Traffic deaths: recent evolution and regional differences in Bahia State, Brazil

Mortes no trânsito: evolução recente e diferenças regionais na Bahia, Brasil

Muertes de tráfico: evolución reciente y diferencias regionales en Bahía, Brasil

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Abstract

This study describes the temporal evolution of mortality due to traffic accidents in regions within Bahia State, Brazil, from 1996 to 2007, using data from the Brazilian Mortality Information System. We calculated overall rates of mortality due to traffic accidents and specific rates by type of victim. Temporal evolution was analyzed by means of correlations between rates and years of study, as well as polynomial regression models to evaluate trends. During the study period, the regions analyzed accounted for 60% of deaths due to traffic accidents in Bahia. Excess mortality among males and superior percentage of deaths in young individuals were observed. Overall, the evolution of global rates showed decreases beginning in 1998, but growth resumption in 2000, although the trend was not statistically significant. Regional differences were more marked when analyzing rates according to type of victim. However, a growing trend was observed in most locations for rates of accidents involving motorcyclists, which, in conjunction with other findings, substantiates concerns regarding the current situation of increased deaths involving motorcycles in Brazil.

Traffic Accidents; Mortality; External Causes

Resumo

O estudo descreve a evolução temporal da mortalidade por acidentes de trânsito em regiões da Bahia, Brasil, entre 1996 e 2007, a partir de dados do Sistema de Informação sobre Mortalidade. Foram calculadas taxas globais de mortalidade por acidentes de trânsito e específicas por tipo de vítima. A evolução foi analisada por meio de correlação entre essas taxas e os anos do estudo, além de modelos de regressão polinomial para avaliar tendência. No período, as regiões estudadas concentraram 60% das mortes por acidentes de trânsito ocorridas no estado. Foram observados sobremortalidade masculina e maior percentual de óbitos em indivíduos jovens. No geral, a evolução das taxas globais mostrou decréscimo a partir de 1998, mas teve retomada de crescimento em 2000, sem revelar tendência. As diferenças regionais foram mais marcantes quando as taxas foram analisadas segundo tipos de vítima, no entanto, na maioria dos locais, foi observada tendência crescente para taxas de acidentes com motociclistas, sustentando, com outros achados, as preocupações com a conjuntura atual das mortes envolvendo motocicletas no país.

Acidentes de Trânsito; Mortalidade; Causas Externas

Introduction

Traffic is one of the expressions of urban contexts that strongly influences the life and health of the population. Among its negative consequences, traffic accidents grow ever more prominent as a serious public health problem of global scale. This situation is taking shape as an "epidemic of modernity," since the number of fatal and nonfatal casualties, public sector costs, compromised quality of life for affected individuals, and loss of production due to premature deaths and their consequences are shown to be growing exponentially [1,2,3].

The intersection of different fields of knowledge and intervention in the composition of the "transit" environment, such as traffic engineering, urban planning, law, education, and others, gives the occurrence of traffic accidents a complex and multidimensional character. Furthermore, the strong connotation of randomness presented in popular culture by the term "accident" contributes to the naturalization of these events [4]. For this reason, recent international literature has avoided that designation in order to separate the problem from the stigma of unpredictability. In Brazil, despite the use of the term, transport/traffic accidents are considered unintentional but avoidable [5,6].

In general, questions of the intensification of motorization, increasing industrialization, migration processes and their consequent unplanned urbanization over time are visualized as part of the emergence and worsening of traffic accidents [6]. The situation appears more serious in developing countries because investments in road safety and urban planning are unable to match the pace of growth of vehicle fleets. Moreover, in the context of contributing human factors, certain lifestyles and the behaviors of specific groups stand out, such as young men who associate daring traffic attitudes with virility and power and so-called modern, accelerated, and hyper-consumerist lifestyles, which generate fragile interpersonal relationships prone to the culture of individualism and intolerance [6,7].

The impact of accidents on morbi-mortality of populations is reflected in high frequencies of injuries, hospitalizations, and deaths, which are shown to be on the rise in many developing countries. Traffic accidents have come to represent 2.2% of mortalities worldwide and result in the deaths of over 1.2 million people each year, principally among young men [3]. In Brazil, such events constitute the second cause of death among all external causes and, despite reductions afforded by the new Brazilian Traffic Code instituted in 1998, considerable rate increases are observed since 2001, suggesting a trend of gradual diminishment of the effect of this legislation [8].

This situation is no longer exclusive to large urban centers, considering the important trend of interiorization, whereby external causes previously restricted to metropolitan areas have progressively become more common in the interior of the country during the last decade. Studies [9,10] highlight until 1999 the dynamic hubs of violence were located in capital cities and major metropolitan areas. However, since that time the participation of small municipalities in the occurrence of homicides and traffic accidents has risen, while the share of capital cities and metropolitan areas has gradually fallen. In 2002, for example, metropolitan areas accounted for less than 25% of traffic accident deaths nationwide [9], and in 2004 there was a higher concentration of such deaths in municipalities with fewer than 100,000 inhabitants [11].

Bahia State stands out in terms of the volume of accidents and fatalities. In fact, data from the State Health Department show that among the northeastern Brazilian states, Bahia was second in the absolute number of deaths from this cause in 2005, and the eighth when compared to all states nationwide. Moreover, increased rates of mortality have been observed in recent years [12]. Accordingly, this study aims to describe the temporal evolution of traffic accident mortality in different regions of Bahia, identifying differences in this event between locations according to evolutionary behavior and type of victim. It is believed that knowledge of regional inequalities in the distribution of deaths from accidents may indicate elements essential to the implementation of public policies and control actions.

Methods

This is a descriptive study of ecological design using secondary data of traffic accident deaths for the period 1996 to 2007 in the most populous geographical microregions of Bahia State, which are regions with resident populations of 500,000 inhabitants or more throughout the entire historical sequence. Thus, the six microregions studied were Salvador, Ilhéus-Itabuna, Feira de Santana, Porto Seguro, Vitória da Conquista, and Jequié.

