Vol. 13(2), pp. 141-149, April-June 2021
DOI: 10.5897/JPHE2021.1321
Article Number: 30032E166861
ISSN 2141-2316

http://www.academicjournals.org/JPHE

ACADEMIC JOURNALS
expand your knowledge

Journal of Public Health and Epidemiology

Full Length Research Paper

Analysis of the environmental factors associated with deaths from road traffic crashes in Benin from 2008 to 2015

Donatien Daddah[1,2*], Yolaine Glèlè Ahanhanzo[2], Alphonse Kpozehouen[2], Bella Hounkpe Dos Santos[1,2], Huguette Tédji[3], Edgard-Marius Ouendo[2] and Alain Leveque[1]

[1]Ecole de Santé Publique, Université Libre de Bruxelles, Brussels, Belgium.
[2]Institut Régional de Santé Publique, Ouidah, Benin.
[3]Centre National de Sécurité Routière, Benin.

Received 13 April, 2021; Accepted 10 May, 2021

In most African countries, road safety policies are mainly focused on the human factor. In order to inform policy makers about the role of other factors in road mortality, this study aims to analyse the road and environmental factors associated with traffic mortalities in Benin. This is a cross-sectional study using secondary data from road accidents collected by the police between 2008 and 2015. The database included the circumstances of the crashes as well as data on the road infrastructure, the environment and the vehicles involved. A multiple logistic regression analysis identified the environmental factors predicting fatalities. Over the study period 42,846 traffic crashes were reported by the police in Benin of which 1,043 were fatal, that is a proportion of fatal crashes of 2.4% (95% CI [2.3, 2.6]). The risk factors for mortality were rural areas (aOR =2.78, 95% CI [2.38, 3.24]), straight road sections (aOR =1.32, 95% CI [1.07, 1.63]), market days and festival days, (aOR =1.57, 95% CI [1.02, 2.41]) and (aOR =1.57, 95% CI [1.18, 2.10]) respectively. Lighting levels and weather conditions were not significantly associated with road mortalities. This study confirms the contribution of environmental factors to road mortalities in Benin. Involving communities in raising awareness on road safety in rural areas and strengthening road control systems, especially on market and festival days, could help limit the number of road deaths.

Key words: Mortality, traffic crashes, environment factor.

INTRODUCTION

Road crashes are a public health problem (World Health Organization (WHO), 2004). They cause around 1.35 million deaths worldwide each year, making them the eighth leading cause of death (WHO, 2018). Developing countries bear the greatest burden, with three times as many road traffic deaths as developed countries. For

*Corresponding author. E-mail: donadah@yahoo.fr.

example, in the WHO African region, the road death rate was estimated at 26.6 deaths per 100,000 inhabitants compared to 9.3 deaths in the European region (WHO, 2015). Almost half of all deaths on the world's roads are among those with the least protection, motorcyclists, cyclists and pedestrians, who also account for the majority of road crash victims in Africa (WHO, 2015). Most road safety interventions in Africa focus on road users and very few take environmental factors into account. Studies in a few countries have shown that the characteristics of the area of crash occurrence, road surface conditions, and light and weather conditions are associated with road traffic mortalities (Hamad et al., 2016; Wangdi et al., 2018; Deme, 2019).

In Benin, according to road safety statistics compiled by the national centre for road safety, called the Centre National de Sécurité Routière (CNSR), an average of 5,700 road crashes were recorded each year, with more than 700 deaths per year (Centre National de Sécurité Routière (CNSR), 2018). Hospital mortality due to traffic crashes was 12% according to a study conducted in some referral hospitals, with more than 74% of them involving motorised two-wheelers (Kpozèhouen et al., 2016). Studies on the epidemiology of road accidents are very recent in Benin and very few studies have been published on the subject. One published study on environmental factors only considered pedestrians (Glèlè-Ahanhanzo et al., 2021). A better understanding of the relationship between environmental factors and traffic fatalities among all road users would help to better guide road safety interventions, which until now have been mainly user-based. Thus, in order to contribute to a holistic road safety policy, the present study aims to analyse the environmental and road-related risk factors for road traffic mortalities in Benin.

MATERIALS AND METHODS

Study framework

Benin is a country in the West African sub-region. According to data from the National Institute of Statistics and Economic Analysis, called Institut National de Statistique et d'Analyse Economique (INSAE), it covers an area of 114,763 km² and has a population of almost 11,000,000 (Institut National de Statistique et d'Analyse Economique (INSAE), 2018). It is subdivided into 12 departments (Figure 1). Its economic capital Cotonou, located in the coastal region, is home to a large proportion of the country's vehicles and accounts for almost half of the country's crashes (Glèlè-Ahanhanzo et al., 2021). Benin's asphalt road network was 2,685 km long in 2016, with a continuous deterioration in the road pavement condition index from 75% in 2013 to 46% in 2016 (Ministère des Infrastructures et des Transports (MIT), 2017).

Type of study, population and sampling

This is a cross-sectional study using secondary quantitative data on road crashes collected by the police between 2008 and 2015. The statistical unit studied is the road traffic crash (collision between a moving vehicle and a person or an object occurring on a road network open to traffic). All 42,846 road crashes recorded between 2008 and 2015 were included in the study.

