ARTICLE

Analysis of factors associated with traffic accidents of cyclists attended in Brazilian state capitals

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Abstract Introduction: *Brazil has the sixth largest bicycles fleet in the world and bicycle is the most used individual transport vehicle in the country. Few studies address the issue of cyclists' accidents and factors that contribute to or prevent this event.* Methodology: *VIVA is a cross-sectional survey and is part of the Violence and Accidents Surveillance System, Brazilian Ministry of Health. We used complex sampling and subsequent data review through multivariate logistic regression and calculation of the respective odds ratios.* Results: *Odds ratios showed greater likelihood of cyclists' accidents in males, people with less schooling and living in urban and periurban areas. People who were not using the bike to go to work were more likely to suffer an accident.* Discussion: *The profile found in this study corroborates findings of other studies. They claim that the coexistence of cyclists and other means of transportation in the same urban space increases the likelihood of accidents.* Conclusion: *The construction of bicycle-exclusive spaces and educational campaigns are required.*

Key words *Traffic accidents, Bicycling, Epidemiological surveys, Accidents and Statistical modeling*

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Introduction

With approximately 48 million bicycles, Brazil has the sixth largest fleet of bicycles in the world, behind only China, India, USA, Japan and Germany[1]. Bicycle is the most used individual means of transportation in the country. Bicycles share with pedestrians most normal movements of 90% of Brazilian municipalities' total.

Despite this reality, the necessary infrastructure for the use of bicycles in the country is not available everywhere and there are few studies on bicycles used as means of transport. Less is known about cyclists' traffic accidents, despite being frequent in many countries, causing deaths and disabilities, especially in children and young adults[2-5].

Traffic accident-related studies point to cyclist data underreporting[6]. In Pelotas, Rio Grande do Sul[7], comparing information from police reports and emergency care attendances for two years found 33.0% underreporting with regard to accidents with bodily injury for this group. In Londrina, Paraná, police records coverage for bicycle accidents was 8.0%, while car accidents stood at 72.0%[8].

Bacchieri and Barros[9] show that approximately 1.2 million people worldwide die from traffic accidents every year and over 90% of these deaths occur in low- and middle-income countries. It is worth noting that, in addition to family suffering for the deaths and physical disabilities, victims' costs to health systems are high. The World Health Organization (WHO) estimates that annual losses due to Traffic Accidents exceed US$ 500 billion.

In Brazil, the number of deaths and serious injuries exceeds 150,000 people and the Institute of Applied Economic Research (IPEA) estimates that total annual costs of accidents are R$ 28 billion. Cyclists' deaths rose from 1% (396 deaths) to 4% (1,556 deaths) from 1998 to 2008, with peak recorded in 2006 (1,668 deaths).

In the period 2000-2010, 32,422 deaths of cyclists suffering traumas in traffic accidents (CTAT) in Brazil were identified, equivalent to 8.3% of all road traffic accidents[1].

In Brazil, some information systems provide data on accidents involving cyclists, such as Police Report (BO); Traffic Accident Registration Report of the National Traffic Department (DENATRAN); Work Accident Notification (CAT); Hospital Information System of the Unified Health System (SIH/SUS); Mortality Information System of the SUS (SIM/SUS) and the Violence and Accidents Surveillance System (VIVA – Survey).

Among these, we highlight the last three, since they are directly managed by the health sector, they have data on the outcome of the accident, they show the severity of the accident and some factors associated with the accident.

This study aimed to describe accidents involving cyclists registered in the VIVA survey conducted in 2014 and to analyze the factors associated with these accidents.

Methodology

We used the 2014VIVA survey, which is part of the Violence and Accidents Surveillance System, Ministry of Health, and aims to analyze the trend of violence and accidents and to describe the profile of violence (interpersonal or self-inflicted) and accidents (traffic, falls, burns, among others) attended in Brazilian urgent and emergency care facilities.

The 2014 VIVA survey is the fifth survey conducted by this surveillance system. Its data was collected in 30 consecutive days from September to November 2014 in 12-hour shifts chosen by probabilistic draw in urgent and emergency care services within the Unified Health System. Shifts were used as primary sampling units (PSU) and facilities as strata of the sampling plan.

This survey included care provided in urgent and emergency care services located in 24 state capitals and the Federal District, as well as 11 selected municipalities.

This paper only included state capitals that participated in the VIVA survey in its analysis because they concentrate most attendances to accidents and violence victims, totaling 86 urgent and emergency care services and accounting for 55,950 attendances. Accidents had 15,499 attendances, of which 1,652 refer to cyclists, representing 10.7% of the total traffic accident attendance.

Methodology was divided into two stages. The first stage addressed data description and the second stage conducted a multivariate analysis.