The choice to work with geographical microregions as territorial units was made for two reasons. In the first place, the group of municipalities that constitute these microregions was stable throughout the series. In other words, there was no change in the composition of each location during the 12 years of the study. In the second place, this method provided the possibility of ad-

dressing the phenomenon in a broader area that includes not only municipalities, but also a considerable road system. Bahia State, located in the Northeast region of Brazil, has 417 municipalities and 32 geographical microregions. Its population in 2010 was estimated at 14,016,906 inhabitants distributed in a territory of 564,830km² (Brazilian Institute of Geography and Statistics. http://www.ibge.gov.br/estadosat/perfil.php?sigla=ba, accessed on 13/Oct/2011). The road system has a total length of 124,545km divided between federal (5,100km), state (19,800km), and municipal (99,600km) roads (Department of National Transportation Policy, Transportation Ministry. Transportation and maps information database. http://www.transportes.gov.br/bit/estados/info-ba.htm, accessed on 07/Oct/2010), many of which have important roles in the economic activities and tourism of the state and throughout the country.

The six microregions studied account for 33.0% (137) of the state's municipalities and approximately 50.0% of the resident population during the study period (Health Informatics Department–DATASUS. Health information. http://www.tabnet.datasus.gov.br/cgi/tabcgi.exe?ibge/cnv/popba.def, accessed on 07/Oct/2010). The Salvador microregion, located in the metropolitan mid-region, is composed of 10 municipalities and is the most populous of all the locations studied, with 3,466,703 inhabitants in 2007. The other regions have larger numbers of municipalities, between 17 and 41, with resident populations ranging from 550,000 to just over one million. These are located in the following portions of the state: south (Ilhéus-Itabuna and Porto Seguro microregions), south central (Vitória da Conquista and Jequié), and north central (Feira de Santana). With regard to the vehicle fleet, the six areas studied include nearly 70% of the state total (DATASUS. http://www.tabnet.datasus.gov.br/cgi/tabcgi.exe?ibge/cnv/popba.def, accessed on 07/Oct/2010) (National Transportation Department. http://www.denatran.gov.br/frota.htm, accessed on 09/Nov/2009). The reference population was comprised of the residents of each microregion in each year of the study period.

In calculating of mortality rates, the resident population for each location was used as the denominator, based on the 1996 population count, the 2000 census, and Brazilian Institute of Geography and Statistics inter-census projections for the other years, obtained at the website of the DATASUS (http://www.tabnet.datasus.gov.br/cgi/tabcgi.exe?ibge/cnv/popba.def, accessed on 07/Oct/2010). The number of traffic accident deaths was extracted from the Mortality Information System (http://www2.datasus.gov.br/DATASUS/index.php?area=040804, accessed on 20/Apr/2010). For the selection of cause of death, the codes employed were those between V01 and V89 (land transport accidents) specifically classified as "traffic accident" in the 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) [13].

The rates estimated for each microregion were: overall traffic accident mortality rate (V01-V89) per 100,000 inhabitants, pedestrian traffic accident mortality rate (V01-V09) per 100,000 inhabitants, motorcyclist traffic accident mortality rate (V20-V29) per 100,000 inhabitants, and motor vehicle occupant traffic accident mortality rate (V30-V79) per 100,000 inhabitants. To permit comparability, all of these indicators were standardized for age using the direct method based on the 2000 population of Bahia (DATASUS. http://www.tabnet.datasus.gov.br/cgi/tabcgi.exe?ibge/CNV/popba.def, accessed on 07/Oct/2010).

The evolutionary behavior of deaths (V01-V89) was evaluated by age group and sex. No change was observed in the pattern of occurrence of these events between categories for these variables. For this reason, the results of mortality differentials are presented by sex and age group for the average annual rate for the period (1996-2007) in each study location. This coefficient was estimated using as numerator the total number of accumulated deaths for the period and as denominator the population at the midpoint of the period (average resident populations in 2001 and 2002, since this is an even numbered series), divided by 12 years (population base of 100,000 inhabitants). Subsequently, relative risk (RR) and 95% confidence intervals (95%CI) were calculated using a 5% significance level and considering female sex as the referent.

Analysis of the temporal evolution of mortality was initially done descriptively in order to assess correlations between time (calendar year) and each indicator, using the Spearman correlation coefficient and considering as statistically significant p-values < 0.05. Polynomial regression models were then estimated to assess trends. These models have the advantages of ease of preparation and interpretation, in addition to great statistical power [14]. The four standardized mortality rates for different categories of traffic accidents were employed as dependent variables (Y), while the sequential years were used as independent variables (X). This was centralized at the series midpoint to avoid autocorrelation between terms in the regression equation (X - 2001). Scatter plots of dependent and independent variables were used to visualize the function that best expressed the relationship be-

tween them. Subsequently, first order ($Y = \beta_0 + \beta_1 X$), second order ($Y = \beta_0 + \beta_1 X + \beta_2 X^2$), third order ($Y = \beta_0 + \beta_1 X + \beta_2 X^2 + \beta_3 X^3$), and exponential ($Y = e^{\beta_0 + \beta_1 X}$) models were tested, where β_0 is the average coefficient for the period and β1 is the average annual increment. The choice of model was based on the following criteria: best function according to the scatterplot, best fit by residual analysis (normality of errors and homoscedasticity), greater statistical significance (ANOVA p-value), and higher coefficient of determination (R^2). In cases of statistically similar models, the simplest was selected. Trends were considered significant at the $p < 0.05$ level.

The program TabWin (DATASUS. http://portal.saude.gov.br/portal/se/datasus/area.cfm?id_area=732) was used for data tabulation; Excel 1997 (Microsoft Corp., United States) for the construction of indicators, standardization of rates, and preparation of graphics; and Stata 7.0 (Stata Corp., College Station, USA) to estimate relative risks and confidence intervals. Trend analysis was performed with SPSS 15.0 (SPSS Inc., Chicago, USA).

The study was approved by the Research Ethics Committee of the Institute of Collective Health, Federal University of Bahia, registration n. 025-10/CEP-ISC, in accord with ethical principles for research involving humans.

