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Influence of Risky Behaviors upon the Involvement in Traffic Accidents: An Analysis at the University of Brasília

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Abstract

It is known that traffic accidents are caused by three main factors: road, vehicle and human ones. Since the majority of accidents is attributed to road users, many efforts have been made, such as the promotion of campaigns in road safety. In Brazil, the Yellow May is responsible for making the society aware of the fatalities in traffic so that it can change the users' behaviors into the development of a safer system. During the 2018 Yellow May campaign, a questionnaire survey was conducted in the University of Brasília to verify if specific behaviors were related to the involvement of the population in traffic accidents and several methods were employed to answer this question: descriptive statistics, the Cochran-Armitage Trend test, the Kruskal Wallis test, odds ratio, linear regression and ordered logit models. The results were consistent with Brasília's reality concerning the usage of the crosswalks and the disrespect to the speed limits. Besides that, the tests, the odds ratio and the linear regression presented satisfactory results, whereas the usage of the ordered logit models demonstrated not fair ones in terms of the p-value, although the coefficients were adequate. Therefore, it was possible to see that some behaviors, specially the ones related to the usage of cell phones, represent a significant correlation to the involvement in traffic accidents and specific campaigns, regarding these attitudes, are needed to reduce the occurrences related to them.

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Keywords: Traffic Campaigns, Risky Behaviors, Traffic Accidents, Questionnaire

1. Introduction

Approximately 1.2 million people die every year on roads, making traffic accidents a leading cause of death. This is one of the reasons why the United Nations (UN) promoted the Decade of Action for Road Safety, from 2011 to 2020, because they recognized that the road safety is mandatory to ensure healthy lives and to make cities safe, resilient and sustainable (WHO, 2015). Concerning the Brazilian reality, the UN classified the country in the 148th position among 182 nations studied, with an estimated rate of 23.4 fatalities per 100.000 population.

Such index contradicts with the UN's evaluation of Brazil's traffic laws, since drink-driving, motorcycle helmets, seat-belt and child restraint laws were considered to be safe, with only restrictions to the settlement of speed limits.

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Other countries, such as the United States, present laws that diverge from the UN's requirements and, even though, present 10.6 fatalities per 100.000 population (WHO, 2015).

Road traffic accidents are attributed, mainly, to road, vehicle and human factors (Haddon, 1968) and the study of the causes of these accidents may indicate the best alternatives for intervention. However, the majority of the accidents are attributed to road users, since they are responsible for about 85% of such occurrences in Brazil (Branco, 1999).

In order to change driver's attitude in the traffic system, campaigns are generally promoted. The content of the campaigns will clearly influence its effect and, because of it, the messages need to be persuasive and reach the target audience (Phillips et al., 2011). One of the main recommendations for campaigns is to include both primary (behavior) and secondary objectives (attitudes) to make a change with greater accuracy. Also, small effects can be important, even though the number might not be so meaningful at first (CAST, 2009). Traffic campaigns are intended to change behaviors and this may reduce fatalities. If at least one life is saved, there can be seen signs of positive results.

Indeed, campaigns generally have a great effect in road safety. Phillips et al. (2011) used a meta-analysis technique to investigate if they had an overall significant accident-reducing effect. After the analysis of 119 studies, the authors concluded that the reduction was about 9%, coming to similar results to the ones presented by Elvik et al. (2009). They also verified that, to achieve immediacy in the delivery of a campaign message, it is necessary to increase campaign effect in the shorter term and complement long term effects using mass-media.

In Brazil, one of the most important campaigns in road safety is called the Yellow May, that was born with the goal of making the society aware of the high number of deaths and injuries in traffic all over the world. In 2018, the movement came to its fifth edition with a slogan that "We are the Traffic,", suggesting a direct involvement of the population into the campaign's actions and proposing a reflection concerning a new way of facing mobility: in terms of a safer system (Maio Amarelo, 2018).

The movement was inspired by similar campaigns, such as the National Breast Cancer Awareness Month (BCAM), and its color is yellow due to its meaning in a traffic system: advertisement. This is the same message that the campaign wants to achieve into the population.

Therefore, during a Yellow May campaign in 2018, a questionnaire survey was conducted in the University of Brasília (UnB) to investigate the behaviors and the involvements of the university community in traffic accidents. The objective of this study is to verify if specific actions performed by the population – as pedestrians or drivers – are related to have experienced an accident, being both victims or responsible for it.

