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A STUDY OF THE RELATIONSHIP BETWEEN LEFT TURN ACCIDENTS AND DRIVER AGE IN ARIZONA

Special Report

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16. Abstract

The findings of this research investigation supports the hypothesis that the elderly driver group is disproportionally represented in left turn accidents. Drivers over 70 averaged more left turn accidents per mile than drivers between the ages of 20 to 69. In addition, left turn accidents represent a much larger proportion of total accidents for drivers over 65 than for any other group.

A reduction of permissive left turns could aid older drivers. The permissive type of left turn requires the driver to monitor the traffic light and on-coming opposing traffic for a suitable gap. The resulting lengthened information gathering and decision process of older drivers can lead to the increase in left turn accidents.

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INTRODUCTION

Special Report 218, Transportation in an Aging Society, by the Transportation Research Board (TRB) addresses a problem posed by the changing character of the driving population (1). The current design and operational standards used are based on data collected when the driving population consisted primarily of younger persons; there were very few elderly drivers at that time.

The number of individuals statewide at or above the age 65 quadrupled from 1960 to 1985, while the entire state population merely doubled. The 65+ population will be 7.5 times larger 25 years from now than in 1985, or 9.7 times greater than in 1960, while total population state wide will increase 2.1 and 5 times, respectively. The rate of growth for retirement age individuals, then, is about twice the rate of growth for the entire population. It is possible that the driving characteristics of older drivers may require changes in traffic control and operations in order to assure a safe and efficient system is in place.

There is every indication that these older individuals will continue to drive, although annual miles driven may decrease for those aged 60 and above (2). Nationally, the average age for licensed drivers has been shifting upwards, and more older drivers are continuing to hold licenses. Arizona appears to be no exception. Statistics show that Arizona ranks third nationally in the percent of individuals of driving age who hold licenses (3).

Profile of the Older Driver

Very little has been published that relates advancing age to specific types of accidents or remedial measures that might reduce age-related accidents. The factors of aging that are thought to affect the driving task, on the other hand, have been thoroughly studied. Vision and hearing decline with age (4), although research linking age-related decline in specific visual and auditory functions to driving ability is scarce.

Aging also affects cognitive functions involved in driving. Yank (1986) states:

> The cognitive or decision-making process involved in the driving task can be characterized as a continuing series of events in which a driver perceives the changing traffic conditions around him, develops responses to them, selects the most appropriate responses to them, selects the most appropriate responses, and acts.
>
> The literature is fairly consistent in indicating that older people need more information than younger people in order to make a decision, more time to select an appropriate response, and more time in which to respond...research has been converging upon the theory that the slower reaction times of older adults results...from a decline in the central function of the brain...(p. 752).

In addition, physical factors such as rheumatism and arthritis which are more prevalent in older people may make the driving task more demanding. Specifically, these disabilities may contribute to a tendency to swing wide before or during turning. The older driver may also have more difficulty reacting to sudden changes in traffic situations (5).

There is every indication, then, that physical and cognitive changes may make the driving task more difficult for older drivers t and may in fact increase the probability of accidents. Left turn maneuvers require the acquisition and processing of diverse traffic and traffic control information, traffic unit position and speed as well as vehicle paths of travel. For this reason, it is hypothesized that specific actions such as left turns may show the greatest impact of the aging process on driving ability. Decrements in driver attention and motor performance may lead to involvement in a greater proportion of left-turn accidents by elderly drivers than would be expected in the general population.

This study was conducted to determine if there is a significant relationship between left-turn type accidents and age of the driver and to identify specific intersection characteristics which may contribute to the disproportionate representation of older drivers in left-turn accidents.

DATA COLLECTION PROCEDURE

Two different types of data were collected: accident information and intersection information.

Accident Data

Accident summary statistics were obtained for the years 1984-88 from the Arizona Department of Transportation's DART (Data Analysis and Retrieval Technique) program. Statistics for left turn accidents at intersections were isolated for detailed study. In addition, a report of the number of valid drivers by age was obtained from the Motor Vehicle Division.

The data provided the age of the drivers involved, as well as the type of accident. The basic data are from the "Arizona Accident Report" forms prepared by police officers who investigate reported accidents. The authors acknowledge that accident data is not always accurate nor correct.

Errors can arise anywhere in the process from the officer filling out a form at the scene of an accident to the data entry in the computer system. But this method remains the best way to analyze accident characteristics because of its comprehensives.

The study examines age of drivers involved in the accident, and injury severity and a number of other characteristics only available in the computer database records.

