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Geographic distribution of deaths among elderly due to traffic accidents*

Distribuição geográfica dos óbitos de idosos por acidente de trânsito

Distribución geográfica de fallecimientos de ancianos por accidentes de tránsito

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ABSTRACT

Objective: Analyze traffic accidents with fatalities involving elderly people according to the condition of the injured subjects, place of occurrence and cause of death, preparing maps of geographic distribution. **Methods:** A cross-sectional study was developed at the Police Station for Traffic Crimes Punishment in Teresina in 68 accident and police investigation records from 2010 to 2011. Local Moran Index and Kernel density were used for spatial analysis. **Results:** Regarding the condition of the elderly at the time of the accident, 57.3% of the deceased were pedestrians. In regard to the place of occurrence and the first cause listed, it was found that 49.6% of the deaths occurred at the scene, with multiple trauma being the major cause. **Conclusion:** The deaths were concentrated in urban areas, with agglomeration of neighborhoods with a high rate of traffic accidents, presenting positive correlation, also highlighting the existence of regions with higher density of occurrences.

Keywords: Elderly; Traffic accidents; Death; Spatial analysis.

RESUMO

Objetivo: Analisar os acidentes de trânsito envolvendo idosos em que ocorreu desfecho fatal, segundo condição do acidentado, local de ocorrência e causa do óbito, elaborando mapas de distribuição geográfica. **Métodos:** Estudo transversal realizado na Delegacia de Repressão aos Crimes de Trânsito de Teresina, em uma população de 68 boletins de registro de acidente e inquéritos policiais de idosos nos anos de 2010 e 2011. Na análise espacial utilizaram-se o Índice Local de Moran e a densidade de Kernel. **Resultados:** Em relação à condição do idoso no momento do acidente, comprovou-se que 57,3% dos óbitos foram de pedestres. Considerando o local de ocorrência e a primeira causa registrada, constatou-se que 49,6% ocorreram no local do acidente, a maior causa o politraumatismo. **Conclusão:** Os óbitos concentraram-se na área urbana, com aglomerado de bairros com alta ocorrência de acidente, apresentando correlação positiva, evidenciando também a existência de regiões com maior densidade de ocorrências.

Palavras-chave: Idoso; Acidentes de trânsito; Óbito; Análise espacial.

RESUMEN

Objetivo: Analizarlos accidentes de tránsito que involucran apersonas de edad avanzada que se produjeron desenlace fatal, de acuerdo a la condición áspera, lugar de ocurrencia y causa de la muerte, la elaboración de mapas de distribución geográfica. **Métodos:** Estudio transversal en el Precinto Represión de Delitos de Tráfico de Teresina, en una población de boletines ficha 68 accidentes y las investigaciones de la policía en 2010y 2011. El análisis espacial se utilizó el índice de Moran ubicación y la densidad Kernel. **Resultados:** En cuanto a la condición de personas de edad avanzada en el momento del accidente, se encontró que57,3% de las muertes fueron peatones. Teniendo en cuenta el lugar de ocurrencia y la pregunta primero registrado, se encontró que el 49,6% estaban en la escena, siendo la mayor causa del politraumatismo. **Conclusión:** Las defunciones se produjeron en la zona urbana, con el racimo de los barrios con alta incidencia de accidentes, y positivamente relacionados, mostrando también la existencia de regiones con mayores ocurrencias de densidad.

Palabras clave: Anciano; Accidentes de tránsito; Muerte; Análisis espacial.

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INTRODUCTION

Worldwide, 5.8 million people die every year as a consequence of trauma, which corresponds to 10% of all deaths, of which about one-quarter are due to traffic accidents[1].

Mortality rate as result of these accidents in middle-income countries is 20.1 per 100,000 inhabitants, whereas in high and low-income countries it is 8.7 and 18.3 per 100,000 inhabitants, respectively. Therefore, middle-income countries present the highest rates, representing 80% of the worldwide deaths due to accidents, although they represent 72% of the world's population and only own 52% of all the worldwide registered vehicles[2].

Brazil has high mortality rates caused by road accidents. According to the Global Status Report on Road Safety, the situation is worrying, since the country ranks the fifth position in road accident death rate in the world, behind countries such as China, India, Russia and the United States[3].

