INVESTIGATIONS OF CRASHES AND CASUALTIES ASSOCIATED WITH OLDER DRIVERS

Project G.8

Project Team:

Donald W. Reinfurt, PI
J. Richard Stewart
Jane C. Stutts
Eric A. Rodgman

University of North Carolina
Highway Safety Research Center

November 2000

INVESTIGATIONS OF CRASHES AND CASUALTIES ASSOCIATED WITH OLDER DRIVERS

Project G.8

Project Team:

Donald W. Reinfurt, PI
J. Richard Stewart
Jane C. Stutts
Eric A. Rodgman

University of North Carolina
Highway Safety Research Center

November 2000

TABLE OF CONTENTS

BACKGROUND/LITERATURE

Older persons are the fastest growing segment of the U.S. population. By 2020 it is estimated that 17 percent of the population will be 65 or older, and almost half of the people in that age group will be 75 or older (Harkey, Huang and Zegeer, 1995). And persons age 85 and older are emerging as the fastest growing segment of our driving population (NHTSA, 1999). These older persons also comprise an increasing proportion of our licensed drivers. Data from the Federal Highway Administrations' (FHWA's) highway statistics reports show that, while in 1965 only 7.6 percent of all licensed drivers were aged 65 and older, by 1985 it was 11.9 percent, an increase of over 56 percent (Stutts and Martell, 1992).

In recent years, much has been written about the frequency and nature of older driver (usually 65 years or older) crashes, often comparing them with younger drivers (UMTRI, 1995; Stutts and Martell, 1992; McGuire, 1999). Likewise, mileage crash risks of older drivers compared with younger drivers – generally based on data from the National Personal Transportation Survey – has been examined over the years. In brief, although crash risks of drivers over age 55 increase at an increasing rate, older drivers generally limit their driving to less hazardous times and situations (e.g., daytime in less congested areas or in good weather) (UMTRI, 1995).

Special problems of the older drivers have also been increasingly investigated with encouraging engineering and special licensing countermeasures emerging. Among the studies dealing with special problems at intersections are papers by Viano (1996) and McGuire (1999): Problems on freeways have been reported in Harkey et al. (1995) and FHWA (1996) among others. And engineering guidelines are provided in FHWA's "Older Driver Highway Design Handbook: Recommendations and Guidelines" (1999).

The literature abounds with studies dealing with medical (e.g., vision), perception, attention and/or licensing problems of older drivers (UMTRI, 1995; Stutts, 1998a; Stutts, 1998b; Sims, Owsley, Allman, Ball, and Smoot, 1998).

However, far less is known about crashes **caused** by older drivers, i.e., crashes where the older driver is **at-fault**. For example, for which specific driving maneuvers is the older driver especially at-fault? Are there particular problems by road type, by environment (rural vs urban) by weather conditions? Do these problems escalate with age beyond age 65? Have at-fault crash types and maneuvers changed over the last decade? What about the harm (or injury causation) to the other driver in older driver at-fault crashes vs the harm to the older driver? Do older drivers have particular problems with pedestrians?

The primary OBJECTIVES of this study are:

To better understand and quantify older (65+) driver crashes and violations by

- Systematically examining/modeling **at-fault** crashes and related injuries associated with older drivers using a variety of North Carolina and national data sources where a driver in two-vehicle crashes is **at-fault** if one or more violations (contributing circumstances) are attributed to that driver and none to the other driver;
- Predicting **at-fault** motor vehicle crash involvements and violations per driver as a function of driver age, gender and population density of area of residence; and
- Forecasting to 2020 the magnitude and nature of older driver **at-fault** crashes and casualties.

THE DATA

A variety of data bases were utilized in this study. Linked statewide data (crash and driver history) from North Carolina were utilized first to explore the nature of crashes involving older drivers and injuries resulting from these crashes, to characterize crashes in which older drivers were increasingly likely to be at-fault, to estimate the extent of injuries in the other vehicle and finally, from driver histories, to estimate expected numbers of at-fault older driver crashes and injuries. The North Carolina crash data was also used to explore the police narratives for examining "why" older drivers were having problems in certain situations (e.g., left-turn maneuvers).

National data (FARS (Fatality Analysis Reporting System) and GES (General Estimates System)) were used to examine the generalizability of the North Carolina results to the United States. And national mileage estimates by age of driver (NPTS (National Personal Transportation Survey) were used to project at-fault older driver crashes to the year 2020.

More specifically, the following data bases were examined in this study:

- North Carolina crash data (1987-96); approximately 200,000 reportable ($500 property damage and/or personal injury) crashes per year of which a total of 825,000 comprised the main study group (i.e., drivers age 45 and older)
    - Special NC crash data sets
        - 1998 crashes to examine potential biases in using **violations** rather than **charges** or **convictions** to determine fault in two-vehicle crashes
        - North Carolina police-reported crash narratives
            - To help define at-fault
            - To examine "reasons" (explanations) indicated by older at-fault drivers
            - To study special problems of older drivers at non-signalized intersections
- North Carolina driver history file (1996): contains histories of crashes and violations for 2.66 million N.C. drivers age 45 and older (approximately 927,000 age 65 and older and 382,000 age 75 and above)
- FARS (1992-97): detailed information on over 100,000 fatal crashes involving drivers 45 years of age and older with 37,000 two-vehicle fatal crashes involving cars and light trucks
- GES (1998 - a probability sample of approximately 13,000 police-reported two-vehicle crashes involving at least one driver 45+ years old): for repeating the North Carolina analysis on national data to test for applying the NC results to the US
- NPTS (primarily 1995 but also 1967, 1977, 1983, and 1990): based on a nationwide sample of approximately 20,000 drivers, it provides estimates of annual mileage for drivers by age, sex, and rural/urban location.

ANALYSIS AND RESULTS

The purpose of the analyses which follow was to investigate the nature of crashes caused by older drivers, and injuries to others resulting from these crashes. For these analyses, a data file was developed containing records for all reportable crashes occurring in North Carolina during the years 1987-1996 in which at least one crash-involved driver was 45 years old or older. The basic data file contained approximately 800,000 records. The file contained records for both single vehicle crashes and multiple vehicle crashes. Since the primary focus of the study was on older driver crashes involving other drivers and occupants, a data sub-file was developed containing records only for crashes involving exactly two vehicles. This file, containing over 550,000 records, included information concerning the crash itself, and information about both crash-involved drivers and vehicles. For each crash, a "case" driver was selected whose age was restricted to be 45 years or greater. When both drivers met the age restriction the first driver listed on the crash report was selected as the "case" driver. No restrictions were placed on the "other" driver in the crash.

Indications of fault or responsibility for crashes are available from several variables or data items on statewide accident report forms (PARs). For the North Carolina police accident form, these include (1) violation indicated (contributing circumstances); (2) driver charged; and (3) the police narrative. With respect to (1), the officer may check as many items as are appropriate in Figure 1. If the violation(s) warrants it, the officer may then charge the driver with

CIRCUMSTANCES CONTRIBUTING TO THE COLLISION (Check as many as apply)

DRIVER 1	DRIVER 2		DRIVER 1	DRIVER 2		DRIVER 1	DRIVER 2	
❑	❑	1. None	❑	❑	10. Pass stopped school bus	❑	❑	19. Safe movement violation
❑	❑	2. Alcohol use	❑	❑	11. Passing on hill	❑	❑	20. Following too closely
❑	❑	3. Drug use	❑	❑	12. Passing on curve	❑	❑	21. Improper backing
❑	❑	4. Yield	❑	❑	13. Other improper passing	❑	❑	22. Improper parking
❑	❑	5. Stop sign	❑	❑	14. Improper lane change	❑	❑	23. Unable to determine
❑	❑	6. Signal	❑	❑	15. Use of improper lane	❑	❑	24. Left of center
❑	❑	7. Exceeding speed limit	❑	❑	16. Improper turn	❑	❑	25. Right turn on red
❑	❑	8. Exceeding safe speed	❑	❑	17. Improper or no signal	❑	❑	26. Other ________
❑	❑	9. Failure to reduce speed	❑	❑	18. Improper vehicle equipment			________

Figure 1. (from the North Carolina PAR).

the violation(s). And most often, the corresponding narrative provides insight into the driver contribution to the crash.

Certainly, there are far too many narratives to read for the current study. And often the officer does not charge the driver when, from the narrative, it appears that the driver was indeed at-fault in the crash. Hence, using violation indicated to assign fault appeared the most promising procedure for this study.

To examine the validity of this implicit assumption of fault, 93 North Carolina crash reports meeting the necessary criteria were examined in detail. Table 1 shows a cross-tabulation of driver age vs a combination variable for at-fault (i.e., whether the driver was actually charged vs whether the driver "should have been charged" based on all the information on the PAR). From the crash reports and from table 1, it is clear that (1) for almost all two-vehicle crashes, one (and only one) driver had violations indicated; (2) neither driver was charged in over half of the crashes; and (3) there were no evident age biases (65+ group vs 16-64 group) in the assignment of violation(s) judging from information from the complete PAR.

Table 1. Violations Indicated in Two-Vehicle Crashes

Driver Charged / "Should Be Charged" / Driver Age	**Yes**		**No**		
	Yes	No	Yes	No	Total
< 65	16 (42.1%)*	1 (2.6%)	18 (47.4%)	3 (7.9%)	38
65+	20 (41.7%)*	0 (0%)	23 (47.9%)	5 (10.4%)	48

*Row %

NOTE: 5 cases with both charged
2 cases pending

To further examine biases in using **violation indicated** vs **charged** vs **conviction** (from the driver history file), we looked at the nature of the two-vehicle crashes involving an older driver (OD = 65+) and a younger driver (YD < 65), one of whom was **at-fault**, and examined the subset where the driver was **charged**. From this group, we then followed up with the driver history file to examine characteristics of the subset of drivers for which there was a **conviction**. Of particular interest were biases (re charges and/or convictions) by age, sex, injury severity and/or nature of the violation.

Figure 2 provides the final data files used for this analysis. There were 125,537 two-vehicle crashes in North Carolina in 1998 of which 15,796 involved an older (65+) driver (OD) and a younger (< 65) driver (YD) with one and only one driver at-fault. In these crashes, 62.5 percent of the time the OD had the violation(s). And 44.2 percent of the OD were charged with the violation(s) compared with 51.2 percent of the YD. However, 34.0 percent of the charged OD were indeed convicted compared with 28.5 percent of the YD. Overall, 15.0 percent of the OD with violations were convicted compared with 14.6 percent of the YD.

Tables 2-5 provide percentage distributions for OD vs YD when at-fault (VIOLATION vs CHARGED vs CONVICTION) by age pairs (Table 2), by gender pairs (Table 3), by injury severity (Table 4), and by violation type (Table 5).

Of interest in this investigation are changes in the percentage distributions when the OD is in violation (i.e., columns 1, 3, and 5 in Table 2 for violations, charges, and convictions, respectively) vs when the YD is in violation (i.e., columns 2, 4, and 6 in Table 2). These distributions are remarkably similar as one goes from the larger data set (OD violations, N=9876) to the progressively smaller files (OD charges (N=4364) and OD convictions (N=1485)). Although the most apparent changes occur with violation type and driver injury, there are no clear biases with respect to age, gender, driver injury or violation type in defining **at-fault** as **violation indicated**.

Thus, for the purposes of this study, a driver was considered to be responsible or **at-fault** for a two-vehicle crash if violations were indicated for that driver and none were indicated for the other driver in the crash. A cross-tabulation of violations indicated for case drivers and other drivers is shown in table 6. The lower left-hand cell of the table shows that 45.3 percent of the case drivers were considered at-fault, while the upper right-hand cell shows a nearly equal number of other drivers (45.2%) to be at-fault. Fault could not be assigned for the cells where neither or both drivers had violations indicated.

In order to illustrate the overall relationship between driver age and the likelihood of being at-fault in a two-vehicle crash, figure 3 shows the percentage of drivers **at fault** for each year of age from 45 to 95 years. The curve shown in figure 3 was produced by fitting a logistic regression to the response variable – case driver **at-fault** (yes or no). The explanatory variables

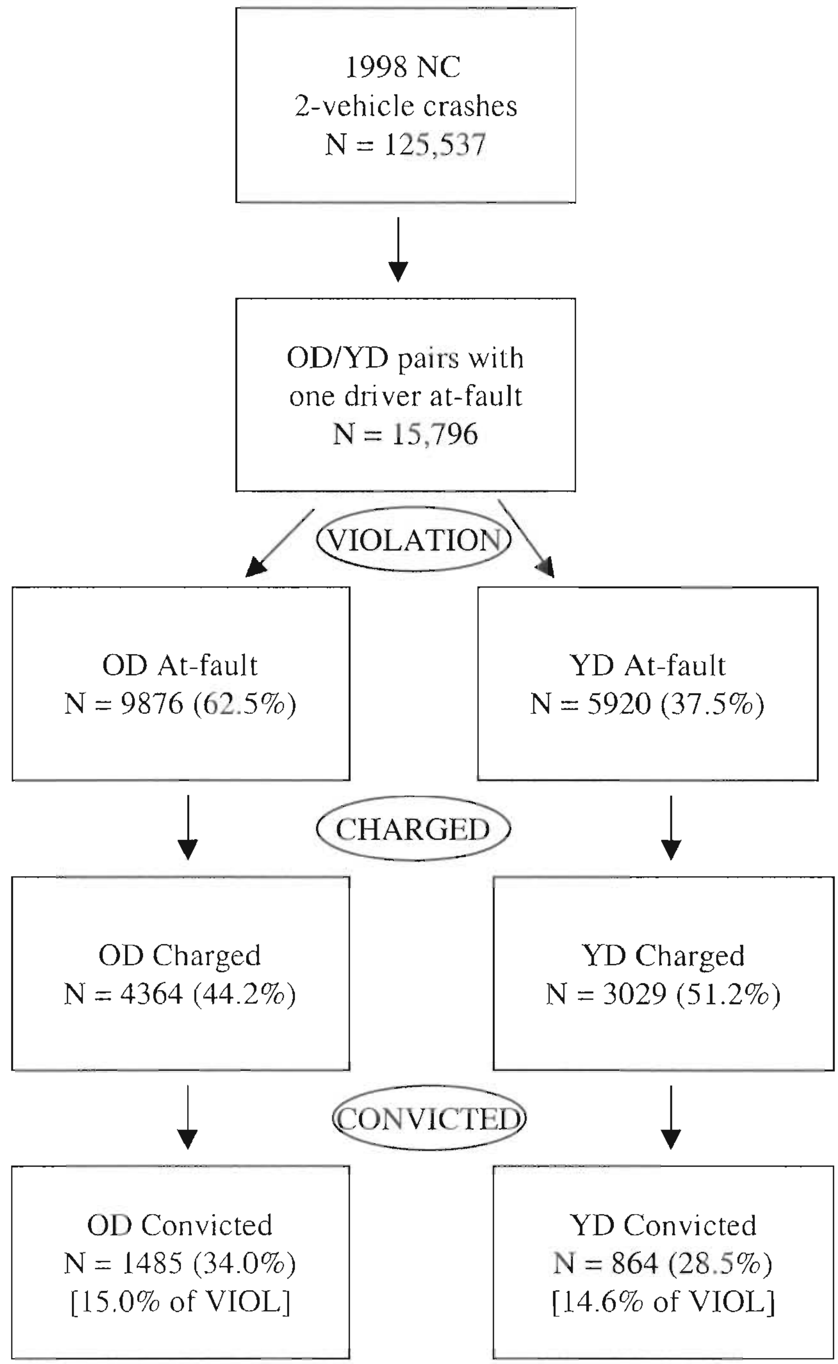

Figure 2. Data sets for examining violations vs charges vs convictions.

