Older driver *involvement in* injury crashes *in Texas • 1975-1999*

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FOREWORD

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Executive Summary

According to the National Highway Traffic Safety Administration, older drivers are more likely than drivers in their thirties, forties, or fifties to be involved in traffic crashes, and they are more likely to be killed in traffic crashes. The number of Americans 65 years of age and older is expected to double between 2000 and 2030. Americans are living longer and driving longer. Together these trends suggest that the number of older drivers killed on U.S. streets and highways will grow.

The literature suggests that older drivers are more fragile than younger drivers—that is, in crashes of comparable severity, older drivers are more likely than younger drivers to be seriously injured or killed. Medical conditions and use of medications have also been associated with the involvement of older drivers in crashes. With advancing age, sensory and motor capabilities decline and perceptual/cognitive and attentional impairment become more common, and the relative likelihood of traffic crashes increases. Although many older drivers may attempt to adjust to functional difficulties by driving less and avoiding difficult driving conditions, such as driving at night, in rainy weather, or in heavy traffic, older drivers still have a heightened risk of being involved in traffic crashes.

In this study, 25 years of police-level crash data from nearly 4 million injury crashes in the state of Texas were analyzed to determine the association between driver age and four factors: *fragility*—the likelihood of death among drivers involved in injury crashes; *illness*—the likelihood that drivers were ill or suffering from some other physical defect at the time of their crashes; *perceptual lapses*—the likelihood that drivers involved in crashes failed to yield the right of way or disregarded traffic signs or signals; and *left turns*—the likelihood that left turns were involved in injury crashes. The purpose of the study was to further understand these four factors and other variables and to portray in graphical format their association with crashes involving older drivers.

The control variables used in the analyses included whether drivers were involved in single-vehicle or multiple-vehicle crashes; whether the crash occurred in an urban or a rural setting; the driver's sex; the light conditions at the time of the crash (daylight or darkness); and whether or not the crash was related to an intersection. Additional analyses examined two-vehicle, intersection-related crashes in which the vehicles approached one another from opposite directions or approached one another at an angle.

Because older drivers do not constitute a homogeneous population, three different age thresholds were used in defining this group: 65 and older, 75 and older, and 85 and older. Drivers aged 55 to 64, those nearing traditional retirement age, constituted the comparison group in the analyses.

When the analyses controlled for crash type (single-vehicle vs. multiple-vehicle), population density (rural vs. urban), driver sex (male vs. female), light condition (daylight vs. darkness), and intersection relatedness, drivers in the three older age categories, compared with drivers aged 55–64, were found to be more likely to die in injury crashes:

- Drivers 65+ years of age were 1.78 times as likely to die

- Drivers 75+ years of age were 2.59 times as likely to die

- Drivers 85+ years of age were 3.72 times as likely to die

Other analyses that controlled for crash type, population density, driver sex, light condition, and intersection relatedness showed that when compared to 55-64 year old drivers, the three older age groups became progressively more likely to (1) have been ill or suffering some other physical defect at the time of their crashes, (2) have suffered perceptual lapses that contributed to their crashes (such as failure to yield the right of way or disregarding signs or signals), and (3) have been involved in left-turn crashes.

Introduction

According to the National Highway Traffic Safety Administration (NHTSA), on a per-mile basis, older drivers are relatively more likely to be involved in traffic crashes than drivers in their thirties, forties, or fifties. Furthermore, older drivers are more likely to be killed in traffic crashes than drivers in their thirties, forties, or fifties, both on a per-mile and a per-licensed-driver basis (NHTSA, 1993, figures 6, 7, and 8).

The number of persons in the United States 65 years of age and older will increase from about 35 million in 2000 (12.4 percent of the population) to an estimated 71 million by 2030 (19.6 percent of the population) (CDC, 2003). Moreover, Americans are living longer and driving longer. The implications of a growing population of older citizens—and older drivers—are profound. If older drivers are more likely to be involved in traffic crashes and more likely to die as a result of those crashes, then, other things being equal, the number of older drivers killed on U.S. streets and highways is destined to grow.

In Texas, from which the data for this study were drawn, between 1975 and 1999, the number of licensed drivers increased from 7,743,779 to 13,902,660—a factor of 1.79—and the median age of licensed drivers increased from 36 to 40 years (Figure 1). Furthermore, as the following chart shows, the numbers of drivers in the older age categories increased more dramatically than those in the younger age categories.

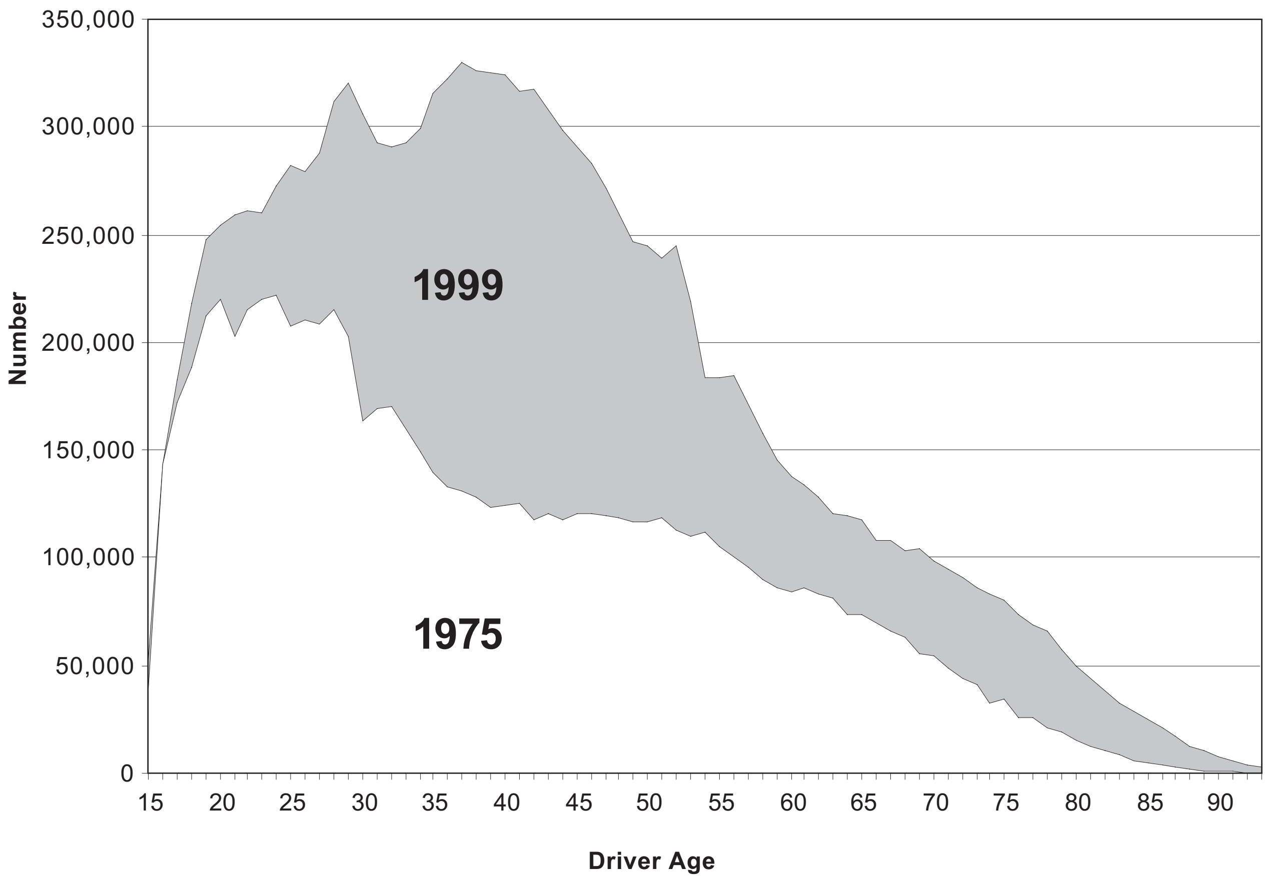
Texas Drivers	**1975**		**1999**		**Increase in Licensed Drivers**
All Ages	7,743,779	*(100.00%)*	13,902,660	*(100.00%)*	1.79
Under 65	6,998,929	*(90.38%)*	12,261,588	*(88.20%)*	1.75
65 and Older	744,850	*(9.62%)*	1,641,072	*(11.80%)*	2.20
75 and Older	195,298	*(2.52%)*	646,905	*(4.65%)*	3.31
85 and Older	16,386	*(0.21%)*	109,430	*(0.79%)*	6.68

By 2030, nearly 22,100,000 Texans will be licensed to drive. This estimate assumes conservatively that the same proportion of the state's population (stratified by age categories) will receive licenses in 2030 as in 1999.[1]

Texas Drivers	**Projection for 2030**	
All Ages	22,091,144	*(100.00%)*
Under 65	17,938,480	*(81.20%)*
65 and Older	4,152,664	*(18.80%)*
75 and Older	1,545,427	*(7.00%)*
85 and Older	228,153	*(1.03%)*

[1]Projections of the Texas population to 2030 were provided by the Office of the State Demographer, Department of Rural Sociology, Texas A&M University.

Figure 1. Number of Licensed Texas Drivers, by Age and Year (1975 vs. 1999)



The literature suggests that older drivers are more fragile than younger drivers—that is, in traffic crashes of comparable severity, older drivers are more likely than younger drivers to be seriously injured or killed (Barancik et al., 1986; Zhang et al., 2000; Evans, 1988; 2001; Li, Braver, and Chen, 2003). There is also a large and growing literature related to medical conditions (Drachman and Swearer, 1993; Koepsell, et al., 1994; Gresset and Meyer, 1994; Foley, Wallace, and Eberhard, 1995) and medications (Ray et al., 1992; Foley, Wallace, and Eberhard, 1995; Sims et al., 1998; McGwin et al., 2000) associated with older drivers and the increased likelihood of involvement in traffic crashes.

With increasing age, sensory and motor capabilities decline, perceptual/ cognitive and attentional impairment become more common, driving becomes more difficult, and, other things being equal, traffic crashes become relatively more likely (Fell, 1976; Owsley et al., 1991; Stelmach and Nahom, 1992; Ball et al., 1993; Lundberg et al., 1998; Stutts, Stewart, and Martell, 1998). There is evidence that many older drivers attempt to compensate for these functional difficulties by driving less and avoiding certain kinds of driving, such as driving at night, in rainy weather, or in heavy traffic (Ball et al., 1998; Gallo, Rebok, and Lesikar, 1999). Nevertheless, older drivers have a heightened risk of being involved in traffic crashes.

Perhaps because of the diminishing of functional capabilities with age, intersection-related crashes are relatively more common for older drivers, and left turns are particularly problematic (Matthias, Nicholas, and Thomas, 1996; Preusser et al., 1998; Staplin, et al., 1998; Finison and Dubrow, 2002).

In this study, 25 years of police-level crash data from the state of Texas were analyzed to determine the association between driver age and four factors: *fragility*—the likelihood of death among drivers involved in injury crashes; *illness*—the likelihood that drivers were ill or suffering from some other physical defect at the time of their crashes; *perceptual lapses*—the likelihood that drivers involved in crashes failed to yield the right of way or disregarded traffic signs or signals; and *left turns*—the likelihood that left turns were involved in injury crashes. The purpose of the study was to further document the role of these four factors, along with variables related to crash conditions and circumstances, and to portray in graphical format their association with crashes involving older drivers.

Methods

Data on more than 7 million drivers involved in injury crashes in Texas during a 25-year period were analyzed to determine how fragility (defined as the likelihood of death among drivers), illness (the likelihood that driver has an illness or a physical defect), perceptual lapses (the likelihood that the driver failed to yield the right of way or disregarded traffic signs or signals), and left turns (the likelihood that the driver was making a left turn) vary with driver age.

For the first three factors—fragility, illness, and perceptual lapses—the relationship with driver age was further subdivided to evaluate differences between single-vehicle and multiple-vehicles crashes (variable name, “crash type”), rural and urban settings (“population density”), male and female drivers (“driver sex”), daylight and darkness (“light condition”), and intersection-related or non-intersection-related crash site (“intersection relatedness”). These five variables are also used to control for differences in crash circumstances between the comparison group and the three older driver categories and, thereby, to more accurately portray the effect of driver age on fragility, perceptual lapses, and illness.

For the fourth factor, left turns, the effects of driver age are depicted by population density, driver sex, and light condition. Finally, for two-vehicle, intersection-related crashes in which one vehicle is going straight and the other is turning left, the relative likelihood that a driver is making a left turn is depicted by driver age.

Analyses were carried out to compare drivers 55–64 years old with drivers in three age categories—65 and older, 75 and older, and 85 and older—while controlling for crash type, population density, driver sex, light condition, and intersection relatedness. There is no universally accepted definition of an "older driver," and the three thresholds for older drivers used here demonstrate that where the line is drawn in defining "older drivers" may have a considerable effect on the results of these analyses. Drivers in their sixties, seventies, eighties, and nineties are by no means homogeneous in fragility, likelihood of suffering an illness or physical impairment, or susceptibility to perceptual lapses.

When working with small data sets, it may be necessary to define the threshold for older drivers at a younger age to garner a larger sample and achieve greater statistical stability. Doing so, however, may obscure an outcome that would have resulted if the sample had been large enough to allow a higher threshold. The database in this study, comprising 25 years of crash data collected in a large state, is sufficiently large in most cases to allow us to set the threshold for an older drivers at 85 years and still have a fairly stable sample with which to work.

The age range for the comparison group used in this study (55–64 years) is conservative. Had a younger comparison group been used, for example, all drivers under age 65 or all drivers between the ages of 35 and 64, the findings might have been more dramatic. On balance, however, it seemed more appropriate to compare the older driver age groups with a comparison group that was not far removed from the traditional retirement age.

None of the analyses conducted in this study employ "exposure" data. No crash rates (e.g., crashes per 100,000 licensed drivers) or fatality rates (e.g., fatalities per 100 million vehicle miles of travel) are provided. All of the analyses are

Table 1. Injury Crashes, Severity of Injuries Sustained by Drivers in Injury Crashes, and Severity of Injuries Sustained by All Persons Injured in Crashes, by Year (Texas, 1975–1999)

		Driver Injury Severity*						Severity of All Injuries Recorded*			
Year	Injury Crashes	Not Injured	C-Level Injury	B-Level Injury	A-Level Injury	Fatal Injury	Drivers in Injury Crashes	C-Level Injury	B-Level Injury	A-Level Injury	Fatal Injury
1975	95,455	73,655	32,062	36,811	10,752	1,898	155,178	57,323	63,309	18,330	3,429
1976	99,128	76,353	35,572	38,145	10,962	1,784	162,816	62,308	64,402	18,572	3,230
1977	110,153	83,506	39,786	43,024	12,461	2,066	180,843	68,700	71,878	21,057	3,698
1978	121,466	92,169	45,318	48,033	13,225	2,262	201,007	77,229	79,159	21,840	3,980
1979	126,478	96,611	48,137	50,196	13,453	2,375	210,772	80,236	81,868	22,446	4,229
1980	127,440	95,848	46,361	52,392	14,292	2,524	211,417	76,924	85,312	23,728	4,424
1981	140,533	106,995	52,548	57,478	16,010	2,738	235,769	86,901	92,838	26,457	4,701
1982	139,611	106,524	52,991	56,374	15,502	2,407	233,798	87,847	91,426	25,393	4,271
1983	141,023	107,200	56,612	56,376	15,500	2,173	237,861	91,493	91,308	25,356	3,823
1984	149,009	113,971	62,948	58,089	15,821	2,277	253,106	101,468	93,416	25,836	3,913
1985	154,927	119,595	69,929	57,348	16,103	2,151	265,126	111,396	93,232	26,381	3,682
1986	157,635	125,451	76,583	50,789	15,838	2,004	270,665	123,548	84,385	26,187	3,568
1987	149,794	118,571	76,921	45,523	15,182	1,780	257,977	125,498	76,217	25,180	3,261
1988	155,008	133,978	83,714	45,810	15,399	1,919	280,820	136,622	76,867	25,356	3,395
1989	156,282	135,262	87,540	45,562	14,898	1,881	285,143	142,234	75,914	24,882	3,361
1990	165,306	143,860	97,272	46,374	15,034	1,842	304,382	159,613	77,847	25,116	3,243
1991	164,166	143,757	101,497	43,388	13,950	1,640	304,232	167,353	72,716	23,361	3,079
1992	173,203	154,221	112,385	42,633	13,591	1,652	324,482	186,733	72,517	22,775	3,057
1993	180,884	162,104	121,213	42,779	13,774	1,709	341,579	203,132	72,541	23,218	3,037
1994	194,724	173,741	133,853	45,462	14,731	1,803	369,590	226,310	75,911	24,616	3,142
1995	198,883	177,264	136,550	47,421	14,812	1,782	377,829	230,949	78,748	24,562	3,172
1996	207,882	180,869	143,883	51,696	15,587	2,129	394,164	239,646	84,990	25,761	3,738
1997	208,674	183,977	144,123	51,980	15,130	2,015	397,225	238,460	84,518	24,833	3,508
1998	205,383	180,869	141,708	52,127	14,334	2,078	391,116	232,083	83,148	23,430	3,576
1999	206,326	182,295	142,166	53,210	14,115	2,089	393,875	231,452	85,208	22,788	3,519
Total	3,929,373	3,268,646	2,141,672	1,219,020	360,456	50,978	7,040,772	3,545,458	2,009,675	597,461	90,036

*The definitions of injuries, from the *Manual on Classification of Motor Vehicle Traffic Accidents in Texas* (ST-102) (various years) and *Motor Vehicle Traffic Accidents in Texas* (various years), Texas Department of Public Safety, Austin, are as follows:

> "**Fatal Injury** is any injury that results in death within thirty days of the motor vehicle traffic accident." This definition was in effect from 1983 to 1999. From 1978 to 1982, a fatal injury was defined as having occurred within 90 days of the accident, and before 1978, the time until death was not specified in the definition.
>
> "**Incapacitating** (A-level) **Injury** is any injury, other than a fatal injury, which prevents the injured person from walking, driving or normally continuing the activities he was capable of performing before the injury occurred."
>
> "**Nonincapacitating Evident** (B-level) **Injury** is any injury, other than a fatal injury or an incapacitating injury, which is evident to observers at the scene of the accident in which the injury occurred."
>
> "**Possible** (C-level) **Injury** is any injury reported or claimed which is not a fatal injury, incapacitating injury or nonincapacitating evident injury."

expressed in terms of frequencies, proportions (percentages), and relative proportions (relative likelihoods).

TEXAS CRASH DATA

Table 1 provides an overview of the injury crash data available for use in this study. Between 1975 and 1999, the Texas Department of Public Safety recorded 3,929,373 injury crashes on streets and highways in the state, collectively involving a total of 7,040,772 drivers. Of the 90,036 fatalities recorded for those crashes, 50,978 (56.62 percent) were drivers. Drivers also accounted for 360,456 (60.33 percent) of the 597,461 A-level injuries recorded in this period (see table footnote). For B-level and C-level injuries, drivers constituted 60.66 percent (1,219,020) and 60.41 percent (2,141,672) of all injured persons, respectively.

Although the Department of Public Safety database includes data on crashes that do not involve injuries, on July 1, 1995, the department ceased coding crashes that involved only property damage unless one or more vehicles were towed from the scene. After that date, with less severe crashes no longer being recorded, the database is systematically skewed toward more severe crashes. Therefore, in order to use a consistent data set, this study includes only data for crashes in which someone was injured.

When working with data generated from field reports such as the police-level data used here, we should bear in mind that the data are often subjective and are open to interpretation. Consider a hypothetical example: A vehicle leaves the highway at a shallow angle at 2:00 A.M. and strikes a tree. The driver is killed. No one else is in the vehicle, and no one saw the crash. The road is straight and dry, and the vehicle has no obvious tire or brake defects, and there are no skid marks on the road. The driver had not been drinking. The investigating officer records that the driver was "asleep or fatigued" in response to the question "Did the driver exhibit some defect?" This response may be correct. Alternatively, the driver may have strayed from the highway while tuning the radio or retrieving a dropped cigarette; his crash may have had nothing to do with sleepiness or fatigue.

Officers' subjective impressions may be influenced any number of factors, including driver age. In the absence of other information, a 75-year-old man involved in a crash will more likely be assumed to be suffering from an illness or some other physical defect than a 25-year-old man. Similarly, officers may assume that older drivers are more likely to fail to yield the right of way and may select this option in their reports more frequently than is warranted. Thus the Texas crash database may contain age-related coding biases, and this possibility should be borne in mind in evaluating the results.

Fragility

Fragility may be thought of as the likelihood that an injury of a given severity will result from an insult of a given intensity. If we assume that older drivers are more fragile than younger drivers, we would expect older drivers to be more likely than younger drivers to suffer an injury of a given severity when involved in crashes of comparable severity. In this study, fragility is defined as the likelihood of death for drivers of a given age group when involved in crashes in which one or more persons are injured.

Although drivers in the older age groups are more likely to be killed in injury crashes than drivers in younger age groups, it does not necessarily follow that the observed differences in the proportions killed in the different age groups are due solely to the greater fragility of older drivers. The types of vehicles that people drive, the conditions under which those vehicles are driven, and the circumstances of the crash vary with driver age—as does the level of trauma experienced by the drivers.