Parallel to this, among the main changes the country has gone through in the last century, the demographic revolution stands out, with an increase in the percentage of the elderly population, from 9.1% in 1999 to 11.3% in 2009, which currently accounts for over 22 million people, exceeding the number of elderly individuals in several European countries such as France, England and Italy, as estimated by the United Nations[4].

Furthermore, it is particularly worth mentioning data found in a systematic review of the Brazilian academic production about external causes and violence within the elderly population, which identified, from the death rate point of view, the prominence of traffic accidents among this population[5].

In the light of this reality, the authors of this study decided to investigate the elderly mortality rate in this specific region of the country, with the purpose of analyzing traffic accidents with fatal outcome, according to the elderly condition, place of occurrence and cause of death, by producing geographical distribution maps.

METHODS

A cross-sectional study was developed with data obtained from the Police Station for Traffic Crimes Punishment in Teresina, in a population comprising 68 accident and police investigation reports of elderly individuals from both genders, living in this capital city, who had been victims of traffic accidents in this city, between 2010 and 2011, with a fatal outcome. Data were collected by using a form validated by experts in trauma care and descriptively analyzed using the software Statistical Package for the Social Sciences (SPSS).

For spatial analysis, the addresses of the places where the accidents occurred, resulting in death, were geocoded. The points were marked with the use of a global positioning system (GPS), the Garmin Etrex Legend GPS Receiver. After the geocoding, the points were gathered into a single shapefile for the development of maps through the Geographic Information

System (GIS), using the software Terraview 4.2.2, provided by the National Institute of Spatial Research (INPE, as per its acronym in Portuguese).

The cartographic base of the city of Teresina was used, and spatial autocorrelation was determined through the Local Moran's I with a Box Map. The punctual intensity of the event was also investigated and examined through the Kernel smoothing method.

The study proposal was submitted to the Human Research Ethics Committee and approved under CAEE Nº 02342412.9.0000.5393.

RESULTS

Table 1 describes deaths among the elderly victims of traffic accidents, considering age groups. A mean age of 69 (SD = 6.7), median of 68, and variation between 60 and 90 years was found. Most deaths occurred among men (75%) and the age group between 60 and 69 years (54.4%). Regarding the condition of the elderly at the time of the accident, it was proved that 57.3% of the deceased ones were pedestrians. Considering the place of occurrence and the first cause recorded on the death certificate, 49.6% of the deaths occurred at the accident scene, and the major cause was multiple trauma (39.5%), followed by traumatic brain injury (23.5%). Regarding the deaths occurred in the hospital, most occurred in the emergency room (22.2%).

Figure 1 shows the punctual distribution of places where traffic accidents with the elderly occurred, according to the death occurrence site. There was a concentration of deaths caused by traffic accidents in the urban area, but a significant number was also observed in the city rural area.

Of the 68 deaths registered at the Police Station for Traffic Crimes Punishment in the researched period, 34 occurred at the accident site itself and 34 occurred later. Among those that occurred later, 28 were in health centers where the elderly were assisted after the accident, and six occurred at their homes after hospital discharge, having been recorded in medical reports as caused by traffic accidents. Among deaths that occurred in the hospital, most were in the emergency room.

Figure 2 presents the Box Map of the elderly deaths caused by traffic accidents in Teresina. In this quantitative Box Map of deaths occurred in Teresina in 2010 and 2011, neighborhoods in dark grey present high death numbers caused by traffic accidents, with a positive correlation, and neighborhoods in light grey present low death numbers caused by traffic accidents with a positive correlation. In this respect, the neighborhoods of Santa Maria da Codipi, Zoobotânico, Piçarreira, Morada do Sol, Nossa Senhora de Fátima, Horto, Jóquei, São Cristovão, Santa Isabel, Gurupi, Tabuleta, Redenção, Lourival Parente, São Lourenço and Parque Piauí, located in caption 1, exhibited high death numbers caused by traffic accident with a positive correlation.