Table 2. **Driver Age** Distributions for VIOLATIONS vs CHARGES vs CONVICTIONS (NC 2-vehicle OD-YD crashes)

AGE		VIOLATIONS At-Fault		CHARGES At-Fault		CONVICTIONS At-Fault	
OD	YD	OD	YD	OD	YD	OD	YD
65-74	16-24	12.9*	25.4	14.0	28.0	12.7	28.3
	25-44	27.1	31.0	26.9	30.3	24.3	29.5
	45-64	14.6	15.6	15.3	14.3	14.4	12.7
75+	16-24	10.6	10.0	10.1	10.4	10.4	12.7
	25-44	22.8	11.8	22.5	11.3	25.1	11.5
	45-64	12.0	6.2	11.2	5.7	13.1	5.3

*Col. %

Table 3. **Driver Gender** Distributions for VIOLATIONS vs CHARGES vs CONVICTIONS (NC 2-vehicle OD-YD crashes)

GENDER		VIOLATIONS At-Fault		CHARGES At-Fault		CONVICTIONS At-Fault	
OD	YD	OD	YD	OD	YD	OD	YD
Male	Male	29.3*	33.8	32.0	37.1	33.5	41.4
	Female	26.7	26.1	28.1	24.7	27.5	24.0
Female	Male	22.8	21.3	20.8	20.5	20.7	19.1
	Female	21.2	18.8	19.1	17.7	18.3	15.5

*Col. %

Table 4. **Driver Injury** Distributions for VIOLATIONS vs CHARGES vs CONVICTIONS (NC 2-vehicle OD-YD crashes)

INJURY*		VIOLATIONS At-Fault		CHARGES At-Fault		CONVICTIONS At-Fault	
OD	YD	OD	YD	OD	YD	OD	YD
A+K	A+K	.6**	.6	.7	.8	.7	.7
	B+C	1.2	.8	1.4	1.3	1.4	1.8
	O	.5	.6	.5	.9	.3	1.3
B+C	A+K	.6	.5	1.0	.6	1.2	.7
	B+C	12.8	9.5	17.7	12.7	19.7	15.9
	O	6.8	21.7	7.8	23.6	7.0	22.5
O	A+K	.5	.1	.8	.1	1.1	.2
	B+C	22.5	7.5	24.9	8.0	25.5	9.3
	O	54.5	58.7	45.2	52.0	43.1	47.6

*KABCO injury where K = killed; A = incapacitating, B = moderate or non-incompacitating, C = minor, 0 = no injury

**Col. %

Table 5. **Violation Type** Distributions for VIOLATIONS vs CHARGES vs CONVICTIONS (NC 2-vehicle OD-YD crashes)

VIOLATION TYPE*	VIOLATIONS At-Fault		CHARGES At-Fault		CONVICTIONS At-Fault	
	OD	YD	OD	YD	OD	YD
Alcohol/Drugs	.7**	2.0	1.5	3.8	2.9	8.2
Speed	18.7	35.7	21.0	38.5	21.1	37.5
Reckless	5.1	4.2	3.3	3.9	2.9	3.7
Traffic Control	35.4	26.5	42.4	29.9	46.1	28.5
Other Moving	8.7	9.6	6.6	6.3	5.8	6.0
Safe Movement	31.4	22.0	25.2	17.6	21.2	16.1

*Alcohol/drugs
Speed (e.g., exceed safe speed, fail to reduce speed)
Reckless (e.g., pass on curve, left of center)
Traffic control (e.g., yield violation, traffic signal violation)
"Safe Movement"

** Column %

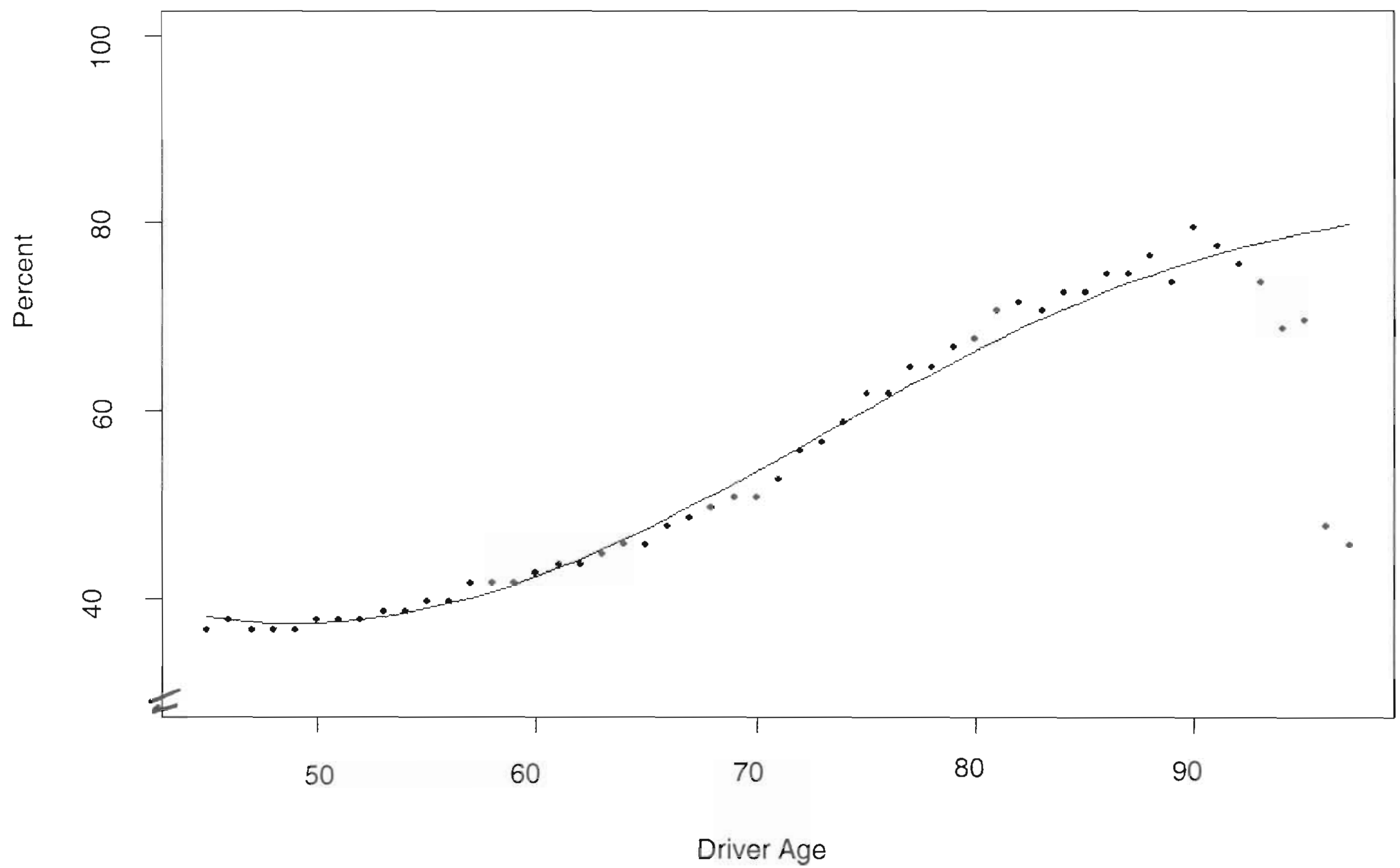

Figure 3. Percent **at-fault** in two-vehicle North Carolina crashes

Table 6. **Violations Indicated** for Case and Other Drivers in Two-Vehicle Crashes

	Violations Indicated Other Driver		
Violations indicated case driver	No	Yes	Total
No	8,557 1.6%	240,454 45.2%	249,000
Yes	241,354 45.3%	42,040 7.9%	283,394
Total	249,911	282,494	532,405

were case driver age, age^2, and age^3 (i.e., powers of age). Figure 3 shows the percentage at-fault increasing steadily from the early 60's to late 80's. As would be expected sample sizes became quite small for the very oldest age groups.

As stated earlier, the primary objective of this study was to identify driver maneuvers, crash types, or situations which account for a large share of older driver at-fault crashes and/or where drivers become increasingly more likely to be at-fault in two-vehicle crashes with increasing age. Driver or vehicle maneuver is an item on the North Carolina crash report form which is coded for each crash-involved driver/vehicle This variable was of particular interest since it describes the maneuver the driver was attempting when the crash occurred. Figure 4 shows the distribution of maneuvers for case drivers 65 years old or older in all crashes and in at-fault crashes. Two maneuvers stand out from figure 4, going straight which accounts for 47 percent of all older driver crashes and 39 percent of older driver at-fault crashes, and left-turn maneuvers which account for 20 percent and 27 percent of all and at-fault crashes, respectively. Maneuvers other than left-turn for which the percent in at-fault crashes exceeded the percent in all crashes were changing lanes, right turns, backing, and starting in road.

Figure 5 shows the distribution of crash type in all older driver crashes and in their at-fault crashes. Note that the crash types left-turn and right-turn would typically be used to classify a crash where either of the two vehicles was making a left-turn or right-turn maneuver, not necessarily the case driver/vehicle. Left-turn crashes and angle crashes stand out because they

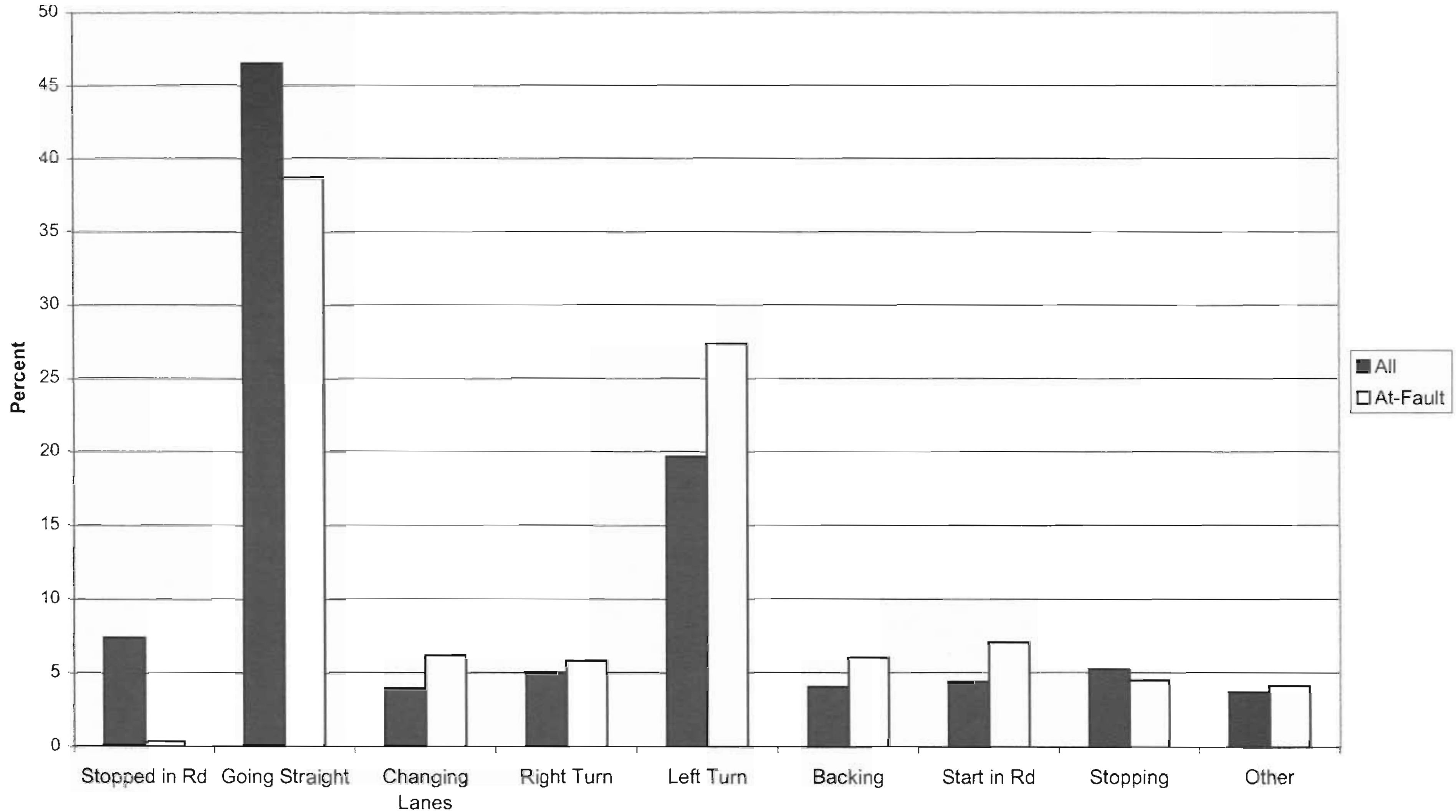

Figure 4. Distribution of **driver maneuvers** in all crashes involving drivers age 65+ and in those crashes where the older driver was at-fault.