Intersection Data

The original intention of the authors was to send data collection sheets on each intersection to the various jurisdictions around the State of Arizona. It was presumed that the local traffic engineers would be best qualified to supply the data. However, after attempting to see how much time and effort would be required to collect the data at one city, it was realized that jurisdictions would be unable to provide the time and manpower needed to collect the data while still performing normal tasks required of them.

Additionally, having over twenty different people fill out the data collection sheets caused some concern about consistency. Therefor, three graduate research assistants were employed to collect the data. This ensured that the data would be collected and the sheets filled out in a uniform, similar manner. It also would limit the amount of time jurisdictions would have to spend helping with the study.

Some of the small jurisdictions outside the Phoenix metropolitan area said they would be able to provide the data. IT was important that intersections from a variety of communities be included in the study. The data collection sheets were mailed to them. All jurisdictions contacted were helpful and cooperative.

Each of the larger jurisdictions was contacted and told of the scope and purpose of the study. Most were able to provide the research assistants with the he necessary maps and files to collect the data. Data were obtained from most of the major metropolitan areas around Arizona including Phoenix, Tucson, Flagstaff, and Yuma. Approximately 600 intersections statewide were included in the study.

The intersection data were broken down into three categories: general information, geometric information, and signal information.

General Information

street orientation

speed limits

type of area

street classification

traffic volumes (ADT)

type of control (signal, stop)

Geometric Information

number of lines

lane types (left only, right only, thru)

median (yes/no)

Signal Information

type of phasing (permitted left/permissive left)

clearance intervals (yellow, all-red)

General Information

The type of area (CBD, industrial/commercial, residential, rural) was determined from aerial photographs. Speed limits were obtained either from prepared maps or from a written record of the city's speed limits. The street classification (arterial, collector, local) was also determined from either the photographs or written record.

Geometric Data

The data items collected were the number and type of lanes on each approach and whether there was a median or not. Length and width of lanes were considered to be too difficult to accurately collect for all intersections, only in cased where a lane was much wider or narrower than the standard width was it noted.

Geometric data were collected primarily by aerial photographs. A few of the cities did not have aerial photographs at a scale small enough to be readable. The number of intersections in those cities was small, therefore, the data collected by an on-site inspection of each intersection.

Signal Information

Signal data were usually obtained from the jurisdiction's traffic engineer. Many of the cities have their signal timing information in a computer database. Only the yellow and all-red clearance intervals were collected since these, for the most part, remain constant. Other variables (such as cycle length and green time) vary throughout the day. Collecting this information would not have had much meaning in the scope of the study since the time of day that accidents occurred was not being examined.

After all the intersection data were collected, the data were entered into a computer database for analysis. The intersection data were linked to the accident data and run through a statistical package to determine any correlation's between the two.

DATA ANALYSIS

Accident statistics were aggregated by age of driver in five year increments. Drivers less than 16 years of age were excluded from analysis. This group was small and do not have licenses.

The number of left-turn accidents by age group for the four-year study period is presented in Figure 1. There appears to be a general "practice effect" due to age; in other words, the number of left-turn accidents appears to decrease with age of the driver. A slight increase was found for drivers at or above the age of 70.

It was felt that these differences could be reflective of the number of drivers in each age group; specifically, the increase in number of accidents at or above age 70 could be due to a larger number of drivers in that group. For this reason, the number of valid licensed drivers (not suspended, canceled, revoked or deceased) in that group. The results for 1988 are shown in Figure 2. Form this graph, it is apparent that elderly drivers are not involved in a greater number of left-turn accidents per capita. The only prominent defect is a decreased tendency to be involved in a left-turn accident with increasing years of driving experience.

These results may be misleading, however. Although no statistics are available for miles driven by age in Arizona, the national statistics clearly demonstrate that miles driven decrease with advancing age. For reference, annual miles driven by age are presented in Table 1.

Number of left-turn accidents for each age group was thus adjusted for miles driven (Figure 3). These results present quite a different picture. When the relative exposure of each age group is taken into account, the familiar "practice effect" emerges, with drivers averaging fewer accidents per miles driven with increasing age. this pattern, however, only holds true until approximately middle age. After the age of 55 there does seem to be an increase in accident rates for older drivers. this increase is especially prominent for drivers over age 70.

Is this increase simply an indication that advancing age leads to an increased probability of accident involvement of all types, or is there, as hypothesized, an increased likelihood that the older driver will be involved in a left turn accident? To answer this question, the number of accidents involving a left turning movement were divided by the total number of accidents for each age group. The results, expressed in percentage form, are presented in Figure 4.