Neighborhoods in medium grey also presented high death occurrences. However, for being surrounded by neighborhoods

Table 1. Distribution of elderly deaths by traffic accident according to age group, gender, condition of the elderly, place of occurrence and cause of death. Teresina, Piauí, 2010/2011

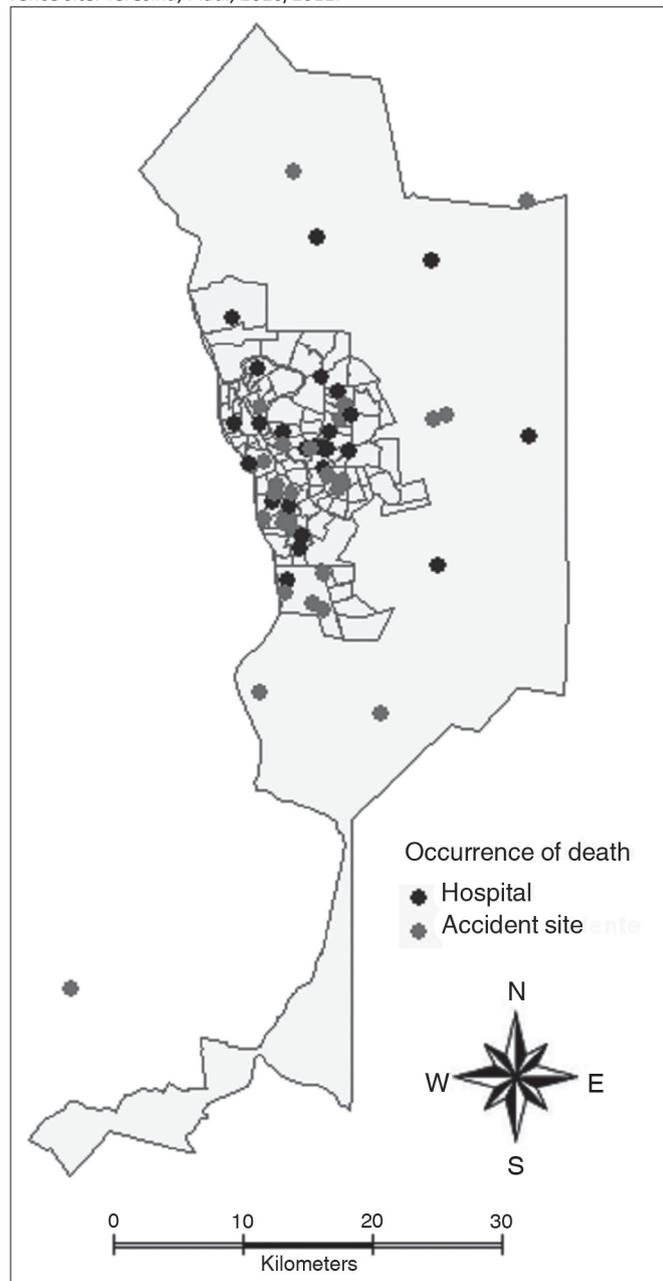| Variables | Mean (SD) | Median | Variation | Age group (years) | | | | | | Total | |
| | | | | 60 to 69 | | 70 to 79 | | ≥ 80 | | | |
				N	%	N	%	N	%	N	%
	69 (6.7)	68	[60; 90]								
Gender											
Male				31	45.6	16	23.5	4	5.9	51	75
Female				6	8.8	10	14.7	1	1.5	17	25
Elderly condition											
Pedestrian				15	22.2	20	29.2	4	5.9	39	57.3
Motorcyclist				10	14.6	2	3.0	-	-	12	17.6
Car occupant				6	8.8	1	1.5	1	1.5	8	11.8
Cyclist				5	7.3	2	3.0	-	-	7	10.3
Unknown				1	1.5	1	1.5	-	-	2	3.0
Place of death											
Accident scene				20	29.2	12	17.4	2	3.0	34	49.6
Emergency room				6	8.9	6	8.9	3	4.4	15	22.2
Home				4	5.9	2	3.0	-	-	6	8.9
Intensive care unit				3	4.4	3	4.4	-	-	6	8.8
Nursing ward				2	3.0	1	1.5	-	-	3	4.5
Surgical center				1	1.5	1	1.5	-	-	2	3.0
Recovery room				1	1.5	1	1.5	-	-	2	3.0
Death cause											
Multiple trauma				13	19.0	12	17.5	2	3.0	27	39.5
Traumatic brain injury				8	11.7	6	8.8	2	3.0	16	23.5
Respiratory failure				7	10.2	4	5.9	-	-	11	16.1
Cardiac arrest				1	1.5	2	3.0	-	-	3	4.5
Hypovolemic shock				2	3.0	1	1.5	-	-	3	4.5
Cervical fracture				1	1.5	1	1.5	-	-	2	3.0
Cerebral edema				1	1.5	-	-	1	1.4	2	2.9
Thromboembolism				1	1.5	-	-	-	-	1	1.5
Meningoencephalitis				1	1.5	-	-	-	-	1	1.5
Septicemia				1	1.5	-	-	-	-	1	1.5
Post-traumatic stress disorder				1	1.5	-	-	-	-	1	1.5
Total				37	54.4	26	38.2	5	7.4	68	100