Data sources

The data used in this study come from the national database of road crashes recorded from January, 1st 2008 to December, 31st 2015. It is preserved by CNSR, which is the public institution responsible for implementing the national road safety policy. As such, one of its responsibilities is the management of the national road crash information system (CNSR, 2018). Information on the people involved is aggregated by crash, and victims were classified in this database as slightly injured, seriously injured and killed (death at crash location or during transport to hospital). This database is based on the paper forms of crash reports drawn up by the national police, known as "Bulletin d'Analyse des Accidents Constatés" (BAAC). It contains data on the circumstances of the crashes, the characteristics of the road infrastructure (road, profile, perceived state of the road), the users involved (number of people involved, severity of the crash, type of collision), the time of occurrence (time, month, year), type of day, lighting, atmospheric conditions, geographical characteristics (area, place, region of occurrence). The individual characteristics of the victims and the state of the vehicles involved are not available.

Variables studied

The hypothesis of this study was that road and environmental factors are associated with the risk of death among road users involved in a traffic crash. The dependent variable was therefore the fatal traffic crash. It was a binary qualitative variable coded "No" if no death was recorded during the crash and "Yes" if at least one death was recorded during the crash. The variables used are area, regions, location, lighting, weather conditions, road alignment, road profile, perceived road condition, and the time, month and type of day the crashes occurred. Geographical coordinates were not used because they contain a lot of missing data. Individual variables are not included in this database, as they could have helped to understand better the influence of roads and the environment on traffic mortalities.

Data analysis

The data were processed using Stata 15 software. Descriptive statistics were presented as a mean (standard deviation) for the quantitative variables. The categorical variables were presented as proportions. Pearson's chi-square test or Fisher's exact test was used for their comparison when the theoretical values are less than (5) five. A multiple logistic regression model was used by selecting variables with a p-value of less than 0.1 in the univariate analysis. The suitability of the final model was tested using the goodness of fit test of Hosmer and Lemeshow (1980). An association was considered to be statistically significant for p-values less than or equal to 0.05. The strength of the associations between the dependent variable and the other variables was assessed using odds ratios (OR) followed by 95% confidence intervals (95% CI).

