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**Research Article**

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# Analysis of factors influencing the severity of traffic accidents among elderly drivers

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**Abstract** To study the factors influencing the severity of traffic accidents of elderly drivers, the article used SPSS software to statistically analyze the traffic accident data released by the U.S. Department of Transportation, and constructed a total of 10 independent variables with whether the accident occurred with injuries as the dependent variable and whether it was a weekend, whether it was a rush hour, light conditions, weather, age, gender, whether it carried hazardous materials, whether it was speeding, the total number of lanes on the road, and the speed limit. Logistic model. The results showed that the number of traffic accidents and the number of casualties among older drivers were greater during weekdays, noon and afternoon time of the day. The severity of accidents was significantly correlated with age, speeding, total number of lanes, speed limit, weekend, and weather at the 0.05 level, and the model passed the test. The results of the study help traffic managers to take measures to reduce the severity of traffic accidents among older drivers.

**Keywords** Traffic accidents; SPSS; Logistic model; Data processing

## 1. Introduction

China entered an aging society at the beginning of the 21st century, and the proportion of elderly people has been increasing. By the end of 2021, the population aged 60 and above in China reached 267.36 million, accounting for 18.9% of the total population, and the proportion of people aged 60 and above is expected to reach 34.1% by 2050. China's population structure has changed from young to middle-aged, and the aging of the population will further intensify. As the elderly population continues to increase, the social problems brought by the elderly will become more and more prominent, such as traffic safety issues. Several studies have shown that the odds of car accidents are on the rise for older drivers aged 60 and above [1]. Studies have found that when faced with traffic emergencies, older drivers are less able to handle them and are prone to collisions. Older drivers are more prone to accidents due to their greater speed standard deviation and greater headway volatility, and their driving stability is poorer [2]. The number of accidents among elderly drivers is higher when they perform driving behaviors such as turning and lane changing at intersections. With rising incomes and changing lifestyles, more and more elderly people continue to own and prefer to drive small cars for travel. In developed countries, especially in the United States, private car travel is the main mode of travel for older adults [3]. Using literature research, questionnaires, and data analysis, it was found that most young and middle-aged people in China currently continue to keep their small cars for travel after the age of 60, and that those with high incomes and driving licenses have a greater preference for small car travel in old age. However, compared with young

drivers, the physiological and psychological indicators of elderly drivers gradually decline, and their ability to discriminate and react to traffic conditions decreases, thus increasing their traffic risks [4]. There are more studies on the physiological characteristics and driving characteristics of elderly people, but fewer analyze the factors affecting traffic accidents of elderly drivers.

In terms of research methods on factors influencing accident severity, most scholars have used econometric models to study the degree of influence of independent variables with accident severity as the discrete dependent variable. Based on the accident data reported by the North Carolina police in the United States from 1997 to 2002, the injury severity of machine-off-road accidents was classified into four levels, and the factors of accident severity were studied and the results were predicted using multinomial logit models [5]; in terms of traffic accident severity research, the use of ordered logit models led to the limitations of the proportional dominance assumption due to the overestimation or underestimation of accident probabilities for low versus high severity [6]. When the dependent variable categories are divided into three or more, the multinomial logit model is most widely used, and the multinomial logit model is more applicable than the random parametric logit model in studying the severity of traffic accidents [7], so this paper uses the multinomial logit model to study the severity of traffic accidents of elderly drivers.

In summary, scholars at home and abroad have achieved rich results in analyzing the physiological characteristics of elderly people and the severity of traffic accidents, but there are fewer studies on traffic accidents of elderly drivers. In this paper, based on the above research, we investigate the factors influencing the severity of traffic accidents of elderly drivers and the degree of their influence by combining the traffic accident data in Texas, USA [8], construct a binomial logit model, analyze the role of each factor, and propose targeted countermeasures for improvement.

## 2. Theory and Methods

### 2.1 Logistic model

Logistic regression analysis is a multiple regression analysis method that studies the relationship between the results of a dependent variable being dichotomous or multicategorical and certain influencing factors [9]. According to whether the dependent variable is dichotomous or multicategorical, logistic regression can be divided into dichotomous logistic regression and multicategorical logistic regression accordingly. In this paper, binomial logistic regression analysis is used, with whether the injury is the dependent variable y, and y takes the value of 0 or 1,0 represents the occurrence of an accident without injury and 1 represents the occurrence of an accident with injury. The model is as follows.

$$y = \ln\left(\frac{P}{1-P}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_P X_P$$

The following are the steps of logistic regression analysis.

