



Deaths due to motorcycle accidents and their association with variables related to social reproduction in a northeastern Brazilian state

Muertes por accidente de motocicleta y su asociación con variables relacionadas a la reproducción social en un estado del noreste brasileño

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ABSTRACT The objective of this article was to identify the association between motorcycle deaths and variables related to Samaja's theory of social reproduction in the period 2000-2005 in the state of Pernambuco. An ecological, case-control study was carried out, with municipalities as the unit of analysis. Cases were defined as the 20% of municipalities with the highest local empirical Bayesian coefficients for mortality due to motorcycle accidents, and controls as the 40% with the lowest coefficients. The municipalities with the greatest chances of high coefficients for mortality due to motorcycle accidents showed high population growth factors and increases in the total fleet of motorcycles, with low population densities, low GDP per capita, and more than 20 motorcycles per thousand inhabitants. We conclude that the variables related to macro-policies proved to have greater force in explaining higher chances of motorcycle death.

KEY WORDS accidents; traffic; mortality; motorcycles; case-control studies; ecological studies; Brazil.

RESUMEN El objetivo de este artículo es identificar el comportamiento de las muertes por accidentes de motocicleta y las variables relacionadas con la teoría de la reproducción social de Samaja, para el período 2000-2005 en el estado de Pernambuco, Brasil. Se realizó un estudio ecológico con abordaje caso-control. La unidad de análisis fue el municipio. Los casos fueron definidos considerando el 20% de los municipios con los mayores coeficientes bayesianos empíricos locales de mortalidad por accidentes de motocicleta y los controles, como el 40% de los municipios con menores coeficientes de mortalidad por accidentes de motocicleta. Los municipios con mayor probabilidad de altos coeficientes de mortalidad por accidentes de motocicleta mostraron factores de crecimiento poblacional altos, así como de crecimiento de la flota de vehículos, bajas densidades demográficas, bajo PBI per cápita, y más de 20 motocicletas por mil habitantes. Se concluye que las variables relacionadas a las macropolíticas mostraron una mayor fuerza para explicar las probabilidades de defunciones por accidentes de motocicleta.

PALABRAS CLAVES Accidentes de Tránsito; Mortalidad; Motocicletas; Estudios de Casos y Controles; Estudios Ecológicos; Brasil.

INTRODUCTION

It is estimated that every 15 minutes one person dies due to traffic accidents in Brazil.⁽¹⁾ The socioeconomic consequences amount to approximately 16 trillion US dollars per year, which was updated in April 2011 by the Institute for Applied Economic Research (IPEA).^(2,3) They also represent the disintegration of the family nucleus, suffering, negative effects, and other consequences that are not measured, but still have a high impact on people's quality of life.⁽⁴⁾

Developing countries, such as Brazil, account for nearly 90% of the deaths due to traffic accidents around the world, although they barely own 48% of the total motor vehicle fleet. The main victims of these accidents in these countries are pedestrians, cyclists, and motorcyclists.⁽⁵⁾

The epidemiological pattern of traffic accidents in Brazil has a basic feature: the intensity of the accidents is varied and their distribution is heterogeneous throughout the country's territory, showing a strong increasing trend in several municipalities, which mainly have small populations (less than 50,000 inhabitants) and medium-sized populations (between 50,000 and 100,000 inhabitants). The increase in motorcycle accidents is striking and has led to a rise in deaths and disabilities in higher proportions than in any other means of transport.⁽⁶⁾

In the state of Pernambuco, the motorcycle mortality rate increased by 875% between 1996 (0.4 per 100,000 inhabitants) and 2006 (3.9 per 100,000 inhabitants).⁽⁶⁾ However, there are still few studies seeking to understand and explain these phenomena beyond the fragmentation and positivist reductionism paradigms. The programs to promote safety and prevention of accidents, which have existed in Brazil for 40 years, were based on those theories. None of them includes the concepts of determinism and social reproduction in the understanding and explanation of such detriment to health.