- Younger drivers may be involved in systematically more severe crashes than older drivers. If so, older drivers may be even more fragile than the crash fatality data suggest.

- If older drivers are indeed more fragile than younger drivers, then a minor crash that produces a reportable injury in an older driver might produce none in a younger driver. Thus, minor collisions involving older drivers may be more likely to be included in the database than minor collisions involving younger drivers. Therefore, the percentage of older drivers killed in injury crashes may be artificially low, when compared to younger drivers.

Illness

For each driver included in the Texas crash database, "driver defect" information was collected. Eight substantive driver defect codes are available to investigating officers. For 6,923,316 (98.33 percent) of the drivers in the data set, none of the codes applied. For the remaining 1.67 percent of the drivers, the codes were distributed as follows:

Eyesight defective	2,434
Hearing defective	190
Limbs missing	149
Other physical defects	1,379
Ill	25,822
Fatigue or asleep	86,503
Mentally defective	286
Other handicap	693

The most frequent driver defect cited, "fatigue" or "asleep", is more commonly reported in younger drivers. For older drivers, "illness" and "other physical defects" are relatively more common. Unfortunately, the nature of the illnesses observed by the investigating officers is unknown. Any number of medical problems—nausea, vertigo, heart attack—might be classified under this heading. Similarly, the nature of "other physical defects" is unknown—except that they were probably not a visual or hearing defect or a missing limb, since these codes were explicitly available for officers to use.

In the analyses in this study, data on drivers who were recorded as having an illness and those recorded as suffering from some other physical defect were combined. No effort was made to analyze these groups of drivers separately.

Perceptual Lapses

The Texas crash database contains a variable referred to as "first contributing factor." This variable is coded into 11 substantive categories for all drivers involved in crashes, as shown in the chart below along with the number of cases in each category. If none of these categories apply, the variable is coded "not applicable" (4,288,099 cases). Each of the 11 substantive categories refers to a driver action or condition that may have contributed to the crash. For the analyses in this study, the 11 categories were compressed into the three factors shown on the left side of the chart.

Perceptual Lapse	Disregarded stop sign or light	120,333
	Disregarded stop and go signal	260,785
	Disregarded yellow light	182
	Failed to yield right of way	877,369
Speeding	Speeding, over the limit	210,822
	Speeding, unsafe for conditions	1,142,550
Other	Wrong way on one-way road	9,738
	Wrong side, not passing	67,777
	Improper turn, wide right	15,873
	Improper turn, cut corner on left	5,943
	Improper turn wrong lane	41,301

In this scheme, failing to yield the right of way or disregarding a sign or signal are simply categorized as perceptual lapses. However, a driver who disregards a sign or signal or fails to yield the right of way has not necessarily suffered a perceptual lapse just before the crash. For example, a driver may fail to yield the right of way when his or her foot slips off the brake. Likewise, a driver who speeds, makes an improper turn, or drives on the wrong side of the road may in fact have been "inattentive" or "distracted" in the seconds leading up to the crash. Nevertheless, the elements of the definition provide a reasonable surrogate for perceptual lapses. The definition implies that a driver who fails to yield the right of way or disregards a sign or signal has very likely had some sensory, perceptual, attentional, or cognitive lapse that was contributory to the crash.

Left Turns

Each crash in the Texas database is coded to indicate "vehicle movement and manner of collision." There are 42 substantive categories for this variable, 14 of which indicate that one or more vehicles were turning left. Of the 7,040,772 drivers considered, 1,438,908 (20.44 percent) were involved in some sort of left-turn crash, as shown below.

Single motor vehicle turning left	49,798
Two motor vehicles approaching at an angle: #1 straight, #2 left turn	427,868
Two motor vehicles approaching at an angle: #1 right turn, #2 left turn	4,078
Two motor vehicles approaching at an angle: both turning left	6,979
Two motor vehicles approaching at an angle: #1 left turn, #2 stopped	8,678
Two motor vehicles going in same direction: #1 straight, #2 left turn	204,942
Two motor vehicles going in same direction: #1 right turn, #2 left turn	474
Two motor vehicles going in same direction: both turning left	10,507
Two motor vehicles going in same direction: #1 left turn, #2 stopped	1,465
Two motor vehicles going in opposite directions: #1 straight, #2 left turn	716,081
Two motor vehicles going in opposite directions: #1 right turn, #2 left turn	3,515
Two motor vehicles going in opposite directions: both turning left	3,048
Two motor vehicles going in opposite directions: #1 left turn, #2 stopped	941
Two motor vehicles—other: #1 left turn, #2 parked	534

GRAPHICAL AND STATISTICAL ANALYSES

Most of the graphs provided in this report depict driver age (ranging from 15 to 93 years) along the abscissa and other measures, expressed as percentages, along the ordinate. The data points in the graphs are fitted with ordinary least squares polynomial regression equations. Many of the figures depict two functions to represent two subgroups, such as male and female drivers by age. Such figures are intended to provide "fine-grain" snapshots of the variation in selected measures by driver age.

RELATIVE LIKELIHOODS[2]

For many of the analyses, the degree to which older drivers, whether defined as 65 and older, 75 and older, or 85 and older, are overrepresented in the data is shown relative to a standard comparison group, namely, drivers in the 55–64 age group. These analyses seek to show "recent" changes in the older driver age categories, that is, changes in older drivers relative to drivers within a decade of the traditional retirement age.

Consider the following example.

Driver	DRIVERS IN INJURY CRASHES (TEXAS, 1975–1999)					
Age				Relative	95% Confidence Interval	
Category	Killed	Total	Probability	Likelihood	Low	High
55–64	3,899	424,522	0.0092	-	-	-
65+	5,871	415,415	0.0141	1.54	1.48	1.60
75+	2,889	151,242	0.0191	2.08	1.98	2.18
85+	589	22,089	0.0267	2.90	2.67	3.16

In this example, the probability of death for drivers in the 65+ age category (p1 in the formula below) is estimated as the number of drivers killed divided by

[2]The statistical procedures in this section are explained in more detail in Sahai and Khurshid (1996).

the number of drivers at risk, that is, the total number of drivers. The probability of death for the comparison group of drivers aged 55–64 (p2) is calculated in the same fashion. The *relative likelihood* (RL) of death for drivers aged 65 and over is 1.54. In other words, other things being equal, drivers 65 and older are 1.54 times as likely as drivers aged 55 to 64 to die in injury crashes. In mathematical terms, the relative likelihood of death for drivers in the 65+ age category can be expressed as follows:

$$RL_{65+} = \frac{p_1}{p_2} = \frac{\left[\frac{5,871}{415,415}\right]}{\left[\frac{3,899}{424,522}\right]} = \frac{0.0141}{0.0092} = 1.54$$

To estimate the standard error (SE) about the natural logarithm of the RL [i.e., ln(RL) = 0.4310], we may use the following equation:

$$SE_{1n(RL)} = \sqrt{\frac{1-p_1}{n_1\,(p_1)} + \frac{1-p_2}{n_2\,(p_2)}} = 0.0205$$

where p1 and p2 are as previously defined and n1 and n2 represent the number of drivers at risk in the older age category and the comparison group, respectively.

Under the null hypothesis that there is no difference between drivers in an older age category and the comparison group, the sampling distribution for the natural logarithm of the RL [i.e., ln(RL)] is asymptotically normal with a mean of zero and the standard error shown above. Thus, a standard normal (z) test can be defined as:

$$z = \frac{1n(RL)}{SE_{1n(RL)}} = 20.98$$

The 95 percent confidence interval (CI95) about the ln(RL) may be expressed as follows:

$CI_{95} = 1n(RL) \pm 1.96 (SE_{1n(RL)}) = 0.3907$ (lower) and 0.4713 (upper)

Thus, the 95 percent confidence interval about the RL is simply achieved through exponentiation:

$CI_{95} = e^{1n(RL) \pm 1.96 (SE_{1n(RL)})} = 1.4781$ (lower) and 1.6020 (upper)

In this example, and in many of the analyses carried out in this study, the samples are very large. Under these circumstances, large z's and small 95 percent confidence intervals are to be expected.

Note that when the 95 percent confidence interval about the estimated relative likelihood (RL) does not contain 1.00, the result is significant at an _ level of 0.05 (assuming a two-tailed test). In this particular example, the RL is estimated to be 1.54. The 95 percent confidence interval about this estimate is 1.48 to 1.60. Since 1.00 is not included within the confidence interval, we can say that 1.54 is significantly different from 1.00 at an _ level of 0.05, that is, that death is significantly more likely among drivers in the 65+ age category than in the comparison group.

AD HOC ADJUSTMENTS OF THE DATA

Consider the following hypothetical example:

Driver Age Group	Driver Sex	Driver Deaths	Drivers at Risk	Percent Dead
85+	Male	400	800	50.0
	Female	50	200	25.0
	Total	**450**	**1,000**	**45.0**
55–64	Male	700	1,400	50.0
	Female	350	1,400	25.0
	Total	**1,050**	**2,800**	**37.5**

Now imagine that we do not know the sex of the 1,000 drivers who are 85 years of age and older, and we do not know the sex of the 2,800 drivers who are between 55 and 64 years of age—that is, we have only the data from the bold rows. Under these circumstances, we might divide 45.0 percent by 37.5 percent and conclude that drivers 85 and older are 1.20 times as likely as drivers in the 55–64 age group to die in crashes.

Turning now to the unbolded rows in the chart, note that 50 percent of the males in the 85+ age group died, and 50 percent of the males in the 55–64 age group died. Furthermore, 25 percent of the females in the 85+ age group died, and 25 percent of the females in the 55–64 age group died. In other words, when sex is taken into account, the likelihood of death is comparable for the two age groups. Thus, the calculated relative likelihood of 1.20 reflects only a difference in the proportions of men and women involved in crashes in the two age groups—not differential fragility. In the 85+ age group, 80 percent of the drivers are male, and in the 55–64 age group, 50 percent are male. This difference in proportions must be taken into account in our analysis.

The next chart is based on the previous one but includes both observed and expected deaths for the 85+ age group. If 50 percent of the males in the 55–64 age group died, we would expect that 50 percent of the males in the 85+ age group (400 of 800 at risk) would have died had they been equally fragile. Similarly, if 25 percent of the females in the 55–64 age group died, we would expect that 25 percent of the females in the 85+ age group (50 of 200 at risk) would have died had they been equally fragile.

	55–64 Age Group			85+ Age Group		
Driver Sex	Driver Deaths	Drivers at Risk	Percent Dead	Drivers at Risk	Observed Deaths	Expected Deaths
Male	700	1,400	50.0	800	400	400
Female	350	1,400	25.0	200	50	50
Total	**1,050**	**2,800**	**45.0**	**1,000**	**450**	**450**

If we divide the sum of the observed deaths by the sum of the expected deaths (450/450), the resultant relative likelihood is 1.00. Thus, when driver sex is taken into account in this hypothetical example, drivers in the 85+ age group are as likely to die as those in the 55–64 age group—not 1.20 times as likely.

In Appendix A, the five variables depicted in Figures 3 through 7—crash type, population density, driver sex, light condition, and intersection relatedness—are used simultaneously to adjust the data and account for the fact that the circumstances and conditions surrounding the injury crashes of drivers in different age groups differ. In making these adjustments, the fragility of the drivers in the older age categories may be more appropriately compared with the fragility of drivers in the 55–64 age group.

Appendices B and C provide estimates of the degree to which drivers in the older age categories are more likely than those in the comparison group to be "ill" or to suffer a "perceptual lapse," respectively, at the time of their crashes. The arithmetic used in Appendices B and C is identical to that used in Appendix A.

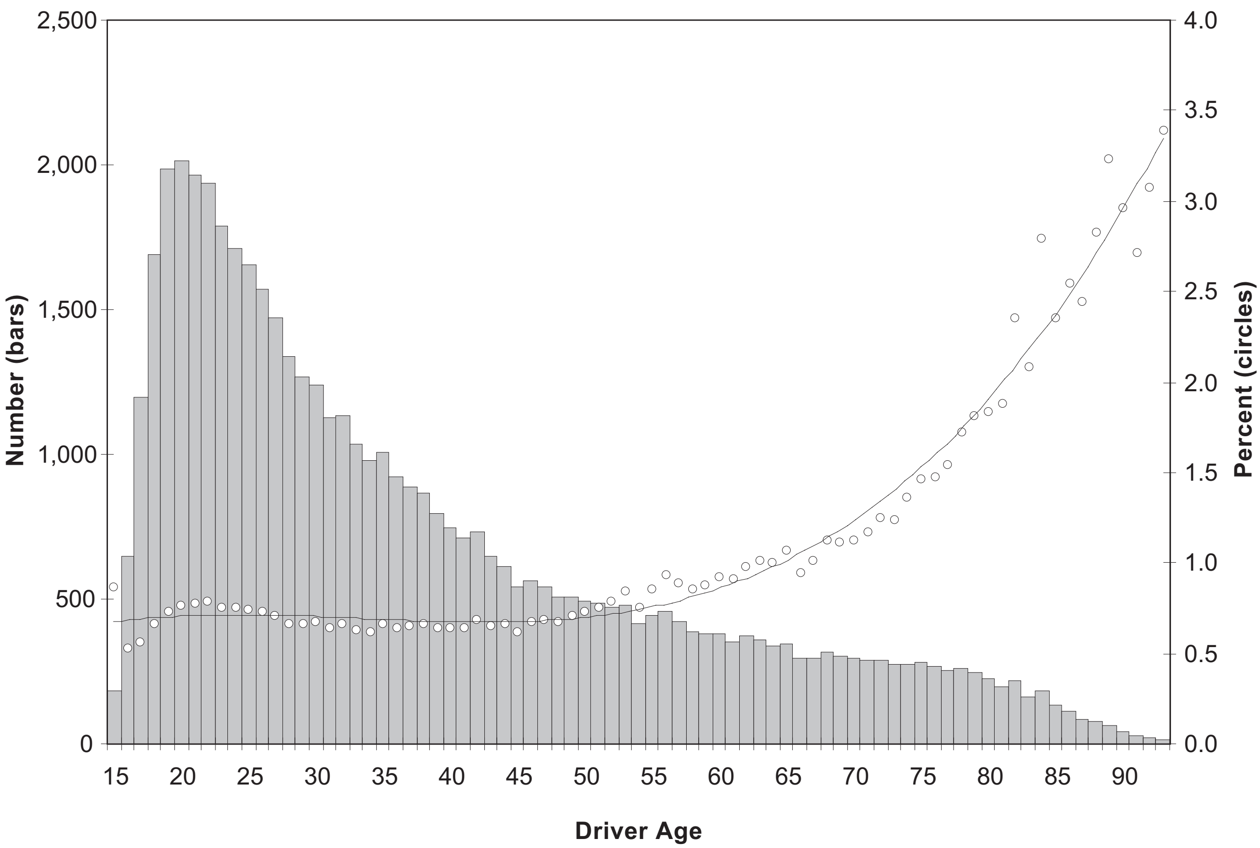
Results

FRAGILITY

Figure 2 shows the number and percentage of drivers killed in injury crashes by age. The number of drivers killed, represented by vertical bars, is measured along the left axis; the percentage of drivers killed, represented by dots, is measured along the right axis. The figure shows that, generally speaking, the likelihood of driver death in an injury crash is a positively accelerated, increasing function of age.

It is estimated that drivers in the 65+ age category are 1.54 times as likely to be killed as drivers in the comparison group (the 55–64 age group, in all analyses). The 95 percent confidence interval about this estimate is 1.48 to 1.60 (see chart below). For drivers in the 75+ and 85+ age categories, death is 2.08 and 2.90 times as likely, respectively.

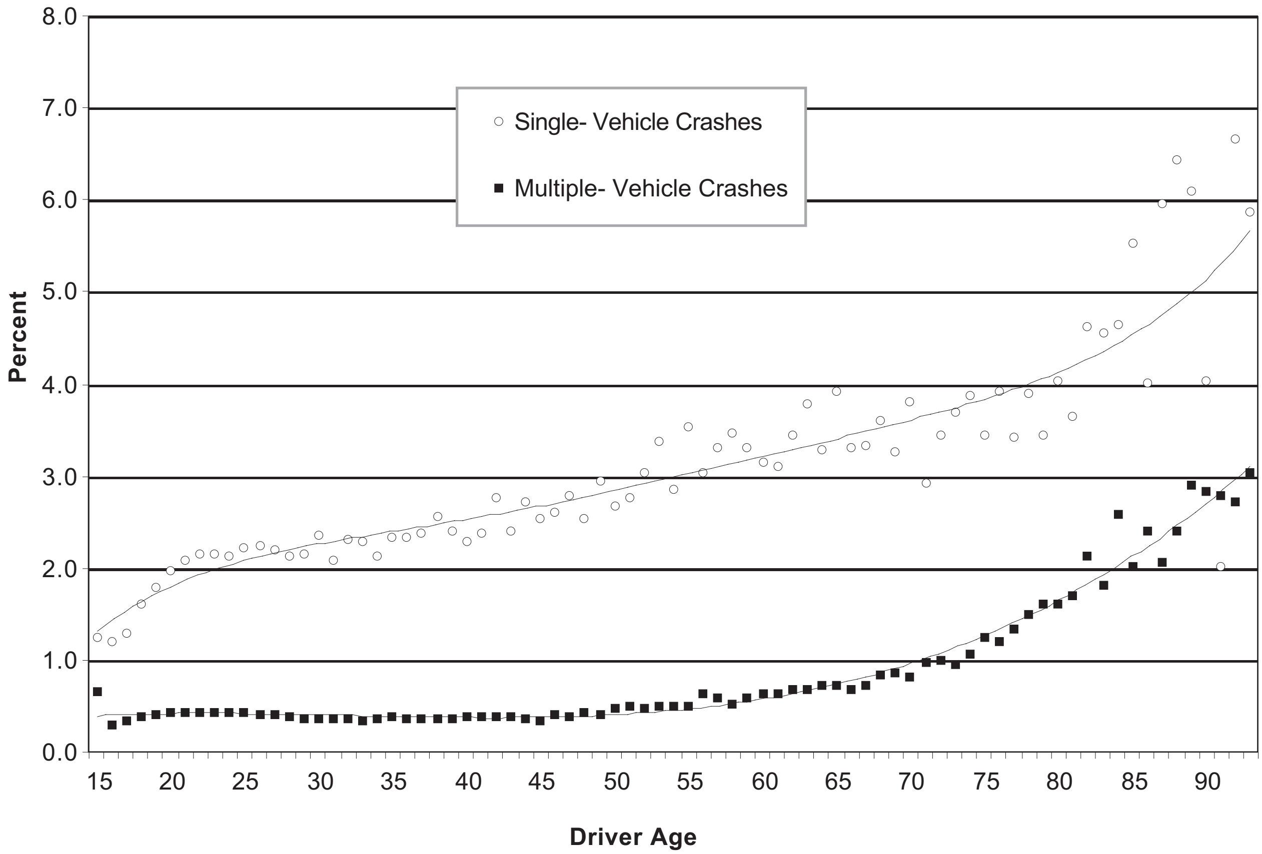
Figure 2. Number and Percent of Drivers Killed in Injury Crashes, by Age



Driver		DRIVERS IN INJURY CRASHES (TEXAS, 1975–1999)				
Age				Relative	95% Confidence Interval	
Category	Killed	Total	Probability	Likelihood	Low	High
55–64	3,899	424,522	0.0092	-	-	-
65+	5,871	415,415	0.0141	1.54	1.48	1.60
75+	2,889	151,242	0.0191	2.08	1.98	2.18
85+	589	22,089	0.0267	2.90	2.67	3.16

Overall, drivers involved in single-vehicle injury crashes are 4.89 times as likely to be killed as drivers involved in multiple-vehicle injury crashes (Figure 3).[3] In both types of crashes, the likelihood that the driver will be killed increases with age, and the likelihood of death for drivers in the three older age categories is significantly greater than the likelihood of death for drivers in the

Figure 3. Percent of Drivers Killed in Injury Crashes, by Age and Crash Type (Single Vehicle vs. Multiple Vehicle)



comparison group. For single-vehicle injury crashes, the relative likelihoods of death for drivers in the 65+, 75+, and 85+ age categories are 1.11, 1.21, and 1.56, respectively. For multiple-vehicle injury crashes, the comparable relative likelihoods are 1.89, 2.76, and 3.92.[4]

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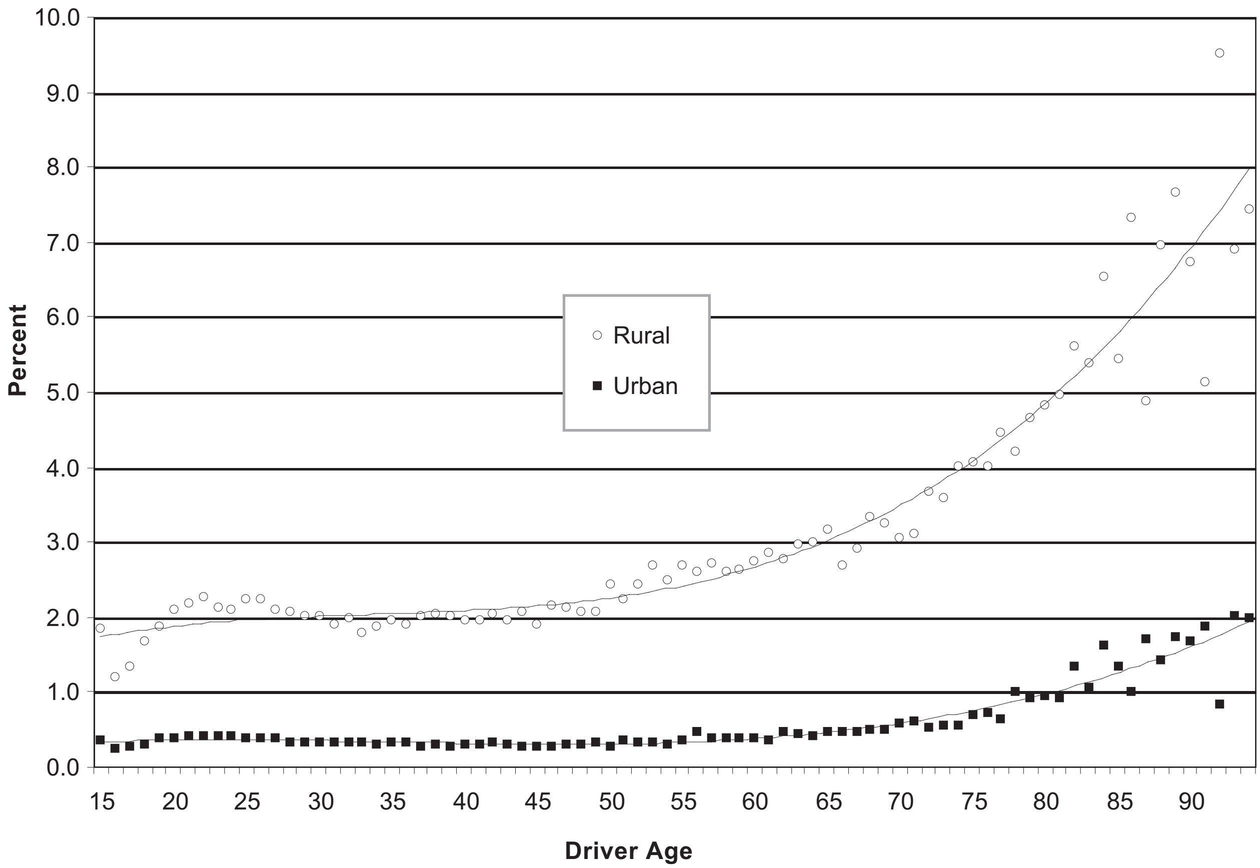
[3]Of 1,100,533 drivers involved in single-vehicle injury crashes, 24,675 (2.24 percent) were killed. Of 5,623,818 drivers involved in multiple-vehicle injury crashes, 25,778 (0.46 percent) were killed. Thus, other things being equal, drivers involved in single-vehicle injury crashes were 4.89 times as likely to be killed as drivers involved in multiple-vehicle injury crashes. Given these large sample sizes, 4.89 is obviously significantly different from 1.00—that is, the likelihood of driver death in single-vehicle injury crashes is significantly greater than the likelihood of death in multiple-vehicle injury crashes. The z-test shown in the Methods section can be used if desired.

