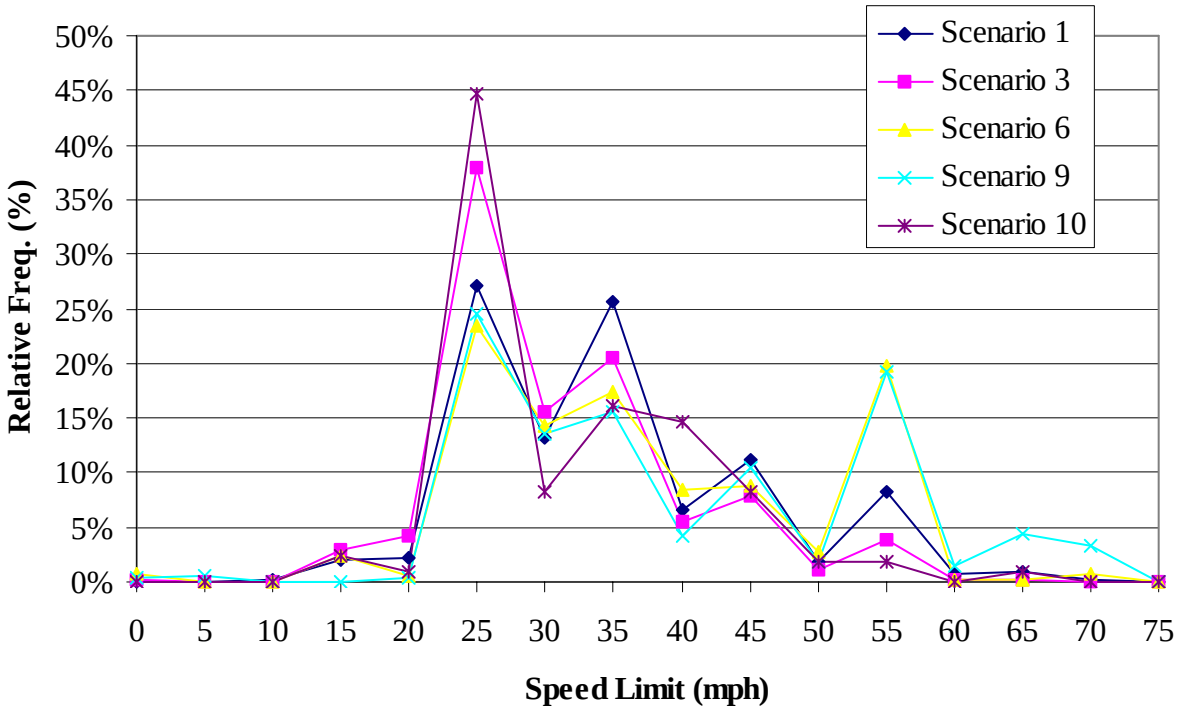

Figure 6. Speed Limit Distribution for Non-Junction Scenarios
(Based on 1995-1998 GES)

rearranged into the following four device categories:

Traffic Control Device
Code 01 = "3-Color Signal"
Code 21 = "Stop Sign"
Code 00 = "No Controls"
All Other Codes = "Other Signs"

Table 11 provides GES statistics on the distribution of intersection pedestrian pre-crash scenarios (2, 4, 5, and 7) and vehicle backing up scenario (8) by traffic control device. The 3-color signal was the most dominant device in pre-crash scenarios at intersections and was noted in about 45% of all pedestrian crashes cumulatively across pre-crash scenarios 2, 4, 5, 7, and 8. Specifically, this traffic control device was reported in about 60% of pedestrian crashes in the combined pre-crash scenarios 4 and 5 at intersections where the vehicle was turning. The "no controls" was the second most dominant and was cited in about 36% of the pedestrian crashes covered in Table 11. It should be noted that "no controls" refers to the direction of the trafficway the vehicle is traveling on. In particular, "no controls" prevailed in about 37% of the crashes in pre-crash scenario 2 involving a vehicle going straight and a pedestrian(s) crossing the roadway at an intersection. The stop sign was reported in about 16% of all crashes in Table 11 and about 18% of all crashes in pre-crash scenario 2. Figure 7 illustrates the overall distribution of traffic control device for pedestrian pre-crash scenarios at intersections.

Table 11. Distribution of Traffic Control Device Statistics for Pedestrian Pre-Crash Scenarios at Intersections (Based on 1995-1998 GES)

Traffic Control Device	Scenario					Total
	2	4	5	7	8	
3-Color Signal	40.1%	57.7%	61.8%	36.0%	7.1%	45.2%
Stop Sign	17.8%	14.5%	18.4%	8.0%	1.9%	15.5%
No Controls	36.6%	25.9%	18.9%	55.6%	89.3%	36.0%
Other Signs	5.5%	1.9%	0.9%	0.3%	1.6%	3.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

- "No controls" refers to the direction of the trafficway the vehicle is traveling on.

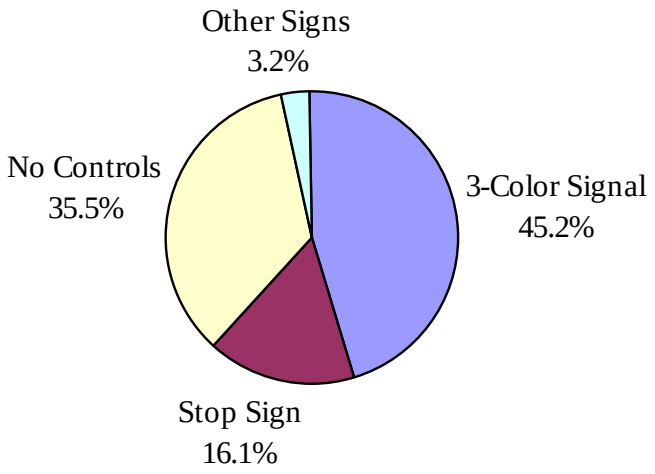

Figure 7. Distribution of Aggregate Traffic Control Device Statistics for Pedestrian Pre-Crash Scenarios at Intersections (Based on 1995-1998 GES)

4.4. Relation to Roadway

The *Relation to Roadway* variable from the GES "Accident File" indicates the location with respect to the roadway of the first harmful event in the crash. This variable was broken down into four categories as follows:

Relation to Roadway
Code 01 = "On Roadway"
Code 02 = "On Shoulder or Parking Lane"
Code 03 = "Off Roadway/Shoulder/Parking Lane"
Code 04 = "On Median"
All Other Codes = "Other"

Table 12 displays GES statistics on relation to roadway for all ten pedestrian pre-crash scenarios. Overall, about 96% of all these crashes occurred on the roadway. As

expected, the majority of crashes occurred on the roadway in each scenario except for scenario 9 where the pedestrian was not in the roadway at non-junction. In pre-crash scenario 6 where the vehicle was going straight and the pedestrian was walking along the roadway at non-junction, about 6% of the crashes occurred on the shoulder or parking lane. This statistic is the highest for crashes occurring on the shoulder or parking lane among the other nine scenarios, excluding scenario 9.

Table 12. Relation to Roadway Statistics for Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

Relation to Roadway	Scenario										Totals
	1	2	3	4	5	6	7	8	9	10	
On Roadway	97.8%	99.9%	99.9%	99.3%	99.6%	91.4%	100.0%	87.8%	4.9%	99.9%	96.1%
On Shoulder or Parking Lane	1.4%	0.0%	0.0%	0.0%	0.3%	6.2%	0.0%	4.2%	23.3%	0.0%	1.3%
Off Roadway/Shoulder/Parking Lane	0.7%	0.1%	0.1%	0.5%	0.2%	2.4%	0.0%	7.9%	67.8%	0.0%	2.3%
On Median	0.2%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	3.9%	0.1%	0.2%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	15,000	13,000	7,000	5,000	3,000	2,000	2,000	1,000	1,000	70,000

4.5. Relation to Crosswalk

The *Non-motorist Location* variable from the GES "Person File" reports the location of non-motorists (e.g., pedestrians) at the time of impact. Codes 01, 11, and 20 indicate that the pedestrian was in the crosswalk at the time of impact. Codes 02, 08, 09, 12, 18, 19, 98, and 99 refer to other or unknown locations when the pedestrian was struck. Table 13 provides GES statistics on the location of pedestrians at the time of crash. These statistics represent the number of pedestrians involved and not the number of crashes. Thus, the frequency values in Table 13 are higher than the values in Tables 8 and 12 because some crashes involved more than one pedestrian.

Overall, about 17% of all pedestrians involved in the 10 pre-crash scenarios were in the crosswalk at the time of impact. Almost all pedestrians involved in pre-crash scenarios at non-junctions (scenarios 1, 3, 6, 9, and 10) were reported not in the crosswalk at the time of crash. In contrast, about 38% of all pedestrians involved in pre-crash scenarios at intersections (scenarios 2, 4, 5, and 7) were present in the crosswalk at the time of impact. Between 45% and 50% of the pedestrians were in the crosswalk in pre-crash scenarios 4 and 5 that involved vehicles turning right or left at intersections.

Table 13. Relation to Crosswalk Statistics for Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

In Crosswalk	Scenario										Totals
	1	2	3	4	5	6	7	8	9	10	
Yes	0.5%	31.2%	0.2%	46.6%	49.2%	0%	25.0%	16.8%	0%	0%	16.6%
No	99.5%	68.8%	99.8%	53.4%	50.8%	100%	75.0%	83.2%	100%	100%	83.4%
% Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total	21,000	16,000	13,000	7,000	6,000	4,000	2,000	2,000	2,000	1,000	74,000

Note: Values in Table represent 4-year averages.

5. CONTRIBUTING FACTORS AND CIRCUMSTANCES

The GES crash database includes many variables pointing to driver and pedestrian factors that may have contributed to the cause of pedestrian crashes. Also included in the GES are variables referring to the environmental conditions that describe the crash circumstances. Unfortunately, the GES does not contain variables that directly indicate the primary cause of the crash. Thus, the GES variables were investigated in an attempt to identify one dominant factor or multiple factors that might have contributed to the cause of each crash. The association of one dominant contributing factor with a crash was achieved by using a priority scheme as described below. Driver and pedestrian factors were separately examined and later correlated to provide a comprehensive distribution of crash contributing factors.

5.1. Priority-Based Contributing Factors

A priority-based scheme was devised to deduce one dominant contributing factor for each crash by ranking driver or pedestrian factors in a descending order where the top factor superseded all other factors below it on the list. For instance, alcohol or drugs superseded other factors such as impairment, distraction, and speeding. In turn, the impairment factor superseded the distraction and speeding factors. Thus, this analysis first determined the portion of crashes that involved alcohol or drugs and then adopted a process of elimination to quantify the involvement of other factors. The remaining crashes were secondly examined to identify the portion of crashes that were attributed to impairment. After, the involvement of each of the other factors such as distraction or speeding was sequentially determined from the remaining crashes.

5.1.1. *Priority-Based Driver Contributing Factors*

The following list ranks driver contributing factors that are available from GES variables:

1. Alcohol/Drugs
2. Impaired
3. Driver Distracted By
4. Driver Vision Obscured By
5. Speeding/Reckless Driving
6. Sign/Signal Violation
7. Driver Lost Control
8. Other Violation Charged
9. Hit & Run

The *Hotdeck Imputed Police Reported Alcohol Involvement* variable indicates that a driver had consumed an alcoholic beverage. The *Person's Physical Impairment* variable attempts to identify driver physical impairments that may have contributed to the cause of the crash such as ill, blackout, drowsy, fatigued, or impaired due to previous injury. The *Driver Distracted By* variable attempts to capture distractions that may have influenced

driver performance and contributed to the cause of the crash. These distractions include passengers, vehicle instrument display, phone, other internal distractions, other crash, or external distractions. The *Driver's Vision Obscured By* attempts to identify visual circumstances that may have contributed to the cause of the crash such as rain, snow, fog, bright sunlight, other vehicles, trees, or other physical obstructions. Driver or witness statements are not considered unless verified by the investigating police officer. The *Imputed Violations Charged* variable indicates the type of violation charged to the driver of a vehicle involved in the crash such as speeding/reckless driving and sign/signal violation. The *Critical Event* variable indicates whether or not the driver lost control prior to the crash. The *Imputed Hit and Run* variable is coded when a motor vehicle in transport or its driver departs from the scene of the crash. If the driver leaves the scene, with or without the vehicle, the police accident report typically contains little information about the drivers' actions, and therefore contributing factors are generally unknown. However, very few cases of hit and run crashes in the GES might contain information on whether or not the driver was drunk or impaired typically reported by eyewitnesses.

Other pedestrian crashes not linked to any of the contributing factors listed above were separated by the following environmental factors to establish other circumstances that might have potentially contributed to the crash:

- Day/Clear
- Day/Adverse
- Night/Clear
- Night/Adverse

This priority-based scheme identifies dominant factors that might have contributed to the cause of the crash by deductive reasoning and does not generally describe the environmental conditions at the time of the crash. This analysis considered the combination of the *Imputed Light Condition* and *Imputed Atmospheric Conditions* variables from the GES. The *Imputed Light Condition* variable denotes general light conditions at the time of the crash, taking into consideration the existence of external roadway illumination fixtures. All non-daylight conditions, including dark but lighted, dusk, and dawn, were grouped as "night." The *Imputed Atmospheric Conditions* variable points to general atmospheric conditions at the time of the crash such as clear or adverse weather. All adverse weather conditions that include rain, sleet, snow, fog, and smog were categorized as "adverse." The lighting and weather conditions in combination constitute another important crash contributing factor, both of which may make it difficult for the driver to see pedestrians.

Figure 8 illustrates the distribution of crash contributing factors in all ten pedestrian pre-crash scenarios defined in Table 8. The relative frequency of each factor was determined following our priority-based scheme, starting clockwise from "Alcohol/Drugs" as the top factor. The sum of all relative frequencies shown in Figure 8 adds up to 100% since one contributing factor was attributed to each driver. Approximately 48% of all crashes in Figure 8 were attributed to alcohol/drugs, distraction, vision obscuration, speeding, traffic violations, or hit and run. The other 52% of the crashes were described in terms of the

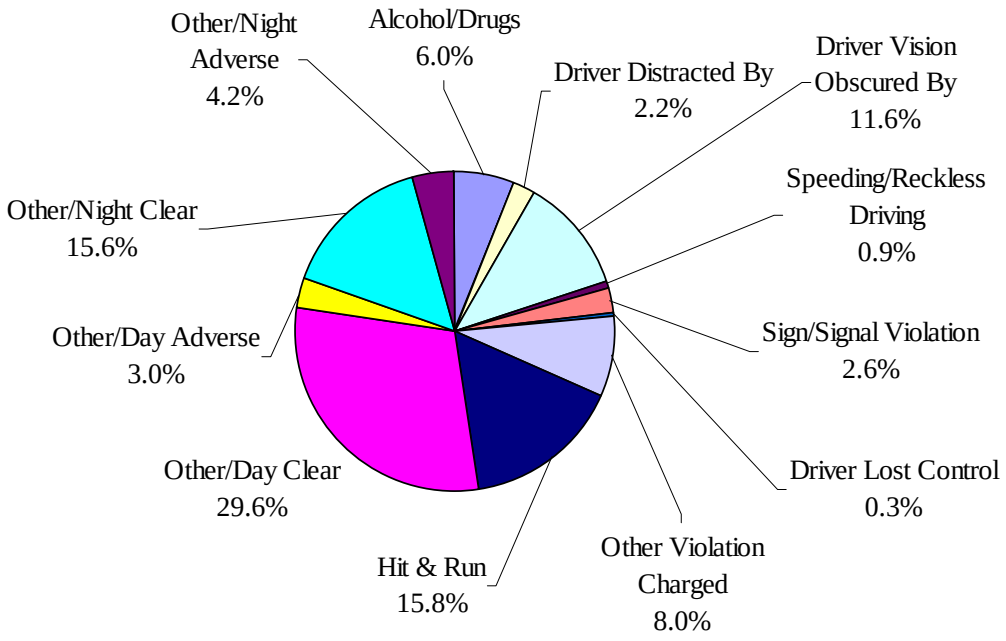

Figure 8. Distribution of Priority-Based Contributing Factors in Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

environmental conditions that existed at the time of the crash. About 23% of these crashes occurred at night and/or in adverse weather, indicating that visibility might have played a dominant role in the crash. The remaining 30% of these crashes happened in clear day conditions. One can deduce from this last statistic that the driver might have been inattentive or distracted, or that the pedestrian might have contributed to the cause of the crash.

Table 14 breaks down the driver contributing factors for each individual scenario. Alcohol or drugs accounted for 6% of all pedestrian crashes in the ten pre-crash scenarios as illustrated in Figure 9. The relative frequency of this factor was greater than 10% in pre-crash scenarios 6 and 9 that involved a pedestrian walking along the roadway or not in the roadway at non-junction. Overall, driver impairment (excluding alcohol or drugs) was negligible and accounted for merely 0.1% of all crashes in the ten pedestrian pre-crash scenarios. This particular factor was cited in about 1% of all crashes in pre-crash scenario 6 that involved a pedestrian walking along the roadway at non-junction. The highest contribution of driver distraction was reported at about 10% in pre-crash scenario 9 where the pedestrian was struck off the roadway at non-junction. The obstruction of driver vision was dominant (> 34%) in pre-crash scenarios 3 and 7 that involved a pedestrian darting onto the roadway at non-junction or intersection. Speeding or reckless driving prevailed in about 9% of all crashes in pre-crash scenario 9 where the pedestrian was not in the roadway at non-junction. Sign/signal violation was cited predominantly in pre-crash scenarios 4 and 5 that involved a vehicle turning at an intersection, in comparison to other scenarios. Drivers lost control of the vehicle in just 0.3% of all

Table 14. Breakdown of Priority-Based Driver Contributing Factors by Individual Pedestrian Pre-Crash Scenario (Based on 1995-1998 GES)

Contributing Factor	Scenario									
	1	2	3	4	5	6	7	8	9	10
Alcohol/Drugs	6.1%	7.2%	1.4%	2.8%	9.3%	14.6%	1.3%	8.6%	16.3%	8.3%
Impaired	0.1%	0.1%	0.0%	0.0%	0.0%	0.8%	0.0%	0.0%	1.0%	0.0%
Driver Distracted By	3.0%	0.8%	1.0%	3.0%	1.1%	3.2%	0.2%	4.9%	9.8%	6.4%
Driver Vision Obscured By	3.6%	5.4%	41.8%	5.1%	1.5%	4.0%	34.4%	0.7%	1.4%	4.2%
Speeding/Reckless Driving	1.6%	0.4%	0.2%	0.8%	0.2%	0.9%	0.0%	0.3%	8.6%	0.0%
Sign/Signal Violation	0.3%	3.3%	0.0%	8.8%	12.2%	0.0%	0.3%	0.0%	0.0%	0.0%
Driver Lost Control	0.0%	0.1%	0.0%	0.2%	0.4%	0.2%	0.0%	0.0%	9.5%	0.0%
Other Violation Charged	8.5%	9.7%	3.3%	13.5%	5.5%	4.1%	4.8%	11.6%	9.9%	21.6%
Hit & Run	15.0%	22.3%	3.1%	14.5%	22.3%	27.8%	1.8%	26.9%	23.7%	20.1%
Other/Day Clear	32.6%	26.1%	34.3%	32.4%	30.5%	12.8%	34.5%	24.4%	11.0%	23.7%
Other/Day Adverse	2.8%	4.9%	1.2%	3.2%	4.9%	2.5%	1.9%	2.8%	0.0%	0.0%
Other/Night Clear	21.9%	15.0%	11.7%	9.9%	7.8%	24.9%	15.9%	11.4%	8.7%	14.9%
Other/Night Adverse	4.5%	4.8%	1.9%	6.0%	4.4%	4.3%	4.9%	8.6%	0.0%	0.7%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	15,000	13,000	7,000	5,000	3,000	2,000	2,000	1,000	1,000

crashes in the ten scenarios and substantially in about 10% of all crashes in scenario 9. The driver was charged with other traffic violations significantly in pre-crash scenario 10 (22%) that involved a pedestrian playing/working in the roadway at non-junction. Other violations were charged to drivers appreciably in at least 10% of the crashes in scenarios 2 and 4 occurring at intersections. The driver hit a pedestrian and fled the scene of the crash considerably in most scenarios except for scenarios 3 and 7 involving a pedestrian darting onto the roadway.

The driver was not drunk, impaired, distracted, speeding, or charged with any violations; did not see pedestrian due to vision obstruction; or hit pedestrian and fled the scene in about 52% of all crashes covered in Table 14. The atmospheric conditions of these crashes were examined to find out whether visibility or inattention, not mentioned in police-accident reports, might have played a role in the crash. Night and/or adverse weather conditions were reported in about 32% of crashes in pre-crash scenario 6 where the pedestrian was walking along the roadway at non-junction. Moreover, these conditions were prevalent in about 29% of crashes in scenario 1 that involved a pedestrian crossing the roadway at non-junction. Among all pre-crash scenarios, scenario 9 had the least number of crashes (9%) attributed to night or adverse weather conditions. On the other hand, daylight and clear weather were reported individually in over 30% of the crashes in scenario 1 (pedestrian crossing at non-junction), scenarios 3 and 7 (pedestrian darting onto roadway), and scenarios 4 and 5 (vehicle turning at intersection). Under these conditions, the driver might have been inattentive or the pedestrian might not have seen or misjudged the distance to the vehicle.