with lower numbers of deaths, such as Angelin, Três Andares, Cidade Nova, Dirceu, Centro, Primavera, Real Copagre, Mocambinho, Porto do Centro, and Vale quem Tem, they presented a negative correlation. Finally, the neighborhoods in black color showed low number of deaths, surrounded by neighborhoods with significant death occurrences, verifying a negative correlation.

Figure 3 shows the Kernel density estimate of elderly deaths. The figure presented above found clear concentrations of death occurrence points in two areas of the city of Teresina. The first one comprising the area of the neighborhoods of São João, Recanto das Palmeiras, São Cristovão, São Raimundo and Santa Isabel. The second area of concentration of points comprises the area

Figure 1. Elderly deaths caused by traffic accidents, according to the occurrence site. Teresina, Piauí, 2010/2011.

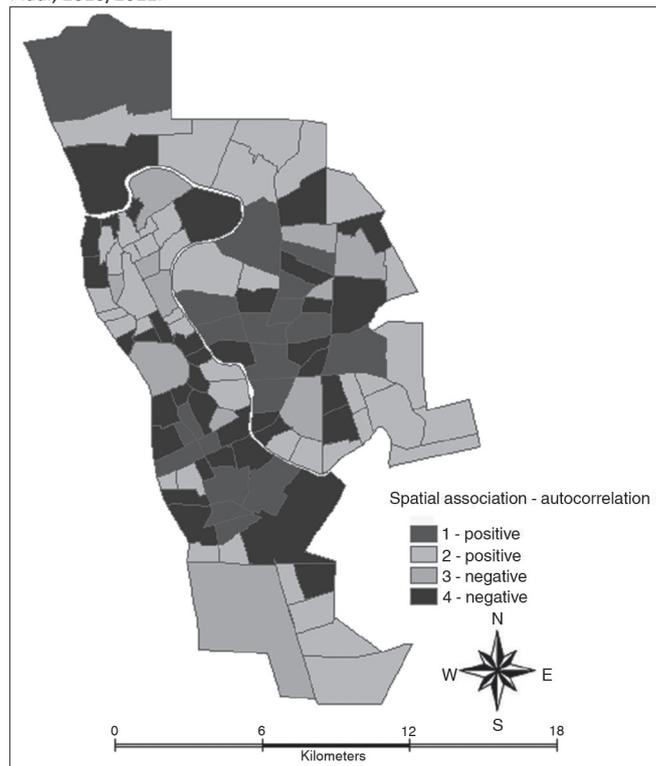**Figure 2.** Box Map of elderly deaths caused by traffic accident. Teresina, Piauí, 2010/2011.


by gender and age by the Brazilian Health System Information (DATASUS[7], as per its acronym in Portuguese) for 2011. Hence, these are higher numbers than the ones reported by the Ministry of Health for this age group in 2010, which corresponded to 30.8 deaths per 100 thousand inhabitants[8].

In the United States of America, from 2000 to 2006, the mortality rate due to car accidents with people aged 65 years or older decreased 13%, but the mortality rate caused by accidents with motorcycles increased 145.8%. As regards morbidity, there was a reduction of 16% of injuries in car occupants, but an increase of 86% was observed in injuries involving motorcycles[9].

A study conducted in Turkey with 2,003 patients to determine the traffic accidents epidemiology and analyze costs verified an increase of mortality rate as age advanced, and such fact was attributed to the presence of comorbidities and weaker compensation mechanisms among the elderly[10].

