Chapter

Probability to Be Involved in a Road Accident: Transport User Socioeconomic Approach

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Abstract

Road education is one of the most relevant issues focused to reduce traffic accidents, so it is important to analyze the driver's behavior on the roads. International research has found evidence for a relationship between socioeconomic characteristics and traffic accidents. In this sense, the chapter shows a methodology to estimate the probability to be involved in a road accident, considering the road education and the socioeconomic characteristics of the population of a specific region, taking the Santiago de Querétaro city (in México) as a study case. Through a logit model estimation and a survey applied to pedestrian, cyclist, motorcyclist, car driver, and freight driver allow us to determine which socioeconomic variables and road education are significant to determine the probability of being involved in a road accident.

Keywords: traffic accidents, probability, road education, socioeconomic level, transport modes, logit

1. Introduction

The present chapter shows one of the most relevant issues regarding the area of road safety since according to the WHO, road accidents are among the ten leading causes of death in the world [1]. "In Mexico, it is estimated that between 70% and 90% of traffic accidents are attributed to the driver, with human errors and driver offenses in traffic regulations as the two main contributing factors" [2].

Shell [3] exposes "Improving road education involves an analysis of human behavior, where both classroom instruction on safety issues, laws and regulations, vehicle operation, and those factors affecting driving are combined." It is for these reasons that "the vast majority of road education exams have focused on accidents" [4]. The factors in these studies include age, income, and driver's attitude.

In relation to the implementation of any road safety system, Ker *et al*. [5] and Mackay and Tiwari [6] acknowledge that human errors should be minimized in order to significantly improve road safety. In the circumstances of drivers, traffic safety policies recently implemented have been focused on improving their traffic behavior [7], particularly to endorse a better attitude when using roads [8–10]. Nonetheless, Mirzaei *et al*. [7] reported that while many drivers show a positive safety attitude in regards to traffic, there are specific circumstances that may induce a poor traffic performance from some of these road users. Therefore, the authors inform us about the need to illuminate such situations, containing any potential cultural aspects. For the diverse groups of road users, Factor *et al.* [11, 12] proposed a theoretical model to analyze the influence that some social and cultural characteristics of these groups have on traffic safety, reporting that road safety differs in cultural and social features, including lifestyles and attitudes.

This study analyzed together the socioeconomic and road knowledge characteristics of these users to determine the probabilities of being involved in a road accident. This issue arises from the research that has been done [3], which informs us that those who have knowledge of road education are less likely to be involved in accidents or to carry out traffic violations. Whereas Factor *et al*. [12], using a logistic regression, found a relationship between socioeconomic status and presence in traffic accidents, as to say there is a direct correlation between higher level of education and greater socioeconomic status, which lowers the probability of being involved in a road accident.

It is worth mentioning that the present research aims to develop a methodology to create, step by step, a model that determines which socioeconomic variables and road education are significant to determine the probability of being involved in a road accident, which was applied to a case study in the city of Santiago de Querétaro.

This is why it is important to analyze the behavior of drivers on public roads since one of the main factors of road accidents is the lack of education and knowledge that these users may have about road safety. Not only does lack of knowledge influence road safety but also social factors, such as differing cultures, social behavior, the age of a driver, and the socioeconomic status of the drivers. This is an explanation as to the importance of doing the study because knowing these aspects that were previously mentioned, are all aspects that can attribute to a driver's performance when operating a vehicle.

2. Background

When examining the number of road mishaps as a meaning of a given country's economic level, Xu *et al*. [13] concluded that "road users' income is a determining factor for road safety." Concurring to its 2013 Global Status Report on road safety, such a conclusion is also reached by the World Health Organization, as low- and middle-income countries show higher traffic death rates when associated with high-income economies. Additional authors also report this cause–effect relationship [12, 14–16]. Overall, these authors claim that a low per capita income is a decisive factor for traffic crashes.

These accidents affect different social areas, and for this reason the subject of road education is a responsibility that belongs to a whole society, which encompasses pedestrians, cyclists, motorcyclists, drivers of vehicles, passengers, and transportation. Improving road education involves an analysis of human behavior, where both classroom instruction on safety issues, laws and regulations, vehicle operation, and those factors affecting driving, as well as vehicle driving practice are combined with a trained instructor [3]. It is for these reasons that the vast majority of road education exams have focused on accidents [4].

