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Artigo original

Epidemiological profile, temporal trend and spatial analysis of the mortality of traumatized pedestrians in land transport collision in Alagoas, Brazil, 2007-2016

Perfil Epidemiológico, tendência temporal e análise espacial da mortalidade de pedestres traumatizados em acidentes de trânsito em Alagoas, Brasil, 2007-2016

Perfil epidemiológico, tendencia temporal y análisis espacial de la mortalidad de peatones lesionados en accidentes de tránsito en Alagoas, Brasil, 2007-2016

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RESUMO

Introdução: Os pedestres, juntamente com os ciclistas e motociclistas, constituem o grupo mais vulnerável aos acidentes de trânsito no Brasil e no mundo. Objetivou-se analisar o perfil epidemiológico, a tendência e a distribuição geográfica da mortalidade de pedestres em acidentes de transporte terrestre em Alagoas, Brasil, 2007-2016. **Métodos**: Estudo ecológico incluindo todas as mortes de pedestres em acidentes de transporte em Alagoas, Brasil, 2007-2016 (código V00 a V09 da classificação internacional de doenças). Foram analisadas variáveis sociodemográficas e as taxas de mortalidade por sexo. Para análise estatística, foi utilizado o modelo de regressão do ponto de inflexão, o modelo bayesiano empírico local e a estatística de varredura espacial. **Resultados**: No período, foram 1135 óbitos de pedestres, destacando-se: sexo masculino (76,38%), idade > 50 anos (36,92%) e raça parda (82,47%). A taxa de mortalidade específica na população geral diminuiu de 7,56/100.000 em 2007 para 1,13/100.000 em 2016 (APC -17,6%, IC95% -21,3 a -13,2, p <0,001). Na população masculina, a taxa passou de 12,15 para 1,77/100.000 (APC -18,0%, IC95% 21,8 a 13,9, p <0,001). Por outro lado, na população feminina, a tendência de queda ocorreu apenas a partir de 2013 (APC -30,4%, IC95% -48,2 a -6,4, p<0,001), cuja taxa de mortalidade atingiu 0,55/100.000 em 2016. Um cluster espacial foi identificado envolvendo 40 municípios (RR 14,73; p<0,001). Esses municípios registraram 506 óbitos, o que correspondeu a 44,58% de todos os registros estaduais no período. **Conclusões**: A mortalidade de pedestres ainda é um importante problema de saúde pública em Alagoas, com ênfase na mortalidade masculina e na concentração geográfica na parte central do estado.

Palavras-Chave
Acidente de trânsito; Mortalidade; Epidemiologia; Saúde pública.

ABSTRACT

Background: The pedestrians, along with cyclists and motorcyclists constitute the group most vulnerable to traffic collision in Brazil and worldwide. We analyzed the epidemiological profile, trend and geographic distribution of pedestrian mortality in land transport collision in Alagoas, Brazil, 2007-2016. **Methods**: Ecological study including all pedestrian deaths in transport collision in Alagoas, Brazil, 2007-2016 (code V00 to V09 of the international classification of diseases). Sociodemographic variables and mortality rates according to sex were analyzed. For statistical analysis we used the inflection point regression model, the Local Empirical Bayesian Model and the spatial scan statistic. **Results**: In the period, there were 1135 pedestrian deaths, highlighting: male gender (76.38%), age> 50 years (36.92%) and brown race (82.47%). The specific mortality rate in the general population decreased from 7.56/100,000 in 2007 to 1.13/100,000 in 2016 (APC -17.6%, 95%CI -21.3 to -13.2, p<0.001). In the male population, the

Keywords
Collision, traffic; Mortality; Epidemiology; Public Health.

rate went from 12.15 to 1.77/100,000 (APC -18.0%, 95%CI 21.8 to 13.9, p<0.001). On the other hand, in the female population, the downward trend only occurred from 2013 (APC -30.4%, 95%CI -48.2 to -6.4, p<0.001), whose mortality rate reached 0.55/100,000 in 2016. Pedestrian mortality is a major public health problem in Alagoas, with emphasis on male mortality and geographic concentration in the central part of the state. **Conclusions**: Pedestrian mortality is a major public health problem in Alagoas, with emphasis on male mortality and geographic concentration in the central part of the state.