[4]The analysis of the information in Figure 3 clearly shows that the likelihood of driver death in single-vehicle injury crashes is greater than the likelihood of driver death in multiple-vehicle

Figure 4. Percent of Drivers Killed in Injury Crashes, by Age and Population (Rural vs. Urban)



Overall, if age is not taken into account, drivers involved in injury crashes in rural areas are 5.8 times as likely as to be killed as drivers involved in injury crashes in urban areas (Figure 4). With increasing age, the likelihood of a driver's being killed in an injury crash increases in both rural areas and urban areas. For drivers in the 65+, 75+, and 85+ age categories, the relative likelihoods of death in rural injury crashes are 1.41, 1.79, and 2.32, respectively, and for urban injury crashes, 1.68, 2.42, and 3.52.

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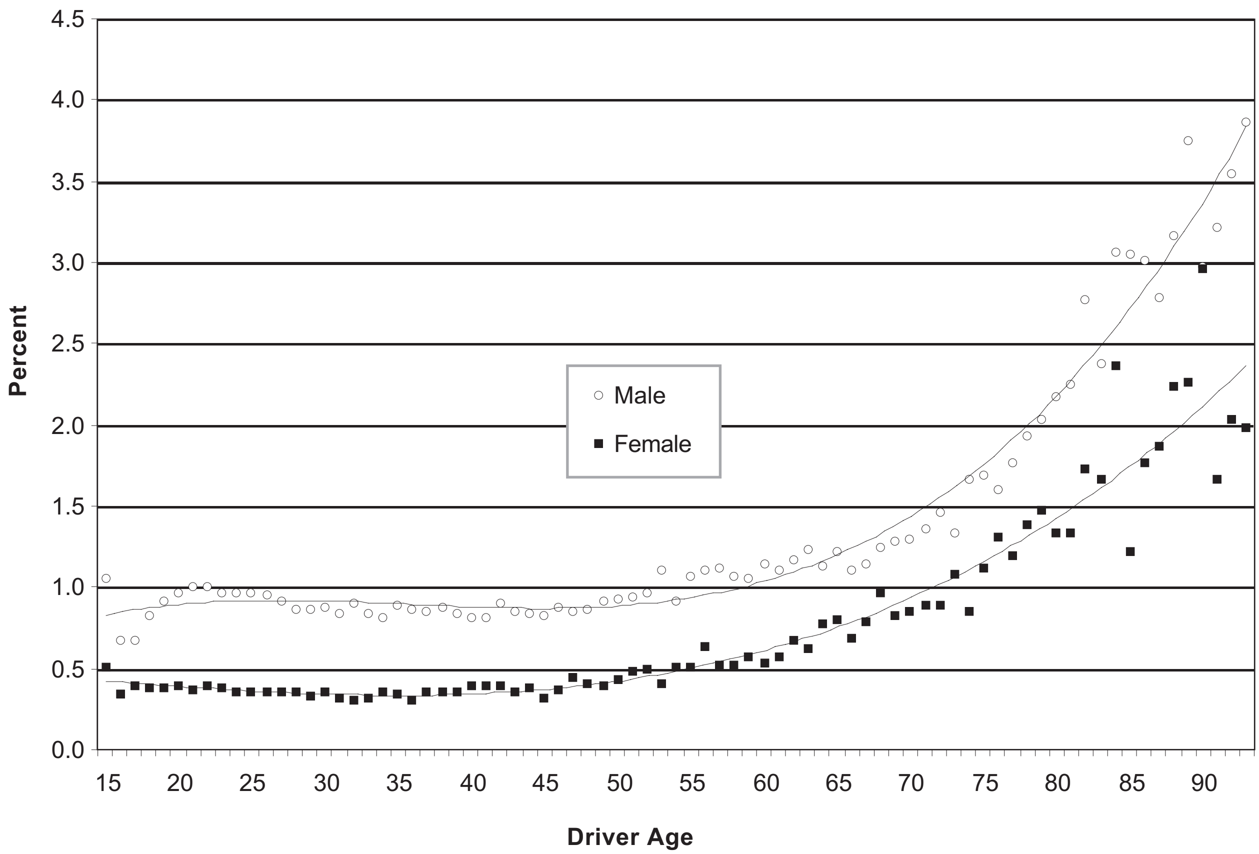
injury crashes. However, given that multiple-vehicle crashes necessarily include two or more drivers, whereas single-vehicle injury crashes necessarily include only one driver, it stands to reason that the plots of the multiple-vehicle data generally fall below those of the single-vehicle data. The same phenomenon will be manifest for other crossing variables that correlate with crash type. For example, to the extent that crashes in urban settings are more likely than rural crashes to be multiple-vehicle crashes, we might expect the percentage of drivers killed in rural

Figure 5. Percent of Drivers Killed in Injury Crashes, by Age and Sex



Male drivers involved in injury crashes are 2.25 times as likely as female drivers to be killed (Figure 5). Generally speaking, the likelihood of death in creases for both males and females with increasing age. For males in the three older age categories, the relative likelihoods of death are 1.46, 1.98, and 2.83, respectively, and for females, 1.85, 2.49, and 3.07.

Drivers involved in injury crashes that occur during hours of darkness, in-

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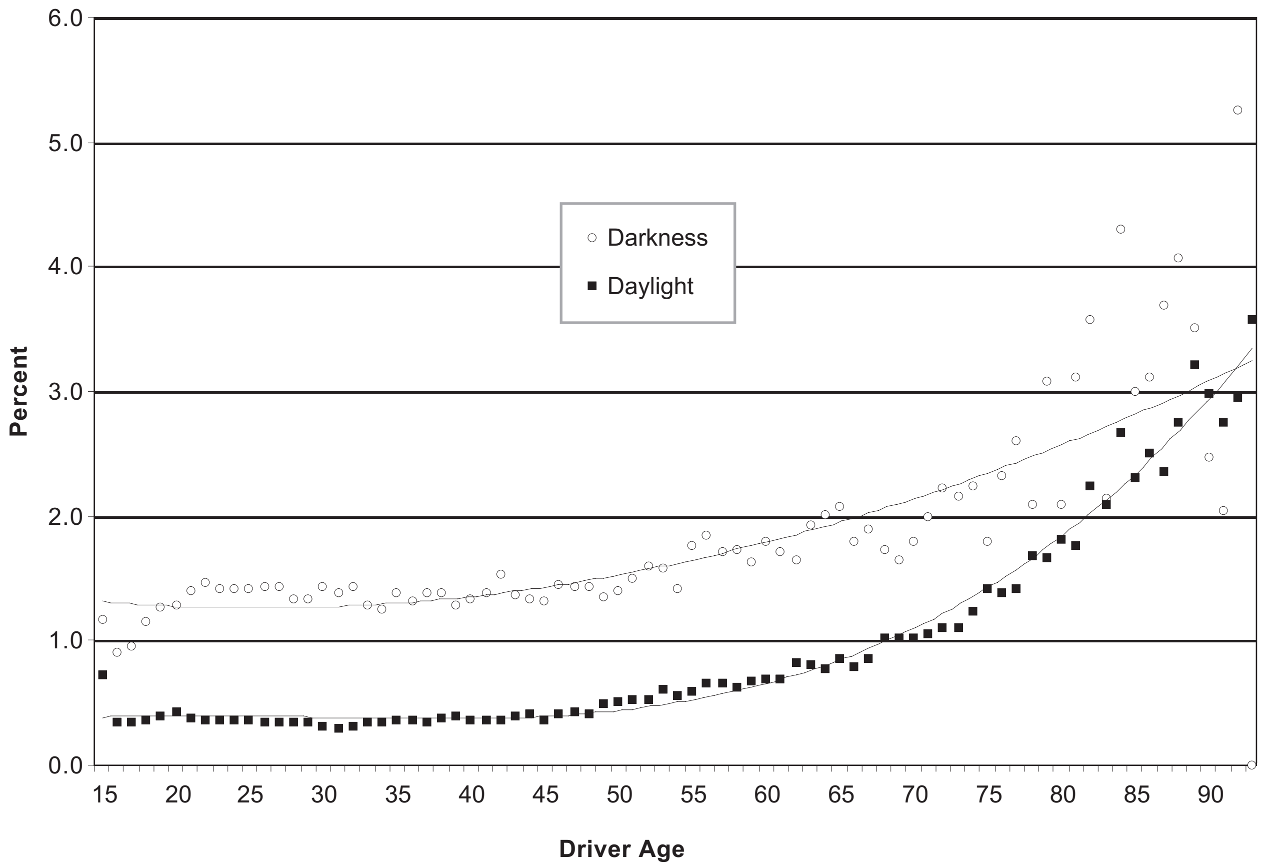
injury crashes to be greater than the percentage of drivers killed in urban injury crashes (Figure 4). To the extent that intersection-related crashes are more likely than non-intersection-related crashes to be multiple-vehicle crashes, other things being equal, we might expect to see a lower percentage of drivers killed in intersection-related injury crashes than in injury crashes that are not intersection related (Figure 7). More detail on the relative likelihood of death in the three older age groups is provided in Appendix A.

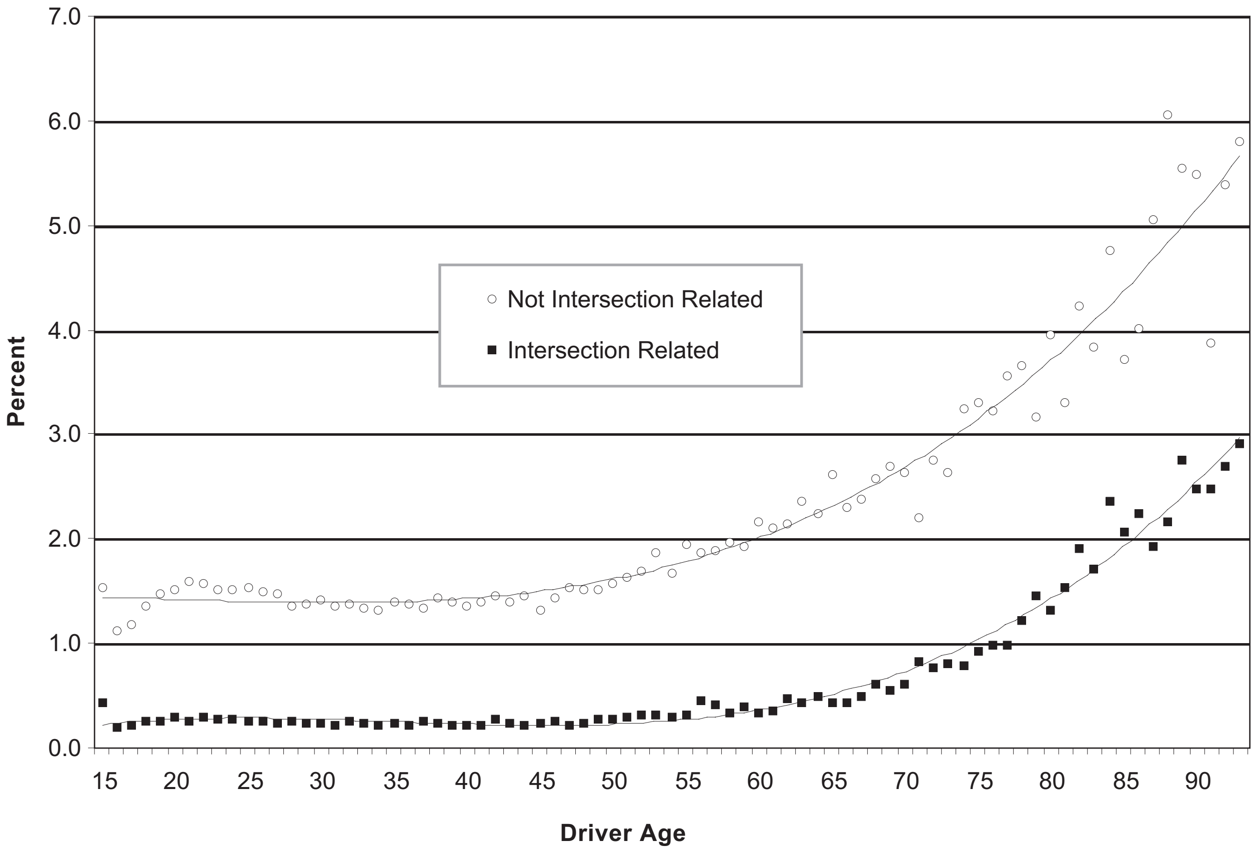
Figure 6. Percent of Drivers Killed in Injury Crashes, by Age and Light Condition



cluding dawn and dusk, are 2.90 times as likely to be killed as those involved in injury crashes during hours of daylight (Figure 6). Under both light conditions, the likelihood of death increases with age. For drivers in the three older age categories, the relative likelihoods of death in daylight injury crashes are 1.89, 2.66, and 3.79, respectively, and for injury crashes during hours of darkness, 1.18, 1.44, and 1.76.

Figure 7 depicts driver deaths in injury crashes by whether the crashes were intersection related. Intersection-related crashes include those that occur within an intersection, are “intersection related,” or involve a driveway access. Injury crashes that are not intersection related are 4.91 times as likely as intersection-related injury crashes to produce a driver fatality. Here, too, with increasing age, drivers are more likely to be killed in both intersection-related crashes and crashes

Figure 7. Percent of Drivers Killed in Injury Crashes, by Age and Intersection Related



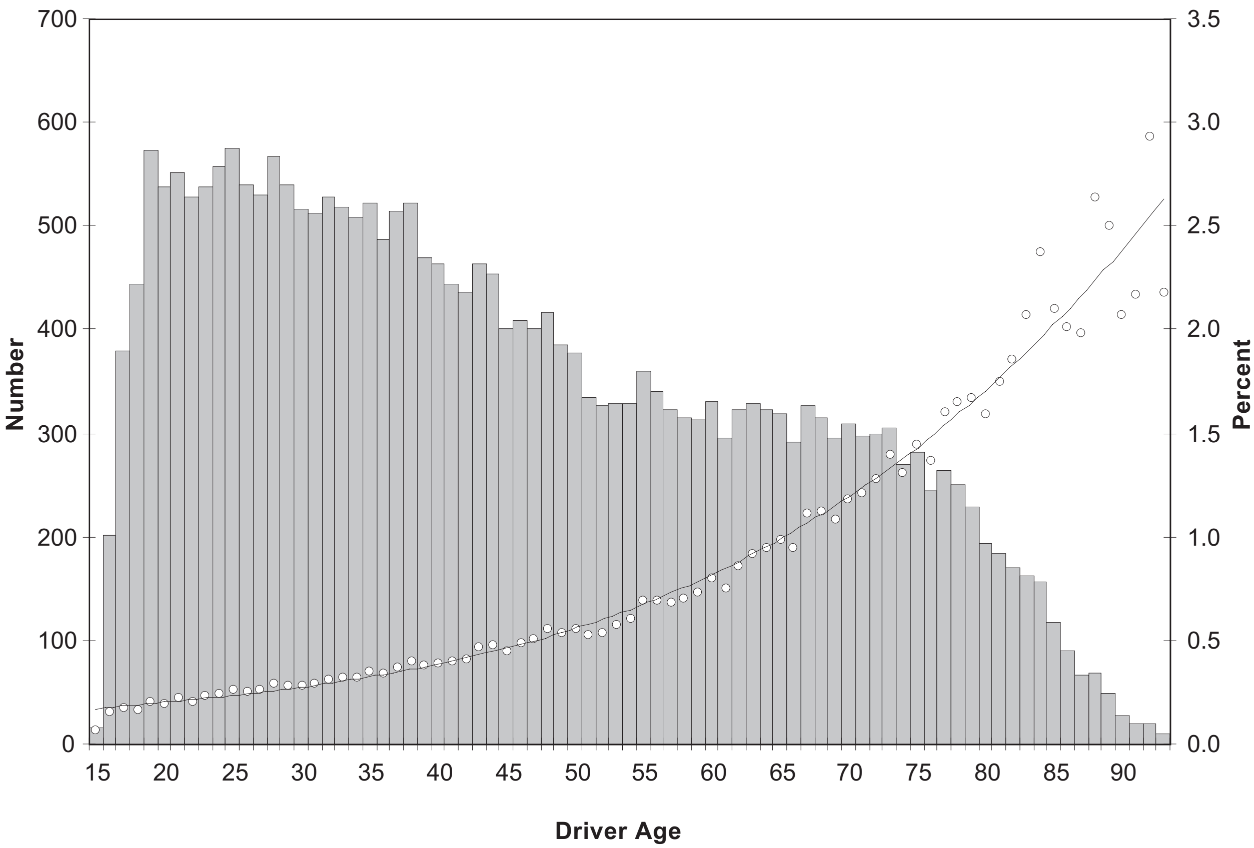
that are not intersection related. For drivers in the three older age categories, the relative likelihoods of death in intersection-related injury crashes are 2.38, 3.69, and 5.72, respectively, and for injury crashes that are not intersection related, 1.43, 1.81, and 2.25.

When all five factors depicted in Figures 3 through 7—crash type, population density, driver sex, light condition, and intersection relatedness—are considered simultaneously (see Appendix A) the following relative likelihoods result:

- Drivers 65 years of age and older are 1.78 times as likely those aged 55 to 64 to die in an injury crash.

- Drivers 75 years of age and older are 2.59 times as likely as those aged 55 to 64 to die in an injury crash.

