Risk for injuries among motorcyclists involved in traffic incidents*

RISCO DE LESÕES EM MOTOCICLISTAS NAS OCORRÊNCIAS DE TRÂNSITO

RIESGO DE LESIONES EN MOTOCICLISTAS EN ACCIDENTES DE TRÁNSITO

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ABSTRACT

The objective of this study was to identify, among motorcyclists involved in traffic incidents, the factors associated with risk of injuries. In 2004, in the city of Maringá-PR, it was determined that there were a total of 2,362 motorcyclists involved in traffic incidents, according to records from the local Military Police. Multivariate analysis was applied to identify the factors associated with the presence of injury. A significantly higher probability of injury was observed among motorcyclists involved in collisions (odds Ratio= 11.19) and falls (odds Ratio= 3.81); the estimated odds ratio for females was close to four, and those involved in incidents including up to two vehicles were 2.63 times more likely to have injuries. Women involved in motorcycle falls and collisions with up to two vehicles stood out as a high-risk group for injuries.

DESCRIPTORS
Accidents, traffic
Wounds and injuries
Risk factors
External causes

RESUMO

Este estudo teve como objetivo identificar entre os motociclistas envolvidos em ocorrências de trânsito fatores associados ao risco de lesões. No ano de 2004, foram identificados, em Maringá-PR, um total de 2.362 motociclistas envolvidos em ocorrências de trânsito com registro nos boletins da Polícia Militar. Para identificar os fatores associados à presença de lesão, foi utilizada a análise multivariada. Uma probabilidade, significantemente mais elevada de motociclistas se ferirem, foi observada entre aqueles envolvidos em colisão (Odds Ratio = 11,19) e quedas (Odds Ratio = 3,81); para o sexo feminino, a razão de chance estimada foi em torno de 4, e aqueles que estiveram envolvidos em ocorrências com até dois veículos, mostraram 2,63 vezes mais chances de apresentar lesões que os demais. Mulheres, envolvidas em ocorrências com motocicleta do tipo quedas e colisões com até dois veículos destacaram-se como grupo de risco para apresentar lesões.

DESCRITORES
Acidentes de trânsito
Ferimentos e lesões
Fatores de risco
Causas externas

RESUMEN

Identificar entre los motociclistas involucrados en accidentes de tránsito factores asociados al riesgo de lesiones. En 2004, fueron identificados en Maringá-PA, un total de 2362 motociclistas involucrados en accidentes de tránsito, registrados en boletines de la Policía Militar. Para identificar los factores asociados a la presencia de lesión, se utilizó el análisis multivariado. Una probabilidad, significativamente más elevada de que los motociclistas sufran heridas, se observó entre aquellos involucrados en colisión (Odds Ratio=11,19) y caídas (Odds Ratio=3,81); para el sexo femenino, la razón de posibilidad estimada estuvo en torno de cuatro, y aquellos que estuvieron involucrados en accidentes con hasta dos vehículos mostraron 2,63 veces más chances de presentar lesiones que los demás. Las mujeres involucradas en accidentes motociclísticos del tipo caídas y colisiones con hasta dos vehículos se destacaron como grupo de riesgo para presentar lesiones.

DESCRITORES
Accidentes de tránsito
Heridas y traumatismos
Factores de riesgo
Causas externas

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INTRODUCTION

Using a motorcycle for transportation has rapidly increased in the past few years. Along with this growth, traffic accident events involving these vehicles have also increased in number, transforming it into an important cause of injury, disability and death[1-2].

The motorcycle is often used as a means of transportation for individuals working long hours, rendering users vulnerable to periods of fatigue, as well as diminished reflexes and concentration.

Some of the reasons for the elevated risks involving motorcyclists are: lack of attention or neglect on the part of other vehicles drivers; the complexity of dealing with a motorcycle, which requires excellent motor skills and physical coordination; diminished reflexes due to alcohol, medications and drug abuse by motorcyclists; lack of preparation and training; an excess of confidence; and motorcyclists' attraction to risk-taking behavior[1].

For motorcyclists, despite the progress that has been made in terms of safer motor vehicle designs, inequality in protection conditions and higher exposure on the road compared to other vehicles are determining morbidity-mortality factors[3].