5.1.2. *Priority-Based Pedestrian Contributing Factors*

This analysis also investigated pedestrian conditions or actions that might have contributed to the cause of pedestrian crashes. A priority-based scheme was adopted to identify one dominant pedestrian contributing factor for each crash based on the following list:

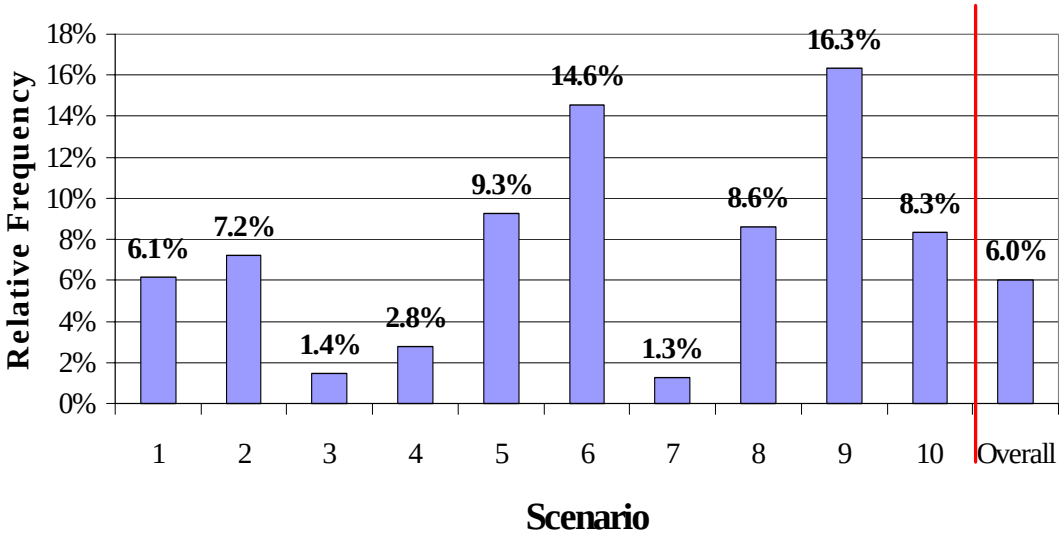

Figure 9. Distribution of Driver Alcohol/Drugs Involvement in Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

1. Alcohol/Drugs
2. Impaired
3. Improper Crossing

The alcohol/drugs factor denotes if the police reported alcohol or drugs involvement on the pedestrian. The impaired factor indicates if the pedestrian was physically impaired including drowsiness, sleepiness, illness, or actual physical impairment. The improper crossing factor refers to whether the pedestrian was jaywalking either at an intersection or non-junction. Figure 10 shows the overall breakdown of pedestrian contributing factors for the top ten scenarios starting clockwise from "Alcohol/Drugs" as the most important factor. These statistics were based on the number of pedestrians involved in pedestrian crashes and not on the number of crashes since one crash might involve more than one pedestrian. Overall, about 7% of the pedestrians were under the influence of alcohol or drugs at the time of the crash. In comparison, about 6% of drivers were under the influence of alcohol or drugs in pedestrian crashes. Of the remainder, less than 1% of the pedestrians were impaired while roughly 21% improperly crossed the roadway at the time of the crash.

Table 15 breaks down pedestrian contributing factors by each of the ten pedestrian pre-crash scenarios listed in Table 8. About 11% of pedestrians were under the influence of alcohol or drugs in pre-crash scenario 6 that involved pedestrian(s) walking along the roadway at non-junction, the highest percentage among the ten scenarios. Pre-crash scenario 6 also involved about 15% of drivers who were under the influence of alcohol or drugs as seen in Figure 9. The involvement of pedestrians under the influence of alcohol or drugs was also reported to be considerably high at about 10% in each of pre-crash

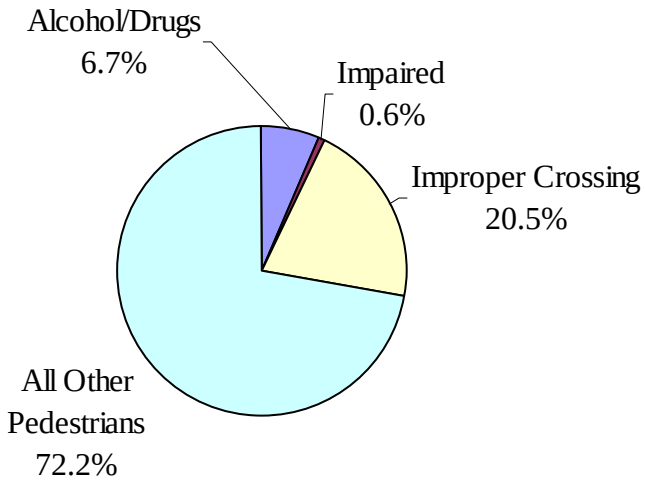

Figure 10. Breakdown of Priority-Based Pedestrian *Contributing Factors* for Top Ten Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

scenarios 1 and 2 that involved a vehicle going straight and pedestrian(s) crossing the roadway at non-junction or intersection. As observed in Figure 11, the highest percentage of improper crossings was reported at about 45% in pre-crash scenario 1. This is to be expected since this scenario involved pedestrian(s) crossing the roadway at non-junction. In contrast, only 17% of the pedestrians crossing the roadway at an intersection in pre-crash scenario 2 were cited with improper crossing.

5.1.3. *Priority-Based Driver/Pedestrian Contributing Factors*

This section correlates driver contributing factors with pedestrian contributing factors using the priority-based scheme of identifying dominant factors so as to achieve a better understanding of crash causation. Appendix A provides these statistics in ten tables that cover each of the ten most common pedestrian pre-crash scenarios. Table 16 shows one such table on driver/pedestrian contributing factors for the most frequent pre-crash scenario 1 that involved a vehicle going straight and pedestrian(s) crossing the

Table 15. Breakdown of Priority-Based Pedestrian Contributing Factors by Individual Pre-Crash Scenarios (Based on 1995-1998 GES)

Contributing Factor	Scenario									
	1	2	3	4	5	6	7	8	9	10
Alcohol/Drugs	9.9%	9.5%	3.9%	3.0%	2.0%	10.5%	3.1%	0.6%	0.7%	0.0%
Impaired	0.4%	1.0%	0.3%	0.6%	0.0%	1.8%	0.0%	0.8%	0.0%	0.0%
Improper Crossing	44.5%	17.1%	8.7%	8.0%	9.5%	0.0%	8.1%	16.7%	0.5%	0.0%
All Other Pedestrians	45.1%	72.3%	87.0%	88.4%	88.5%	87.7%	88.8%	81.9%	98.8%	100.0%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	16,000	13,000	7,000	6,000	4,000	2,000	2,000	2,000	1,000

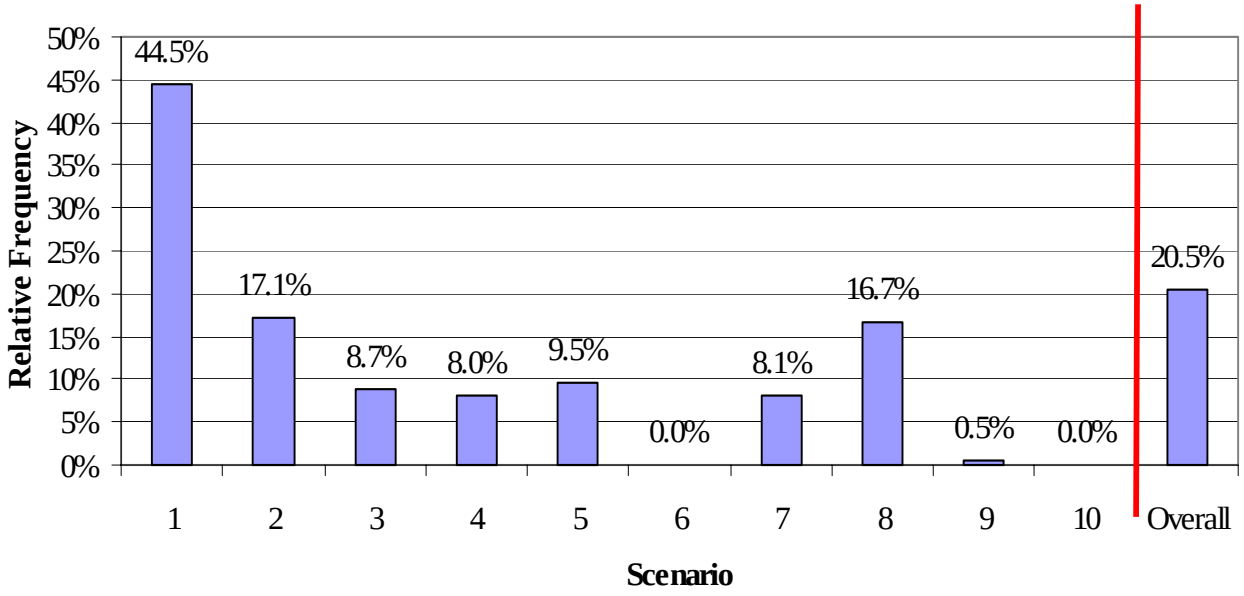

Figure 11. Distribution of Priority-Based "Improper Crossing" by Pedestrian Pre-Crash Scenario (Based on 1995-1998 GES)

roadway at non-junction. Both the pedestrian and the driver were under the influence of alcohol or drugs in about 1% of the crashes in pre-crash scenario 1. Around 5% of the pedestrians were improperly crossing the roadway in pre-crash scenario 1 where the driver fled the scene. About 31% of the 21,000 pedestrians involved in this scenario were improperly crossing the roadway in crashes that did not include any reported driver contributing factor as listed in Table 16.

5.2. Non-Prioritized Driver Contributing Factors

Table 17 lists the statistics of all factors that might have contributed to the cause of a crash without any factor prioritization. The sum of relative frequencies in each scenario does not equal 100% because some crashes in the GES data did not have any of the given contributing factors associated with them. However, multiple factors could be associated with a crash and are therefore double-counted in Table 17. Figure 12 shows the distribution of the "Driver Vision Obscured By" factor that was a relatively insignificant contributing factor in most of the scenarios except for pre-crash scenarios 3 and 7 involving pedestrian(s) darting onto the road. This factor was reported in about 44% and 35% of the crashes respectively in pre-crash scenario 3 at non-junction and pre-crash scenario 7 at intersection. In most cases, standing traffic or parked vehicles on the side of the road obscured the driver's vision. As detailed later in this report, children made up a large percentage of pedestrians darting onto the roadway. In scenarios 4 and 5 involving a turning vehicle, vision obscuration was reported more in left-turning vehicle than in right-turning vehicle crashes. Figure 13 reveals the distribution of "Speeding/Reckless Driving," "Driver Lost Control," and "Driver Distracted By" factors over the ten pre-crash scenarios listed in Table 8. It is clearly evident that each of these three contributing factors was mostly reported in pre-crash scenario 9 involving pedestrian(s) not in the

Table 16. Breakdown of Priority-Based Driver/Pedestrian Contributing Factors in Pre-Crash Scenario 1 (Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.8%	0.1%	2.0%	3.5%	6.4%
Impaired	0.0%	0.0%	0.1%	0.0%	0.1%
Driver Distracted By	0.1%	0.0%	0.7%	2.3%	3.1%
Driver Vision Obscured By	0.2%	0.0%	1.6%	1.8%	3.6%
Speeding/Reckless Driving	0.0%	0.0%	0.6%	0.9%	1.6%
Sign/Signal Violation	0.0%	0.0%	0.1%	0.3%	0.4%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.1%
Other Violation Charged	0.3%	0.0%	3.3%	5.1%	8.7%
Hit & Run	0.9%	0.0%	5.1%	9.2%	15.3%
Other/Day Clear	1.4%	0.1%	16.4%	13.9%	31.8%
Other/Day Adverse	0.1%	0.0%	1.7%	1.1%	2.8%
Other/Night Clear	5.3%	0.2%	10.6%	5.6%	21.6%
Other/Night Adverse	0.7%	0.1%	2.3%	1.4%	4.5%
% Total	9.9%	0.4%	44.5%	45.1%	100.0%
			Number of Pedestrians in Scenario =		21,000

Table 17. Breakdown of Non-Prioritized Driver Contributing Factors (Based on 1995-1998 GES)

Contributing Factor (Non-Priority)	Scenario									
	1	2	3	4	5	6	7	8	9	10
Alcohol/Drugs	6.1%	7.2%	1.4%	2.8%	9.3%	14.6%	1.3%	8.6%	16.3%	8.3%
Impaired	0.4%	0.3%	0.1%	0.0%	0.0%	1.3%	0.0%	0.3%	1.0%	2.2%
Driver Distracted By	3.2%	1.0%	1.0%	3.0%	1.2%	3.5%	0.2%	4.9%	10.2%	6.4%
Driver Vision Obscured By	4.3%	5.6%	43.6%	5.2%	1.7%	5.6%	34.9%	0.7%	1.4%	4.2%
Speeding/Reckless Driving	2.2%	0.4%	0.3%	0.9%	0.2%	0.9%	0.0%	1.3%	9.6%	3.5%
Sign/Signal Violation	0.4%	4.7%	0.0%	11.0%	12.5%	1.1%	1.1%	0.0%	0.0%	0.0%
Driver Lost Control	0.3%	0.1%	0.0%	0.2%	0.4%	0.3%	0.0%	0.0%	14.6%	1.2%
Other Violation Charged	10.5%	11.6%	8.1%	15.3%	8.1%	8.7%	7.2%	12.5%	16.0%	23.2%
Hit & Run	19.1%	27.6%	3.8%	16.4%	29.9%	39.4%	2.7%	33.5%	37.5%	22.3%
Total	21,000	15,000	13,000	7,000	5,000	3,000	2,000	2,000	1,000	1,000

roadway at non-junction. It should be noted that this scenario also had the highest relative frequency of "Alcohol/Drugs" involvement among the ten scenarios.

Figure 14 illustrates the distribution of violations cited to drivers involved in each of the ten pedestrian pre-crash scenarios. The highest relative frequency of sign/ signal violation citations among the ten scenarios was reported at about 13% in pre-crash scenario 5 that involved a vehicle turning right and pedestrian(s) crossing the roadway at intersection. The highest relative frequency of "other" violations among the scenarios was noted at about 23% in pre-crash scenario 10 that involved pedestrian(s) playing/ working in the roadway at non-junction. About 26% of drivers were cited with traffic violations in scenario 4 involving a vehicle turning left at intersection, which was the highest percentage among the ten scenarios.

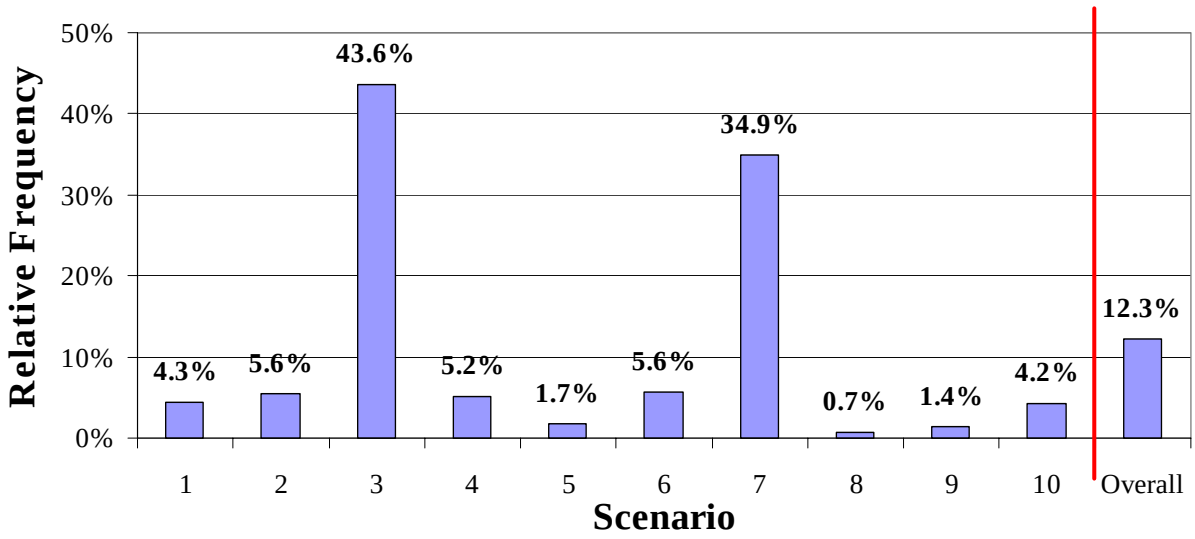

Figure 12. Distribution of "Driver Vision Obscured By" Contributing Factor (Based on 1995-1998 GES)

Table 18 shows a symmetric matrix correlating driver contributing factors to paint a better picture of the multiple factors that might have contributed to the cause of the crash. Due to the symmetric nature of this table, half the cells are empty due to redundant information, the lower part below the diagonal of the matrix being a mirror image of the upper part. Table 18 provides the complete set of contributing factors attributed to drivers in pre-crash scenario 1 involving a vehicle going straight and pedestrian crossing the roadway at non-junction. As seen in Table 18, 4% equaling roughly 70% of the crashes in which alcohol or drugs was involved (6%) were also coded as "Hit & Run" in the GES. Appendix B contains ten tables for each of the ten pedestrian pre-crash scenarios listed in Table 8. Generally, there was minor cross-correlation among driver contributing factors. The most striking cross-correlation was that roughly 70% of all crashes in the top ten pre-crash scenarios in which the driver was under the influence of alcohol or drugs were also coded as hit and run.

5.3. Atmospheric Conditions

In an effort to determine what else could have contributed to pedestrian crashes other than the factors that are detailed above, an analysis of atmospheric conditions present in these crashes was performed. Atmospheric conditions relate to whether or not the crash happened during the daytime or nighttime and in clear or adverse weather conditions. Table 19 lists the results of this analysis for each of the ten scenarios. Figure 15 displays the breakdown of atmospheric conditions for all scenarios combined. Most pedestrian crashes occurred in daytime under clear weather conditions, comprising about 58% of all crashes in the top ten pre-crash scenarios. Moreover, clear weather and daytime were reported respectively in about 87% and 64% of these crashes.

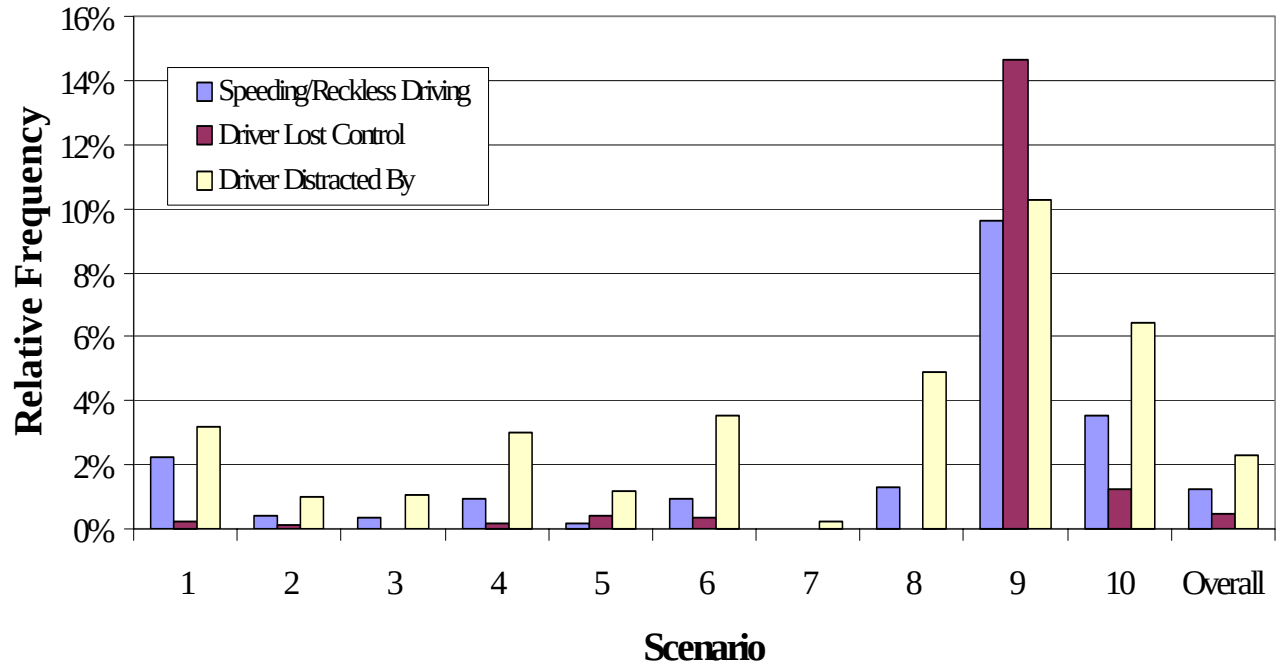

Figure 13. Distribution of "Speeding/Reckless Driving," "Driver Lost Control," and "Driver Distracted By" Contributing Factors (Based on 1995-1998 GES)

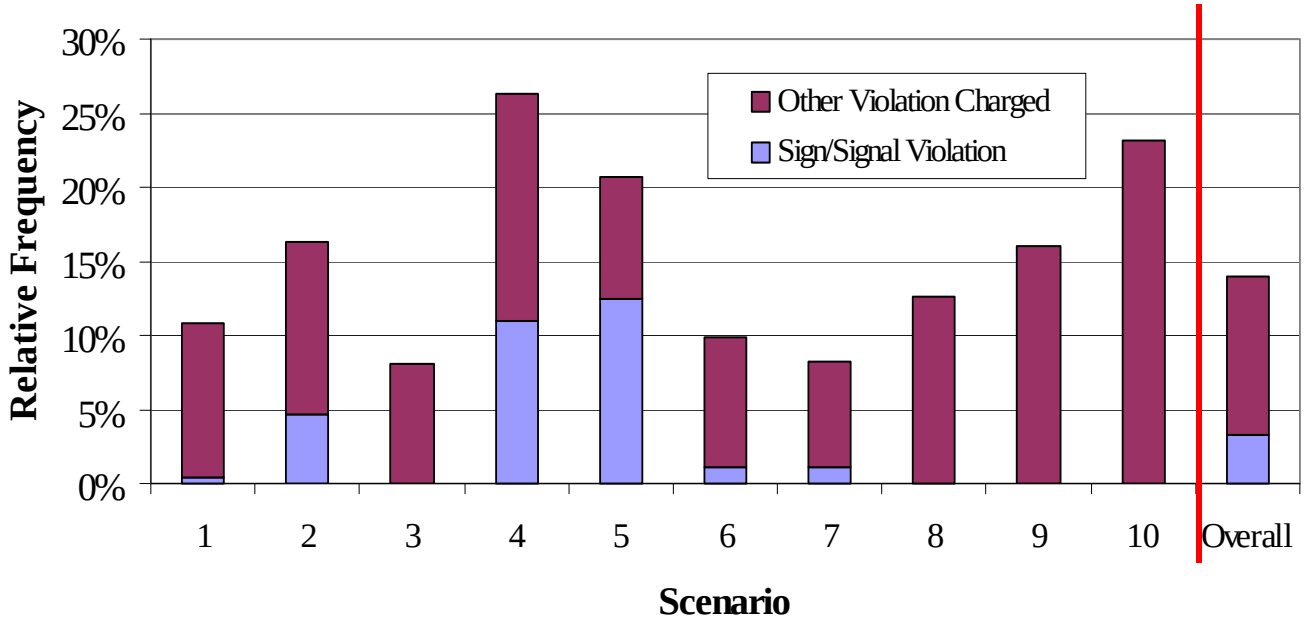

Figure 14. Distribution of "Sign/Signal Violation" and "Other Violation Charged" Contributing Factors (Based on 1995-1998 GES)

Table 18. Breakdown of Non-Prioritized Driver Contributing Factors for Pre-Crash Scenario 1 (Based on 1995-1998 GES)

Scenario 1	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	6.1%	0.3%	0.1%	0.0%	0.1%	0.0%	0.2%	0.2%	4.2%
Impaired		0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			3.2%	0.1%	0.0%	0.0%	0.0%	0.3%	0.2%
Driver Vision Obscured By				4.3%	0.4%	0.0%	0.0%	0.5%	0.6%
Speeding/Reckless Driving					2.2%	0.0%	0.0%	0.0%	0.1%
Sign/Signal Violation						0.4%	0.0%	0.0%	0.0%
Driver Lost Control							0.3%	0.0%	0.2%
Other Violation Charged								10.5%	1.1%
Hit & Run									19.1%
						Crash Population =			21,000

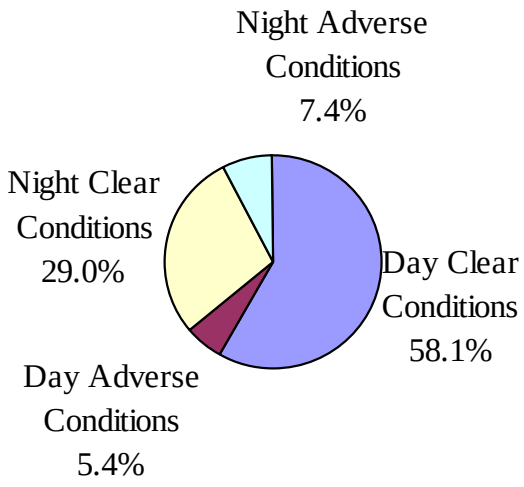

Figure 15. Distribution of Atmospheric Conditions Statistics for Ten Pedestrian Pre-Crash Scenarios Combined (Based on 1995-1998 GES)

Figure 16 displays the breakdown of atmospheric conditions for each pedestrian pre-crash scenario independently. Most crashes in pre-crash scenario 6 involving pedestrian(s) walking along the roadway at a non-junction occurred at night. The highest relative frequency of crashes under "night/adverse" conditions was reported in pre-crash scenario 8 that involved a backing vehicle. About twice as many crashes in scenario 1, where the vehicle was going straight and pedestrian was crossing the roadway at a non-junction, occurred under "night/adverse" conditions than in "day/adverse" conditions.