Ethical considerations

The database of recorded crashes was made available to the

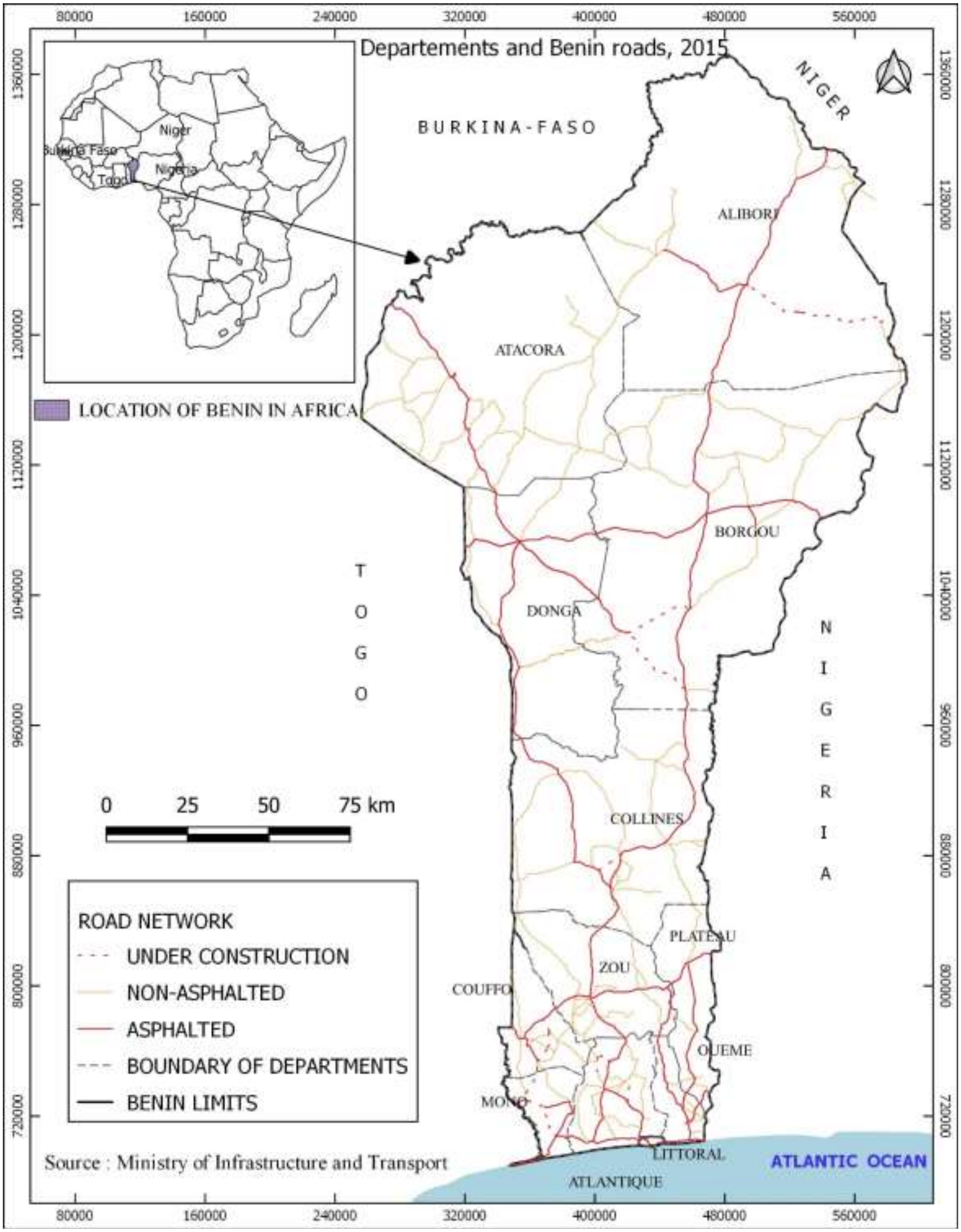

Figure 1. Map of Benin's departments and roads.

Ouidah's Regional Institute of Public Health (IRSP) by the CNSR. 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. In addition, the provisions of the

Table 1. Different types of traffic crashes in Benin, 2008 to 2015.

Types of traffic crashes	Number	%
Free fall	18595	43.4
Pedestrians vs. other motor vehicles	3684	8.6
Motorised two-wheelers vs. other motor vehicles	15738	36.7
Light vehicles and middle vs. heavy vehicles	4,652	10.9
Other collisions	177	0.4
TOTAL	**42846**	**100**

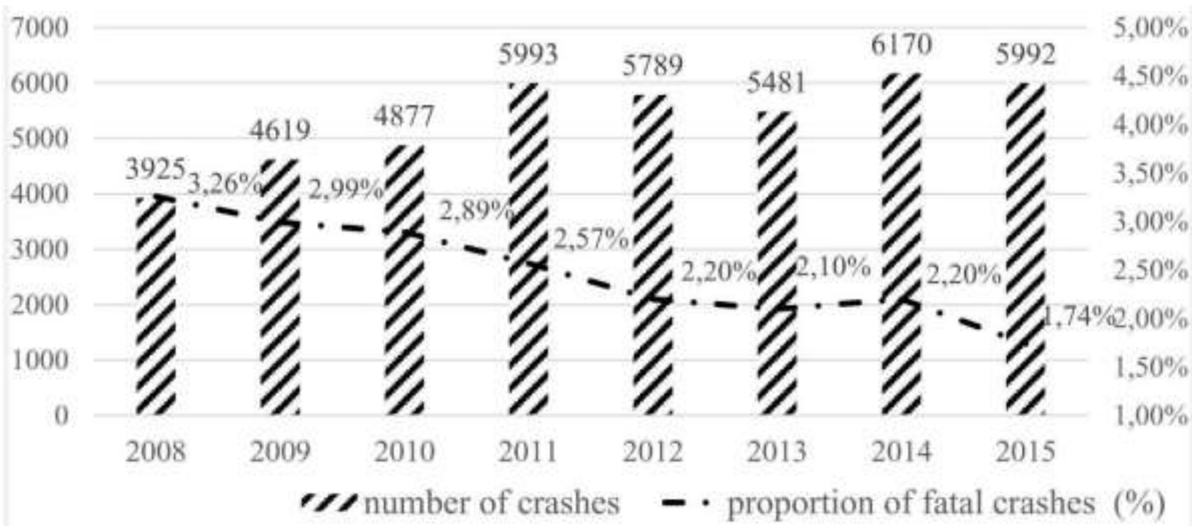

Figure 2. Trends in recorded traffic crashes in Benin (2008 to 2015).

Beninese law on the protection of personal data have been respected and the database does not contain any personal data.

RESULTS

Description of the study population

Over the study period 42,846 traffic crashes were reported to the police in Benin of which 1,043 were fatal, that is a proportion of fatal crashes of 2.4% (95% CI [2.3, 2.6]). In terms of collisions, the most frequent crashes are free falls (43.4%), followed by crashes between motorised two-wheelers and other motor vehicles (36.7%) (Table 1). The annual number of traffic crashes increased from 3,925 to 5,993 between 2008 and 2011, which is an average increase of 15.4%. Beyond that, between 2011 and 2015, the incidence of crashes changed dramatically. On the other hand, the ratio of fatal traffic crashes decreased from 3.26% to 1.74% between 2008 and 2015, which is an average decrease of 1.8% (Figure 2).

Factors associated with deaths

Univariate analysis

The proportion of deaths due to crashes was higher in rural areas (6.3%), away from intersections or level crossings (3.3%). These deaths were also higher at night without public lighting (2.9%), with fog or dust presence (3.2%). Fatalities occurred more on straight roads (2.5%), at the bottom of a descent (sloping road) (5.0%) and during market days (6.5%) (Table 2).