Along with cyclists and pedestrians, motorcyclists are extremely exposed and vulnerable, resulting in traffic accident events causing severe injuries and death[4-5].

Mortality due to motorcycle accidents is a public health problem. Of no less importance are the problems occurring in injured individuals as a result of these accidents due to motorcyclists and their passengers' vulnerability[6-7].

Acknowledging the factors related to the morbidity and mortality of motorcycle accident victims facilitates the understanding of the reality of these events and contributes to improving specific decision-making and planning, in addition to providing information about the event characteristics.

In Brazil, there are few investigations analyzing the associated factors of injury risks exclusive to motorcyclists. Findings around the globe analyze victims from different types of events. However, some authors acknowledge limitations and confirm that these victims, due to specific influencing factors, must be studied separately[8-9].

In light of these aspects, and considering the importance of traffic accident events involving motorcycles causing injuries both by incidence and by severity and consequences, this present study intends to demonstrate the associated factors of injury risks to motorcyclists involved in traffic accident events.

> Mortality due to motorcycle accidents is a public health problem. Of no less importance are the problems occurring in injured individuals as a result of these accidents due to motorcyclists and their passengers' vulnerability.

METHOD

This is an analytical, descriptive epidemiological and retrospective study[10]. Data were obtained from Traffic Accident Events Reports (*Boletins de Ocorrência de Acidente de Trânsito*-BOAT) provided by the Military Police. Motorcyclists involved in traffic accidents throughout the period of January 1st to December 31st of 2004 in the city of Maringá – Paraná were included in this study.

Reports from the year 2004 were taken from the police files and analyzed month by month. When records indicated the occurrence of a motorcycle traffic accident, the information was then transferred to a specific data collection instrument, built specifically for this purpose. All reports regarding the period of this study were analyzed and reviewed twice to ensure the inclusion of all motorcyclists involved in traffic accidents and the associated data.

For the purpose of analysis, the group of injured motorcyclists included those who had reported the traffic accident in an Official Report, as well as the presence of bodily injuries or death as a result of the traffic accident. In order to identify the percentage of injured motorcyclists from the Integrated System of Emergency and Trauma Care (*Sistema Integrado de Atendimento ao Trauma e Emergência*-SIATE), all Rescue Care Emergency Reports (*Relatórios de Atendimento do Socorrista* - RAS) from 2004 were consulted.

At the end of data collection, all information regarding the motorcyclists was transferred to an Excel® built database, and within this information database the probable risk factors were included (independent variables), along with the dependent variable of this study, injury events. For data analysis and interpretation, *Statistica* 7.1® and the Statistical Analysis System® (SAS – 9.1) were used.

Initially, a descriptive analysis of each of the independent variables was performed. This procedure had the objective of evaluating the impact of the uninformed data and also to characterize the motorcyclists involved in traffic accidents. Throughout this phase, the descriptive analysis also included central tendency measures (mean, median, mode and standard deviation). Variables lacking information in $\geq 10\%$ of the cases were excluded from the association analyses.

In order to compare the groups of individuals with and without injuries, bivariate analysis and the Chi-Square Test were used. The Fisher Exact Test was used when more than 20% of the expected contingency tables' frequency was less than or equal to five.

The logistic regression model was adjusted for each one of the independent variables. For the logistic model,

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those variables that reached a value p≤0.20 in the bivariate analysis were selected.

In the multivariate analysis for logistic regression, the baseline categories were: events involving more than two vehicles for the variable 'number of vehicles involved in the accident'; running over involved pedestrians, animals and cyclists for the variables 'type of accident' and 'type of impact'; description of the position of individuals in the vehicle; time of day of the accident (appropriate light); signage present; and sex of the involved motorcyclist.

Variables unbalancing the model or that were not significant in the Chi-Square Test (in other words, those that were not associated with the dependent variable in the model composition) were excluded. Model appropriation was evaluated by the Hosmer-Lemeshow Test[11].

This study was approved by the Research and Ethics Permanent Committee Involving Human Beings of Universidade Estadual de Maringá, Statement No. 354/2005. Data resource use was authorized by the 4th Military Police Battalion and SIATE.

