Understanding the factors of road crash severity in Benin: a matched case-control study

Donatien Daddah,[1,2] Yolaine Glèlè Ahanhanzo,[1] Alphonse Kpozehouen,[1] Bella Hounkpe Dos-Santos,[1,2] Emmanuel Bonnet,[3] Alain Levêque,[2] Yves Coppieters[2]

[1]Regional Institute of Public Health-Ouidah, Benin; [2]School of Public Health, Université Libre de Bruxelles, Belgium; [3]Institute for Research on Sustainable Development (Prodig CNRS – IRD), Paris 1 Panthéon-Sorbonne University, AgroParisTech, Aubervilliers, France

Abstract

Background. In Benin, due to the unavailability of comprehensive data on road crashes, road safety policies are mainly based on partial statistics provided by the police. These remain unreliable in terms of injury severity and risk factors. This study aims to determine the factors influencing the severity of injuries after a road crash in Benin.

Methods. The present nested case-control study, matched for age and sex, was based on a hospital cohort of road crash victims set up in five hospitals in Benin between July 2019 and January 2020. A sample of severely injured patients according to the Abbreviated Injury Scale (cases) was compared to non-severely injured patients (controls).

Results. The severe crash occurred mainly during the night between 8 p.m. and midnight (36.2% of cases *vs*. 24.4% of controls) and on main roads (57.8% of cases *vs*. 34.7% of controls). Factors associated with injury severity were the time of the crash: night between 8 p.m. and midnight [Adjusted Odd Ratio (AOR): 2.1; CI 95%: 1.4-3.2], major roads (national interstate roads and national roads) (AOR: 2.8; CI 95%: 2.0-4.0) and non-work-related travel (AOR: 1.8; CI 95%: 1.2-2.7).

Conclusions. Factors associated with road crash severity in Benin were night-time, main roads, and non-work related travel. Raising user awareness about compliance with traffic rules and improving public lighting, especially along main roads could help reduce the number of serious injuries.

Correspondence: Donatien Daddah, Regional Institute of Public Health-Ouidah, Benin.
Tel.: +229.97167245.
E-mail: donadah@yahoo.fr

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Introduction

Every year, road crashes result in more than 1.35 million deaths worldwide, and about 50 million are injured.[1] According to the World Bank's Road Safety Report, road deaths and serious injuries are unacceptable, preventable, and hinder economic growth in developing countries.[2] "Road crashes take an unacceptable toll, particularly on people in poor countries" said Dr. Margaret Chan, World Health Organization (WHO) Director-General, at the launch of the 3rd Global Status Report on Road Safety.[3]

Approximately 90% of road crashes occur in these countries, and vulnerable road users such as pedestrians, cyclists, and motorcyclists bear the greatest burden with more than half of all road deaths worldwide.[1,3] Africa is the most affected continent with almost three times as many deaths as European countries (26.6 and 9.3 deaths per 100,000 inhabitants respectively).[3] The high severity and mortality of road traffic crashes in developing countries is thought to be related to the increase in the number of motor vehicles, poor enforcement of road safety measures, inadequate health infrastructure, and insufficient access to health services.[4] Despite the implementation of the Decade of Action for Road Safety, the trend has not been favorable, especially in low- and middle-income countries.[5] According to Etienne Krug, at the adoption of the Stockholm Declaration marking the end of the Decade of Action for Road Safety (2011-2020), no low-income country had reduced the number of road traffic injuries.[6]

In Benin, statistics on serious and fatal road injuries come mainly from the police. This source indicates that in 2018, non-fatal severe accidents accounted for 42% of all accidents. A total of 736 deaths were recorded, compared with WHO estimates of

approximately 2,986 deaths (95% CI, 2458-3514) for the same year.[1,7] According to this source, in 2018, severe nonfatal crashes accounted for 42% of all crashes, and 736 deaths were recorded compared to the WHO estimate of about 2,986 (95% CI 2458-3514) deaths for the same year. This underestimation of road accident statistics in Benin has been found in other studies in West Africa;[8] however, the parameters used by the WHO for these estimates do not always reflect reality.[9] This raises the challenge of the quality of road accident data in Africa.

Hospital sources of road crash data are limited as the national health information system collects only aggregate data for patients involved in motor vehicle crashes. Information on injury severity is not available. For police data, the statistical unit of analysis is the road crash, individual victim data are not very detailed, and the assessment of severity is based on subjective criteria of police officers without medical skills.