Step 1: Variable assignment and the significance of partial regression coefficients, logistic regression analysis is not strict on the requirements of independent variables, it can be dichotomous variables, unordered categorical variables, ordered categorical variables or quantitative variables. However, the independent variables should be assigned with reasonable values. The estimated values, signs and meanings of the parameters may change if the variables are assigned in different ways for the same data [10]. Therefore, whether the variables are assigned reasonably or not directly affects the effect of logistic regression.

Step 2: Parameter estimation, the estimation of partial regression coefficients is often done by using great likelihood estimation.

Step 3: Hypothesis testing of the model. The commonly used tests are likelihood ratio G test, red pool information criterion, SC test method, and scoring test.

## 3. Case Study Analysis

### 3.1 Analysis of temporal characteristics of traffic crashes of elderly drivers

The data sources were selected from the data system released by the U.S. Department of Transportation for three years of crash data from 2016 to 2018. The data of 18,771 elderly driver traffic accidents over 60 years old were collated as samples, and the characteristics of elderly driver traffic accidents were studied from the day-by-day and time-by-time changes in the number of accidents as well as the number of injuries, respectively.

The data study shows that there is variability in the daily distribution of the number of accidents and injuries among older drivers, with more accidents and injuries on weekdays than on weekends. The number of accidents and the proportion of injured people were more or less the same from Monday to Wednesday, at around 15%; on Thursday and Friday, the highest number of accidents and the proportion of injured people exceeded 16%; the situation improved during the weekend, with the proportion of accidents and the number of injured people dropping significantly on Saturday and Sunday compared to weekdays, with Sunday being the best, with the proportion of accidents dropping to 9% and the proportion of injured people The number of accidents dropped to 9% and the number of injuries dropped to 9.65%..

The data show that the number of traffic accidents and injuries of elderly drivers vary in hourly distribution, with more accidents and injuries in the midday and afternoon of each day. The number of accidents and the number of casualties were significantly higher from 12:00 to 17:00 than during other hours, accounting for 56.22% and 50.75% of the total number of accidents and injuries respectively, with the maximum value occurring from 16:00 to 17:00, when the number of accidents reached 9.01% and the number of injuries reached 8.99%. There are no more traffic accidents in the morning rush and night time, so older drivers are more likely to have traffic accidents at noon and afternoon.

Therefore, during the weekday, midday and afternoon hours of the day are the high incidence of traffic accidents among older drivers. Potential reasons may be that private trips of elderly people are concentrated in this time period, while some elderly people are still engaged in work or labor, and their bodies are more sleepy at noon and afternoon after meals, which increases the probability of fatigue driving and leads to accidents.

### 3.2 Data overview and variable description

The data selected for this paper were obtained from traffic accident data released by the U.S. Department of Transportation, and after screening and eliminating accident cases with incomplete records, we finally obtained 18,771 traffic accident data of elderly drivers over 60 years of age as the research sample for the analysis of factors affecting the severity of traffic accidents of elderly drivers.

In this paper, we chose whether or not to be injured as the dependent variable, and 10 independent variables were selected for analysis based on the accident records. These were whether it was a weekend, whether it was a rush hour, light conditions, weather, age, gender, whether it was carrying hazardous materials, whether it was speeding, the total number of lanes on the road, and the speed limit. The fields corresponding to the dependent variable and each independent variable, as well as the variable description, assignment, frequency, and percentage status, are shown in Table 1.

**Table 1:** Description and assignment of variables

| Variable Name | Field | Variable Description | Assignment | Frequency | Percentage% |
|---|---|---|---|---|---|
| Dependent variable | NUM_INJ | No | 0 | 8797 | 46.8 |
| | | Yes | 1 | 9973 | 53.2 |
| Whether or not the weekend | DAY_WEEK | No | 0 | 13457 | 71.7 |
| | | Yes | 1 | 5313 | 28.3 |
| Whether it's | HOUR | No | 0 | 11086 | 59.1 |