RESULTS

Traffic accident events compound analysis identified 2362 motorcyclists involved in this type of event. Of this total, 1863 were injured and 499 were uninjured. Most injured individuals (1743 motorcyclists, (93.56%) were registered both in the Traffic Accident Event Reports (BOAT) through the Military Police and the Rescue Care Emergency (RAS) through the Integrated System of Emergency and Trauma Care (SIATE).

Results demonstrate that male individuals were most commonly involved in traffic accident events, corresponding to 1861 (78.79%) individuals. The male to female ratio was 4.2:1. Regarding age, findings demonstrated that the majority of victims (51.49%) were between 20 and 29 years of age. The age bracket between 30 and 39 years was the second most frequent in the analyzed group (20.27%) and the lowest frequencies were observed in the extreme age brackets (up to 9 years of age and 60 years and older). Combining the young adult individuals' age brackets from 20 to 39 years, findings demonstrate that more than 70.00% of the involved motorcyclists belonged to this age group. Age variation among motorcyclists was between two and 69 years, with a mean of 27.94 years, (±9.76) and a median and mode of 25 and 22 years, respectively.

The greatest majority of the studied populations were motorcyclists, and they were 6.62 times more frequent than passengers. Of 441 women, 248 (56.24%) were motorcyclists and 193 (43.76%) were passengers; 93.72% of men were motorcyclists rather than passengers.

Of all motorcyclists involved in traffic accident events, 78.88% were injured. More than half of the injured individuals (56.82%) were referred to tertiary hospitals. From the group of 2362 motorcyclists, a total of 29 (1.22%) died; 11 victims (0.46%) died at the accident site and 18 (0.76%) died in the hospital.

In regards to data descriptive analysis, the lack of records concerning the use of a helmet was observed for 14.87% of the motorcyclists, and this was the only variable excluded from the association analysis because it occurred in more than 10% of the studied cases.

The comparison between motorcyclists with and without injuries according to personal characteristics and the events in which they were involved is presented in Tables 1 and 4.

In Table 1, the comparison of injured and non-injured motorcyclists did not reach significant levels for the variables related to the traffic accident event location; however, road signs and light were selected from the independent variables for the multiple logistic regression analysis (p< 0.20).

Table 1- Distribution of the motorcyclists involved in traffic accident events with or without injuries and the related p values, according to local characteristics – Maringá, PR, 2004

| Variables | Categories | Motorcyclists | | | | p |
| | | Injured | | Not Injured | | |
		Nº	%	Nº	%	
Area (2362)	Urban	1849	99.24	495	99.20	1.0000
	Rural	14	0.76	4	0.80	
Light (2268)*	Suitable	1600	89.64	443	91.71	0.1980
	Unsuitable	185	10.36	40	8.29	
Weather conditions (2270)*	Good	1504	84.16	405	83.86	0.8885
	Bad	283	15.84	78	16.14	
Road Signs (2190)*	Present	1277	74.15	366	78.20	0.1240
	Absent	445	25.85	102	21.80	

Source: Traffic Accident Event Reports from the Military Police, Note: (n=2362)
*The difference between the total number and the observed number constitutes uninformed data.

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In Table 2, the age of involved vehicles was not related to the presence of injuries. Also, there was no statistically significant association between injured motorcyclists and the following variables: number of vehicles involved, type of accident and impact. The proportion of injured motorcyclists was higher than the non-injured motorcyclists when one and two vehicles were involved, as compared to three or more vehicles. In the group of injured motorcyclists, falls, truck, car and heavy-duty truck collisions and collisions with fixed objects were proportionally more frequent. In the same way, transverse collisions, collisions with fixed objects and collisions with animals were most common in terms of type of impact.

Table 2 – Distribution of the motorcyclists involved in traffic accident events with or without injuries and the related p values, according to the vehicle's age, number of vehicles involved, type of accident and type of impact – Maringá, PR, 2004

