Safety Analysis for Older Drivers at Signalized Intersections

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Abstract: The proportions of older drivers continue to increase since baby boom generation is becoming old. The level of mobility of older drivers is also increasing. Older drivers begin to noticeably be over-involved in fatal crashes. Intersections appear to be hazardous to older drivers, particularly left turn due to one or more of: sensory, perceptual, cognitive, physical and general driving knowledge deficiencies. The safety concern of older drivers is also becoming significant. Ten years of crash data has been extracted from Kansas accident report system. It has been analyzed using SAS (statistical analysis system) software. Five different age groups have been considered. Comparison has been made between different age groups of the same gender, and the same age group for different gender. Effects of light condition, weather condition, surface type, surface condition, road character and construction/maintenance zone on older drivers' safety have also been considered in this study. It has been found out that proportion of older drivers in through movement involved in accident decreases as age increases whereas the proportion of left turn accidents increases with age, left turn is harder for females in all age groups, and proportion of right turn accidents has no specific trend. Most of the accidents have taken place during daylight when there are no adverse weather conditions on dry surface, straight and level road, and blacktop surface type.

Key words: Traffic safety, older drivers, intersections.

1. Introduction

The proportions of older drivers continue to increase since baby boom generation is becoming old [1, 2]. The level of mobility of older drivers is also increasing [3]. Older drivers are the fastest growing segment of the driving population [4]. In 2000, the elderly accounted for 12.4% of the U.S. population. It is estimated that persons who are 65 years old and over will make up more than 15% of the total drivers [5], the number will approximately be 50 million in 2020 [6] and 20% of the total drivers in 2030 [7]. According to FHWA (Federal Highway Administration), if design is controlled by 85th percentile performance requirements, individual over 65 years old will be the design driver in the early 21st century [8].

Older drivers begin to noticeably be over-involved in fatal crashes. In the next 30 years, due to the increased number of older drivers, the number of fatalities involving older drivers is expected to increase three to four times if there is no change in the current crash rates [7, 9]. Some of the factors for higher fatality rates are related to body frailty and environmental factors [10-13]. The higher crash propensity of older drivers is often attributed to typical aging-related deterioration [14-16]. A recent written report identified five main deficiencies present in older drivers. These include: sensory, perceptual, cognitive, physical and general driving knowledge deficiencies [17].

Intersections appear to be hazardous to elderly drivers [1, 18], particularly left turn. Studies have indicated that a large majority of accidents involving elderly drivers take place at intersections. The main difficulties elderly drivers face at intersections are: estimation of a safe gap and speed of other vehicles,

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fast execution of driving maneuvers, failure to sense and comprehend traffic signals and signs, inability to perceive and process information about high traffic volumes, failure to signal their turns, poor positioning when turning left along with a general lack of caution, frequent failure to stop, and jerky or abrupt stops [2, 9].

The safety concern of older drivers is becoming significant. In this study, ten years crash data at signalized intersections in Kansas has been analyzed and comparison has been made for drivers in five different age groups for men and women. Different severity levels have been considered separately and finally, overall crash data has been analyzed for through, left turn and right turn movements.

2. Objectives

The main objectives of this study are:

- (1) Analyze crash data at signalized intersections in Kansas for older drivers;
- (2) Compare the result within the same age group and different gender and different age group of the same gender; and
- (3) Determine the effect of light condition, weather condition, surface type, surface condition, road character and construction/maintenance zone on the safety of older drivers.

3. Data and Methodology

Ten years of crash data, 1993-2002, have been extracted from Kansas accident report system data base for drivers older than 29 years. TH (Through), RT (right turn) and LT (left turn) crashes have been considered separately. The various injury severities are considered: D (disabled-incapacitating), F (fatal injury), I (injury-not incapacitating), N (not injured) and P (possible injury).

Many researchers commonly classify the elderly population into three subgroups as younger old: ages 65-74, older old: ages 75-84 and oldest old: ages over 85 [19]. In another study, drivers from ages 30 to 50 as middle-aged, ages 65 to 74 as young elderly, over

Table 1 Five age groups for this study.

Serial number	Age group	Remark
1	30-49	Comparison group
2	50-64	
3	65-74	
4	75-84	
5	> 85	

75 as old elderly [1]. Five age groups have been considered in this study as shown in Table 1.

SAS (statistical analysis software) has been used to analyze the data in this study. Then comparison has been made for different age groups of the same gender and the same age group for different gender.