RESUMEN

Introducción: Los peatones, junto con ciclistas y motociclistas, constituyen el grupo más vulnerable a los accidentes de tránsito en Brasil y en el mundo. El objetivo fue analizar el perfil epidemiológico, tendencia y distribución geográfica de la mortalidad de peatones en accidentes de transporte terrestre en Alagoas, Brasil, 2007-2016. **Métodos**: Estudio ecológico que incluye todas las muertes de peatones en accidentes de transporte en Alagoas, Brasil, 2007-2016 (código V00 a V09 de la clasificación internacional de enfermedades). Se analizaron variables sociodemográficas y tasas de mortalidad por sexo. Para el análisis estadístico, se utilizaron el modelo de regresión de punto de inflexión, el modelo bayesiano empírico local y las estadísticas de barrido espacial. **Resultados**: En el período, ocurrieron 1135 muertes de peatones, con destaque para: sexo masculino (76,38%), edad > 50 años (36,92%) y mestizo (82,47%). La tasa de mortalidad específica en la población general disminuyó de 7,56/100.000 en 2007 a 1,13/100.000 en 2016 (APC -17,6%, IC 95% -21,3 a -13,2, p<0,001). En la población masculina la tasa aumentó de 12,15 a 1,77/100.000 (PCA -18,0%, IC95% 21,8 a 13,9, p <0,001). En cambio, en la población femenina la tendencia a la baja se presentó recién a partir de 2013 (APC -30,4%, IC95% -48,2 a -6,4, p<0,001), cuya tasa de mortalidad alcanzó 0,55/100.000 en 2016. A Se identificó un conglomerado espacial involucrando 40 municipios (RR 14.73; p<0.001). Esos municipios registraron 506 defunciones, lo que correspondió al 44,58% de todos los registros estatales en el período. **Conclusiones**: La mortalidad de los peatones sigue siendo un importante problema de salud pública en Alagoas, con énfasis en la mortalidad masculina y la concentración geográfica en la parte central del estado.

Palablas Clave
Accidente de tránsito;
Mortalidad;
Epidemiología;
Salud pública.

Introduction

Traffic collision are among the most serious public health problems, given the physical, social, psychological and economic damage they cause (1,2). They are also one of the five main causes of premature death and cause potential loss of life (1,3) In addition, the financial costs and the burden of the Unified Health System (SUS) stand out for the care of injured individuals (1-4) Brazil ranked 3rd on the list of countries with the highest number of traffic accident deaths in 2013 5 and its projections indicate that the increase in absolute number of traffic deaths will increase by more than half by 2020 (1).

The United Nations (UN) has designated the period of 2011 to 2020 as the 'Decade of Action for Road Safety', inviting member countries to achieve targets for the reduction and stabilization of traffic-related deaths (4). The effort is justified by the fact that land transport collision currently represent the main cause of unnatural death in several countries (5,6). However, more measures need to be implemented because if the same mortality reduction pace continues in Brazil, the country will not reach the proposed Sustainable Development Goals, which is to reduce by half the number of deaths per 100,000 inhabitants (7).

Each year, it is estimated that there are about 1.2 million deaths from this event, corresponding to 12.0% of all deaths on the planet (5,6). Additionally, about 50% of total traffic-related deaths occur among the most vulnerable agents, such as pedestrians, cyclists and motorcycles (8) In the period of 2000 to 2015, 466 thousand fatal victims of traffic collision were registered in Brazil. Of these, 31.80% (n = 148.205) were pedestrians (7)

Alagoas is the second smallest state in the Northeast region of Brazil and has the lowest human development index among the Brazilian states (0.631) and more than 90% of the municipalities are classified as very high social vulnerability (9). Between 2000 and 2015, Alagoas recorded 2,952 fatal victims of pedestrians in land transport collision, which corresponds to 5.86 deaths per 100,000 inhabitants (10).

This study aims to describe the epidemiological profile and analyze the trend and geographical distribution of pedestrian mortality in land transport collision in Alagoas, Brazil, 2007-2016.