In this study, Samaja's theory of social reproduction is applied to interpret the results. This theory is based on two concepts and one methodological principle. The first concept considers human life as a complex articulation of multiple socio-historical processes of production

and reproduction of life itself, throughout which different tensions and conflicts arise and trigger actions of repair and transformation. The second concept establishes that the results of those socio-historical processes are structured through strata, at different levels of integration, which are ordered as structural and functional hierarchies that are organized in an upward direction, following the direction of its production, and in a downward direction, following the direction of its reproduction.^(9,10)

The methodological principle states that it is necessary to investigate not only the composition and functioning of the structures (organism, individual, family, market, and so on), but also, and especially, their history: that is to say, the process of emergence of some levels from previous conflicts and imbalances.^(9,10)

According to Milton Santos⁽¹¹⁾ and Samaja,⁽¹²⁾ the concept of space goes beyond the notions of surface and geographic area, also including the social aspects; given that space is an element of society, just as the economic, political-institutional, and cultural-ideological elements, these accidents must be related to the space where they occur.

As this category is used in this study through the unit of analysis "municipalities," it seeks to maintain that approach and is adapted to Samaja's theoretical model.^(9,11)

The objective of this study is to identify the existing association between deaths due to motorcycle accidents and the variables related to the dimensions of the social reproduction processes that may explain the heterogeneous spatial distribution of the accidents.

METHODS

The geographic area of study was the state of Pernambuco, which has 184 municipalities – excluding the archipelago of Fernando de Noronha – grouped into 12 development regions.

This is an ecological, case-control study, being the municipality the unit of analysis. It is a hybrid study design used in an innovative way, which is intended to understand the differences in the situations related to health status among populations.

Researchers carried out an analysis of the deaths due to motorcycle accidents that occurred in the state of Pernambuco between January 1, 2000 and December 31, 2005. The sample included cases and controls in a proportion of one case every two controls. The cases were defined as 20% of the municipalities with the highest local empirical Bayesian coefficients of mortality due to motorcycle accidents; and controls were defined as 40% of the municipalities with the lowest coefficients already mentioned, which resulted in a total amount of 37 municipalities as cases and 75 as controls. This procedure is justified through the selection of extreme situations, for which the characteristics of each group were more emphasized. Furthermore, the study observes the criterion that the controls belong to the same population in which the cases originated, apart from the inclusion of two controls per case in the analysis of the proportion.^(13,14)

The coefficients were calculated considering the deaths due to motorcycle accidents as the numerator and population as the denominator.

To correct any random fluctuation in small populations or in small numbers of occurrences, the mortality coefficients were recalculated through the local empiric Bayesian method assuming that there is autocorrelation in the rates of the neighboring areas. The rates of those areas were re-estimated through the weighted average of the value measured and the average rate of the vicinity, which weight was inversely proportional to the population of each area.^(15,16)

The exclusion criterion used for the municipalities was based on those that had more than 10% of wrongly defined deaths.

The study covered all those deaths included under the code "Motorcycle rider injured in transport accident" (V20-29) from the International Classification of Diseases (10th revision) (ICD 10), which were registered with the Mortality Information System (SIM) based on the death of residents of the state of Pernambuco that occurred between 2000 and 2005.

The explanatory variables were selected based on the bibliography⁽¹⁷⁻²¹⁾ and were grouped according to the dimensions used by Samaja. Based on this approach, the theory of social reproduction occurs in four different dimensions: the bio-communal, consciousness and conduct, economic, and eco-political dimensions.

Bio-communal reproduction refers to how members reproduce biologically and renew their interrelations, building the communal environment where they fulfill themselves as individuals.

The self-consciousness and conduct reproduction, which is related to the production of culture, is reflected through symbolic networks mediated by the language, and the creation and transmission of the learning experience (beliefs, abilities to make *the others* internalize those ideas in terms of the authority and to stand out as a singular individual). The economic reproduction, which includes the means of livelihood and work, does not have as an immediate objective the production of the organism itself, but the production and exchange of goods at all levels, mediating the bio-communal, self-consciousness and conduct, and eco-political reproduction.