In Brazil, the mortality rate by road traffic accident per 100 thousand inhabitants in Brazilian capital cities in 2007 showed that among ten cities with higher risks, five were located in the Northern region, four in Center-west region and one in the Northeast region. Teresina was the ninth largest northeastern capital city in road traffic accidents, with a standardized and gross mortality rate of 22.3 and 21.5 per 100 thousand inhabitants, respectively. Among Brazilian capital cities initially selected for the project Vida no Trânsito (Life in Traffic), Teresina presented the highest growth in vehicle fleet in the first four months of 2010, corresponding to 4.2%[3].

of the neighborhoods of Tabuleta, Redenção, Morada Nova, Triunfo and Lourival Parente.

DISCUSSION

The coefficients of mortality by traffic accident among the elderly population for the city of Teresina in 2010 and 2011 corresponded to 43.4 and 54.4 deaths per 100 thousand inhabitants, respectively, based on the last census for 2010[6] and the Brazilian Institute of Geography and Statistics (IBGE, as per its acronym in Portuguese) population estimate, stratified

Figure 3. Kernel density estimate of elderly deaths caused by traffic accident. Teresina, Piauí, 2010/2011.
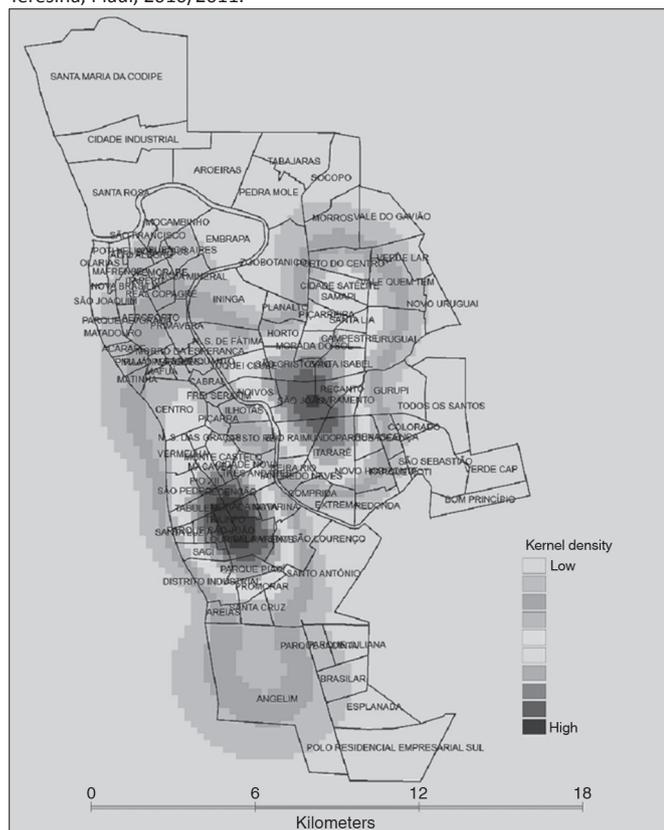
A study conducted in Minas Gerais with information recorded at the Mortality Information System database, highlighted the significant coefficient of mortality by traffic accidents among the elderly, which were the second category of death by this cause. In this age group, traffic mortality was 2.5 times higher than the total of deaths of children and adolescents, with a mean number of deaths of 85.22 elderly people/100,000 inhabitants per year[11]. In another study conducted in Minas Gerais about mortality among the elderly by external causes, between 1999 and 2008, the coefficients of transport accidents throughout the researched period were considered high[12].

Based on the presented data, it was observed that the mortality rate by traffic accident among the study's elderly population was higher than that verified in the country. It is believed that the deaths among the injured elderly of this study were caused by several factors, such as the anatomical and functional alterations of the injured elderly, associated with the occurrence of certain diseases, and conditions of public roads, one of them being the short time of traffic lights. It is also believed that another factor for these deaths was the conductors' particular way of driving their vehicles, especially motorcyclists, who often drive at a fast speed, higher than that permitted by law, maybe due to the commercial rules established between employers and clients[13]. It is also important to mention health care services, taking into account that the municipal reference service to trauma care of Teresina is often with its occupancy rate above its service capacity.