4. Results and Discussions

4.1 Linear Regression

Intercept, slope, and coefficient of determination (R^2) have been determined by using SAS based on age group as independent variable and severity level as dependent variable. The results are shown in Table 2. The higher the coefficient of determination, the better the linear model compared to intercept only model. T-test has been done to determine the significance of the intercepts and slopes at 5% significance level. The slopes and intercepts that are not significant are indicated by * in the table. If slope is not significant, there is no linear relationship between severity level and age group. The intercepts for TH are higher for males than that of females at all age groups as shown in Fig. 1. The slope shows a decrease in proportion of TH accident for a unit increase in age group. The magnitude of slopes for females are higher than that of males in disabled and possible injury cases whereas higher for males in fatal, injury (not incapacitated), and not injured cases. As a result, there is no specific trend in slope unlike the intercept.

Table 2 also shows the linear model coefficients for LT accidents. Unlike that of TH accident, the intercepts for females are higher than that of males. The slopes for males are higher than that of females except in disabled case. Both the slope and intercept

Table 2 Summary statistics of linear models for various severity levels.

Severity	Statistics	Sex					
		Female			Male		
		TH	LT	RT	TH	LT	RT
<i>D</i>	Intercept	97.20	1.80	1.00*	101.36	-2.64*	1.28*
	Slope	-6.96	6.55	0.41*	-5.27	5.46	-0.19*
	R^2	0.93	0.94	0.62*	0.94	0.96	0.24*
<i>F</i>	Intercept	86.24	12.38*	1.38*	105.59	-5.68*	0.07*
	Slope	-0.78*	1.04*	-0.26*	-6.23	6.01	0.23*
	R^2	0.02*	0.04*	0.25*	0.94	0.97	0.28*
<i>I</i>	Intercept	91.13	7.47*	1.40	96.60	1.10*	2.30
	Slope	-4.84	4.51	0.34	-5.09	5.10	-0.01*
	R^2	0.78	0.75	0.89	0.79	0.79	0.01*
<i>N</i>	Intercept	87.06	9.34	3.60	89.86	5.80	4.35
	Slope	-4.53	3.73	0.80	-4.98	4.39	0.59
	R^2	0.93	0.92	0.95	0.98	0.98	0.88
<i>P</i>	Intercept	88.04	10.36	1.60*	91.79	5.32*	2.89
	Slope	-4.49	3.81	0.68*	-4.05	3.93	0.12*
	R^2	0.98	0.95	0.55*	0.94	0.95	0.08*

* Not significant at 5% significance level.

Fig. 1 Intercept at different severity levels. Note: D—Disabled (incapacitating), F—Fatal injury, I—Injury (not incapacitating), N—Not injured, P—Possible injury.

are not significant for fatal injury for female.

Statistical estimates for linear model of RT accident are also shown in Table 2. There is no defined trend for RT accident case unlike LT and TH. The slopes

and intercepts change in magnitude and sign at different severity levels. The intercepts for males are higher at all severity levels except for fatal injury as shown in Fig. 1. Intercepts are not significant at

severity levels of disabled and fatal injury for both females and males, possible injury for females. Slopes are not significant for both females and males at severity levels of disabled, fatal injury and possible injury. Slopes for females have higher magnitude than that of males except at fatal injury.

4.2 Comparison of the Same Gender in Different Age Groups

The data have been analyzed using different severity levels as replicates for both females and males. Table 3 shows comparison for the same gender in different age groups. The letters in the parenthesis show whether the means are significantly different from each other or not. If they are the same letter, they are not significantly different and vice versa. There is no significant difference for females in age group 1, 2 and 3 for both TH and LT accidents. Age groups 4 and 5 are not significantly different from each other, but significantly different from groups 1, 2 and 3 for both TH and LT accidents. There is no significant difference for all age groups for RT.

TH in age groups 1 and 2, 3 and 4, 4 and 5 are not significantly different from each other for males. LT in age groups 1 and 2, 2 and 3, 4 and 5 are not significantly different. There is no significant difference for all age groups in the case of RT for males like that of females.

4.3 Comparison of the Same Age Group for Different Gender

Comparison has been made for females and males in the same age group for TH, LT and RT accidents. TH and LT for females and males are not significantly different except for age group 1. RT for females is not significantly different from that of males for all age groups as shown in Table 4.