Methods

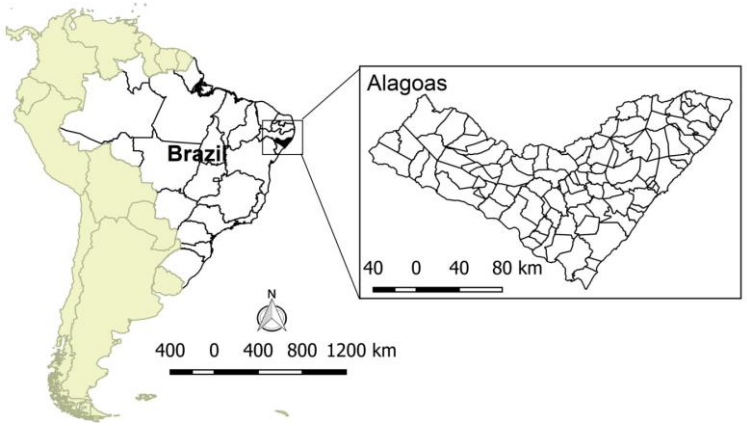
Study design, population and period

This is a ecological study involving all registered traumatized pedestrians' deaths in land transport collision between 2007 and 2016 in Alagoas/Brazil.

Study Scenario

The study was conducted in Alagoas, having as analysis units the 102 municipalities. Alagoas, the second smallest state in northeastern Brazil, has an estimated population of 3.3 million inhabitants (112.13 inhabitants/km²) **(Figure 1).**

Figure 1- Geographic localization of the study area. Alagoas, Brazil.



Variables included in the study

Epidemiological variables: gender(Male; female), Age range (< 10, 10 to 14, 15 to 19, 20 to 29, 30 to 39, 40 to 49, 50 to 59, 60 or more), Skin color (White, Black, Yellow, Brown, Indigenous, Ignored) Years of study (None, 1 to 3, 4 to 7, 8 to 11, 12 or more, Ignored), Place of occurrence (Hospital, Other health facilities, Residence, Public road, Others, Ignored) ICD-10 Category (V01 to V09). The specific mortality rate was analyzed using the following equation: "Annual mortality rate=" ("Number of pedestrian deaths in traffic collision in the place and year")/"Population residing at the place and period" x 100,000

Data Collection Procedures

Data were obtained from the Mortality Information System (Sistema de Informação sobre Mortalidade, SIM) (http://datasus.saude.gov.br/). In the selection of the data, ICD-10 were considered: V01- Pedestrian traumatized by collision with a pedal vehicle, V02- Pedestrian traumatized by collision with a two- or three-wheeled motor vehicle, V03- Pedestrian traumatized by collision with a car, "pick up " or truck, V04- Pedestrian injured in collision with transport vehicle and heavy or a bus, V05- Pedestrian injured in collision with train or a rail vehicle V06- Pedestrian traumatized in collision with other non-motorized vehicle, V09- Pedestrian injured in other traffic collision and non-specified transport collision. Deaths by municipality of residence were included. The population data needed to calculate the mortality rate were obtained from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, IBGE).

Statistical treatment

Statistical treatment was performed in three stages. First, a simple descriptive analysis was conducted. The second stage was characterized by temporal analysis with the use of joinpoint regression model (11). This model tests whether a multi-segmented line is statistically better to describe the temporal evolution of a dataset than is a straight or less-segmented line (11). Trends were classified as increasing, decreasing or stationary. It calculated the annual percent change (APC) with a confidence interval of 95% (CI95%) and the statistical significance of 5%. The analysis was conducted with the Joinpoint regression program (version 4.6.0.0- National Cancer Institute, Bethesda, MD, USA).

In the third stage, spatial statistics was used to identify areas with higher mortality risk. Initially, the municipal rates were submitted to smoothing by local empirical Bayesian model in order to reduce the

random fluctuation of data (12). The objective of this model is to identify a posteriori distribution (unobserved quantities of a given phenomenon), based on the application of Bayes' theorem, involving sample data (likelihood function), and the application of a set of observed data (a priori distribution) (12).