Multivariate analysis

The variables significantly associated with traffic crash mortalities were the area and place of crash occurrence, the road layout, its profile, the time of occurrence, the region of occurrence, the month of the year and the type of day on which the crash occurred. Adjusted for the other variables, the risk of death from traffic crashes was higher in rural area (aOR =2.78, 95% CI [2.38, 3.24]) on straight stretches of road compared to bends, (aOR

Table 2. Factors associated with fatal traffic crashes in Benin, 2008 to 2015.

Variables	Number of traffic crashes (%)	Proportion of fatal crashes	p	Crude OR	IC 95%	Adjusted OR	IC 95%
Area of occurrence	**42,846**		**< 0.001**				
Urban	33,292 (77.70)	1.3		1	-	1	-
Rural	9,554 (22.30)	6.3		5.01*	(4.42 - 5.68)	2.78*	(2.38 - 3.24)
Place of occurrence	**42,786**		**< 0.001**				
Intersection	14,172 (33.12)	0.7		1	-	1	-
Off intersection	28,462 (66.52)	3.3		4.78*	(3.89 - 5.88)	2.72*	(2.18 - 3.40)
Level crossing	152 (0.36)	3.3		4.79*	(1.92 - 11.92)	2.46	(0.97 - 6.25)
Lighting conditions	**42,846**		**0.001**				
Day	30,262 (70.63)	2.4		1	-	1	
Night Without lighting	8,789 (20.51)	2.9		1.24*	(1.07 - 1.43)	0.90	(0.59 - 1.37)
Night with lighting	3,795 (8.86)	1.9		0.80	(0.63 - 1.02)	1.14	(0.71 - 1.83)
Weather conditions	**42,729**		**0.321**				
Good	40,774 (95.42)	2.4		1	-	-	-
Poor	1,955 (4.58)	2.8		1.15	(0.87 - 1.52)	-	-
Road layout	**42,726**		**0.003**				
Straight line	36,028 (84.32)	2.5		1.40*	(1.15 - 1.71)	1.32*	(1.07 - 1.63)
Bend	6,145 (14.38)	1.8		1	-	1	-
Narrowed roadway	553 (1.29)	2.2		1.19	(0.65 - 2.18)	0.61	(0.31 - 1.18)
Profile	**42,816**		**0.016**				
Flat	40,545 (94.70)	2.4		0.86	(0.64 - 1.14)	1.72*	(1.21- 3.78)
Sloping	1,835 (4.29)	2.8		1	-	1	-
Bottom of a descent[a]	281 (0.66)	5.0		1.83*	(1.00 - 3.36)	1.97*	(1.04- 3.72)
Top of a descent[b]	155 (0.36)	3.9		1.64	(0.72 - 3.72)	1.31	(0.54 - 3.13)
Perceived condition of the roadway	**42,776**		**0.856**				
Good	37,451 (90.37)	2.4		1	-	-	-
Degraded	3,319 (8.01)	2.4		1.04	(0.82 - 1.31)		
Under construction	670 (1.62)	2.1		0.89	(0.52 - 1.51)	-	-
Time	**42,846**		**0.044**				
0h am-7h am	3,362 (7.85)	3.1		1.27*	(1.00 - 1.60)	1.31*	(1.02- 1.67)
7h am-7h pm	29,452 (68.74)	2.4		0.97	(0.84 - 1.13)	1.04	(0.68- 1.59)
7h pm-12h pm	10,032 (23.41)	2.4		1	-	1	-
Region	**42,846**		**< 0.001**				
North	4,766 (11.12)	6.1		4.89*	(4.20 - 5.70)	2.83*	(2.38 - 3.36)
Centre	5,637 (13.16)	5.8		4.57*	(3.95 - 5.30)	2.27*	(1.91- 2.69)
South	32,443 (75.72)	1.3		1	-	1	-
Month	**42,846**		**0.052**				
January	3,443 (8.04)	3.0		1.67*	(1.21 - 2.30)	1.42*	(1.02 - 1.98)
February	3,337 (7.79)	2.6		1.48*	(1.06 - 2.06)	1.28	(0.91 - 1.81)
March	3,755 (8.76)	2.7		1.54*	(1.12 - 2.12)	1.42*	(1.02 - 1.98)
April	3,829 (8.94)	2.6		1.43*	(1.04 - 1.98)	1.31	(0.94 - 1.82)
May	3,605 (8.41)	2.1		1.14	(0.81 - 1.61)	1.10	(0.77 - 1.55)

Table 2. Contd.