2. Method

The data was collected in the months prior to the Yellow May 2018 campaign, more specifically in March and April. The questionnaire was developed in the Google Forms® platform and it was spread exclusively online. The target audience was the public of the University of Brasília, that is, students, professors, collaborators, servants and others that used its services, such as the library, the restaurant and banks.

The questionnaire was anonymous, allowing the respondents to answer it as honestly as possible. Its goal was to raise people's awareness not only to their behaviors in traffic that may lead to accidents, but also to the problem that occurs in Brazil regarding the violence in traffic. Questionnaires have been used in many cases to investigate people's perceptions and behaviors in a transport system, such as Wu et al. (2018) and Dabbour et al. (2018).

To analyze the data, distinctive methods were used, in addition to the descriptive statistics. They are described in the following subsections. To compute these methods, the software SAS® was used.

2.1. Cochran-Armitage Trend Test

Armitage and Cochran emphasized the importance of ordinal categories in a contingency table, so they modified the Pearson chi-squared test in order to include the possibility of a progression between the variables. They used a linear probability model fitted by ordinary least squares, and the null hypothesis of independence is H_0: $\beta = 0$ (Agresti, 2007). If such hypothesis is rejected, with a specific level of significance, there is an association between the variables.

This test indicates only that there is a relationship, according to a p-value, but does not express the magnitude of the association.

2.2. Kruskal-Wallis Test

When there is data available in an ordinal form, the Kruskal-Wallis test can be an alternative to assure if several samples come from the same population. Kruskal and Wallis (1952) stated that, in some cases, ranking the variables might be a solution, because there is no assumption that the variables are normally distributed, as seen as in the chi-squared test. The test statistic (H) to be computed is:

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{c} \frac{R_i^2}{n_i} - 3 \times (N+1) \tag{1}$$

Where, C = the number of samples;
n_i = the number of observations in the ith sample;
N = the number of observations in all sample combined;
R_i = the sum of the ranks in the ith sample.

Large values of H lead to the rejection of the null hypothesis and can be compared to a level of significance, expressed by a p-value.

2.3. Odds Ratio

The odds ratio (OR) can be computed when there is a dichotomous response variable with outcomes event and nonevent (SAS, 2009). Used for 2x2 contingency tables, the ratio of the odds (θ) in two populations can be expressed by (Agresti, 2007):

$$\theta = \frac{\pi_1 / (1-\pi_1)}{\pi_2 / (1-\pi_2)} \tag{2}$$

Where, π = probability of success;

If an event is equally probable in both groups, the OR is equal to one. When it is greater than 1, the first group is more likely to have a success than the subjects in the second group, and vice-versa.

2.4. Linear regression

A linear regression model can be expressed by:

$$y = \alpha + \beta x + \varepsilon \tag{3}$$

Where, y = independent variable;
α, β = coefficients obtained from the regression;
x = dependent variable;
ε = standard error.

The model can be used for binary responses, but it can be employed only for a restricted range of x values, since linear functions take values over the entire real line. Most of the linear regression models use the maximum likelihood for a normal distribution with a constant variation, that is, the least squares (Agresti, 2007).

2.5. Ordered logit model

The ordered logit model is a regression model for an ordinal responsible variable. In such model, the logit of each cumulative probability is a liner function of the variables with constant regression coefficients (Grilli and Rampichini, 2014). Such model can be written as (Williams, 2006):

$$P(Y_i > j) = g(\mathrm{X}\beta_j) = \frac{\exp(\alpha_j + X_i\beta_j)}{1+\exp(\alpha_j + X_i\beta_j)}, \mathrm{j} = 1, 2, ..., \mathrm{M}-1 \quad (4)$$

Where M is the number of categories of the ordinal dependent variable and *i* is the number of dependent variables. The probabilities that *Y* will take on each of the values 1, …, M are equal to:

$$\begin{aligned} &P(Y_i = 1) = 1 - g(X_i\beta_1) \\ &P(Y_i = j) = g(X_i\beta_{j-1}) - \mathrm{g}(X_i\beta_j),\ j = 2, ..., M-1 \\ &P(Y_i = M) = g(X_i\beta_{M-1}) \end{aligned} \quad (5)$$

In this case, Y_i can be used to obtain the latent variables (Y_i^*), estimated by linear equations. These latent variables are segregated by ordered numerical values according to the categories of the independent variable (Coutinho et al, 2015). The structure of a latent model can be reduced to (Greene and Hensher, 2009):

$$Y_i^* = \beta_j X_i + \varepsilon_i \quad (6)$$

3. Results

The results will be presented in three specific sections, containing different approaches. Firstly, descriptive statistics were used to analyze the results of the questionnaire. Subsequently, statistics tests and quantitative indexes were obtained to verify how the behaviors (and also gender and age) were related to the involvement in traffic accidents. Finally, an attempt of the utilization of a logit regression model was conducted.