4.4 Effect of Light and Weather Condition

Most of the accidents have taken place during

daylight as shown in Fig. 2a. The proportion of the accident increases as age increases and the magnitude is higher for female in all age group during daylight. Dark while there is light on street has the second highest magnitude, but the magnitude decreases as age increases. Since most of the accidents take place during daylight and dark while street lights are on, light condition is not the main cause of accidents for older drivers.

Most of the accidents have taken place when there is no adverse condition. The proportion of the accident increases as age increases and the magnitude is higher for female in all age groups when there is no adverse condition as shown in Fig. 2b. The second highest proportion of accidents has happened when there is rain, mist, or drizzle whereas the magnitude reduces as age increases and higher for females unlike when no adverse conditions. The proportion of accidents during the rest of weather conditions is not significant. Since most of the accidents have taken place when there is no adverse condition, weather condition is not the main problem for older drivers.

4.5 Effect of Surface Type and Condition

Effect of surface type is indicated in Fig. 3a. The highest proportion of accidents has taken place on blacktop, followed by concrete. The magnitude is the same on blacktop and concrete surface for almost all age groups. Accidents on the rest of surface types are not significant.

The magnitude of the accident increases with age on dry surface condition as indicated in Fig. 3b whereas accident decreases as age increases on wet surface condition. The magnitude of the accident is higher for female in all age groups on dry surface condition whereas lower for female on wet surface condition. The remaining surface conditions have less contribution. Surface condition is not the main cause of accidents since most of the accidents have taken place on dry surface condition.

Table 3 Comparison of the same gender in different age groups.

Age group	Female			Male		
	TH	LT	RT	TH	LT	RT
30-49	82.18 ^a	15.34 ^a	2.48 ^a	90.52 ^a	7.12 ^a	2.36 ^a
50-64	83.96 ^a	13.74 ^a	2.30 ^a	87.99 ^a	9.59 ^{ab}	2.41 ^a
65-74	80.25 ^a	16.75 ^a	3.00 ^a	82.88 ^b	14.49 ^b	2.64 ^a
75-84	71.86 ^b	25.12 ^b	3.02 ^a	76.10 ^{bc}	21.10 ^c	2.79 ^a
> 85	66.63 ^b	29.28 ^b	4.09 ^a	70.83 ^c	26.26 ^c	2.91 ^a

Note: The same letter in the parenthesis indicates that the means are not significantly different for different age group for the same gender and movement type, e.g., there is no significant difference for all age groups in the case of RT for both male and female age groups.

Table 4 Comparison of the same age group of different gender.

Age group	Through			Left turn			Right turn		
	Female	Male	Similar	Female	Male	Similar	Female	Male	Similar
30-49	82.18	90.52	No	15.34	7.12	No	2.48	2.36	Yes
50-64	83.96	87.99	Yes	13.74	9.59	Yes	2.30	2.41	Yes
65-74	80.25	82.88	Yes	16.75	14.49	Yes	3.00	2.64	Yes
75-84	71.86	76.10	Yes	25.12	21.10	Yes	3.02	2.79	Yes
> 85	66.63	70.83	Yes	29.28	26.26	Yes	4.09	2.91	Yes

(a) Light condition

(b) Weather condition

Fig. 2 Effect of light and weather condition.

(a) Surface type

(b) Surface condition

Fig. 3 Effect of surface type and condition.

Fig. 4 Effect of road character and construction/maintenance zone.

4.6 Effect of Road Character and Construction/Maintenance Zone

Most of the accidents have happened on straight and level road as shown in Fig. 4a. The magnitude of accident slightly increases as age increases. The magnitude for female is higher on straight and level road whereas equal on straight on grade except last age group. Accidents on the remaining road characters are insignificant.

Fig. 4b shows the effect of construction/maintenance zone. About 98% of the accidents have taken place on no construction/maintenance zone. The remaining zones cause insignificant accidents.

5. Conclusions

Ten years, 1993-2002, accident data have been extracted from Kansas accident report system data base, and analyzed using SAS software for five different age groups. Five severity levels have been considered for both females and males. Based on this study, the following conclusions have been made:

(1) Proportion of older drivers in through lane involved in accident decreases as age increases whereas the proportion of left turn accident increases with age;

(2) Left turn is harder for females in all age groups;

(3) Proportion of right turn accident has no specific trend unlike through and left turn accidents at signalized intersections; and

(4) Most of the accidents have taken place during daylight when there are no adverse conditions on dry surface, straight and level road and blacktop surface type.

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