Table 20 presents statistics correlating driver contributing factors with atmospheric conditions for pre-crash scenario 1 involving a vehicle going straight and pedestrian(s)

Table 19. Breakdown of Atmospheric Conditions Statistics by Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

Atmospheric Conditions	Scenario										Overall
	1	2	3	4	5	6	7	8	9	10	
Day Clear Conditions	50.8%	56.1%	70.3%	65.1%	66.0%	35.7%	67.6%	54.7%	55.5%	64.1%	58.1%
Day Adverse Conditions	3.9%	8.0%	3.3%	6.9%	7.7%	4.8%	5.3%	7.0%	5.2%	1.7%	5.4%
Night Clear Conditions	37.5%	27.4%	21.8%	19.1%	20.3%	52.4%	22.2%	18.4%	34.3%	33.6%	29.0%
Night Adverse Conditions	7.8%	8.5%	4.6%	9.0%	6.0%	7.0%	4.9%	19.8%	5.1%	0.7%	7.4%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	15,000	13,000	7,000	5,000	3,000	2,000	2,000	1,000	1,000	70,000

crossing the roadway at non-junction. All crashes in this scenario in which the driver was impaired occurred at nighttime. Moreover, roughly 75% of the crashes in which the driver's vision was obscured happened in daytime and clear weather conditions. Appendix C presents similar statistics for each of the ten pedestrian pre-crash scenarios defined in Table 8. These statistics are based on a non-prioritized breakdown of driver contributing factors and therefore do not sum to 100% since multiple factors were associated with each crash and, on the other hand, some crashes did not have any of the given contributing factors associated with them.

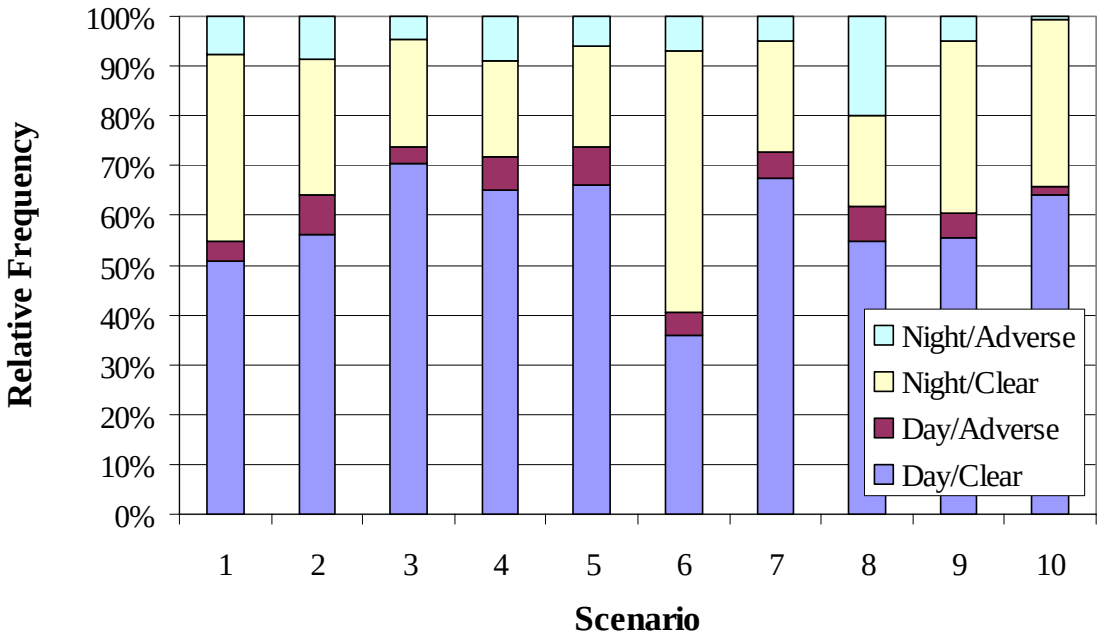

Figure 16. Distribution of *Atmospheric Conditions* for Each Pedestrian Pre-Crash Scenario Independently (Based on 1995-1998 GES)

Table 20. Breakdown of Driver Contributing Factors vs. Atmospheric Conditions for Scenario 1 – Non-Priority (Based on 1995-1998 GES)

Scenario 1	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	2.2%	0.5%	3.1%	0.4%	6.1%
Impaired	0.0%	0.0%	0.3%	0.1%	0.4%
Driver Distracted By	1.7%	0.0%	1.2%	0.4%	3.2%
Driver Vision Obscured By	3.2%	0.1%	0.5%	0.6%	4.3%
Speeding/Reckless Driving	1.2%	0.0%	0.5%	0.5%	2.2%
Sign/Signal Violation	0.1%	0.1%	0.2%	0.0%	0.4%
Driver Lost Control	0.2%	0.0%	0.1%	0.0%	0.3%
Other Violation Charged	5.3%	0.2%	4.4%	0.7%	10.5%
Hit & Run	7.9%	0.8%	8.9%	1.5%	19.1%
			Crash Population =		21,000

As seen in Appendix C, about 90% of "Driver Distracted By" crashes and 80% of "Driver Vision Obscured By" crashes in pre-crash scenario 2 (vehicle going straight and pedestrian crossing roadway at intersection) occurred in daytime and clear weather. All "Driver Distracted By" crashes and around 71% of "Driver Vision Obscured By" crashes in pre-crash scenario 3 (vehicle going straight and pedestrian darting onto roadway at non-junction) happened in daytime and clear weather. Almost 70% of "Sign/Signal violation" crashes in pre-crash scenario 4 involving left-turning vehicle took place in daytime and clear weather. About 57% of "Driver Distracted By" crashes in scenario 4 were reported to occur at nighttime and under clear weather, which constituted the highest relative frequency of "Driver Distracted By" under "Night & Clear" conditions among the ten scenarios. Most "Driver Distracted By," "Driver Vision Obscured By," and "Sign/Signal violation" crashes in pre-crash scenario 5 involving right-turning vehicle took place in daytime and clear weather. In pre-crash scenario 6 involving pedestrian(s) walking along the roadway, about 50% of "Driver Vision Obscured By" crashes took place during nighttime. In scenario 7 involving pedestrian(s) darting onto the roadway at intersection, almost 77% of "Driver Vision Obscured By" crashes occurred in daytime and clear weather. The statistics for the remaining 3 scenarios are provided in Tables C8-C10, which were derived from small number of GES cases. Overall, most "Driver Distracted By" crashes occurred in daytime and clear weather conditions except for pre-crash scenario 4 (vehicle turning left). Similarly, most "Driver's Vision Obscured By" crashes took place in daytime and clear weather conditions except for pre-crash scenario 6 (pedestrian walking along roadway).

6. AGE INVOLVEMENT

6.1. Driver Age

The age of the driver of the striking vehicle at the time of the crash, with respect to the person's last birthday, is found in the *Age* variable located in the GES "Person File" [6]. The distribution of driver age within each pre-crash scenario as defined in Table 8 is shown in Table 21, with the "Total" row reflecting number of drivers. The "Totals" column reflects the overall age group breakdown and not the addition of each row in the Table. Note that the "Under 20" age category is composed of drivers aged from 14 years to 19 years old. This information is valuable in determining which driver age groups are most susceptible to each scenario analyzed.

Table 21. Driver Age Distribution for Pre-Crash Scenarios
(Based on 1995-1998 GES)

AGE (years)	Scenario										Totals
	1	2	3	4	5	6	7	8	9	10	
Under 20	10.0%	11.3%	12.5%	12.7%	11.1%	15.6%	8.2%	8.8%	14.2%	8.3%	11.3%
20-24	13.4%	9.7%	11.1%	7.3%	4.8%	10.3%	22.0%	4.4%	10.2%	13.7%	10.7%
25-29	10.6%	11.5%	13.3%	11.2%	12.7%	4.7%	5.9%	15.3%	10.6%	12.3%	11.2%
30-34	16.0%	13.5%	12.8%	12.5%	9.8%	14.2%	12.2%	10.4%	16.1%	12.1%	13.7%
35-39	14.1%	13.4%	10.8%	14.0%	12.2%	8.4%	16.0%	21.8%	10.6%	20.9%	13.2%
40-44	10.3%	9.5%	10.7%	7.7%	11.0%	8.5%	9.9%	9.6%	7.3%	4.3%	9.8%
45-49	5.2%	5.1%	9.0%	8.4%	7.2%	3.2%	4.3%	3.3%	7.9%	6.8%	6.2%
50-54	5.2%	7.0%	4.8%	9.2%	6.2%	10.9%	5.2%	8.1%	6.4%	11.5%	6.5%
55-59	3.9%	3.3%	4.7%	2.9%	8.4%	1.6%	1.9%	5.2%	1.2%	0.7%	3.9%
60-64	3.4%	4.3%	4.0%	5.3%	4.4%	12.9%	5.2%	4.3%	3.7%	2.8%	4.5%
65-69	3.2%	2.2%	2.1%	1.9%	4.5%	2.4%	4.1%	5.2%	7.8%	3.5%	2.9%
70-74	2.0%	2.4%	2.9%	2.6%	1.5%	2.2%	1.2%	1.4%	0.0%	0.8%	2.2%
75-79	0.9%	2.3%	0.9%	2.4%	2.2%	1.3%	0.5%	1.1%	4.0%	2.3%	1.5%
80-84	0.9%	1.6%	0.3%	0.7%	0.9%	2.8%	3.5%	0.7%	0.0%	0.0%	1.0%
85+	0.9%	3.0%	0.0%	1.2%	3.0%	0.9%	0.0%	0.2%	0.0%	0.0%	1.3%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	15,000	13,000	7,000	5,000	3,000	2,000	2,000	1,000	1,000	70,000

Figure 17 displays the percent distribution of each age category for the ten scenarios as an aggregate as well as the licensed driver population distribution in the U.S. as of 1998 (see Table F2 in Appendix F) [7]. Overall, the age group of 30-34 years old enveloped the greatest frequency of drivers involved in pedestrian crashes, accounting for almost 14% of the total drivers in the pedestrian crash problem. When compared to the national licensed driver population distribution, all age groups under 40 years old were over-represented. Conversely, age groups above 40 years old were under-represented except for the 85+ age category, which was slightly over-represented in the crash population. Drivers in the 85+ age category were involved in about 1.3% of pedestrian crashes, while accounting for 0.9% of all licensed drivers. Younger drivers, especially those aged under 20 years old, were the most likely to be involved in pedestrian crashes relative to the licensed driver population. Drivers aged less than 20 years old were involved in 11.3%

of pedestrian crashes and yet only comprise 5.3% of the total licensed driver population. Older drivers, those aged 40 years and older, composed a significantly less percentage of drivers involved in pedestrian crashes relative to the overall licensed driver population. Overall, drivers under the age of 45 years old accounted for about 70% of the total driver population in the pedestrian crash problem.

Driver *age* distributions per scenario are enclosed in Appendix D in Figures D1 through Figure D5, with two scenarios displayed per Figure along with the licensed driver population distribution.

The breakdowns of driver *age* for scenario 1 and scenario 2 along with the distribution of the licensed driver population are also shown in Figure 18 (also Figure D1, Appendix D). It is clearly seen from this Figure that both scenarios hold similar driver age characteristics and follow the overall pedestrian crash driver distribution as shown in Figure 17. Drivers younger than 40 years old were over-represented while older drivers were under-represented in the crash problem when compared to the overall distribution of licensed drivers in the U.S. The same observation holds true for scenarios 3 and 4 as shown in Figure 19 (also Figure D2, Appendix D). The driver age distributions for the other scenarios are not as uniform (Tables D3-D5, Appendix D) because of the relative small sample size of the crash population in those scenarios and the potential sampling errors associated with the GES database.

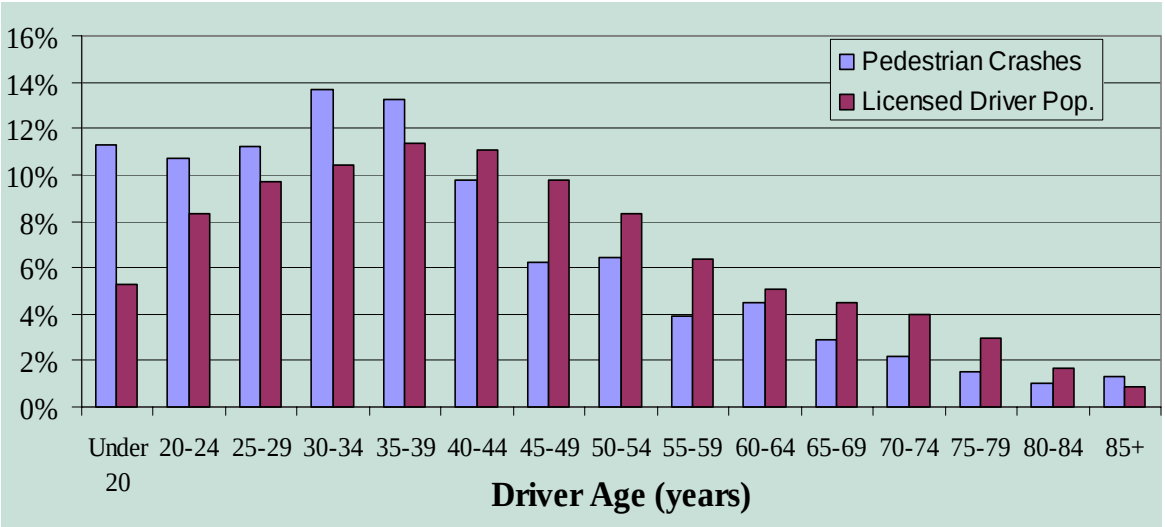

Figure 17. Driver Age Distribution for Aggregate Scenario Total and Overall Licensed Driver Population (Based on 1995-1998 GES)

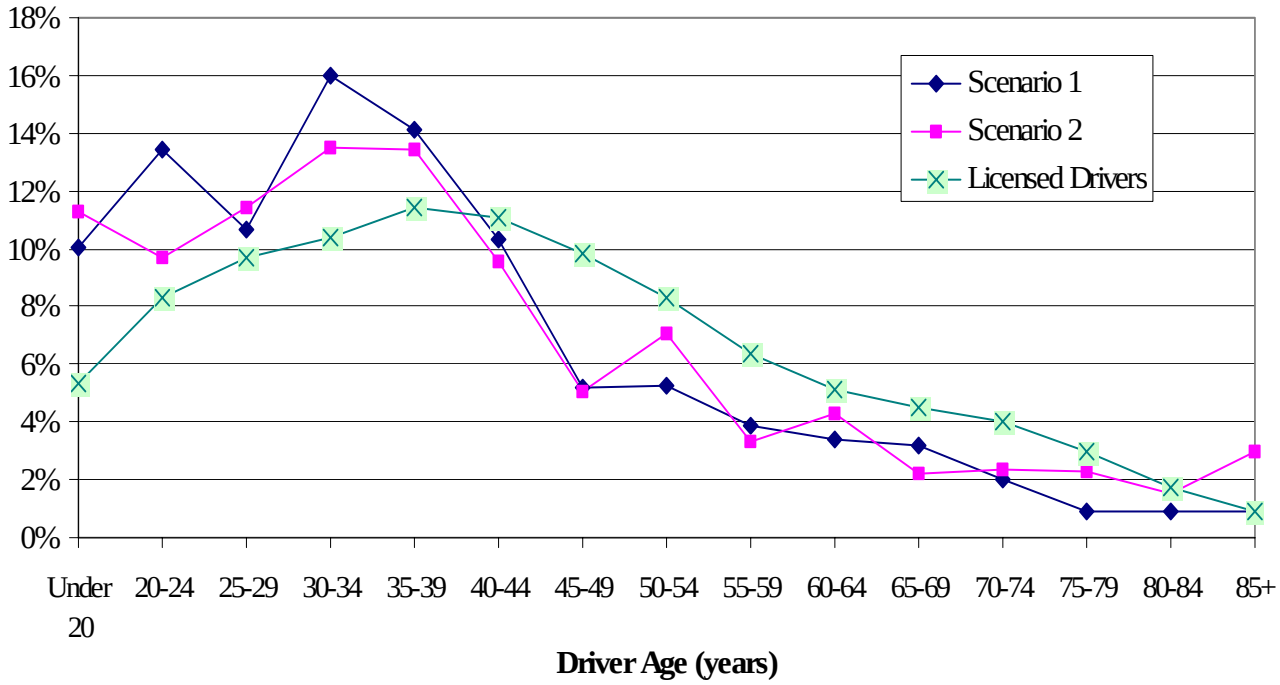

Figure 18. Driver Age Distribution for Scenario 1 and Scenario 2 and Overall Licensed Driver Population (Based on 1995-1998 GES)

Another way to compare driver age statistics would be to normalize the crash rate by driving exposure for each age group. Table 22 displays the results of normalizing the driver crash involvement rate per 100 million vehicle miles traveled (VMT) across all age categories based on driving exposure statistics obtained from the 1995 *Nationwide Personal Transportation Survey* [10]. As shown in the column representing the overall driver involvement rate, there were about 5.3 yearly crashes per 100 million VMT across all scenarios and age groups combined. Drivers in the age group of 85+ years old had the highest involvement rate at 27.9 crashes per 100 million VMT. The youngest segment of the driving population (under 20 years old) retained the second-highest driver involvement rate of 16.7 crashes per 100 million VMT. In general, the middle-age driving population tended to have the lowest crash involvement rate over all of the ten pre-crash scenarios. Figures D6 through D8 in Appendix D display the driver involvement rates based on VMT per age group for each scenario independently. A general observation is that the graphic of driver crash involvement per VMT follows a "U" shape curve in which the youngest and oldest age groups tend to have a higher involvement rate while the middle-aged groups tend to have a lower involvement rate. Again, the driver involvement rate for the less populated scenarios is not as uniform, as shown in Figure D8, due to the relative small sample size of the crash population in those scenarios and the potential sampling errors associated with the GES database.