Figure 8. Number and Percent of Drivers in Injury Crashes Impaired by Illness or Other Physical Defects, by Age



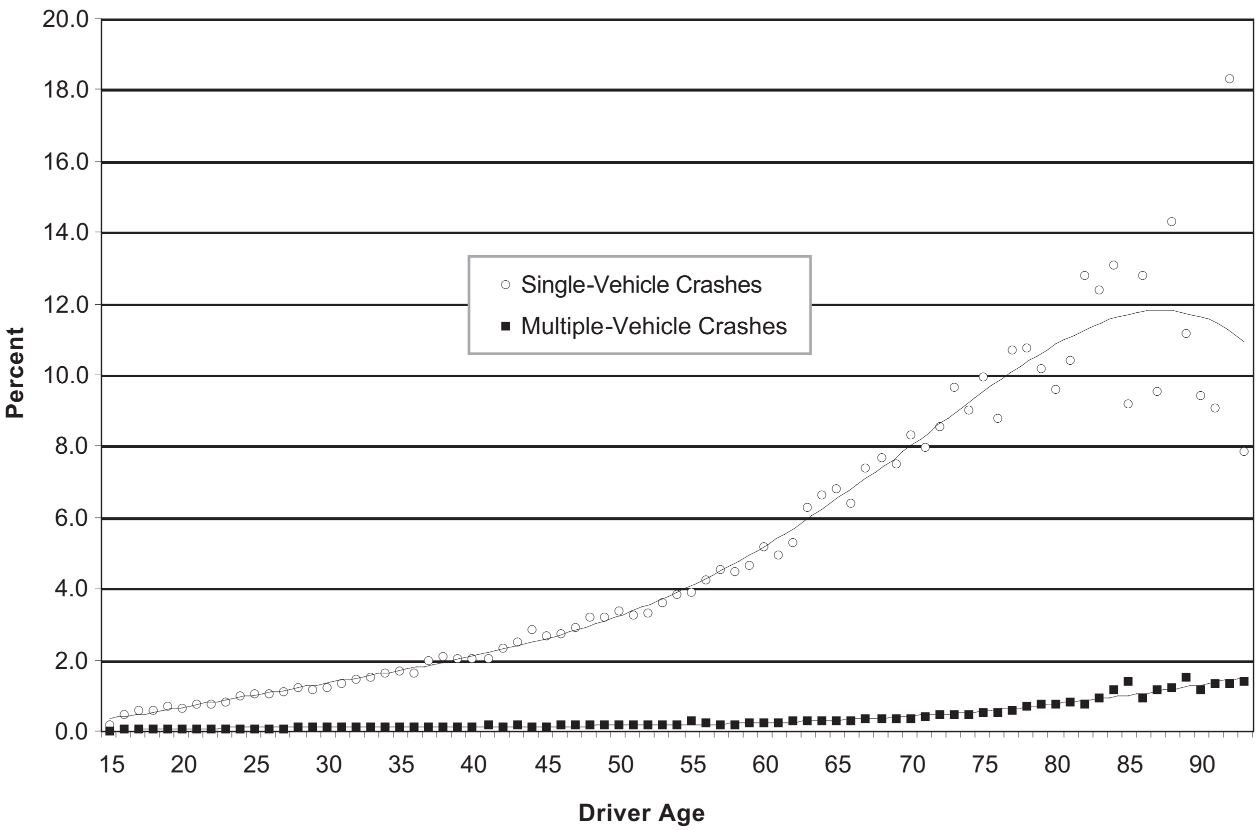
- Drivers 85 years of age and older are 3.72 times as likely as those aged 55 to 64 to die in an injury crash.

ILLNESS

Figure 8 depicts the number and percentage of drivers impaired by illness or some other physical defect at the time of their injury crash by age. The number of drivers impaired by illness or some other physical defect is represented by vertical bars and is measured along the left axis, and the percentage of impaired drivers is represented by dots and measured along the right axis. The likelihood that a driver involved in an injury crash was impaired by illness or some other physical defect increases dramatically with age.

Drivers in the 65+ age category are 1.78 times as likely drivers in the compari-

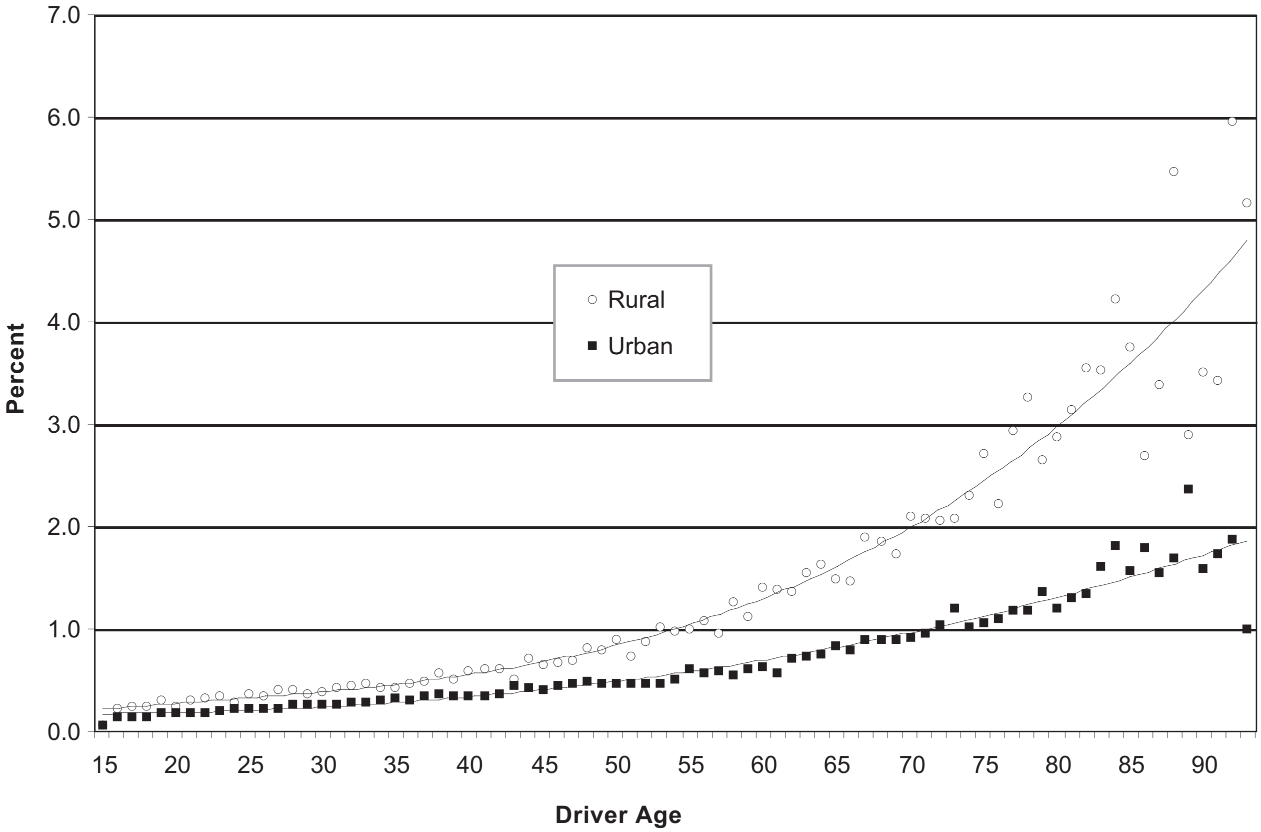
Figure 9. Percent of Drivers in Injury Crashes Impaired by Illness or Other Physical Defects, by Age and Crash Type (Single Vehicle vs. Multiple Vehicle)



son group to be impaired by illness or some other physical defect at the time of their crash. For drivers in the 75+ and 85+ categories, respectively, the relative likelihoods of impairment are 2.28 and 2.97. The 95 percent confidence intervals about these estimates are shown below.

Driver Age Category	DRIVERS IN INJURY CRASHES (TEXAS, 1975–1999) Illness	Total	Probability	Relative Likelihood	95% Confidence Interval Low	High
55–64	3,247	424,522	0.0076	-	-	-
65+	5,666	415,415	0.0136	1.78	1.71	1.86
75+	2,639	151,242	0.0174	2.28	2.17	2.40
85+	502	22,089	0.0227	2.97	2.71	3.26

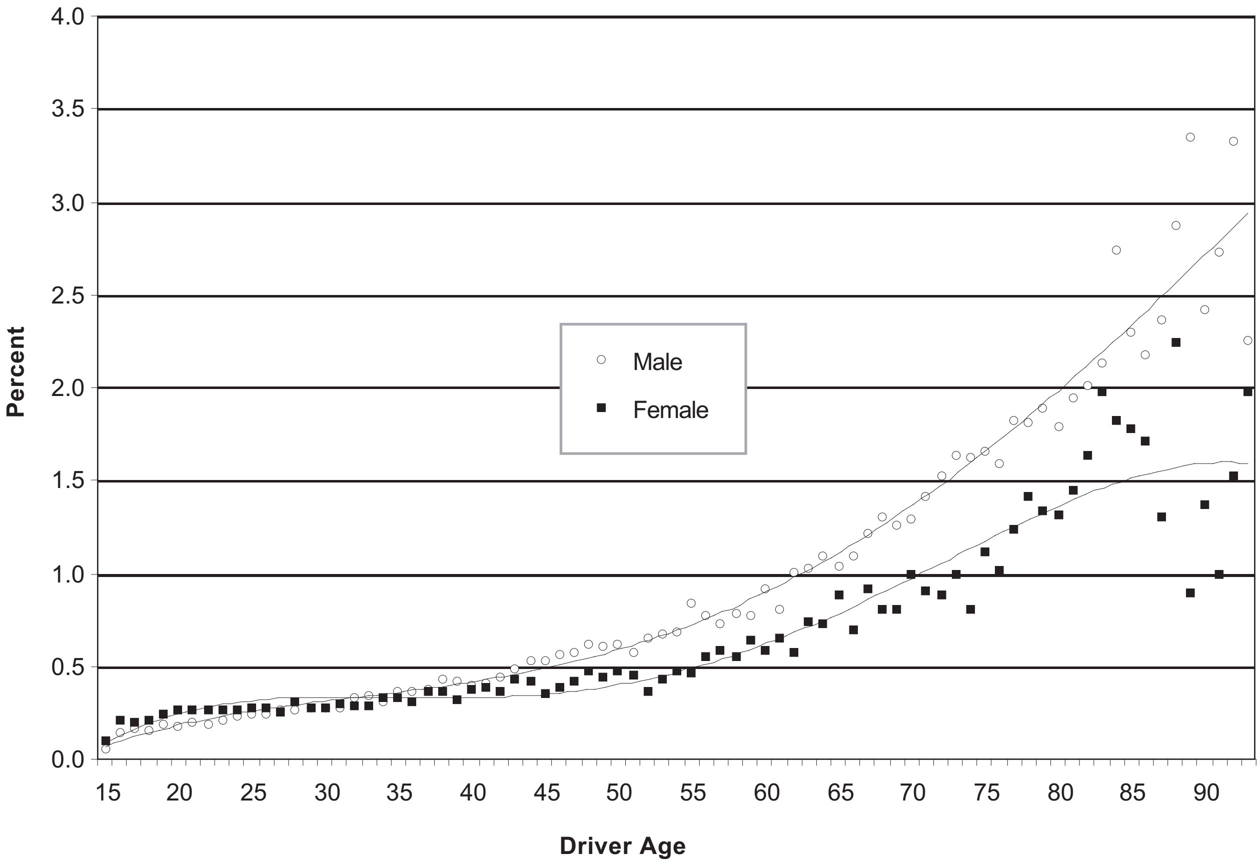
Figure 10. Percent of Drivers in Injury Crashes Impaired by Illness or Other Physical Defects, by Age and Population (Rural vs. Urban)



Impairment due to illness or some other physical defect is 12.35 times as likely for drivers in single-vehicle injury crashes as for those in multiple-vehicle injury crashes (Figure 9). In single-vehicle crashes, drivers in the 65+, 75+, and 85+ age categories are, respectively, 1.80, 2.17, and 2.28 times as likely as those in the comparison group to be impaired by illness or some other physical defect, and in multiple-vehicle crashes, the relative likelihoods are 2.16, 3.27, and 5.46.

Drivers involved in injury crashes in rural areas are 1.77 times as likely as those in urban areas to be impaired by illness or some other physical defect. As driver age increases, the proportion of drivers impaired also increases in both rural and urban areas (Figure 10). In rural areas, drivers in the older age categories are, respectively, 1.87, 2.49, and 3.12 times as likely as those in the comparison group to be impaired, and in urban areas, 1.71, 2.11, and 2.76 times as likely.

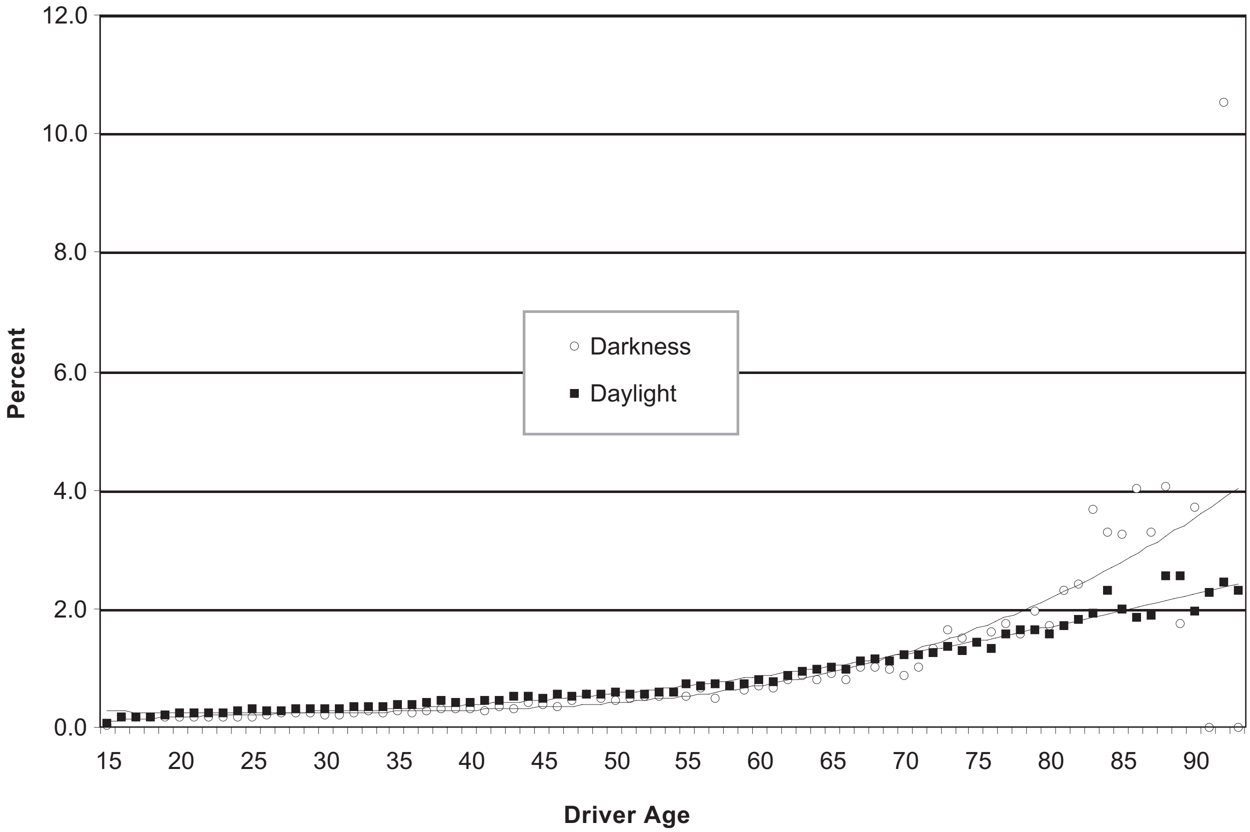
Figure 11. Percent of Drivers Impaired by Illness or Other Physical Defects, by Age and Sex



Male drivers involved in injury crashes are 1.14 times as likely as female drivers to be impaired by illness or some other physical defect. Again, the likelihood of impairment increases with age for both males and females (Figure 11). Males in the older age groups are 1.80, 2.29, and 3.03 times as likely, respectively, to be impaired as those in the comparison group, and females in the older groups are 1.78, 2.33, and 2.79 times as likely to be impaired as females in the comparison group.

Although the data depicted in Figure 12 might appear to suggest that the likelihood of impairment due to illness or some other physical defect among drivers in injury crashes is comparable during hours of daylight and hours of darkness, if driver age is disregarded, impairment is 1.57 times as likely during hours of daylight. The likelihood of impairment increases with age during both

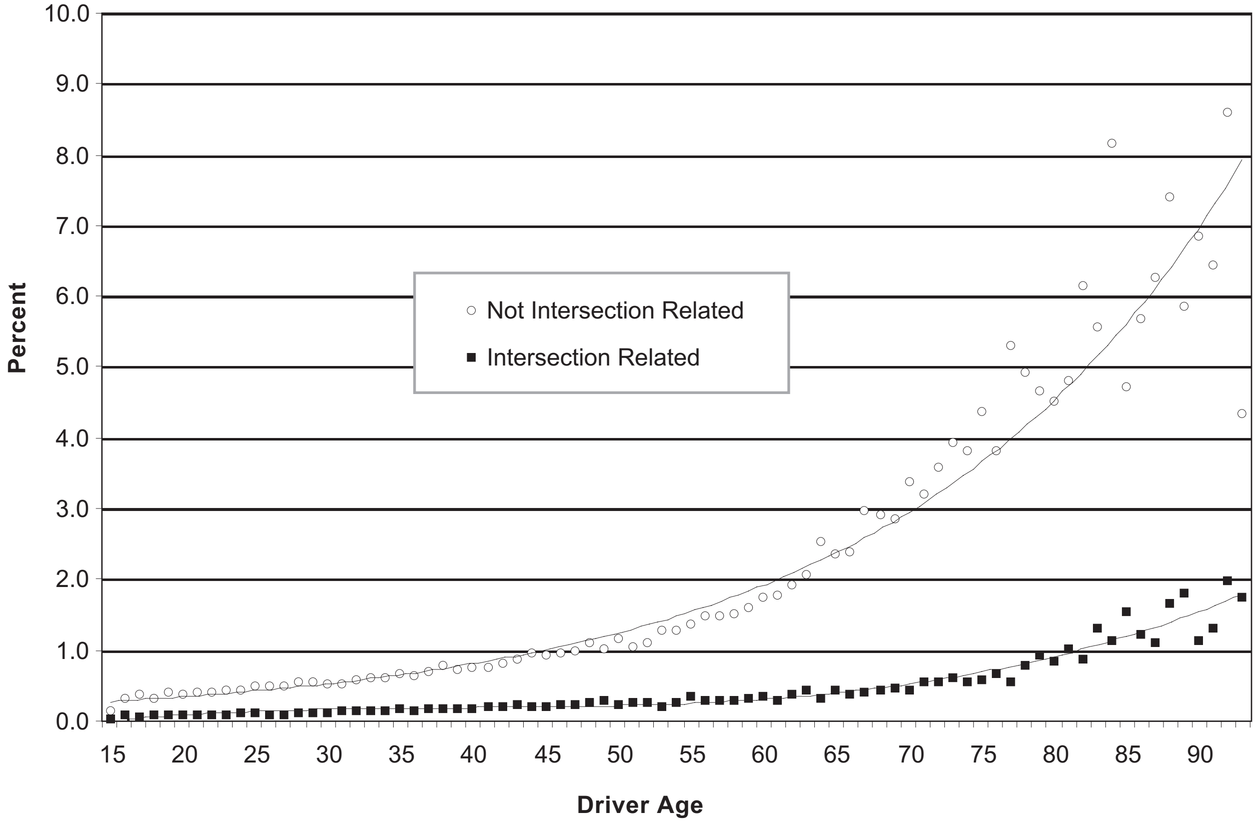
Figure 12. Percent of Drivers in Injury Crashes Impaired by Illness or Other Physical Defects, by Age and Light Condition



daylight and darkness conditions. During hours of daylight, impairment is 1.73, 2.14, and 2.76 times as likely for drivers in the three older age categories as for the comparison group, and during hours of darkness, 2.01, 3.13, and 5.22 times as likely.

