

Severity factors of road crashes in Benin: A matched case-control study

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Abstract

Background

In Benin, the management of serious road crash patients remains a challenge due to the inadequacy of the technical facilities. In the absence of hospital data, road safety policies are based on data from police sources, which remain unreliable in terms of crash severity. The risk factors for serious crashes are not clearly determined in Benin. This study aims to understand the factors influencing the severity of injuries after a crash in order to help decision-makers develop road safety policies and laws.

Methods

The present case-control study, matched for age and sex, is based on a hospital cohort of road crash victims set up in five hospitals in Benin in 2020. A sample of 199 severely injured cases (AIS Severity Score ≥ 3) was compared to 398 slightly injured controls (AIS Severity Score < 3). The dependent variable was injury severity according to the AIS Severity Scale. The independent variables were socio-demographic, behavioural, environmental or vehicle-related variables and history, habits and lifestyle variables. A stepwise conditional logistic regression was used to assess the association between the independent variables and injury severity.

Results

Night time, between 8 pm and 12 am, is the time of greatest risk for road users, with more than 37% of serious injuries vs. 25% of minor injuries ($p= 0.009$). The variables associated with injury severity were night time, between 8 pm and 12 am, (aOR: 1.7; CI95%: 1.1-2.5), main roads (interstate roads or national roads) (aOR: 2.4; 95% CI: 1.6-3.5) and private trips (aOR: 2.3; CI95%: 1.4-3.8).

Conclusions

Improvements to public lighting, the obligation of a driving licence for motorcyclists, raising user awareness about compliance with traffic rules, coupled with police controls on the main roads, especially at night, will help reduce the severity of crashes in Benin.

Key words: Road crash, matched case-control, severity, AIS, Benin.

Background

According to the World Bank's Road Safety Report 2017, road deaths and serious injuries are unacceptable, preventable and hinder economic growth in developing countries (1). 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 (2, 3). Africa is the continent that pays the highest price, 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). In addition, behavioural risk factors play an important role in the occurrence and severity of road crashes in Africa (5).

In Benin, statistics on serious and fatal road traffic injuries come mainly from the police. According to this source, in 2018, serious non-fatal crashes accounted for 42% of all crashes with 736 deaths against a WHO estimate of about 2,986 (95% CI 2458-3514) for the same year (2, 6). Road safety policies, due to the lack of usable hospital crash data, rely on police data which are unreliable in terms of crash severity.

A study conducted in Europe has shown that police data on serious injuries have many biases that can affect road safety issues (7). Another study in France highlighted the need for hospital-based crash severity data to avoid under-reporting and mis-assessment of the severity of crashes (8).

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 (9).

Road crash severity factors from hospital sources have been very little explored in Benin. The present study, carried out on a hospital cohort of road crash victims, hypothesises that the severity of injuries is related to behavioural and environmental factors. The main objective of this research is to help reduce the number of serious injuries on the roads in Benin through prevention.

Material and method

Type of study

This is a matched case-control study.

Study population

The target population was road traffic accident patients admitted to one of the five study hospitals.

Inclusion criteria

-Cases were patients with severe injuries (AIS score of 3 or more).

-Controls were patients with less severe injuries (AIS score less than 3).

Data source

The present study was carried out on a multi-centre hospital cohort of road crash victims called the "TraumAR Cohort". It was set up in Benin as part of the research project "ReMPARt", which aims to prevent road crashes. Data collection took place in five high-use hospitals in Benin, known in French as CNHU-HKM; CHUD-BA; CHUD-OP; Hôpital de zone de Ménontin and Hôpital de zone de Boko (Fig.2).

Data were collected from July 2019 to January 2020 using a questionnaire administered by trained interviewers. During training, each question was reviewed in French and local languages to harmonise understanding. This tool was pre-tested in a hospital other than those selected for data collection. Patients were enrolled in the cohort as they were admitted to the hospitals. Data were collected immediately after medical diagnosis and first aid had been administered to the injured. The questionnaire was completed at the patient's bedside after reading and handing over an information note and signing the free and informed consent form. The questionnaire was administered directly to the patients or to one of their parents if they were unable to answer. In cases of multiple admissions, less severely injured patients not requiring hospitalisation were enrolled first, and more severely injured patients were enrolled after emergency care had been provided.

The administration of this questionnaire was followed by observation and exploitation of the medical file for additional clinical and paraclinical data. If necessary, the attending physician was asked to clarify the medical information contained in the file. All the data were centralised in a secure database.

The questionnaire included the following data: general information, socio-demographic, behavioural, environmental, vehicle, history and lifestyle variables.

This initial collection was supervised by three doctoral students in public health who had the role of checking the quality and completeness of the records. Completeness was assessed by cross-referencing the statistics of the crash entries with the survey database. Simple random sampling of the forms was done to assess the quality of entry for all variables in the sampled form. Missing patients were searched in the department or contacted by telephone.