Regarding age, on the other hand, much of the road safety literature focuses on high-risk drivers, often being young, low-income men with low education [17]. It is recognized that older people appear to be more safety-conscious [18].

In terms of income, it should be noted that per capita income has been identified as a determinant of overall injury mortality [19]. Based on research conducted by Zmud and Arce [20, 21], it is ensured that lower-middle income groups may be at increased risk of occupant motor vehicle injuries. Attitude is a very important factor in road education, which also predicts longitudinally an unsafe driver [22].

2.1 Multi-criteria models for the decision-making process

For this process, three decision-making models are discussed that are based on the manipulation of the simple related data that provide the means to develop indicators in a systematic way [23]. These decision-making criteria represent a multi-criteria approach, which must be compared with other processes of several criteria such as the qualification model, the hierarchical analytical process (AHP), and the multiple attribute utility theory. The AHP method is a method that has been applied to deal with problems in different areas, matching the sentences of intangible qualitative criteria with tangible quantitative criteria [24]. The AHP method was initially developed by Saaty [25], with the objective of determining the relative importance of a set of alternatives in a multi-criteria decision problem. There are three main steps in the AHP: design of the hierarchy, a prioritization procedure, and the calculation of the results.

3. Methodology

Recent road safety research focuses on the need to improve the "behavior" of drivers [7]. In this sense, we did not give the task of evaluating 5 (five) road users, such as pedestrian, cyclist, motorcyclist, vehicle driver, and freight truck driver.

The study consisted of an evaluation of the previously mentioned users determined by a sample size as a significant representation; this evaluation was applied through a questionnaire designed for each type of user, which was divided into two parts; the first containing information such as general data, socioeconomic level, age and origin of acquired knowledge and accident, second is designed with information such as regulations or recommendations, traffic signals, current situation in road safety and human factors, infrastructure, courtesy and urbanity and applied situations. It should be noted that because each questionnaire was designed by user type there are variants in some questions.

This research also has an important message for society and aims to contribute knowledge on the subject as well as to help in the reduction of traffic accidents in our country. For the execution of this project, we will be using the five steps of methodology to conduct this investigation, we will also describe each of these steps:

3.1 Step 1: knowledge of the context of the variables to be evaluated and their development

The main objective of this stage consists of bounded problems for which the fundamental parameters can be defined. For this activity, some elements are incorporated in the analysis and are obtained from a review of global, national, and local literature in relation to safety education programs and driving tests. As a result of this analysis, a list of specific questions involving six common variables around which two or three user-related questions are written is based on the comparative analysis of the necessary knowledge. Each question was obtained through a review of the literature, the resulting number of questions for each of the users of the infrastructure is as follows: 24 for drivers of vehicles, 24 for freight conductors, 24 for motorcycle users, 21 for bicycle users, and 21 for pedestrians.

3.2 Step 2: structuring the questionnaire and evaluation

Within this stage, once the questions were established in the context of the selected variables two parallel processes will be carried out: the planning for the execution of the survey and the establishment of the weighting factors for the survey questions. The AHP method will be selected for this process, as it represents a structured and computerized process in which comparisons are made on a peer basis, which provides some evidence regarding the assessments made by experts of the Mexican Institute Transport (IMT) and the Autonomous University of Querétaro (UAQ). To obtain the reason scales of the AHP methodology, we compared the set of peer evaluations for each question. The peer comparison was as follows: 1 = equal, 3 = moderate, 5 = strong, 7 = very strong, and 9 = extreme.

3.3 Step 3: experimental design and sample size for survey operation

In this step, we will determine the size of the sample of users of the road examined which is calculated according to the number of inhabitants of the area [26] and the means of transport chosen by the users, as reported by Obregón and Betanzo [27].

$$n = \frac{N * Z\alpha^2 p * q}{d^2 * (N-1) + Z\alpha^2 * p * q} \tag{1}$$

Where N is the total number of inhabitants in the area (804 663 de Santiago de Queretaro), $Z\alpha$ = 1.96 (for a reliability 95%), p = expected proportion (in this case 5% = 0.05), q = 1 - p (in this case 1- 0,05 = 0,95), and d = precision (can be 1% to 3%; 2% was selected).