Studies in Europe and Africa showed that police data on severe injuries have many biases that can affect road safety issues.[10,11] Another study highlighted the need for hospital data on crash severity to avoid under-reporting and mis-assessment.[12]

According to the International Traffic Safety Data and Analysis Group, a medical definition of injury severity would promote a greater understanding of the consequences of road crashes and help monitor their progress.[13]

Road crash severity factors from hospital sources have been very little explored in Benin. The present study hypothesizes that the severity of road traffic injuries is related to behavioral and environmental factors and that taking these factors into account in road safety policies would contribute to reducing the severity of road crash injuries.

Thus, the objective of this study was to determine the factors associated with the severity of road crashes in Benin.

Materials and Methods

Type of study

This is a nested case-control study, matched for age and sex, conducted on a cohort of road crash victims set up in Benin between July 2019 and January 2020.

Study setting

Data collection took place in the following five hospitals: i) Hubert Koutoukou Maga national university hospital; ii) departmental university hospital of Oueme-Plateau; iii) Menontin district hospital; iv) departmental university hospital of Borgou-Alibori; v) Boko district hospital.

These hospitals distributed throughout the country were selected: i) based on their status as referral centers for several other health care facilities; ii) because of their geographic location with easy access along the main roads; iii) also based on the high reputation of these hospitals and on the annual number of admissions, for road traffic crashes, reported by Benin's national health information and management system in 2018.

Data source and selection of participants

The present study was carried out on a hospital cohort of road crash victims called the "TraumAR Cohort". It was set up in Benin as part of the research project "ReMPARt", Multidisciplinary Research for Road Crash Prevention, which aims to prevent road crashes. Data were collected by questionnaire from July 2019 to January 2020. Patients were enrolled in the cohort as they were admitted to the hospitals. The questionnaire was completed at the patient's bedside after signing the free and informed consent form. This was followed by observation and exploitation of the medical record for additional clinical and paraclinical data. In order to prevent information bias, the same questionnaire was administered to all accident victims regardless of the severity of the injuries. Initial data were collected by means of an electronic questionnaire containing general information on the patient, his or her history, sociodemographic, behavioral, environmental, vehicle-related variables, consequences of the crash, patient management, and satisfaction data. A baseline functional assessment was performed using the Washington Group questionnaire.[14]

Study population

An initial prospective cohort was used. All persons admitted directly for road crashes to one of the five cohort data collection hospitals were eligible for the study. The patient recruitment process has been reported in different studies.[15,16] Briefly, individuals were eligible for inclusion regardless of age if they were: a) victims of road crashes in Benin between July 2019 and January 2020; b) residing in Benin; c) gave consent to participate in the study. Injury data were extracted from medical records and coded for severity by trained physicians using the Abbreviated Injury Scale (AIS). This scale classifies injuries by body region into 6 categories of severity, with AIS 1 being minor and AIS 6 being maximal. A severe injury was defined as an AIS score greater than or equal to 3 (AIS≥3).[17] The Maximum Abbreviated Injury Scale, also scored from 1 to 6, corresponds to the highest AIS score of the most severe injury identified in a patient from the six body regions (head, face, chest, abdomen, extremities including pelvis, and superficial region). In this study, cases were patients with severe injuries and controls were patients with only non-severe injuries. This study was conducted according to the principles expressed in the Declaration of Helsinki. The protocol describing this study was approved by the Ethics Committee of the University of Parakou (Benin) under the reference 0182/CLERB-UP/P/SP/R/SA.

Sample size and sampling

In order to define the number of subjects needed for our study, the Dupont formula was used.[18] To have good statistical power a case was matched with 2 controls in a 1:2 ratio. The matching criteria in this study were age and sex as in other studies.[19,20] After calculating the required sample size of 597, computerized random sampling in Stata 15 software was used to select 199 cases for 398 controls (Figure 1).

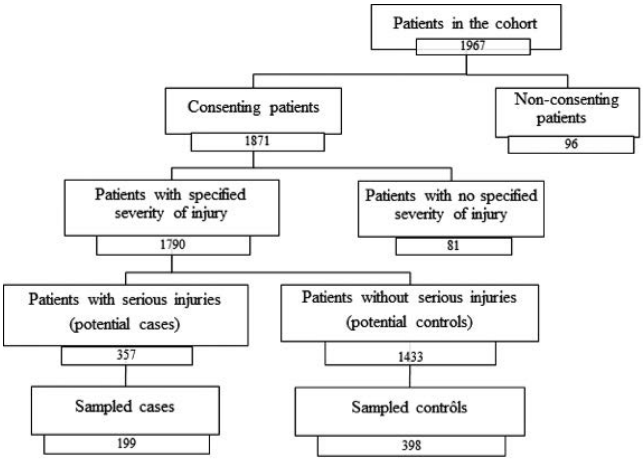

Figure 1. Case and control selection process.