Drivers involved in injury crashes that are not intersection related are 4.07 times as likely as drivers involved in intersection-related crashes to be impaired by illness or physical defect. In both intersection-related crashes and crashes that are not related to intersections, the likelihood that a driver will be impaired at the time of the crash increases with age (Figure 13). Drivers in the 65+, 75+, and 85+ age categories involved in intersection-related crashes are, respectively, 1.99, 2.82, and 4.64 times as likely as those in the comparison group to be impaired, and

Figure 13. Percent of Drivers in Injury Crashes Impaired by Illness or Other Physical Defects, by Age and Intersection Related



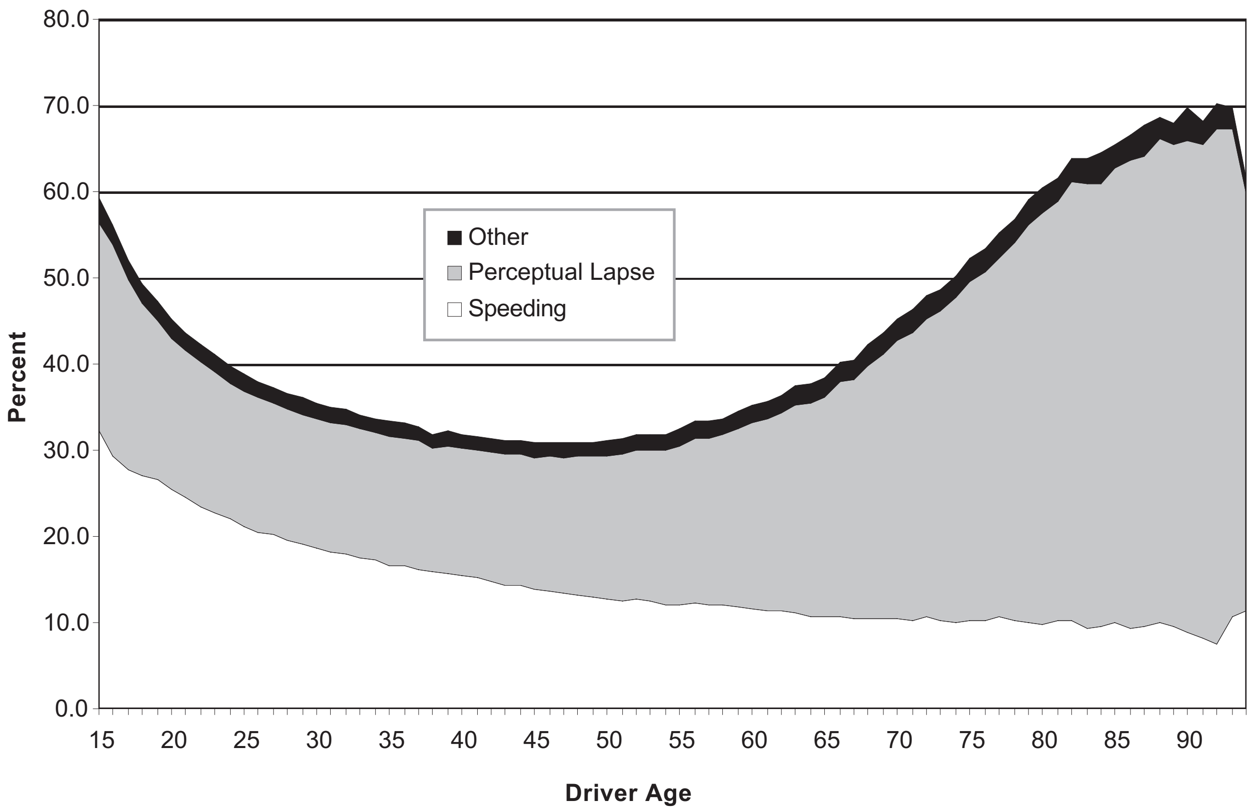
those involved in crashes that are not related to intersections are 2.14, 2.95, and 3.48 times as likely.

When all five factors depicted in Figures 9 through 13—crash type, population density, driver sex, light condition, and intersection relatedness—are considered simultaneously (see Appendix B), the following relative likelihoods result:

- Drivers 65 years of age and older are 1.83 times as likely as those aged 55 to 64 to be impaired by illness or some other physical defect at the time of their injury crash.

- Drivers 75 years of age and older are 2.38 times as likely as those aged 55 to 64 to be impaired by illness or some other physical defect at the time of their injury.

Figure 14. Percent of Drivers in Injury Crashes, by First Contributing Factor and Age

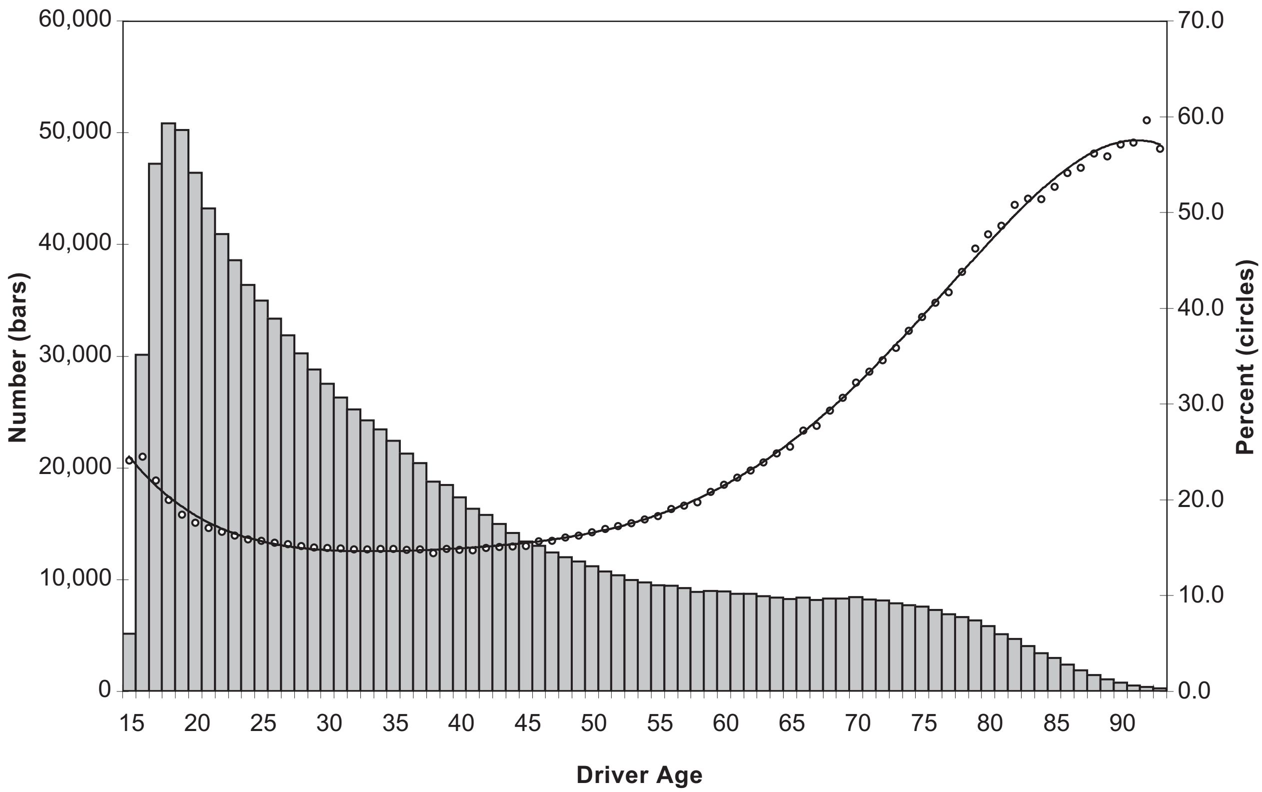


- Drivers 85 years of age and older are 3.06 times as likely as those aged 55 to 64 to be impaired by illness or some other physical defect at the time of their injury crash.

PERCEPTUAL LAPSES

As Figure 14 shows, 59 percent of 15-year-old drivers involved in injury crashes were speeding, suffered perceptual lapses—that is, failed to yield the right of way or disregarded a traffic sign or signal—or committed some other error that contributed to their crashes. For drivers aged 55 to 64, the proportion is 35 percent. For drivers in the three older age categories, the proportions are 49 percent, 59 percent, and 67 percent, respectively. Note that among younger drivers, speeding is relatively more common than perceptual lapses. Beginning at age 42,

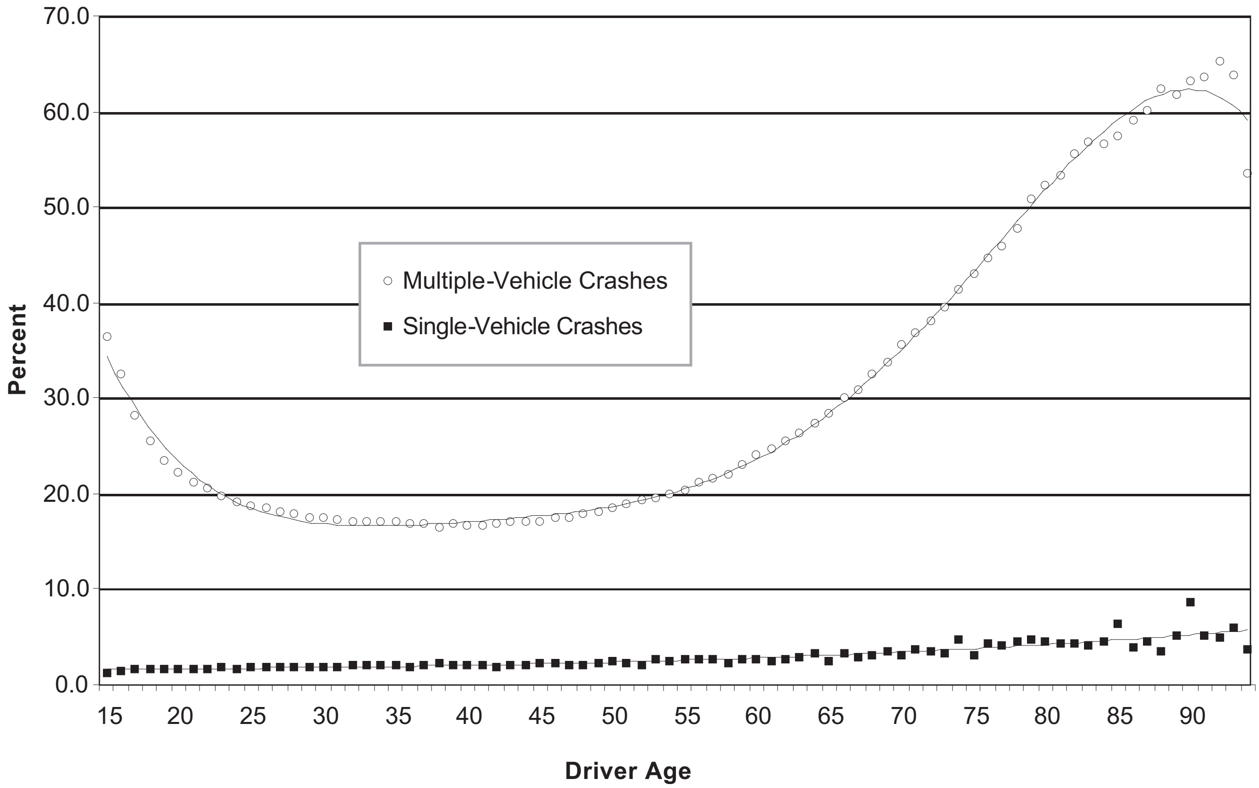
Figure 15. Number and Percent of Drivers in Injury Crashes Who Suffered Perceptual Lapses, by Age



however, perceptual lapses become relatively more common than speeding.

Figure 15 depicts the number and percentage of drivers in injury crashes who suffered some perceptual lapse. The number of drivers suffering perceptual lapses is represented by vertical bars and is measured along the left axis; the percentage of drivers suffering perceptual lapses is represented by dots and measured along the right axis. For drivers 55 to 64 years old, 21.03 percent were reported to have suffered perceptual lapses. For drivers in the three older age categories, the percentages were 36.47, 46.18, and 54.57, respectively. Relative to the comparison group, drivers in the older age categories were, respectively, 1.73, 2.20, and 2.59 times as likely to have suffered a perceptual lapse.

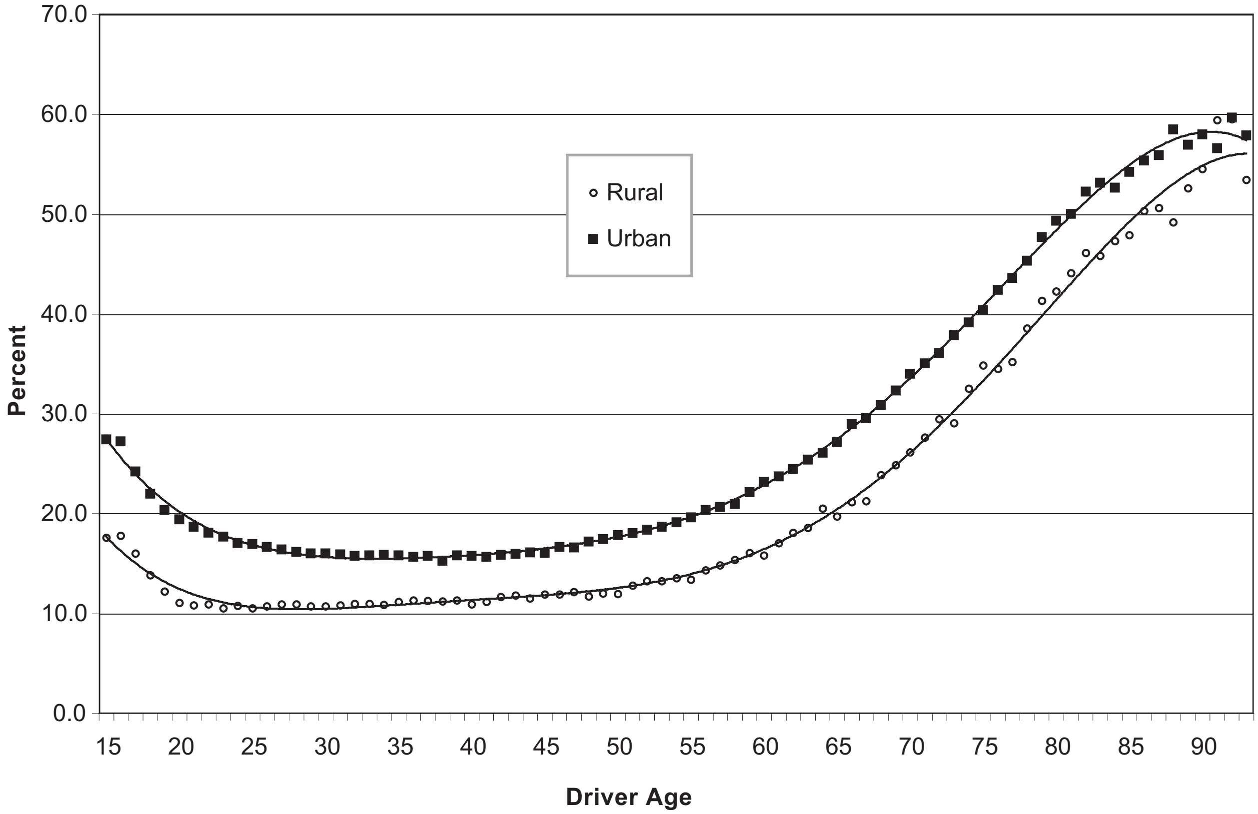
Figure 16. Percent of Drivers in Injury Crashes Who Suffered Perceptual Lapses, by Age and Crash Type (Single Vehicle vs. Multiple Vehicle)



Driver	DRIVERS IN INJURY CRASHES (TEXAS, 1975–1999)					
Age Categ.	Inattentive	Total	Probability	Relative Likelihood	95% Confidence Interval Low	High
55–64	89,294	424,522	0.2103	-	-	-
65+	151,480	415,415	0.3647	1.73	1.72	1.75
75+	69,845	151,242	0.4618	2.20	2.18	2.21
85+	12,053	22,089	0.5457	2.59	2.56	2.63

Not surprisingly, perceptual lapses are significantly more common in multiple-vehicle injury crashes than in single-vehicle injury crashes—10.79 times as common (Figure 16). The relative likelihoods of these lapses among drivers in

Figure 17. Percent of Drivers in Injury Crashes Who Suffered Perceptual Lapses, by Age and Population (Rural vs. Urban)

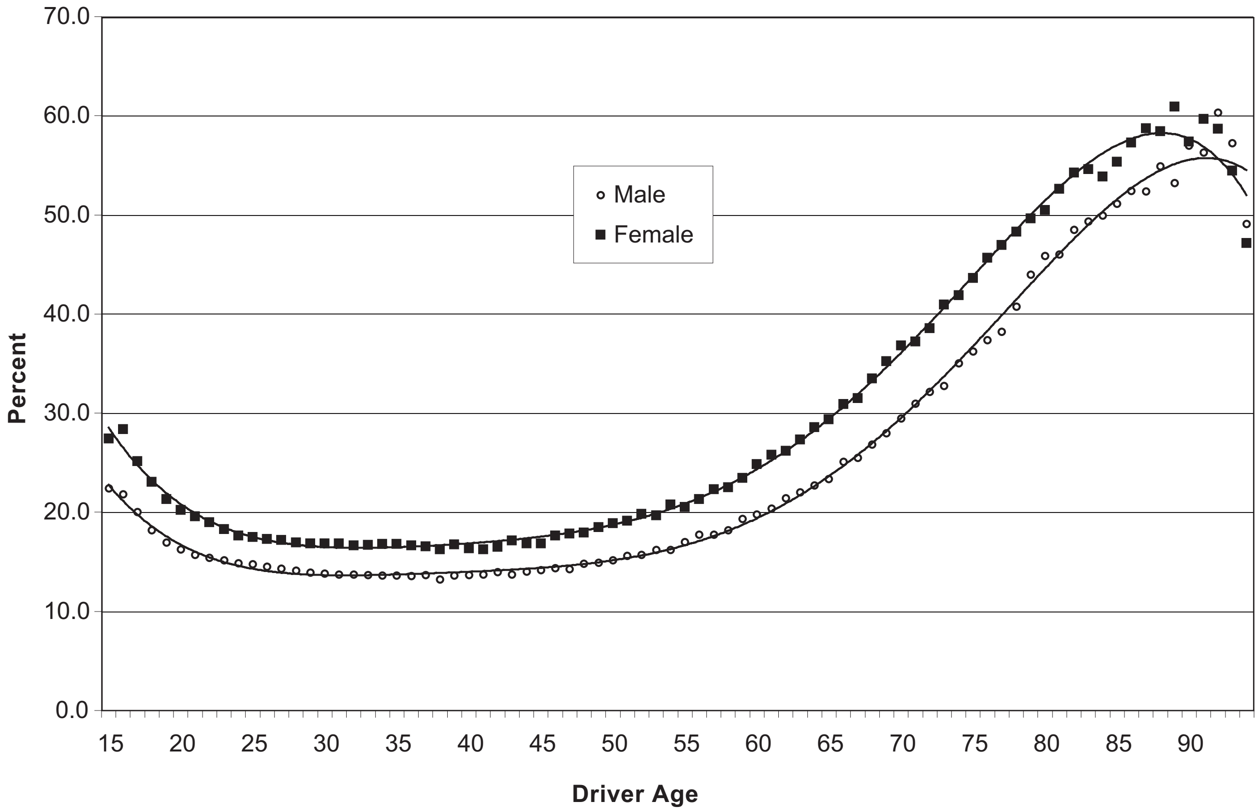


the three older age categories in single-vehicle injury crashes are 1.35, 1.60, and 1.90, respectively, and in multiple-vehicle crashes, 1.72, 2.17, and 2.57.

Perceptual lapses are 1.43 times as common among drivers involved in urban crashes than those involved in rural crashes (Figure 17). Drivers in the older age categories involved in injury crashes in rural areas were, respectively, 1.87, 2.49, and 3.12 as likely to have suffered a perceptual lapse as drivers in the comparison group, and in urban areas, 1.71, 2.11, and 2.76 times as likely.

Female drivers involved in injury crashes are 1.22 times as likely as male drivers to be reported as having suffered a perceptual lapse (Figure 18). Women in the older age categories are, respectively, 1.78, 2.33, and 2.79 times as likely to have suffered such a lapse as drivers in the comparison group; for men the figures are 1.80, 2.29, and 3.03.

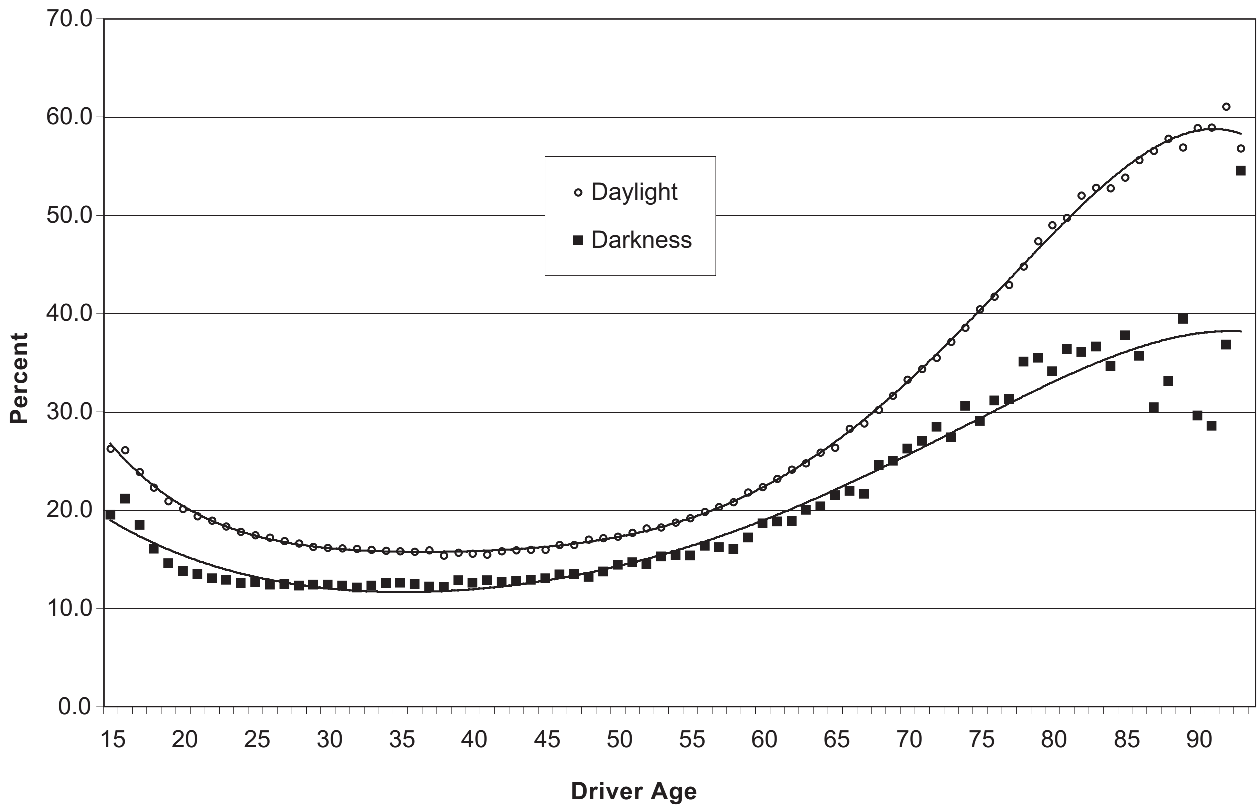
Figure 18. Percent of Drivers in Injury Crashes Who Suffered Perceptual Lapses, by Age and Sex



Drivers involved in injury crashes during daylight hours are 1.40 times as likely as those involved in injury crashes during hours of darkness to suffer perceptual lapses (Figure 19). During hours of daylight, drivers in the 65+, 75+, and 85+ age categories involved in injury crashes are, respectively, 1.73, 2.14, and 2.76 times as likely as drivers in the 55–64 age group to suffer perceptual lapses, and during hours of darkness, they are 2.01, 3.13, and 5.22 times as likely to suffer such lapses.