Results

External causes represented the third cause of death between 1996 and 2007 in all regions, whereas traffic accidents had different positions, being first among external causes in Jequié and Vitória da Conquista, but surpassed by aggressions in other areas. During this period, the six microregions studied accounted for 60% of all deaths due to traffic accidents (9,032) occurring in Bahia State. The highest frequency was observed in Salvador (2,661 deaths), followed by Ilhéus-Itabuna, Porto Seguro, and Vitória da Conquista. The greater portion of these deaths was concentrated in municipality centers. With the exception of the municipality of Porto Seguro, which accounted for only 16% of the deaths in its region, the remaining municipality centers were responsible for over half occurrences.

The greater portion of deaths was among males (between 78.5% and 84.1%) and young adults, especially between 20 and 29 years of age (over 20%). The variables race/skin color and education had a high rate of missing information on death certificates. Nevertheless, considering available information, the highest percentages of death were observed in "brown" (*pardo*) subjects (between 35% and 60%, approximately) and those with 0-3 years of schooling (Table 1).

With regard to type of victim, it was observed that vehicle occupants had higher rates of death in almost all regions, with the exception of Salvador, where pedestrian fatalities predominated (35.7%). More than 90% of deaths in the victim category "other" (V80-89) was classified with code V89.2 (unspecified traumatized person in a motor vehicle traffic accident). Motorcyclist deaths had rates between 5.8% and 14%, with the microregion Jequié presenting the highest percentage (Table 1).

Estimated mortality rates by sex and age group revealed a greater risk for men as compared to women in all age groups, especially in individuals from 30 to 39 years of age (statistically significant RRs from 5.3 to 7.7). Additionally, the highest mortality rates were observed for men in younger age groups (30-49 years old), as compared to women, for whom the risk increased with advancing age (especially 50 years and older). Only in Salvador was a higher coefficient encountered for elderly males (60 years and older), indicating that in this location elderly people, regardless of gender, had a higher risk of traffic accident death than younger individuals (Table 2).

Regarding the evolution of mortality, distinct evolutionary patterns were observed in the different regions studied, both in terms of the magnitude and behavior of rates, especially for specific types of victims. Correlation and regression coefficients are presented in Tables 3 and 4, respectively. In general, the overall mortality rate (Figure 1) began to fall in 1998 and coefficient growth resumed in 2000 and 2001. However, no statistically significant trend was encountered, with the exception of the Jequié microregion, which showed a pattern of increase with a non-constant mean increment of 0.71 deaths, consistent with the correlation results (Table 3); and Feira de Santana, which showed statistical significance in the estimated regression model, with a non-constant decreasing trend (β1 = -0.23) (Table 4).

Specific rates by type of victim revealed the most striking regional differences. For the category of pedestrians, the highest rates were encountered in the Porto Seguro region throughout much of the series and remained well above the other locations beginning in 2002, reaching 5-6 deaths per 100,000 inhabitants (Figure 1). In this region, a statistically significant positive correlation was encountered between the pedestrian death rate and the years studied (Table 3). However, regression models indicated stability for this series (Table 4). Noteworthy is the increasing behavior of rates in Salvador, which presented

Table 1

Percentage distribution of traffic accident deaths by sociodemographic variables and geographical microregions. Bahia State, Brazil, 1996-2007.

Variables	Porto Seguro	Ilhéus-Itabuna	Vitória da Conquista	Jequié	Feira de Santana	Salvador
Sex *						
Male	82.2	78.5	84.1	82.4	83.2	79.4
Female	17.8	21.5	15.9	17.6	16.8	20.6
Age group (years) *						
0-9	5.5	6.5	4.7	4.8	3.7	4.1
10-19	14.3	12.9	10.2	10.2	11.7	10.5
20-29	25.4	23.6	25.5	24.4	26.7	23.9
30-39	20.8	19.9	21.4	19.3	20.3	20.0
40-49	16.5	15.6	16.3	16.7	15.9	16.9
50-59	9.1	10.1	10.5	11.5	10.5	11.6
60 and over	8.4	11.4	11.4	13.1	11.2	13.0
Race/Skin color **						
White	14.1	8.6	20.1	12.3	11.7	8.2
Black	6.0	5.0	6.0	5.6	7.7	4.7
Brown (*pardo*)	57.5	46.2	49.6	34.6	48.3	62.6
Yellow	0.2	0.1	0.4	-	0.1	0.1
Indigenous	0.6	0.1	0.2	-	-	-
No Information	21.6	40.0	23.6	47.5	32.2	24.4
Schooling (years)						
0-3	20.6	21.1	22.4	11.1	15.1	25.0
4-7	11.2	10.0	17.4	7.4	15.5	23.6
8 or more	9.7	8.5	7.7	4.9	10.9	23.6
No information	34.9	47.7	38.9	67.4	45.4	24.3
Unknown	23.6	12.7	13.6	9.2	13.1	3.5
Type of victim						
Pedestrian	24.6	28.2	23.1	21.2	28.8	35.7
Bicyclist	1.0	1.5	1.2	1.2	0.2	1.3
Motorcyclist	6.6	6.2	6.2	14.0	5.8	8.4
Occupant	40.3	49.1	55.4	33.9	40.1	30.1
Others	27.5	15.0	14.1	29.7	25.1	24.5

Source: Health Informatics Department (Mortality Information System. http://www.datasus.gov.br/tabnet, accessed on 20/Apr/2010). Brazilian Institute of Geography and Statistics (http://www.ibge.gov.br/estadosat/perfil.php?sigla=ba, accessed on 13/Oct/2011).

* Deaths with unknown sex and age were excluded;

** For the years 1997-2007.

positive correlation and growing trend, with best linear model fit. In Ilhéus-Itabuna, reduction was observed in the rates (Figure 1), with a non-constant average annual decrease of 0.06 (Table 4).