Variables

The dependent variable is the severity of the injuries according to the AIS scale. This variable was coded 1 for cases, patients with severe injuries, and 0 for control, patients without severe injuries according to this scale.

Dependent variables were: i) socio-demographic variables as gender (male/female), age, marital status (single, married or engaged, divorced or widowed), professional status (no occupation, in employment, in training), history of chronic disease, history of a previous crash; ii) behavioural variables as wearing protective gear (helmet or seatbelt), drinking alcohol, smoking, use of psychoactive products, taking sleeping pills, distraction during the crash, fatigue or drowsiness during the crash; iii) environmental or vehicle-related variable as type of user (pedestrians, motorcyclists, other road users), time of the crash (12 am-6 am, 7 am-7 pm, 8 pm-12 am), perceived visibility level (good, poor, acceptable), type of road (major roads, other roads), crash location (intersection, off-intersection, parking area), perceived pavement condition (good, poor, under construction), antagonist (none, fixed obstacle, moving vehicle, pedestrian, animal or projectiles), driver of the vehicule , reason for travel (non-work related, professional), location of the referral hospital (Cotonou, Parakou, Porto-Novo).

Processing and analysis

The data were processed and analyzed using Stata 15 software. Variables were described for cases and controls. Quantitative descriptive statistics were presented as a mean (standard deviation) after checking for normality. Qualitative data were presented as a percentage. The chi-square test or Fisher's exact test was used to compare proportions.

The dependent variable injury severity was cross-tabulated with each of the independent variables. The chi-square test was used to compare proportions. Student's t-test was used for comparison of means after checking conditions. A simple conditional logistic regression was performed for the univariate analysis. For this regression, the crude odds ratio (COR) followed by its 95% confidence interval was used to measure the association between dependent and independent variables. The modeling was carried out to assess the association between the independent variables and the dependent variable using a top-down conditional multiple logistic regression. The adjusted odds ratio (AOR) followed by its 95% confidence interval was used to identify factors associated with injury severity. All covariates were examined for inclusion in the conditional logistic regression model for a P<0.1 on univariate analysis. Variables with a P-value greater than 0.05 were gradually removed from the initial model. Colinearity between variables was sought. A difference was considered statistically significant for a P-value less than or equal to 0.05.

Results

Socio-demographic characteristics of cases and controls

In the present study, no socio-demographic variables were significantly associated with injury severity. The majority of road crash victims were married (71.4% of cases *vs*. 63.8% of controls) and employed (83.9% of cases *vs.* 79.4% of controls) (Table 1).

Behavioral, history, habits and lifestyle factors of cases and controls

In this study, 52.9% of cases *vs*. 62.8% of controls were wearing protective gear (helmet or seat belt). Similarly, 64.3% of cases *vs*. 62.6% of control reported having driven under the influence of alcohol. Finally, 8.5% of cases *vs*. 12.8% of controls reported being distracted at the time of the crash. No behavioral, history, habits, and lifestyle variables were significantly associated with injury severity (Table 1).

No history, habit, or lifestyle variables were significantly associated with injury severity. The majority of patients (78.4% of cases *vs*. 79.9% of controls) had no history of chronic disease. Similarly, 65.8% of cases *vs*. 59.1% of controls had no history of crashes (Table 2).

Environmental and vehicle factors of cases and controls

The severe crash occurred mainly during the night between 8 p.m. and midnight (36.2 of cases *vs*. 24.4 of controls; P=0.010). These road crashes were significantly more severe on major roads (national interstate roads and national roads) (57.8 of cases *vs*. 34.7 of controls; P<0.001) and non-severe on other roads (alleys and rural roads) (42.2 of cases *vs*. 65.3 of controls; P<0.001). Severely injured patients were more likely to travel for non-work-related reasons (76.4% in cases *vs*. 65.1% in controls; P=0.005). The hospitals in Porto-Novo (45.7% cases *vs*. 29.9% controls) and Parakou (18.6% cases *vs*. 15.3% controls) received more serious than non-serious injuries (P<0.001) (Table 3).