For the identification of risk areas, a purely spatial scanning statistic was used with the Poisson's discrete probability model, the maximum risk population estimated at 50%.13 The test used to identify clusters is based on the maximum likelihood method, the alternative hypothesis of which is that there is high risk inside the window compared to outside the window. Monte Carlo simulations (we used 999 permutations) were used to obtain the p-values. Clusters were considered to be significant when their p-value was <0.05 (13). Clusters with p<0.05 were considered significant. At this stage, Terra View (version 4.2.2), SatScan (version 9.1) and QGis (version 2.14.11) software were used.

Ethical aspects

As it used secondary data in the public domain, it was not considered by the Research Ethics Committee.

Results

From 2007 to 2016, there were 1,135 deaths of pedestrians traumatized in land transport collision. Of these, 76.38% (n=867) were male, 36.92 % (n=419) aged 50 years or older, 82.47% (n=936) of the brown race and 49.96% (n=567) of deaths occurred on the public road itself **(Table 1)**.

Table 1- Sociodemographic characterization of pedestrian mortality deaths in land transport collision. Alagoas, Brazil, 2007-2016 (n=1135).

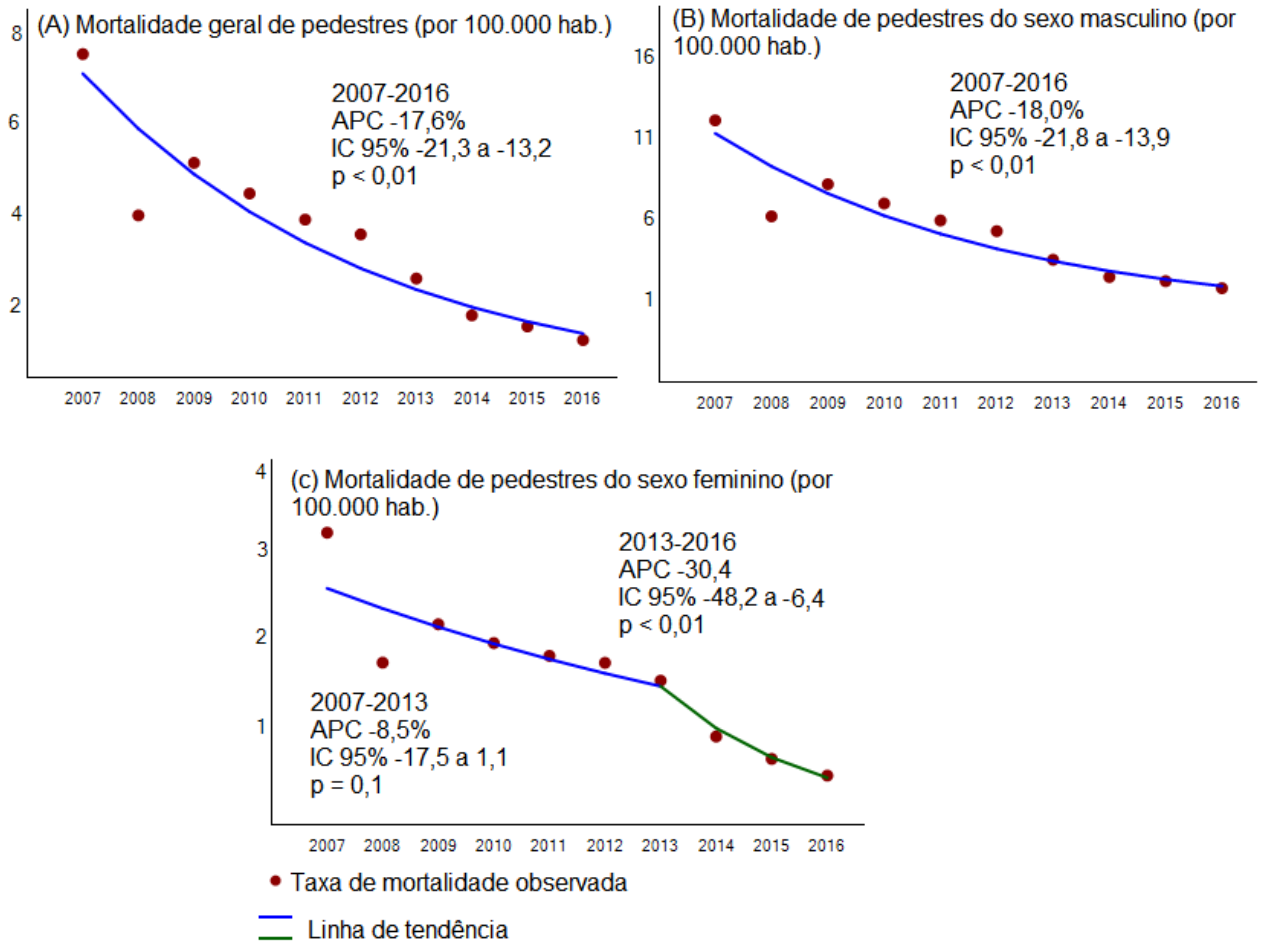
Variable	Male N (%) 867 (76.38%)	Female N (%) 267 (23.52%)	Total N (%) 1.135* (100.0%)
Age Range			
< 10	64 (7.38)	41 (15.35)	106 (9.34)
10 to 14	47 (5.42)	12 (4.49)	59 (5.20)
15 to 19	48 (5.57)	20 (7.49)	68 (5.99)
20 to 29	141 (16.26)	26 (9.75)	167 (14.71)
30 to 39	137 (15.79)	23 (8.61)	160 (14.10)
40 to 49	130 (14.99)	26 (9.75)	156 (13.74)
50 to 59	111 (12.80)	34 (12.73)	145 (12.78)
60 or more	189 (21.79)	85 (31.83)	274 (24.14)
Skin color			
White	29 (3.35)	20 (7.49)	49 (4.32)