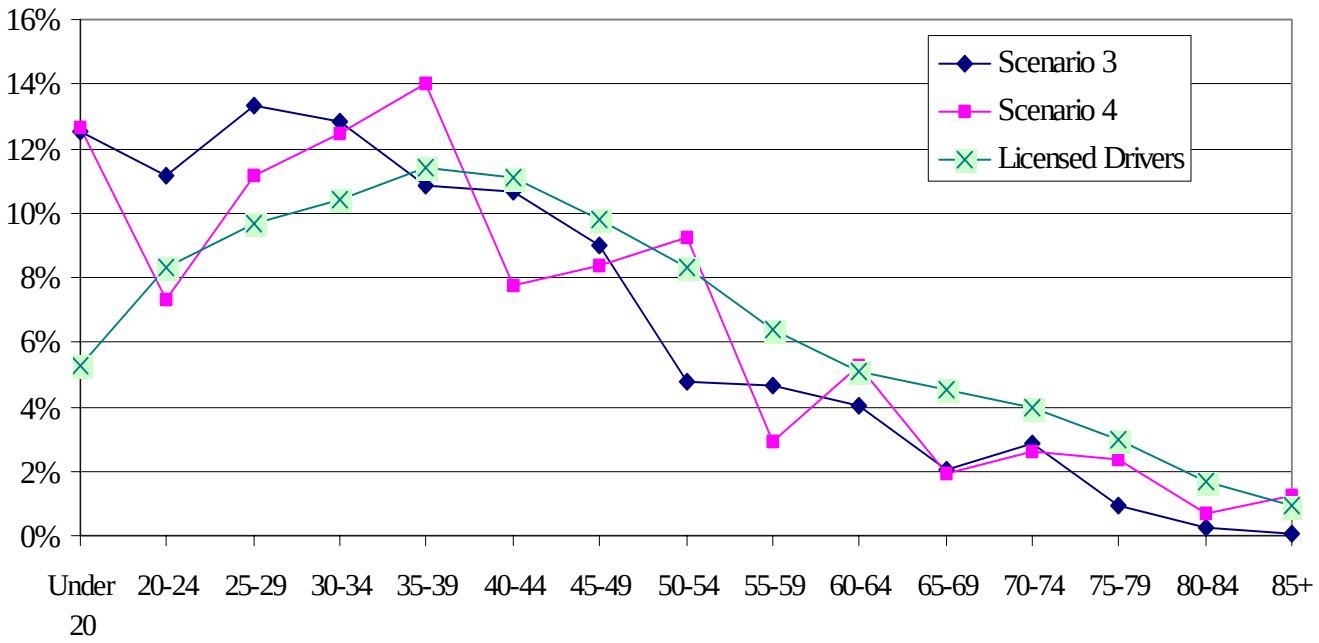

Figure 19. Driver Age Distribution for Scenario 3 and Scenario 4 and Overall Licensed Driver Population (Based on 1995-1998 GES)

Table 22. Driver Involvement per 100 Million VMT per Age Group for Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

AGE (years)	Scenario										Overall per Age Group
	1	2	3	4	5	6	7	8	9	10	
Under 20	4.4	3.6	3.4	1.9	1.2	1.0	0.3	0.4	0.3	0.2	16.7
20-24	2.7	1.4	1.4	0.5	0.2	0.3	0.4	0.1	0.1	0.1	7.1
25-29	1.5	1.2	1.2	0.5	0.4	0.1	0.1	0.2	0.1	0.1	5.3
30-34	2.1	1.3	1.1	0.5	0.3	0.3	0.2	0.1	0.1	0.1	6.0
35-39	1.8	1.2	0.8	0.6	0.4	0.2	0.2	0.3	0.1	0.1	5.5
40-44	1.3	0.9	0.8	0.3	0.3	0.2	0.1	0.1	0.0	0.0	4.1
45-49	0.7	0.5	0.8	0.4	0.2	0.1	0.1	0.0	0.1	0.0	2.9
50-54	1.0	1.0	0.6	0.6	0.3	0.3	0.1	0.1	0.1	0.1	4.1
55-59	0.9	0.6	0.7	0.2	0.5	0.1	0.0	0.1	0.0	0.0	3.2
60-64	1.1	1.0	0.8	0.6	0.3	0.6	0.2	0.1	0.1	0.0	4.8
65-69	1.3	0.7	0.5	0.3	0.4	0.1	0.2	0.2	0.2	0.1	4.0
70-74	1.2	1.0	1.1	0.5	0.2	0.2	0.1	0.1	0.0	0.0	4.4
75-79	1.0	1.8	0.6	0.9	0.6	0.2	0.1	0.1	0.2	0.1	5.7
80-84	2.1	2.7	0.4	0.5	0.5	1.0	0.8	0.2	0.0	0.0	8.3
85+	5.7	13.5	0.2	2.5	4.5	0.8	0.0	0.1	0.0	0.0	27.9
Overall	1.6	1.1	1.0	0.5	0.4	0.2	0.2	0.2	0.1	0.1	5.3
Total Crash Pop.	21,000	15,000	13,000	7,000	5,000	3,000	2,000	2,000	1,000	1,000	70,000

Yet another method of analyzing the driver age statistics would be to normalize them by the number of licensed drivers per age group. Table 23 shows the breakdown of the driver involvement rate per 1,000 licensed drivers for each age group across all ten scenarios per year based on 1995-1998 GES statistics. Overall, there were about 0.38 driver involved in pedestrian crashes per 1,000 licensed drivers. Drivers aged less than 20 years old held the highest probability of being involved in a crash with pedestrians at over 0.8 driver per 1,000 licensed drivers. Nearly 6 drivers per 10,000 licensed drivers in the 85+ age group were involved in crashes with pedestrians, the age group thus having the second-highest driver involvement rate based on the licensed driver population. Figures E7 through E9 in Appendix E display the driver involvement rates per 1,000 licensed drivers across each age group for each scenario independently. Generally, the Figures show that younger drivers had the highest crash involvement rate based on the licensed driver population in their own age group. The crash involvement rate declined with age until it climbed again for the oldest segment of driver population (85+). Once again, the driver involvement rate is not as uniform in the latter scenarios, as shown in Figure D11, due to the relative small sample size of the crash population in those scenarios and the potential sampling errors associated with the GES system.

Table 23. Driver Involvement per 1,000 Licensed Drivers per Age Group for Pedestrian Pre-Crash Scenarios (Based on 1995-1998 GES)

AGE (years)	Scenario										Overall per Age Cat.
	1	2	3	4	5	6	7	8	9	10	
Under 20	0.21	0.17	0.17	0.09	0.06	0.05	0.02	0.02	0.01	0.01	0.81
20-24	0.18	0.09	0.09	0.03	0.02	0.02	0.03	0.01	0.01	0.01	0.49
25-29	0.12	0.10	0.10	0.04	0.04	0.01	0.01	0.02	0.01	0.01	0.44
30-34	0.17	0.11	0.09	0.05	0.03	0.02	0.01	0.01	0.01	0.01	0.50
35-39	0.14	0.10	0.07	0.05	0.03	0.01	0.02	0.02	0.01	0.01	0.44
40-44	0.11	0.07	0.07	0.03	0.03	0.01	0.01	0.01	0.00	0.00	0.33
45-49	0.06	0.04	0.06	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.24
50-54	0.07	0.07	0.04	0.04	0.02	0.02	0.01	0.01	0.00	0.01	0.29
55-59	0.07	0.04	0.05	0.02	0.04	0.00	0.00	0.01	0.00	0.00	0.23
60-64	0.08	0.07	0.06	0.04	0.02	0.04	0.01	0.01	0.00	0.00	0.33
65-69	0.08	0.04	0.03	0.02	0.03	0.01	0.01	0.01	0.01	0.00	0.24
70-74	0.06	0.05	0.05	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.21
75-79	0.03	0.06	0.02	0.03	0.02	0.01	0.00	0.00	0.01	0.00	0.19
80-84	0.06	0.07	0.01	0.02	0.01	0.03	0.02	0.00	0.00	0.00	0.23
85+	0.11	0.27	0.00	0.05	0.09	0.02	0.00	0.00	0.00	0.00	0.56
Overall	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.38
Total Crash Pop.	21,000	15,000	13,000	7,000	5,000	3,000	2,000	2,000	1,000	1,000	70,000

6.2. Pedestrian Age

Table 24 presents the distribution of pedestrian *age* within each pre-crash scenario with the "Total" row reflecting the number of pedestrians and not crashes. Table 24 also shows the age distribution for the ten scenarios combined, as shown on the "Totals" column to the right of the table.

Table 24. Pedestrian Age Distribution for Pre-Crash Scenarios
(Based on 1995-1998 GES)

AGE (years)	Scenario										Totals
	1	2	3	4	5	6	7	8	9	10	
0-4	4.4%	2.0%	16.5%	1.1%	0.6%	0.4%	4.8%	1.9%	1.0%	11.9%	5.1%
5-9	13.1%	9.5%	34.4%	2.5%	1.3%	3.9%	36.6%	1.9%	3.2%	20.6%	13.9%
10-14	11.3%	17.3%	20.0%	8.9%	4.1%	10.1%	22.1%	5.4%	7.7%	13.6%	13.4%
15-19	10.8%	10.3%	9.2%	9.3%	13.5%	21.9%	13.9%	9.1%	10.4%	2.6%	11.0%
20-24	8.7%	7.6%	2.7%	8.7%	6.9%	10.6%	7.2%	10.3%	12.9%	3.3%	7.4%
25-29	7.4%	7.8%	3.0%	9.5%	6.6%	6.5%	1.3%	6.9%	8.8%	16.4%	6.8%
30-34	7.4%	9.2%	2.0%	6.0%	11.5%	7.6%	2.3%	9.9%	2.6%	7.2%	6.9%
35-39	9.0%	8.5%	1.4%	9.7%	7.5%	5.7%	2.8%	13.4%	16.4%	8.4%	7.5%
40-44	6.9%	5.7%	4.3%	9.8%	8.8%	8.5%	2.2%	5.0%	6.0%	9.0%	6.5%
45-49	5.1%	4.9%	1.3%	6.9%	7.6%	7.2%	1.3%	7.9%	13.7%	1.8%	5.0%
50-54	3.4%	3.0%	1.4%	6.1%	6.3%	5.6%	2.1%	5.1%	6.1%	4.0%	3.6%
55-59	2.4%	3.2%	1.3%	3.7%	4.3%	4.0%	0.1%	2.1%	0.0%	0.0%	2.6%
60-64	1.4%	1.3%	0.9%	4.4%	5.0%	2.0%	0.4%	2.8%	7.3%	0.7%	2.0%
65-69	2.2%	2.6%	0.3%	3.3%	6.0%	3.2%	0.5%	8.1%	2.0%	0.4%	2.5%
70-74	2.3%	2.2%	0.2%	4.7%	4.9%	1.1%	1.5%	2.7%	0.0%	0.0%	2.2%
75-79	2.1%	2.8%	0.5%	2.5%	1.8%	0.4%	0.0%	2.9%	1.5%	0.0%	1.8%
80-84	0.8%	1.3%	0.6%	2.0%	2.2%	1.3%	0.5%	2.7%	0.6%	0.0%	1.2%
85-89	0.9%	0.6%	0.0%	0.7%	0.7%	0.0%	0.3%	0.9%	0.0%	0.0%	0.6%
90-94	0.3%	0.2%	0.0%	0.0%	0.3%	0.0%	0.0%	0.6%	0.0%	0.0%	0.2%
95+	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	16,000	13,000	7,000	6,000	4,000	2,000	2,000	2,000	1,000	74,000

As can be readily seen, children accounted for a great portion of pedestrians in every pre-crash scenario based on GES statistics. In the scenario in which the *vehicle is going straight and pedestrian is darting onto the roadway at a non-junction* (scenario 3), the age range of 0-14 years accounted for about 71% of that scenario's pedestrians. Nearly 50% of this group that comprised 34.4% of the total number of pedestrians in that scenario were in the 5-9 year-old age category. The same basic scenario but at an "intersection" (scenario 7) had similar results. About 64% of that scenario's crashes involved a pedestrian with age between 0 and 14 years old. About 46% of pedestrians playing or working in the roadway, as defined by scenario 10, were in the age bracket of 0 to 14 years old. Around 22% of pedestrians who were walking along the roadway at a non-junction, as defined by scenario 6, were between 15 and 19 years old.

Overall, children ranging from 0 to 14 years old accounted for roughly one-third of all pedestrians in the top ten pre-crash scenarios. The single highest age bin is the range of 5 to 9 year-olds, which accounted for about 14% of all pedestrians in the pre-crash scenarios. By contrast, pedestrians aged 60 years old or older accounted for 10.5% of all pedestrians.

The crash-involved pedestrian age distribution was also compared to the age distribution of the U.S. population based on data estimated by the U.S. Bureau of the Census from 1998 [8]. Figure 20 displays the percent distribution of each age category for the overall crash-involved pedestrian population, as well as the age distribution for the U.S. population. It shows the over-representation of young persons aged from 5 to 24 years

old and the under-representation of all others in the pedestrian crash population. More specifically, pedestrians aged from 5 to 9 years old represented nearly 14% of the pedestrians in this crash type and yet they only make up about 7.4% of the U.S. population (See Table F1 in Appendix F for actual population distribution numbers as of 1998 estimated by the U.S. Bureau of the Census). It should be noted that exposure data on walking by different age groups would be a better relative measure of risk by age group but such data are not readily available.

Pedestrian age distributions per scenario compared to the U.S. population distribution are enclosed in Appendix E in Figures E1 through Figure E5, with two scenarios displayed per Figure along with the U.S. population age distribution.

The breakdowns of crash-involved pedestrian age for scenario 1 and scenario 2 along with the age distribution of the U.S. population are also shown in Figure 21. As shown on the Figure for these two pre-crash scenarios, younger pedestrians were more likely to be struck by motor vehicles than older pedestrians. Furthermore, pedestrians in these two scenarios were over-represented in the 5 to 34 years old age groups. In scenario 2, defined *as vehicle going straight and crossing the roadway at an intersection*, roughly 17% of the pedestrians were aged from 10 to 14 years old.

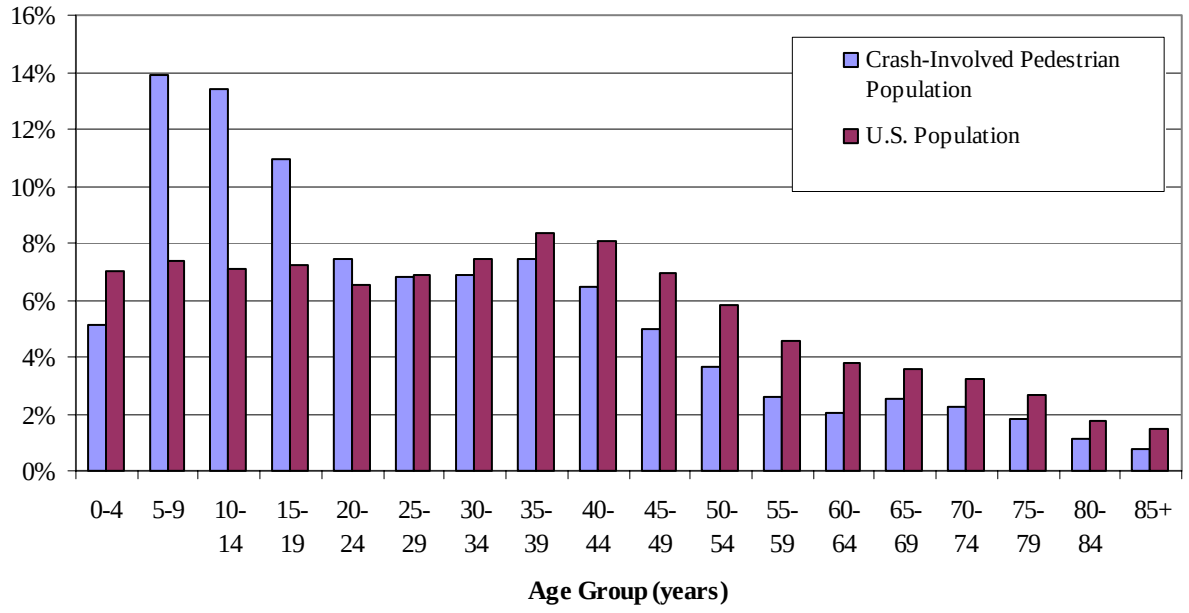

Figure 20. Crash-Involved Pedestrian Age Distribution and Overall Age Distribution of U.S. Population (Based on 1995-1998 GES)

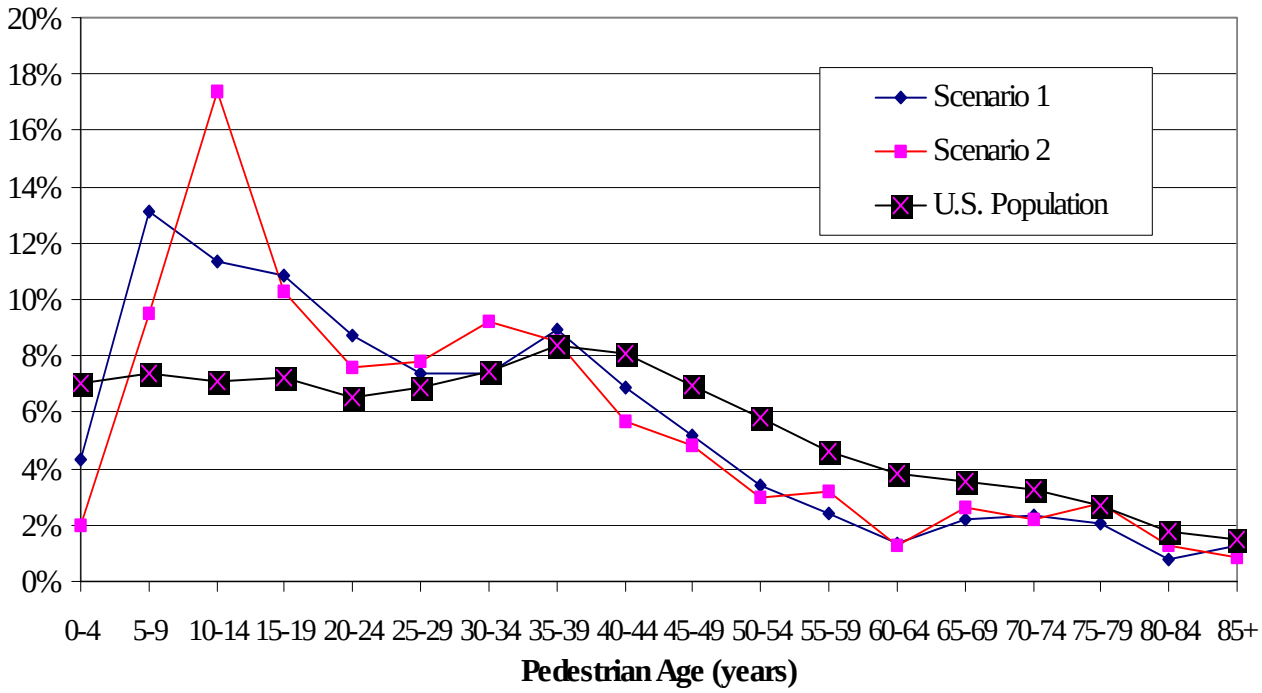

Figure 21. Crash-Involved Pedestrian Age Distribution for Scenarios 1 and 2 and Overall U.S. Population (Based on 1995-1998 GES)

As seen in Appendix E, scenario 3 has a very high relative frequency of pedestrians aged from 5 to 9 years old. It indicates that roughly 35% of pedestrians darting onto the roadway at a non-junction were in that young age group. As shown in the same Figure, scenario 4 has a pedestrian age distribution that more closely follows the U.S. population's age distribution. Scenario 4 is defined as *vehicle turning left and pedestrian crossing roadway at an intersection.*

Scenarios 5 and 6, as displayed in Figure E3 in Appendix E, show a relative over-representation of pedestrians in the 15 to 19 years old age group. Scenario 5 also shows a noticeable over-representation of older age pedestrians specifically those in the 60 to 74 years old range. Since scenario 5 is defined as *vehicle turning right and pedestrian crossing roadway at an intersection*, this could mean that the driver misjudged the walking speed of the pedestrian crossing the roadway and struck them. Since older pedestrians tend to need more time to cross the roadway, driver gap misjudgment could be a factor in this scenario.

Scenario 7 has a very high relative frequency of pedestrians aged from 5 to 9 years old as seen in Figure E4 in Appendix E. It indicates that nearly 37% of pedestrians darting onto the roadway at an intersection were in that young age group. This is roughly the same percentage of 5 to 9 years old pedestrians as in scenario 3 where the pedestrians darted onto the roadway at a non-junction.

7. CRASH SEVERITY

According to GES statistics about 74,000 pedestrians were involved in 70,000 pedestrian crashes in 1998. Analyzing the severity of pedestrians' injuries per pre-crash scenario gives insight as to the severity of each scenario relative to the overall pedestrian crash problem as well as relative to the other scenarios.

7.1. Number of Pedestrians per Crash

Table 25 presents GES statistics on the distribution of the "number of pedestrians involved per crash" in each of the ten scenarios as defined in this report, with the "Total" row accounting for the total number of pedestrians per scenario. As expected, most crashes involved one single pedestrian, accounting for about 96% of the crashes in the ten pre-crash scenarios. Crashes in which two pedestrians were involved accounted for 3.4% of the aggregate scenario population. Scenarios 6 and 9 (see Table 8) show the highest relative concentration of two-pedestrian crashes among the ten scenarios, both at 6% of each scenario. They are closely followed by scenario 8 with 5.8% of that scenario's crashes involving two pedestrians. In terms of absolute crashes, scenario 1 has the highest number of two-pedestrian crashes, accounting for about 700 such crashes. Overall, about 2,600 multi-pedestrian crashes occurred per year within the ten pedestrian pre-crash scenarios based on 1995-1998 GES statistics.

Table 25. Number of Pedestrians per Crash for Pre-Crash Scenarios
(Based on 1995-1998 GES)

# Of Peds. Per Crash	Scenario										Totals
	1	2	3	4	5	6	7	8	9	10	
1	96.5%	96.0%	98.3%	95.0%	96.8%	92.8%	98.9%	93.8%	91.1%	95.3%	96.3%
2	3.2%	3.8%	1.6%	4.6%	3.1%	6.1%	0.9%	5.9%	6.1%	2.3%	3.4%
3	0.2%	0.2%	0.1%	0.4%	0.2%	1.1%	0.2%	0.3%	2.8%	2.3%	0.3%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	16,000	13,000	7,000	6,000	4,000	2,000	2,000	2,000	1,000	74,000

7.2. Pedestrian Injury Severity

The injury severity sustained by the pedestrian in a crash is determined by querying the GES database for the codes associated with the *Injury Severity* variable found in the "Person File" [6]. The codes for this variable indicate the maximum police reported injury severity for each pedestrian following a KABCO injury scale as shown below.

Injury Severity
Code 00 = "No Injury (O)"
Code 01 = "Possible Injury (C)"
Code 02 = "Non-Incapacitating Injury (B)"

Code 03 = “Incapacitating Injury (A)”
Code 04 = “Fatal Injury (K)”
Code 05 = “Injured, Severity Unknown (U)”
Code 06 = “Died Prior to Crash”

Figure 22 displays the aggregate pedestrian *Injury Severity* distribution for all ten pre-crash scenarios. Overall, most pedestrian injuries were “non-incapacitating” in nature, accounting for about 35% of all injuries. “Incapacitating” injuries accounted for 23% and “Fatal” injuries accounted for nearly 4% of all pedestrian injuries within the ten pedestrian pre-crash scenarios.