June	3,321 (7.75)	2.0		1.12	(0.79 - 1.60)	1.03	(0.71 - 1.48)
July	3,427 (8.00)	2.6		1.44*	(1.03 - 2.00)	1.39	(0.99 - 1.95)
August	3,580 (8.36)	2.7		1.54*	(1.11 - 2.12)	1.45*	(1.03 - 2.02)
September	3,544 (8.27)	2.2		1.21	(0.86 - 1.70)	1.23	(0.87 - 1.74)
October	3,758 (8.77)	2.4		1.36	(0.98 - 1.88)	1.24	(0.88 - 1.75)
November	3,393 (7.92)	1.8		1	-	1	-
December	3,854 (9.00)	2.5		1.40*	(1.01 - 1.93)	1.34	(0.96 - 1.87)
Type of day	**42,107**		**< 0.001**				
Weekend	9,721 (23.09)	2.6		1.18*	(1.02 - 1.37)	1.04	(0.90 - 1.22)
Party Eve	371 (0.88)	3.5		1.62	(0.93 - 2.84)	1.50	(0.84 - 2.67)
Festival day	708 (1.68)	3.4		1.57*	(1.04 - 2.38)	1.57*	(1.02 - 2.41)
Market day	891 (2.12)	6.5		3.11*	(2.36 - 4.11)	1.57*	(1.18 - 2.10)
Ordinary day	30,416 (72.24)	2.2		1	-	1	-

[a]bottom of sloping road; [b]top of sloping road; *Significant Odds Ratio (OR).

=1.32, 95% CI [1.07, 1.63]). This risk on flat roads and downhill roads was higher than on roads with a gradient, (aOR =1.72, 95% CI [1.21, 3.78]) and (aOR =1.97, 95% CI [1.04, 3.72]) respectively. Crashes occurring between 12pm -7 am were also more fatal than those occurring during the day, (aOR =1.31, 95% CI [1.02, 1.67]). Crashes occurring in the northern and central region were also more fatal than those occurring in the southern regions (aOR =2.83, 95% CI [2.38, 3.36]) and (aOR =2.27, 95% CI [1.91, 2.69]) respectively. Compared to November, January and March were more fatal, (aOR =1.42, 95% CI [1.02, 1.98]). August was also more deadly than November, (aOR =1.45, 95% CI [1.03, 2.02]). Finally, the risk of death due to traffic crashes was higher on festival days and market days compared to ordinary days, (aOR =1.57, 95% CI [1.02, 2.41]) and (aOR =1.57, 95% CI [1.18-2.10]) respectively. Adjusted for the other variables, there is no difference in the risk of traffic fatalities depending on road, lighting or weather conditions.

DISCUSSION

Characteristics of the road crashes

This study aims to analyse the road and environmental factors associated with road deaths in Benin. The results show that the area, region, place of occurrence, road layout, profile, type of day, time and month of occurrence are the factors associated with death by road traffic crashes in Benin.

The proportion of fatal crashes was 2.4% (95% CI [2.3, 2.6]) over the period 2008-2015. This result is lower than the 6% observed in Côte d'Ivoire (Bénié Bi Vroh et al., 2016) in a study of police-recorded crashes, and even lower than the 16.7% and 18.5% found respectively in Rwanda and Ethiopia (Patel et al., 2016; Asefa et al., 2014) in studies of crash data from police sources. The proportion of fatal crashes observed in this study could be explained by the low completeness of police data, which does not capture all crashes. Indeed, several authors have shown that very few low and middle-income countries have an effective traffic-specific monitoring system (Bhatti and Salmi, 2012; Puvanachandra et al., 2012). This underestimation is noted in several other studies (Getachew et al., 2016; Sanyang et al., 2017). This hampers the implementation of appropriate measures to reduce serious traffic crashes.

Most of the road users involved in traffic crashes were in motor vehicles: 43.4% motor vehicle free fall, 36.7% motorized two-wheelers vehicles vs. other motor vehicles, and very few involved pedestrians (8.6%). This is similar to the findings of other studies (Afukaar et al., 2003; Hesse et al., 2014; Shokouhi and Rezapur-Shahkolai, 2018). However, these observations are different from those described by other authors who found 25.5% of users involved in traffic crashes were motorised two-wheeler users and 59% pedestrians (Bénié Bi Vroh et al., 2016; Blankson al., 2019).

Nearly 78% of traffic crashes in Benin occurred in urban areas, and this was also the case in Ivory Coast, with more than 93% of crashes occurring in urban areas (Bénié Bi Vroh et al., 2016). Rural roads posed a greater risk of death from traffic crashes than urban roads, (aOR =2.78, 95% CI [2.38, 3.24]). This is corroborated by the observations of Bénié Bi Vroh who found that the proportion of fatal crashes was higher in rural areas (Bénié Bi Vroh et al., 2016). The same observation was also made in China, with an increase in trauma deaths in general and in rural areas in particular (Li et al., 2020). Further research on motorised two-wheelers in France found that more than two thirds of all motorized two-wheeler users killed in crashes were killed outside urban areas (Jean-Yves., 2019). However, the opposite results were found for cyclists in Canada, where road crashes were more fatal in urban areas (Gaudet et al., 2015). The preponderance of fatal crashes in rural areas in the present study could be explained by the lack of public lighting in this area at night, the scarcity and poor level of technical facilities for dealing with emergencies, the poor state of the roads and the low frequency of police roadside checks, which encourages traffic violations, and therefore fatal crashes.

The likelihood of a road crash fatality was higher away from intersections than at intersections, (aOR =2.72, 95% CI [2.18, 3.40]). A large majority of fatal crashes (81.9%) observed in a Ghanaian study occurred away from intersections (Damsere-Derry et al., 2010). Also, research by Leni et al. in Indonesia found that the risk of pedestrian deaths decreased by 4.69% at intersections compared to straight roads (Leni et al., 2019). However, these findings differed from other studies where crashes were more frequent at intersections (Altwaijri et al., 2012; Bonnet et al., 2017; Reardon et al. 2017).