Finally, drivers involved in intersection-related crashes are 30.66 times as likely to have suffered perceptual lapses as drivers whose injury crashes were not intersection related (Figure 20). In intersection-related crashes, drivers in the three older age categories are 1.99, 2.82, and 4.64 times as likely as drivers in the comparison group to have had perceptual lapses, and in crashes that are not in-

Figure 19. Percent of Drivers in Injury Crashes Who Suffered Perceptual Lapses, by Age and Light Condition

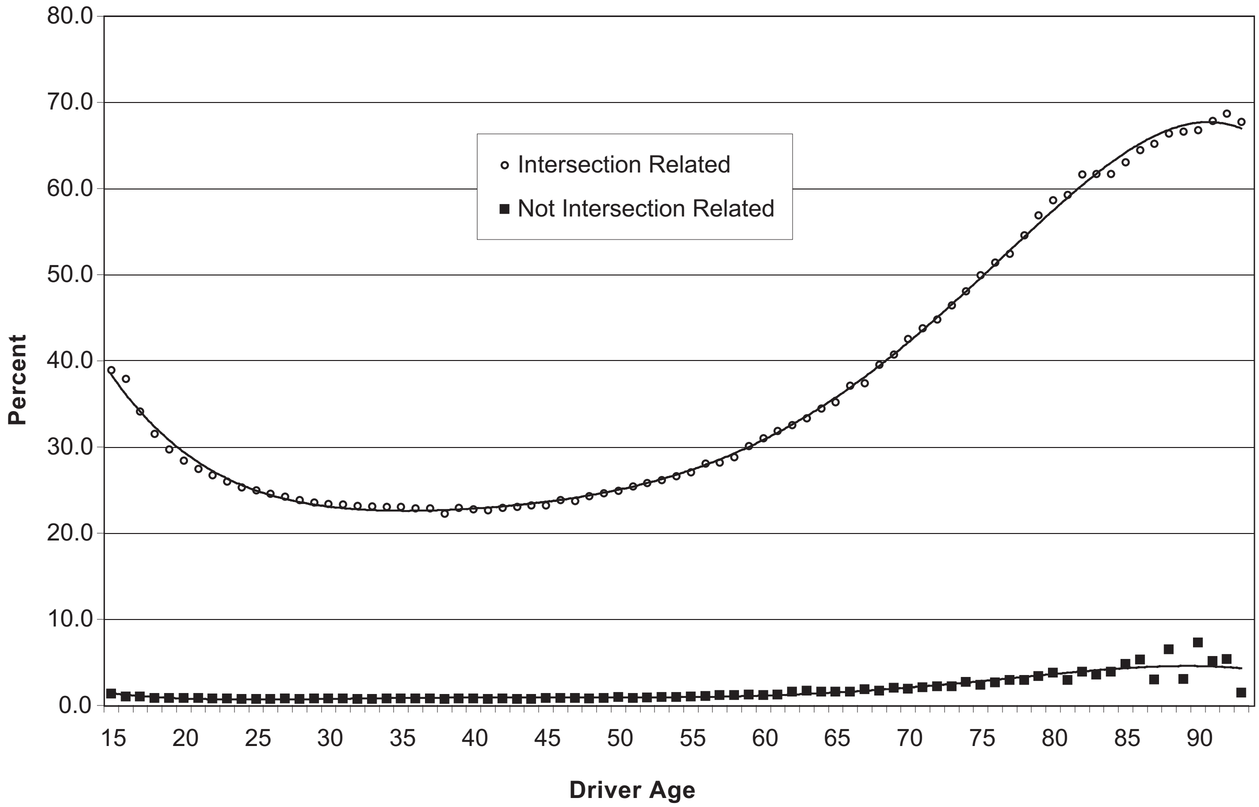


tersection related, 2.14, 2.95, and 3.48 times as likely.

When all five factors depicted in Figures 16 through 20—crash type, population density, driver sex, light condition, and intersection relatedness—are considered simultaneously (see Appendix C) the following relative likelihoods result:

- Drivers 65 years of age and older are 1.56 times as likely as those aged 55 to 64 to have suffered perceptual lapses.
- Drivers 75 years of age and older are 1.89 times as likely as those aged 55 to 64 to have suffered perceptual lapses.
- Drivers 85 years of age and older are 2.17 times as likely as those aged 55 to 64 to have suffered perceptual lapses.

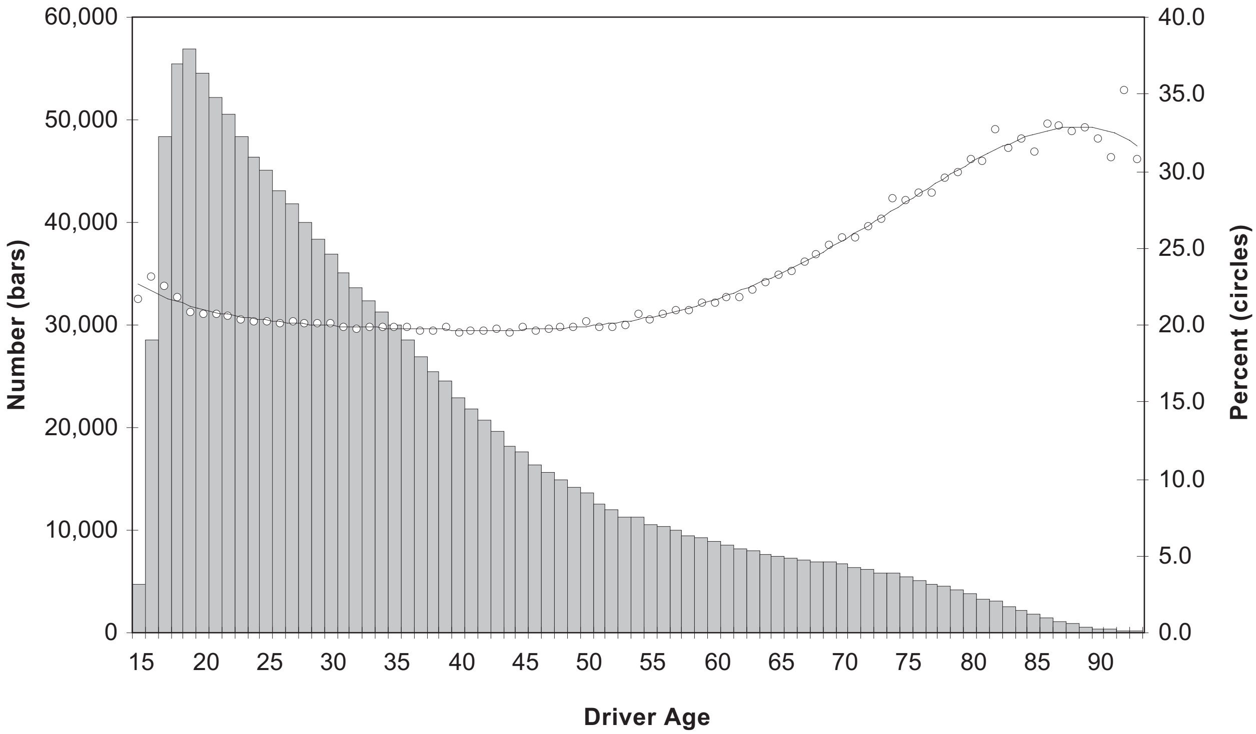
Figure 20. Percent of Drivers in Injury Crashes Who Suffered Perceptual Lapses, by Age and Intersection Relatedness



LEFT TURNS

Figure 21 depicts the number and percentage of drivers involved in left-turn injury crashes by age. The vertical bars represent the number of drivers, and the dots represent the percentage of drivers. For drivers 35 to 54 years of age, 19.80 percent were involved in left-turn injury crashes. For drivers in the comparison group (55–64 years old), the percentage is 21.38. The relative likelihoods that drivers in the older age categories were involved in left-turn crashes are shown below.

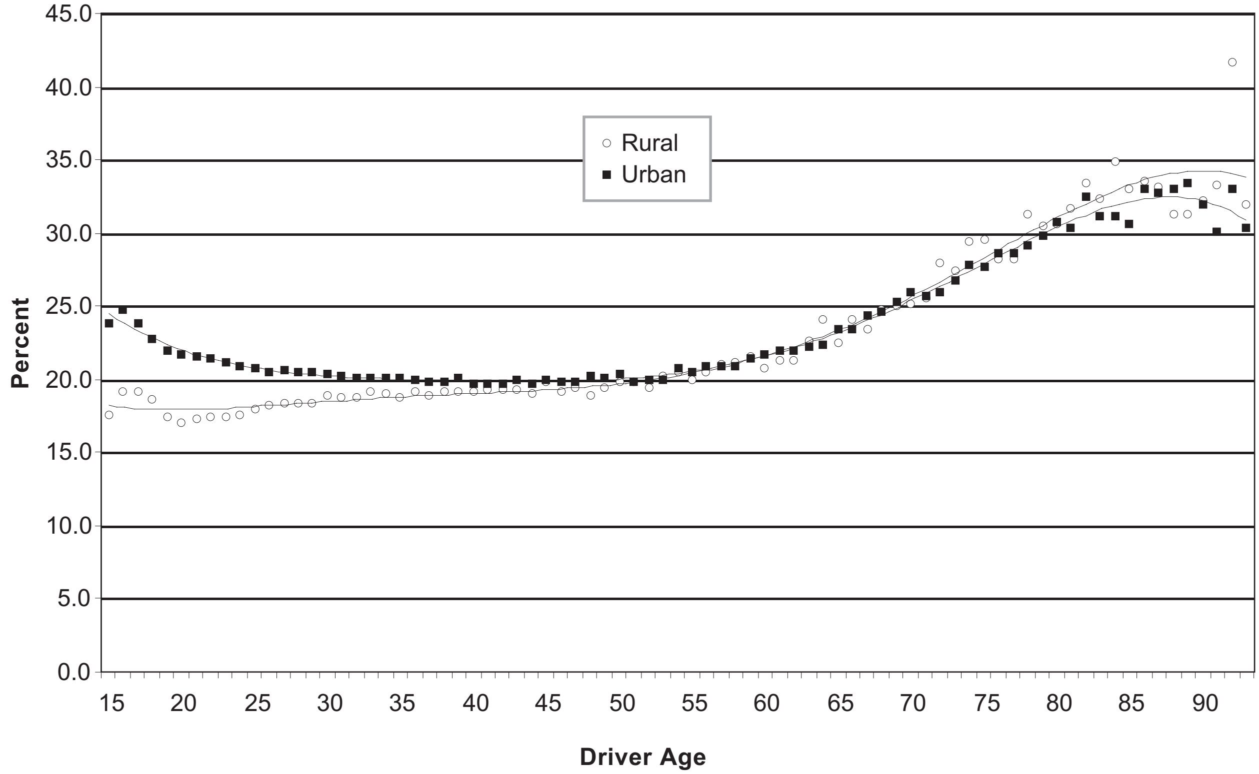
Figure 21. Number and Percent of Drivers in Injury Crashes Who Were Involved in Left Turn Crashes by Age



Driver	DRIVERS IN INJURY CRASHES (TEXAS, 1975–1999)					
Age Categ.	Left-turn Crashes	Total	Probability	Relative Likelihood	95% Confidence Interval Low	High
55–64	90,746	424,522	0.2138	-	-	-
65+	112,098	415,415	0.2699	1.26	1.25	1.27
75+	45,619	151,242	0.3016	1.41	1.40	1.42
85+	7,127	22,089	0.3227	1.51	1.48	1.54

Figure 22 depicts the percentages of drivers involved in left-turn injury crashes by whether the crash occurred in a rural or urban area and driver age. Drivers in the 65+, 75+, and 85+ age categories operating in rural areas are, respectively, 1.28, 1.45, and 1.54 times as likely to be involved in left-turn injury crashes as

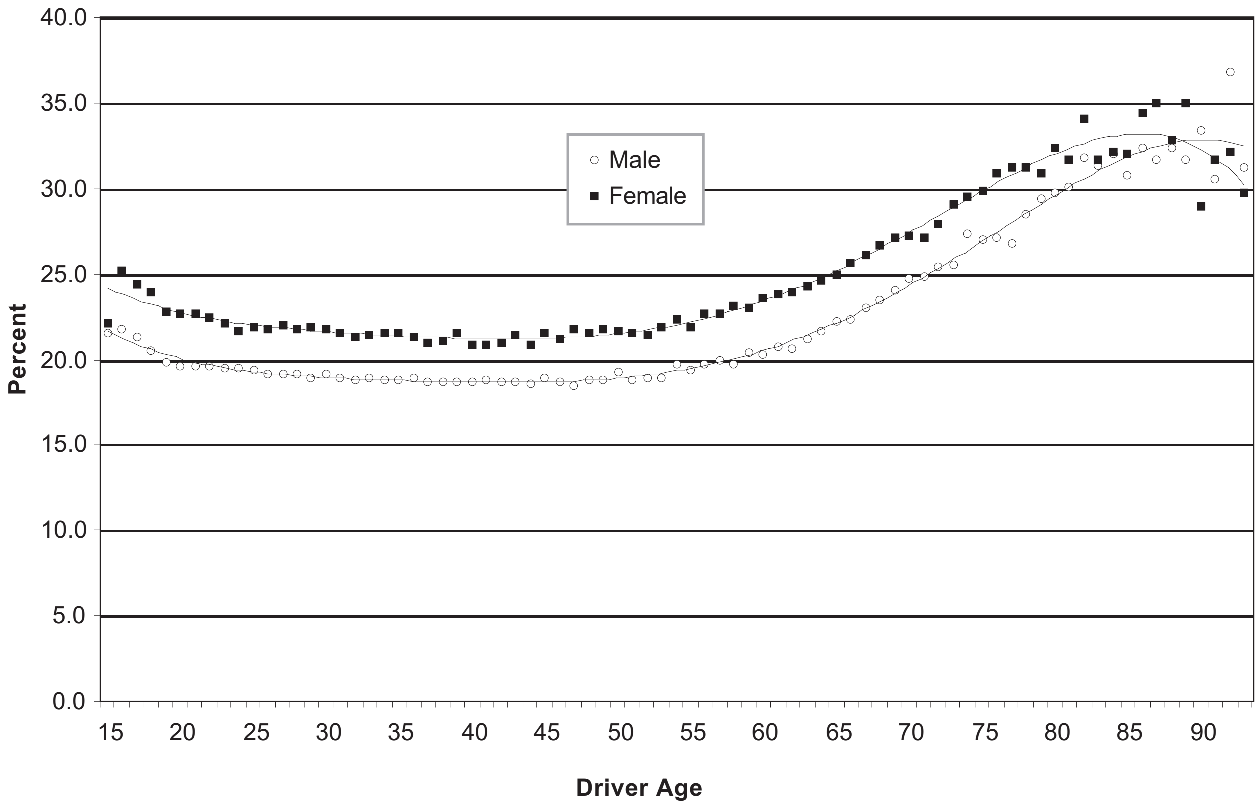
Figure 22. Percent of Drivers Who Were Involved in Left Turn Crashes, by Age and Population (Rural vs. Urban)



drivers in the 55–64 age group. In urban areas, the corresponding relative likelihoods are quite similar: 1.26, 1.40, and 1.50.

Figure 23 shows that female drivers are relatively more likely than male drivers to be involved in left-turn injury crashes. Overall, 22.50 percent of female drivers and 19.79 percent of male drivers were involved in left-turn injury crashes—that is, females were 1.14 times as likely as males to be involved in left-turn injury crashes. Males in the older age categories are significantly more likely than those in the comparison group to be involved in left-turn injury crashes: for males in the 65+, 75+, and 85+ age categories, the relative likelihoods are 1.28, 1.44, and 1.57, respectively. Older females are also significantly more likely than those in the comparison group to be involved in left-turn injury crashes. For females in the three older age categories, the relative likelihoods of being involved in left-

Figure 23. Percent of Drivers Who Were Involved in Left Turn Crashes, by Age and Sex

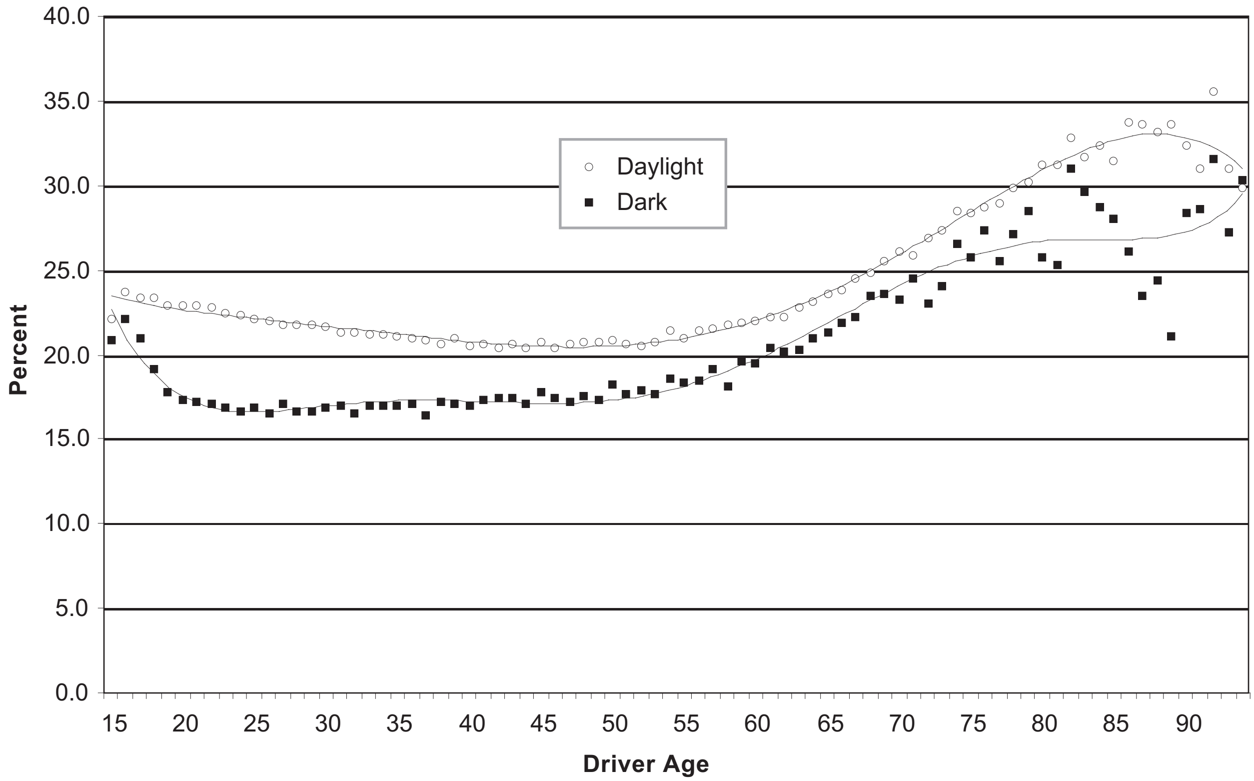


turn injury crashes are 1.23, 1.36, and 1.42.

Figure 24 depicts the percentages of drivers involved in left-turn injury crashes during hours of daylight (22.19 percent) and darkness, including dawn and dusk (17.70 percent), by driver age. Left-turn injury crashes are 1.25 times as likely to occur during hours of daylight than during hours of darkness. During hours of daylight, drivers in the older age categories are, respectively, 1.25, 1.39, and 1.49 times as likely as those in the comparison group to be involved in left-turn injury crashes, and during hours of darkness, 1.25, 1.39, and 1.35 times as likely.