Motorcyclist mortality showed growth beginning in 1999 in all locations (Figure 2). In the correlation analysis, only Vitória da Conquista microregion did not show statistically significant positive correlation (Table 3), while regression models showed increasing trends in most microregions, including Vitória da Conquista. The exception to this pattern occurred in Ilhéus-Itabuna, although the absence of statistical significance was borderline ($p = 0.052$). The increase in such deaths was most marked in Jequié, where an explosive behavior was documented, reaching the highest coefficients in 2001, 2003, and 2005-2007 (4.1 deaths per 100,000 inhabitants at the end of the series). In this location, rates had a constant mean increment of 0.36 deaths per year. In the other regions with increasing tendency, the increases were not constant (Table 4).

Vehicle occupant mortality rates evolved similarly to the overall rate, decreasing in 1998/1999

Table 2

Average annual coefficient of traffic accident mortality per 100,000 inhabitants, by age group and sex, male relative risk (RR) with 95% confidence interval (95%CI), and geographical microregion. Bahia, Brazil State, 1996-2007.

Microregions/Age group (years)	Mortality coefficient			RR (95%CI) exposed = Male
	Total	Male	Female	
Porto Seguro				
0-19	8.3	11.6	4.8	2.41 (1.89-3.07)
20-29	28.1	47.7	8.2	5.78 (4.51-7.41)
30-39	30.9	54.7	7.1	7.68 (5.75-10.27)
40-49	34.3	57.5	10.6	5.41 (3.99-7.33)
50-59	29.9	48.8	10.4	4.69 (3.15-6.99)
60 and over	24.1	36.0	11.6	3.11 (2.11-4.58)
Ilhéus-Itabuna				
0-19	5.0	7.1	2.9	2.41 (1.89-3.07)
20-29	16.6	26.7	6.6	4.05 (3.20-5.12)
30-39	18.4	31.5	5.9	5.33 (4.08-6.97)
40-49	18.9	31.0	6.7	4.65 (3.45-6.27)
50-59	18.5	30.9	6.1	5.05 (3.46-7.38)
60 and over	16.1	22.3	9.8	2.26 (1.65-3.09)
Vitória da Conquista				
0-19	4.6	6.7	2.4	2.83 (2.00-4.01)
20-29	19.7	34.1	5.4	6.29 (4.63-8.55)
30-39	22.6	40.6	5.2	7.75 (5.49-10.95)
40-49	23.6	38.6	9.3	4.12 (2.91-5.83)
50-59	21.1	37.5	5.7	6.60 (4.11-10.58)
60 and over	18.3	32.8	4.5	7.22 (4.55-11.48)
Jequié				
0-19	3.5	4.9	2.0	2.42 (1.59-3.67)
20-29	15.3	25.8	4.7	5.54 (3.80-8.09)
30-39	16.5	29.1	4.0	7.25 (4.64-11.34)
40-49	18.9	32.8	5.3	6.23 (3.92-9.88)
50-59	19.0	32.8	6.5	5.06 (3.01-8.51)
60 and over	14.3	24.3	5.7	4.27 (2.68-6.79)
Feira de Santana				
0-19	2.2	3.2	1.2	2.66 (1.72-4.23)
20-29	12.3	21.5	3.5	6.09 (4.46-8.30)
30-39	14.0	25.6	3.7	6.92 (4.91-9.75)
40-49	14.3	27.0	3.3	8.16 (5.40-12.34)
50-59	14.3	25.7	4.8	5.33 (3.41-8.31)
60 and over	11.8	21.4	4.5	4.79 (3.15-7.27)
Salvador				
0-19	2.1	3.1	1.2	2.50 (1.97-3.17)
20-29	6.8	12.1	2.1	5.86 (4.76-7.21)
30-39	7.2	13.0	2.2	5.89 (4.70-7.38)
40-49	8.6	14.4	3.5	4.11 (3.26-5.17)
50-59	10.4	18.5	3.6	5.16 (3.87-6.88)
60 and over	12.0	22.4	5.4	4.13 (3.25-5.26)

Source: Health Informatics Department (Mortality Information System. http://www.datasus.gov.br/tabnet, accessed on 20/Apr/2010). Brazilian Institute of Geography and Statistics (http://www.ibge.gov.br/estadosat/perfil.php?sigla=ba, accessed on 13/Oct/2011).

Table 3

Spearman correlation coefficients between traffic accident mortality rates (global and by victim category) and years of the historical sequence, by geographical microregions. Bahia State, Brazil, 1996-2007.

Rates	Porto Seguro	Ilhéus-Itabuna	Vitória da Conquista	Jequié	Feira de Santana	Salvador
Global	0.340	0.049	0.091	0.715 **	- 0.102	0.357
Pedestrians	0.578 ***	- 0.455	- 0.263	0.119	0.007	0.916 #
Motorcyclists	0.754 **	0.795 **	0.406	0.975 #	0.910 #	0.912 #
Occupants	0.406	0.797 **	0.392	0.231	0.517	0.224

Source: Health Informatics Department (Mortality Information System. http://www.datasus.gov.br/tabnet, accessed on 20/Apr/2010). Brazilian Institute of Geography and Statistics (http://www.ibge.gov.br/estadosat/perfil.php?sigla=ba, accessed on 13/Oct/2011).

* Rate standardized by the direct method based on the Bahia population in 2000;

** p-value < 0.01;

*** p-value < 0.05;

p-value < 0.001.

Table 4

Analysis of trends results for traffic accident mortality (global and by victim category), by geographical microregions. Bahia State, Brazil, 1996-2007.