The risk of mortalities at the bottom of a descent versus on sloping roads was higher, (aOR =1.97, 95% CI [1.04, 3.72]) in this study. This contrasts with the study by Wu (2018) which concluded that the risk of a crash on uphill roads was higher than on flat roads.

Depending on the time of day in the present study, the risk of a crash fatality is higher between 12pm-7am compared to other times of the day. This result contrasts with the results observed in Iran, where crashes were more fatal during the day (Lankarani et al., 2014; Chong et al., 2018; Shokouhi and Rezapur-Shahkolai, 2018). Also, in a South African study, 40% of crash fatalities occurred between 4 pm and 11 pm. (Verster and Fourie, 2018). However, this could be explained in Benin context by driving at night under the influence of psychoactive substances, the effects of sleep on heavy goods vehicle drivers, frequent traffic violations at night (speeding, failure to obey traffic signs) and the poor availability of emergency services at night.

The northern and central regions have a higher risk of death than the southern regions, (aOR =2.83, 95% CI [2.38, 3.36]) and (aOR =2.27, 95% CI [1.91, 2.69]) respectively. This can be explained by the low population density of these regions, the low traffic flow, but above all by the speeding and driving of users under the influence of psychoactive substances.

The highest prevalence of crashes is observed in December (9%). Similar results were obtained in South Africa (11%) and in Pakistan (13.5%) (Verster and Fourie, 2018; Zia et al., 2014).

Market and festival days were more fatal, (aOR =1.57, 95% CI [1.18, 2.10]) and (aOR =1.57, 95% CI [1.02, 2.41]) respectively. This is different from the findings of Verster and Fourie (2018) who noted that weekends posed a greater risk of death. In Benin context, festival days generate great excitement with many road users on the roads (family trips, preparations for the festival). As for market days, there is an increased flow of people and goods with congestion on the roads. Almost all markets are located near major roads, leading to conflicts between road and markets users.

This study did not find a significant difference in the risk of mortalities depending on road lighting conditions. This is contrary to the observations of Moradi et al. who reported that lighting influences traffic mortalities (Moradi et al., 2019). Similarly, Ethiopian research found that crashes were more likely to result in death during the day than at night with a significant difference (Tadege, 2020). Patel et al. also noted in Rwanda that 65.9% of fatal crashes occurred during the day (Patel et al., 2016), and this is also found in several studies, including the Huang study in Nepal on pedestrian crashes with a higher proportion during the day (Huang et al., 2016). On the other hand, in Kenya, it has been found that the night is more often conducive to serious crashes (Mogaka et al., 2011). The same finding was made by another Iranian study which reported that crashes were more likely to result in pedestrian fatalities under night lightning conditions than during the day (Hasani et al., 2018). Finally, a Finnish study found that fatal pedestrian crashes decreased significantly on roads with lit street lamps (Malin et al., 2020). There were no significant differences in mortality risk according to weather conditions in the present study. This is not the case in other studies where the risk of crashes due to loss of control of motorbikes is significantly higher in bad weather (Wu, 2018). This observation is supported by a Cameroonian publication which showed that crashes are more serious in bad weather (Wu, 2018); while another Cameroonian publication showed that crashes are more serious in rainy conditions (Testa et al., 2014). This assertion is supported by a Kenyan study, whose authors identified rain as a factor that increases the risk of serious crashes (Sangkharat et al., 2021; Mogaka et al., 2011). In addition, atmospheric conditions such as dust have been identified as being linked to serious crashes (Lankarani et al., 2014). Finally, Jalilian et al. (2019) in Iran concluded that the risk of serious crashes was 2.6 times higher in cloudy weather than in clear weather. As far as the perceived condition of the road surface is concerned, it is not related to traffic fatalities in this study.

Road and environmental factors were associated with the risk of death among road users involved in a traffic crash, so the original hypothesis is confirmed.

Limitations of the study

The data used, from police sources, does not consider unrecorded crashes, which constitute a significant proportion of crashes. This warrants complementary studies at health facilities, which represent an additional source of traffic crash data to police sources. The poor completeness of the geolocation data limited the exploitation of geographical data for the explanation of certain environmental factors.

Conclusion

Road crashes are a scourge that needs to be better explored in Benin in order to reduce the impact on the health and well-being of the population. This national study analysed the road and environmental factors that contribute to the occurrence of fatal road traffic accidents in Benin. Involving communities in raising awareness on road safety in rural areas and strengthening road control systems, particularly on market or festival days, could help limit the number of road deaths. This research will be used as an advocacy tool for the authorities to guide road safety policies in Benin.

CONFLICTS OF INTEREST

The authors have not declared any conflict of interest.

ACKNOWLEDGEMENTS

The authors would like to thank the national Centre for Road Safety (CNSR) for making the road accident database available. They also appreciate the Directorate General of Police for its contribution to the collection of these data.