The eco-political reproduction refers to the social relations responsible for the reproduction of the social macro environment and the territorial/environmental conditions, in which the other three dimensions (bio-communal, consciousness and conduct, and economic dimensions) are included and, in a certain way, are subordinated. The eco-political reproduction also comprises the material and legal relations arising from the macro policies which constitute the State and define its essence.

The automobile and motorcycle fleet growth factors have a strong impact on the ecosystem. In Brazil, those factors are also stimulated through State macro policies, as will be explained later. For that reason, those factors were included within the eco-political dimension.

The data sources of independent variables arise from the Census carried out in 2000 by the Brazilian Institute of Geography and Statistics (IBGE) [*Instituto Brasileiro de Geografia e Estatística*], the Pernambuco State Planning and Research Agency [*Agência Estadual de Planejamento e Pesquisas de Pernambuco*], and the Atlas of Human Development [*Atlas do Desenvolvimento Humano no Brasil*] prepared by the United Nations Development Programme (UNDP), the State Traffic Department of Pernambuco [*Departamento Estadual de Trânsito de Pernambuco*] (DETRAN), and the Brazilian National Traffic Department (DENATRAN) [*Departamento Nacional de Trânsito*].

The variables considered in each dimension were the following:

- *Bio-communal dimension*: deaths due to motorcycle accidents represented by their mortality coefficients.
- *Economic dimension*: GINI index; income ratio of 20% of the richest individuals to the income of 40% of the poorest individuals; GDP per capita; Municipal Human Development Index [Índice de Desenvolvimento Humano Municipal] (MHDI); the percentage of heads of household whose income is lower than two and a half minimum salaries; the percentage of income earned by 20% of the richest individuals; the percentage of income earned by 20% of the poorest individuals; the percentage of the population who completed less than 5 years of education; the percentage of the population who completed more than 12 years of education.
- *Eco-political dimension*: population; population growth factor per year; population density; automobile fleet growth factor per year; motorcycle fleet growth factor per year; total fleet growth factor per year; the ratio of the number of motorcycles per inhabitant; the ratio of the number of automobiles per inhabitant; the ratio of the total number of motor vehicles per inhabitant; municipalization of traffic control – it includes supervision, signposting, traffic safety and accident prevention activities, as outlined in section 24 of the Brazilian Traffic Code [Código de Trânsito Brasileiro] (CTB).

The authors decided to work using these three dimensions only, since interviews based on a qualitative approach were not carried out for the self-consciousness and conduct dimension.

After creating a database, the researchers performed a descriptive analysis of the distribution of the research variables. The explanatory variables were re-encoded considering the following: value one, those cases in which the value originally observed was superior to the median of the sample group of municipalities, and value zero, the opposite cases; except for the variable “ratio of the number of motorcycles per inhabitant,” in which case the median was used as the cut-off point to increase the sensitivity of the criterion. This cut-off point criterion facilitated the comparison of extreme situations (municipalities that bear the highest mortality coefficients due to motorcycle accidents against the municipalities that bear the lowest coefficients).

To verify the association between the outcome and the explanatory variables, a multivariate analysis was used to calculate the gross and adjusted *odds ratio* (OR), respectively, as a measure of effect. The intervals were defined at a 95% confidence level. Those variables which showed association with a significance level lower than 25% ($p < 0.25$) were included in the multivariate model of logistic regression. The method used to select the variables was the backward stepwise method, with statistical verification of significance level, employing the likelihood ratio test and criteria for the continuity of the variable in the model $p < 0.10$.

For data processing and analysis, the software *Excel* and *Statistical Package Social Sciences* (SPSS) version 17.0 were used. This study was part of the PhD thesis *Epidemiology of traffic accidents focused on motorcycle deaths in the state of Pernambuco: an exacerbation of social violence* [Epidemiología de los accidentes de tránsito con un enfoque en la mortalidad de motociclistas en el estado de Pernambuco: una exacerbación de la violencia social]. This project was approved by the Research Ethics Committee of the Research Center Aggeu Magalhães [Centro de Pesquisas Aggeu Magalhães] (CPqAM), under the Oswaldo Cruz Foundation [Fundação Oswaldo Cruz] (FIOCRUZ).