It is immediately apparent that, of all accidents, older drivers are involved in more left turn accidents than younger drivers. This finding is especially prominent for driver 65 and over. Thus, there a[[ears to be some support for the contention that the probability of involvement in a left turn accident increases with age.

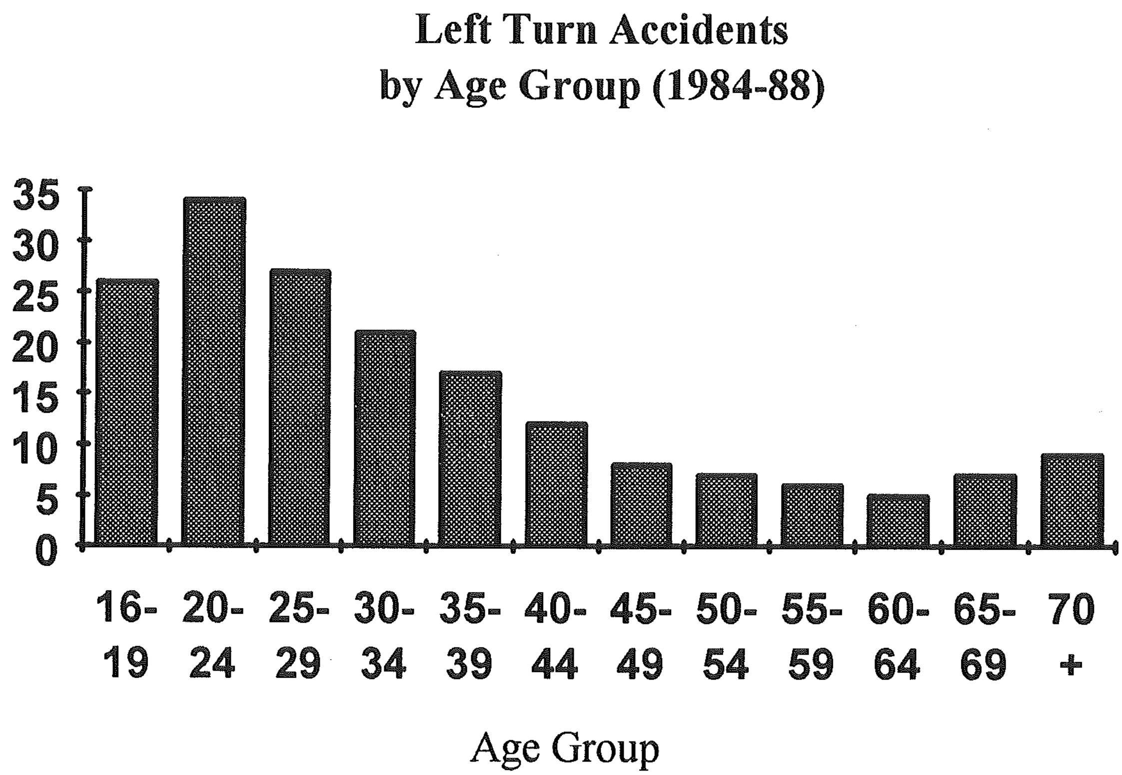


Figure 1

Left Turn Accidents - 1988
per 1000 Licensed Drivers

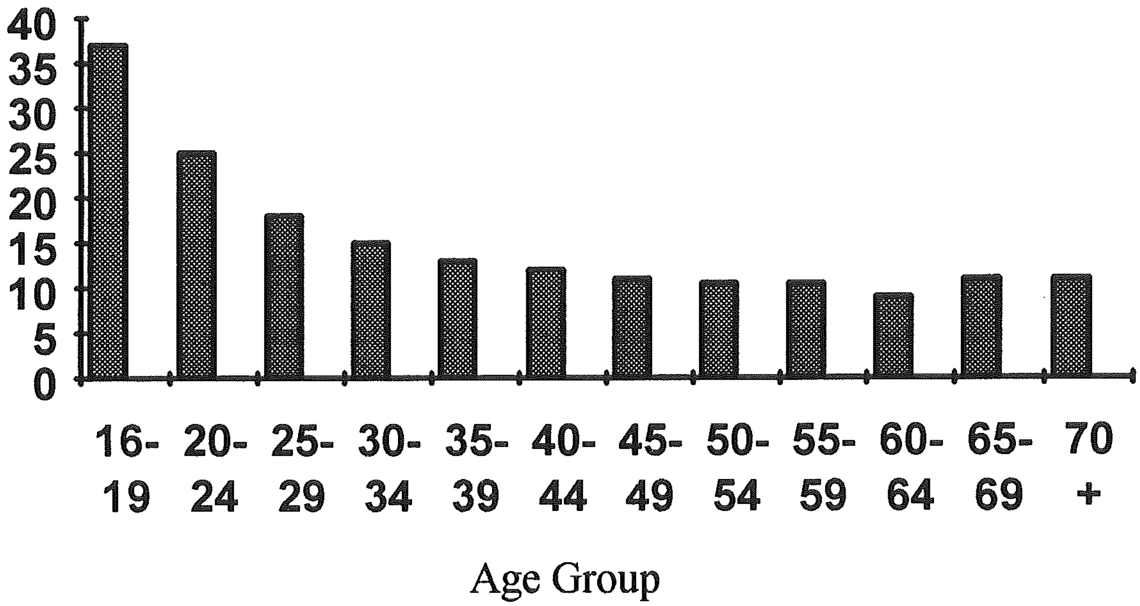


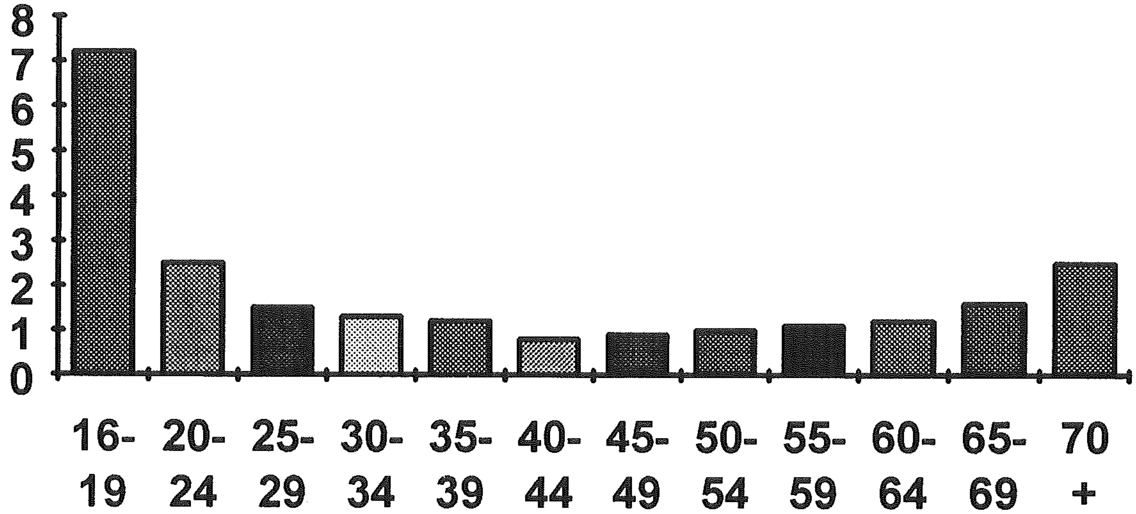
Figure 2

Table 1. Average annual miles driven by age group

Age Group	Annual Miles Driven
16-19	4,985
20-24	10,339
25-29	11,810
30-34	12,126
35-39	12,662
40-44	13,015
45-49	11,805
50-54	10,936
55-59	9,443
60-64	8,568
65-69	6,804
70+	4,348

Source: *Personal Travel in the U.S., Volume II: Nationwide Personal Transportation Study.* U.S. Department of Transportation, November, 1986.

Accidents per 100 Million Miles
(Vehicle miles in 1988)



Age Group
Figure 3

Unfortunately, from these data it is not possible to ascertain which driver was making the left turn when the accident occurred. Perhaps it is the case that older driver were not responsible for the accident occurrences. In order to address this issue, the percent of drivers determined to be at fault was calculated for each group. The results are presented in Figure 5.

As expected, drivers under the age of 20 were found to be at fault more often than any other driver age group under 65. There is an indication, however, that older drivers are generally cited more often with the increasing age. It was discovered, for example, that 62.9 percent of drivers over the age of 70 were cited by the investigating officer at the scene of the accident. Drivers over the age of 70, in fact, received a citation for improper turning almost twice as often as all other drivers combined (5.2% vs. 2.7%).

All data analysis was done using SPSS/PC+ (a statistical software package) in conjunction with dBase III+ (a database software). Both programs were used on an IBM personal computer.

