Correlation Study Between Transit Accident and Routes with Traffic Light Crossings in Rio de Janeiro City

Jaqueline M. R. Vieira and Gisele M. R. Vieira

Abstract**—**This article depicts the analysis of the correlation between traffic accidents and the traffic light crossing roads in twenty-one districts of the city of Rio de Janeiro, made through georeferenced data and in order to measure the flow of vehicles on the roads these neighborhoods. The Pearson coefficient was used as a way to assess the problem, which applied to data of accidents and crossings has important information about the intensity of this correlation. The main reason of this study is due to the high rate of fatal traffic accidents in Rio de Janeiro and the fact there is no specific data traffic flow in these neighborhoods studied. The methodology can provide insight for better understanding of the problem and it can be applied in other neighborhoods where also there is this kind of information.

Keywords**—**GIS (Geographic Information System), georeferenced, Pearson Coefficient, Traffic Accidents.

I. Introduction

EVERY year more than 1.2 million people die as traffic accidents victims in the world and more than ninety percent of these deaths occur in low-income and middle-income countries [1]. According to the report of the United Nations, deaths from traffic accidents are the leading cause of death in the population between 15 and 29 years and they will rise to become the fifth leading cause of death worldwide by 2030, considering all ages [2]. This report also presents Brazil as the fifth largest number of traffic accidents in the world. According to data released by the National Observatory for Road Safety (ONSV), in 2012 the Southeast region had 16,133 casualties of which São Paulo leads this list with more than 7,200 people have lost their lives in traffic accidents. The Rio de Janeiro follows with more than 6,000 deaths this year.

Factors that influence the occurrence of accidents are human, road-environmental and vehicular factors. According [3], the factors contributing to accidents belong to four interrelated groups: the human factors; vehicles; the road, prevailing conditions and built environment and institutional and social factors.

J. M. R. Vieira, Engineering Department, CEFET/RJ, Rua do Areal 522, Parque Perequê, Angra dos Reis, RJ, 23953-030, Brazil, (e-mail: jaqueline.cefetrj@gmail.com) and Defense Engineering Department, IME-Military Institute of Engineering, Praça General Tibúrcio 80, Praia Vermelha, Rio de Janeiro, RJ, 22291-270, Brazil.

G. M. R. Vieira, Mechanical Engineering Department, CEFET/RJ, Av. Maracanã 229, Maracanã, Rio de Janeiro, RJ, 20271-110, Brazil, (e-mail: gisele.vieira@cefet-rj.br).

Almeida [4] reports that the human factor is related to behavior, to education, including education in traffic, the ability of driving the vehicle, as well as the physical and psychological conditions of the individual. In the case of physical conditions, we can consider fatigue and alcohol, among others.

The need for scientific studies on this topic, also due to the fact reported by the World Health Organization, [2] which tells about the high number of traffic accidents in Brazil and the world, in a time where technology provides numerous features and is present in the life of the driving population of vehicles. This report reveals the need for this type of study to the best knowledge of the problem, contributing mainly to the reduction of the number of lives lost in these events.

Rocha [5] showed in his doctoral thesis, a methodology for the spatial analysis of georeferenced accidents in the city of Rio de Janeiro, using some model tests. He documented the multiple regression model showed the best results.

Claude [6] proposed in his work the development of an accident prediction model for intersections located in the urban arterial roads of Taguatinga, in the Federal District.

Robles [7] used the Pearson coefficient to evaluate the correlation between the data of accidents in twenty intersections in the city of São Carlos, São Paulo, and the signaling data. The tested universe was restricted to only 20 crossings. He evaluated the existence of a strong correlation at intersections controlled by STOP and an average correlation in traffic light crossings.

In Rio de Janeiro, there is no official data available that depict the flow of vehicles. Therefore, the importance of the study of methodologies for such representation is evident. The present work is inserted in this context. It proposes to evaluate the correlation between the number of intersections signalized in a group of 21 adjacent neighborhoods and the number of accidents at these locations. The hypothesis is that it is possible to evaluate the flow of vehicles in these neighborhoods through their respective numbers in traffic light crossings. Fig. 1 shows that the study area.