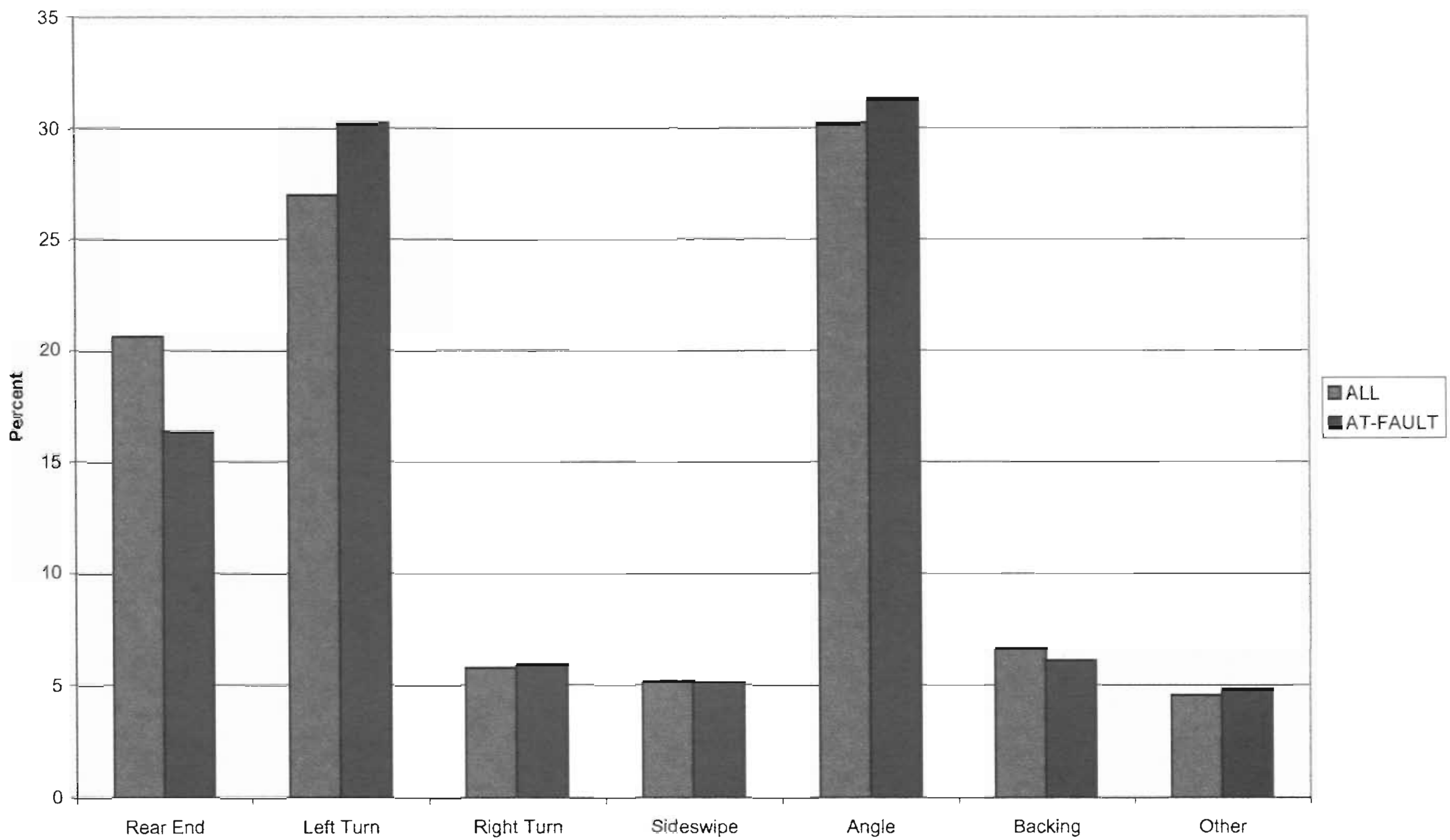

Figure 5. Distribution of **crash types** in all crashes involving drivers age 65+ and in those crashes where the older driver was at-fault.

account for a sizeable percentage of the older driver crashes, and because the percentage of at-fault crashes exceeds that for all crashes. Figures 6 through 8 show distributions of road feature, traffic control device and region of impact for the case vehicle. Roadway intersections, stop signs, and frontal impacts are shown to be indicated in a sizable percentage of older driver crashes and an even larger percentage of their at-fault crashes.

Examining the distribution of crash types occurring when the older (case) driver maneuver was going straight ahead indicated that two crash types, rear-end and angle crashes, together accounted for 67 percent of all older driver crashes and 82 percent of the at-fault crashes involving this maneuver.

Listed below in table 7 are seven categories of two-vehicle crashes based on driver maneuver, and crash type for going straight maneuvers. The table lists the percent of all older crashes falling into each category and the percent of at-fault crashes. The last column of table 7 shows the increase in the percent at fault for drivers 85 years and older versus drivers in the 45-54 year old category. For example, 91 percent of drivers 85 years old or older were classified at-fault when involved in a crash while changing lanes, whereas 82 percent of drivers 45-54 years old were at-fault in this type of crash. By contrast, the corresponding percents were 79 percent versus 46 percent for right-turn maneuver crashes.

Table 7. Categories of Two-Vehicle Crashes Accounting for a Major Proportion of Older Driver (65+) At-Fault Crashes

Category	Percent of All Crashes	Percent of At-Fault Crashes	Percentage Point Increase 45-54 to 85+
Going Straight (angle)	22.2	19.5	+41
Right Turn	5.0	5.8	+33
Left Turn	19.7	27.4	+22
Going Straight (rear end)	9.0	12.4	+11
Starting in Road	4.4	7.1	+9
Changing Lanes	3.9	6.1	+9
Backing	4.1	6.0	+9

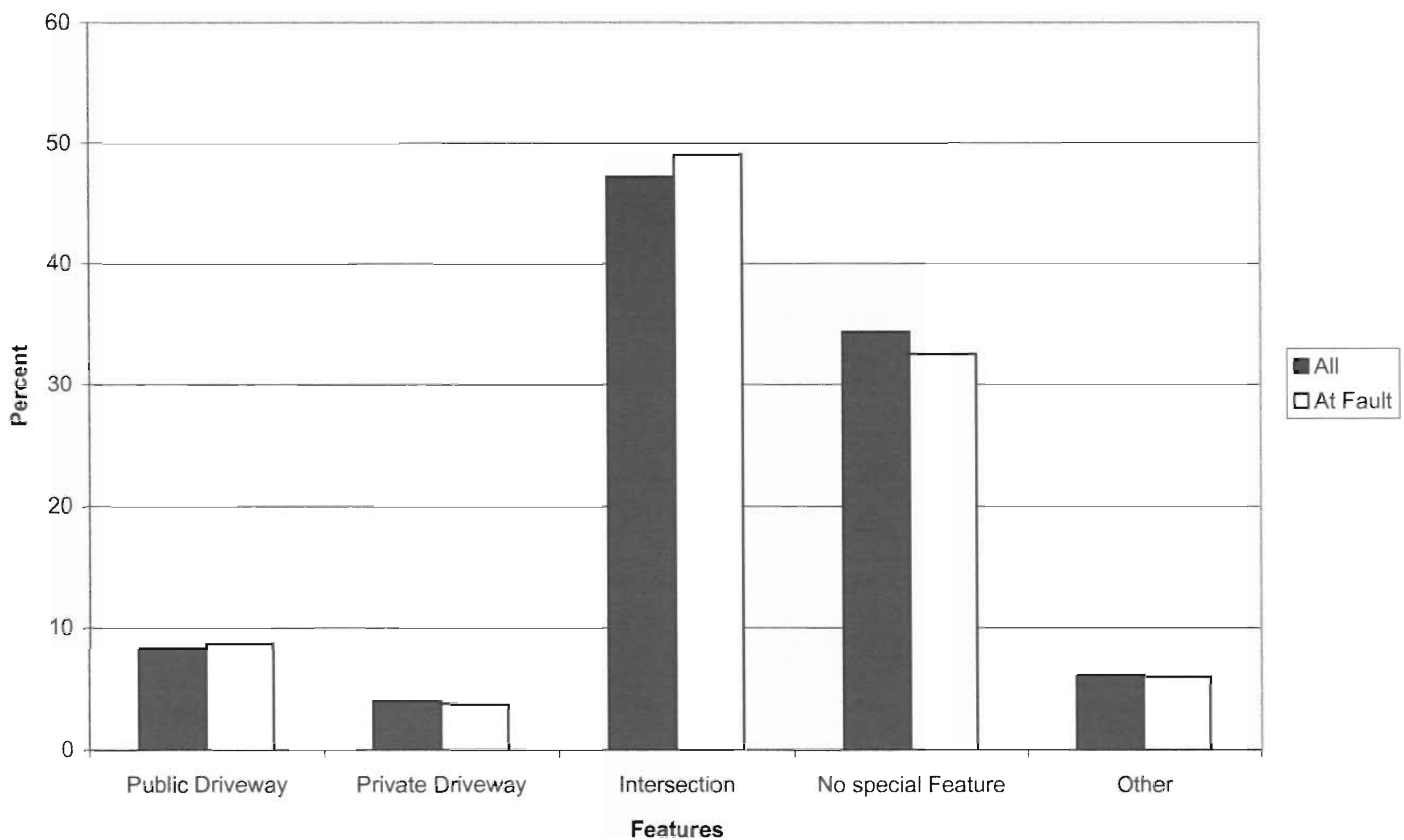

Figure 6. Distribution of **road features** in all crashes involving drivers age 65+ and in those crashes where the older driver was at-fault.

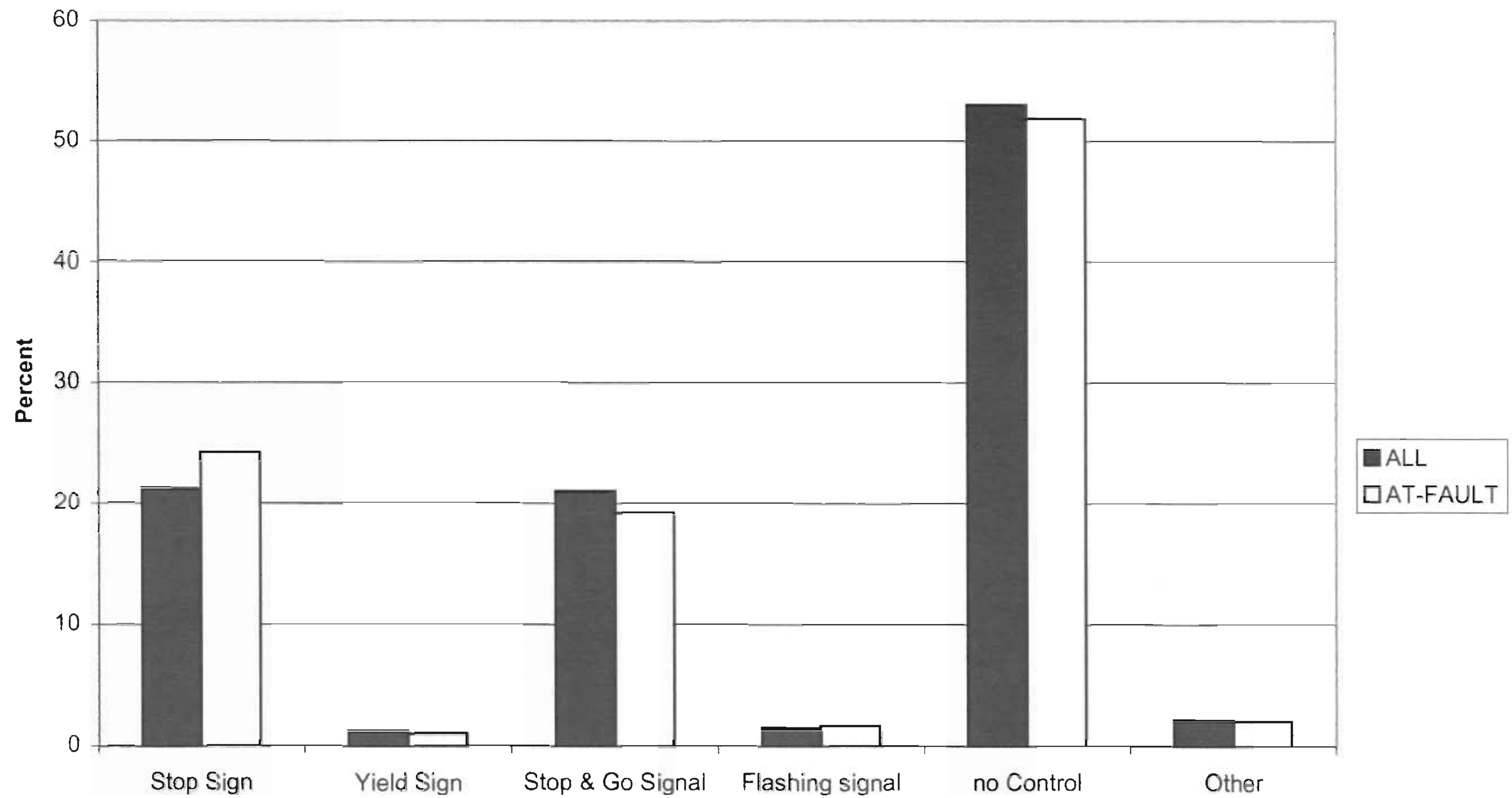

Figure 7. Distribution of **traffic control devices** in all crashes involving drivers age 65+ and in those crashes where the older driver was at-fault.