Mortality rates	Model *	R^2 **	p-value ***	Trend
Global				
Porto Seguro	$Y = 20.77 + 0.36X - 0.07X^2$	0.21	0.346	Stationary
Ilhéus-Itabuna	$Y = 12.39 + 0.09X - 0.03X^2$	0.06	0.740	Stationary
Vitória da Conquista	$Y = 15.98 + 0.04X - 0.21X^2 + 0.01X^3$	0.53	0.096	Stationary
Jequié	$Y = 9.5 + 0.71X + 0.10X^2 - 0.02X^3$	0.68	0.023	Increasing
Feira de Santana	$Y = 6.46 - 0.23X + 0.16X^2$	0.65	0.009	Decreasing
Salvador	$Y = 3.61 + 0.29X + 0.15X^2 - 0.006X^3$	0.55	0.075	Stationary
Pedestrians				
Porto Seguro	$Y = 5.12 + 0.28X - 0.03X^2$	0.45	0.070	Stationary
Ilhéus-Itabuna	$Y = 4.39 - 0.06X - 0.08X^2$	0.59	0.019	Decreasing
Vitória da Conquista	$Y = 3.92 + 0.03X - 0.06X^2$	0.36	0.136	Stationary
Jequié	$Y = 2.20 - 0.09X - 0.002X^2 + 0.003X^3$	0.02	0.975	Stationary
Feira de Santana	$Y = 1.93 - 0.05X + 0.04X^2$	0.20	0.362	Stationary
Salvador	$Y = 1.71 + 0.41X$	0.80	0.000	Increasing
Motorcyclists				
Porto Seguro	$Y = 1.32 + 0.48X - 0.005X^2 - 0.01X^3$	0.87	0.001	Increasing
Ilhéus-Itabuna	$Y = 0.75 + 0.24X + 0.002X^2 - 0.007X^3$	0.60	0.052	Stationary
Vitória da Conquista	$Y = 1.24 + 0.18X - 0.04X^2 - 0.003X^3$	0.66	0.028	Increasing
Jequié	$Y = 1.35 + 0.36X$	0.93	0.000	Increasing
Feira de Santana	$Y = 0.23 + 0.09X - 0.01X^2$	0.83	0.000	Increasing
Salvador	$Y = 0.10 + 0.10X + 0.02X^2$	0.76	0.002	Increasing

(continues)

Table 4 (continued)

Mortality rates	Model *	R^2 **	p-value ***	Trend
Occupants				
Porto Seguro	$Y = 7.95 + 0.19X + 0.001X^2$	0.20	0.359	Stationary
Ilhéus-Itabuna	$Y = 5.79 + 0.70X + 0.01X^2 - 0.01X^3$	0.72	0.012	Increasing
Vitória da Conquista	$Y = 8.38 + 0.98X - 0.09X^2 - 0.02X^3$	0.66	0.027	Increasing
Jequié	$Y = 3.97 + 0.14X - 0.03X^2$	0.10	0.616	Stationary
Feira de Santana	$Y = 2.93 + 0.15X + 0.02X^2$	0.40	0.099	Stationary
Salvador	$Y = 1.21 - 0.05X + 0.04X^2$	0.42	0.084	Stationary

Source: Health Informatics Department (Mortality Information System. http://www.datasus.gov.br/tabnet, accessed on 20/Apr/2010). Brazilian Institute of Geography and Statistics (http://www.ibge.gov.br/estadosat/perfil.php?sigla=ba, accessed on 13/Oct/2011).

Note: the power of X indicates the order of the polynomial of the final model.

* Model: Y = Traffic accident mortality rate per 100,000 inhabitants (global and by victim category); X = year - 2001;

** R^2 = coefficient of determination;

*** F-test p-value.

and increasing again in 2000 (Figure 2). However, statistically significant growth trends were only observed in Vitória da Conquista, with a non-constant mean increment of 0.98 deaths per year, and Ilhéus-Itabuna ($\beta 1 = 0.70$) (Table 4), which also showed a positive correlation ($r = 0.797$, $p < 0.01$) (Table 3).

Discussion

The results of this study reveal the most severe and critical aspect of traffic accidents, manifested in terms of deaths in six microregions of Bahia, which accounted for almost 60% of all deaths in the state due to this cause during the study period. This concentration is likely due to a number of factors including the large aggregate population, since these microregions include the most populous areas of the state, vehicular volume, and high-movement highway systems within their borders. Despite presenting some differences in the pattern of mortality between locations, it is evident that the profile of each microregion in terms of types of victims is similar to that found statewide, nationwide, and in other countries. Thus, our results suggest the reproduction of the problem at different territorial scales.

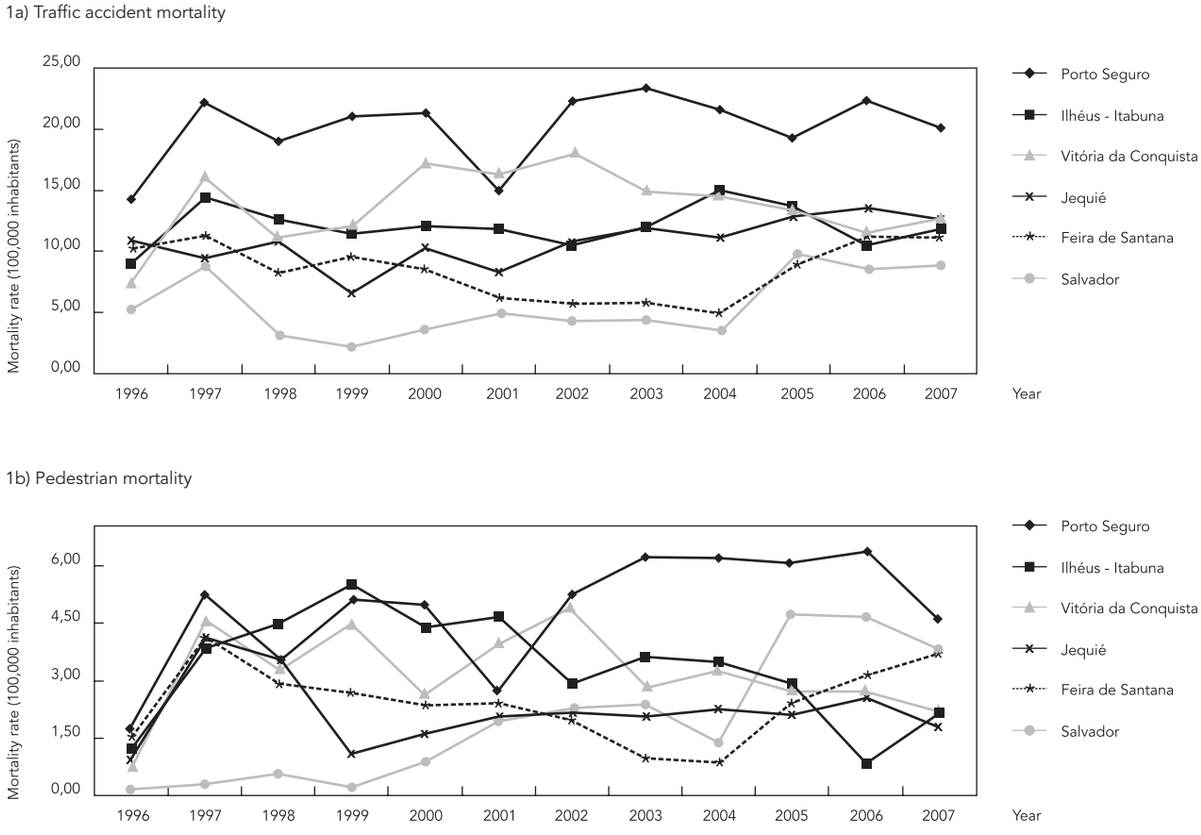
The predominance of deaths among men finds parallel in many studies [1,12,15,16,17], illustrating the differences between genders in mortality due to cause. Excess male mortality is attributed to diverse factors, such as greater historical exposure to motor vehicles, economic opportunities, and types of jobs that expose them to greater risk of accidents than women [18], as well as the symbolic factor of risky traffic behaviors as synonymous with virility [19,20].