SPSS/PC+ was used due to its availability at the university and its ease of use. Additionally, in the first phase of the research the accident data had been entered into dBase III+ files. SPSS/PC+ is able to directly read data files in the dBase format.

Statistical analysis was done primarily by making correlation's between age groups and various data elements. Statistical significance was based upon an alpha-value of 5%. All references to "significance" are based on this value.

Overall, 19.1% of the accidents for this period involved at least one driver at or over the age of 65. The turning driver was at or over 65 years of age in 14.9% of all accidents.

Intersection Control

Of all the traffic variables studied, the variable with the most impact on the older driver was the type of intersection control. A chi square analysis of age of oldest driver by type of intersection control was significant ($X^2 = 8.04$, $p < .005$). Of the left accidents in which at least one driver was at or over 65, 85.6% occurred at signalized intersections, compared to 83.6% of accidents in which both drivers were under 65. (See Figure 6).

A chi square analysis of age of the turning driver by type of intersection control was also significant ($X^2 = 23.82$, $p = 65$); 82.3% occurred at signalized intersections, compared with 78.3% of accidents in which the turning driver was under 65. (See Figure 7). These two results may or may nor be obvious. Unsignalized intersections are usually thought of as being less safe than signalized. However, in the case of the older driver, the addition of a traffic signal adds another level of information for the driver to process. With the presence of a traffic signal, the driver must pay attention to both the light as well as oncoming traffic.