Table 1. Human factors of cases and controls, 2019-2020, Benin.

Variables	Severity of injury (%) or (mean±SD)		P
	Case (n=199)	Control (n=398)	
Marital status			0.153
Single	22.1	29.4	
Married or engaged	71.4	63.8	
Divorced or widowed	6.5	6.8	
Professional status			0. 377
No occupation	6.0	6.8	
In employment	83.9	79.4	
In training	10.1	13.8	
Wearing protective gear (n=385)			0.059
Yes	52.9	62.8	
No	47.1	37.2	
Drinking alcohol			0.675
Yes	64.3	62.6	
No	35.7	37.4	
Smoking			0.077
Yes	15.6	10.5	
No	84.4	89.5	
Use of psychoactive products			0.457
Yes	69.9	66.8	
No	30.1	33.2	
Taking sleeping pills (n=594)			0.465
Yes	2.0	3.0	
No	98.0	97.0	
Distraction during the crash (n=374)			0.227
Yes	8.5	12.8	
No	91.5	87.2	
Fatigue/ drowsiness during crash (n=375)			0.761
Yes	11.1	10.1	
No	88.9	89.9	
History of chronic disease			0.668
Yes	21.6	20.1	
No	78.4	79.9	
History of a previous crash			0.220
Yes	34.2	40.9	
No	65.8	59.1	
Driving experience (years) (374)	18.2 (11.0)	16.8 (9.6)	0.244

Analysis of factors associated with injury severity

Having a road crash between 8 p.m. and midnight (COR: 1.9; CI 95%, 1.3-2.7), on major roads (COR: 2.6; CI 95%, 1.8-3.6), having a non-work related travel (COR: 1.8; CI 95%, 1.2-2.6) and be admitted to referral hospital located in Parakou (COR: 1.8; CI 95%, 1.1-3.0) or Porto-Novo (COR: 2.4; CI 95%, 1.6-3.5) were factors associated with the severity of injuries at univariate analysis (P<0.05) (Table 2).

At multivariate analysis, a night-time crash between 8 p.m. and midnight (AOR: 2.1; CI 95%, 1.4-3.2), major roads (AOR: 2.8; CI 95%, 2.0-4.0) and non-work related travel (AOR: 1.8; CI 95%, 1.2-2.7) were risk factors for serious injury at multivariate analysis (Table 4).

Discussion

Main findings

This study compares patients who sustained serious injuries (cases) with those who sustained non-serious injuries (controls) following a road crash. It reports relevant information on the severity of road crashes in Benin. The results show that the time of the crash, the type of road, and the reason for travel were independently associated with the severity of the injury. These results partially support the starting hypothesis that the severity of road traffic injuries is related to behavioral and environmental factors.

The risk of severe injury was higher at night, particularly between 8 p.m. and midnight, than at other times of the day. The association between the time of crash and injury severity has also been found in many studies in Ethiopia and USA.[21,22] Measures such as the ban on night-time travel in Zambia contributed to an overall 57.5% reduction in road traffic deaths.[23] In contrast, some studies in Brazil and the USA found no difference in severity between night and daytime crashes.[24,25] However, the American study focused on off-road vehicle crashes, which are used more in the USA than in Benin. The severity of night-time crashes in our context could be explained by several factors, including non-compliance with traffic rules at night, driving under the influence of drugs or alcohol, speeding due to low police presence on the roads at night and poor road lighting at night. Municipalities can no longer afford to pay the charges for electrical energy consumption, which explains their non-functionality. In addition, there are many cases of incivility on the part of users and the population, leading to the destruction of electrical installations by vehicles or the theft of batteries from public solar panels. Systematic reviews and one study have confirmed that injury severity is higher on roads without lighting at night and that street lighting can prevent traffic crashes, injuries, and deaths.[26,27] Another study showed that crashes that occurred at night were almost twice as likely to be serious as those that occurred during the day.[21,28,29] In addition, some authors in Egypt found that the severity of injuries in a crash on a road under construction was significantly different between night and day.[30] This would be due to the low visibility of obstacles in a poorly signaled environment.

In this study, crashes that occurred on major roads were the most likely to result in severe injury. This was also found in research conducted by Asare *et al*., where national roads were a risk factor for severe crashes.[31] Studies carried out in the USA, Philippines, Romania, China, and other countries have shown that serious crashes or pedestrian fatalities are more common on major roads such as national highways.[22,32-36]

In the context of this study, the higher severity of crashes on major roads could be explained by speeding, non-compliance with traffic laws, and poor traffic police control. In terms of road infras-

Table 3. Environmental and vehicle factors of cases and controls, 2019-2020, Benin.