According to Eq. (1), 207 individuals were needed. This sample size considers individuals using the different means of transportation listed in **Table 1**, where it can be observed that freight vehicle, motorcycle, and bicycle users were the least frequent road users, with 1%, 1%, and 0.7%, respectively. To increase the reliability of these users, the sample size was increased to 20, for each of these modes. The number of validated questionnaires was 254.

The specific public areas for applying the survey were selected as a function of the type of transport infrastructure user: (1) public spaces, in which people spend at least 10 minutes completing some paperwork; (2) spaces around public schools, in which students move; and (3) recreational areas, in which users have more time to respond the survey (e.g. malls and public parks).

	Freight vehicle	Car	Motorcycle	Bicycle	Walk	Rest	Total
Distribution of users by mean of transport (%)	1.00	32.50	1.00	0.70	10.10	54.00	100
Percentage of sample size per type of infrastructure user	1	33	1	1	10	54	100
Estimated sampled	5	148	5	3	46	246	453
Total sampled	20	148	20	20	46	0	254

Table 1.
Sample and user distribution by transport means in Santiago de Querétaro. Own elaboration by the distribution data from Ref. [27].

3.4 Step 4: database processing

In this process, we will compile the database obtained through the questionnaires applied to each user evaluated. Subsequently, this database will be analyzed to know the socioeconomic and road users' knowledge. In the following graph (see **Figure 1**), the analysis of the variables of road education performed with the results obtained by the surveys in each one of the evaluated users is shown. This shows that the users that resulted with the lowest road knowledge in general are freight drivers (FD) and vehicle drivers (VD), unlike cyclists (C) who obtained the highest level of knowledge. At the same time, we can observe that the motorcyclists (M) obtained a low rating in regulation and recommendations (R&R); in contrast, the pedestrian (P) proved to have low knowledge in courtesy and urbanity (C&U).

The rest of the variables of road education by its initials are classified in the following form: traffic signals (TS), current situation in road safety and human factor (CRS&HF), infrastructure (Infra), and applied situations (AS).

3.5 Step 5: the probabilistic model

In the literature, the use of *Logit* models has been reported to estimate the probability of accidents [7, 28]. In this sense, the present research project estimated the presence of road accidents using *Logit* models. These models are estimated using the commercial software NLOGIT version 5, which was used for the same objective by Tay [29]; who mentions that binary regression models are adequate techniques to predict a binary dependent variable as a function of predictor variables.

Due to its ease in its estimation, the *logit* transformation is one of the most used in studies, this conducive search of a model of choice is more comfortable analytically, and the result was the binary *logit* model. This is under the assumption that ε_n is logistically distributed [29]; and the probability of choosing alternative i is given by Eq. (2).