The descriptive part of data analysis consisted of simple and relative frequencies of variables: Cyclist (yes or no); gender (male and female); age (years); schooling (0-4 years, 5-8 years, 9 to 11 years, 12 years and over); race/skin color (yellow, white, indigenous, brown, black); capital attended; day and period of event; other party involved in the accident (animal, car, bicycle, fixed object, buses, among others); disability (yes or no); al-

cohol use in the last six hours (yes or no); area of event (urban, rural and periurban); use of bicycle to go to work (yes or no); use of safety equipment (yes or no); event occurred on the way to work (yes or no); nature of injury (amputation, cut/laceration, sprain/strain, fracture, etc.); body part affected (mouth/teeth, head/face, abdomen/hip, upper or lower limbs, multiple organs/regions, among others) and evolution (discharge, hospitalization, outpatient referral, death).

The multivariate logistic regression analysis for complex sample data used the following variables: cyclist accident and other traffic accidents (yes = cyclist accident and no = other traffic accidents) as the dependent variable and the following variables: age (years); gender (male/female); schooling (0-4 years, 5-8 years, 9-11 years and 12 years and over); disability (yes or no); alcohol use in the last six hours, self-reported by the victim (yes or no); accident area (urban, rural and periurban), day of the event (Monday through Sunday); and use of bicycle to go to work (yes or no) as possible variables associated with the event, or exposure variables.

Exposures treated in the study (covariates) were temporally associated with the cyclist accident event because they occurred just prior to it, which enabled the assessment of the contributing factors to increase or reduce the likelihood of this type of accident[10].

The model exposure covariates were included in blocks, according to the hierarchical analysis proposed by Olinto et al.[11], that is, more proximal variables containing features related to individuals were included in the model first, and then more distal variables were further considered, because they were related to the event (Figure 1).

This study used the manual selection of variables as defined by Colosimo and Giolo[12], which defines the systematic removal of variables in the multivariate model according to statistical significance. Initially, covariates inherent to the victim, such as age, gender, schooling, disability and the use of alcohol in the last six hours prior to the accident were included in the regression model.

Covariates with a p-value greater than 0.05 according to the Wald's test were systematically manually removed from the model. The disability covariate with p-value of 0.993 was excluded from the model to enable a new adjustment. All other variables were significant, but one of the categories of the schooling variable (category 9-11 years schooling years) was not significant. Thus, we decided to make a new categorization of the schooling variable, with two new categories, namely, 0-8 schooling years and 9 schooling years and over.

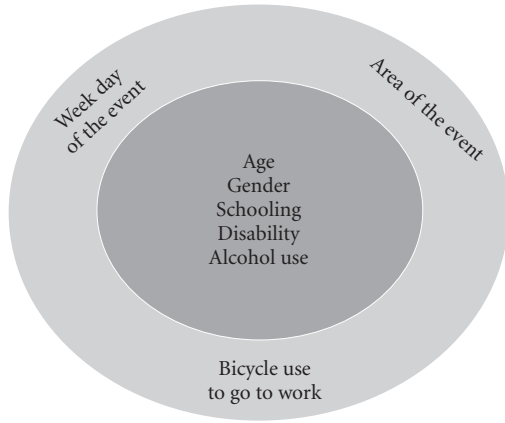

Figure 1. Hierarchical model for the selection of variables tested in the model.

Event-related covariates were inserted in the second stage of the manual covariates inclusion procedure, that is, the area and day of the event. After the inclusion of these two new covariates, the use of alcohol in the last six hours (p-value 0.212) and the day of the event (p-value 0.369) were not significant anymore and, therefore, were removed from the model. The variable area of the event was significant but was recoded into two categories – urban + periurban and rural, since the periurban category was not significant.

The bicycle use to go to work variable, which was significant (p-value 0.00) and was maintained in the final model, was included in the regression in the third and final stage of manual inclusion of variables. However, the age variable became not significant (p-value 0.627) and was dropped from the final model. Odds ratios were calculated (OR) to assess the association between the crash event with cyclists and variables gender, schooling, accident occurred on the way to work and the area of the event.

The regression analysis was adjusted using SPSS software[13] version 20, in the complex sample module, applying logistic regression to evaluate associations and odds ratios, between accidents with cyclists and other covariates selected in the survey[14,15].

The 2014 VIVA Survey study was approved by the National Research Ethics Commission (CONEP), the Ministry of Health.

Results

Descriptive Analysis

Some 1,652 attendances for road traffic accidents involving cyclists were recorded at urgent and emergency care services and state capital emergencies participating in the 2014 VIVA Survey. Of these, 75.1% (1,241) were male; in relation to age group, 28% (463) were aged between 20 and 39 years, 26.5% (437) between 10 and 19 years, and 21.7% (358) were aged between 0 and 9 years.