| | | | | | |
|---|---|---|---|---|---|
| peak | | Yes | 1 | 7684 | 40.9 |
| Light conditions | LGT_COND | With light | 1 | 14859 | 79.2 |
| | | Without light | 2 | 3307 | 17.6 |
| | | Dawn | 3 | 221 | 1.2 |
| | | Dusk | 4 | 383 | 2.0 |
| Whether | WEATHER | Sunny | 1 | 16925 | 90.2 |
| | | Rainy | 2 | 1446 | 7.7 |
| | | Snowy | 3 | 321 | 1.7 |
| | | Foggy | 4 | 60 | 0.3 |
| Age | AGE | Continuous variable | | | |
| Sex | SEX | Male | 1 | 11201 | 59.7 |
| | | Female | 2 | 7569 | 40.3 |
| Whether hazardous materials are carried | HAZ_INV | No | 1 | 18760 | 99.9 |
| | | Yes | 2 | 10 | 0.1 |
| Whether or not speeding | SPEEDREL | No | 0 | 17575 | 93.6 |
| | | Yes | 1 | 1195 | 6.4 |
| Total number of lands | VNUM_LAN | Single lane | 1 | 349 | 1.9 |
| | | Two lanes | 2 | 6934 | 36.9 |
| | | Four lanes and above | 3 | 11487 | 61.2 |
| Speed limit | VSPD_LIM | <=30 | 1 | 3208 | 17.1 |
| | | (30, 60] | 2 | 11196 | 59.7 |
| | | >60 | 3 | 4368 | 23.2 |

### 3.3 Binomial Logit Model Analysis

A binary logit model was used to analyze the relationship between the influence of each variable on whether a traffic accident resulted in injury. The Hosmer test was used to determine whether the binary logit model was a good fit to the current data set. As shown in Table 2, the significance is greater than 0.05, which proves that the fit is good.

**Table 2:** Hosmer-Lemeshaw test

| Step | chi-square | Degree of freedom | Significance |
|---|---|---|---|
| 1 | 3.956 | 8 | 0.861 |

A binary logit model was constructed with whether or not to be injured as the dependent variable and 10 variables as independent variables. At a significance level of 0.05, a total of 6 independent variables, namely, age, whether or not to speed, total number of road lanes, speed limit, whether or not to weekend, and weather, were found to be significantly correlated with whether or not to be injured. Table 3 shows the results from the analysis of the six independent variables, which include the reference categories, regression coefficients, significance, and confidence ratios for each subvariable.

(1) In terms of whether it was a weekend, using weekdays as the reference, older drivers were less likely to have an injury accident on weekends, and the probability of having an injury accident on weekends was 0.813 times higher than the probability of having an injury accident on weekdays.

(2) In terms of weather, using sunny days as a reference, the probability of injury accidents on rainy,

snowy, and foggy days was 0.869 times, 0.643 times, and 0.972 times, respectively, the probability of injury accidents on sunny days. The potential reason is that elderly people are more cautious and drive at lower speeds in special weather conditions, which reduces the severity of accidents.

(3) In terms of driver age, the risk of injury accidents increases by 0.6% for each additional year of age. The potential reason for this is that older drivers are less aware of recognizing hazards and have poorer reaction times, leading to a greater probability of injury accidents.

(4) In terms of whether or not to speed, older drivers are 1.452 times more likely to be involved in an injury accident under speeding conditions than they are to be involved in an injury accident under normal driving conditions. The potential reason is that when speeding, due to excessive speed, the field of view becomes narrower, the clarity is poor, and it is difficult to obtain enough road information to make accurate judgments about road conditions, etc.

(5) Regarding the number of lanes, elderly drivers are more likely to be involved in injury accidents when driving on two-lane versus four-lane highways and above than on single-lane highways. The probability of a serious injury accident on a two-lane highway is 1.245 times higher than on a single-lane highway, and the probability of an injury accident on a four-lane highway and above is 1.089 times higher than on a single-lane highway. The potential reason is that single-lane highways have narrower road surfaces, resulting in lower speeds, while two-lane or wider highways have faster speeds and more intertwining, making older drivers more likely to be involved in injury accidents.

(6) In terms of speed limits, compared to low speed limits below 30km/h, older drivers are more likely to have serious injury accidents and fatal accidents at speeds greater than 30km/h limits, especially at speeds greater than 60km/h. Older drivers are 1.218 and 1.339 times more likely to have an injury accident at 30 to 60km/h and greater than 60km/h than at speeds below the 30km/h limit. The potential reason for this is that the higher the speed limit is set, the higher the speed of the vehicle will generally be, and the slower reaction time of elderly drivers increases the severity of the accident.