3.1. Descriptive Statistics

The sample consisted of 1287 respondents, in which 75,06% were students of the University of Brasília and 20,05% were professors or collaborators. The remaining 4,89% were related to former students or people not directly involved to the university, although they were users of some facilities in the campus, such as the library, that is open to the general public. Among such public, 46,23% were males and 53,22%, females. 7 people preferred not to inform the gender. Fig. 1 represents the age of the populations surveyed, divided by groups.

Besides that, it was asked the nature of their trips, in terms of the mode choice. 70,32% said that they drive an automotive vehicle on a regular basis or even daily, whereas 29,22% claimed that they exclusively used the public transport to make long distance trips. Also, 14,30% used bicycles for usual trips, including both inside the campus and throughout the city.

People were questioned to select behaviors that were common for them in the traffic system, including the ones related to pedestrians, drivers and bicycle users. Such results are presented in Fig. 2 with the corresponding behaviors shown in Table 1. It must be reinforced that the results are related to the amount of sample specific for the category in which the behavior applies to. For instance, the number of people who use the proper bicycle safety gear represented a significant percentage (35,87%) because it was compared to the 376 people that use such mode on their trips.

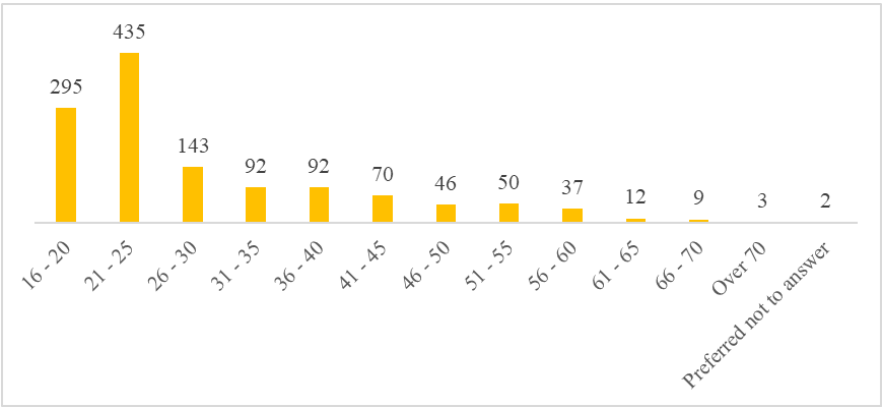

Fig. 1. Age of the Sample.

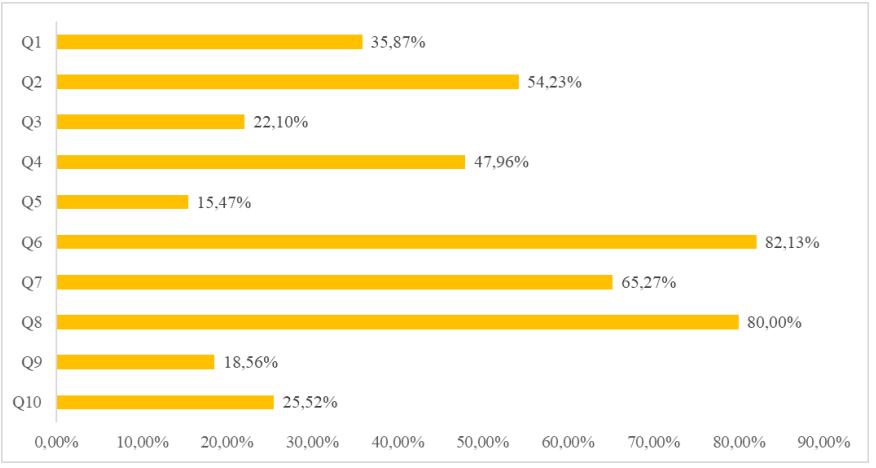

Fig. 2. Behaviors Performed by the Sample Related to the Involvement of Traffic Accidents.