Regarding race / skin color, 63.4% (1,047) were brown. Schooling mentioned was 0-4 years for 37.2% (615) of victims, followed by 5 to 8 years for 21.7% (359). Some 95.3% (42) of these victims did not have a disability.

State capitals with a higher proportion of attendances for road traffic accidents involving cyclists were Boa Vista (11.1% -184) and Brasilia (6% - 99), and those with lower proportions were Belo Horizonte (1.3% - 21) and Salvador (1.5% - 24). Regarding the area of the event, 93.8% (1,550) occurred in the capitals' urban or periurban area.

These cyclists collided with a car in 23.2% (383) of the cases, and a motorcycle in 13.2% (218) of the cases. In 87.2% (1,440) of these cases, the victim was the driver of the bicycle, and 90.5% (1,495) did not use any safety equipment at the time of the accident.

The victim reported alcohol use in the six hours prior to the event in 10.8% (178) of these accidents, and 17.1% (282) of these occurred on the way to work. The nature of injury was cut/laceration in 39.3% (649), and sprain/strain in 15.9% (263).

Of the injured cyclists, 31.5% (521) had their lower limbs affected, while 20.9% (346) had their upper limbs affected. In 17.3% (286) of these cases, multiple organs/body parts were affected. In 40% (661), attendance took place in the afternoon and in 30.6% (506) in the morning; 47.8% (790) were serviced from Monday to Wednesday; where 73.1% (1,208) were discharged and 11.1% (183) were hospitalized.

Analysis of factors associated with accidents (Logistic Regression)

The Table 1 shows the results of the multivariate logistic regression for complex samples: Wald's test, p-value, ORs values, confidence intervals and the final statistical model obtained.

Gender odds ratio (male x female) was 1.59, which indicates that men are 59.0% more likely to be victims of accidents when driving a bike when compared to women.

As for schooling, the odds ratio was 0.42, so the group of 9 and over schooling years is 58.0% less likely to suffer crash cycling compared people with 0-8 schooling years.

Odds ratio for those who suffered an accident on the way to work was 0.68, which indicates that whoever was on the way to work was 30.0% less likely to be an accident victim while riding a bike when compared to those using the bike for other activities.

Odds ratio for the area of the event was 3.24, indicating that the likelihood of accidents with cyclists in urban and periurban areas is 224.0% higher than the rural area.

Discussion

The profile of injured cyclists attended at the services participating in the VIVA Survey were consistent with other studies on the casualty profile for traffic accidents.

The Global Status Report on Road Safety of the World Health Organization shows that almost half of all traffic accidents deaths in the world involve most vulnerable victims (pedestrians, cyclists and motorcyclists), and death probability for each type of victim varies by region. In the Americas, 3% of all traffic deaths occur among cyclists, 20% among motorcyclists and 22% among pedestrians[16].

The vulnerability of cyclists partly occurs because bicycles are hybrid vehicles, which sometimes circulate as other vehicles and other times as pedestrians, contending with them sidewalks' space[17].

Bicycles' shared traffic with motor vehicles is the main factor of insecurity, facilitating accidents. This information was reiterated in this study where major accidents refer to the bicycle-car crash.

The predominance of accidents involving young men and was found in other studies, such as that from Gawryszewski et al.[18] in São Paulo, which found that men and women accounted for 74.2% and 25.8% of total attendances, respectively; and that carried out in Londrina, where 50% of the victims were between 17 and 31 years of age[19].

This profile is repeated in international studies, such as that of Boström and Nilsson[20], who

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Table 1. Factors associated with accidents involving cyclists attended in the 2014 VIVA survey (numbers, proportions, Wald's test, p-value, ORs, lower and upper limits of ORs' confidence interval of 95%).

	Cyclist		Non-cyclists (Other accidents)		Wald	Value	OR	Lower Limit	Upper Limit
	N	%	N	%	F	p		(OR)	(OR)
Gender					16.4	0.00	1.59	1.27	1.98
Male	1241	11.3%	9779	88.7%					
Female	411	9.2%	4064	90.8%					
Schooling					16.4	0.00	0.42	1.27	1.98
0-8 years	974	15.1%	5492	84.9%					
9 years and over	403	5.4%	6997	94.6%					
Event on the way to work					12.6	0.00	0.68	0.56	0.84
Yes	282	6.7%	3923	93.3%					
No	787	9.9%	7128	90.1%					
Area of event					34.8	0.00	3.24	2.19	4.79
Urban + Periurban	1550	11.1%	12409	88.9%					
Rural	88	6.3%	1306	93.7%					

Model: Cyclist ~ β0 (Interception) + β1*Gender+ β2*Schooling β3* Event on the way to work + β4*Area of event + Ɛ (error)

found that in Sweden, in the period 1987-1994, men were the most affected in accidents involving bicycles, and younger people represented the most prevalent profile regarding age. Accidents involving women were less severe, with lower mortality for all types of vehicles, except bicycle. In this case, the fatality rate among women was 60% higher than among men.