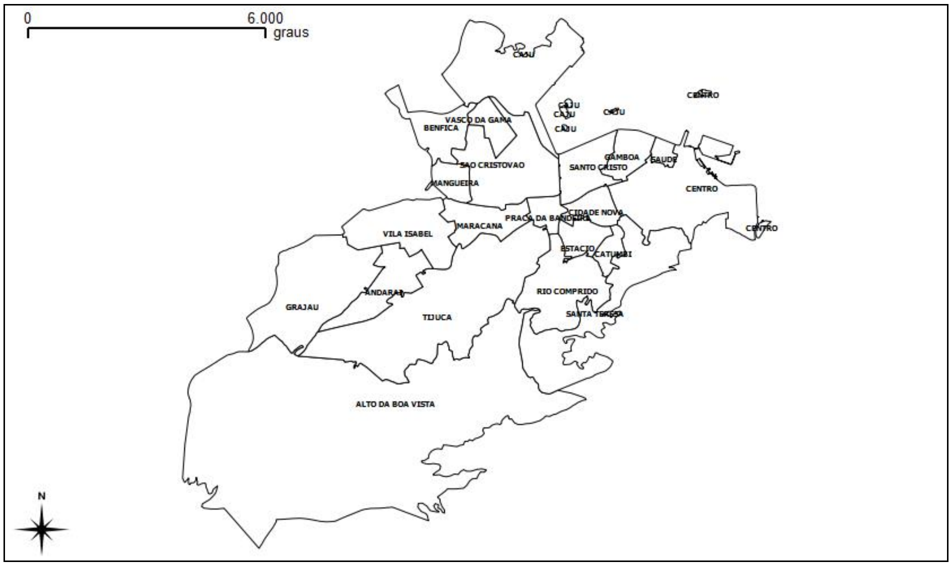

Fig. 1 - Map of the study area

Geographic data of this study were obtained from the cartographic database of the Pereira Passos Institute (IPP) of 1999. The data relating to accidents were obtained from the Traffic Accident Registration Bulletins (BRAT) of 2011. The Military Police of Rio de Janeiro is responsible for making such registration whenever material or physical damage occurs in the accident or both. By the year 2011, the records were made at the scene. Since 2012, the involved in traffic accidents have had the option to fill the data directly in units of the military police and soon afterwards it was also possible to register electronically (eBRAT).

The software used to represent and analyze the way crossings maps is the freeware QGIS version 2.10.1, available from the QGIS community in Brazil. From this representation of the study area is developed a visual analysis through the search and maps and satellite images visualization web service, Google Maps. This freeware service is used associated with QGIZ and such use is shown in Fig. 2 and Fig. 3. These figures show the manual operation of traffic lights identification at an intersection, covering the pathways and identifying the presence of traffic lights.

Fig. 2 - Crossings of Presidente Vargas Avenue represented by the grey marking

Fig. 2 shows how you can identify the exact presence of the cross and Fig. 3 shows the identification of the respective crossings through the Street View Google Maps, where you can view the presence of traffic lights.

Fig. 3 - View of traffic lights at Avenida Presidente Vargas through the Street View Google Maps

II. Methodology

Correlation analysis between the traffic light routes and the number of traffic accidents is performed using the Pearson correlation coefficient, which provides the measure of the degree of linear relationship between two quantitative variables and indicates the strength and the direction of the linear relationship between two variables. Pearson's coefficient (r) ranges from -1 to 1, as represented by (1). The sign indicates the positive direction of the relationship and the value suggests the strength of the relationship between the variables. A perfect relationship has the value of -1 or 1 and zero indicates no linear relationship between the variables.

$$r = \frac{\sum (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\left(\sum (x_i - \bar{x})^2\right)\left(\sum (y_i - \bar{y})^2\right)}} \qquad (1)$$

As the extreme values are not always found, it is important to evaluate the interpretation of the magnitude of these coefficients. Values between 0.10 and 0.29 may be considered small. Values between 0.30 and 0.49 may be considered as average values. Values between 0.50 and 1 can be interpreted as large values [8].

III. Application and Results

It can be seen in Table I that this research was based on data from 3,700 crossings of 21 neighborhoods of the central and northern region of Rio de Janeiro, of which 974 are controlled by traffic lights. The traffic accident data refers to 2011 and they were collected through reports recorded by the military police in the region. The types of accidents considered are: running over, collisions with the victim and collisions victimless. Data for running over were first considered because it is a small percentage and secondly for being used by some police officers to register collisions between cars and motorcycles. The exclusive semaphores pedestrian crossings were not counted because they are outside the scope of this article. Thus, the 4,260 crossings resulted in 3,700 corrected crossings.