Another common finding is predominantly young mortality. In the present study, the young adult age group accounted for over 40% of all deaths, a pattern similar to that encountered in Brazil [15] and in Bahia State [12]. These results indicate the historical persistence of early mortality due to traffic injuries, corroborating the transcendence of these causes. Behavioral theories provide some hypotheses that might explain the contribution of human elements to higher incidence of deaths among young individuals. Accordingly, some typical characteristics of youth, such as impulsivity, lower capacity to evaluate risk, the need for self-affirmation and peer approval, among others, are believed to contribute to dangerous traffic behaviors in this age group [7,19,21].

The variables education and race/skin color showed a considerable percentage of death certificate non-completion in all regions, with education having the poorest quality of recording, a finding which is similar to the results of a study by Souza et al. [22], who found more than 40% non-completion of this variable for traffic accidents in Brazil in 2003. Considering the available information, it was observed that low levels of schooling predominate, a profile found in many developing countries [18], perhaps because education is a predictor of factors or conditions that expose individuals to accidents with more severe consequences, such as being a frequent pedestrian or owning a vehicle in poor condition. For race/skin color, more individuals classified as "brown skinned" died. Some studies [1,12] opted to join the classifications "black" (*preto*) and "brown skinned" (*pardo*) to form the

Figure 1

Global evolution of rates of mortality from traffic accidents and for pedestrians, by geographical microregions. Bahia State, Brazil, 1996-2007.



Source: Health Informatics Department (Mortality Information System. http://www.datasus.gov.br/tabnet, accessed on 20/Apr/2010). Brazilian Institute of Geography and Statistics (http://www.ibge.gov.br/estadosat/perfil.php?sigla=ba, accessed on 13/Oct/2011).
Note: all coefficients were standardized for age by the direct method.

category *negro*, observing the majority of deaths in this group and characterizing its members as the public roadway users most vulnerable to traffic (usually pedestrians) due to the social exclusion of a large portion of these individuals. Araújo et al. [23] observed that the loss of potential years of life due to traffic accidents was 6.4 times higher among *negros* than whites.

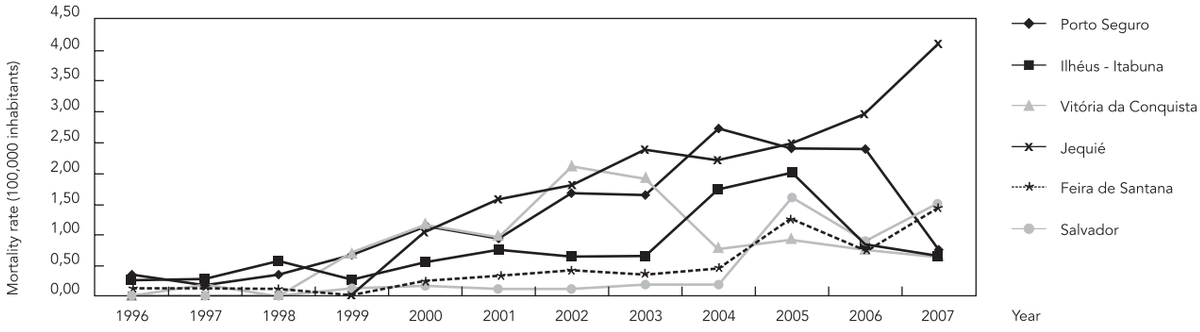
The observed higher frequency of vehicle occupants matches the profile throughout the state, since this category represented 40.4% of all fatalities in 2005 [12]. Only in Salvador were most deaths encountered among pedestrians, following the pattern observed nationally. Standing out among likely explanations for this difference between regions is the possibility that most traffic accident deaths in the Salvador microregion occurred in urban areas, where pedestrians are the users more vulnerable to death. In the other areas, the predominance of vehicle occupant deaths may be due to highway accidents, since the five regions with this concentration are intersected by highways of great economic and touristic importance, some of which pass through cities or other municipalities.