**Table 3:** Parameter estimation results

| Variable Name | Variable Description | Reference Category | β | Sig | Exp（β） |
|---|---|---|---|---|---|
| Whether or not the weekend | Yes | No | -0.107 | 0.001 | 0.813 |
| Whether | Rainy | Sunny | -0.140 | 0.011 | 0.869 |
| | Snowy | | -0.442 | 0.000 | 0.643 |
| | Foggy | | -0.028 | 0.014 | 0.972 |
| Age | Continuous variable | | 0.006 | 0.002 | 1.006 |
| Whether or not speeding | Yes | No | 0.373 | 0.000 | 1.452 |
| Total number of lands | Double lane | Single lane | 0.219 | 0.047 | 1.245 |
| | Four lanes and above | | 0.085 | 0.034 | 1.089 |
| Speed limit | (30, 60] | <=30 | 0.197 | 0.000 | 1.218 |
| | >=60 | | 0.214 | 0.000 | 1.339 |

## 4. Recommendations and Conclusions

### 4.1 Recommendations

This paper gives recommendations and improvement measures from four influencing factors, namely driver

attributes, vehicle attributes, road attributes and environmental attributes, to reduce the probability of serious traffic accidents among elderly drivers and protect property and the lives of traffic participants.

**4.1.1 Driver attributes**

Develop a health check and driving ability assessment system for elderly drivers. In terms of health check, regularly check the medical conditions of elderly drivers and determine whether they are fit to continue driving according to their health condition, especially the visual function of night driving; in terms of driving safety, regularly check the cognitive and reaction ability of elderly drivers and determine whether they are fit to continue driving, especially the driving skills of female elderly drivers; strengthen the requirement for elderly drivers to wear seat belts and enhance the inspection and punishment of The behavior of not buckling seat belts; during weekdays, daily noon and afternoon hours, elderly drivers should pay more attention to safe driving, avoid fatigue driving, or use public transportation to travel.

**4.1.2 Vehicle Attributes**

Add vehicle-assisted driving systems for elderly drivers. Vehicles driven by elderly drivers can apply more lane keeping systems, automatic brake assist systems, driver fatigue warning systems, etc., especially at intersections, multi-lane highways, etc., to overcome the problem of reduced cognitive judgment as well as reaction ability of elderly drivers; strengthen annual vehicle audits as well as inspections, and promptly check vehicles for hidden dangers, and elderly drivers avoid driving elderly vehicles.

**4.1.3 Road attributes**

Lay traffic control, speed bumps, warning facilities, etc. at intersections as much as possible; construction of roads should not be too wide; conspicuous traffic signs and markings should be drawn on multi-lane roads to reduce interweaving; separate speed limits can be considered for elderly drivers to reduce vehicle speed.

**4.1.4 Environmental attributes**

Encourage senior citizens to choose public transportation for commuting, especially during weekdays, noon and afternoon hours every day; traffic management should also be strengthened during non-peak hours to avoid traffic accidents for senior drivers; highways should be equipped with street lights for lighting as much as possible, and drivers should also be required to drive with lights at night to improve the nighttime driving vision for senior drivers; in addition to urban areas, traffic management departments should also strengthen suburban traffic In addition to urban areas, traffic management departments should also strengthen traffic inspection in suburban areas and crack down on traffic violations.

**4.2. Conclusion**

In this paper, we analyzed the traffic accident data of Texas, and found that the number of traffic accidents and fatalities among elderly drivers was higher during weekdays, noon and afternoon. By constructing a binomial logit model, it was found that the severity of traffic accidents for elderly drivers was significantly related to 10 factors: whether it was a weekend, whether it was a rush hour, light conditions, weather, age, gender, whether it was carrying hazardous materials, whether it was speeding, the total number of road lanes, and the speed limit.

Although our traffic conditions are unique, it is informative to learn lessons from traffic accidents in developed countries. The United States, as a developed country, has experienced a rapid growth phase of small car ownership and an aging U.S. population of more than 16%. Therefore, the findings based on the traffic accident data of elderly drivers in the United States can provide a basis for the management decisions of traffic managers in China, and have some reference significance for reducing traffic accidents of elderly drivers in China.

The parameters of the binomial logit model results indicate that older drivers are more likely to be involved in traffic accidents on weekdays, sunny days, driver age, roads with speed limits over 30km/h, speeding, and driving on two-lane roads, with other factors held constant. Due to data limitations, the effects of variables such as driver age, weather, and road conditions on the severity of traffic accidents among older drivers were not studied in this paper, and future research on the extent of the effects of these variables is needed.

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