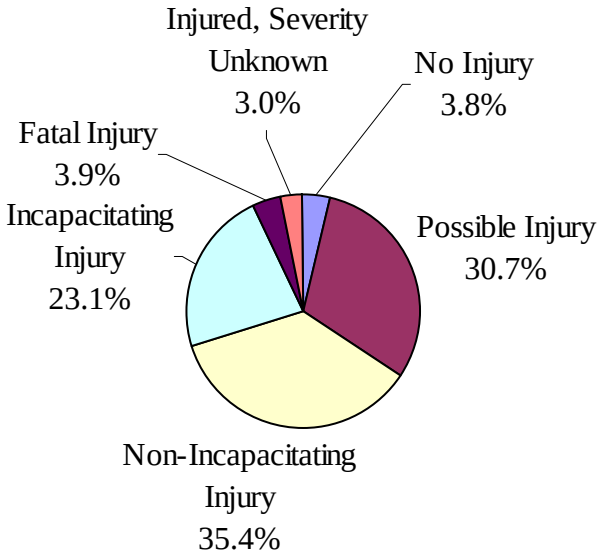

Figure 22. Distribution of Pedestrian Injury Severity over All Pre-Crash Scenarios (Based on 1995-1998 GES)

Table 26 and Figure 23 illustrate the distribution of pedestrian *Injury Severity* for each pre-crash scenario independently. “Incapacitating” and “Fatal” injuries were most common in scenario 9, where the vehicle is going straight and pedestrian is not in roadway at non-junction. Referring back to Table 10, about 41% of crashes in this scenario occurred on roads where the speed limit is 45 mph or above, higher than in any other “non-junction” pre-crash scenario. Also, as reflected in Figures 9 and 13, scenario 9 had the highest relative frequencies of “Alcohol/Drugs” involvement, “Speeding/ Reckless Driving,” “Driver Lost Control” and “Driver Distracted By” contributing factors.

Scenario 6, in which about 33% of crashes occurred where the speed limit is at least 45 mph, contains the second-highest percentage of “Incapacitating” pedestrian injuries. As seen in Figure 23, left-turning vehicles tended to inflict more serious injuries than right-turning vehicles, as denoted by scenarios 4 and 5 respectively. One possible reason for

Table 26. Pedestrian Injury Severity Distribution for Pre-Crash Scenarios
(Based on 1995-1998 GES)

Injury Severity	Scenario										Totals
	1	2	3	4	5	6	7	8	9	10	
No Injury	3.0%	5.6%	3.4%	2.7%	3.5%	0.2%	3.5%	15.0%	0.6%	0.7%	3.8%
Possible Injury	24.0%	32.8%	24.4%	35.5%	58.7%	24.1%	36.1%	43.5%	24.0%	27.1%	30.7%
Non-Incapacitating Injury	34.0%	36.5%	39.2%	40.2%	27.2%	34.1%	32.5%	29.4%	29.1%	46.0%	35.4%
Incapacitating Injury	29.5%	20.9%	23.2%	17.0%	8.6%	32.6%	21.1%	10.0%	37.6%	23.6%	23.1%
Fatal Injury	6.7%	3.3%	3.2%	0.6%	0.1%	6.5%	1.7%	1.6%	7.6%	2.0%	3.9%
Injured, Severity Unknown	2.8%	0.9%	6.6%	4.0%	1.8%	2.4%	5.1%	0.4%	1.1%	0.7%	3.0%
% Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total	21,000	16,000	13,000	7,000	6,000	4,000	2,000	2,000	2,000	1,000	74,000

this phenomenon is the larger turning radius afforded left-turning vehicles, enabling them to turn at a higher velocity than right-turning vehicles [9]. Pedestrians in scenarios 5 and 8 were less likely to receive major injuries as a result of being struck by a vehicle. Since scenario 5 describes vehicles turning right at an intersections and scenario 8 describes vehicles backing up, the relatively low serious injury risk is most likely due to the low speeds involved in these two scenarios. On a relative scale, "non-junction" pedestrian injuries tended to be more serious than "intersection"-related injuries due to the vehicle speeds involved.

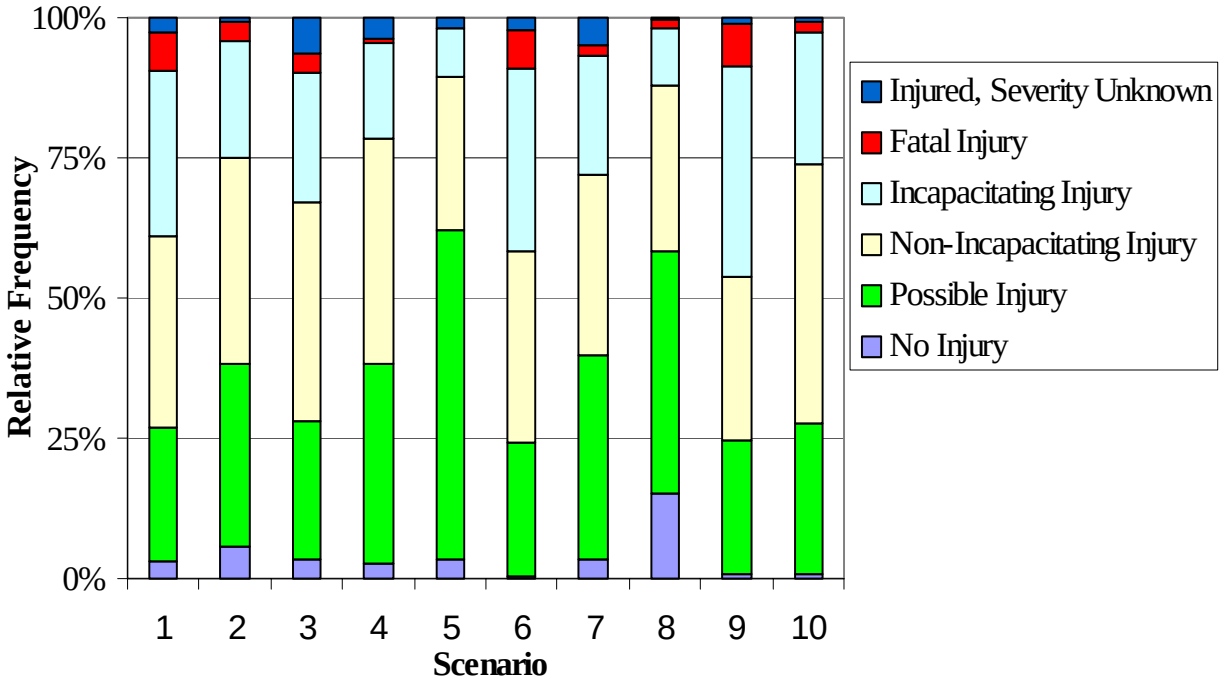

Figure 23. Distribution of Pedestrian *Injury Severity* per Pre-Crash Scenario
(Based on 1995-1998 GES)

7.3. Comparison between GES and FARS Results

A four-year set of FARS databases (1995-1998) was queried and the results were compared to GES statistics. When comparing the FARS pre-crash scenarios to the pre-crash scenarios found from the GES (see Table 8), only scenarios 3 and 4 are common between the FARS and GES databases.

Table 27 compares the two databases for the two common scenarios by displaying the fatality frequency of each scenario relative to all pedestrian fatalities. As seen in Table 27, about 10% of all pedestrian fatalities occurred in the scenario in which the vehicle was going straight and the pedestrian was walking, playing, or working in the roadway based on GES statistics. This is based on the number of fatalities found in scenarios 6 and 10 combined as a percentage of the total number of fatalities over the top ten scenarios in the GES (see Table 26). In comparison, about 25% of all pedestrian fatalities occurred in this same scenario based on FARS statistics. Since the FARS system depends on the total number of actual fatal crashes, it could be determined that pedestrian fatalities for this scenario were under-represented in the GES system. In contrast, fatalities seem to have been over-represented in the GES system in the case in which the vehicle is going straight and the pedestrian either darts, stumbles, or runs into the roadway. Pedestrian fatalities in that category accounted for about 16% of all pedestrian fatalities based on GES statistics while accounting for only 10% based on FARS statistics. The GES calculation is based on the number of fatalities found in scenarios 3 and 7 combined as a percentage of the total number of fatalities over the top ten scenarios in the GES (see Table 26).

Table 27. GES vs. FARS Pre-Crash Scenario Comparison of Fatal Pedestrian Crashes (Based on 1995-1998 FARS and 1995-1998 GES)

Pre-Crash Scenario	Freq. Of Total Fatalities	
	GES*	FARS
Vehicle going straight and pedestrian walk/play/work in roadway	10%	25%
Vehicle going straight and pedestrian darts/stumbles/runs onto roadway	16%	10%

* GES Frequency calculated from pedestrian fatality rate within "Specific" scenarios

8. CONCLUSIONS AND RECOMMENDATIONS

This report presents the results from a study of the pedestrian crash problem in the U.S. based on a four-year set of data from the GES and FARS databases. Specifically, this study identified prevalent pre-crash scenarios, described their physical setting, and provided statistics on driver/pedestrian age and pedestrian injury severity per scenario. This study also examined possible contributing factors that might be prominent in pedestrian crashes. The following is a list of major observations and summary points obtained from the pedestrian crash data analyzed in this study:

1. According to GES statistics, there were about 70,000 vehicle-pedestrian crashes in the U.S. in 1998. Approximately 74,000 pedestrians were involved in such crashes.

2. Younger pedestrians, especially those aged from 5 to 9 years old, were most susceptible vehicle-pedestrian crashes, accounting for nearly 14% of all pedestrians involved in pedestrian crashes. The pedestrian age group of 5-24 years old composed about 46% of the pedestrian crash population and was the only age group over-represented in terms of the U.S. population.

3. Pedestrians aged from 5 to 9 years old had about the same relative frequency in the two pre-crash scenarios where pedestrians darted onto the roadway. This age group accounted for about 35% of the pedestrians in scenario 3 where the vehicle is going straight and pedestrian is darting onto the roadway at a non-junction. The same age group accounted for nearly 37% of the pedestrian population in scenario 7 where the vehicle is going straight and pedestrian is darting onto the roadway at an intersection.

4. Almost 60% of pedestrian crashes in which the pedestrian was walking along the roadway at a non-junction occurred at nighttime. Roughly 43% of pedestrians in this pre-crash scenario were aged from 10 to 24 years old. About 22% were in the 15 to 19 years old age group.

5. Pedestrian injuries tended to be more severe away from junctions. At intersections, injuries were much more severe in the scenario where the vehicle was turning left versus the scenario in which the vehicle was turning right.

6. Pedestrian fatalities accounted for about 14.6% of all vehicle-related fatalities, as determined from FARS statistics.

7. A very high percentage of drivers reported vision obscurity in the pre-crash scenarios where the pedestrian darted onto the roadway, namely scenarios 3 and 7. Almost 44% of drivers reported vision obscurity in scenario 3 at non-junction and about 35% of drivers reported vision obscurity in scenario 7 at intersections.

8. The majority of pedestrian crashes (60%) happened away from intersections.

9. Most pedestrian crashes at non-junctions occurred on straight, non-hillcrest roadways.

10. Most non-junction crashes occurred on roadways with speed limits between 25 mph and 35 mph.

11. 3-color signals were reported in 45% of "intersection" crashes while "no controls" were coded in 36% of "intersection" crashes. It should be noted that "no controls" coding in the GES refers only to the direction of the road the vehicle is traveling on.

12. Overall, about 17% of all pedestrians involved in the ten pre-crash scenarios were in the crosswalk at the time of impact. Almost all pedestrians involved in pre-crash scenarios at non-junctions (scenarios 1, 3, 6, 9, and 10) were reported not in the crosswalk at the time of crash. In contrast, about 38% of all pedestrians involved in pre-crash scenarios at intersections (scenarios 2, 4, 5, and 7) were present in the crosswalk at the time of impact.

13. Hit and run cases were prevalent in pedestrian crashes, ranging from 15 to 19% of these crashes.

14. Alcohol involvement was particularly high for drivers in scenarios 6 and 9 where the pedestrian was either walking along the roadway at non-junctions or simply not in the roadway. On the other hand, a high percentage of drunk pedestrians was observed in scenarios 1, 2, and 6 in which the pedestrian was either crossing the roadway or walking along the roadway.

15. The age group of 30-34 years old had the greatest frequency of drivers involved in pedestrian crashes, accounting for about 14% of all drivers involved in pedestrian crashes. Relative to the licensed driver population, drivers under the age of 20 years old were most likely to be involved in pedestrian crashes. Such drivers comprised about 5.3% of the total licensed driver population and yet were involved in more than 11% of pedestrian-related crashes.

16. According to 1995-1998 FARS data, an average of 5,400 pedestrians are killed in crashes each year. About 25% of those fatalities occurred in the pre-crash scenario where the vehicle is *going straight and the pedestrian is walking/playing/working in roadway*.

Some recommendations are offered below based on our analysis of available data, which would enhance our understanding of the pedestrian crash problem.

1. Data on walking exposure could provide some further insight as to what age groups are most susceptible to the pedestrian crash type. Specifically, seniors are under-represented in pedestrian crash populations as compared to the U.S. population but it could be that they also walk much less than the rest of the population. Comparing pedestrian-related crashes to such exposure data could prove more insightful.

2. A significant number of pedestrian-related crashes occurred at nighttime. Information on what types of clothes the pedestrians are wearing could provide further insight into the development of vehicle-based and vehicle-infrastructure cooperative countermeasure systems. The GES, CDS, and FARS databases do not contain information on this attribute but the Washington State Department of Transportation's crash databases contain a variable on the color of pedestrian clothes which is divided into five categories as follows: "Dark," "Light," Mixed," Retro-Reflective," and "Other Reflective Apparel." Thus, in future analysis, it should be taken into account that the Washington State crash databases contain possible "added value" to the national databases used in this study.

3. Since a very high percentage of drivers reported vision obscurity in the pre-crash scenarios where the pedestrian darted onto the roadway, namely scenarios 3 and 7, the vehicle type breakdown for these scenarios should be investigated.

Finally, the results obtained from this analysis are intended to support effective pedestrian crash countermeasure concept development and provide data for design effectiveness assessments.

9. REFERENCES

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APPENDIX A

This Appendix shows the tables correlating the prioritized driver contributing factors with the pedestrian contributing factors as described in Section 5. These tables are based on the number of pedestrians and not the number of crashes. Table A1 below is a duplicate of Table 16 discussed in subsection 5.1.3.

Table A1. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 1 (Based on 1995-1998 GES)

Driver Contributing Factors	**Pedestrian Contributing Factors**				**Totals**
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.8%	0.1%	2.0%	3.5%	6.4%
Impaired	0.0%	0.0%	0.1%	0.0%	0.1%
Driver Distracted By	0.1%	0.0%	0.7%	2.3%	3.1%
Driver Vision Obscured By	0.2%	0.0%	1.6%	1.8%	3.6%
Speeding/Reckless Driving	0.0%	0.0%	0.6%	0.9%	1.6%
Sign/Signal Violation	0.0%	0.0%	0.1%	0.3%	0.4%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.1%
Other Violation Charged	0.3%	0.0%	3.3%	5.1%	8.7%
Hit & Run	0.9%	0.0%	5.1%	9.2%	15.3%
Other/Day Clear	1.4%	0.1%	16.4%	13.9%	31.8%
Other/Day Adverse	0.1%	0.0%	1.7%	1.1%	2.8%
Other/Night Clear	5.3%	0.2%	10.6%	5.6%	21.6%
Other/Night Adverse	0.7%	0.1%	2.3%	1.4%	4.5%
% Total	9.9%	0.4%	44.5%	45.1%	100.0%
			Number of Pedestrians in Scenario =		21,000

Table A2. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 2 (Based on 1995-1998 GES)

Driver Contributing Factors	**Pedestrian Contributing Factors**				**Totals**
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.9%	0.0%	0.9%	5.4%	7.2%
Impaired	0.0%	0.0%	0.0%	0.1%	0.1%
Driver Distracted By	0.0%	0.0%	0.1%	0.7%	0.9%
Driver Vision Obscured By	0.4%	0.0%	0.6%	4.4%	5.3%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	0.3%	0.3%
Sign/Signal Violation	0.1%	0.0%	0.2%	3.0%	3.2%
Driver Lost Control	0.0%	0.0%	0.0%	0.1%	0.1%
Other Violation Charged	0.2%	0.0%	0.7%	8.7%	9.7%
Hit & Run	2.8%	0.0%	1.3%	17.9%	22.0%
Other/Day Clear	1.1%	0.6%	7.3%	16.7%	25.6%
Other/Day Adverse	0.0%	0.1%	0.5%	4.1%	4.7%
Other/Night Clear	2.6%	0.3%	4.4%	8.2%	15.5%
Other/Night Adverse	1.3%	0.0%	1.1%	2.9%	5.3%
% Total	9.5%	1.0%	17.1%	72.3%	100.0%
			Number of Pedestrians in Scenario =		16,000

Table A3. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 3
(Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.1%	0.0%	0.4%	1.0%	1.6%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	0.0%	0.0%	0.2%	0.9%	1.0%
Driver Vision Obscured By	1.5%	0.1%	7.3%	32.7%	41.5%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	0.2%	0.2%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.0%
Other Violation Charged	0.0%	0.0%	0.0%	3.2%	3.2%
Hit & Run	0.1%	0.0%	0.1%	2.9%	3.1%
Other/Day Clear	0.5%	0.2%	0.7%	33.2%	34.6%
Other/Day Adverse	0.0%	0.0%	0.0%	1.3%	1.3%
Other/Night Clear	1.8%	0.0%	0.1%	9.8%	11.6%
Other/Night Adverse	0.0%	0.0%	0.0%	1.8%	1.8%
% Total	3.9%	0.3%	8.7%	87.0%	100.0%
			Number of Pedestrians in Scenario =		13,000

Table A4. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 4
(Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.0%	0.1%	0.3%	2.6%	3.0%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	0.0%	0.0%	0.1%	2.7%	2.8%
Driver Vision Obscured By	0.0%	0.1%	0.2%	4.9%	5.2%
Speeding/Reckless Driving	0.0%	0.1%	0.1%	0.6%	0.8%
Sign/Signal Violation	0.1%	0.0%	0.2%	8.4%	8.6%
Driver Lost Control	0.0%	0.0%	0.0%	0.6%	0.6%
Other Violation Charged	0.7%	0.2%	0.3%	13.2%	14.4%
Hit & Run	0.3%	0.0%	0.5%	13.1%	13.9%
Other/Day Clear	1.0%	0.1%	4.8%	26.2%	32.1%
Other/Day Adverse	0.1%	0.0%	0.2%	3.0%	3.3%
Other/Night Clear	0.6%	0.0%	0.7%	8.2%	9.5%
Other/Night Adverse	0.2%	0.0%	0.7%	5.0%	5.8%
% Total	3.0%	0.6%	8.0%	88.4%	100.0%
			Number of Pedestrians in Scenario =		7,000

Table A5. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 5
(Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.3%	0.0%	2.0%	6.9%	9.1%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	0.0%	0.0%	0.0%	1.2%	1.2%
Driver Vision Obscured By	0.0%	0.0%	0.4%	1.1%	1.5%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	0.2%	0.2%
Sign/Signal Violation	0.0%	0.0%	0.1%	11.9%	12.0%
Driver Lost Control	0.0%	0.0%	0.0%	0.4%	0.4%
Other Violation Charged	0.2%	0.0%	0.2%	5.1%	5.6%
Hit & Run	0.0%	0.0%	0.1%	23.2%	23.3%
Other/Day Clear	0.1%	0.0%	4.6%	25.8%	30.4%
Other/Day Adverse	0.0%	0.0%	0.0%	4.7%	4.7%
Other/Night Clear	0.2%	0.0%	2.0%	5.3%	7.5%
Other/Night Adverse	1.2%	0.0%	0.2%	2.8%	4.2%
% Total	2.0%	0.0%	9.5%	88.5%	100.0%
			Number of Pedestrians in Scenario =		6,000

Table A6. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 6
(Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	1.0%	1.8%	0.0%	12.4%	15.3%
Impaired	0.0%	0.0%	0.0%	2.2%	2.2%
Driver Distracted By	0.0%	0.0%	0.0%	3.0%	3.0%
Driver Vision Obscured By	0.4%	0.0%	0.0%	3.8%	4.2%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	0.8%	0.8%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	0.0%	0.0%	0.0%	0.1%	0.1%
Other Violation Charged	1.1%	0.0%	0.0%	3.6%	4.8%
Hit & Run	2.9%	0.0%	0.0%	23.6%	26.4%
Other/Day Clear	0.2%	0.0%	0.0%	11.7%	11.9%
Other/Day Adverse	0.0%	0.0%	0.0%	2.3%	2.3%
Other/Night Clear	4.2%	0.0%	0.0%	20.6%	24.9%
Other/Night Adverse	0.6%	0.0%	0.0%	3.4%	4.1%
% Total	10.5%	1.8%	0.0%	87.7%	100.0%
			Number of Pedestrians in Scenario =		4,000

Table A7. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 7
(Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.0%	0.0%	0.0%	1.2%	1.2%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	0.0%	0.0%	0.0%	0.2%	0.2%
Driver Vision Obscured By	0.5%	0.0%	2.5%	31.0%	34.0%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation	0.0%	0.0%	0.3%	0.0%	0.3%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.0%
Other Violation Charged	0.0%	0.0%	0.0%	4.7%	4.7%
Hit & Run	0.0%	0.0%	0.5%	1.2%	1.8%
Day Clear Conditions	0.7%	0.0%	4.1%	30.2%	35.0%
Day Adverse Conditions	0.0%	0.0%	0.7%	1.2%	1.9%
Night Clear Conditions	1.3%	0.0%	0.0%	14.8%	16.0%
Night Adverse Conditions	0.6%	0.0%	0.0%	4.2%	4.8%
% Total	3.1%	0.0%	8.1%	88.8%	100.0%
			Number of Pedestrians in Scenario =		2,000

Table A8. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 8
(Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.5%	0.0%	0.8%	6.8%	8.1%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	0.0%	0.0%	0.0%	9.0%	9.0%
Driver Vision Obscured By	0.0%	0.0%	0.3%	0.4%	0.7%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	0.3%	0.3%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.0%
Other Violation Charged	0.0%	0.0%	1.5%	10.4%	11.9%
Hit & Run	0.0%	0.0%	6.5%	18.7%	25.2%
Other/Day Clear	0.1%	0.8%	3.1%	19.3%	23.3%
Other/Day Adverse	0.0%	0.0%	0.5%	2.1%	2.6%
Other/Night Clear	0.0%	0.0%	3.8%	6.9%	10.7%
Other/Night Adverse	0.0%	0.0%	0.3%	8.0%	8.3%
% Total	0.6%	0.8%	16.7%	81.9%	100.0%
			Number of Pedestrians in Scenario =		2,000