$$P_n(i) = \frac{1}{1 + e^{-\mu\left(V_{in} - V_{jn}\right)}} \tag{2}$$

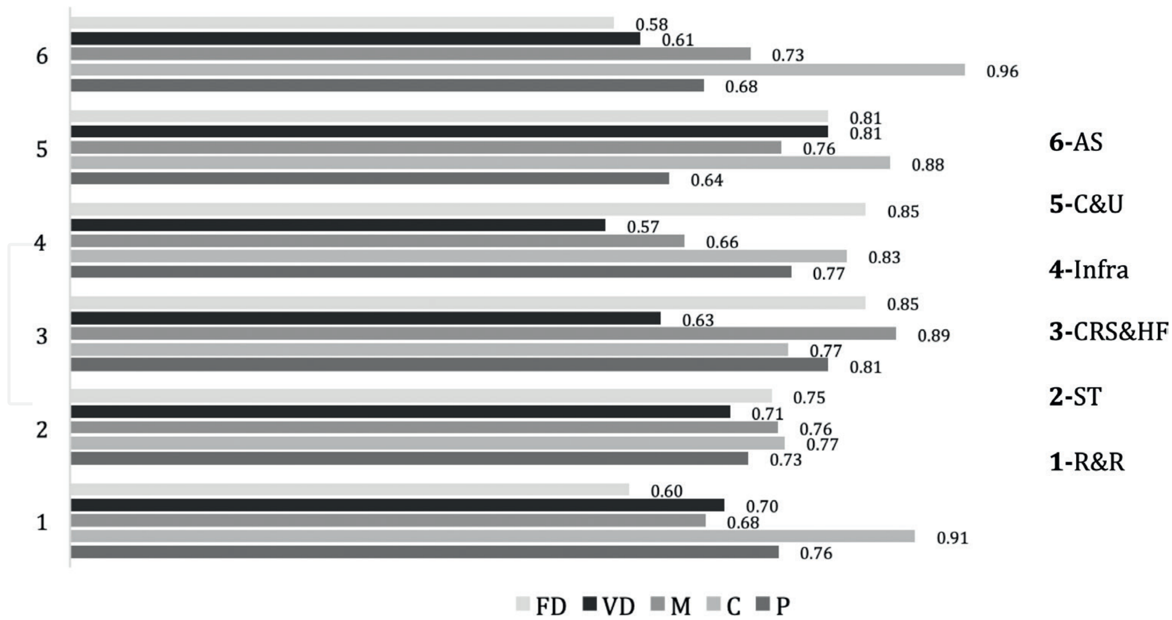

Figure 1.
Road education grade of each user.

For this model, the dependent variable $P(i)$, is a probability (between 0 and 1) that cannot be observed; only the choices of each individual are observed and these are variables (0 and 1).

4. Results and discussion

This section describes the *logit* models estimated to determine which socioeconomic and road education variables are significant to determine the probability of being involved in a road accident considering the means of transport used in their mobility. Depending on the mode of transport, the survey asks the user if they have been in a traffic accident in their life and during the last 12 months. Subsequently, each of the models obtained from each analyzed user is described. It should be noted that the first model (Model 1) was analyzed requesting the user if he has been involved in a traffic accident in his life. Unlike the second model (Model 2), which represents if you have been in a traffic accident in the last 12 months.

4.1 Freight driver

Two models were analyzed, in the first model, it can be seen that the significant variable is the income. Unlike Model 2, the most significant variable turned out to be the years with the driver's license (YDL) that the user has. It is worth mentioning that the variable that resulted most significantly in freight driver to determine the probability of being involved in a road accident is theincome (0.8345) (**Table 2**).

4.2 Vehicle driver

The first two models were analyzed, showing the following variables that are significant: if the user has a driver's license (DL) and the age at which the road

	Model 1		Model 2	
	Coef	SE Coef	Coef	SE Coef
Intercept	−3.7912*	2.0713	-21.4281 ·	16.6554
	(−1.830)		(−1.287)	
Income	0.8345*	0.4865	—	—
	(1.715)		—	
YDL	—	—	−0.7845 ·	0.6018
	—		(−1.304)	
*Note: ***, **, *, · = significance at 1, 5%, 10%, and 15% level.*				

Table 2.
Logit model, freight driver probability to be involved in a traffic crash.

	Model 1		Model 2	
	Coef	**SE Coef**	**Coef**	**SE Coef**
Intercept	−1.2401*	0.6994	−2.9609**	1.1795
	(−1.773)		(−2.510)	
Age	—	—	−0.8669***	0.2815
	—		−3.079	
Income	—	—	0.4208**	0.1791
	—		(2.349)	
DL	2.2472***	0.6498	2.4749**	1.0788
	(3.458)		(2.294)	
ARK	−0.4100**	0.1866	—	—
	(−2.197)		—	
*Note: ***, **, *, = significance at 1, 5%, and 10% level.*				

Table 3.
Logit models, vehicle driver probability to be involved in a traffic crash.

knowledge was obtained (ARK). In Model 2, the most significant variables were age (Age) and income (Income). It should be noted that the variable that resulted most significantly in vehicle drivers is driver's license (2.4749) (**Table 3**).

4.3 Motorcyclist

Two models were analyzed in Model 1, we can see the following variables that are significant: the level of road knowledge (LRK) and the courtesy and urbanity (C&U) that the user has. In Model 2, only a significant variable was obtained, which is the years with a driver's license (YDL) that the user has. It is worth mentioning that the variable that was most significant in motorcyclists to determine the probability of being involved in a road accident is the courtesy and urbanity (27.5462) (**Table 4**).