Table 1. The number of deaths and the average rate of mortality due to motorcycle accidents in case and control municipalities. Pernambuco, Brazil, 2000-2005.

Variables	Cases	Controls
Deaths per year		
2000	60	45
2001	58	53
2002	65	62
2003	83	87
2004	69	121
2005	82	110
Total number of deaths	417	478
Number of municipalities	37	75
Population of the municipalities	1,197,838	5,086,547
Average mortality rate per year (per 100,000 inhabitants)	5.80	1.57

Source: Own elaboration.

RESULTS

Table 1 shows the data of mortality due to motorcycle accidents during the period under study according to the situation of the municipalities. It is highlighted that in the “case” municipalities the

rate of mortality due to motorcycle accidents is nearly four times higher than in the control group.

Table 2 shows the variables that had a significant association ($p < 0.25$) with the outcome in the bivariate analysis. Therefore, the following variables were not included in the multivariate analysis: Municipal Human Development Index;

Table 2. Deaths due to motorcycle accidents in the case and control municipalities, and explanatory variables, gross odds ratio and 95% confidence interval. Pernambuco, Brazil, 2000-2005..

Variables/categories	Cases	Controls	Gross OR	95% CI	<i>p-value</i>
Population growth factor per year					
> 1.01	24	32	2.48	1.098; 5.607	0.04
< 1.01	13	43			
Total fleet growth factor per year					
> 1.10	24	32	2.48	1.098; 5.607	0.04
< 1.10	13	43			
Municipalization of traffic control					
Yes	1	10	5.54	0.681; 45.028	0.09
No	36	65			
Population density inhabitant/km ²					
> 96.69	5	51	0.07	0.025; 0.212	0.00
< 96.69	32	24			
GDP per capita (BRL)					
> 2,247.61	27	29	4.28	1.809; 10.137	0.00
< 2,247.61	10	46			
GINI Index					
> 0.58	19	27	0.53	0.240; 1.184	0.15
< 0.58	18	48			
Percentage of income earned by 20% of the richest individuals					
> 60.61	22	34	1.77	0.796; 3.930	0.23
< 60.61	15	41			
Ratio of the income of 20% of the richest individuals to the income of 40% of the poorest individuals					
> 14.44	22	34	1.77	0.796; 3.930	0.23
< 14.44	15	41			
Percentage of heads of household whose income is lower than 2.5 minimum salaries					
> 18.16	13	43	0.4	0.178; 0.911	0.04
< 18.16	24	32			
Ratio of the number of motorcycles per 1,000 inhabitants					
> 20 motorcycles	22	20	4.03	1.755; 9.270	0.00
< 20 motorcycles	15	55			

Source: Own elaboration.

Table 3. Deaths due to motorcycle accidents and explanatory variables, adjusted odds ratio, 95% confidence intervals, and p-value, in the multivariate analysis. Pernambuco, Brazil, 2000-2005.

Variable	Adjusted OR	95% CI	p-value
Population growth factor per year			
< 1.01	1	-	-
> 1.01	5.53	1.65; 18.54	0.01
Total fleet growth factor per year			
< 1.10	1	-	-
> 1.10	2.60	0.85; 7.95	0.09
Population density inhabitant/km ²			
< 96.69	1	-	-
> 96.69	0.05	0.01; 0.22	0.00
GDP per capita (BRL)			
< 2,247.61	1	-	-
> 2,247.61	3.62	1.05; 12.45	0.04
Ratio of the number of motorcycles per 1,000 inhabitants			
< 20 motorcycles	1	-	-
> 20 motorcycles	9.22	2.68; 31.65	0.00

Source: Own elaboration.

the percentage of income earned by 20% of the poorest individuals; the percentage of the population who completed less than 5 years of education; the percentage of the population who completed more than 12 years of education; population size; automobile fleet growth factor per year; motorcycle fleet growth factor per year; the ratio of the number of automobiles per inhabitant; the ratio of the total number of motor vehicles per inhabitant. The variables that had a significant association with the dependent variable in the multivariate analysis are shown in Table 3.