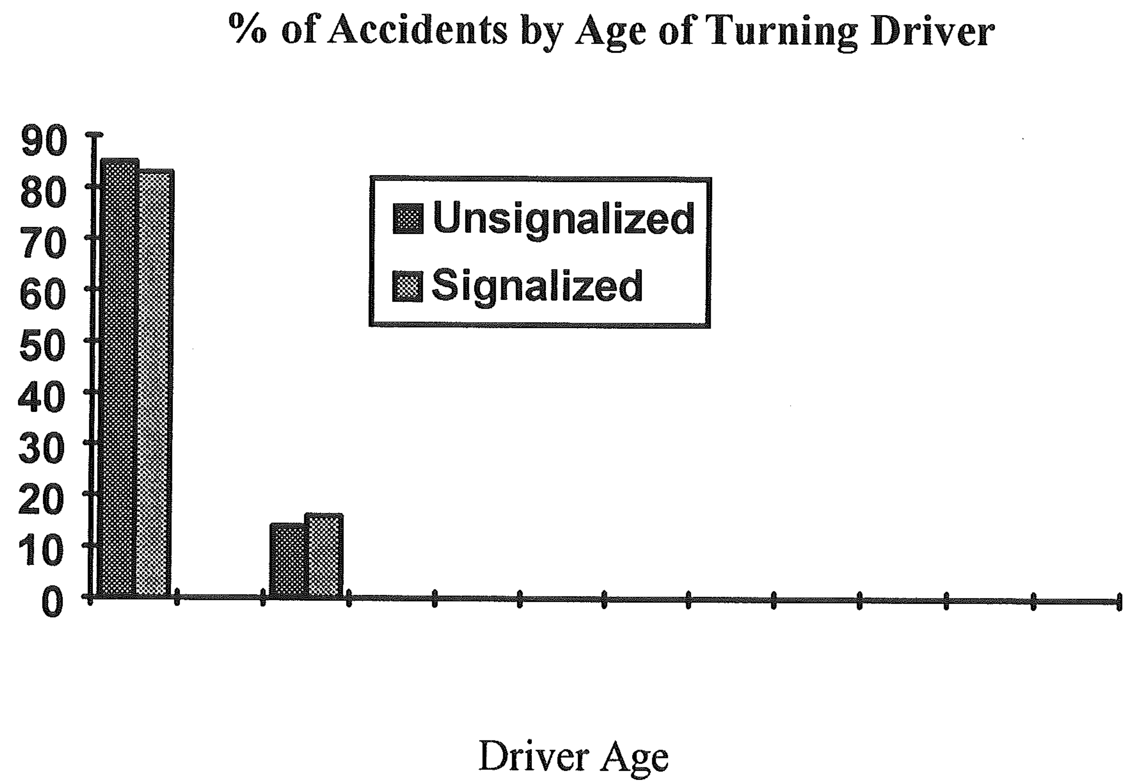


Figure 4

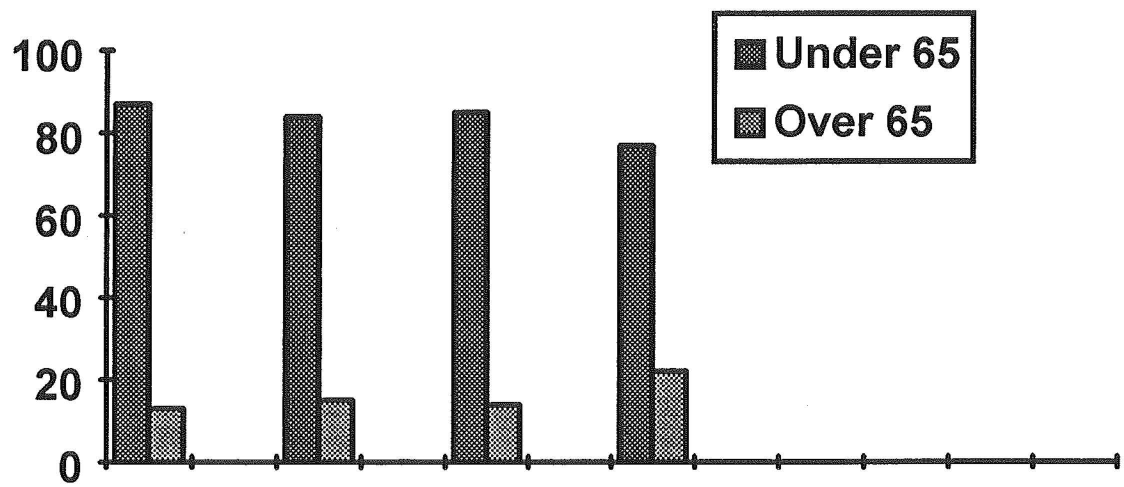
It may also be conceivable that the green light gives the older driver a false sense of right-of-way. That is, the green light communicates the idea that the driver has the right-of-way regardless of the fact that oncoming traffic has a green light as well. What does this mean when the question of what to do about it is asked? It is ridiculous to suggest removing traffic signals where older drivers are experiencing a lot of left-turn accidents. What it does suggest is that engineers must concentrate their efforts at improving signalized intersections.

There are a number of issues that can be examined on future research. This may include the number and size of signal heads used, longer clearance intervals, including use of the all-red feature, the positioning of those signal heads and how many overhead signals are used.

Number of Lanes

A chi square analysis of the number of opposing lanes by age of the turning driver was significant ($X^2 = 11.75$, $p = .02$). Generally, it appears that as the number of lanes increases, there is an increased percentage of accidents in which the turning driver is at or over age 65. (See Figure 8). This would seem intuitively obvious. As the number of lanes increases, the older driver has to watch for gaps in each of several lanes. This again is related to the issue of amount of information that must be processed in a relatively short time which can cause problems for come older drivers.

% of Accidents by Age of Turning Driver and # of Opposing Lanes



Number of Opposing Lanes

Figure 5

As with intersection control, accident rates do not govern how many lanes a road should have. Since that is determined by capacity analysis and travel demand (among other things), engineers must determine ways help the older driver to navigate through larger intersections.

One treatment that may help is the use of painted "carets" to give the left turning driver a better view of oncoming traffic. Another possible solution is to examine what type of phasing is being used. Safety benefits of different type of left-turn phasing is covered in the next section.

There is an indication that the type of intersection may also be a factor. A chi square analysis revealed that older drivers were more likely than driver under 65 to be involved in accident in a four-leg intersection ($X^2 = 8.04$, $p < .005$). The chi square analysis for age of turning driver by type of intersection, however, was not significant.

Left-turn Phasing

Type of control was deemed to be the most important traffic variable. Due to the fact that the overwhelming majority of accidents occurred at signalized intersections, further analysis concentrated on signalized intersections.

A chi square analysis of left turn phasing be age of turning driver for signalized intersections only was significant (X2 = 13.99, p .0009). An examination of the means reveals that older drivers fare better at protected or permissive/protected intersections. Figure 9 shows that accidents at protected intersection account for about the same percentage of the total left-turn accidents (6.0% for drivers under 65, 5.6% for driver 65 and older). However, there is a pronounced difference in percentage of accidents at permissive and protected/permissive controlled intersections.

For older drivers, permissive phasing accounts for 53.2% of all left turn accidents where the older driver is turning. Only 41/3% of the accidents are at permissive/protected intersections.