	Model 1		Model 2	
	Coef	**SE Coef**	**Coef**	**SE Coef**
Intercept	−5.9537 ·	3.7085	−4.8979 ·	3.6383
	(−1.605)		(−1.346)	
LRK	1.0178 ·	0.7227	—	—
	(1.408)		—	
YDL	—	—	−0.4753 ·	0.2785
	–		(−1.707)	
C&U	27.5462 ·	17.581	—	—
	(1.567)		—	
*Note: ***, **, *, · = significance at 1, 5%, 10%, and 15% level.*				

Table 4.
Logit models, motorcyclist probability to be involved in a traffic crash.

	Model	
	Coef	**SE Coef**
Intercept	0.9418 ·	1.9526
	(0.482)	
Income	0.5037 ·	0.3304
	(1.524)	
C&U	−18.9062 ·	13.2425
	(−1.428)	
*Note: ***, **, *, · = significance at 1, 5%, 10%, and 15% level.*		

Table 5.
Logit model, cyclist probability to be involved in a traffic crash.

4.4 Cyclists

For this user, only one model was analyzed, due to the fact that the data obtained show that they were not involved in an accident in the last 12 months. In the following model, the following variables were found to be significant: income (Income) and courtesy and urbanity (C&U) that these users may have on the infrastructure. It should be mentioned that the variable that was most significant in cyclists is the courtesy and urbanity of users (−18.9062) (**Table 5**).

4.5 Pedestrian

As we analyzed Model 1, we can see the following variables that were significant: age (Age) and applied situations of users (AS). In contrast to Model 2, the most significant variables were the income (Income), level of road knowledge (LRK) they believe they have, and the age at which they obtained road knowledge (ARK). The significant variables that influence the probability of the pedestrian being involved in a traffic accident are applied situations (−10.2266) and the age at which they obtained road knowledge (−1.2199) (**Table 6**).

	Model 1		Model 2	
	Coef	**SE Coef**	**Coef**	**SE Coef**
Intercept	−1.286*	0.6501	−6.0174*	3.2642
	(−1.859)		(−1.843)	
Income	—	—	0.8987*	0.4893
	—		(−1.837)	
Age	0.5841**	0.2457	—	—
	(−2.377)		—	
LRK	—	—	1.139*	0.6655
	—		(−1.712)	
ARK	—	—	−1.2199*	0.685
	—		(−1.781)	
AS	−10.2266*	5.358	—	—
	(−1.909)		—	

*Note: ***, **, *, · = significance at 1, 5%, 10%, and 15% level.*

Table 6.
Logit model, pedestrian probability to be involved in a traffic crash.

5. Conclusions

The chapter shows how the statistical *logit* probability model can characterize the effect of socioeconomic and educational factors on the population and the probability of being involved in a traffic accident. The overall result for the population surveyed identify both the level of road education and the income of the users' infrastructure. The significant variables that influence the probability of the user being involved in a traffic accident by transport mode are as follows:

Amongst freight drivers, it was found that the most significant variables influencing the probability of being involved in a road accident are income and years with a driver's license. Vehicle drivers, age (Age), income (Income), if you have a driver's license (DL), and the age at which you gained road knowledge (ARK) were found to be the most significant variables to determine the probability of being in a road accident. It was found that for motorcyclists the factors were the level of road knowledge (LRK) they were considered to have, years of driver's license (YDL) and Courtesy and Urbanity (C&U) as being the most significant variables for these users. For cyclists, it was found that income as well as courtesy and urbanity were the most significant variables. On the other hand, for pedestrians, it was found that the income, age, level of roadway knowledge that they considered to have, the age at which they obtained road knowledge, and the situations applied were the most significant variables.

In the case of motorized means of transport, the following aspects should be considered; age of users, socioeconomic characteristics, age and origin of acquired knowledge, and courtesy and urbanity. In the case of nonmotorized means of transport, the aspects to be taken into account are age, socioeconomic characteristics, age and origin of acquired knowledge, courtesy and urbanity, and the situations applied in this way.

The results of this research can be useful in defining road safety policies. In this sense, Mirzaei et al. [7] suggest that campaigns could be carried out to strengthen educational programs to minimize the probability of road accidents, considering the socioeconomic status and road education aspects of road users.

Conflict of interest

The authors declare no conflict of interest.

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