ABREVIATIONS

AOR, Adjusted Odd Ratio; **BAAC,** Bulletin d'Analyse des Accidents Constatés; **CI,** Confidence Interval; **CNSR,** Centre National de Sécurité Routière; **INSAE,** Institut National de Statistique et d'Analyse Economique; **MIT,** Ministère des Infrastructures et des Transports; **OR,** Odd Ratio; **WHO,** World Health Organization.

REFERENCES

Afukaar FK, Antwi P, Ofosu-Amaah SJ (2003). Pattern of road traffic injuries in Ghana: implications for control. Injury Control and Promotion Safety *10*(1-2):69-76.

Altwaijri S, Quddus M, Bristow AJ (2012). Analysing the severity and frequency of traffic crashes in riyadh city using statistical models. International Journal of Transportation Science and Technology 1(4):351-364.

Asefa F, Assefa D, Tesfaye G (2014). Magnitude of, trends in, and associated factors of road traffic collision in central Ethiopia. BMC Public Health *14*(1):1072.

Bénié Bi Vroh J, Tiembre I, Ekra DK, Ano Ama MN, Ka OM, Ncho Dagnan S, Tagliante-Saracino J (2016). Determinants of Fatal Road Traffic Injuries in Cote d'Ivoire from 2002 to 2011. Sante Publique *28*(5):647-653.

Bhatti JA, Salmi LR (2012). Challenges in evaluating the decade of action for road safety in developing countries: a survey of traffic fatality reporting capacity in the Eastern Mediterranean region. Traffic Injury Prevention *13*(4):422-426.

Blankson PK, Amoako JKA, Asah-Opoku K, Odei-Ansong F, Lartey MY (2019). Epidemiology of injuries presenting to the accident centre of Korle-Bu Teaching Hospital, Ghana. BMC Emergency Medicine 19(1):39.

Bonnet E, Nikiéma A, Traoré Z, Sidbega S, Ridde V (2017). Technological solutions for an effective health surveillance System for road traffic crashes in Burkina Faso. Global Health Action 10(1):1295698.

Centre National de Securité Routière (2018). Annuaire des statistiques des accidents de la voie publique au Bénin 2016. Retrieved from Cotonou: https// : benin.opendataforafrica.org/djqzpee/sécurité-routière-statistique-des-accidents-de-la-route-et-victimes-au-bénin-par-département-et-comm

Chong SL, Chiang LW, Allen JrJC, Fleegler EW, Lee LK (2018). Epidemiology of Pedestrian–Motor vehicle fatalities and injuries, 2006–2015. American Journal of Preventive Medicine 55(1):98-105.

Damsere-Derry J, Ebel BE, Mock CN, Afukaar F, Donkor P (2010). Pedestrians' injury patterns in Ghana. Accident; Analysis and Prevention 42(4):1080-1088.

Deme D (2019). Review on factors causes road traffic accident in Africa. Journal of Architecture and Construction 2(3):41-49.

Gaudet L, Romanow NT, Nettel-Aguirre A, Voaklander D, Hagel BE, Rowe BH (2015). The epidemiology of fatal cyclist crashes over a 14-year period in Alberta, Canada. BMC Public Health 15(1):1142.

Getachew S, Ali E, Tayler-Smith K, Hedt-Gauthier B, Silkondez W, Abebe D, Deressa W, Enquessilase F, Edwards JK (2016). The burden of road traffic injuries in an emergency department in Addis Ababa, Ethiopia. Public Health Action 6(2):66-71.

Glèlè-Ahanhanzo Y, Kpozèhouen A, Sossa-Jerôme C, Sopoh GE, Tedji H, Yete K, Levêque A (2021). "My right to walk, my right to live": pedestrian fatalities, roads and environmental features in Benin. BMC Public Health *21*(1):162.

Hamad AEAEE, Hiba Mohammed Elhassan Ali Elawad (2016). Factors Contributing In Road Traffic Accidents In Sudan. Journal of Basic Applied Research International 16(1):66-73.

Hasani J, Khorshidi A, Erfanpoor S, Nazparvar B, Hashemi Nazari SS (2018). Comparison of risk factors for pedestrian fatality in urban and suburban traffic accidents. Archives of Trauma Research 7(2):39-44.

Hesse CA, Ofosu JB (2014). Epidemiology of road traffic accidents in Ghana.

Hosmer DW, Lemeshow S (1980). Goodness-of-fit tests for the multiple logistic regression model. Communications in Statistics—Theory and Methods 9:1043-1069.

Huang L, Adhikary KP, Choulagai BP, Wang N, Poudyal AK, Onta SR (2016). Road Traffic Accident and its Characteristics in Kathmandu Valley. Journal of the Nepal Medical Association 55(203):1-6.

Institut National de Statistique et d'Analyse Economique (2018). Fiche de données sur la population au Bénin. . Retrieved from https://insae-bj.org/statistiques/indicateurs-recents/43-population

Jalilian MM, Safarpour H, Bazyar J, Keykaleh MS, Malekyan L, Khorshidi A (2019). Environmental related risk factors to road traffic accidents in Ilam, Iran. Medical Archives *73*(3):169.