Table A9. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 9 (Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.4%	0.0%	0.0%	16.4%	16.8%
Impaired	0.0%	0.0%	0.0%	0.9%	0.9%
Driver Distracted By	0.0%	0.0%	0.0%	8.8%	8.8%
Driver Vision Obscured By	0.0%	0.0%	0.0%	1.2%	1.2%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	7.7%	7.7%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	0.0%	0.0%	0.0%	9.3%	9.3%
Other Violation Charged	0.0%	0.0%	0.0%	12.4%	12.4%
Hit & Run	0.3%	0.0%	0.0%	21.9%	22.2%
Other/Day Clear	0.0%	0.0%	0.0%	12.5%	12.5%
Other/Day Adverse	0.0%	0.0%	0.0%	0.0%	0.0%
Other/Night Clear	0.0%	0.0%	0.5%	7.7%	8.2%
Other/Night Adverse	0.0%	0.0%	0.0%	0.0%	0.0%
% Total	0.7%	0.0%	0.5%	98.8%	100.0%
			Number of Pedestrians in Scenario =		2,000

Table A10. Prioritized Driver/Pedestrian Contributing Factors Breakdown for Scenario 10 (Based on 1995-1998 GES)

Driver Contributing Factors	Pedestrian Contributing Factors				Totals
	Alcohol/Drugs	Impaired	Improper Crossing	All Other Peds.	
Alcohol/Drugs	0.0%	0.0%	0.0%	11.8%	11.8%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	0.0%	0.0%	0.0%	6.0%	6.0%
Driver Vision Obscured By	0.0%	0.0%	0.0%	4.3%	4.3%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.0%
Other Violation Charged	0.0%	0.0%	0.0%	21.6%	21.6%
Hit & Run	0.0%	0.0%	0.0%	19.5%	19.5%
Other/Day Clear	0.0%	0.0%	0.0%	22.1%	22.1%
Other/Day Adverse	0.0%	0.0%	0.0%	0.0%	0.0%
Other/Night Clear	0.0%	0.0%	0.0%	14.0%	14.0%
Other/Night Adverse	0.0%	0.0%	0.0%	0.7%	0.7%
% Total	0.0%	0.0%	0.0%	100.0%	100.0%
			Number of Pedestrians in Scenario =		1,000

APPENDIX B

This Appendix shows the tables containing the complete driver contributing factors breakdown for each pedestrian pre-crash scenario, starting with Table B1 for pre-crash scenario 1 and ending with Table B10 for pre-crash scenario 10. These tables give a complete (non-prioritized) picture of the entire set of driver contributing factors in each scenario. That is, these tables contain every factor that was present for the driver in every crash for each pre-crash scenario. Each cell in the tables is not mutually exclusive and therefore can only be compared to the shaded value given in the same row. Shaded values represent the total percentage of each contributing factor relative to each scenario (see Table 18 for comparison of Table B1). Due to the symmetric nature of Tables B1 through B10, half of the cells in each table are empty due to redundant information, the lower part below the diagonal of the matrix being a mirror image of the upper part. See Section 5.2 for a discussion of the results presented herein.

Table B1. Driver Contributing Factors Breakdown for Scenario 1
(Based on 1995-1998 GES)

Scenario 1	**Driver Contributing Factors**								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	6.1%	0.3%	0.1%	0.0%	0.1%	0.0%	0.2%	0.2%	4.2%
Impaired		0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			3.2%	0.1%	0.0%	0.0%	0.0%	0.3%	0.2%
Driver Vision Obscured By				4.3%	0.4%	0.0%	0.0%	0.5%	0.6%
Speeding/Reckless Driving					2.2%	0.0%	0.0%	0.0%	0.1%
Sign/Signal Violation						0.4%	0.0%	0.0%	0.0%
Driver Lost Control							0.3%	0.0%	0.2%
Other Violation Charged								10.5%	1.1%
Hit & Run									19.1%
						Crash Population =			21,000

Table B2. Driver Contributing Factors Breakdown for Scenario 2
(Based on 1995-1998 GES)

Scenario 2	**Driver Contributing Factors**								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	7.2%	0.2%	0.1%	0.1%	0.0%	0.2%	0.0%	0.2%	5.3%
Impaired		0.3%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%	0.0%
Driver Distracted By			1.0%	0.1%	0.0%	0.2%	0.0%	0.2%	0.2%
Driver Vision Obscured By				5.6%	0.0%	0.9%	0.0%	1.2%	0.0%
Speeding/Reckless Driving					0.4%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation						4.7%	0.0%	0.0%	0.0%
Driver Lost Control							0.1%	0.1%	0.0%
Other Violation Charged								11.6%	0.4%
Hit & Run									27.6%
						Crash Population =			15,000

Table B3. Driver Contributing Factors Breakdown for Scenario 3
(Based on 1995-1998 GES)

Scenario 3	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	1.4%	0.1%	0.0%	0.6%	0.0%	0.0%	0.0%	0.1%	0.6%
Impaired		0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			1.0%	0.9%	0.0%	0.0%	0.0%	0.2%	0.0%
Driver Vision Obscured By				43.6%	0.1%	0.0%	0.0%	4.6%	0.4%
Speeding/Reckless Driving					0.3%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation						0.0%	0.0%	0.0%	0.0%
Driver Lost Control							0.0%	0.0%	0.0%
Other Violation Charged								8.1%	0.1%
Hit & Run									3.8%
						Crash Population =			13,000

Table B4. Driver Contributing Factors Breakdown for Scenario 4
(Based on 1995-1998 GES)

Scenario 4	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	2.8%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.2%	1.9%
Impaired		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			3.0%	0.0%	0.0%	0.2%	0.0%	0.6%	0.1%
Driver Vision Obscured By				5.2%	0.1%	1.9%	0.0%	0.6%	0.1%
Speeding/Reckless Driving					0.9%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation						11.0%	0.0%	0.0%	0.1%
Driver Lost Control							0.2%	0.2%	0.0%
Other Violation Charged								15.3%	0.4%
Hit & Run									16.4%
						Crash Population =			7,000

Table B5. Driver Contributing Factors Breakdown for Scenario 5
(Based on 1995-1998 GES)

Scenario 5	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	9.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.1%	7.6%
Impaired		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			1.2%	0.2%	0.0%	0.1%	0.0%	0.0%	0.1%
Driver Vision Obscured By				1.7%	0.0%	0.2%	0.0%	0.3%	0.0%
Speeding/Reckless Driving					0.2%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation						12.5%	0.0%	0.0%	0.0%
Driver Lost Control							0.4%	0.0%	0.0%
Other Violation Charged								8.1%	0.8%
Hit & Run									29.9%
						Crash Population =			5,000

Table B6. Driver Contributing Factors Breakdown for Scenario 6
(Based on 1995-1998 GES)

Scenario 6	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	14.6%	0.5%	0.2%	0.2%	0.0%	0.0%	0.0%	0.6%	11.6%
Impaired		1.3%	0.0%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			3.5%	1.5%	0.0%	0.6%	0.0%	1.3%	0.3%
Driver Vision Obscured By				5.6%	0.0%	0.0%	0.0%	1.3%	0.0%
Speeding/Reckless Driving					0.9%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation						1.1%	0.0%	0.0%	0.6%
Driver Lost Control							0.3%	0.0%	0.2%
Other Violation Charged								8.7%	2.2%
Hit & Run									39.4%
						Crash Population =			3,000

Table B7. Driver Contributing Factors Breakdown for Scenario 7
(Based on 1995-1998 GES)

Scenario 7	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.9%
Impaired		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Vision Obscured By				34.9%	0.0%	0.8%	0.0%	2.1%	0.3%
Speeding/Reckless Driving					0.0%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation						1.1%	0.0%	0.0%	0.0%
Driver Lost Control							0.0%	0.0%	0.0%
Other Violation Charged								7.2%	0.5%
Hit & Run									2.7%
						Crash Population =			2,000

Table B8. Driver Contributing Factors Breakdown for Scenario 8
(Based on 1995-1998 GES)

Scenario 8	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	8.6%	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.7%	6.6%
Impaired		0.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
Driver Distracted By			4.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Vision Obscured By				0.7%	0.0%	0.0%	0.0%	0.0%	0.0%
Speeding/Reckless Driving					1.3%	0.0%	0.0%	0.0%	1.0%
Sign/Signal Violation						0.0%	0.0%	0.0%	0.0%
Driver Lost Control							0.0%	0.0%	0.0%
Other Violation Charged								12.5%	0.6%
Hit & Run									33.5%
						Crash Population =			2,000

Table B9. Driver Contributing Factors Breakdown for Scenario 9
(Based on 1995-1998 GES)

Scenario 9	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	16.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	1.7%	13.9%
Impaired		1.0%	0.0%	0.0%	1.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			10.2%	0.0%	0.0%	0.0%	1.6%	0.4%	0.4%
Driver Vision Obscured By				1.4%	0.0%	0.0%	0.0%	0.0%	0.0%
Speeding/Reckless Driving					9.6%	0.0%	2.2%	0.0%	0.0%
Sign/Signal Violation						0.0%	0.0%	0.0%	0.0%
Driver Lost Control							14.6%	3.6%	1.3%
Other Violation Charged								16.0%	2.2%
Hit & Run									37.5%
						Crash Population =			1,000

Table B10. Driver Contributing Factors Breakdown for Scenario 10
(Based on 1995-1998 GES)

Scenario 10	Driver Contributing Factors								
Driver Contributing Factors	Alcohol/ Drugs	Impaired	Driver Distracted	Vision Obsc.	Speeding/ Reckless	Sign/Signal Viol.	Lost Control	Other Viol.	Hit & Run
Alcohol/Drugs	8.3%	2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	2.2%
Impaired		2.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By			6.4%	0.0%	1.7%	0.0%	0.0%	0.0%	0.0%
Driver Vision Obscured By				4.2%	0.7%	0.0%	0.0%	0.0%	0.0%
Speeding/Reckless Driving					3.5%	0.0%	1.2%	0.0%	1.2%
Sign/Signal Violation						0.0%	0.0%	0.0%	0.0%
Driver Lost Control							1.2%	0.0%	1.2%
Other Violation Charged								23.2%	1.6%
Hit & Run									22.3%
						Crash Population =			1,000

APPENDIX C

This Appendix shows the atmospheric conditions breakdown of the non-prioritized driver contributing factors for each scenario independently, starting with Table C1 for pre-crash scenario 1 and ending with Table C10 for pre-crash scenario 10. These tables are based on a non-prioritized breakdown of driver contributing factors and therefore do not sum to 100%. This is due to the facts that some crashes in the GES data did not have any of the given contributing factors associated with them and, on the other hand, multiple factors could be associated with a crash and are therefore double-counted in these tables. The totals for each row represent the non-prioritized frequency of each contributing factor relative to the pre-crash scenario (see Table 20 for comparison of Table C1). See Section 5.3 for a discussion of the results presented herein.

Table C1. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 1 (Based on 1995-1998 GES)

Scenario 1	**Atmospheric Conditions**				**Total**
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	2.2%	0.5%	3.1%	0.4%	6.1%
Impaired	0.0%	0.0%	0.3%	0.1%	0.4%
Driver Distracted By	1.7%	0.0%	1.2%	0.4%	3.2%
Driver Vision Obscured By	3.2%	0.1%	0.5%	0.6%	4.3%
Speeding/Reckless Driving	1.2%	0.0%	0.5%	0.5%	2.2%
Sign/Signal Violation	0.1%	0.1%	0.2%	0.0%	0.4%
Driver Lost Control	0.2%	0.0%	0.1%	0.0%	0.3%
Other Violation Charged	5.3%	0.2%	4.4%	0.7%	10.5%
Hit & Run	7.9%	0.8%	8.9%	1.5%	19.1%
			Crash Population =		21,000

Table C2. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 2 (Based on 1995-1998 GES)

Scenario 2	**Atmospheric Conditions**				**Total**
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	3.8%	0.1%	3.1%	0.2%	7.2%
Impaired	0.1%	0.0%	0.2%	0.0%	0.3%
Driver Distracted By	0.9%	0.0%	0.1%	0.0%	1.0%
Driver Vision Obscured By	4.4%	0.2%	0.5%	0.4%	5.6%
Speeding/Reckless Driving	0.3%	0.1%	0.0%	0.0%	0.4%
Sign/Signal Violation	3.6%	0.1%	0.7%	0.3%	4.7%
Driver Lost Control	0.1%	0.0%	0.0%	0.0%	0.1%
Other Violation Charged	7.7%	1.4%	1.7%	0.8%	11.6%
Hit & Run	15.5%	1.4%	8.3%	2.3%	27.6%
			Crash Population =		15,000

Table C3. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 3 (Based on 1995-1998 GES)

Scenario 3	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	0.6%	0.1%	0.7%	0.0%	1.4%
Impaired	0.0%	0.0%	0.0%	0.0%	0.1%
Driver Distracted By	1.0%	0.0%	0.0%	0.0%	1.0%
Driver Vision Obscured By	31.1%	1.9%	8.9%	1.8%	43.6%
Speeding/Reckless Driving	0.1%	0.0%	0.2%	0.0%	0.3%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.0%
Other Violation Charged	6.0%	0.3%	1.5%	0.2%	8.1%
Hit & Run	2.3%	0.1%	0.7%	0.7%	3.8%
			Crash Population =		13,000

Table C4. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 4 (Based on 1995-1998 GES)

Scenario 4	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	1.6%	0.1%	0.8%	0.2%	2.8%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	1.2%	0.0%	1.7%	0.1%	3.0%
Driver Vision Obscured By	4.6%	0.3%	0.2%	0.1%	5.2%
Speeding/Reckless Driving	0.6%	0.1%	0.1%	0.1%	0.9%
Sign/Signal Violation	7.6%	1.0%	1.5%	0.9%	11.0%
Driver Lost Control	0.0%	0.0%	0.2%	0.0%	0.2%
Other Violation Charged	9.9%	1.0%	2.8%	1.6%	15.3%
Hit & Run	11.5%	1.5%	2.8%	0.6%	16.4%
			Crash Population =		7,000

Table C5. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 5 (Based on 1995-1998 GES)

Scenario 5	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	7.0%	0.0%	2.1%	0.2%	9.3%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	0.9%	0.0%	0.1%	0.2%	1.2%
Driver Vision Obscured By	1.6%	0.1%	0.0%	0.0%	1.7%
Speeding/Reckless Driving	0.2%	0.0%	0.0%	0.0%	0.2%
Sign/Signal Violation	10.0%	0.1%	2.0%	0.5%	12.5%
Driver Lost Control	0.4%	0.0%	0.0%	0.0%	0.4%
Other Violation Charged	6.4%	0.6%	0.8%	0.3%	8.1%
Hit & Run	17.6%	2.0%	9.6%	0.6%	29.9%
			Crash Population =		5,000

Table C6. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 6 (Based on 1995-1998 GES)

Scenario 6	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	2.8%	1.9%	9.0%	0.8%	14.6%
Impaired	0.8%	0.0%	0.4%	0.2%	1.3%
Driver Distracted By	3.0%	0.0%	0.5%	0.0%	3.5%
Driver Vision Obscured By	2.7%	0.2%	1.7%	1.0%	5.6%
Speeding/Reckless Driving	0.5%	0.0%	0.5%	0.0%	0.9%
Sign/Signal Violation	0.6%	0.0%	0.6%	0.0%	1.1%
Driver Lost Control	0.0%	0.0%	0.2%	0.2%	0.3%
Other Violation Charged	4.0%	0.2%	4.2%	0.2%	8.7%
Hit & Run	14.7%	2.1%	21.1%	1.5%	39.4%
			Crash Population =		3,000

Table C7. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 7 (Based on 1995-1998 GES)

Scenario 7	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	0.9%	0.4%	0.0%	0.0%	1.3%
Impaired	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Distracted By	0.0%	0.2%	0.0%	0.0%	0.2%
Driver Vision Obscured By	26.9%	2.8%	5.3%	0.0%	34.9%
Speeding/Reckless Driving	0.0%	0.0%	0.0%	0.0%	0.0%
Sign/Signal Violation	0.6%	0.0%	0.4%	0.0%	1.1%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.0%
Other Violation Charged	5.5%	0.7%	1.0%	0.0%	7.2%
Hit & Run	1.5%	0.3%	0.9%	0.0%	2.7%
			Crash Population =		2,000

Table C8. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 8 (Based on 1995-1998 GES)

Scenario 8	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	1.8%	0.6%	1.9%	4.4%	8.6%
Impaired	0.0%	0.0%	0.3%	0.0%	0.3%
Driver Distracted By	4.9%	0.0%	0.0%	0.0%	4.9%
Driver Vision Obscured By	0.7%	0.0%	0.0%	0.0%	0.7%
Speeding/Reckless Driving	1.3%	0.0%	0.0%	0.0%	1.3%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	0.0%	0.0%	0.0%	0.0%	0.0%
Other Violation Charged	10.1%	0.9%	0.9%	0.7%	12.5%
Hit & Run	14.4%	3.7%	4.8%	10.6%	33.5%
			Crash Population =		2,000

Table C9. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 9 (Based on 1995-1998 GES)

Scenario 9	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	4.5%	0.0%	9.6%	2.3%	16.3%
Impaired	1.0%	0.0%	0.0%	0.0%	1.0%
Driver Distracted By	9.4%	0.0%	0.8%	0.1%	10.2%
Driver Vision Obscured By	0.0%	1.4%	0.0%	0.0%	1.4%
Speeding/Reckless Driving	7.9%	1.7%	0.0%	0.0%	9.6%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	8.6%	3.8%	1.8%	0.4%	14.6%
Other Violation Charged	12.9%	0.0%	1.6%	1.5%	16.0%
Hit & Run	10.6%	0.5%	23.4%	3.1%	37.5%
			Crash Population =		1,000

Table C10. Driver Contributing Factors vs. Atmospheric Conditions Breakdown for Scenario 10 (Based on 1995-1998 GES)

Scenario 10	Atmospheric Conditions				Total
Driver Contributing Factors	Day & Clear	Day & Adverse	Night & Clear	Night & Adverse	
Alcohol/Drugs	2.2%	0.0%	6.1%	0.0%	8.3%
Impaired	0.0%	0.0%	2.2%	0.0%	2.2%
Driver Distracted By	4.8%	0.0%	1.7%	0.0%	6.4%
Driver Vision Obscured By	4.2%	0.0%	0.0%	0.0%	4.2%
Speeding/Reckless Driving	1.9%	0.0%	1.7%	0.0%	3.5%
Sign/Signal Violation	0.0%	0.0%	0.0%	0.0%	0.0%
Driver Lost Control	1.2%	0.0%	0.0%	0.0%	1.2%
Other Violation Charged	12.1%	1.0%	10.1%	0.0%	23.2%
Hit & Run	20.3%	0.7%	1.3%	0.0%	22.3%
			Crash Population =		1,000

APPENDIX D

This Appendix shows the driver age breakdown for each scenario independently, starting with Figure D1 for pre-crash scenarios 1 and 2 and ending with Figure D5 for pre-crash scenarios 9 and 10. The distribution of licensed drivers is also shown in each Figure to aid in the comparison [7]. Figures D6 through D8 show the driver involvement rate per 100 million VMT and Figures D9 through D11 show the driver involvement rate per 1,000 licensed drivers. See Section 6 for a discussion of the results presented herein.