It should be noted that the final model obtained shows the profile of excessively exposed municipalities, which have more chances of presenting higher rates of mortality due to motorcycle accidents. Considering this profile, the municipalities characterized as being under major risk are those which have high population growth factors, high total vehicle fleet growth factors, low population densities, low GDP per capita, and more than 20 motorcycles per 1,000 inhabitants.

DISCUSSION

The most important finding of this study was to empirically prove the connection of the rapid population growth, the increase in the vehicle fleet, and the motorcycle/inhabitant ratio with the deaths due to traffic accidents, information that is not usually considered when this subject is addressed. In this way, this study gives continuity to a topic addressed in the research study entitled "Spatial study of mortality due to motorcycle accidents in Pernambuco" [*Estudo espacial da mortalidade por acidentes de motocicleta em Pernambuco*],⁽⁸⁾ whose results suggest the necessity of establishing associations between those deaths and the variables that better explain them. For this reason, this study covered the same period and database used in that research study. Moreover, it was proved that the situation remains practically unaltered, and therefore, a new study is not necessary.

The variables *automobile fleet growth factor* and *motorcycle fleet growth factor*, which are

included in the eco-political dimension, are grounded in the fact that the increasing production of automobiles and motorcycles and the idea that the motorization of society means “progress,” which is even represented as the access of the poor to motor vehicles, give rise to State macro policies that spread into other dimensions and, in a certain way, subordinate them.

Based on an ecological, case-control study – an alternative to other forms of analysis traditionally used – which applies the explanatory model of Samaja’s social reproduction, markers of social determinism were included to interpret the results. In this way, through a creative approach, it was shown that the variables having statistically significant associations with the deaths due to motorcycle accidents are those grouped into the eco-political dimension, which is determined by the hegemonic policies of the State apparatus. Also, it was proved that the variables reproduce themselves overlapping each other in the other dimensions in an upward and downward way.

In this discussion, it is explained how history and the policies chosen have influenced the formation of a harmful context, which is favorable for the production and reproduction of traffic accidents and, particularly, of motorcycle accidents.

Almeida Filho⁽²²⁻²⁴⁾ states that there is no logical impediment to carry out a case-control study based on population groups, which was the method applied in this analysis. However, there are some limitations beyond the design of an ecological study due to the existence of an under-recording in secondary data. Moreover, the space category is represented by the municipalities, and the data used show the municipality as a whole, without differentiating its intra-spatial particularities. Another limitation to be considered relates to the method of quantitative analysis (multivariate logistic regression) that verifies the association between the variables from the perspective of linear causality, also from not having applied a hierarchical analysis. Nevertheless, the researchers tried to minimize that issue using a broader approach to interpret and reflect on the obtained results.

Historical and political reasons caused an increase in the ratio of the number of motorcycles per inhabitant in Brazil. Purchasing of motorcycles is directly associated with and is favored by an industrialization model, known as the

“developmentalist” model, which was adopted by Brazil and by the globalized world. This model introduced the logic of a voracious market aimed at producing increasingly fast and practical motor vehicles, such as motorcycles. The automobile industry established in Brazil has become the backbone of industrialization in the country.⁽²⁵⁾

According to Vasconcelos,⁽²⁵⁾ since 1994, federal policies have supported the widespread use of motorcycles through legislation related to production, tax exemption, and financing facilities. Between 1992 and 2007, the sales of motorcycles increased 12 times, whereas the sales of automobiles increased only 4 times.

Beginning in the middle of the 1990s, the motorcycle started to be intensely used also as a work tool, in addition to being a means of transport; the motorcycle has perfectly adapted itself to the changing behavior of the economy, which promoted the services sector and favored the growth of informal employment, a precarious labor market, and unemployment. The growth of e-commerce, which became popular through the Internet, also corresponded to that period. These conditions emerged under the aegis of the deregulation policy that is so highly valued in the so-called modern labor relations, thereby expanding the group of vulnerable individuals.