Jean-Yves Fournier JY, Boulisset V (2019). Type de motocyclette et risque de décès par accident chez les motocyclistes. Carnets d'accidentologie pp. 15-30.

Kpozèhouen A, Paraïso M, Glèlè Ahanhanzo Y, Azandjeme C, Agueh V (2016). Issue des accidents de la voie publique : analyse à partir de données hospitalières, Bénin. Revue d'Épidémiologie et de Santé Publique 64:S215-S216.

Lankarani KB, Heydari ST, Aghabeigi MR, Moafian G, Hoseinzadeh A, Vossoughi M (2014). The impact of environmental factors on traffic accidents in Iran. Journal of injury and violence research 6(2):64-71.

Leni SM, Jachrizal SR, Kusuma A, Bulan SO, Rudrokasworo SN (2019). Analyzing driving environment factors in pedestrian crashes injury levels in Jakarta and the surrounding cities. Journal of Applied Engineering Science 17(4):482-489.

Li Y, Pu M, Wang Y, Feng T, Jiang C (2020). Analysis of the reduction in injury mortality disparity between urban and rural areas in developing China from 2010 to 2016. BMC Public Health 20(1):903.

Malin F, Silla A, Mladenović MN (2020). Prevalence and factors associated with pedestrian fatalities and serious injuries: case Finland. *European Transport Research Review 12* : 1-17.

Ministère des Infrastructures et des Transports (2017). Annuaire des Statistiques 2013-2016. Retrieved from https://transports.bj/wpcontent/uploads/2018/03/Annuaire_Statistique_TPT_2013_2016_VF.pdf.

Mogaka EO, Ng'ang'a Z, Oundo J, Omolo J, Luman E (2011). Factors associated with severity of road traffic injuries, Thika, Kenya. The Pan African Medical Journal 8:20. DOI: 10.4314/pamj.v8i1.71076

Moradi A, Ameri P, Rahmni K, Najafi M, Jamshidi E, Fakhri Y, Khazaei S, Moeini B, Amjadian M (2019). Factors affecting the severity of pedestrian traffic crashes. Archives of Trauma Research 8(2):46-56.

Patel A, Krebs E, Andrade L, Rulisa S, Nickenig Vissoci JR, Staton C (2016). The epidemiology of road traffic injury hotspots in Kigali, Rwanda from police data. BMC Public Health 16.

Puvanachandra P, Hoe C, El-Sayed HF, Saad R, Al-Gasseer N, Bakr M, Hyder AA (2012). Road traffic injuries and data systems in Egypt: addressing the challenges. Traffic injury prevention 13(1):44-56.

Reardon JM, Andrade L, Hertz J, Kiwango G, Teu A, Pesambili M, El-Gabri D, Hocker M, Mvungi M, Vissoci JRN (2017). The epidemiology and hotspots of road traffic injuries in Moshi, Tanzania: an observational study. Injury 48(7):1363-1370.

Sangkharat K, Thornes JE, Wachiradilok P, Pape FD (2021). Détermination de l'impact des précipitations sur les accidents de la route en Thaïlande. Héliyon (Heliyon) 7(2)e06061. https://doi.org/10.1016/j.heliyon.2021.e06061

Sanyang E, Peek-Asa C, Bass P, Young TL, Daffeh B, Fuortes LJ (2017). Risk factors for road traffic injuries among different road users in the Gambia. Journal of environmental and health public: *2017*.

Shokouhi M, Rezapur-Shahkolai F (2018). Fatal Road Traffic Injuries in Hamadan Province, Iran. Journal of Disaster and Emergency Research 1(2):67-74.

Tadege M (2020). Determinants of fatal car accident risk in Finote Selam town, Northwest Ethiopia. BMC Public Health *20*(1):624.

Testa J, Sobngwi-Tamebekou J, Salmi LR, Lagarde E (2014). Les déterminants de la gravité des accidents de la route en zone rurale africaine : une étude sur l'axe Yaoundé-Douala, Cameroun. Revue d'Épidémiologie et de Santé Publique 62:S201.

Verster T, Fourie E (2018). The good, the bad and the ugly of South African fatal road accidents. South African Journal of Science *114*(7-8): 63-69.

Wangdi C, Gurung MS, Duba T, Wilkinson E, Tun ZM, Tripathy JP (2018). Burden, pattern and causes of road traffic accidents in Bhutan, 2013-2014: a police record review. *International journal of injury control and safety promotion 25*(1) : 65-69.

World Health Organization (WHO) (2004). Global status report on road safety.

World Health Organization (WHO) (2015). Global status report on road safety.

World Health Organization (WHO) (2018). Global status report on road safety.

Wu D (2018). Quantification des causes des accidents de deux/trois-roues motorisés et de leurs conséquences corporelles (approche épidémiologique).Université de Lyon. Thesis ⟨NNT: 2018LYSE1175⟩. ⟨tel-02006570⟩

Zia Y, Sabir M, Saeed IU (2014). Pedestrian injuries and fatalities by patterns in reported road traffic crashes-Islamabad. Journal of Pakistan Medical Association 64(10):1162-1165.