| Variables | Categories | Motorcyclists | | | | p |
| | | Injured | | Not Injured | | |
		Nº	%	Nº	%	
Involved Vehicle age (2251)*	Up to 5 years old	1052	59.07	286	60.85	
	Up to 10 years old	431	24.20	107	22.77	0.7724
	More than 10 years old	298	16.73	77	16.38	
Number of vehicles involved (2362)	One	534	28.66	131	26.26	
	Two	1273	68.34	330	66.13	<0.0001
	Three or more	56	3.00	38	7.61	
Type of accident (2362)	Motorcycle striking pedestrian/animal	98	5.27	92	18.44	
	Motorcycle versus non-motorized vehicle	74	3.98	44	8.82	
	Motorcycle versus motorcycle	137	7.35	79	15.84	
	Motorcycle versus car/truck	1014	54.43	227	45.49	<0.0001
	Motorcycle versus heavy- duty vehicle	104	5.58	21	4.20	
	Motorcycle versus fixed object	39	2.09	1	0.20	
	Fall while on motorcycle	397	21.30	35	7.01	
Type of impact (2362)	Lateral collision	295	15.84	85	17.04	
	Transverse collision	694	37.26	146	29.25	
	Head-on collision	54	2.90	13	2.61	
	Rear-end collision	208	11.17	82	16.44	
	Collision with fixed object	39	2.10	1	0.20	<0.0001
	Multiple impacts	78	4.18	45	9.01	
	Pedestrian collision	47	2.52	92	18.44	
	Animal collision	51	2.73	-	-	
	Fall while on motorcycle	397	21.30	35	7.01	

Source: Traffic Accident Event Reports from the Military Police
Note: (n=2362)
* The difference between the total number and the observed number constitutes uninformed data.

Results presented in Table 3 demonstrate that there was no statistically significant association between the presence of injuries and the time, day of the week and/or month of the event.

Data demonstrated in Table 4 show that the presence of injuries was statistically significant when associated with gender and the position of the vehicle. The injured group included a higher percentage of female motorcyclists (22.17% versus 6.53%) and passengers (16.48% versus 0.60%).

Although there was no association observed between the presence of injuries and the age brackets of the motorcyclists/passengers, it is interesting to highlight that the 13 children (between two and nine years) involved in the accidents were injured as a consequence of the accident.

Table 5 presents the multiple logistic regression model in relation to the dependent variable presence of injury resulting from the trauma.

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Table 3 – Distribution of the motorcyclists involved in traffic accident events with or without injuries and the related p values, according to the date and time of the accident – Maringá, PR, 2004

Variables	Categories	Motorcyclists				p
		Injured		Not Injured		
		Nº	%	Nº	%	
Time (2362)	6:00 to 11:59 A.M.	458	24.58	132	26.46	0.7779
	12:00 to 5:59P.M.	664	35.65	178	35.67	
	6:00 to 11:59P.M.	600	32.21	156	31.26	
	12:00 to 5:59A.M.	141	7.56	33	6.61	
Day of the week (2362)	Sunday	224	12.03	49	9.82	0.4981
	Monday	232	12.46	76	15.24	
	Tuesday	272	14.60	68	13.63	
	Wednesday	262	14.06	70	14.02	
	Thursday	240	12.88	67	13.43	
	Friday	313	16.80	91	18.23	
	Saturday	320	17.17	78	15.63	
Month of the event (2362)	January	129	6.93	27	5.42	0.6303
	February	121	6.49	38	7.62	
	March	176	9.45	44	8.82	
	April	134	7.19	34	6.82	
	May	142	7.63	41	8.22	
	June	166	8.92	36	7.22	
	July	136	7.31	50	10.02	
	August	187	10.03	48	9.61	
	September	156	8.37	48	9.61	
	October	182	9.76	50	10.02	
	November	164	8.80	43	8.61	
	December	170	9.12	40	8.01	

Source: Traffic Accident Event Reports from the Military Police, Note: (n=2362)

Table 4 – Distribution of the motorcyclists involved in traffic accident events with or without injuries and the related p values, according to personal characteristics – Maringá, PR, 2004