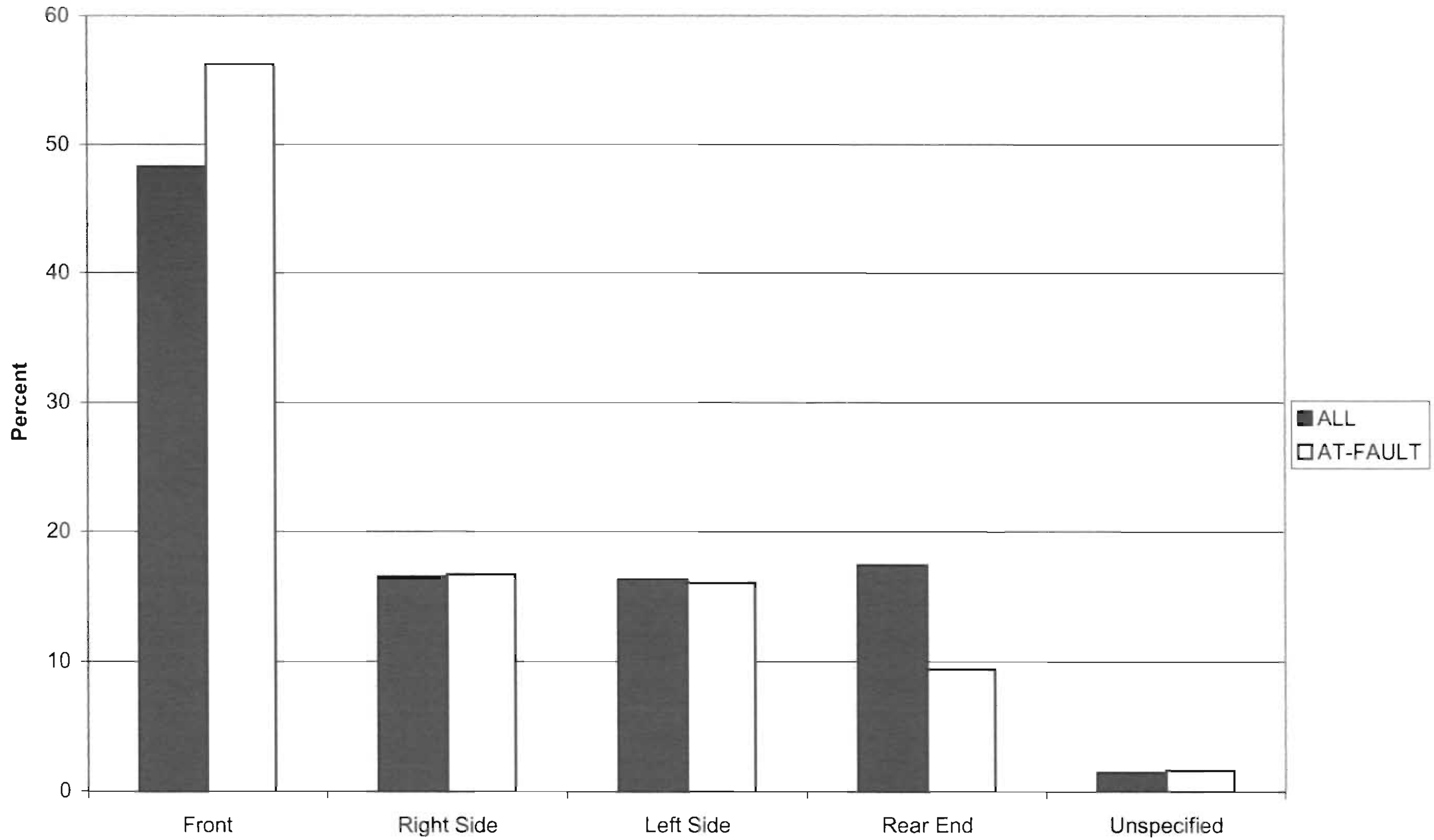

Figure 8. Distribution of **region of impact** in all crashes involving drivers age 65+ and in those crashes where the older driver was at-fault.

From the results of table 7, the categories of crashes which best meet the criteria described earlier as representing situations that are particularly troublesome for older drivers are left-turn maneuver crashes, right-turn maneuver crashes, and going straight angle collisions. Logistic regression models were fit to the at-fault variable for each of these three categories to further explore the role of driver age in conjunction with other confounding variables on the likelihood of the driver being at-fault. In addition to powers of driver age, other factors included in the models were roadway feature, traffic control, region of impact, and locality, which were crash variables which showed the strongest association with the driver being classified at-fault. Driver gender was also included as a variable of particular interest.

Since certain combinations of the levels of roadway feature and traffic control device occurred very infrequently, these two variables were combined into a single variable, loc-type, having the levels,

1. Driveway (public and private),
2. Stop sign, yield sign, or flashing signal at intersection of roadways or at no special feature,
3. Stop and go signal at roadway intersection or at no special feature,
4. Intersection with no control,
5. No special feature, no control,
6. All other (includes combinations of traffic control and roadway feature such as alley intersection with no control, railroad crossing with flashing signal, etc.)

Left-Turn Maneuver Crashes

The percentages of drivers classified as at-fault in two-vehicle crashes while making left-turn maneuvers are plotted in figure 9 as a function of driver age. As in figure 3, the smooth curve of figure 9 derives from a logistic regression curve based on a cubic polynomial of driver age. The percentage of at-fault crashes while making a left-turn can be seen to increase steadily with age from about age 60 through the early 80's. To further investigate the nature of these left-turn maneuver crashes, logistic regression models containing other crash variables were fit to the data.

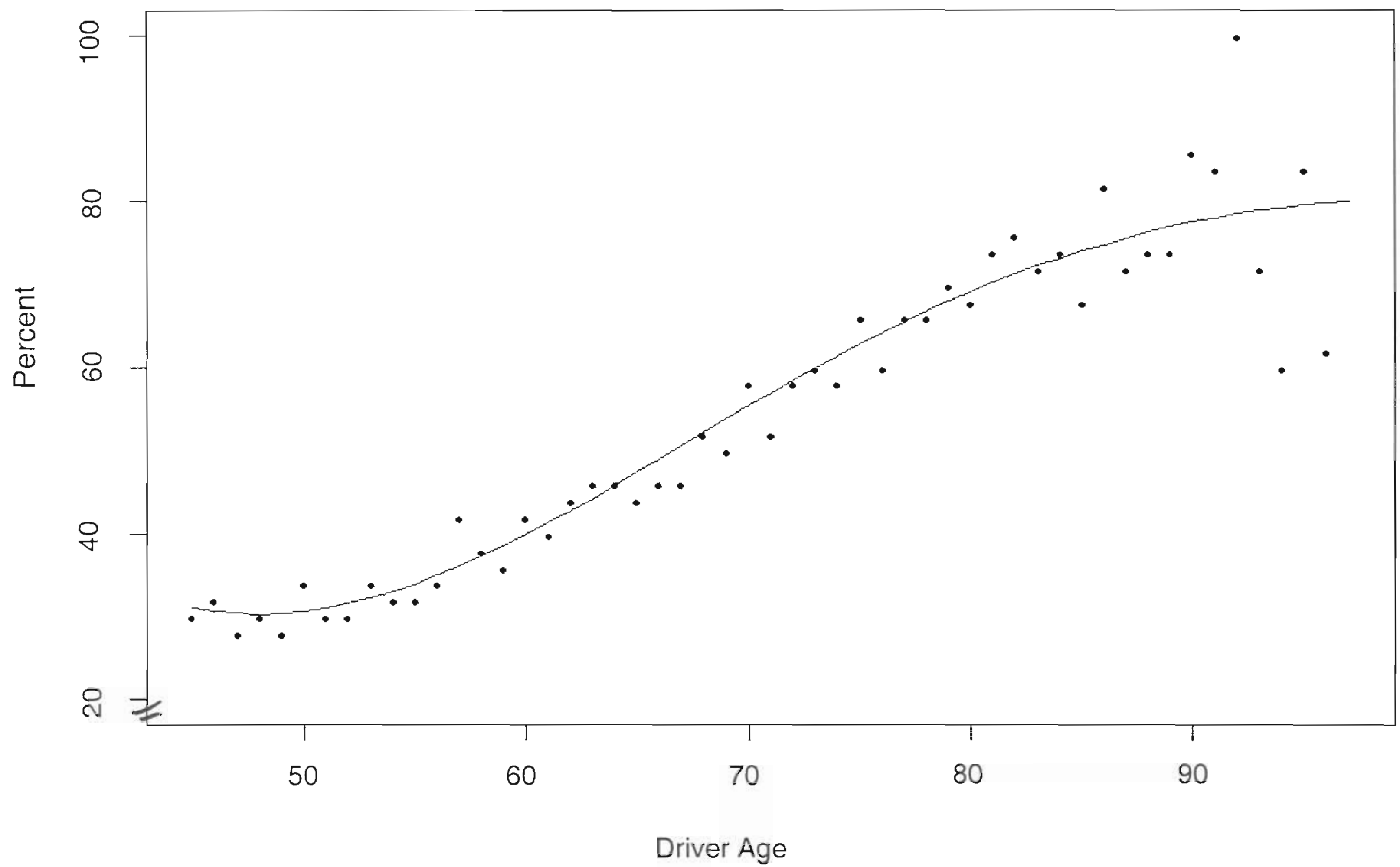

Figure 9. Percent **at-fault**, left-turn maneuver crashes.

Table 8 gives the likelihood ratio statistics from a model containing the factors loc-type, region of impact, locality, and driver gender in addition to the age effects. Parameter estimates, standard errors, and odds ratios for the class variables are presented in table 9. These results show, for example, that older drivers are particularly likely to be at-fault in frontal and right side impact crashes at stop controlled intersections.

Table 8. Likelihood Ratio Statistics for Left-Turn Model.

Source	DF	χ^2	P-value
Age	1	23.7	<0.0001
Age^2	1	23.3	<0.0001
Age^3	1	18.8	<0.0001
Loc-type	5	2,492.6	<0.0001
Region	3	5,734.4	<0.0001
Locality	1	222.1	<0.0001
Gender	1	24.5	<0.0001

Right-Turn Maneuver Crashes

Figure 10 and tables 10 and 11 show results from models for fault in right- turn maneuver crashes in the same format as the left-turn results. Right-turn maneuver crashes account for far fewer crashes than left-turn maneuver crashes, and the likelihood of being at-fault is generally lower. The increase in this likelihood with increasing age is, however, quite similar.

Model results show that driver gender is not a significant variable; older drivers are, again, most likely to be at-fault at stop sign-controlled intersections, while frontal and left-side collision crashes most often result in the driver being at-fault.

Table 9. Left-Turn Model Parameter Estimates.

Factor	Level	Estimate	S.E.	Odds Ratio
Loc-type	Driveway	0.5365	0.0282	1.71
	Stop Sign	1.2571	0.0264	3.52
	No Control (intersections)	0.5996	0.0276	1.82
	No Control (no special feature)	0.7160	0.0258	2.05
	Other	0.5832	0.0390	1.79
	Stop & Go Signal	(-)	(-)	1.00
Region of Impact	Front	1.3457	0.0268	3.84
	Right	1.6844	0.0313	5.39
	Left	0.2509	0.0280	1.29
	Rear	(-)	(-)	1.00
Locality	Urban & Mixed	0.3586	0.0238	1.43
	Rural	(-)	(-)	1.00
Gender	Male	-0.0843	0.0170	0.92
	Female	(-)	(-)	1.00

Table 10. Likelihood Ratio Statistics for Right-Turn Model

Source	DF	χ^2	P-value
Age	1	7.33	<0.0068
Age^2	1	7.44	<0.0064
Age^3	1	6.08	<0.0136
Loc-type	5	510.69	<0.0001
Region	3	3,524.71	<0.0001
Locality	1	41.43	<0.0001
Gender	1	0.02	0.3907

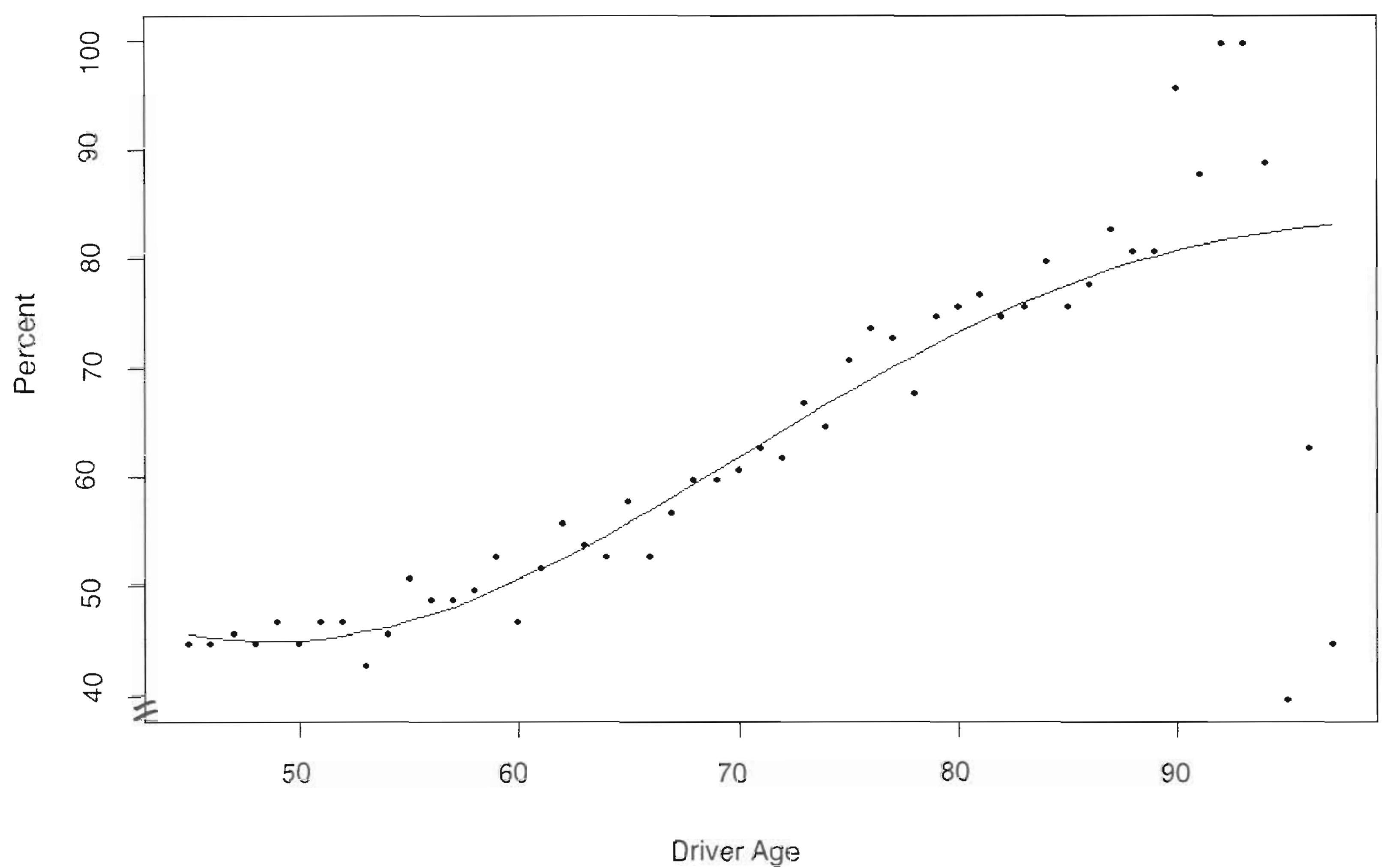

Figure 10. Percent **at-fault**, right-turn maneuver crashes

Table 11. Right-Turn Model Parameter Estimates

Factor	Level	Estimate	S.E.	Odds Ratio
Loc-type	Driveway	-0.1394	0.0509	0.87
	Stop Sign	0.8582	0.0518	2.36
	No Control (intersections)	-0.2173	0.0615	0.80
	No Control (no special feature)	-0.0315	0.0479	0.97
	Other	0.1776	0.0680	1.19
	Stop & Go Signal	--	--	1.00
Region of Impact	Front	2.4370	0.0459	11.44
	Right	1.3734	0.0506	3.95
	Left	2.0533	0.0564	7.79
	Rear	--	--	1.00
Locality	Urban & Mixed	0.3555	0.0553	1.43
	Rural	--	--	1.00