It may be asserted that motorcycle workers are typical representatives of the new capitalist labor relations. Therefore, under this *model*, these workers, who came to stay, have become an important part of the capitalist system and have occupied a place in the intricate socio-economic network of contemporary society. Although this category of workers is stigmatized, discriminated, and condemned, this social group is being increasingly required.

This new actor in traffic, the motorcyclist, has to fight for space with the rest of the actors who practically do not recognize him, but he has achieved it by force.⁽²⁵⁾

Not even traffic legislation could resist the power of motorcycle manufacturers. Although section 56 of the Brazilian Traffic Code banned motorcycle circulation between automobile lines, the president imposed a veto over this section on the grounds that “prohibiting motorcycle and scooter drivers from passing between automobiles placed in contiguous lines severely restricts the

use of this kind of vehicle, which is widely used around the world in order to guarantee fast traffic flow.” [Own translation]

Referring to the population growth factor per year, which is a characteristic of the municipalities with the highest mortality rate due motorcycle accidents, it is known that the rapid and poorly organized growth has harmful social, economic, and environmental consequences that also affect people’s health.⁽⁷⁾ The effects of this growth are further seen in the traffic flow, causing the municipalities to have increasingly larger areas of conflict for pedestrians or non-motorized vehicles, also from causing real urban chaos.

This study has found that the lowest population densities have greater odds of dying due to motorcycle accidents. It is a fact that a collective urban public transport service that includes buses or similar vehicles practically does not exist in those places. In Brazil, buses are managed by private companies which only have profit-making purposes. Areas of low population densities imply few passengers per kilometer, which makes this transport service a barely profitable activity, forcing people to use motorcycles, motorcycle taxis, conventional taxis – which is much more expensive – or to walk. The transport and flow of vehicles that used to be animal-powered were abruptly replaced by motorcycles, which certainly contributed to the increase in the number of accidents.

In the cities characterized by uncontrolled growth of the total vehicle fleet, which does not necessarily imply that they represent the areas with the highest population density as seen in many of the municipalities under study, some circulation techniques are applied to optimize the flow of automobiles only. These techniques endanger the urban space for all those that are part of the traffic, but mainly for those whose physical and dynamic characteristics are more vulnerable, such as pedestrians, cyclists, and motorcyclists.⁽²⁶⁾

Furthermore, in flagrant violation of the Traffic Code, the municipalization of traffic control, which may be a mechanism to balance these disparities, has not been applied in most of the municipalities. In the state of Pernambuco, until 2005, after more than 12 years since the Traffic Code had come

into force, only 18 municipalities established municipal traffic control, and this number increased to 24 municipalities in 2011.

The GDP per capita, an element of the economic dimension, showed that, as the GDP decreases, the municipality has greater odds of having higher coefficients of mortality due to motorcycle accidents. This fact confirms the results obtained in other studies⁽²⁷⁾ which associate misery and poverty with high rates of mortality due to traffic accidents, even though other studies presented different results.⁽²¹⁾

It should be highlighted that this article addresses only deaths due to motorcycle accidents, whereas there is another aspect that is as serious as mortality, or even harder: the morbidity resulting from these accidents. Thus, it can be concluded that the municipalities that match the profile described in this study may be showing a deficiency in emergency medical assistance.

This extreme situation may act as a necessary deterrent, in the sense of preventing and reducing social violence which is highly exacerbated in motorcycle accidents and also, in turn, is a characteristic of the socio-economic context that the Brazilian society has developed. The answers may arise from the collective effort through the re-evaluation of the State action, which aims at the impartial empowerment of all the actors involved, through consistent actions to promote safety and accident prevention.

CONCLUSIONS

The variables related to the macro policies (eco-political dimension), which have proved to be highly associated with mortality, are those that constitute the power of the State and define its essence. Therefore, based on the evidence provided by this study, it may be asserted that the traffic accidents, especially motorcycle accidents in Brazil, are symbols of the chosen “developmentalist” model, which only considers economic growth and ignores the processes of social determination and reproduction, citizenship, and human rights.

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