Table 1. Questions used to Evaluate the Sample's Behavior.

Number	Question
Q1	I use the proper safety gear when I use a bicycle.
Q2	Sometimes I walk (on the sidewalk or in the crosswalk) typing on my phone.
Q3	I drive and talk on the phone at the same time.
Q4	Sometimes I read WhatsApp messages while driving.
Q5	I cross the traffic light that has just gotten red (or else I will have to wait a long time until the next opportunity).
Q6	When I am about to cross the street, I pay attention if drivers have seen me.
Q7	I always use the seat belt when I am on the rear seat of vehicles.
Q8	Sometimes I run over the speed limit.
Q9	Drinking and driving may be acceptable, depending on how much I have drank.
Q10	Sometimes I commit a park violation because the campus does not provide enough parking lots.

Such results bring important conclusions when it is emphasized that the survey was conducted in Brasília. Such city presents unique characteristics when compared to others in the country, including aspects related to the respect to the crosswalks and to the expressways inside the urban environment.

Since 1998, there has been an intense campaign to make drivers pay careful attention to the pedestrian crossings and stop whenever a person intends to get to the other side of the road. Through a great effort of advertisement and enforcement, today drivers widely respect the crosswalks and pedestrians are encouraged to make the "life signal", in which they make drivers aware of their intention to cross the street, signalizing it with a gesture.

Besides that, Brasília possesses many expressways, with at least two lanes for each traveling direction. Because they are inserted into the city, where there are numerous pedestrians and cyclists, the speed limits tend to be lower, generally 60 km/h. However, these expressways are characterized by many segments in tangent, with minimum curves, and this induces the development of higher speeds than the ones posted.

Because of these scenarios, it is consistent that more than 80% of the sample pay attention to drivers before crossing a street and run over the speed limit. Although it is great to see that more than 4/5 of the population surveyed properly uses the pedestrian crossing, the fact of people running over the speed limit indicates that solutions are needed to change this behavior. One alternative is to make the surrounding environment of these roads less similar to a highway and introduce elements that turns drivers' perceptions into an urban city, such as the mixed use of space and the reduction of wide areas (SeMob, 2015).

The results have also shown that talking on the phone while driving is a problem less severe than reading messages and texting, since the latter is more than double of the former. It is an evidence that specific campaigns must be developed in order to make drivers conscious of the possible outcomes of taking a look at the phone to read or answer messages, since it produces visual, cognitive and physical distraction (Caird et al., 2014).

15% of drivers admitted that they sometimes cross the traffic light that has just gotten red and such attitude may cause fatal accidents, mainly in high demanded intersections, since the chances of angle and sideswipe collisions increase. Moreover, despite Brazil's regulations regarding the problem of drinking and driving are well evaluated by the WHO (2015), almost 20% of drivers stated that there might be no consequence if they ingest alcoholic beverages before driving. These two behaviors are clear examples that there are actions that the population does not face as prejudicial, but they may represent a significative impact in road safety.

Many drivers commit park violations inside the campus because, according to them, the university does not provide enough parking lots. One example of a bad consequence of this action is the double parking, and it reduces the drivers' visibility when looking for parking spots. In extreme circumstances, this may influence collisions with pedestrians on their way to their vehicles.

It is important to see satisfactory results in terms of cyclists using appropriate gear and people wearing seat belts in the rear seat of vehicles. The usage of safety equipment, although they will not prevent the occurrence of traffic accidents, are good measures that can reduce the severity of them and, consequently, the number of fatalities.

Additional questions were asked to verify the involvement of the UnB's academics in traffic accidents. Such questions were not only used to investigate if they have ever been involved in crashes, but also to make them aware of the accidentality problem in Brazil. The results are presented in Table 2.

Table 2. Questions used to Evaluate the Sample's Involvement in Traffic Accidents.

Number	Question	Yes	No
Q11	Have you ever suffered or been involved in a traffic accident?	55,63%	44,37%
Q12	Do you know someone (family or friend) that has suffered or been involved in a traffic accident?	92,07%	7,93%
Q13	Have you ever lost someone close (family or friend) in a traffic accident?	32,17%	67,83%

Regarding Q11, the population could be more specific about their involvement. 41,48% of the people who have been involved in traffic accidents said that they contributed to it, independently if they were drivers, pedestrians or cyclists on that occasion. The remaining 58,52% assured that they were only victims or passengers during the traffic accidents.