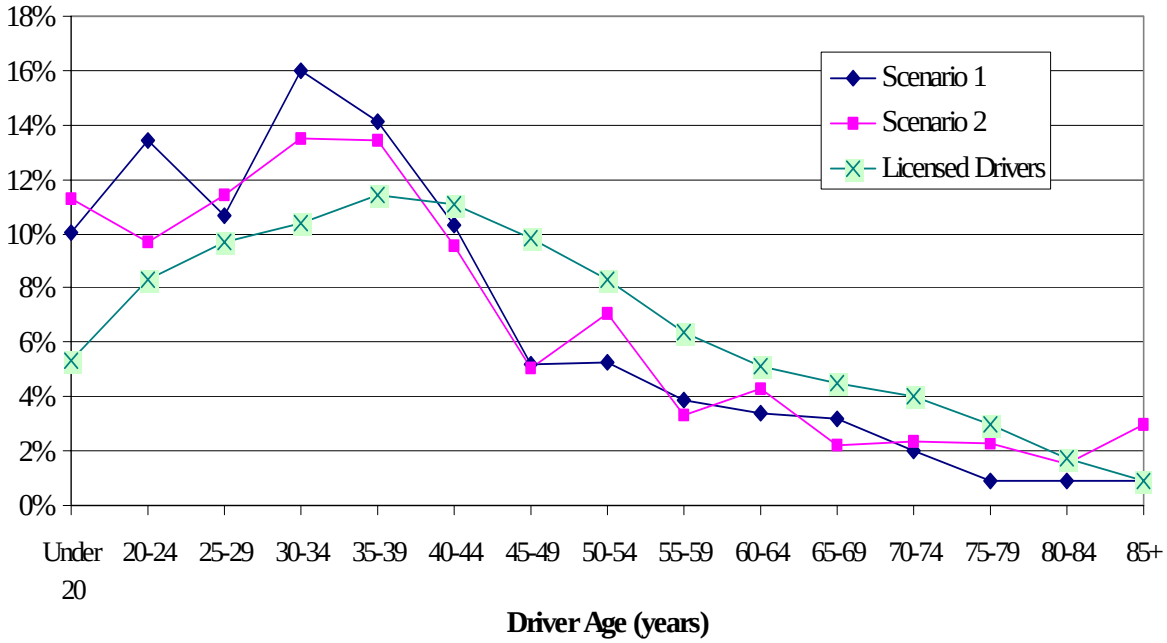

Figure D1. Driver Age Distribution for Scenario 1 and Scenario 2 and Overall Licensed Driver Population (Based on 1995-1998 GES)

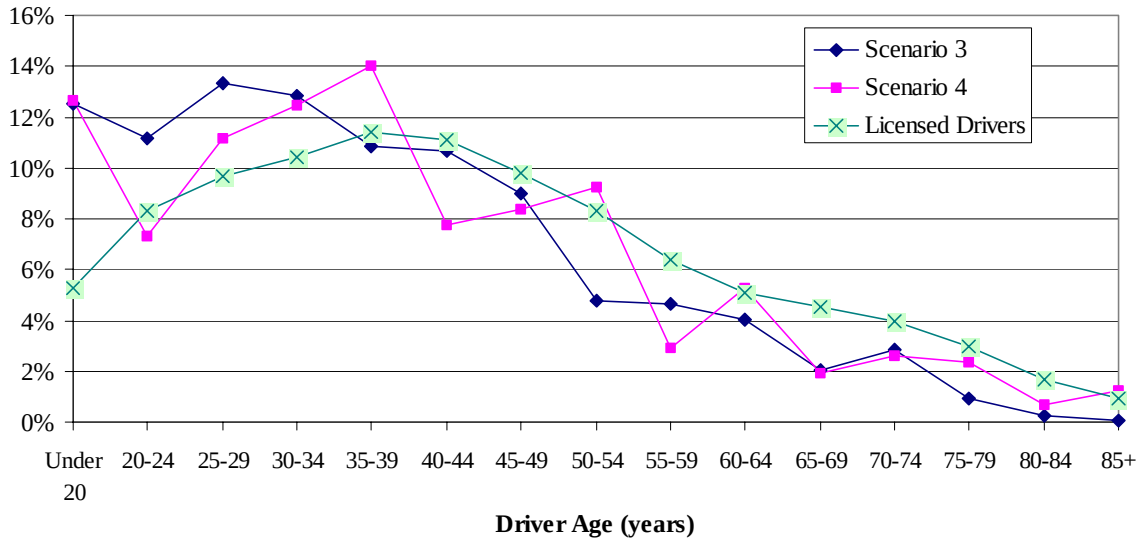

Figure D2. Driver Age Distribution for Scenario 3 and Scenario 4 and Overall Licensed Driver Population (Based on 1995-1998 GES)

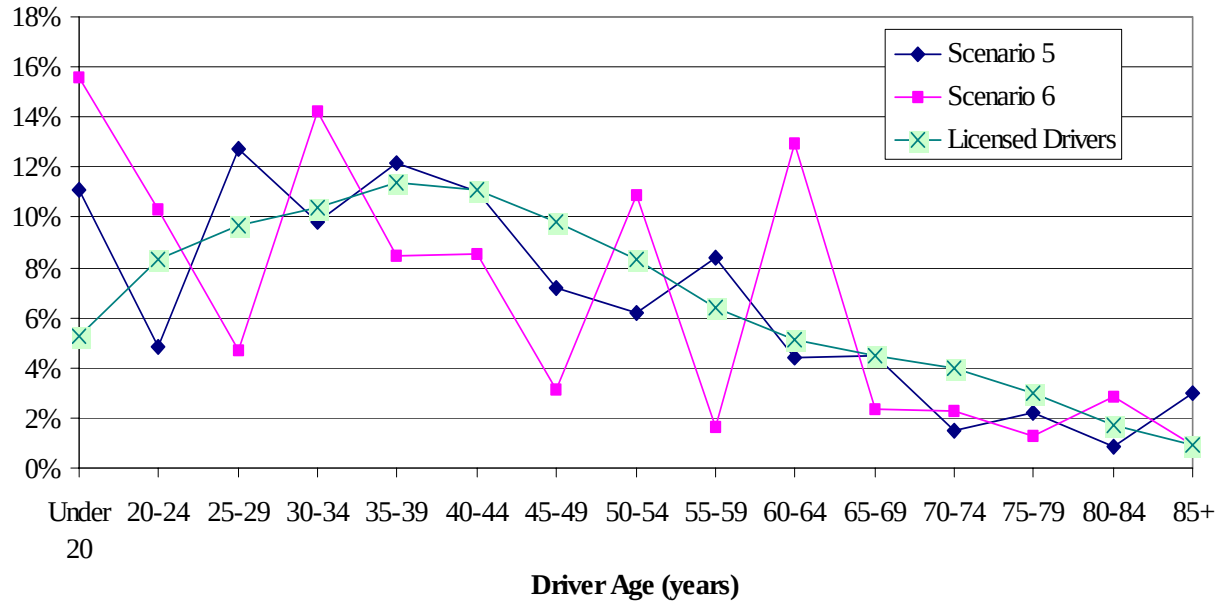

Figure D3. Driver Age Distribution for Scenario 5 and Scenario 6 and Overall Licensed Driver Population (Based on 1995-1998 GES)

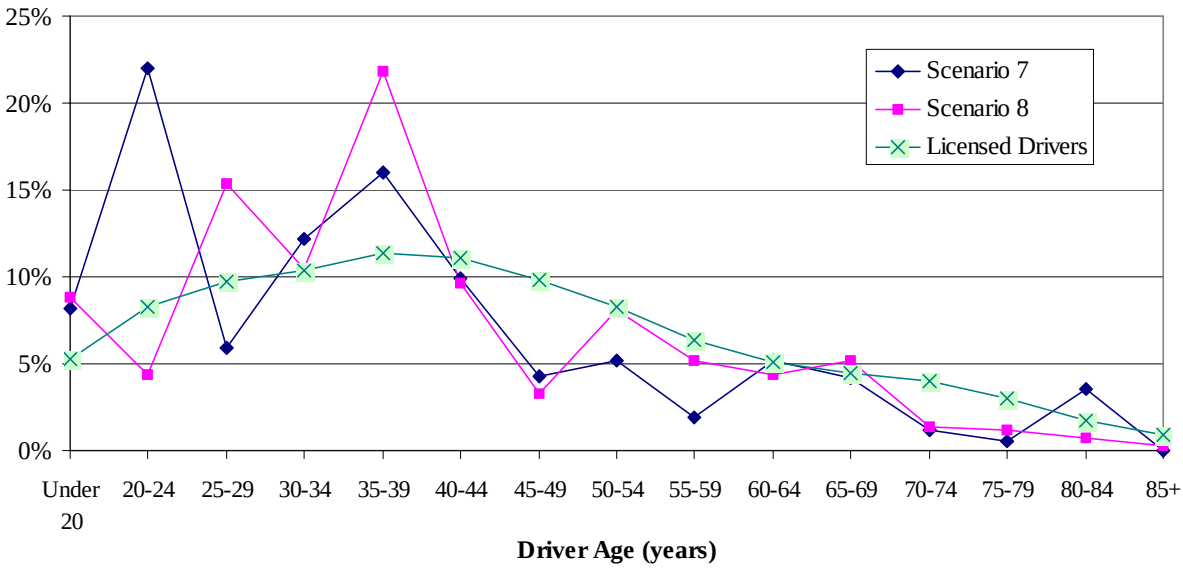

Figure D4. Driver Age Distribution for Scenario 7 and Scenario 8 and Overall Licensed Driver Population (Based on 1995-1998 GES)

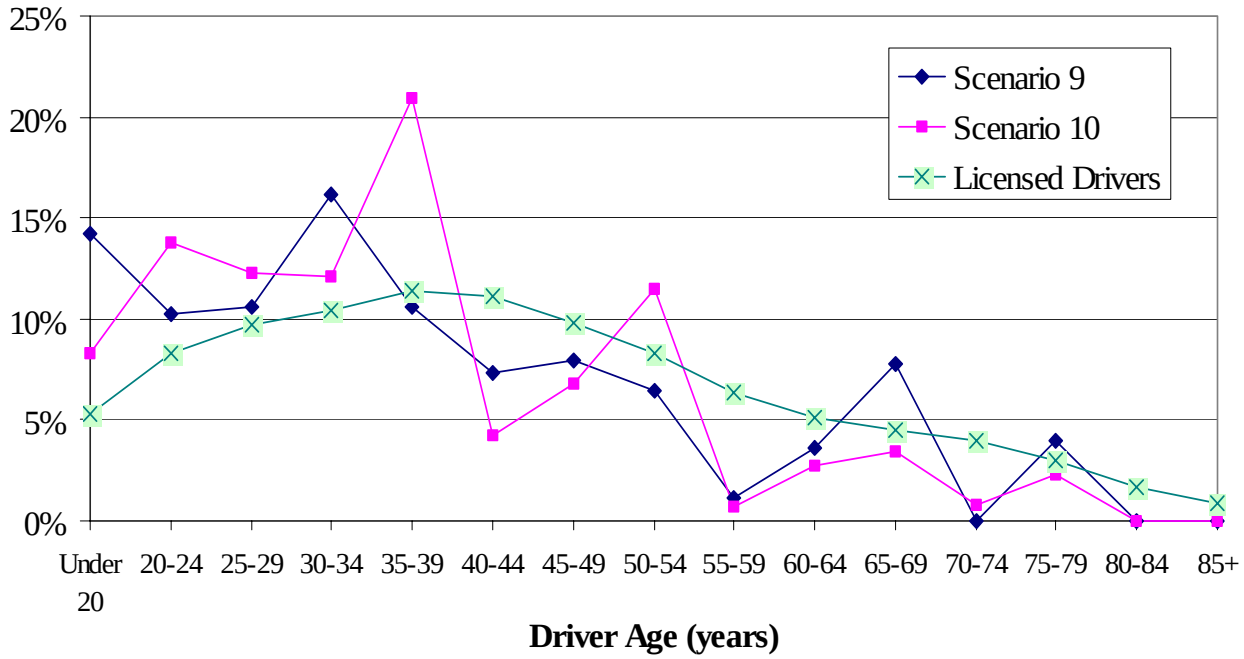

Figure D5. Driver Age Distribution for Scenario 9 and Scenario 10 and Overall Licensed Driver Population (Based on 1995-1998 GES)

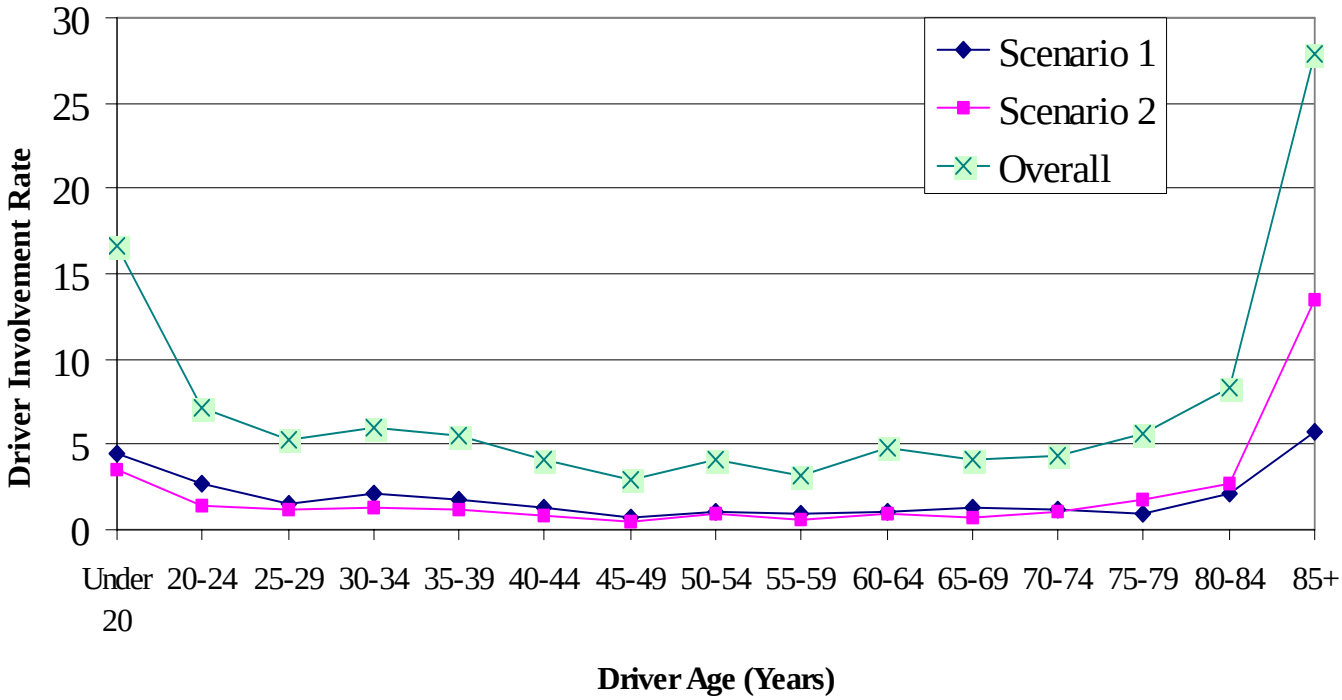

Figure D6. Number of Drivers per Age Group in Scenarios 1 and 2 and Overall Licensed Driver Population per 100 Million VMT (Based on 1995-1998 GES)

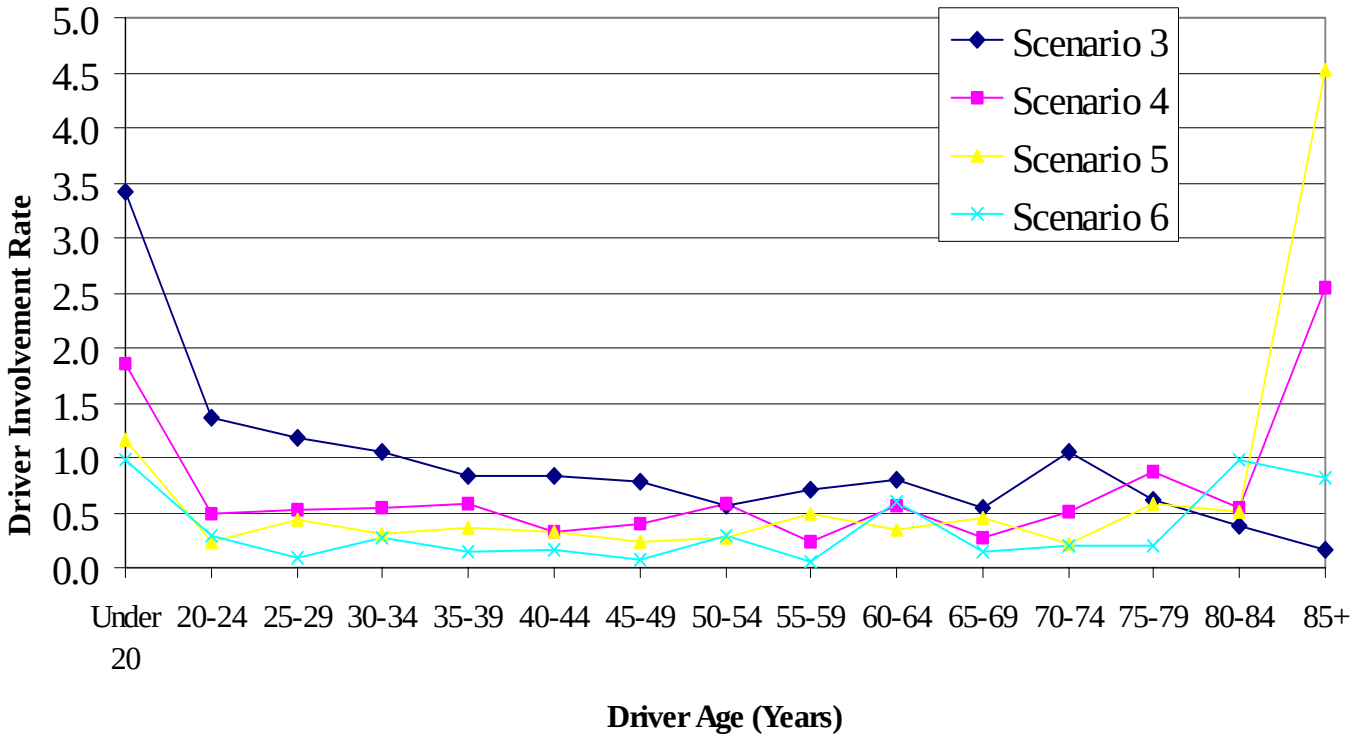

Figure D7. Number of Drivers per Age Group in Scenarios 3 through 6 per 100 Million VMT (Based on 1995-1998 GES)

Figure D8. Number of Drivers per Age Group in Scenarios 7 through 10 per 100 Million VMT (Based on 1995-1998 GES)

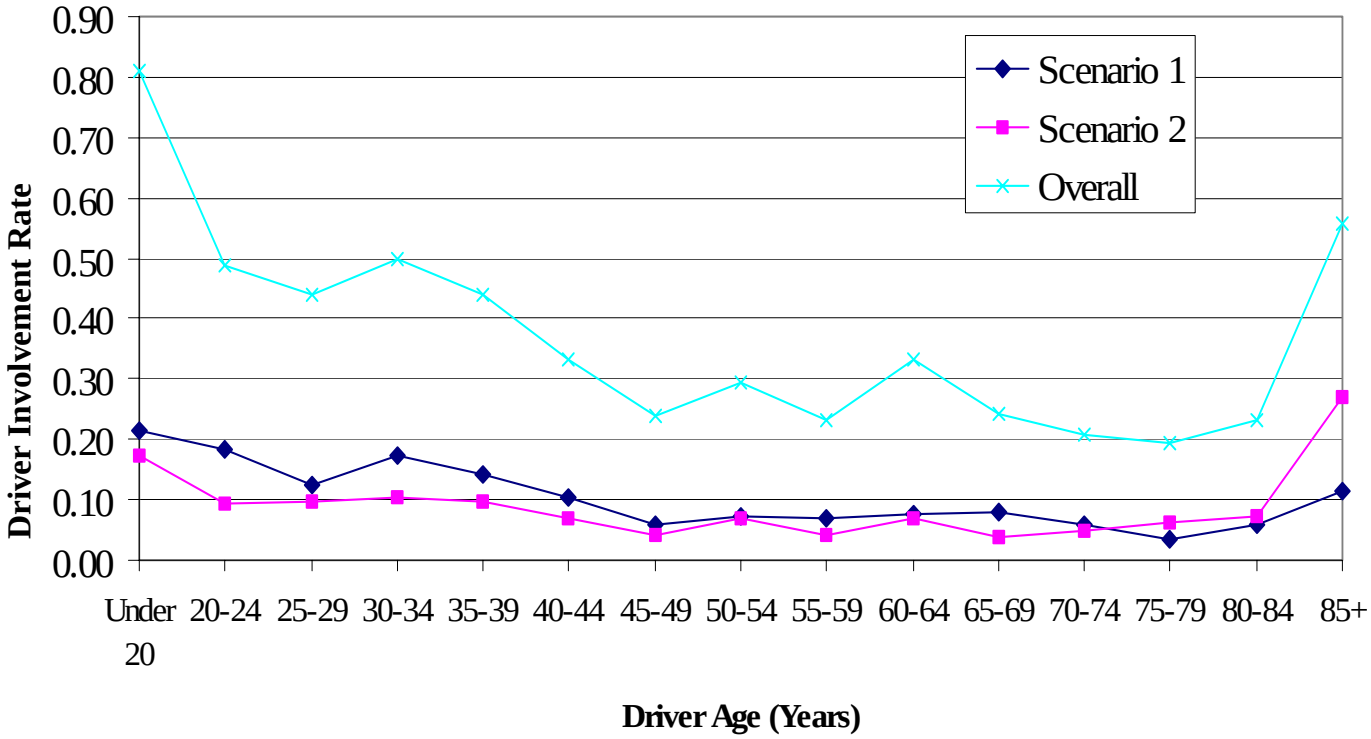

Figure D9. Number of Drivers per Age Group in Scenarios 1 and 2 and Overall Licensed Driver Population per 1,000 Licensed Drivers (Based on 1995-1998 GES)

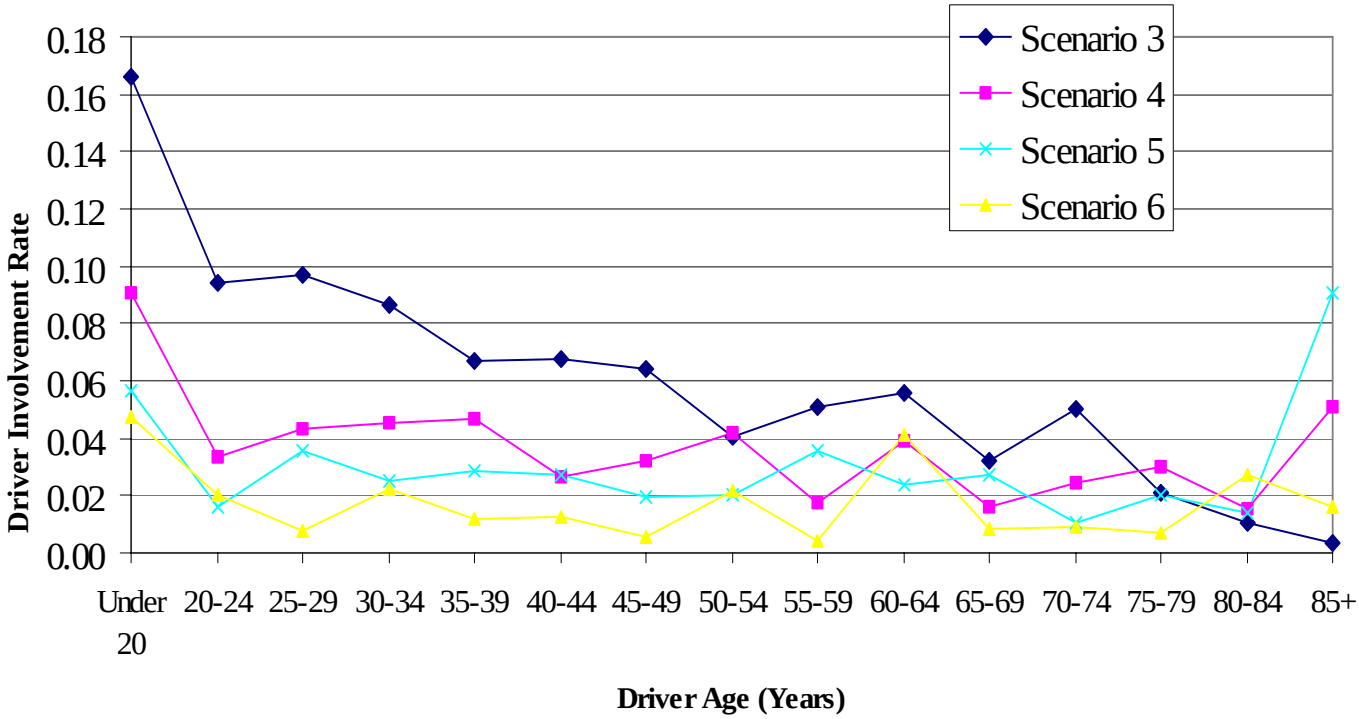

Figure D10. Number of Drivers per Age Group in Scenarios 3 through 6 per 1,000 Licensed Drivers (Based on 1995-1998 GES)