Black	8 (0.92)	1 (0.37)	9 (0.79)
Yellow	1 (0.11)	0 (0.00)	1 (0.09)
Brown	725 (83.63)	210 (78.65)	936 (82.47)
Indigenous	0 (0.00)	0 (0.00)	0 (0.00)
Ignored	104 (11.99)	36 (13.49)	140 (12.33)
Years of study			
None	11 (1.28)	11 (4.12)	22 (1.94)
1 to 3	20 (2.30)	5 (1.87)	25 (2.20)
4 to 7	102 (11.76)	24 (8.99)	126 (11.10)
8 to 11	25 (2.88)	5 (1.87)	30 (2.64)
12 or more	0 (0.00)	0 (0.00)	0 (0.00)
Ignored	709 (81.78)	222 (83.15)	932 (82.12)
Place of occurrence			
Hospital	404 (46.60)	127 (47.56)	532 (46.88)
Other health facilities	2 (0.23)	1 (0.38)	3 (0.26)
Residence	5 (0.58)	4 (1.50)	9 (0.79)
Public road	441 (50.86)	126 (47.19)	567 (49.96)
Others	15 (1.73)	8 (2.99)	23 (2.02)
Ignored	0 (0.00)	1 (0.38)	1 (0.09)
ICD-10 Category			
V01	3 (0.35)	0 (0.00)	3 (0.26)
V02	11 (1.28)	5 (1.87)	16 (1.42)
V03	5 (0.58)	1 (0.37)	6 (0.53)
V04	2 (0.23)	1 (0.37)	3 (0.26)
V05	3 (0.35)	0 (0.00)	3 (0.26)
V06	3 (0.35)	0 (0.00)	3(0.26)
V09	840 (96.86)	260 (97.39)	1101 (97.01)

Legend: V01- Pedestrian traumatized in collision with a pedal vehicle, V02- Pedestrian traumatized in collision with a two or three-wheel motor vehicle, V03- Pedestrian traumatized in collision with a car, pick up or pickup truck , V04- Pedestrian traumatized by collision with a heavy transport vehicle or a bus, V05- Pedestrian traumatized by collision with train or a rail vehicle, V06- Pedestrian traumatized by collision with another non-motorized vehicle, V09- Pedestrian traumatized in other traffic collision and traffic collision not specified. * (one) case ignored.