It is noted that almost the totality of the sample surveyed (more than 92%) know someone close who has been involved in traffic accidents, so it is indeed a problem with the public of the university. In addition, more than 1/3 of the population lost someone due to traffic accidents. These results are an indication that additional campaigns must be conducted with this target group, not necessarily in May, but throughout the entire year.

3.2. Statistical Methods

In order to verify if the behaviors were related to the occurrence of traffic accidents, in a more general way, the sample was reduced to the people who identified themselves as at least casual drivers, answering positively questions Q3, Q4, Q5, Q8 and Q9, or that claimed that drove automotive vehicles on a regular basis. After such considerations, there were 904 respondents.

Besides that, questions Q2 and Q6 were included into the analysis due to the university's characteristic. The campus has a high extension and the majority of the population needs to change buildings and, to do so, they act as pedestrians, since it is needed to use crosswalks in most of the cases. Because of that, it was supposed that all the academics of the University of Brasília can be classified as pedestrians.

Q1, Q7 and Q10 were excluded because the number of cyclists was not significative and it was assumed that committing parking violations would not influence road safety as meaningfully as the other questions. Also, Q1 and Q7 are related to reducing the severity of traffic accidents and not the involvement.

Therefore, these seven questions (Q2, Q3, Q4, Q5, Q6, Q8 and Q9), as well as age and gender, were included into the analysis. It must be stated that the majority of the parameters have a binary response, except for the age, in which the data is numerical. For the gender, it was used that 1 = Male and 2 = Female.

Concerning Q6, it must be reinforced that this variable was, among the selected, the only one referent to a positive behavior. However, in order to unify the investigation and obtain coefficients that indicate the same aspects for all the questions, its answers were inverted, so that it could be interpreted as a negative behavior. This was possible because it as a binary question and it will influence the interpretation of both the odds ratio and the logit regression results.

These parameters were correlated to Q11 to investigate if any of these characteristics would influence the involvement in traffic accidents. To do such analysis, in terms of an association, the Cochran-Armitage and the Kruskal-Wallis tests were computed. The choice of these tests was done due to the ordinal property of Q11: never involved in traffic accidents, involved as victims or passengers or involved as a contributor to the accident.

The p-values and the corresponding statistics to measure these associations are presented in Table 3. The p-values indicate only if there is a relationship, concerning a level of significance, and do not state the magnitude of it.

Table 3. P-Values to Measure the Association between the Variables

Variable	P-value	Statistic
Age	< 0.0001	Kruskal-Wallis
Gender	0.0611	Cochran-Armitage
Q2	0.0028	Cochran-Armitage
Q3	0.0192	Cochran-Armitage
Q4	0.0004	Cochran-Armitage
Q5	0.0894	Cochran-Armitage
Q6	0.3870	Cochran-Armitage
Q8	0.1452	Cochran-Armitage
Q9	0.0157	Cochran-Armitage

With a level of significance of 10%, only questions Q6 and Q8 were not related to the involvement in traffic accidents and this can be explained due to the characteristics of Brasília. As previous highlighted, using crosswalks and running over the speed limits are behaviors so natural to the population (as shown in Fig. 2) that this might have biased the result.

To apply the odds ratio, since it requires 2x2 contingency tables, the Q11 was simplified into a yes or no response. Because of that, the results presented in Table 4 have not considered if the respondent classified himself / herself as a

victim (or passenger) or responsible for the accident. Table 5, still, shows the results for the linear regression used for age, considering that it is a numerical variable. The same consideration about Q11 was used to make possible the comparison between both methodologies.

Table 4. Results of the Odds Ratio for the Ordinal Variables

Variable	Value	95 % Confidence Intervals
Gender	0.927	0.709-1.214
Q2	1.402	1.071-1.837
Q3	1.148	0.823-1.603
Q4	1.458	1.110-1.915
Q5	0.975	0.654-1.452
Q6	0.902	0.635-1.281
Q8	1.108	0.811-1.515
Q9	1.251	0.867-1.806

Table 5. Results of the Linear Regression for the Variable Age

Parameter	Estimate	Standard Error	P-value
Intercept	0.4628	0.4364	< 0.0001
Age	0.0051	0.0013	< 0.0001

As stated before, values of OR greater than 1 indicate that the individuals in the group in which the variable is present have a bigger chance of being involved in traffic accidents. The only exception is related to gender, since it is a categorical (and not binary) data, and values smaller than 1 show that men are more propense to have experienced traffic accidents. Concerning the linear regression, a positive value for the variable refers to an increasing chance of being involved in an accident.