In their study in emergency facilities in São Paulo, Gawryszewski et al.[18] noted that, in the age group 0-4 years, 40.4% of attendances for traffic accidents had a cyclist as victim, while in the 10-14 years age group, these victims accounted for 62.5% of cases with injuries. In this study, it was not possible to determine the amount of these injuries sustained during recreational activities.

Lower schooling was associated with a higher risk of cyclists accidents in this study, a fact borne out by a study conducted by Bacchieri et al.[2] on the use of bicycles among workers, which pointed out that schooling had inversely proportional linear association with the outcome.

Authors demonstrated, in addition to the high prevalence of bicycle use among workers with low schooling level (33.9%), a probability approximately five times higher of those workers using the bike compared to workers with over nine years schooling.

Pezzuto[21] notes that despite the potential use of bicycle as a means of transport toward sustainable Brazilian cities, its use is higher for recreation purposes.

This data helps to explain the finding of this study, in which the likelihood of accidents at other times than the commuting to work is higher than the commute to work.

The greater frequency of accidents with cyclists in times that were not transiting on the way to work also refers to the discussion of traffic vulnerable groups, since the age variable was no longer significant with the introduction of this variable in the multivariate analysis, which suggests that children in leisure activities are the most vulnerable age group.

Regarding the use of safety equipment, studies show that the use of helmets among cyclists is low worldwide, despite evidence that its use can reduce around 63% to 88% of the risk of head injury in this group[22].

Regarding safety equipment required by the Brazilian Traffic Code (CTB), only 0.3% of the observed bikes were fully compliant, while 14.0% were totally non-compliant[9]. Most of them (55.0%) had only one of the required equipment[17].

Moreover, in a study conducted at seven hospitals in Seattle, USA, Rivara et al.[22] inferred that the helmet use reduced by 93% the risk of death compared to those not using the device and that driving a bicycle over 15 mph increased by 2.6 times the risk of fatal accident.

Another important issue is cyclist accidents' underreporting. The highest proportion of accidents with cut/laceration and sprain/strain as na-

ture of injury suggest that accidents involving cyclists are mostly minor accidents and only those who sustained serious injuries go to the hospital. This fact is consistent with findings of this study, where most attendances for accidents involving cyclists resulted in discharge after treatment.

This is corroborated by Bacchieri and Barros[9] as to the severity of the accident. It points out that 75.0% of cyclists had scrapes and abrasions, while 25.0% sustained injuries that are more serious. In Maringá, State of Paraná, pedestrians and cyclists showed 119% and 65% higher risk of hospitalization for traffic accidents, respectively, when compared to car occupants. In 1998, 47% of deaths were pedestrians and cyclists[23].

In Maringá, cyclists accounted for 18% of deaths from traffic accidents in 1992. The pattern of use of this means of transportation may be common in Brazilian rural cities, with mild temperatures and flat topography being an economical alternative, especially among lower income social groups[24].

The largest proportion and likelihood of accidents in urban and periurban areas can be explained by the fact that data used in this study were from national capitals. Yet we can infer that underreporting is greater and severity lower in rural areas, often not reaching hospitals.

Finally, an important limitation of findings must be observed: since the group of individuals who had not suffered bicycle accidents is formed by individuals who have suffered other accidents, groups tend to be more homogeneous, because risk factors for the various types of traffic accidents overlap, which could lead to an underestimation of the results of the multivariate analysis.

It is important to consider that the VIVA survey does not intend to extrapolate its findings to all hospitals that perform the same type of attendance in Brazil. Results can and should be extrapolated to the total attendances of hospitals that were part of the investigation in the Brazilian state capitals.

Conclusion

This study achieved the objective of analyzing the factors associated with the occurrence of accidents with cyclists by examining the main causes, among those available in the database, comparing their findings with literature and raising possible causal hypotheses that contribute to the occurrence of this type of accident.

Despite the findings and vulnerabilities found in this study, bicycle is one of the healthiest means of transport (if all safety aspects are preserved), since it can bring many positive effects to people's health, such as reducing the prevalence of chronic non-communicable diseases.

Thus, findings of this study highlight the need for discussion on actions to reduce the occurrence of traffic accidents involving cyclists. Such measures include wider proposals such as the revaluation of public policies that encourage individual automobile transport, and even specific interventions, such as creating safe spaces for leisure, educational programs for the general population and improved enforcement of traffic laws. Another factor that could lead to a reduction of these accidents is the use of safety equipment.

Collaborations

CAM Sousa, CA Bahia and P Constantino participated equally in all stages of preparation of the article.

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