Straight Ahead Angle Crashes

Model results for at-fault in crashes involving angle collisions while going straight ahead are presented in figure 11 and tables 12 and 13. As shown earlier, this type of crash accounts for a large proportion of older driver at-fault crashes, and figure 10 again shows the percentage of at-fault to steadily increase with driver age from about age 60 to the mid 80's.

From tables 12 and 13, it may be noted that the factor, region of impact, was not included in the model. In these crashes, the likelihood of being at-fault was essentially the same for all regions including rear-end. Stop-controlled intersections again stood out as locations where older drivers were more likely to be at-fault in two vehicle crashes.

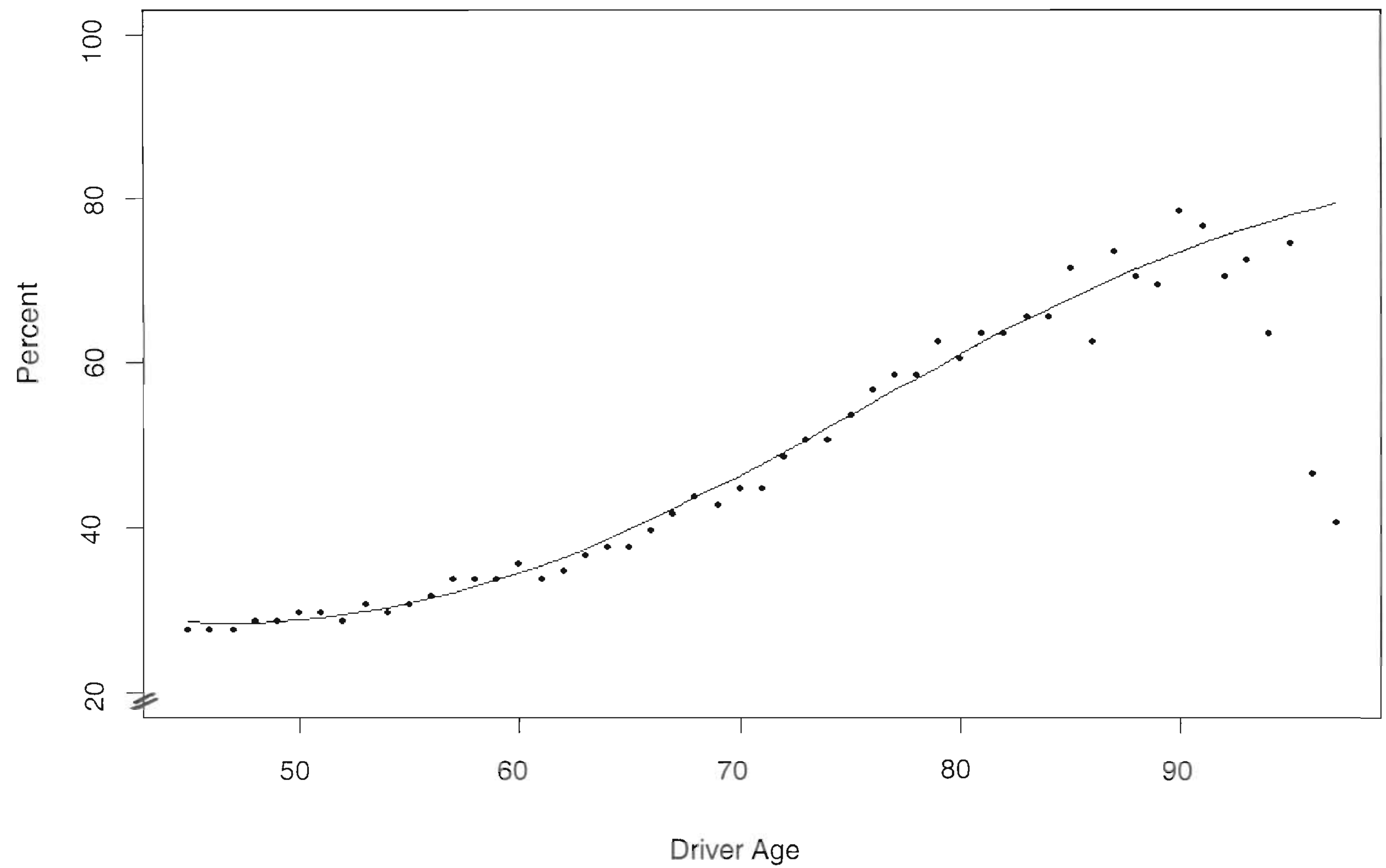

Figure 11. Percent **at-fault**, going straight, angle crashes.

Table 12. Likelihood Ratio Statistics for Going Straight, Angle Collision Model

Source	DF	χ^2	P-value
Age	1	35.15	<0.0001
Age^2	1	32.55	<0.0001
Age^3	1	22.32	<0.0001
Loc-type	5	4,932.67	<0.0001
Locality	1	15.75	<0.0001
Gender	1	219.20	<0.0001

Table 13. Going Straight, Angle Collision Model Parameter Estimates

Factor	Level	Estimate	S.E.	Odds Ratio
Loc-type	Driveway	-0.8226	0.0319	0.44
	Stop Sign	0.4439	0.0162	1.56
	No Control (intersections)	-0.0048	0.0336	1.00
	No Control (no special feature)	-0.7559	0.0229	0.47
	Other	-0.2632	0.0314	0.77
	Stop & Go Signal	--	--	1.00
Locality	Urban & Mixed	-0.0724	0.0182	0.93
	Rural	--	--	1.00
Gender	Male	-0.1940	0.0131	0.82
	Female	--	--	1.00

Injuries in the Other Vehicle

Overall, 7.3 percent of all two-vehicle crashes involving a case driver aged 45 years or older resulted in an injury of severity level B (moderate injury) or worse in the other vehicle. This percent increased with increasing case driver age from 7.1 percent for drivers in the 45-54 year old range to 8.7 percent for drivers over 85. An injury in the other vehicle occurred in 7.8 percent of the crashes when the case driver was at-fault versus 7.0 percent when the case driver was not at-fault. With respect to driver maneuver/crash type, 9.1 percent of left-turn maneuver crashes resulted in injuries in the other vehicle, 3.3 percent of right-turn maneuver crashes, and 11.0 percent of going straight, angle crashes.

For each of the three maneuvers analyzed above (i.e., left-turn, right-turn, going straight angle), logistic regression models were also developed for a response variable indicating an injury of severity level B or greater in the other vehicle. Explanatory variables included case driver age, at-fault, and the other factors included in the at-fault models.

Locality was an important predictor in each of these models, with higher injury rates occurring in rural locations than in mixed or urban. Injury rates were somewhat higher when the case driver was male and higher in left-turn crashes and going straight, angle collision crashes when the case driver was at-fault. For left-turn and going straight, angle collision frontal impacts resulted in the highest injury rates followed by side impacts then rear end impacts. Rear impacts to the case vehicle resulted in the highest injury rates in the other vehicle for right-turn maneuver crashes. Though statistically significant, location type seemed to have a relatively minor effect on injury rates. The highest injury rates corresponded to stop-controlled intersections for right-turn and going straight angle collisions, while intersections with no traffic controls had the highest injury rate for left-turn maneuver crashes.

Comparison of Older Driver Crashes with Those of Very Young Drivers

All of the preceding analyses were directed toward characterizing crashes caused by older drivers and injuries resulting from these crashes. Changes in these characteristics with increasing driver age from age 45 onward were explored. To provide a more complete perspective, this section provides a brief comparison of older driver crashes with those of very young drivers (ages 16-19).

For these analyses, two additional North Carolina data files were examined. One contained data on all North Carolina 1999 crash involvements. Of 388,821 crash-involved drivers, 12.2 percent were 16-19 years old, while 7.6 percent were 65 or older. The crashes of these two groups differed in several respects. About 20 percent of the young drivers' crashes would be classified as single vehicle crashes (e.g., ran-off-road, hit fixed object, overturned), while only about 7 percent of the older drivers' crashes were of these types. Vehicle maneuver was coded as straight ahead in 61 percent of the young driver involvements versus 50 percent of the older drivers. On the other hand, 22 percent of the older drivers were involved in turning maneuvers versus 14 percent for these youngest drivers.

No violation was indicated for 44 percent of the older drivers and for 34 percent of the young drivers. A speeding related violation was indicated for 13 percent of the older drivers versus 33 percent of the young drivers. On the other hand, failure to yield and safe movement violations were indicated for 13 percent and 16 percent of the older driver involvements versus 7 percent and 11 percent, respectively, for the young driver involvements.

Older drivers tended to be slightly more seriously injured with 0.67 percent killed and 2.18 percent seriously (Level A) injured. The corresponding injury rates for the young drivers were 0.19 percent and 1.67 percent.

The second data file was another two-vehicle crash file, this time containing data on drivers of **all ages** from 1999 North Carolina crashes. One of the two drivers in each crash was randomly assigned to be the case driver and was classified as at-fault if a violation or contributing factor was associated with this driver and none was associated with the other driver. Figure 12 is a scatter plot which shows the percent of drivers at-fault in these two-vehicle crashes for each year of age from 16-94. The smooth curve was produced by a scatter plot smoothing procedure. Since only a single year of crash data was used, sample sizes became very small for the oldest age categories. For example, there were more than 8,000 18-year old drivers but only about 600 81-year old drivers.

In summary, these analyses show that not only do young drivers tend to be involved in different types of crashes than older drivers (e.g., single vehicle crashes), but when involved in two-vehicle crashes a high percent of the very young drivers are at-fault. The percent decreases rapidly with age until about age 25, then begins to increase dramatically again at about age 65.

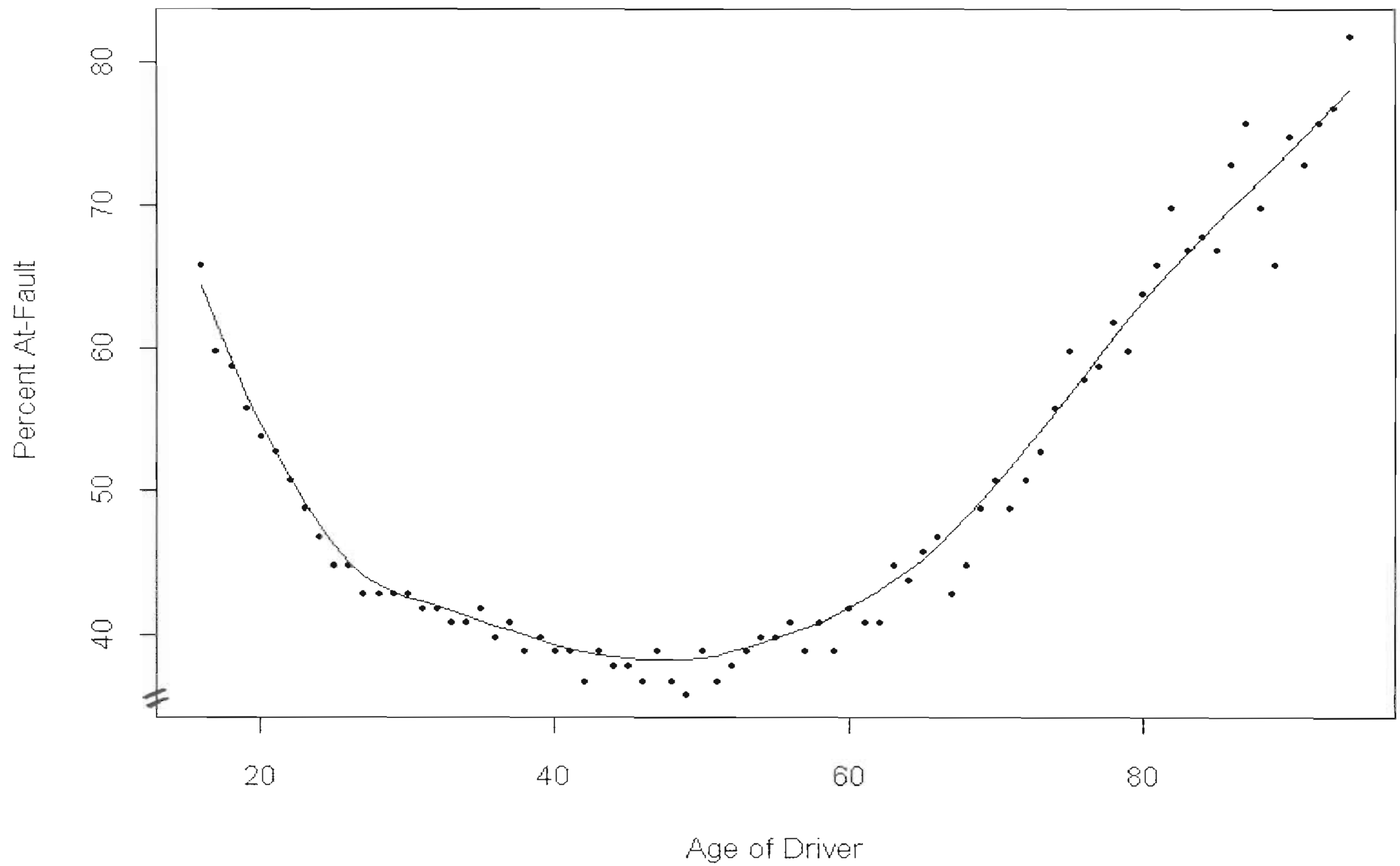

Figure 12. Percent **at-fault** in two-vehicle North Carolina crashes (all ages)

Other North Carolina Analyses

The analyses presented above represent the main thrust of the exploration of crashes caused by older drivers and their consequences. In the early exploratory stages of the study, a number of other results were obtained. In fact, much of the early effort involved examining changes over time in many of the quantities and relationships. In general, these analyses revealed very little change over the 10-year time span of the North Carolina data. This is illustrated by figure 13, which shows the percent of drivers at-fault in two vehicle crashes as a function of age category for 5 two-year subsets (for simplicity of presentation and sample size considerations) of the North Carolina crash file.