Table I - Data referring to the 21 neighborhoods studied

NEIGHBOR.	CROSSINGS	TRAFFIC LIGHT CROSS.	ACCIDENTS	% TRAFFIC LIGHT CROSS.	CORRECTED CROSS.
ALTO DA BOA VISTA	168	11	322	7,86%	140
ANDARAI	166	18	401	10,84%	130
BENFICA	155	32	603	20,65%	120
CAJU	137	8	197	5,84%	110
CATUMBI	80	18	119	22,50%	72
CENTRO	724	270	4806	37,29%	640
CIDADE NOVA	132	21	609	15,91%	120
ESTÁCIO	91	16	295	17,58%	80
GAMBOA	109	7	277	6,42%	98
GRAJAÚ	198	63	407	31,82%	163
MANGUEIRA	75	6	121	8,00%	61
MARACANÃ	113	19	1100	16,81%	99
PRAÇA DA BANDEIRA	96	22	614	22,92%	81
RIO COMPRIDO	185	46	706	24,86%	169
SANTA TERESA	280	5	229	1,79%	235
SANTO CRISTO	139	28	929	20,14%	105
SAUDE	42	12	217	28,57%	36
SÃO CRISTOVÃO	344	52	1494	15,12%	302
TIJUCA	736	230	2241	31,25%	681
VASCO DA GAMA	68	18	169	26,47%	55
VILA ISABEL	222	72	1214	32,43%	203
TOTAL	**4260**	**974**	**17070**	**0,2286385**	**3700**

The Table I data are used by QGIS program. It provides several tools to generate relevant analysis such as the example of the Centro neighborhood in Rio de Janeiro, where you can see in Fig. 4 that 90% of 4,806 accidents indicated in Table I occurred at Presidente Vargas Avenue, which has 46 traffic light crossing represented with the red mark (dark color).

The President Vargas Avenue is a very important route in the Centro neighborhood in Rio de Janeiro and its 46 traffic lights are indicators of the flow of vehicles passing through it. Just as the Centro neighborhood in Rio de Janeiro, Fig. 5 shows the Tijuca neighborhood and the main concentration of accidents in Maracanã Avenue, the upper route, and in Conde de Bonfim Street, the road below the Maracanã Avenue.

Fig. 5 shows the information that the highest concentration of accidents in the Tijuca neighborhood is related to two way with high flow of vehicles in these locations. You can also check that these two routes have almost 80 traffic light crossings, a strong indicator of high flow of vehicles there.

From the data presented in Table I is calculated the Pearson coefficient for the evaluation of the correlation between traffic light crossings and the number of accidents. The obtained value of 0.914972 (Pearson coefficient 1) gives an indication of the existence of a strong correlation between the data presented. As well as being close to unity, the greater is the indication of a static dependency between the data. This represents that since the larger the number of traffic light intersections, the larger the number of accidents and the indication of high flow of vehicles in the area.

This study conducts a second analysis using Pearson's coefficient. This second analysis is to evaluate the correlation between the number of accidents and the proportion of traffic light crossings. The value found is 0.544227 (coefficient of Pearson 2) and it indicates medium-to-strong correlation, according [8]. This value is influenced by some specific realities that are outside of what we want to prove in this work. The example of this is the fact that some neighborhoods with a low percentage of traffic lights present a high accident rate, as the case of Alto da Boa Vista with only 7.8% of traffic light crossing and the total of 322 accidents. Similarly, other neighborhoods with a high percentage of traffic lights, as the case of Grajaú, with 31.8%, that has only 407 accidents, a number considered low for the respective percentage of traffic light crossings.

In order to strengthen the conclusions of the study with the Pearson coefficient, an analysis was elaborated using classifications with equal intervals and it is shown in Fig. 6, Fig. 7 and Fig. 8. In all applications of this classification, we used four classes with the aim of grouping neighborhoods with similar characteristics and to comparing these regions. Fig. 6 shows the classification of neighborhoods studied according to the percentage of intersections with traffic lights, where it can be observed that the Centre, Tijuca, Vila Isabel and Grajaú neighborhoods have the highest percentage of traffic light crossings.

Fig. 7 shows the classification of the 21 neighborhoods in the number of accidents. We can observe that the largest number of accidents occurs in the Centro neighborhood.

Fig. 4 - The red marking (dark color) represents the accidents in the Centre neighborhood in Rio de Janeiro and the grey marking is their crossings (QGIS Software associated with Google Maps)

Fig. 5 - The marking red (dark color) represents the accidents in the Tijuca neighborhood in Rio de Janeiro and the grey marking is their crossings (QGIS Software associated with Google Maps).

Fig. 6 also shows the Centro in the neighborhood group with the highest percentage of traffic light crossings, which contributes greatly to prove the hypothesis presented in this work.

Fig. 8 shows the classification according to the amount of traffic light crossings and presents the neighborhoods of Centro and Tijuca as the neighborhoods with the highest amount. This analysis again provides indicative of the high flow of vehicles in these neighborhoods.

It is important to consider the risk that each individual is subject, from the moment you decide to move from one place to another, either on foot or by vehicle. This exposure can be defined as the rate of contact with a potentially harmful agent or event. Pedestrian or vehicle exposure is therefore defined as the rate of pedestrian or vehicle contact with potentially harmful situations involving moving vehicles [9].