Variables	Severity of injury (%) Case (n=199)	Control (n=398)	P
Type of user			0.448
Pedestrians	17.1	14.1	
Motorcyclists	75.4	79.9	
other road users	7.5	6.0	
Time of the crash			0.010
12 pm-6 am	6.5	7.3	
7 am-7 pm	57.3	68.3	
8 pm-12 pm	36.2	24.4	
Perceived visibility level (595)			0.773
Good	74.1	76.4	
Poor	13.2	12.8	
Acceptable	12.7	10.8	
Type of road			<0.001
Major roads[a]	57.8	34.7	
Other roads[b]	42.2	65.3	
Crash location			0.324
Intersection	7.1	8.3	
Off intersection	85.9	87.4	
Parking area	7.0	4.3	
Perceived pavement condition			0.536
Good	80.4	83.4	
Poor	14.1	12.8	
Under construction	5.5	3.8	
Antagonist			0.096
None	11.6	15.1	
Fixed obstacle[c]	7.5	6.3	
Moving vehicle	79.4	73.6	
Pedestrian animals or projectiles	1.5	5.0	
Driver (386)			0.137
Yes	71.0	77.8	
No	29.0	22.2	
Reason for travel			0.005
Non-work related	76.4	65.1	
Professional	23.6	34.9	
Location of the referral hospital			<0.001
Cotonou	35.7	54.8	
Parakou	18.6	15.3	
Porto-Novo	45.7	29.9	

[a] national interstate roads and national roads; [b]alleys and rural tracks; [c]standing vehicles or fixed objects on the road.

Table 4. Factors associated with injury severity in patients, multivariate analysis.

Variables	AOR† (95%CI)	P
Time of the crash		0.003
12 am-6 am	1.3 (0.6-2.6)	
7 am-7 pm	1	
8 pm-12 am	2.1 (1.4-3.2)	
Type of road		<0.001
Major roads[a]	2.8 (2.0-4.0)	
Other roads[b]	1	
Reason for travel		0.006
Non-work related	1.8 (1.2-2.7)	
Professional	1	

†Matched Adjusted Odd Ratio (AOR): calculated with conditional logistic regression methods; [a]national interstate roads and national roads; [b]alleys and rural tracks.

tructure, poor road signs, inadequate roadsides and light pillars are also risk factors for severe injuries to road users.

In this study, although not significant, alcohol users suffered more serious injuries. Similar results were found by Bogstrand *et al*. and Gómez-García *et al*. in which alcohol was also associated with serious injuries in road accident victims.[37,38] Similarly, Lasota *et al*. found that pedestrians under the influence of alcohol are involved in the most serious crashes resulting in death.[39] However, some studies have not identified alcohol as a risk factor for crash severity.[40,41]

The study results show that the majority of patients were traveling for non-work related travel and were at greater risk for serious injury than patients traveling for professional reasons.

Other studies have also shown that users on non-work related travel are more likely to be severely injured than those on professional travels regardless of the time of day.[42-44]

The reason is that during professional travels, users take more precautions such as wearing a helmet or a seatbelt, driving more cautiously, and respecting the rules of the road. As soon as the responsibility of the employee on mission is established, he is not covered by insurance. This is not the case for non-work related travel where very minor precautions are taken.

The main limitation of this study was that behavioral variables such as distraction, fatigue, and drowsiness during the crash, wearing protective gear, drinking alcohol, smoking and taking sleeping pills were collected on the basis of patient reports. Some variables had missing data due to the patient's liberty to choose whether or not to complete certain questions. This could have introduced a bias in the study. To mitigate this, patients were informed that the data collection had no legal implications, which reassured them to provide accurate information. However, this study has the advantage of filling a gap in providing evidence on the severity of road crashes in Benin.

Conclusions

This study identified night-time, major roads, and non-work-related travel as risk factors for serious road injuries in Benin. These results are of great interest to policymakers. Raising compliance with awareness of road traffic laws, improving public lighting along major roads and police enforcement could help reduce serious road injuries in Benin.

This study addresses part of the need for hospital data on the severity of road crashes in Benin. Further studies in several countries are needed to improve the availability of hospital data on road crash severity in Africa.

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