In this study, considering the condition of the deceased elderly due to traffic accidents, it was found that most of them were pedestrians. In a study conducted in the United States, the mortality rate of elderly individuals was significantly higher than that of non-elderly people. As regards pedestrians, the mortality rate was twice that of the non-elderly, although they presented similar scores in the trauma severity level at the time of their admission[14].

In Brazil, pedestrians amounted almost one third of the deaths by traffic accidents, about 10 thousand deaths per year, between 1998 and 2008[15]. A study conducted in the city of Campinas proved that of every one thousand accidents involving motorcycles, four had caused the death of pedestrians, with records of 6.7 deaths of pedestrians run over by motorcyclists, to one fatal run over by car. Furthermore, promoting awareness concerning safe driving among conductors, especially of motorcycles, combined with the intensification of control and innovation in monitoring motorcyclists remain a challenge[16].

Considering this context and the significant growth in vehicle fleet observed in Teresina, preventive measures are needed to reduce factors that contribute for the occurrence of accidents with elderly pedestrians. With this in mind, it is noticed that in order to maintain the health and safety of this population, it is of upmost importance to reduce risks that aggravate their health, with the planning of gerontological measures for the prevention of run over occurrences. However, a better control by traffic authorities is also necessary, with interventions towards conductors' awareness, maintenance of public road conditions and speed control by means of systematic and comprehensive control, with adoption of punitive measures for traffic violators.

By examining places of deaths, it was found that most deaths occurred at the accident scene, caused mainly by multiple trauma, thus showing the elderly's greater vulnerability, probably due to the reduction of physiological reserve. Among the hospitalized individuals, most deaths occurred in the emergency room.

In this respect, the need for a more rigorous evaluation for correct diagnosis of the injured elderly has been discussed, both for first aid and re-evaluation at the time of hospital discharge. In this context, the role of experts in gerontology in medical care teams is of utmost importance to the elderly traumatized, as recommended by the Statute of the Elderly[17], as well as the incentive for continuous training and education of professionals, as indicated by the Health Pact[18].

A study conducted in the United States recommended special attention for the elderly, victims of trauma, since the higher the number of admissions by this cause in this age group, the higher the importance of care improvement and prevention of complications. The study also indicates multidisciplinary care so that this vulnerable population may return to their heathy functional condition previous to the injury occurrence[19].

It is worth mentioning the need for third-party evaluation for severe cases, in victims with difficulty in expressing their complaints and those with neurological sequelae, since

in these groups, the number of hidden injuries increases significantly, which may occur with the elderly, even because of communication difficulties[20].

Reinforcing the issue related to the presence of professionals in gerontology in care teams for elderly victims of accidents and violence, the researchers of a study that analyzed Brazilian hospital services for elderly victims of accidents and violence in five Brazilian capital cities, reported that medical care for these patients is difficult for the services, due to the need for a multidisciplinary team[21], which is not observed in most Brazilian emergency services.

In addition, traumatized elderly individuals with risk clinical factors associated with acute injury require early monitoring, since their hemodynamics conditions may be masked with associated diseases and use of medications. There is also the risk that neurological symptoms may be mistaken with the altered state of the level of consciousness related to the age. For this reason, services must develop specific protocols, considering that these symptoms may be found in the traumatized elderly[20].

Therefore, the qualification of professionals who work in this area is important for the identification, practice, monitoring and appropriate referral of accident and violence cases with the elderly, and this training must begin in undergraduate courses, with further specialization in graduate courses. However, these concerns must also be understood by the institutions, with the adoption of coherent actions, such as adequacy of resumes, provision of special training courses, community and inter-sectoral interaction in this field[22].

On the other hand, it was also observed that for a complete analysis of death occurrences by traffic accident, complete record of the occurrence sites are needed, since this is the only way to accurately distinguish the risk areas of such occurrences.

Despite the evolution of the Mortality Information System, there is still a need for improving information quality, especially in the identification of different types of external causes[23]. Among them, traffic accidents draw attention, since their occurrence site is not always recorded appropriately. Often, only the place of death occurrence is informed, which is not always the accident occurrence site.

The present study is the first to use the spatial analysis technique to investigate the deaths of the elderly by traffic accident in Teresina, of which 92.6% of positive results of the accident addresses were found in police records filed by the repression for traffic crimes agency. The mentioned capital city is subdivided into 114 neighborhoods, distributed into five regions: city downtown, and northern, southern, eastern and southeast zones.