Another analysis investigated the question of older drivers striking pedestrians as well as older pedestrians being struck by motor vehicles. From the 10-year data file of crash-involved drivers 45 years old and older, 4,995 motor vehicle drivers were involved in striking pedestrians while 4987 pedestrians in the specified age range were struck by motor vehicles. Table 14 shows the distribution of these drivers and pedestrians by age. Note the dramatic shift in the percentage being hit as a pedestrian compared to hitting a pedestrian with increasing age.

Table 14. Age Distribution of Drivers and Pedestrians

	Age					
Crash Type	45-54	55-64	65-74	75-84	85+	Total
Hit ped	2,042 (40.8)*	1,414 (28.3)	993 (19.9)	488 (9.8)	58 (1.2)	4,995
Hit as ped	1,928 (38.7)	1,300 (26.1)	968 (19.4)	619 (12.4)	172 (3.4)	4,987
Ratio (struck/striking)	0.944	0.919	0.975	1.27	2.97	0.998

*Row %

Vehicle maneuvers associated with an older driver striking a pedestrian and pedestrian actions associated with being struck were also examined. Going straight was by far the most

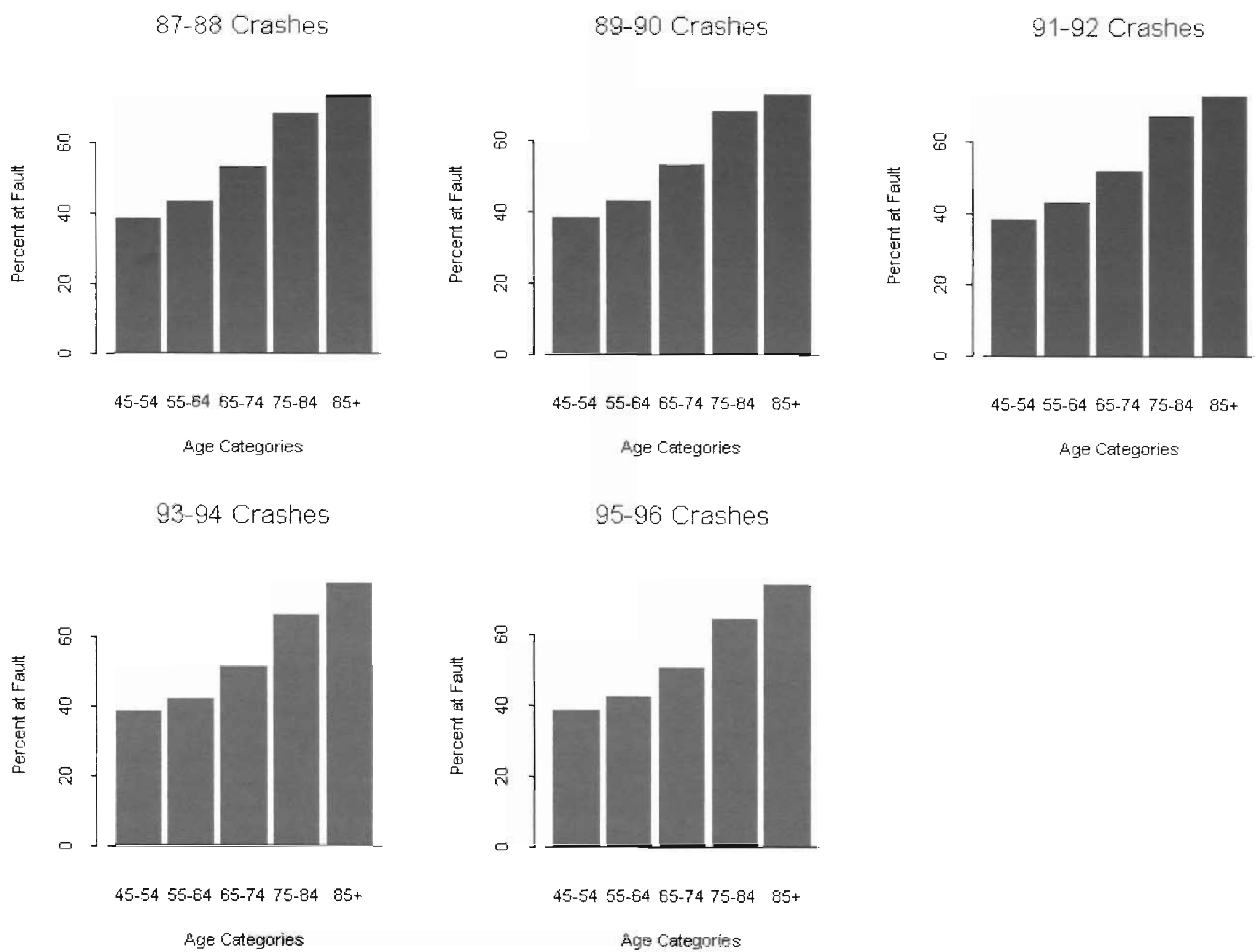

Figure 13. Distribution across years (1987-1996) of **at-fault** drivers in North Carolina two-vehicle crashes

prevalent vehicle maneuver **in striking** a pedestrian, accounting for about 74 percent of such crashes overall. This percentage decreased, however, with driver age going from 76 percent for the youngest group to 60 percent for the oldest. Backing was the next most prevalent maneuver accounting for nearly 9 percent of the incidents. The percent associated with this maneuver increased with driver age from 7.4 percent to 15.5 percent. Parking and leaving parked position were other maneuvers increasingly associated with older drivers. For these two maneuvers combined, the percent to which they were associated with striking pedestrians increased from 2.2 percent for the youngest drivers to over 12 percent for the very oldest drivers.

Crossing the street not at an intersection and crossing at an intersection were the pedestrian actions most associated with the pedestrian being **struck**, accounting for 32 percent and 14 percent, respectively, of the cases. The percentages increased with increasing pedestrian age for both pedestrian actions going from 30 percent to 40 percent for crossing not at an intersection, and from 13 percent to 20.5 percent for crossing at an intersection over the five age categories. Walking with traffic was associated with 9 percent of the 45-54 year old pedestrians who were struck. This percent decreased with increasing pedestrian age to 2.3 percent for those 85 and over. For walking against traffic, the percentages went the other way, however, from 4 percent to 7.6 percent for the youngest vs oldest pedestrians.

In a separate analysis to determine "why" (according to the police narrative) the older driver was at-fault according to the various violations indicated (e.g., stop sign violation) on the PAR, we examined a total of 263 hard copies of police reports for two-vehicle crashes involving an older driver and a younger (< 65) driver where the older driver was at-fault. This problem identification effort was carried out to see if there were specific candidate problems (e.g., difficulty seeing out of the side and/or rear view mirrors), which could be studied with full-fledged narrative searches using tailored key words (e.g., rear view) for performing the searches.

The results of this examination for two-vehicle crashes is presented in Table 15. For the majority of cases, no specific "Driver Reason" was given in the narrative. However, for the remaining crashes, the overwhelming (over 75%) reason offered was "Did not see" and it was most associated with yield violations, lane changes and turning maneuvers. Other less frequent explanations included "Skidded on the wet road", "Misjudged...", and an occasional "Foot slipped off the brake".

Table 15. Violation Indicated (police) vs "Driver Reason" (narrative search) for Sample of Older (65+) Driver At-fault Crashes Involving Two Vehicles.

Violation Indicated / "DRIVER REASON"	Yield	Stop Sign	Signal	Speed: Failed to Reduce	Speed: Excessive	Turn	Lane Change	Left of Center	Merge	Backing	Right Turn on Red	Alcohol (Drugs)	Other
TOTAL (N = 263)	75 (28.5%)	17 (6.5%)	13 (4.9%)	37 (14.1%)	14 (5.3%)	42 (16.0%)	30 (11.4%)	10 (3.8%)	6 (2.3%)	5 (1.9%)	8 (3.0%)	4 (1.5%)	2 (1.0%)
None indicated	59	8	9	22	8	30	20	6	3	2	2	4	0
DID NOT SEE	14	8	4	9	2	10	6	2	3	3	3	0	0
Distracted/ inattentive	1	0	0	2	1	0	0	0	0	0	1	0	0
Blinded	1	0	0	2	0	2	1	0	0	0	0	0	0
Attempted to avoid/skidded	0	1	0	1	2	0	2	2	0	0	1	0	0
Foot slipped off brake	0	0	0	1	1	0	1	0	0	0	1	0	2

As problems for older drivers at stop sign-controlled intersections surfaced in several analyses, hard copies of crashes at stop sign-controlled intersections were examined for both older (65+) and younger (45 - 64) drivers who were at-fault in their crashes. Of particular interest was the maneuver that the driver was attempting to make at the stop sign and what the investigating officer indicated as the main reason why that driver "caused" or was at-fault in the crash. A total of 178 FARs were examined -- 127 where the older driver was at-fault (intentionally over-sampled) and 51 for the somewhat younger driver.

The results are summarized in Table 16 where, due to small frequencies, "right turn," "lane change" and "slow or stopped in travel" are collapsed into the "other maneuver" category. The "other" group for officer judgment consists of "run stop sign" and "dropped item in car".

As is clear in Table 16, the older driver is much more likely to convince the police that they "failed to see" (19.7% for OD vs 3.9% for YD) and somewhat more likely to just have "failed to yield" (22.8% vs 15.7% for OD vs YD, respectively). As has been a consistent theme and appears to be true at stop sign-controlled intersections, the intended next maneuver in these situations (where the driver is at-fault) was much more likely to be "making a left turn" for the older driver than for his/her younger counterpart (30.7% vs 19.6%). The reverse holds for "going straight" through the intersection (42.5% vs 52.9% for OD vs YD, respectively).

Estimation of Older Driver Crashes in North Carolina

In the previous sections, crash data were examined to determine situations where older drivers were most likely to be responsible for two-car crashes. Another major area of interest is in making projections of **expected numbers of crashes caused by older drivers** as this population increases over time. A first step in this process was to estimate expected crashes per licensed driver under current driving conditions. For this purpose, 1995 crash data were linked to driver history records for all NC drivers who were 45 years old or older in 1996. The resulting data file contained over 2.6 million records. Using data from this file, a Poisson regression model was fit to a response variable which indicated the count of two-car crashes in 1995 for each licensed driver. Explanatory variables in this model were driver age in five categories (45-54, 55-64, 65-74, 75-84, 85 and over), driver gender, and a categorical variable indicating three levels of county population (i.e., low < 100,000; medium 100,000 - 300,000; high > 300,000) where the crashes occurred. The model was fit using SAS Proc GENMOD, and included the

Table 16. Maneuver vs. "Officer Judgment" of Driver Error (narrative search) for Sample of Older (65+) vs. Younger (45 - 64) Driver At-fault Crashes at at Stop Sign-Controlled Intersections

		OD Maneuver					YD Maneuver			
"Officer Judgment"	Total	Going Straight	Left Turn	Starting In Road	Other Maneuver*	Total	Going Straight	Left Turn	Starting in Road	Other Maneuver*
TOTAL	127	54 (42.5%)***	39 (30.7%)	25 (19.7%)	9 (7.1%)	51	27 (52.9%)***	10 (19.6%)	8 (15.7%)	6 (11.8%)
Failed to see	25 (19.7%)****	10	8	5	2	2 (3.9%)****	-	1	1	-
Failed to look left	31 (24.4%)	10	10	10	1	12 (23.5%)	5	2	4	1
Failed to yield	29 (22.8%)	10	11	6	2	8 (15.7%)	6	1	1	-
Failed to stop slow	16 (12.6%)	10	-	4	2	15 (29.4%)	11	1	-	3
Pulled out in path	22 (17.3%)	10	10	-	2	11 (21.6%)	3	4	2	2
Other**	4 (3.1%)	4	-	-	-	3 (5.9%)	2	1	-	-

*Other maneuver = Right turn + Lane change + Slow or stopped in travel
**Other Officer Judgment = Ran stopped sign + Dropped item in car

***Row % (within age group)
****Col % (within age group)

significant interactions of age by gender and population by gender in addition to the main effects. Table 17 gives the likelihood ratio statistics for this model. Expected two-car crashes per year/1,000 drivers for drivers 65 and over are shown in table 18. The last two columns of table 18 show expected at-fault crashes and at-fault crashes resulting in injuries of level B or higher in

Table 17. Likelihood Ratio Statistics for Two-Car Crash Model.