Over the time series, the specific mortality rate in the general population decreased from 7.56/100,000 in 2007 to 1.13/100,000 in 2016 (APC -17.6%, 95%CI -21.3 to -13.2, p<0.001). In the male population, the rate went from 12.15 to 1.77/100,000 (APC -18.0%, 95%CI 21.8 to 13.9, p<0.001). On the other hand, in the female population, the downward trend only occurred from 2013 (APC -30.4%, 95%CI -48.2 to -6.4, p<0.001), whose mortality rate reached 0.55/100,000 in 2016 **(Figure 2)**.

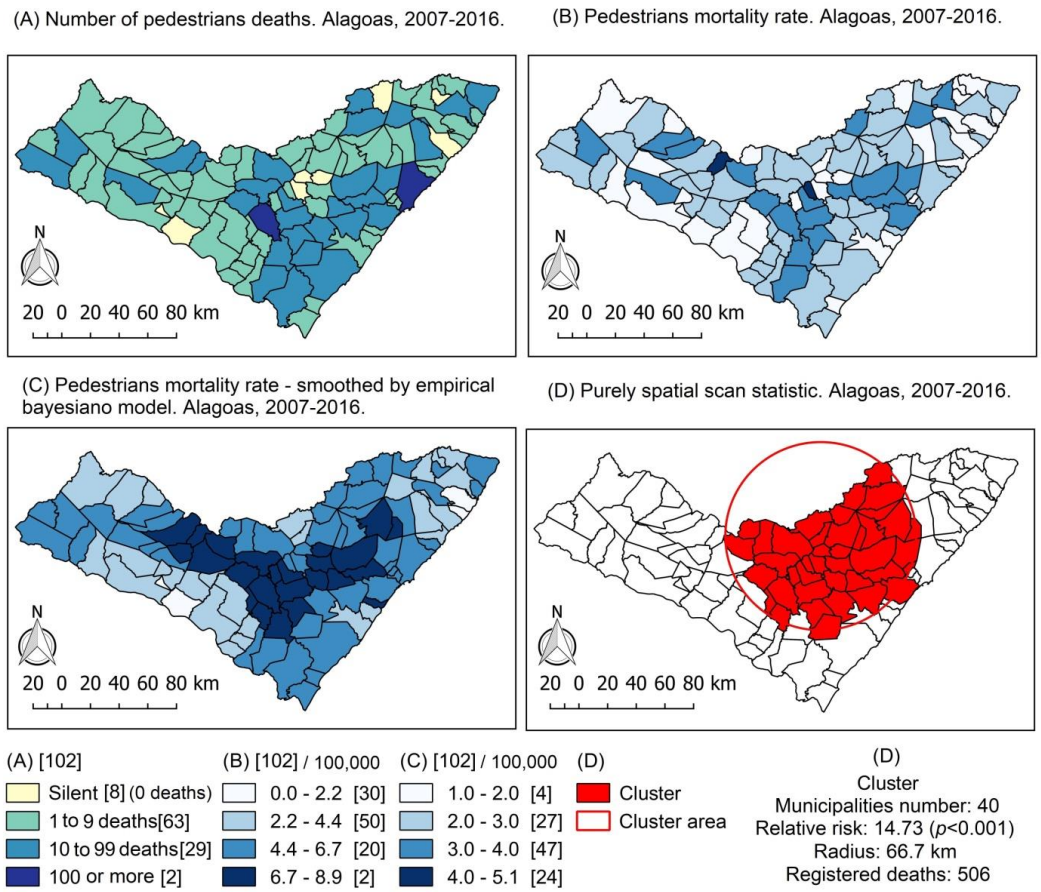
Figure 2- Temporal evolution of pedestrian mortality in land transport collision. Alagoas, Brazil, 2007-2016 (n=1135).



Eight municipalities (7.84%) did not register any deaths in the analyzed period, therefore, they were considered silent and only two (Maceió-n=304 and Arapiraca-n=116), registered more than 100 deaths. The highest mortality rates were recorded in Dois Riachos (8.88/100,000 inhabitants), Belém (8.48/100,000 inhabitants) and Taquarana (6.59/100,000 inhabitants). Smoothing by the local empirical Bayesian model reduced random fluctuation and showed the highest mortality rates in the central part of the state, composed of 24 locations around the municipality of Arapiraca.