The figure illustrating the deaths by occurrence site enabled the clear visualization of the number of accidents with fatal victims in the urban area of the city. However, the number of occurrences in the rural area draws attention, demonstrating that in this area, although traffic is lower, other factors may be intervening to the occurrence of fatal accidents, such as speed excess, lack of inspection and speed control devices, besides the environmental conditions found in the area rural roads, such as the precarious pavement conditions and the presence of animals on lanes (Figure 1).

The areas with high risk of death indicated by the Box Map, as well as areas of high death density demonstrated by the Kernel density in some neighborhoods of the city, allows inferring the existence of a pattern in the occurrence of these events. A similarity was observed when comparing the places of accidents in which victims died in the hospital and those accidents in which deaths occurred at the place itself, that is, it was verified that areas with high occurrence of accidents are the same in both situations (Figure 3).

A possible hypothesis for the high rates of accidents found in neighborhoods such as Zoobotânico, São João, Recanto das Palmeiras, São Cristóvão, Santa Isabel and Gurupi is based on the existence of state highways, such as the PI-112 and the PI-113 that link the capital city to the north of the state and the BR-343, a diagonal federal highway that links the state capital city to the coast, and links Piauí to the state of Ceará. Likewise, the neighborhoods of Tabuleta, Redenção, Lourival Parente, São Lourenço, Parque Piauí and Angelim are located around highway PI-130, which leads to the state southeastern cities as well to the highway BR-226, a cross-country road that links the Northeast region to the Center-west region, and the BR-316, a diagonal federal highway that links the state to the country's North region (Figure 3).

On the other hand, it was also verified that neighborhoods such as Dirceu Arcoverde, the most populous of the city and others such as Piçarreira presented a high number of fatal accidents (Figure 2). These neighborhoods, in turn, have intense trade, schools, health centers and markets around them, which attracts many people, especially pedestrians, who, with the high number of motor vehicles, including buses, generate a higher risk and exposure for more vulnerable users, the elderly amongst them.

It is important to note that neighborhoods such as Nossa Senhora de Fátima, Horto and Jóquei Clube, located in the most upscale area of the capital city, also presented high death occurrences (Figure 2). Such neighborhoods have a high concentration of pubs and restaurants, which may encourage the consumption of alcoholic beverages, factor that is relevant to traffic accidents.

A cross-sectional study conducted with data of 13,305 road accidents registered in 2008 and 2009 in Ciudad Juarez in Mexico identified, by means of spatial analysis, the risk areas of these occurrences and showed the possibility of low cost measures for the reduction of mortality rates and injuries. This leads to the conclusion that this technique is helpful to define areas with high level traffic accidents, implement a preventive approach and establish itself as a supporting tool for road safety measures[24].

A Brazilian study using spatial analysis highlighted the importance of preventing and ontrolling these occurrences. A study conducted in Pernambuco aiming to characterize the

epidemiological profile of traffic victims and the distribution of services by transport accident based on spatial analysis, showed the utmost importance of the integration between the healthcare sector and other agencies for the implementation of preventive and corrective measures[25].

A study conducted in São Paulo, with the use of spatial analysis to identify city agglomerations with a high level of admission rates by motorcycle accident, highlighted the importance of this analysis technique for the implantation of interventions in areas with high occurrence of accidents[26].

Another study conducted in São Paulo, for the identification of spatial agglomerations of micro-regions according to death rates by traffic accident before and after the amendment of "Lei Seca" (an anti-drinking and driving law), concluded that most micro-regions had worsened their rates and showed places where surveillance activities must be reviewed to ensure higher prevention and traffic safety[27].

CONCLUSION

The present investigation showed that the main importance of the spatial analysis consisted in being characterized as an important tool for the identification of agglomerations that have high death risks by traffic accident, highlighting areas with a high number of accidents. It is particularly worth mentioning the importance of this technique for the determination of priority areas for the implementation of interventions for prevention and control of these events, enabling actions of public management from different areas, as well as of health care professionals working in several health care programs from different groups of users of the health system, especially those who are more vulnerable, such as the elderly.

The development of further studies about this issue with the use of the spatial analysis technique may be of utmost importance for the region's public health.

ACKNOWLEDGEMENT

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