Q5 and Q6 presented an OR smaller than 1, although the index for Q5 was very close to the unity. However, the confidence intervals contemplated that, with a 5% level of significance, that such behaviors might also be associated to the occurrence of traffic accidents. Q6 demonstrated an unsatisfactory result as well, as seen in Table 3 with the usage of the Cochran-Armitage test.

Regarding the remaining variables, the values of the OR were consistent with expected: a negative behavior, such as reading messages and using the cell phone in the crosswalk, occasions the involvement in traffic accidents. The same interpretation applies for the fact of being male, since the OR was smaller than 1. The linear regression coefficient for age was positive, which indicates that older people are more likely to have been involved in traffic accidents and a possible explanation for that is the time of exposure.

3.3. Ordered Logistic Regression

The same variables used in the previous section were applied in an attempt of an ordered logit regression model. Therefore, Table 6 presents the estimates for the coefficients, the standard error and the p-values. The justification of the usage of such model is due to the ordinal characteristic of Q11, as previously displayed (never involved in traffic accidents, involved as victims or passengers or involved as a contributor to the accident).

In order to agree with the odds ratio and linear regression analyses, the coefficients, except the intercepts and gender, were expected to be positive. However, questions Q3 and Q6 produced divergent results in terms not only of the coefficient, but also due to the p-value.

The p-value, with a level of significance of 10%, considered that only the variables age, Q2 and Q4 properly fit the model. Both questions are related to the usage of texting or reading messages in the traffic system and they are consistent with the conclusions of Caird et al. (2014).

Although the p-values did not present good results, the estimates of the coefficients were coherent, since most of the negative behaviors indicated that they contribute to the involvement in traffic accidents.

Such high p-values may indicate several things:

- The size of the sample was not enough to produce better results;
- The technique for extracting information from the respondents was not efficient;
- The logit model does not fit the model. It is needed to find additional regression models to test the data from the questionnaire.

Table 3. P-Values to Measure the Association between the Variables

Parameter	Estimate	Standard Error	P-value
Intercept 1	-0.7330	0.3299	0.0263
Intercept 2	-2.1506	0.3372	< 0.0001
Age	0.0295	0.0056	< 0.0001
Gender	-0.1153	0.1261	0.3607
Q2	0.4457	0.1377	0.0012
Q3	-0.0871	0.1688	0.6056
Q4	0.4213	0.1430	0.0032
Q5	0.2185	0.1926	0.2565
Q6	-0.0621	0.1657	0.7076
Q8	0.0758	0.1537	0.6222
Q9	0.0161	0.1753	0.3587

Concerning questions Q3 and Q6, in which the estimates were negative, some points can be highlighted. Q6 produced not decent results in the three different approaches (Cochran-Armitage test, odds ratio and ordered logit regression). In addition to being a scenario very usual for the population of Brasília, in general, this was the only question that the answers were inverted to make the comparison clearer. Q3, on the other hand, refers to the usage of the cell phone when driving. The question did not make a specification about how the cell phone was being used (earphones, Bluetooth, speaker or holding the device) and this needs to be clarified in further studies.

4. Conclusions

Since human factors contribute the most to the occurrence of traffic accidents, specific actions need to be performed in order to reduce the negative behaviors in the transportation system, such as campaigns and enforcements. Through a questionnaire obtained as a result of a campaign, it was investigated if some variables were related to the involvement in traffic accidents. In most of the cases, the results were consistent in terms of coefficients, but the p-values were not all satisfactory, especially referring the ordered logit model.

Because of that, a reevaluation of the questionnaire is needed to verify if there are better ways of extracting data from the sample. Since the survey is to be done every year as part of the campaign, improvements are necessary to acquire the best information possible and also to make the population aware of the problem (in terms of questions Q11, Q12 and Q13). Also, a larger sample is expected, considering that this may be one of the reasons why the ordered logistic regression did not present the most satisfactory results.

For further campaigns, additional efforts must be made into the usage of cell phones when driving or walking (on the sidewalk or in the crosswalk), since it was the most significative element to the involvement of traffic accidents in all the methodologies used.

However, it must be stated that campaigns like this are expected to happen throughout the entire year and not only in May, because traffic accidents persist, specially in Brazil, where many efforts are still needed in road safety.

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