Figures 25 and 26 present data on injury crashes involving left turns, but now including only two-vehicle crashes at intersections in which one vehicle is going straight and the other is turning left. The percentages reported in these

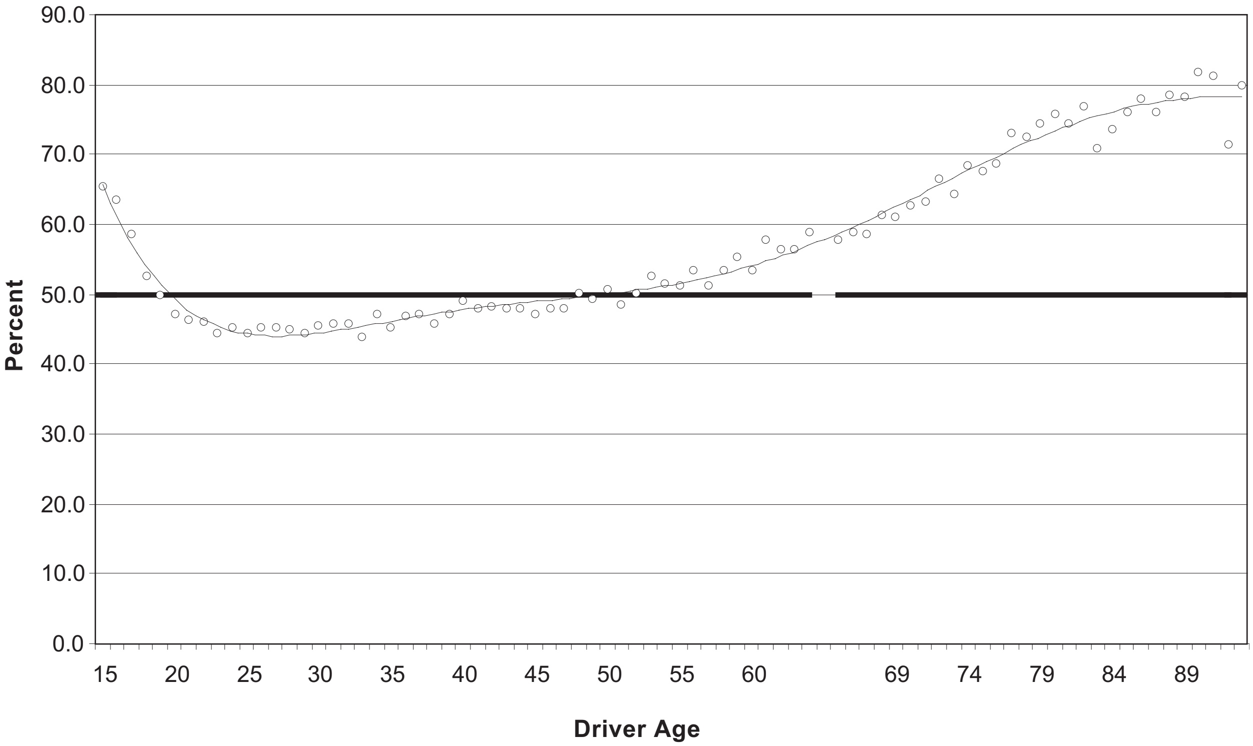
Figure 24. Percent of Drivers Involved in Left Turn Crashes, by Age and Light Condition



figures refer only to the drivers who were making a left turn in a left-turn injury crash, not all drivers involved in left-turn injury crashes. In Figure 25 the two vehicles are approaching each other at an angle, and in Figure 26, the two vehicles are approaching each other from opposite directions.

Since each driver in Figure 25 and each driver in Figure 26 is either going straight ahead or turning left, and since each crash involves two drivers, it follows that a driver chosen at random has a probability of 0.50 of turning left and a probability of 0.50 of going straight. In both of these figures, the bold horizontal line at 50 percent represents the line on which the data would have fallen had driver age been unrelated to whether the driver was turning left or going straight ahead. Both figures show clearly that older drivers are much more likely to have been turning left than to have been going straight ahead.

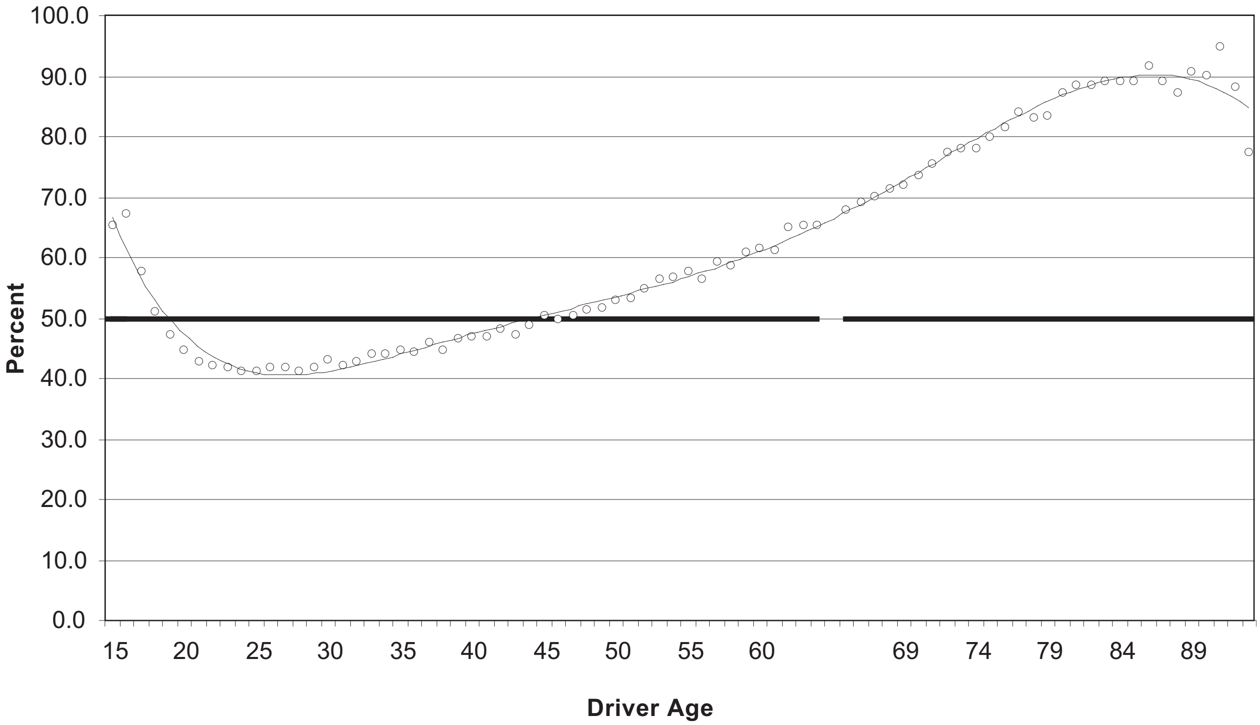
Figure 25. Percent of Drivers Turning Left in Two-Vehicle Injury Crashes at Intersections When Vehicles Are Approaching at an Angle (One Going Straight and the Other Turning Left), by Age



In Figure 25, drivers in the comparison group (55–64 years of age) are turning left in 54.63 percent of the cases, slightly above our overall expectation of 50 percent. For drivers in the 65+, 75+, and 85+ age categories, 66.51 percent, 73.13 percent, and 77.51 percent, respectively, are turning left. Drivers in these three age categories are 1.22, 1.34, and 1.42 times as likely to be turning left as drivers in the comparison group.

In Figure 26, drivers in the comparison group are turning left in 60.94 percent of the cases. For drivers in the three older age categories, the corresponding figures are 78.39 percent, 85.48 percent, and 89.65 percent, respectively. Among drivers 85 years of age and older, almost nine out of ten were turning left. The relative likelihoods of drivers in the older age categories turning left are 1.29, 1.40, and 1.47.

Figure 26. Percent of Drivers Turning Left in Two-Vehicle Injury Crashes at Intersections When Vehicles Are Approaching from Opposite Directions (One Going Straight and the Other Turning Left), by Age



Discussion

In this study, data collected over 25 years on injury crashes in the state of Texas were analyzed to determine how certain driver and accident characteristics vary with driver age. The study examined four factors in particular that the literature has suggested are associated with older drivers involved in crashes—fragility, illness, perceptual lapses, and left turns. Relative likelihoods of death, illness, perceptual lapses, and left turns were computed for drivers in three older age categories, defined with successively higher age thresholds (65 and older, 75 and older, and 85 and older), in comparison with drivers aged 55–64.

	Older Driver Age Category		
	65+	**75+**	**85+**
Death	1.54	2.08	2.90
Illness	1.78	2.28	2.97
Perceptual Lapse	1.73	2.20	2.59
Left Turns	1.26	1.41	1.51

These relative likelihoods were then recalculated controlling for crash type (single-vehicle vs. multiple-vehicle), population density (rural vs. urban), driver sex (male vs. female), light condition (daylight vs. darkness), and intersection relatedness. The following results were obtained.[5]

	Older Driver Age Category		
	65+	**75+**	**85+**
Death	1.78	2.59	3.72
Illness	1.83	2.38	3.06
Perceptual Lapse	1.56	1.89	2.17

To the extent that the numbers in the second chart differ from the numbers in the first chart, the controlling variables are of consequence in the analysis. Note that in the second chart, the calculated relative likelihoods of death and illness for the older age categories increased, while the calculated relative likelihoods for perceptual lapse decreased. That is to say, when older drivers are put on a more comparable footing with drivers between 55 and 64 years of age, death and illness may be even more of a problem for older drivers than might at first appear to be the case, while perceptual lapses may be somewhat less of a problem.

It should be noted that other variables, such as vehicle type, "striking" or "struck" vehicle in multiple-vehicle crashes, primary point of impact on the vehicle, and so forth might have been used to control for differences in crash circumstances between the older age categories and the comparison group. Had other consequential control variables been used, the calculated relative likelihoods might have been somewhat different.

Adjusting the data to account for differences in crash circumstances between drivers in the older age categories and the comparison group is more logi-

[5] "Left turn" crashes are nearly always intersection related, and they typically involve two or more vehicles. Since "intersection relatedness" and "crash type," two of the five controlling variables used throughout this study are non-informative in left-turn crashes, no attempt was made to adjust or weight the data, though the remaining three variables (driver sex, population density, and light condition) might have been used for this purpose.

cally compelling when calculating the relative likelihood of death than when calculating the relative likelihood of illness and perceptual lapses. Death is an outcome variable, whereas illness and perceptual lapses are circumstantial variables that are themselves associated with the likelihood of a crash. The adjusted relative likelihoods of illness and perceptual lapse should be read with this caveat in mind.

The relative likelihoods of death, illness, and perceptual lapses shown in the chart above differ dramatically by age category. These differences clearly illustrate the point that if we simply define older drivers as those who are, say, 65 years of age and older, we may seriously underestimate the magnitude of the problems associated with drivers in their eighties and nineties.

In order to analyze a sample large enough that it contained an adequate number of drivers 85 years of age and older who were involved in crashes, this study used 25 years of data from the Texas crash database. However, using a sample that spans such a long period has a price. As more and more older drivers were being licensed between 1975 and 1999, the roadway and traffic environment in Texas as well as the vehicle fleet changed markedly. Naturally, these changes interact with the other variables in the analyses and influence the results obtained. For example, these factors no doubt influenced the likelihood that drivers would be involved in crashes as well as the likelihood of deaths or injuries being sustained in crashes. Ideally, analyses such as those provided in this study should be conducted with samples drawn from a much shorter time period.

A finding well worth highlighting in this study is the problem of left turns. Figures 25 and 26 are particularly instructive in this regard: they clearly document the magnitude of the left-turn problem that older drivers experience under two different crash scenarios. Further analyses using additional variables might prove interesting. For example, these two figures might be modified to compare rural and urban settings, different types of intersections, and daylight and dark conditions.

Finally, a word about the role of illness in injury crashes. Of 6,744,965 drivers, only 27,017, or 0.40 percent, were found to be ill or suffering from some physical impairment at the time of their crash (Figure 8). Although cases of illness or impairment are relatively rare in the general population, their frequency increases with age. Among drivers in this study who were 85 years of age and older, 2.27 percent were ill or suffering from some physical impairment. Because in the coming years that proportion will apply to an ever-growing base of drivers in that age group, more study should be devoted to learning what kinds and types of illnesses these drivers are suffering.

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APPENDIX A

Table A1 depicts the relative likelihood (RL) of death for drivers in the older age categories (65+, 75+, and 85+) involved in injury crashes when compared with drivers aged 55–64 under 10 different conditions or circumstances:

- Single-vehicle and multiple-vehicle crashes
- Rural and urban crashes
- Male and female drivers
- Hours of daylight and hours of darkness
- Intersection-related crashes and crashes not related to intersections

Altogether, 30 different relative likelihoods are computed—the three older age categories by 10 different conditions or circumstances—and 95 percent confidence intervals are provided for each. As explained in the Methods section in the report, when 1.00 is not contained within the 95 percent confidence interval, the relative likelihood is significantly different from 1.00—that is, the difference between drivers in the older age category and those in the comparison group is statistically significant. The 30 relative likelihoods shown in Table A1 all suggest that drivers in all three older age categories, under all 10 conditions or circumstances, are significantly more likely to die in injury crashes than comparable drivers aged 55–64.

In Table A2, the 423,651 drivers in the comparison group are subdivided into 32 categories of crash conditions and circumstances. The first category is single-vehicle crash, rural setting, male driver, daylight conditions, and intersection-related crash. Of the 1,111 drivers who fall into this category, 19 were killed. Thus, we estimate that for drivers aged 55–64 involved in injury crashes under this set of conditions or circumstances, the probability of death is 0.0171. The remaining categories or rows in Table A2 may be interpreted in similar fashion.

Table A3 depicts 414,618 drivers 65 years of age and older who were involved in injury crashes, 5,865 of whom were killed. Looking at the first category or row—single-vehicle crash, rural setting, male driver, daylight conditions, and intersection-related crash—we see that 36 of 1,183 drivers at risk in this category died. The last column, expected deaths, is simply the corresponding probability of death from

Table A2 (0.0171) multiplied by the number of drivers at risk in this first category (0.0171 _ 1,183 = 20.23). Thus, if drivers in the 65+ age category were as likely as drivers aged 55–64 to die under the conditions or circumstances defined for this first category, we would expect to see 20.23 deaths for this older age group. Instead, 36 deaths were recorded for this category, or 1.78 times as many as we expected. The remaining categories or rows in Table A3 may be interpreted in similar fashion.

In Table A3, when the total number of drivers killed (5,865) is divided by the sum of the expected deaths in the 32 categories (3,302.65), we find that drivers 65 years of age and older who are involved in injury crashes are 1.78 times as likely to die as comparable drivers aged 55–64 when crash type, population, sex, light condition, and intersection relatedness are controlled for. Tables A4 and A5 may be interpreted in similar fashion for drivers in the 75+ and 85+ age categories.

Table A1. Relative Likelihood of Death in Injury Crashes for Drivers in the 65+, 75+, and 85+ Age Categories Relative to Comparison Group of Drivers Aged 55–64, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Factor	Driver Age Category	Drivers in Injury Crashes (Texas, 1975–1999)			Relative Likelihood	95% Confidence Interval	
		Killed	Total	Probability		Low	High
Single-Vehicle Crashes	55–64	1,606	48,091	0.0334			
	65+	1,576	42,623	0.0370	1.11	1.03	1.19
	75+	599	14,819	0.0404	1.21	1.10	1.33
	85+	113	2,174	0.0520	1.56	1.29	1.87
Multiple-Vehicle Crashes	55–64	2,293	376,431	0.0061			
	65+	4,295	372,792	0.0115	1.89	1.80	1.99
	75+	2,290	136,423	0.0168	2.76	2.60	2.92
	85+	476	19,915	0.0239	3.92	3.56	4.33
Rural Crashes	55–64	2,533	92,001	0.0275			
	65+	3,654	94,180	0.0388	1.41	1.34	1.48
	75+	1,737	35,226	0.0493	1.79	1.69	1.90
	85+	348	5,427	0.0641	2.32	2.09	2.60
Urban Crashes	55–64	1,366	332,521	0.0041			
	65+	2,217	321,235	0.0069	1.68	1.57	1.79
	75+	1,152	116,016	0.0099	2.42	2.24	2.61
	85+	241	16,662	0.0145	3.52	3.07	4.03
Male Drivers	55–64	2,985	267,781	0.0111			
	65+	4,159	256,361	0.0162	1.46	1.39	1.52
	75+	2,027	91,860	0.0221	1.98	1.87	2.09
	85+	448	14,189	0.0316	2.83	2.56	3.12
Female Drivers	55–64	910	155,870	0.0058			
	65+	1,706	158,257	0.0108	1.85	1.70	2.00
	75+	859	59,114	0.0145	2.49	2.27	2.73
	85+	141	7,862	0.0179	3.07	2.58	3.66
Daylight	55–64	2,333	336,041	0.0069			
	65+	4,763	362,581	0.0131	1.89	1.80	1.99
	75+	2,528	137,122	0.0184	2.66	2.51	2.81
	85+	542	20,582	0.0263	3.79	3.46	4.16
Darkness (Including Dawn and Dusk)	55–64	1,566	88,481	0.0177			
	65+	1,108	52,834	0.0210	1.18	1.10	1.28
	75+	361	14,120	0.0256	1.44	1.29	1.62
	85+	47	1,507	0.0312	1.76	1.32	2.34
Intersection-Related	55–64	1,145	289,288	0.0040			
	65+	2,976	316,202	0.0094	2.38	2.22	2.55
	75+	1,765	120,809	0.0146	3.69	3.43	3.97
	85+	414	18,275	0.0227	5.72	5.12	6.40
Not Intersection-Related	55–64	2,754	135,234	0.0204			
	65+	2,895	99,213	0.0291	1.43	1.36	1.51
	75+	1,124	30,433	0.0369	1.81	1.69	1.94
	85+	175	3,814	0.0459	2.25	1.94	2.61

Table A2. Drivers 55–64 Years of Age (Comparison Group) Killed in Injury Crashes, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Drivers Killed**	**Total Drivers**	**Estimated Probability of Death**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	19	1,111	0.0171
				No	500	7,131	0.0701
			Dark	Yes	27	768	0.0352
				No	410	5,597	0.0733
		Female	Daylight	Yes	5	520	0.0096
				No	120	3,457	0.0347
			Dark	Yes	5	200	0.0250
				No	56	1,523	0.0368
	Urban	Male	Daylight	Yes	19	3,843	0.0049
				No	172	7,441	0.0231
			Dark	Yes	27	1,786	0.0151
				No	157	5,572	0.0282
		Female	Daylight	Yes	5	2,372	0.0021
				No	48	4,364	0.0110
			Dark	Yes	3	595	0.0050
				No	31	1,684	0.0184
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	244	24,991	0.0098
				No	342	12,489	0.0274
			Dark	Yes	113	6,222	0.0182
				No	329	5,286	0.0622
		Female	Daylight	Yes	111	14,094	0.0079
				No	172	4,816	0.0357
			Dark	Yes	31	2,391	0.0130
				No	48	1,281	0.0375
	Urban	Male	Daylight	Yes	222	109,274	0.0020
				No	154	37,957	0.0041
			Dark	Yes	123	26,373	0.0047
				No	127	11,940	0.0106
		Female	Daylight	Yes	143	81,288	0.0018
				No	56	20,234	0.0028
			Dark	Yes	46	12,919	0.0036
				No	30	4,132	0.0073
Total					3,895	423,651	0.0092

Table A3. Observed and Expected Deaths for Drivers 65+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Drivers Killed**	**Total Drivers**	**Expected Deaths**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	36	1,183	20.23
				No	582	7,014	491.79
			Dark	Yes	23	498	17.51
				No	191	2,844	208.33
		Female	Daylight	Yes	16	687	6.61
				No	220	4,124	143.15
			Dark	Yes	1	176	4.40
				No	27	755	27.76
	Urban	Male	Daylight	Yes	47	4,264	21.08
				No	190	7,306	168.88
			Dark	Yes	21	1,267	19.15
				No	93	3,182	89.66
		Female	Daylight	Yes	24	2,872	6.05
				No	83	4,821	53.03
			Dark	Yes	2	487	2.46
				No	20	1,051	19.35
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	872	32,560	317.92
				No	581	11,449	313.52
			Dark	Yes	124	4,675	84.90
				No	233	2,883	179.44
		Female	Daylight	Yes	410	18,271	143.90
				No	239	4,495	160.53
			Dark	Yes	47	1,787	23.17
				No	49	679	25.44
	Urban	Male	Daylight	Yes	730	127,056	258.18
				No	212	27,315	110.82
			Dark	Yes	150	17,253	80.47
				No	74	5,612	59.69
		Female	Daylight	Yes	431	94,780	166.72
				No	86	13,721	37.98
			Dark	Yes	38	7,790	27.74
				No	13	1,761	12.78
Total					5,865	414,618	3,302.65

Table A4. Observed and Expected Deaths for Drivers 75+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatednes

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Drivers Killed**	**Total Drivers**	**Expected Deaths**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	21	487	8.33
				No	225	2,487	174.38
			Dark	Yes	7	133	4.68
				No	31	650	47.62
		Female	Daylight	Yes	10	299	2.87
				No	91	1,450	50.33
			Dark	Yes	1	66	1.65
				No	8	183	6.73
	Urban	Male	Daylight	Yes	25	1,596	7.89
				No	81	2,646	61.16
			Dark	Yes	6	407	6.15
				No	34	862	24.29
		Female	Daylight	Yes	19	1,181	2.49
				No	34	1,861	20.47
			Dark	Yes	0	161	0.81
				No	6	317	5.84
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	579	13,790	134.65
				No	260	3,705	101.46
			Dark	Yes	50	1,388	25.21
				No	77	701	43.63
		Female	Daylight	Yes	230	7,596	59.83
				No	107	1,515	54.11
			Dark	Yes	24	565	7.33
				No	15	166	6.22
	Urban	Male	Daylight	Yes	452	48,998	99.56
				No	97	7,970	32.33
			Dark	Yes	64	4,738	22.10
				No	18	1,302	13.85
		Female	Daylight	Yes	260	37,118	65.29
				No	35	4,182	11.58
			Dark	Yes	15	2,072	7.38
				No	4	382	2.77
Total					2,886	150,974	1,112.97

Table A5. Observed and Expected Deaths for Drivers 85+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	Population	Driver Sex	Light Condition	Intersection Related	Drivers Killed	Total Drivers	Expected Deaths
Single-Vehicle Crash	Rural	Male	Daylight	Yes	5	100	1.71
				No	43	383	26.85
			Dark	Yes	1	13	0.46
				No	8	83	6.08
		Female	Daylight	Yes	1	47	0.45
				No	12	162	5.62
			Dark	Yes	1	10	0.25
				No	0	23	0.85
	Urban	Male	Daylight	Yes	9	285	1.41
				No	16	399	9.22
			Dark	Yes	2	52	0.79
				No	4	111	3.13
		Female	Daylight	Yes	5	177	0.37
				No	5	276	3.04
			Dark	Yes	0	18	0.09
				No	1	31	0.57
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	164	2,522	24.62
				No	44	538	14.73
			Dark	Yes	6	148	2.69
				No	7	82	5.10
		Female	Daylight	Yes	42	1,080	8.51
				No	10	159	5.68
			Dark	Yes	4	54	0.70
				No	0	17	0.64
	Urban	Male	Daylight	Yes	109	7,868	15.99
				No	19	941	3.82
			Dark	Yes	8	541	2.52
				No	3	123	1.31
		Female	Daylight	Yes	56	5,163	9.08
				No	2	447	1.24
			Dark	Yes	1	167	0.59
				No	1	31	0.23
Total					589	22,051	158.34

APPENDIX B

The findings depicted in Tables B1 through B5 are arithmetically equivalent to those presented in Appendix A, and the explanations provided there are directly applicable here. Whereas the tables in Appendix A focus on the likelihood of death for different age groups, those below focus on the likelihood of illness or other physical defects for different age groups.