The time spent in traffic has always been a recommended indicator of what road safety specialists call a measurement of risk exposure. Considering the pedestrian, the time of exposure can be defined by the time spent by them for crossing a road of a certain width with a particular walking speed, whereas the pedestrian would be at risk only at the time that would be in contact with a road with vehicle flow [10]. The tendency is that in places where people are most at risk, there are more accidents [5]. Just as with pedestrians, the vehicles risk exposure indicator can be defined as the time taken to travel between two points, which depending on the distance to be traveled, the used speed and the movement of vehicles and/or pedestrians on the road it can be larger or smaller. This factor is linked to the duration time of the displacement associated with the flow of vehicles, as a greater risk will occur when you are traveling a long distance in a high flow route.

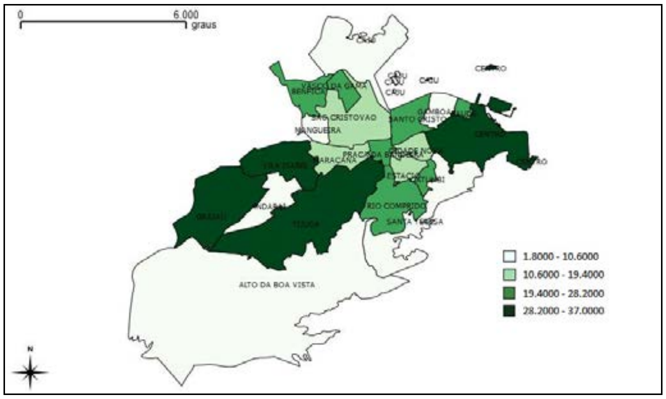

Fig. 6 - Classification according to the percentage of traffic light crossings.

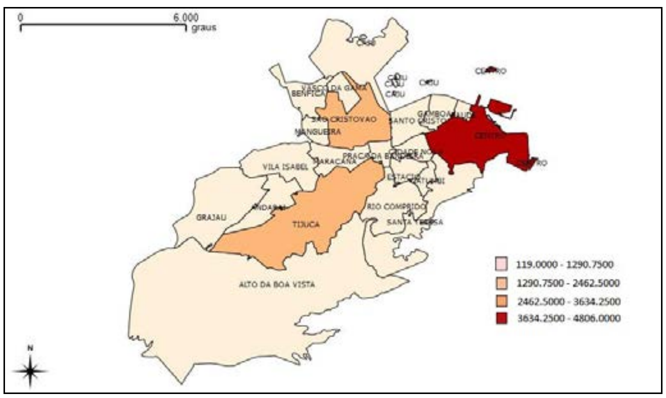

Fig. 7 - Classification according to the number of accidents in the neighborhoods

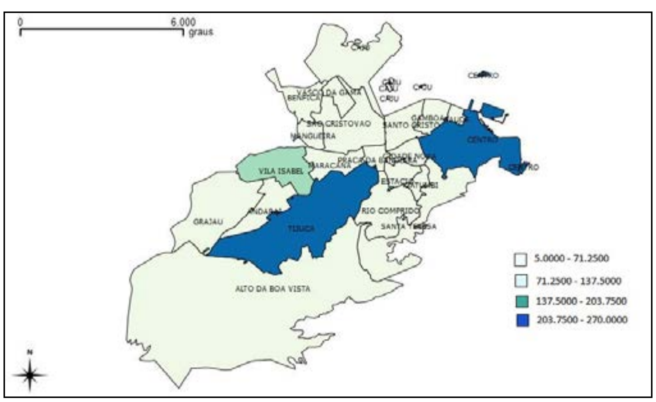

Fig. 8 - A classification according to the number of traffic light crossings

IV. Conclusions

The methodology proposed in this paper confirms the hypothesis that the number of accidents is associated with the number of traffic light intersections, which characterizes a heavy traffic flow. Using the Pearson coefficient between the number of accidents in these neighborhoods and the number of traffic light crossings has the value close to the unit, which proves the existence of a strong relationship between these data.

The second analysis using the Pearson coefficient between the percentage of traffic light crossings and the number of accidents have resulted in the value 0.544227 (Pearson coefficient 2). It indicates a medium-to-strong correlation. The hypothesis of this work is to prove the relationship of neighborhoods with high rates of traffic light crossings with the high rate of accidents. It can be seen from the presented analysis.

For further research, the inclusion of demographic and business data to characterize the flow of vehicles in these neighborhoods of Rio de Janeiro is suggested. In addition, it would be also important to use the Spearman correlation coefficient to test correlations and to make a comparison with the Pearson coefficient. Another important consideration it would be the use of accident data for other years and finally to test the methodology presented in other neighborhoods of Rio de Janeiro and other states.

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