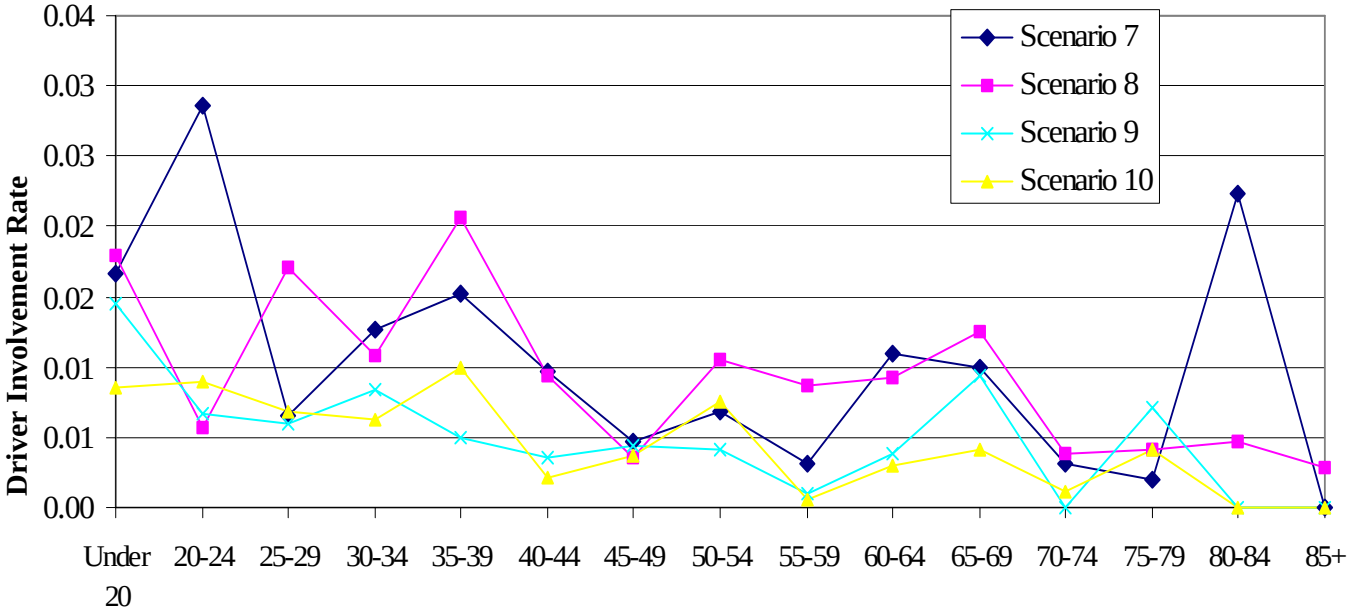

Figure D11. Number of Drivers per Age Group in Scenarios 7 through 10 per 1,000 Licensed Drivers (Based on 1995-1998 GES)

APPENDIX E

This Appendix shows the pedestrian age breakdown for each scenario independently compared to the U.S. population distribution [8], starting with Figure E1 for pre-crash scenarios 1 and 2 and ending with Figure E5 for pre-crash scenarios 9 and 10. See Section 6 for a discussion of the results presented herein.

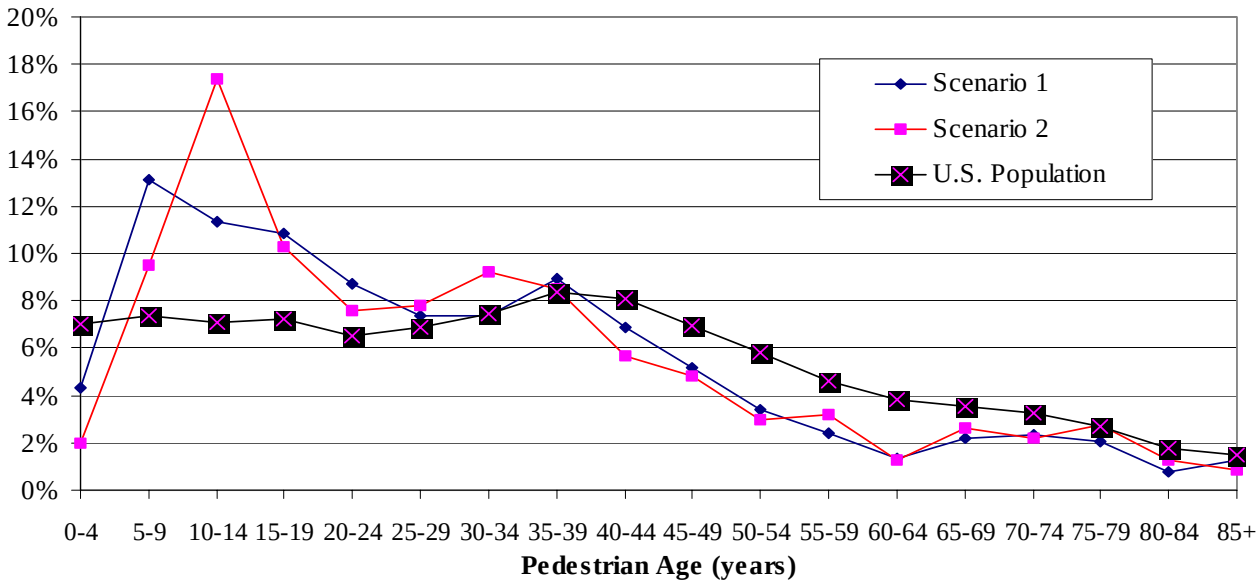

Figure E1. Pedestrian Age Distribution for Scenarios 1 and 2 and Overall U.S. Population (Based on 1995-1998 GES)

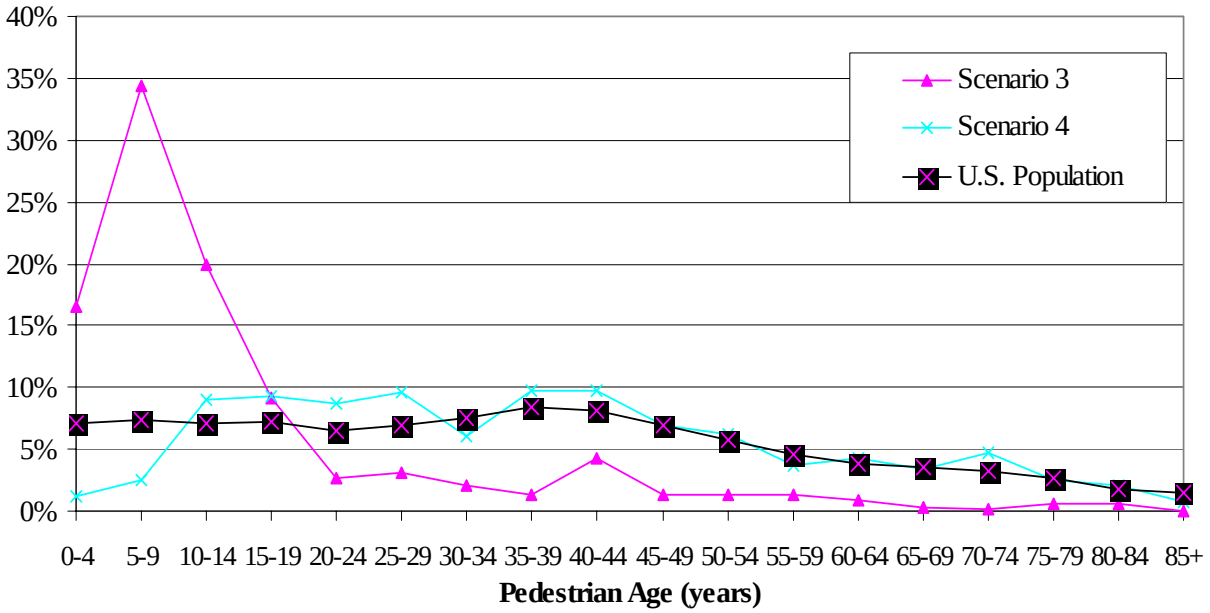

Figure E2. Pedestrian Age Distribution for Scenarios 3 and 4 and Overall U.S. Population (Based on 1995-1998 GES)

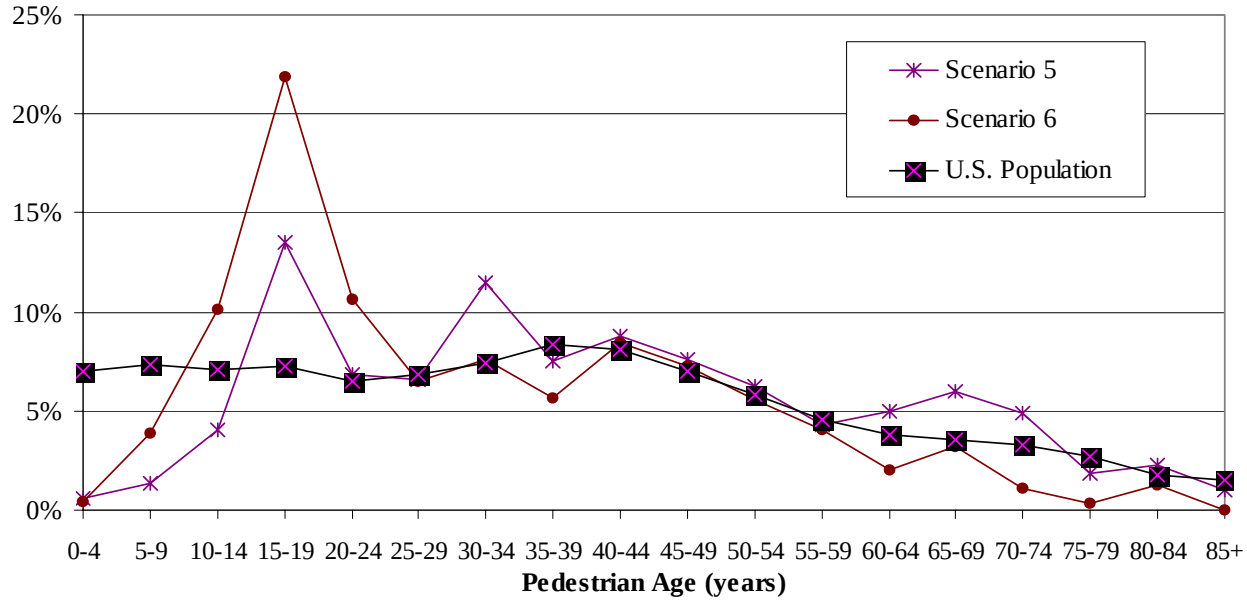

Figure E3. Pedestrian Age Distribution for Scenarios 5 and 6 and Overall U.S. Population (Based on 1995-1998 GES)

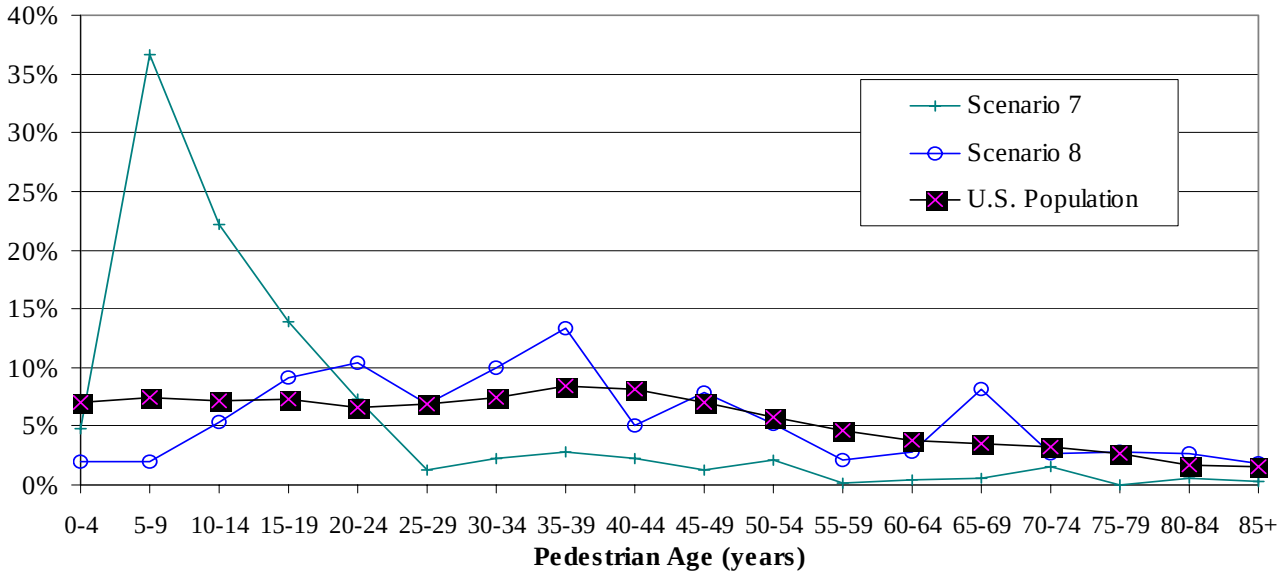

Figure E4. Pedestrian Age Distribution for Scenarios 7 and 8 and Overall U.S. Population (Based on 1995-1998 GES)

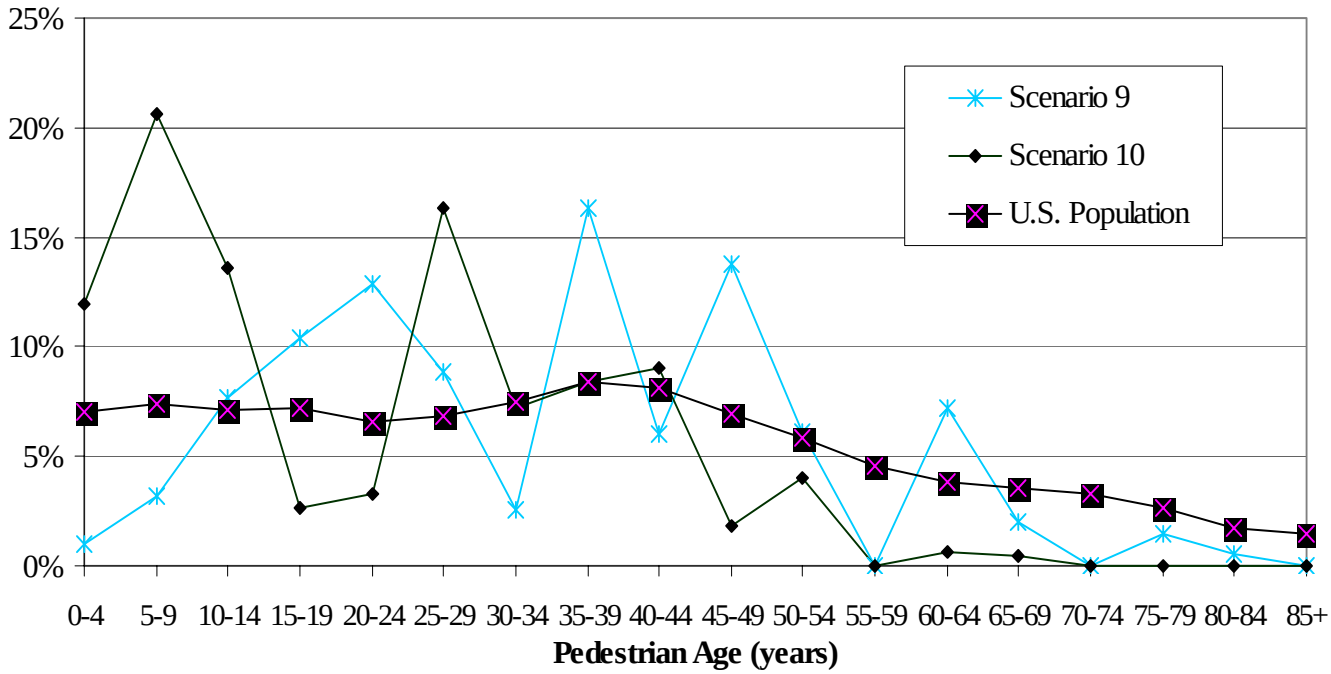

Figure E5. Pedestrian Age Distribution for Scenarios 9 and 10 and Overall U.S. Population (Based on 1995-1998 GES)

APPENDIX F

This Appendix shows the United States distributions of population age as determined by the U.S. Census Bureau [8] and the pedestrian crash population age distribution as determined from the 1995-1998 GES databases. This Appendix also shows the number of licensed drivers by age as published by the Federal Highway Administration [7].

Table F1. Pedestrian Crash Population (Based on 1995-1998 GES) and U.S. Population Distributions by Age

AGE (years)	Population Dist.	
	Crash-Involved Pedestrians	U.S.*
0-4	5.1%	7.0%
5-9	13.9%	7.4%
10-14	13.4%	7.1%
15-19	11.0%	7.2%
20-24	7.4%	6.5%
25-29	6.8%	6.9%
30-34	6.9%	7.5%
35-39	7.5%	8.4%
40-44	6.5%	8.1%
45-49	5.0%	7.0%
50-54	3.6%	5.8%
55-59	2.6%	4.6%
60-64	2.0%	3.8%
65-69	2.5%	3.5%
70-74	2.2%	3.3%
75-79	1.8%	2.7%
80-84	1.2%	1.8%
85+	0.8%	1.5%
Total	74,000	270,248,000

* 1998 US Bureau of the Census Estimates (U.S. Resident)

Table F2. United States Licensed Driver Population Distribution by Age - 1998

Age (years)	Number of Licensed Drivers	Percent of Total Drivers
Under 20	9,782,763	5.3%
20-24	15,366,212	8.3%
25-29	18,028,566	9.7%
30-34	19,180,411	10.4%
35-39	21,136,591	11.4%
40-44	20,462,716	11.1%
45-49	18,164,649	9.8%
50-54	15,324,931	8.3%
55-59	11,838,456	6.4%
60-64	9,447,046	5.1%
65-69	8,336,948	4.5%
70-74	7,431,062	4.0%
75-79	5,544,277	3.0%
80-84	3,178,530	1.7%
85+	1,757,018	0.9%
Total	184,980,176	100.0%

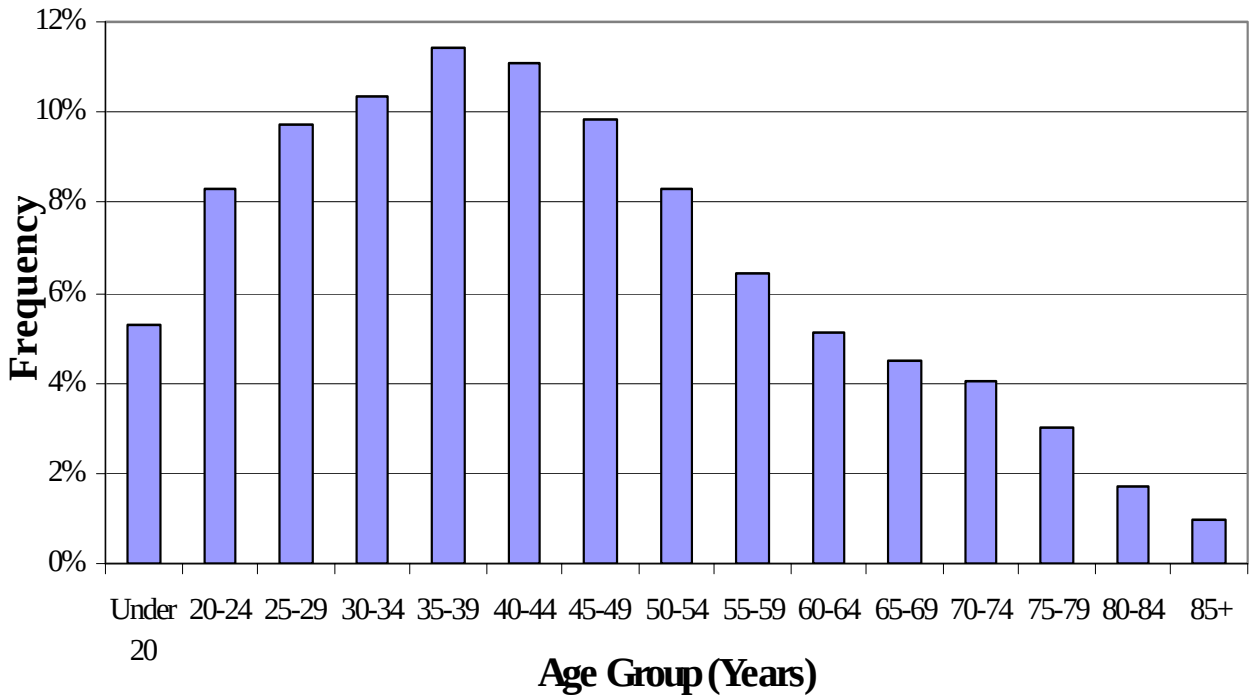

Figure F1. United States Licensed Driver Age Distribution - 1998

DOT-VNTSC-NHTSA-02-02
DOT HS 809 585
April 2003

U.S. Department of Transportation

National Highway Traffic Safety Administration

Research and
Special Programs
Administration
Volpe National
Transportation System Center
Cambridge, MA 02142-1093

Scenario	Scenario Description
1	Vehicle is going straight and pedestrian crossing the roadway
2	Vehicle is going straight and pedestrian darting onto the roadway
3	Vehicle is turning left and pedestrian crossing the roadway
4	Vehicle is turning right and pedestrian crossing the roadway
5	Vehicle is going straight and pedestrian is walking along the roadway
6	Vehicle is going straight and pedestrian is doing "unknown/other"
7	Vehicle is going straight and pedestrian is not in the roadway
8	Vehicle is backing
9	Vehicle is going straight and pedestrian is playing/working in the roadway
10	Other