Source	DF	χ^2	P-value
Age	4	116.55	<0.001
Gender	1	44.31	<0.0001
Population	2	2,225.01	<0.0001
Age x Gender	4	54.14	<0.0001
Pop. x Gender	2	33.29	<0.0001

the other vehicle. These frequencies were derived by again fitting logistic regression models for at-fault and injury in the other vehicle to the crash data, using only age categories, gender, and at-fault (in injury model) as explanatory variables. Estimated proportions were then applied to the all two-car and at-fault two-car crash frequencies, respectively.

Estimates of specific types of crashes (e.g., left-turn maneuver crashes or going straight, angle collisions at stop-controlled intersections) can be made in similar fashion. The crash frequency estimates of table 18 could also be used along with estimates of current (NPTS) and future driving exposure along with estimates of increases in older driver populations to make projections of expected future crashes and injuries caused by older drivers.

Analysis of FARS Data

An analysis essentially paralleling the analysis of the North Carolina data was carried out using data from FARS (Fatality Analysis Reporting System) for the years 1992-1997. A data file was developed which contained approximately 37,000 records of fatal two-vehicle crashes in which at least one driver was 45 years old or older. Vehicle types were restricted to passenger cars, light trucks, vans, and sport utility vehicles. Each record contained information about the crash, the case driver (45 and over) and vehicle, and the other driver and vehicle.

An at-fault variable was defined in terms of contributing factors associated with each driver as with the North Carolina crash data. In these data, the case driver was at-fault in 43 percent of the crashes while the other driver was at-fault in 39 percent.

Table 18. Expected Crashes, At-fault Crashes, and At-fault Crashes Resulting in Moderate to Fatal Injury in Other Vehicle(s)

			Expected Crashes per year/1000 drivers		
Gender	Pop.	Age	All 2-Car	At-Fault	Injury in Other Car
F	L	65-74	23.20	12.47	0.90
		75-84	24.13	16.48	1.27
		85+	14.73	10.76	0.89
F	M	65-74	28.81	15.49	1.12
		75-84	29.97	20.46	1.57
		85+	18.29	13.36	1.10
F	H	65-74	37.50	20.16	1.46
		75-84	39.00	26.63	2.05
		85+	23.80	17.39	1.44
M	L	65-74	32.32	16.41	1.36
		75-84	32.64	21.44	1.88
		85+	21.72	16.16	1.52
M	M	65-74	40.13	20.38	1.69
		75-84	40.53	26.63	2.34
		85+	26.96	20.07	1.89
M	H	65-74	52.23	26.52	2.20
		75-84	52.75	34.66	3.04
		85+	35.09	26.12	2.46

The percentage of drivers at-fault in all FARS two-vehicle crashes is plotted in figure 14 as a function of driver age. The smooth curve is again based on a logistic regression model fitting at-fault to the first three powers of driver age. The percentage of at-fault can again be seen to increase fairly steadily from the mid 60's through the mid 80's.

Table 19 shows categories of FARS two-vehicle crashes, which account for a large proportion of older (65+) driver crashes and at-fault crashes (compare with table 7). Left-turn maneuver crashes and angle collisions with the case driver going straight ahead again accounted for large proportions of older drivers crashes. By contrast, right-turn maneuver crashes accounted for less than one percent of both total crashes and at-fault crashes.

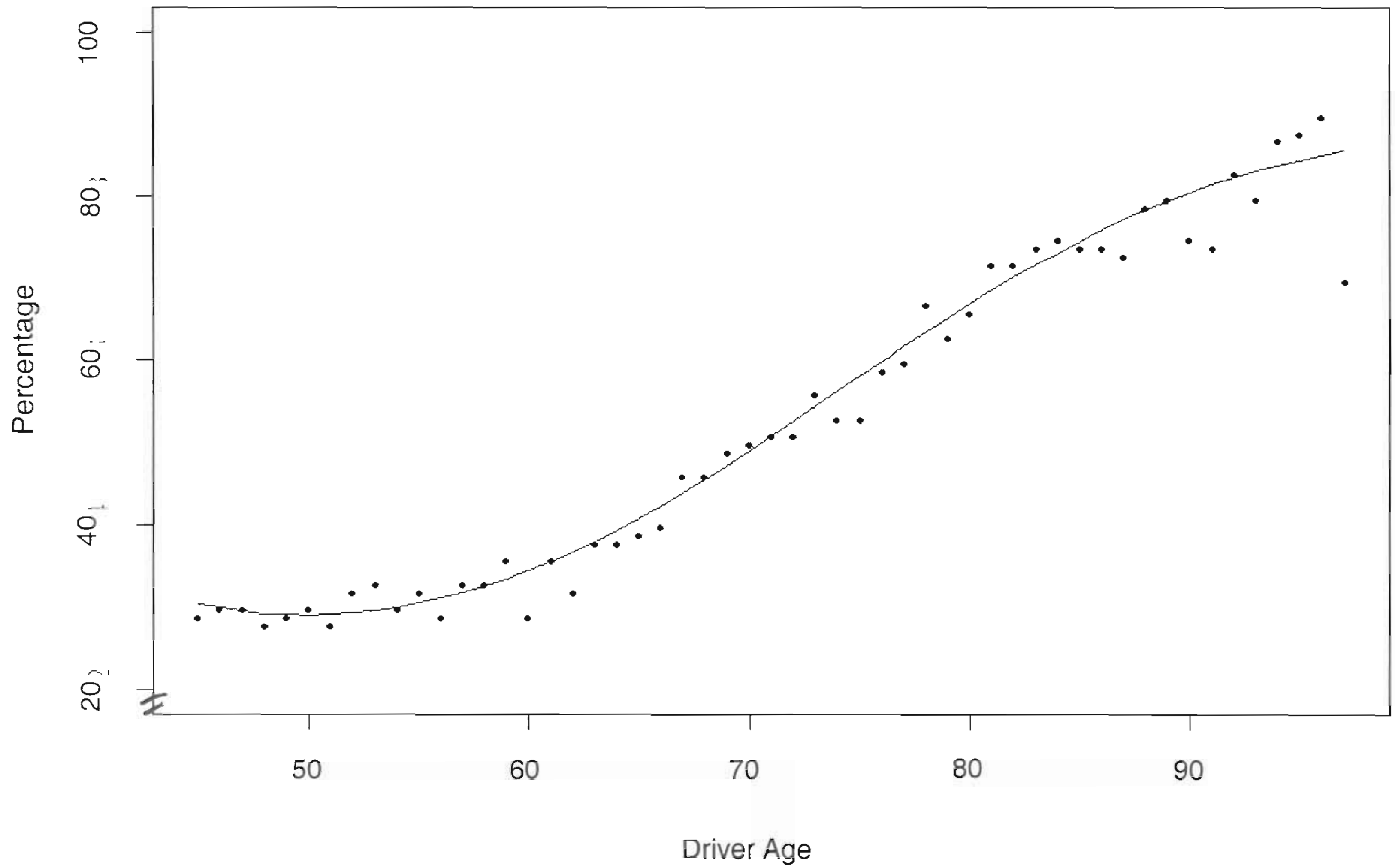

Figure 14. Percent **at-fault** in two-vehicle FARS crashes.

Table 19. Categories of Two-vehicle Crashes Accounting for a Major Proportion of Older Driver (65 and over) At-fault FARS Crashes.

Category	Percent of All Crashes	Percent of At-Fault Crashes	Percentage Point Increase 45-55 to 85+
Going Straight (angle)	34.0	33.7	+40
Left Turn	24.2	34.2	+23
Starting in Lane	4.7	7.2	+18
Negotiate Curve	5.2	3.4	+17
Going Straight - head-on	19.7	11.5	+16
Going Straight - rear end	3.3	2.5	+13

Logistic regression models were developed to again examine the role of certain other crash variables on the likelihood that a driver was at-fault in left-turn maneuver crashes and in going straight angle collisions. Paralleling the North Carolina analyses, the other crash variables included in the models were: region of impact, type of traffic control, type of roadway feature (e.g., intersection), location type (urban/rural) and driver gender. In the left-turn maneuver model, only driver age (1^{st} power), region of impact, and traffic control were significantly associated with being at-fault. Parameter estimates for the factors included in this model are shown in table 20. These results seem quite consistent with those of table 8. In particular, drivers were more likely to be at-fault in left-turn crashes involving frontal and right side impacts, and much more likely when the traffic control was a stop or yield sign versus a traffic signal. The estimated age effect in this model (only the first power of age was statistically significant) was .033. This corresponds to a 3.3 percent increase in the likelihood of being at-fault, given a left-turn crash with each increasing year of age

In the model for going straight angle collisions, significant variables included driver age, $(age)^2$, and driver gender, as well as region of impact and traffic control. As with left-turn crashes, neither roadway feature nor location type was statistically significant. Parameter estimates for the variables in this model are shown in table 21. Results for traffic control and

Table 20. Estimated Effects for Factors in FARS Left-turn Model

Factor	Level	Estimate	S.E.	Odds Ratio
Region of Impact	Front	1.62	0.20	5.05
	Right	1.90	0.20	6.69
	Left	1.12	0.20	3.06
	Rear	–	–	1.00
Traffic Control	No control	0.81	0.08	2.25
	Stop/Yield	1.54	0.11	4.66
	Other	0.25	0.14	1.28
	Stop & Go Signal	–	–	1.00

Table 21. Estimated Effects for Factors FARS Straight Ahead, Angle Collision Model.

Factor	Level	Estimate	S.E.	Odds Ratio
Region of Impact	Front	-0.64	0.16	0.53
	Right	0.63	0.16	1.89
	Left	0.66	0.16	1.83
	Rear	–	–	1.00
Traffic Control	No control	-0.34	0.07	0.71
	Stop/Yield	0.35	0.05	1.42
	Other	-0.02	0.10	0.98
	Stop & Go Signal	–	–	1.00
Gender	Female	0.30	0.04	1.35
	Male	–	–	1.00

gender are in agreement with the North Carolina results, which show drivers more likely to be at-fault when the traffic control is a stop or yield sign, and female drivers more likely to be at-fault than male drivers. Region of impact, however, shows drivers most likely to be at-fault in side-impact crashes, but less likely to be at-fault in frontal crashes than in rear-end crashes. This factor was not significant in the North Carolina data.

Fatalities

A fatality occurred in 66 percent of the case vehicles in the two-vehicle FARS crash file. By contrast, a fatality occurred in 39 percent of the other vehicles. Logistic regression models showed that the likelihood of a fatality in the case vehicle increased with increasing (case) driver age and was higher when the case driver was at-fault. In the other vehicle, the likelihood of a fatality decreased with increasing case driver age, and was lower when the case driver was at-fault. More specifically, the likelihood of a fatality in the case vehicle increased by about 5.5 percent with each increasing year of driver age and was nearly 3.5 times greater when the driver was at-fault. The likelihood of a fatality in the other vehicle decreased by about 5 percent with each increasing year of case driver age, and was only 30 percent as likely when the case driver was at-fault. These age effects seem reasonable given that these are fatal two-vehicle crashes and that the occupants of the case vehicle will, generally, be older than those of the other vehicle.

Characteristics of Driving Records Prior to Fatal Crash Involvement

The FARS data file contains information concerning driver histories for each driver for the three-year period prior to the fatal crash involvement. These were examined to look for evidence of deterioration of the older drivers' performance prior to the fatal crash. Table 22 lists some characteristics of prior crash involvements cross classified by drive age category and fault in the fatal crash. For drivers over age 55 -- regardless of fault in the fatal involvement, prior crash rates tended to increase with increasing age, but for only the oldest age group (85 and over) did these rates exceed those for drivers in the 45-55 year old age group.

Prior violations (convictions) were also examined. In general, rates of prior violations tended to **decrease** with increasing driver age. This was particularly true for prior speeding and DWI convictions.

Table 22. Crash Involvements in Three Years Prior to Fatal Crash.

Age Category	Prior Crash Involvements					
	At-Fault in Fatal			Not At-Fault in Fatal		
	Percent 1 or More	Percent 2 or More	Average Per Driver	Percent 1 or More	Percent 2 or More	Average Per Driver
45-54	14.57	2.80	.183	12.47	1.73	.145
55-64	12.82	2.06	.154	11.45	1.35	.131
65-74	13.39	2.16	.161	11.66	1.64	.137
75-84	14.34	2.20	.171	13.59	1.68	.156
86+Over	17.32	3.18	.208	15.35	2.26	.181

Analysis of GES Data

A third data file that was analyzed was based on the General Estimates System (GES) data for 1998. As before, an analysis file was developed which contained records for all drivers 45 years old or older who were involved in two-vehicle crashes. Vehicles were restricted to passenger cars, light trucks, vans, and utility vehicles. Each record contained information concerning the crash, the case driver (45 and over) and vehicle, and the other driver and vehicle. The file contained 13,059 unweighted records, which represented 1,937,308 weighted cases.

An **at-fault** (yes or no) variable was defined for each driver based on the GES variables, violation charged and critical event initiated by driver/vehicle, in a manner similar to those developed for the North Carolina data and the FARS data. The case driver was classified at-fault in 43 percent of the crashes and the other driver was at-fault in 47 percent.

A plot showing how the percentage of drivers at-fault in two-car crashes in the GES data varies with driver age is shown in figure 15. The smooth curve is from a logistic regression model with age and age^2 as explanatory variables. At the older age categories where the data were quite sparse, the data show considerable variability. In fact, most age categories above 90 contained fewer than 10 actual observations. Nonetheless, the same upward trend with increasing age can be seen in these data.

Table 23 shows two-vehicle crashes involving case drivers 65 years old and older cross-classified by driver/vehicle maneuver and at-fault. Left-turn maneuver crashes again stand out as a maneuver where older drivers are increasingly likely to be at-fault in two-car crashes. Right-turns represent far fewer crashes but still seem to be a maneuver where drivers have more problems as they age. On the other hand, more than 80% of drivers involved in two-vehicle crashes while changing lanes are classified as at-fault regardless of age.