Just as the magnitude and behavior of traffic accident mortality rates vary considerably between regions and countries worldwide [1], the present study also found the reproduction of regional inequalities in different portions of Bahia State, which may have resulted from different local contexts of urban space occupation, levels of

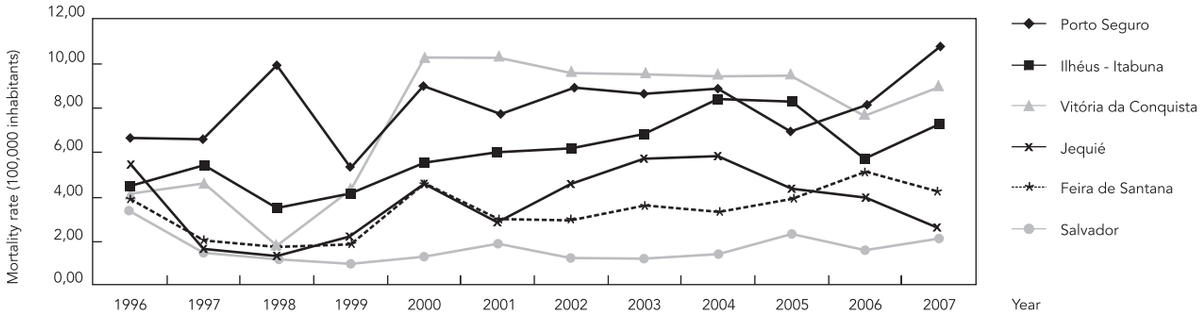
Figure 2

Evolution of traffic accident mortality rates for motorcyclists and vehicle occupants, by geographical microregions. Bahia State, Brazil, 1996-2007.

2a) Motorcyclist occupant mortality



2b) Vehicle occupant mortality



Source: Health Informatics Department (Mortality Information System. http://www.datasus.gov.br/tabnet, accessed on 20/Apr/2010). Brazilian Institute of Geography and Statistics (http://www.ibge.gov.br/estadosat/perfil.php?sigla=ba, accessed on 13/Oct/2011).
Note: all coefficients were standardized for age by the direct method.

motor vehicle use, urban road structuring, proximity to highways, and investments in victim assistance, among other factors.

When comparing the overall rates, the concentration of higher risks of death in the South region of the state was notable. These findings agree with a Bahia State Health Department study [12], which identified regional concentrations of excess risk of death from these causes in the period 1996-2005 coinciding with the spatial distribution of higher coefficients in this study. According to these data, the greatest concentration of excess risk includes all districts in the extreme south of the state, as well as parts of the south and southwest, with a coefficient of 17.1 deaths per 100,000 inhabitants. The lower magnitude encountered in the Salvador and Feira de Santana regions may be due to their higher levels of urban road infrastructure development, considering that their respective municipality centers are the state's capital and second largest city, where implementation of the new Brazilian Traffic Code has probably occurred more effectively, as well as investment in the accident victim assistance system, especially emergency medical services and intensive care.

The observed regional differences also brought into focus another phenomenon previously reported in the Brazilian literature [9,10,11]: the interiorization of various forms of violence, whereby previously metropolitan phenomena come to occur with more frequency in the interior regions of Brazil. A study conducted by the Brazilian Ministry of Health (DATASUS. http://

www.tabnet.datasus.gov/cgi/tabegi.exe?igbe/cnv/popba.def, accessed on 07/Oct/2010) shows that whereas metropolitan regions had the highest rates of traffic accident death until 1998, from 1999 onwards the picture is reversed and other regions account for higher risk levels. Only pedestrian deaths predominate with the highest coefficients in metropolitan areas or very populous municipalities [1]. The Salvador microregion has the lowest risk of traffic accidents as compared to the other regions studied, especially in terms of the global rates for motorcyclists and vehicle occupants.

Several factors may contribute to the spatial migration of the predominance of injuries and deaths related to traffic. Waiselfisz [10] highlights that the new geographic distribution of various forms of violence in Brazil seems to be related to the decentralization of economic development, which causes the interior to emerge as a region of social desirability, impacting the movement of people and vehicles. Therefore, it is necessary for medium and small municipalities to prepare to receive the "burden" of development in terms of urban space organization and efficient enforcement of legislation. Among motorcyclists, greater differences in risk of death seem to exist between low population areas and large urban centers. Between 1998 and 2004 in Brazil, municipalities with populations less than 100,000 inhabitants had the highest rates of mortality in this group [11], as well as microregions in the interior of the Central-West and North regions of the country in the triennium 2002-2004 [1]. A study in Pernambuco found that the risk of dying from accidents involving motorcyclists was higher outside of metropolitan regions [24]. The low acquisition cost of motorcycles and their increased use as work vehicles, coupled with precarious law enforcement in smaller municipalities, may contribute to this condition. According to the Brazilian National Transportation Department (http://www.denatran.gov.br/frota.htm, accessed on 09/Nov/2009), the number of motorcycles is larger in small and medium sized cities in the country. In the present study, the highest percentage of this type of victim and the greatest risk of death was found in the Jequié region.

With respect to temporal evolution, the behavior of the overall mortality rate in most microregions resembles the statewide pattern, with decreasing deaths during years near the implementation of the new *Brazilian Traffic Code* (1998 and 1999), but subsequent elevation that did not reach statistical significance [12]. The reduction of rates during this period is cited in various studies [8,22,25], which point to the positive impact of the traffic code in an immediate but transient reduction of traffic accident mortality indicators, since the decline was sustained until 1999. The subsequent resumption of growth in deaths reflects the gradual loss of effect of this legislation, probably due to relaxing of enforcement and poor societal compliance, as suggested by some researchers [17,25]. Importantly, despite not showing a statistically significant trend, the sharp rise in rates observed in Salvador beginning in 2005 could represent an artificial increase, since there were efforts in that year by the State Health Department, in partnership with the Legal Medicine Institute and the Community Forum for Combating Violence, aimed at improving the quality of information on cause of death [12]. The pattern of increase in the overall rate observed in Jequié may be due to growth in the number of motorcyclist deaths.

Regarding pedestrian mortality rates, the Porto Seguro microregion presented coefficients above the state and country averages in the final years of the series [12,15]. The findings for the Salvador region follow the pattern observed by several studies for large urban areas with intense movement of people and vehicles, whereby pedestrians were the principal victims [16]. Probably, the major urban centers still favor structuring road systems for vehicle traffic, leaving pedestrians in a situation of greater exposure to accidents. The growth trend in pedestrian rates in this location may have been influenced by improved information collection, as previously mentioned.