Variables	Categories	Motorcyclists				p
		Injured		Not Injured		
		Nº	%	Nº	%	
Gender (2302)*	Male	1446	77.83	415	93.47	**<0.0001**
	Female	412	22.17	29	6.53	
Age bracket (2302)*	2 to 9 years	13	0.70	-	-	0.7289
	10 to 19 years	248	13.35	58	13.06	
	20 to 29 years	995	53.56	221	49.78	
	30 to 39 years	368	19.80	111	25.00	
	40 to 49 years	150	8.08	36	8.10	
	50 to 59 years	68	3.65	14	3.15	
	60 to 69 years	16	0.86	4	0.91	
Vehicle position (2362)	Driver	1556	83.52	496	99.40	**<0.0001**
	Passenger	307	16.48	3	0.60	
Length of time with valid driver's license (1883)**	No license/expired license	58	3.99	12	2.81	0.6306
	Less than 1 year	85	5.83	27	6.33	
	Between 1 and 10 years	1025	70.39	297	69.55	
	More than 10 years	288	19.79	91	21.31	
Residence of the involved motorcyclist (2296)*	Maringá	1549	83.59	375	84.65	0.6160
	Other cities	304	16.41	68	15.35	

Source: Traffic Accident Event Reports from the Military Police, Note: (n=2362), * The difference between the total number and the observed number constitutes uninformed data. * The difference between the total number and the observed number includes 310 passengers and 169 cases regarding drivers with no information.

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Table 5 – Multivariate analysis of logistic regression of risk factors for the presence of injuries as a consequence of motorcycle trauma suffered in traffic accidents – Maringá, PR, 2004

Variable	Category	Adjusted OR	CI 95% Adjusted OR	p
Type of accident	Collision	11.19	[6.92 – 18.06]	
	Fall while on motorcycle	3.81	[2.75 – 5.28]	< 0.0001
	Striking animal /pedestrian	1.00	-	
Gender	Female	3.97	[2.66 – 5.91]	< 0.0001
	Male	1.00	-	
Number of vehicles involved in the event	Up to two vehicles	2.63	[1.67 – 4.14]	< 0.0001
	More than two vehicles	1.00	-	

Hosmer-Lemeshow Test for the adequacy of the model: p=0.7284, OR= Odds Ratio, CI= Confidence Interval, Note: (n=2362)

Risk factors for injury resulting from trauma included: collision, fall from the motorcycle, being female and being involved in an accident involving two vehicles. Regarding striking pedestrians or animals the motorcyclists involved were 11.19 times more likely to suffer an injury; those who fell from the motorcycle were 3.81 times more likely to be injured. The risk for the female motorcyclist to be injured was 3.97 times greater than for males. The risk for motorcyclists involved in events with more than two vehicles to be injured was 2.63 times greater than for motorcyclists involved in accidents with three or more vehicles.

The statistical measure indicated by the Hosmer-Lemeshow Test[8] demonstrated a significant likelihood of model adequacy.

DISCUSSION

In Maringá, as well as in other Brazilian urban centers, the use of the motorcycle as a means of transportation to and from places of employment has become more widespread. In the year 2004, the city had a ratio of 916.9 motorcycles per 10,000 inhabitants[12-13].

In that same year, the military police registered 1951 traffic accident events in Maringa involving 2362 motorcyclists. Most of those motorcyclists (78.88%) received injuries, a percentage indicating the fragility of these individuals in traffic accident events.

Morbidity-mortality due to traffic accidents is extremely high throughout the world; however, the proportion of death and injury is particularly high for motorcycle accidents, resulting mainly from higher exposure, lack of observance of traffic laws and risky behavior[14].

Maringá is geographically located in the Northwest region of Paraná. It is a medium-sized city, considered the third largest city in the State of Paraná. Its growth has followed an urban development plan resulting in wide streets and avenues with median strips.

The city is located in a highly influential region due to its strategic physical and territorial positioning, resulting in a convergence of highly important federal and state highways. This location, in addition to its urban consolidation, has resulted in a cluster city which faces the same problems as larger cities: the dispersal of growth in limited areas and the formation of *dorm-cities* within the cities where economic and employment opportunities are fewer.

Plane topography and the predominance of sunny days, with temperatures frequently above 20°C, significantly contribute towards the use of motorcycles and bicycles as means of transportation to and from places of employment.

National and international studies[15-16] have related the occurrence of traffic accidents and the resulting deaths of motorcyclists to vehicle age, length of time holding a valid license, day of the week, month and residence location, with a view to analyzing the motorcycle driver's familiarity with the accident location. In this present study, these variables were not associated with studies that demonstrated the conditions that enhance the risk of traffic accidents or fatalities and are not similar to those that enhance the probability of suffering an injury in a traffic accident involving a motorcycle.