Table 23. Maneuver Accounting for a Major Proportion of Older Drivers (65 and over) At-fault GES Crashes

Maneuver	Percent of All Crashes	Percent of At-fault Crashes	Percentage Point Increase 45-55 to 85+
Left turn	19.3	27.9	+21
Right turn	4.5	4.8	+20
Going straight	46.2	37.7	+18
Changing lanes	3.9	5.9	-1

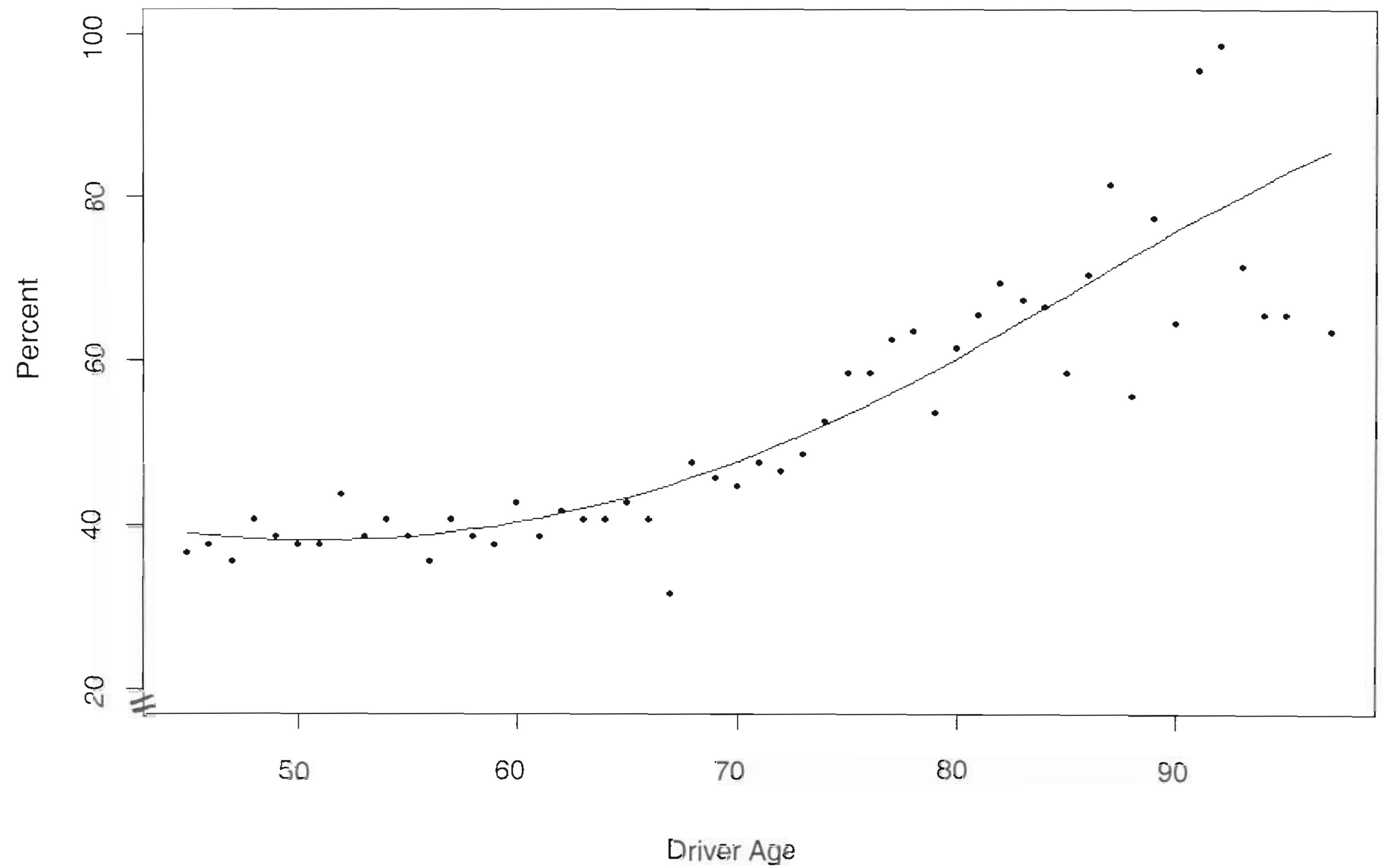

Figure 15. Percent **at-fault** in two-vehicle GES crashes

Most two-vehicle crashes involving a driver going straight were either rear-end crashes or angle collisions, and more than 75 percent of the angle collisions occurred at intersections. Table 24 shows a further breakdown of going straight, angle collisions at intersections by type of traffic control. These results again show that angle collisions involving older drivers going straight at stop- or yield-controlled intersections represent situations where older drivers are increasingly likely to be at-fault.

Table 24. Older Driver Angle Collisions at Intersections

Traffic Control	Percent of All Crashes	Percent of At-Fault Crashes	Percentage Point Increase 45-54 to 85+
Stop/yield sign	11.2	9.0	+37
Stop and go signal	8.3	5.3	+25
No control	2.4	1.6	+18

Given the nature of GES data (i.e., relatively few observations in certain categories, some heavily weighted), no detailed logistic regression models were developed. Instead, the data were used to examine national estimates of all older driver at-fault two-vehicle crashes (table 25); numbers of injured occupants in other vehicles in these older driver at-fault crashes (table 26); older driver left-turn maneuver at-fault crashes (table 27); and numbers of injured occupants in other vehicles resulting from these older driver at-fault crashes (table 28). In making these estimates, both case drivers and other drivers over 65 years of age were included.

Table 25. National Estimates of Two-car Crashes Where Driver 65 Years Old or Older is At-fault

Driver Age	**At-Fault Crashes**	**95% confidence limits**
65 - 74	152,332	(124,750 , 179,914)
75 - 84	129,723	(105,419 , 154,027)
85 & Over	28,322	(18,459 , 38,185)
65 & Over	310,377	(260,718 , 359,976)

Table 26. National Estimates of Injured Occupants in Other Vehicle in Older Driver At-fault Two-car Crashes

Driver Age	Injured Occupants	95% confidence limits
65 - 74	47,794	(35,596 , 59,992)
75 - 84	47,689	(35,507 , 59,871)
85 & Over	7,366	(4,578 , 10,274)
65 & Over	102,849	(83,866 , 121,832)

Table 27. National Estimates of Two-car Crashes Where Driver 65 Years Old or Older is At-fault While Attempting a Left-turn Maneuver

Driver Age	At-Fault Crashes	95% confidence limits
65 - 74	39,570	(29,462 , 49,678)
75 - 84	37,610	(27,896 , 47,334)
85 & Over	9,369	(5,426 , 13,312)
65 & Over	86,549	(68,665 , 104,431)

Table 28. National Estimates of Injured Occupants in Other Vehicle Involved in Two-car Crashes Where Older Diver is At-fault while Making Left-turn Maneuver

Driver Age	Injured Occupants	95% confidence limits
65 - 74	13,338	(9,090, 17,586)
75 - 84	13,325	(9,080, 17,570)
85 & Over	2,577	(1,056, 4,098)
65 & Over	29,240	(20,162, 38,318)

Summary

Relationships between driver age and the likelihood that the older driver is the at-fault driver in a two-vehicle crash were quite consistent across all three data files examined. Plots showing this overall relationship in each of the files were presented in figures 3, 14, and 15. These results are again illustrated in figure 16, which shows the percent of drivers at-fault for five driver age categories for all three data files. Left-turn maneuver crashes were consistently identified as representing a situation where the older driver was increasingly likely to be at-fault. To a lesser extent, older drivers also tended to be more likely at-fault in right-turn maneuver crashes. Since right-turn crashes were, generally, less severe, this crash type was not one which was identified based on FARS data. Crashes where older drivers were going straight ahead and were involved in an angle collision represented another situation where the older driver was increasingly likely to be at-fault. This was especially true at stop-controlled intersections.

An Approach to Making Projections of Crashes and Injuries Caused by Older Drivers

Both the North Carolina analysis and the GES analysis could serve as a basis for making projections or forecasts of expected crashes and injuries **caused** by the older driver population at some future time. For example, estimates of expected at-fault crashes per driver were obtained from the North Carolina data for certain categories of driver age, gender, and county population. Under the assumption that average annual mileage exposure remained the same as in 1995, these rates per driver could be applied to any projected numbers of drivers within the corresponding age by gender by population categories to yield projections of at-fault crashes. Projections of changes in average annual mileage for older drivers could also be incorporated into the forecasts and might lead to a range of projections. Thus, a 10 percent increase in annual mileage might be expected to produce an increase in the expected at-fault crash rate per driver by an amount somewhere between 7 percent and 12 percent, so a range of crash rates could be used to produce a range of forecasts.

The GES sample design is such that the data can be used directly to produce historical national estimates of older driver at-fault crashes and the resulting injuries. Again, if driving exposure was to remain constant, changes in the older driver population would be expected to produce proportional changes in crashes. Projected changes in exposure, likewise, could be factored in as described above.

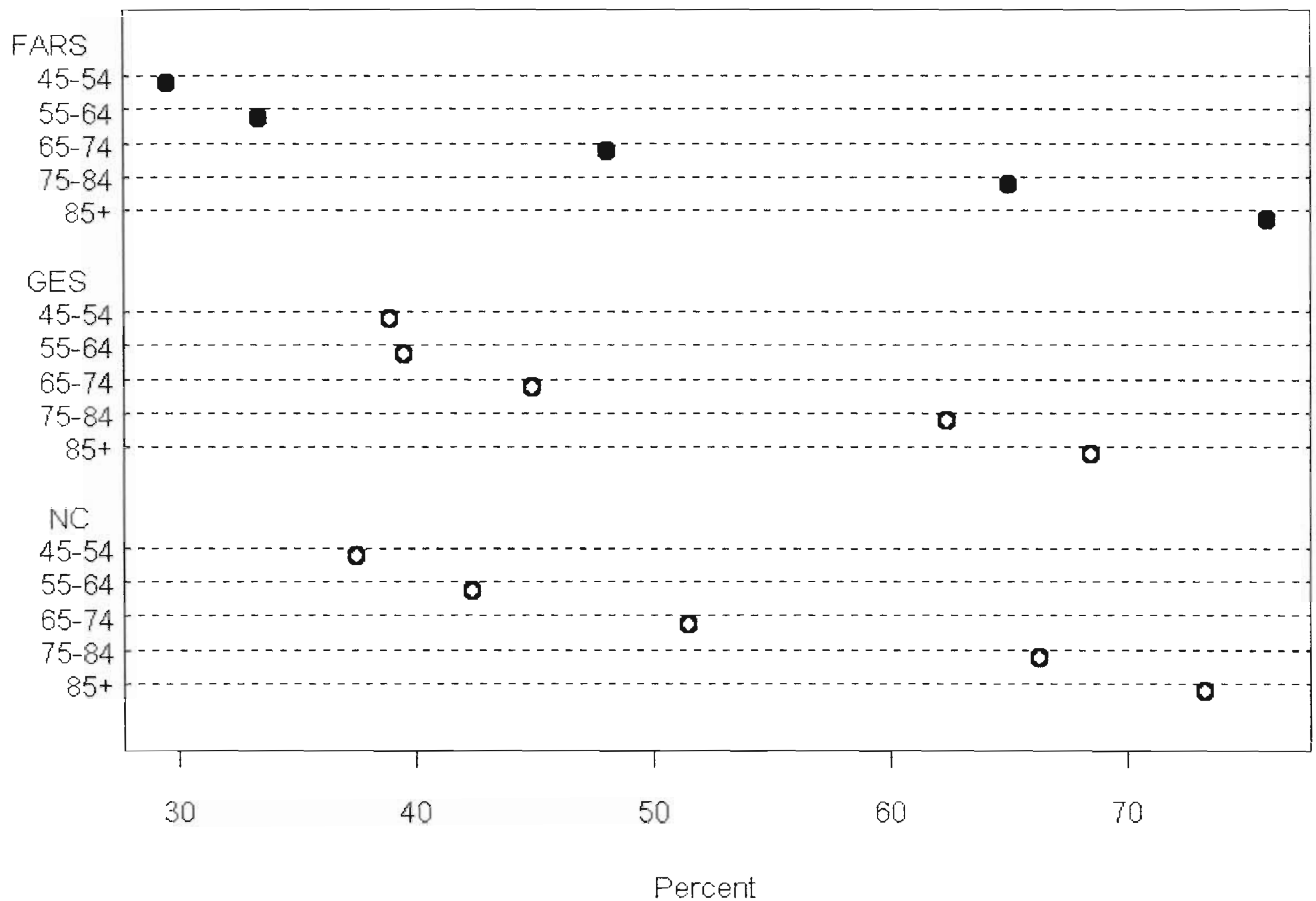

Figure 16. Percent of drivers **at-fault** by age category by data file.

REFERENCES

FHWA. Analysis of older drivers on freeways. Washington, DC: Federal Highway Administration (Report No. FHWA-RD-96-035); 1996.

Harkey, DC; Huang, H; Zegeer, CV. Accident analysis of older drivers on freeways. Chapel Hill, NC: Highway Safety Research Center; 1995.

NHTSA. Traffic Tech. Technology Transfer Series. Washington, DC: National Highway Traffic Safety Administration, No. 205; July 1999.

McGuin, G. Characteristics of traffic crashes among young, middle-aged, and older drivers. Accident Analysis & Prevention. 3, (3): 181-198; 1999.

Sims, RV; Owsley, C; Allman, RM; Ball, K; Smoot, TM. A preliminary assessment of the medical and functional factors associated with vehicle crashes by older adults. Journal of the American Geriatrics Society. 46(5); 556-561; 1998.

Staplin, L; Gish, KW; Decina, LE; Lococo, KH; McKnight, AS. Intersection negotiation problems of older drivers. Washington, DC: National Highway Traffic Safety Administration (Report No. DTNH22-93-C-05237); 1998.

Stutts, JC; Martell, C. Older driver population and crash involvement trends, 1974-1988. Accident Analysis & Prevention. 24(4): 317-327; 1992.

Stutts, JC (a). Do drivers with visual and cognitive impairments drive less? Journal of the American Geriatrics Society. 46(7): 854-861; 1998.

Stutts, JC (b) Cognitive test performance and crash risk in an older driver population. Accident Analysis & Prevention. 30(3): 337-346; 1998.

UMTRI. The safety and mobility of older drivers: What we know and promising research issues. UMTRI Research Review. 26(1): 1-21; 1995.

Viano, DC. Significance of intersection crashes for older drivers. Warrendale, PA: Society of Automotive Engineers (SAE Technical Paper 96045); 1996.