Table B1. Relative Likelihood of Illness or Other Physical Defects for Drivers in the 65+, 75+, and 85+ Age Categories Relative to Comparison Group of Drivers Aged 55–64 Involved in Injury Crashes, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Factor	Driver Age Category	Drivers in Injury Crashes (Texas, 1975–1999)			Relative Likelihood	95% Confidence Interval	
		Illness	Total	Probability		Low	High
Single-Vehicle Crashes	55–64	2,347	48,091	0.0488			
	65+	3,737	42,623	0.0877	1.80	1.71	1.89
	75+	1,572	14,819	0.1061	2.17	2.04	2.31
	85+	242	2,174	0.1113	2.28	2.01	2.59
Multiple-Vehicle Crashes	55–64	900	376,431	0.0024			
	65+	1,929	372,792	0.0052	2.16	2.00	2.34
	75+	1,067	136,423	0.0078	3.27	2.99	3.57
	85+	260	19,915	0.0131	5.46	4.76	6.26
Rural Crashes	55–64	1,152	92,001	0.0125			
	65+	2,207	94,180	0.0234	1.87	1.74	2.01
	75+	1,099	35,226	0.0312	2.49	2.30	2.70
	85+	212	5,427	0.0391	3.12	2.70	3.60
Urban Crashes	55–64	2,095	332,521	0.0063			
	65+	3,459	321,235	0.0108	1.71	1.62	1.80
	75+	1,540	116,016	0.0133	2.11	1.97	2.25
	85+	290	16,662	0.0174	2.76	2.45	3.12
Male Drivers	55–64	2,307	267,781	0.0086			
	65+	3,972	256,361	0.0155	1.80	1.71	1.89
	75+	1,814	91,860	0.0197	2.29	2.16	2.44
	85+	370	14,189	0.0261	3.03	2.72	3.37
Female Drivers	55–64	931	155,870	0.0060			
	65+	1,683	158,257	0.0106	1.78	1.64	1.93
	75+	822	59,114	0.0139	2.33	2.12	2.56
	85+	131	7,862	0.0167	2.79	2.33	3.34
Daylight	55–64	2,662	336,041	0.0079			
	65+	4,964	362,581	0.0137	1.73	1.65	1.81
	75+	2,314	136,399	0.0170	2.14	2.03	2.26
	85+	450	20,582	0.0219	2.76	2.50	3.05
Darkness (Including Dawn and Dusk)	55–64	585	88,481	0.0066			
	65+	702	52,834	0.0133	2.01	1.80	2.24
	75+	292	14,120	0.0207	3.13	2.72	3.60
	85+	52	1,507	0.0345	5.22	3.95	6.90
Intersection-Related	55–64	941	289,288	0.0033			
	65+	2,044	316,202	0.0065	1.99	1.84	2.15
	75+	1,108	120,809	0.0092	2.82	2.59	3.07
	85+	276	18,275	0.0151	4.64	4.06	5.31
Not Intersection-Related	55–64	2,306	135,234	0.0171			
	65+	3,622	99,213	0.0365	2.14	2.03	2.25
	75+	1,531	30,433	0.0503	2.95	2.77	3.14
	85+	226	3,814	0.0592	3.48	3.04	3.97

Table B2. Drivers 55–64 Years of Age (Comparison Group) in Injury Crashes Impaired by Illness or Some Other Physical Defect, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Ill Drivers**	**Total Drivers**	**Estimated Probability of Illness**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	66	1,111	0.0594
				No	467	7,131	0.0655
			Dark	Yes	14	768	0.0182
				No	132	5,597	0.0236
		Female	Daylight	Yes	35	520	0.0673
				No	195	3,457	0.0564
			Dark	Yes	4	200	0.0200
				No	32	1,523	0.0210
	Urban	Male	Daylight	Yes	174	3,843	0.0453
				No	651	7,441	0.0875
			Dark	Yes	43	1,786	0.0241
				No	156	5,572	0.0280
		Female	Daylight	Yes	71	2,372	0.0299
				No	238	4,364	0.0545
			Dark	Yes	10	595	0.0168
				No	53	1,684	0.0315
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	54	24,991	0.0022
				No	58	12,489	0.0046
			Dark	Yes	10	6,222	0.0016
				No	16	5,286	0.0030
		Female	Daylight	Yes	24	14,094	0.0017
				No	34	4,816	0.0071
			Dark	Yes	3	2,391	0.0013
				No	5	1,281	0.0039
	Urban	Male	Daylight	Yes	229	109,274	0.0021
				No	163	37,957	0.0043
			Dark	Yes	44	26,373	0.0017
				No	30	11,940	0.0025
		Female	Daylight	Yes	135	81,288	0.0017
				No	61	20,234	0.0030
			Dark	Yes	22	12,919	0.0017
				No	9	4,132	0.0022
Total					3,238	423,651	0.0076

Table B3. Observed and Expected Illness and Other Physical Defects for Drivers 65+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Ill Drivers**	**Total Drivers**	**Expected Illness**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	136	1,183	70.28
				No	817	7,014	459.34
			Dark	Yes	27	498	9.08
				No	127	2,844	67.07
		Female	Daylight	Yes	63	687	46.24
				No	380	4,124	232.62
			Dark	Yes	12	176	3.52
				No	35	755	15.86
	Urban	Male	Daylight	Yes	311	4,264	193.06
				No	970	7,306	639.19
			Dark	Yes	60	1,267	30.50
				No	173	3,182	89.09
		Female	Daylight	Yes	118	2,872	85.97
				No	436	4,821	262.92
			Dark	Yes	18	487	8.18
				No	45	1,051	33.08
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	246	32,560	70.35
				No	140	11,449	53.17
			Dark	Yes	24	4,675	7.51
				No	30	2,883	8.73
		Female	Daylight	Yes	81	18,271	31.11
				No	60	4,495	31.73
			Dark	Yes	14	1,787	2.24
				No	11	679	2.65
	Urban	Male	Daylight	Yes	576	127,056	266.26
				No	245	27,315	117.30
			Dark	Yes	53	17,253	28.78
				No	37	5,612	14.10
		Female	Daylight	Yes	283	94,780	157.41
				No	95	13,721	41.37
			Dark	Yes	20	7,790	13.27
				No	12	1,761	3.84
Total					5,655	414,618	3,095.84

Table B4. Observed and Expected Illness and Other Physical Defects for Drivers 75+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	Population	Driver Sex	Light Condition	Intersection Related	Ill Drivers	Total Drivers	Expected Illness
Single-Vehicle Crash	Rural	Male	Daylight	Yes	71	487	28.93
				No	346	2,487	162.87
			Dark	Yes	6	133	2.42
				No	53	650	15.33
		Female	Daylight	Yes	39	299	20.13
				No	173	1,450	81.79
			Dark	Yes	8	66	1.32
				No	15	183	3.85
	Urban	Male	Daylight	Yes	129	1,596	72.26
				No	375	2,646	231.49
			Dark	Yes	30	407	9.80
				No	61	862	24.13
		Female	Daylight	Yes	55	1,181	35.35
				No	186	1,861	101.49
			Dark	Yes	9	161	2.71
				No	13	317	9.98
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	171	13,790	29.80
				No	76	3,705	17.21
			Dark	Yes	14	1,388	2.23
				No	16	701	2.12
		Female	Daylight	Yes	60	7,596	12.93
				No	38	1,515	10.70
			Dark	Yes	8	565	0.71
				No	3	166	0.65
	Urban	Male	Daylight	Yes	320	48,998	102.68
				No	104	7,970	34.23
			Dark	Yes	28	4,738	7.90
				No	14	1,302	3.27
		Female	Daylight	Yes	151	37,118	61.64
				No	51	4,182	12.61
			Dark	Yes	8	2,072	3.53
				No	5	382	0.83
Total					2,636	150,974	1,106.89

Table B5. Observed and Expected Illness and Other Physical Defects for Drivers 85+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Ill Drivers**	**Total Drivers**	**Expected Illness**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	13	100	5.94
				No	62	383	25.08
			Dark	Yes	0	13	0.24
				No	13	83	1.96
		Female	Daylight	Yes	8	47	3.16
				No	18	162	9.14
			Dark	Yes	2	10	0.20
				No	2	23	0.48
	Urban	Male	Daylight	Yes	30	285	12.90
				No	48	399	34.91
			Dark	Yes	3	52	1.25
				No	13	111	3.11
		Female	Daylight	Yes	11	177	5.30
				No	16	276	15.05
			Dark	Yes	1	18	0.30
				No	1	31	0.98
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	55	2,522	5.45
				No	14	538	2.50
			Dark	Yes	2	148	0.24
				No	2	82	0.25
		Female	Daylight	Yes	14	1,080	1.84
				No	6	159	1.12
			Dark	Yes	1	54	0.07
				No	0	17	0.07
	Urban	Male	Daylight	Yes	89	7,868	16.49
				No	16	941	4.04
			Dark	Yes	7	541	0.90
				No	3	123	0.31
		Female	Daylight	Yes	39	5,163	8.57
				No	11	447	1.35
			Dark	Yes	0	167	0.28
				No	1	31	0.07
Total					501	22,051	163.55

APPENDIX C

The findings depicted in Tables C1 through C5 are arithmetically equivalent to those presented in Appendix A, and the explanations provided there are directly applicable here. Whereas the tables in Appendix A focus on the likelihood of death for different age groups, those below focus on the likelihood of perceptual lapse for different age groups.

Table C1. Relative Likelihood of Perceptual Lapse for Drivers in the 65+, 75+, and 85+ Age Categories Relative to Comparison Group of Drivers Aged 55–64 Involved in Injury Crashes, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Factor	Driver Age Category	Drivers in Injury Crashes (Texas, 1975–1999)			Relative Likelihood	95% Confidence Interval	
		Perceptual Lapse	Total	Probability		Low	High
Single-Vehicle Crashes	55–64	1,294	48,091	0.0270			
	65+	1,554	42,623	0.0365	1.35	1.26	1.46
	75+	637	14,819	0.0430	1.60	1.46	1.75
	85+	111	2,174	0.0511	1.90	1.57	2.29
Multiple-Vehicle Crashes	55–64	88,000	376,431	0.2334			
	65+	149,926	372,792	0.4022	1.72	1.71	1.73
	75+	69,208	136,423	0.5073	2.17	2.15	2.19
	85+	11,942	19,915	0.6000	2.57	2.53	2.60
Rural Crashes	55–64	14,874	92,001	0.1617			
	65+	29,318	94,180	0.3113	1.93	1.89	1.96
	75+	14,533	35,226	0.4126	2.55	2.50	2.60
	85+	2,741	5,427	0.5051	3.12	3.03	3.22
Urban Crashes	55–64	74,420	332,521	0.2238			
	65+	122,162	321,235	0.3803	1.70	1.69	1.71
	75+	55,312	116,016	0.4768	2.13	2.11	2.15
	85+	9,312	16,662	0.5589	2.50	2.46	2.53
Male Drivers	55–64	51,900	267,781	0.1938			
	65+	86,875	256,361	0.3389	1.75	1.73	1.77
	75+	40,204	91,860	0.4377	2.26	2.23	2.28
	85+	7,540	14,189	0.5314	2.74	2.69	2.79
Female Drivers	55–64	37,253	155,870	0.2390			
	65+	64,347	158,257	0.4066	1.70	1.68	1.72
	75+	29,538	59,114	0.4997	2.09	2.07	2.12
	85+	4,499	7,862	0.5723	2.39	2.34	2.45
Daylight	55–64	73,855	336,041	0.2198			
	65+	137,204	362,581	0.3784	1.72	1.71	1.73
	75+	65,151	137,122	0.4751	2.16	2.14	2.18
	85+	11,525	20,582	0.5600	2.55	2.51	2.58
Darkness (Including Dawn and Dusk)	55–64	15,439	88,481	0.1745			
	65+	14,276	52,843	0.2702	1.55	1.52	1.58
	75+	4,694	14,120	0.3324	1.91	1.85	1.96
	85+	5,28	1,507	0.3504	2.01	1.87	2.15
Intersection-Related	55–64	87,587	289,288	0.3028			
	65+	149,160	316,202	0.4717	1.56	1.55	1.57
	75+	68,847	120,809	0.5699	1.88	1.87	1.90
	85+	11,872	18,275	0.6496	2.15	2.12	2.17
Not Intersection-Related	55–64	1,707	135,234	0.0126			
	65+	2,320	99,213	0.0234	1.85	1.74	1.97
	75+	998	30,433	0.0328	2.60	2.41	2.81
	85+	181	3,814	0.0475	3.76	3.24	4.37

Table C2. Drivers 55–64 Years of Age (Comparison Group) Suffering Perceptual Lapses in Injury Crashes, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Drivers Suffering Perceptual Lapse**	**Total Drivers**	**Estimated Probability Perceptual Lapse**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	54	1,111	0.0486
				No	90	7,131	0.0126
			Dark	Yes	113	768	0.1471
				No	22	5,597	0.0039
		Female	Daylight	Yes	27	520	0.0519
				No	26	3,457	0.0075
			Dark	Yes	32	200	0.1600
				No	5	1,523	0.0033
	Urban	Male	Daylight	Yes	328	3,843	0.0853
				No	85	7,441	0.0114
			Dark	Yes	133	1,786	0.0745
				No	63	5,572	0.0113
		Female	Daylight	Yes	209	2,372	0.0881
				No	41	4,364	0.0094
			Dark	Yes	44	595	0.0739
				No	18	1,684	0.0107
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	7,080	24,991	0.2833
				No	231	12,489	0.0185
			Dark	Yes	1,788	6,222	0.2874
				No	62	5,286	0.0117
		Female	Daylight	Yes	4,430	14,094	0.3143
				No	117	4,816	0.0243
			Dark	Yes	762	2,391	0.3187
				No	20	1,281	0.0156
	Urban	Male	Daylight	Yes	33,260	109,274	0.3044
				No	454	37,957	0.0120
			Dark	Yes	7,981	26,373	0.3026
				No	156	11,940	0.0131
		Female	Daylight	Yes	27,066	81,288	0.3330
				No	249	20,234	0.0123
			Dark	Yes	4,145	12,919	0.3208
				No	62	4,132	0.0150
Total					89,153	423,651	0.2104

Table C3. Observed and Expected Perceptual Lapses Among Drivers 65+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Drivers Suffering Perceptual Lapse**	**Total Drivers**	**Expected Perceptual Lapse**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	101	1,183	57.50
				No	89	7,014	88.52
			Dark	Yes	77	498	73.27
				No	19	2,844	11.18
		Female	Daylight	Yes	46	687	35.67
				No	39	4,124	31.02
			Dark	Yes	13	176	28.16
				No	5	755	2.48
	Urban	Male	Daylight	Yes	469	4,264	363.93
				No	116	7,306	83.46
			Dark	Yes	126	1,267	94.35
				No	34	3,182	35.98
		Female	Daylight	Yes	289	2,872	253.06
				No	58	4,821	45.29
			Dark	Yes	51	487	36.01
				No	17	1,051	11.23
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	15,666	32,560	9,224.31
				No	494	11,449	211.76
			Dark	Yes	2,064	4,675	1,343.44
				No	62	2,883	33.81
		Female	Daylight	Yes	9,574	18,271	5,742.91
				No	200	4,495	109.20
			Dark	Yes	817	1,787	569.51
				No	23	679	10.60
	Urban	Male	Daylight	Yes	59,602	127,056	38,672.35
				No	616	27,315	326.71
			Dark	Yes	7,239	17,253	5,221.10
				No	101	5,612	73.32
		Female	Daylight	Yes	49,208	94,780	31,558.35
				No	415	13,721	168.85
			Dark	Yes	3,566	7,790	2,499.38
				No	26	1,761	26.42
Total					151,222	414,618	97,043.17

Table C4. Observed and Expected Perceptual Lapses Among Drivers 75+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Drivers Suffering Perceptual Lapse**	**Total Drivers**	**Expected Perceptual Lapse**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	56	487	23.67
				No	38	2,487	31.39
			Dark	Yes	25	133	19.57
				No	6	650	2.55
		Female	Daylight	Yes	27	299	15.53
				No	15	1,450	10.91
			Dark	Yes	5	66	10.56
				No	1	183	0.60
	Urban	Male	Daylight	Yes	196	1,596	136.22
				No	47	2,646	30.23
			Dark	Yes	45	407	30.31
				No	11	862	9.75
		Female	Daylight	Yes	129	1,181	104.06
				No	19	1,861	17.48
			Dark	Yes	13	161	11.91
				No	4	317	3.39
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	8,226	13,790	3,906.73
				No	254	3,705	68.53
			Dark	Yes	708	1,388	398.87
				No	19	701	8.22
		Female	Daylight	Yes	4,751	7,596	2,387.56
				No	87	1,515	36.81
			Dark	Yes	291	565	180.06
				No	8	166	2.59
	Urban	Male	Daylight	Yes	27,887	48,998	14,913.64
				No	262	7,970	95.33
			Dark	Yes	2,392	4,738	1,433.81
				No	32	1,302	17.01
		Female	Daylight	Yes	22,873	37,118	12,358.97
				No	189	4,182	51.46
			Dark	Yes	1,120	2,072	664.79
				No	6	382	5.73
Total					69,742	150,974	36,988.23

Table C5. Observed and Expected Perceptual Lapses Among Drivers 85+ Years of Age, by Crash Type, Population, Sex, Light Condition, and Intersection Relatedness

Crash Circumstances					Outcome Measures		
Crash Type	**Population**	**Driver Sex**	**Light Condition**	**Intersection Related**	**Drivers Suffering Perceptual Lapse**	**Total Drivers**	**Expected Perceptual Lapse**
Single-Vehicle Crash	Rural	Male	Daylight	Yes	15	100	4.86
				No	6	383	4.83
			Dark	Yes	2	13	1.91
				No	1	83	0.33
		Female	Daylight	Yes	1	47	2.44
				No	6	162	1.22
			Dark	Yes	0	10	1.60
				No	0	23	0.08
	Urban	Male	Daylight	Yes	37	285	24.32
				No	12	399	4.56
			Dark	Yes	5	52	3.87
				No	0	111	1.26
		Female	Daylight	Yes	20	177	15.60
				No	4	276	2.59
			Dark	Yes	2	18	1.33
				No	0	31	0.33
Multiple-Vehicle Crash	Rural	Male	Daylight	Yes	1,776	2,522	714.49
				No	49	538	9.95
			Dark	Yes	84	148	42.53
				No	3	82	0.96
		Female	Daylight	Yes	746	1,080	339.46
				No	19	159	3.86
			Dark	Yes	31	54	17.21
				No	0	17	0.27
	Urban	Male	Daylight	Yes	5,196	7,868	2,394.80
				No	51	941	11.26
			Dark	Yes	300	541	163.72
				No	3	123	1.61
		Female	Daylight	Yes	3,547	5,163	1,719.09
				No	27	447	5.50
			Dark	Yes	96	167	53.58
				No	0	31	0.47
Total					12,039	22,051	5,549.88