It certainly is not surprising that type of left-turn phasing has an impact on older driver left turn accidents. Traffic engineers presently use two primary factors in determining where to use permissive/protected or protected left-turn arrows: traffic volumes and sight distances. If a left-turn arrow is not warranted under either of those conditions, most likely an arrow will not be installed. Left-turn phasing often makes progression more difficult. It can also increase intersection delay if left-turning volumes are not very heavy.

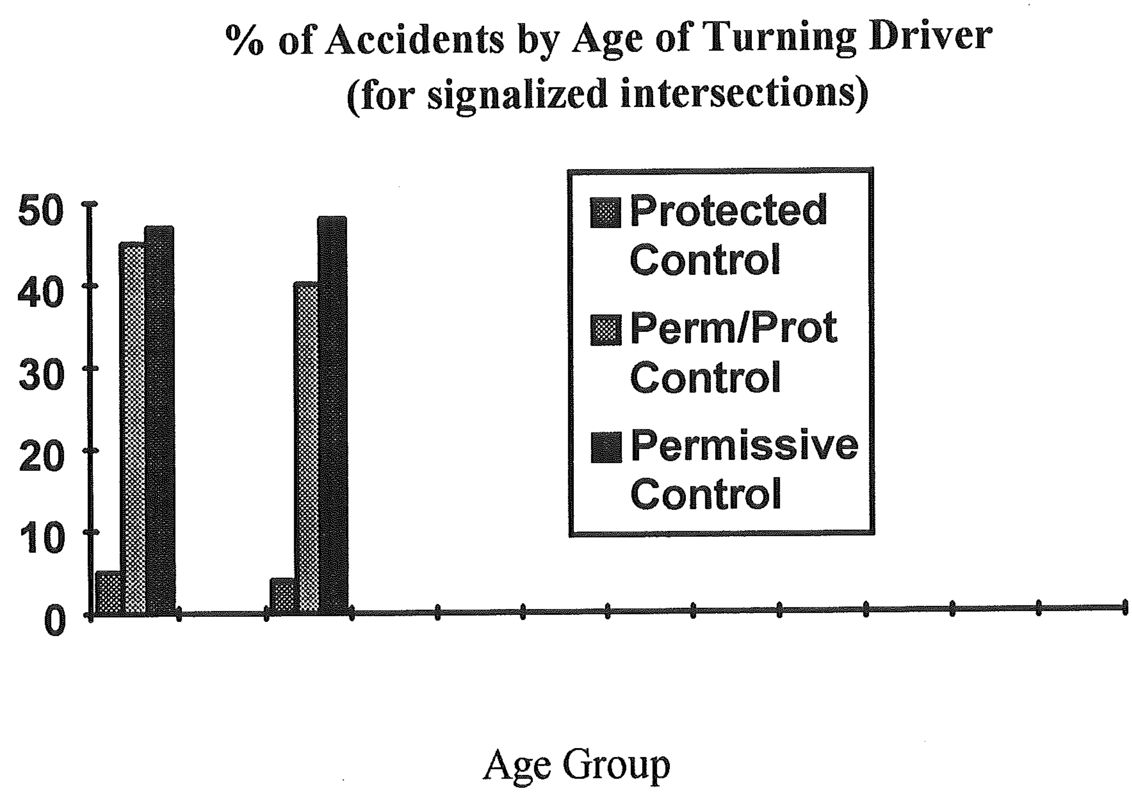


Figure 6

However, this research paper indicates that older drivers have fewer left-turn accidents when some type of left-turn phasing is used.

The authors think that the need for a warrant aimed at reducing older driver accidents is justified. This warrant could be cased on demographics, surrounding land use, or perhaps older driver accident rates. the result could, in effect, lower the left-turn volumes needed to warrant the addition of a left-turn phase. For example, if a jurisdiction institutes a permissive/protection phase at intersections where less than 100 veh/hr turn left, and if that intersection is in an area where there is a high-concentration of older residents, perhaps only 50 veh/hr would warrant a left-turn phase. Or if that intersection is adjacent to a land use that generates a higher percentage of older driver (a senior citizen center, clinic, or church), lowering the needed volume of left turning traffic to satisfy the warrant may be necessary.

Regression Analysis

A stepwise multiple regression analysis was conducted for signalized intersections only. Variables targeted for input into the regression equation were: number of opposing lanes, intersection type, left-turn phasing, presence's/absence of medians, number of left-turn lanes, and age of the turning driver.

The analysis revealed that left-turn phasing was the most important factor relative to turning driver age. ($T = -3.372$, $p = .0007$). In addition, the number of opposing lanes was also found to account for a significant portion of the variance in turning driver age. ($T = -3.937$, $p = .0001$). None of the other traffic variables accounted for a significant portion of the variables.