The highest risks of death for vehicle occupants were encountered in Vitória da Conquista, Porto Seguro, and Ilhéus-Itabuna. In addition to elevated absolute rates in Ilhéus-Itabuna and Vitória da Conquista, these regions also showed statistically significant increases. Contributing to such behavior may have been the proximity of high volume highways. Overall, the rates for this group were sensitive to the effect of the new Brazilian Traffic Code in the years 1998 and 1999, as evidenced by reductions in this period, although the effect also proved to be temporary.

The behavior of mortality from accidents involving motorcyclists shows a more peculiar scenario than that presented for other categories of victims. In virtually all regions, rate increases were observed, a scenario also identified nationally. The location that most stands out is the Jequié microregion, which had only one year of inflection in this coefficient and presents values at the end of the series close to that observed nationally for Brazil [8]. The number of motorcyclist injuries and deaths has increased alarmingly throughout the country and particularly affects a portion of the population characterized by greater economic productivity (20-39 years). A study by the

Ministry of Health indicates an increasing mortality trend among motorcyclists since 1997 in all regions of Brazil [15]. Moreover, it was observed that in 2008 motorcyclist deaths exceeded deaths by accidents involving vehicle occupants for the first time in Brazil. That same year, the Northeast region of Brazil was the region with the second highest rates nationally, reaching 4.7 deaths per 100,000 inhabitants, and Bahia was the state with the highest rate in the region (10.7 deaths per 100.000 inhabitants) [8].

In Brazil, some authors attribute the origin of the growth in morbidity among motorcyclists to a set of factors present since the mid-twentieth century. Standing out among these are: a public policy emphasis on individual modes of transport, to the detriment of the offer of mass public transportation options in keeping with the needs of the population; the advent of outsourcing in the economic production model, which caused the need for greater agility in transportation; and the low offer of employment to a large contingent of the population that adopted the motorcycle as a solution to unemployment, in association with the lower cost of acquisition and maintenance of this type of vehicle. Moreover, Brazil has experienced a rise in the number of professions employing motorcycles, such as motorcycle taxis, recently regulated in Brazil, and the introduction of this vehicle in rural areas to replace traditional means of transport involving draft animals [6,15].

The Jequié region shares some of the historical determinants mentioned above. According to the National Transportation Department (http://www.denatran.gov.br/frota.htm, accessed on 09/Nov/2009), the motorcycle fleet in this location increased from 6,634 in 2001 to 19,557 in 2007 (an increase of over 194% in six years) and represented almost half of all vehicles in 2007. Another important factor observed in the municipal center of Jequié is motorcycle taxi profession, which became an important activity for meeting the transportation needs of this population, as occurred in various municipalities in Bahia, whether legally or illegally.

Another important point is that the mortality curves for this group do not seem to have experienced a positive effect from the new *Brazilian Traffic Code* in any of the locations studied, with the pattern of increase presented creating the appearance that they are at the margins of the regulation. Vasconcelos [26] point out that the exponential growth in traffic deaths associated with motorcycles had the effect of eliminating gains brought about by the *Brazilian Traffic Code* in reducing car accidents. For this reason, the results of the present study with other findings [11,15,24,26,27] justify recent concern over deaths involving motorcycles in Brazil, which constitute one of the most serious contemporary public health problems in the traffic context and present a serious challenge for public policy in diverse sectors.

With regard to the study's limitations, it is relevant to mention that the use of secondary data calls for caution in using the information produced, due to problems of underreporting, underrecording, and poor quality of data completion. Although the Northeast region of Brazil shows the lowest percentage of coverage of the Mortality Information System, coverage in Bahia State has improved, reaching 75.1% in 2006 [15], leading to the belief that the knowledge produced by this research represents a good approximation of reality.

To conclude, the national and international profiles for this problem were found to be reproduced in a state in the Northeast region of Brazil, with mortality being predominantly young and male. Mortality rates varied notably between regions and the phenomenon of interiorization of traffic-related violence at the national level was also observed in a smaller territorial dimension. As for evolution, it was noticed that the reduction some coefficients coincided in time with the initial years of implementation of the new *Brazilian Traffic Code*, but increased again after 2000, although this trend was not statistically significant. Thus, it may be observed that one of the main challenges for reducing the risk of death from this cause is maintaining the protective effect of this legislation. However, this outcome is not observed for motorcyclists, which leads to questions about the adequacy and effectiveness of the existing legislative framework. Finally, it is believed that solutions for safe transit should be interdisciplinary and located within the sphere of public policy.

Resumen

El estudio describe la evolución temporal de la mortalidad por accidentes de tráfico en regiones de Bahía, entre 1996 y 2007, a partir de los datos del Sistema de Información sobre Mortalidad. Se calcularon tasas globales de mortalidad por accidentes de tráfico y específicas por tipo de víctima. La evolución fue analizada por medio de una correlación entre esas tasas y los años del estudio, además de modelos de regresión polinomial para evaluar la tendencia. Durante el período, las regiones estudiadas concentraron un 60% de las muertes por accidentes de tráfico ocurridas en el estado. Se observó sobremortalidad masculina y mayor porcentaje de óbitos en individuos jóvenes. En general, la evolución de las tasas globales mostró un decremento a partir de 1998, pero retomó el crecimiento en 2000, sin revelar una tendencia definida. Las diferencias regionales fueron más marcantes cuando se analizaron las tasas según tipos de víctima, sin embargo, en la mayoría de los lugares se observó una tendencia creciente hacia tasas de accidentes con motociclistas, respaldando, con otros hallazgos, las preocupaciones por la coyuntura actual de muertes en el país donde están involucradas motocicletas.

Accidentes de Tránsito; Mortalidad; Causas Externas

Contributors

P. A. A. Rios was responsible for selecting the topic, project design, data collection and analysis, writing all versions of the article, and approval of the final version. E. L. A. Mota participated in selecting the methodology and collaborated in data analysis and interpretation, revision of all versions of the article, and approval of the final version.

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