The multivariate analysis model demonstrated that risk factors for injuries resulting from trauma were: collision, falling off the motorcycle, being female and being involved in an accident involving up to two vehicles.

The type of accident and impact were associated with the presence of injuries in motorcyclists. Regarding the multivariate analysis of risk factors for injuries, collision was the highlighted item, and motorcyclists involved in collisions had an 11.19 times greater chance of suffering an injury than motorcyclists involved in striking a pedestrian or animal.

In vehicle collisions, one of the most important factors is the speed of the vehicle at the time of the accident. This type of accident involves three distinct acts: the first act occurs when the vehicle collides with the other vehicle or object; the second act occurs when the motorcyclist collides with the vehicle itself or other obstacle; and the third act occurs when internal organs collide against each other,

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or with the confined walls of the chest, abdomen or skull of the motorcyclist due to deceleration forces, resulting in organ rupture. In light of these three simultaneously occurring acts, severe trauma and/or death are not surprising[17].

More than half of fatal accidents and severe injuries result from the collision of two vehicles, such as a motorcycle versus another moving vehicle, usually regular-sized vehicles. The main factor in this type of accident is the difficulty of the driver of the other vehicle to see the motorcycle in time to prevent a collision. The motorcycle has a small front end and, for this reason, it is more difficult to see by drivers of other vehicles, who may not notice its proximity[16].

In motorcycle accidents, falls from motorcycles, in addition to collisions, present increasing frequency[16]. In this present study, this type of accident was seen more often in the group of injured motorcyclists than in the group with no injuries. Findings demonstrate that victims of falls suffer fewer injuries than those individuals involved in collisions (3.81 versus 11.19); however, motorcyclists who fell from their motorcycle had a 3.81 times greater chance of suffering an injury than individuals involved in running over (striking) a pedestrian or animal.

In the present study, results demonstrate that most accidents (68.01%) involved up to two vehicles. A significant statistical association was observed between the number of vehicles involved in the accident and the presence of injuries. In the multivariate analysis, the risk of injury for motorcyclists when up to two vehicles were involved was 2.63 times greater than in events involving more than two vehicles.

Females were found in higher numbers in the injured group than in the non-injured group (22.17% versus 6.53%). Multivariate analysis outcomes demonstrated that being female was a risk factor for injury.

In a study performed in Maringá, risk factors for hospital admittance were identified in victims from various traffic accident categories. Results demonstrated that women presented a 20% higher risk of requiring hospitalization when compared to men, although this association was not included in the multivariate analysis[18].

The risk for injuries in women involved in motorcycle accidents may be related to two important aspects: more recent licensing of women compared to men and the higher number of female passengers.

In this present study, there was no association between the time of license acquisition and injuries suffered. However, in an analysis of the average license holding time for men and women, a ratio of 7.18 $\pm$7.59 to 4.74 $\pm$5.04 was respectively observed.

Men were drivers more frequently than women, who are often passengers. For drivers, the ratio was 7.1 men for every one woman. However, in regards to passengers, the ratio was approximately two women for every one man. For the group analyzed, the passenger's position in the vehicle was associated with injuries.

On a motorcycle, the passenger has greater difficulty maintaining his/her position on the motorcycle compared to the driver, since they cannot count on the handlebar for security and they are solely supported by the driver or the lateral parts of the motorcycle for safety. Moreover, safety equipment must be considered for passengers. A study conducted in Indonesia demonstrated that 79% of the interviewed drivers stated they used helmets versus only 40% of passengers[19].

CONCLUSION

This study demonstrated the fragility of motorcyclists as victims of traffic accident events, since 78.88% of the motorcyclists involved in traffic accident events were injured. Results also demonstrate that the trauma mechanism (type of accident and number of vehicles) is a risk factor for injuries, as well as the high risk of injury for women involved in motorcycle accident events. This is new evidence that must be confirmed in other regions.

Results confirmed the frequency of motorcyclists among traffic accident victims and revealed specifics regarding important epidemiological aspects that may contribute towards improving the care of these individuals and implementing accident reduction policies and strategies involving motorcycles.

Findings in this study demonstrate the importance of focusing on motorcyclists' education, and also on regulating and monitoring these vehicles for safety. We hope that these results will serve as motivation to perform other research that may complement and confirm these findings.

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