The spatial scan statistic pointed to a spatial cluster, involving forty municipalities of the state (Relative Risk= 14.74; p<0.001) and radius of the 66.7km. These municipalities recorded 506 deaths, which corresponded to 44.58% of all state records in the period **(Figure 3)**.

Figure 3- Spatial analysis of pedestrian mortality in land transport collision. Alagoas, Brazil, 2007-2016 (n=1135).



Discussion

The epidemiological profile observed in this study is in line with current literature (3,4,8) Men appear in this study more frequently among the injured (3) and individuals aged 60 or older has 2.78 more likely to have died from an accident in the category of pedestrian (3,4,8).

Although the skin color and education fields were not filled in most individuals, the predominance of brown/black race/color and low schooling can be justified by socioeconomic reasons, since this group, in general, is more subject to a context of pragmatic vulnerability, and therefore are more exposed to the risk of collision such as pedestrians (3-8).

The temporal decline behavior observed in Alagoas has also been observed in all macroregions of the country, although the North and Northeast have slower reductions when compared to other regions. The set of policies and plans developed in recent years may justify this reduction, among which stand out

the Brazilian Traffic Code (Código de Trânsito Brasileiro, CTB) and the "Lei seca". The CTB, in term since January 1998, aimed to reduce the high rate of collision and, consequently, mortality resulting from traffic collision, establishing rules of conduct, infractions and penalties, as well as definitions of traffic crimes. In the year of implementation, the CTB reduced pedestrian mortality, with a reduction of 6.9 deaths per 100,000 inhabitants, with stabilization in the following years, that is, maintaining such reduction (15).

In 2008, came into term the law nº 11,705, called "Lei seca", prohibiting driving under the influence of alcohol. In 2013, the law became even stricter, establishing alcoholemia 0 (zero) and imposing stricter penalties for drivers who drive under the influence of alcohol (1). Nationwide research showed that the implementation of the "Lei seca" resulted in an average reduction of two deaths/100,000 inhabitants every three years (15). In Alagoas, an investigation showed an annual reduction of 11.3% in the mortality rate of motorcyclists in land transport collision after the implementation of the "Lei seca" (16).

The enforcement of Laws, such as "Lei seca", (1,4) the stricter and more effective surveillance of traffic violations, the various government awareness campaigns, in addition to the civil mobilization of people who lost their loved ones, or others who were left with sequelae and seek to raise awareness may have influenced the results found here, which is corroborated by other Brazilian studies (6,8).

In a study of mortality from land transport collision in Brazil, (17) the risk of death for pedestrians reduced in the last decade, and for occupants of vehicles and motorcycles there was a growth, with the highest risk of death in small population municipalities. In Alagoas, the scanning statistic identified a spatial cluster of high relative risk, involving forty municipalities in the interior of the state. This spatial pattern observed for pedestrian mortality is similar to that observed for motorcyclists, in investigations conducted in the state of Alagoas (15,16). These investigations suggest that traffic mortality may be even more severe in the municipalities of the interior.

In smaller municipalities, a whole context of vulnerability is established and increases the risk of mortality, among which stand out: i) lower supply of public transport services, ii) lack and/or absence of traffic enforcement actions, especially due to the lack of human and material resources, iii) reduced number of traffic prevention and education actions, iv) roads without necessary and adequate infrastructure and v) the distance between the place of occurrence of collision and the place of care (1,4,19).

Even considering the methodological care employed, this study has limitations. The first of these refers to the quality of data from the Mortality Information System (Sistema de Informação sobre Mortalidade, SIM), considered to be deficient. Although from 2005, there was an increase in coverage and

a reduction in the percentage of ill-defined causes of death across the country, in 2010 there were still deaths with non-specific codes that, in the case of land transport collision, can reach about 20% of records (20). In addition, the high number of ignored fields in sociodemographic variables also represents a potential limitation of the study.

Conclusion

The study showed that the profile of pedestrian deaths injured in traffic collision in Alagoas was characterized by men, over 50 years old, brown race/color and low schooling. In temporal analysis, the state has a trend of decline in overall mortality and according to gender. The geographical analysis pointed to the existence of a spatial cluster with higher risk of mortality in the interior of the state, which are the priority places for the development of plans and actions that allow the reduction of the problem.

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