Overall, the results indicate that any factor which increases the amount of information to be processed at an intersection increases the likelihood of an accident for an older driver. This is especially the case when the older driver is contemplating making a left-turn at the intersection.

CONCLUSIONS

The findings of this research investigation support the hypothesis that the elderly driver group is disproportionately represented in left-turn accidents. Drivers over 70 averaged more left-turn accidents per mile than drivers between the ages of 20 to 69. In addition, left-turn accidents represent a much larger proportion of total accidents for drivers over 65 than for any other age group.

This is consistent with other documented findings on the aging process. It is generally assumed that executing a left turn requires increased driver attention and motor performance over many other operations so that a large amount of information needs to be processed in a short period of time. The difficulty of this task should be affected be age of the driver, as it has been demonstrated that nonverbal information processing time and reaction time both increase with age (6,7).

Caution should be taken in interpreting specific aspects of these results, however, for two reasons. First, the estimates of annual miles driven by age group are based on a national survey, and thus may not be representative of Arizona driver behavior. Although it is suspected that drivers in Western and Southwestern states average more miles per year than the nationwide estimate, there are no data to support this contention. Second, although there is fault in left turn accidents, this could merely reflect a bias on the part of law enforcement officers--the older driver's confusion could be interpreted as culpability.

A reduction of permissive left turns could aid older drivers. The permissive type of left turn requires the driver to monitor the traffic and on-coming opposing traffic for a suitable gap. The resulting lengthened information gathering and decision process of older drivers can lead to the increase in left turn accidents. This procedure might be considered where capacity and delay problems can be satisfied. The use of protected left turn phasing could be used with longer clearance intervals with longer all-red or blank amber intervals to allow older drivers more time to clear the intersection.

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APPENDIX A
Summary Statistics

Frequency of Left Turn Accidents by Driver Age Group by Year

Age	1984	1985	1986	1987	1988	Total
Unknown	1342	1452	2228	1663	1572	8257
Under 16	106	103	90	128	107	534
16 - 20	6708	6842	7050	6758	6508	33866
21 - 25	6594	7011	7227	6669	6040	33541
26 - 30	4808	5279	5637	5597	5218	26539
31 - 35	3555	3935	4208	4236	4210	20144
36 - 40	2729	3025	3379	3423	3310	15866
41 - 45	1930	2134	2295	2400	2438	11197
46 - 50	1539	1493	1765	1708	1732	8237
51 - 55	1409	1403	1507	1480	1460	7259
56 - 60	1294	1306	1389	1366	1373	6728
61 - 65	1216	1275	1346	1350	1277	6464
66 - 70	1116	1114	1299	1259	1206	5994
71 - 75	823	904	988	997	1018	4730
76 - 80	622	628	704	784	735	3473
81 - 85	297	315	352	377	384	1725
86 - 90	78	92	95	97	106	468
91 - 95	12	12	15	22	18	79
96 - 100	6	8	6	10	12	42

OLDER DRIVER STUDY INTERSECTION DATA

Jurisdiction:________________________________

Location:____

_____Urban _____Rural

_____Commercial _____Residential

Lane Direction	# Thru Lanes	# Right Turn	# Left Turn (If more than 1)
___________	___________		
___________	___________		

Traffic Control: ____Signal ____Stop ____Yield ____None

If Signal: ____Actuated ____Fixed Time

____Protected Left ____Permitted Left

Clearance interval:_____secs. Cycle Length:_____secs.

Signal Phasing Information____

Traffic Volumes:

		Left	Thru	Right
	NB	____	____	____
(if only total is	SB	____	____	____
available, mark in	EB	____	____	____
"Thru" column)	WB	____	____	____

Advance Warning Sign:___Yes ___No ___N ___S ___E ___W

Distance from intersection:_____ft.

Posted Speed Limit:_______

Road Striping: ___Yes ___No Marked Crosswalk: ___Yes ___No

Advance Crosswalk Warning: ___Yes ___No Distance:_______ft.

Lane Width (feet):_____NB _____SB _____EB ______WB

Median: ____Built up _____Painted _____None

Median Width:_______ft.

Turn Lane Length: _______Left _______Right

Angle of Intersection if not 90: ________

Sight Obstructions: ____

Approach/Departure Grades: ____

On-Street Parking (within 200’): ____Yes ____No

Lighting at Intersection: ____Yes ____No

Surface Type:____

Frontage roads near intersection? ____Yes ____No