Selection of participants

Participants were selected from the TraumAR cohort on the basis of injury severity. All patients with missing data on the variable "severity of injury" were excluded from this study. The resulting subsample was subdivided into two groups (cases and controls) (Fig. 1).

Sample size

In order to define the number of subjects needed for our study, the Dupont formula was used (10). To have good statistical power a case was matched with 2 controls, the expected power was 90% with a confidence level of 95% a minimum expected difference in odds ratio between groups of 1.8. In the absence of available statistics, a prevalence of 50% was used with a correlation coefficient of 0.2.

After calculating the required sample size, random sampling was used to select 199 cases for 398 controls, i.e. 597 subjects, using age and sex as matching variables.

Variables

The dependent variable is the severity of the injuries according to the AIS severity scale. In order to limit bias, the coding of lesions was performed retrospectively by a team of physicians experienced in the use of the AIS scale. The AIS (Abbreviated Injury Scale) 2005 version, updated in 2008, widely recommended for the evaluation of the severity of injuries, was chosen (11). This scale classifies injuries by body region into 6 categories of severity, with AIS 1 being minor and AIS 6 being maximal. The Maximum Abbreviated Injury Scale (MAIS), also scored from 1 to 6, corresponds to the highest AIS injury score identified in a patient among the six body regions (head, face, chest, abdomen, extremities including pelvis, and superficial region). This "injury severity" variable was coded 0 for MAIS scores < 3 and 1 for MAIS scores ≥ 3 .

The other variables studied are:

- Socio-demographic variables: gender, age, marital status (single, married or engaged, divorced or widowed) and professional status (no occupation, in employment, in training);

- Behavioural variables: use of protective equipment, distraction during the crash, fatigue/drowsiness during the crash and compliance with road signs. All these variables were coded yes or no;

- Environmental or vehicle-related variables at the time of the crash: type of user (pedestrians, motorcyclists, other road user), 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 (main roads, minor roads), crash location (intersection, non-intersection, parking area), perceived pavement condition (good, poor, under construction), type of obstacle (none, fixed obstacle, moving vehicle, pedestrian/animal or projectiles), driver (yes, no), reason for trip (private, professional) and municipality of the crash (Cotonou, Parakou, Porto-Novo).

-Variables related to history, habits and lifestyle: history of chronic disease, history of a previous crash, driving experience and use of psychoactive products. All these variables were coded yes or no.

Matching

Patients with severe injuries (cases) were matched with patients without severe injuries (controls) in a 1:2 ratio. Control patients had less severe injuries than cases on the AIS severity scale. The matching criteria in the present study were age and gender, as is customary in the literature (12, 13).

Processing and analysis

The data were processed and analysed 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. Modelling 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 value < 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, the majority of crash patients were married (62.3% of cases vs 58.8% of controls; $p=0.704$) and employed (70.8% of cases vs 74.4% of controls; $p=0.618$). No socio-demographic variables were statistically significant (Table 1).

Behavioural factors of cases and controls

More than 55% of cases vs. 43% of controls were not wearing their protective equipment (seat belt or helmet) at the time of the crash ($p=0.025$) and more than 12% of cases vs. 24% of controls reported being distracted at the time of the crash ($p=0.023$). The variables fatigue or drowsiness during the crash and compliance with road signs were not statistically significant ($P > 0.05$) (Table 2).

Environmental and vehicle factors of cases and controls

Road crashes occurred mainly during the day between 7am and 7pm (58% in cases vs 69% in controls; $p=0.009$). These road crashes were more frequent on main roads (national interstate roads and national roads) in cases (56.8%; $p<0.001$), but more frequent on other roads (alleys and rural tracks) in controls (64.1%; $p<0.001$). Patients were more likely to be drivers (63.5% in cases vs. 74.4% in controls; $p=0.032$) and more likely to be travelling privately (78.4% in cases vs. 67.6% in controls; $p=0.006$). Cases and controls were more often involved in crashes in the municipalities of Porto-Novo (46.7%; $p<0.001$) and Cotonou (49%; $p<0.001$) respectively. The other environmental variables were not statistically significant ($p>0.05$) (Table 3).

Factors related to the history, habits and lifestyle of cases and controls

Most patients had no history of crashes (65.7% of cases vs 61.3% of controls; $p=0.450$). The majority of patients reported using psychoactive substances (alcohol, tobacco, drugs or other psychoactive substances) at times (59.3% of cases vs 57.8% of controls; $p=0.725$). No variables related to history, habits and lifestyle were statistically significant ($p > 0.05$) (Table 4).

Univariate and multivariate analysis of factors associated with injury severity

Wearing protective equipment (cOR: 1.9; CI95%: 1.1-3.1), having a road crash between 8pm and 12 am (cOR: 1.6; CI95%: 1.1-2.4), on main roads (cOR: 2.3; CI95%: 1.5-3.3), being a passenger and not a driver of the crashed vehicle (cOR: 2.4; CI95%: 1.4-4.3) were the factors associated with the severity of injury in the patients at univariate analysis. Similarly, a private trip (cOR: 2.4; CI95%: 1.5-3.8) and having a traffic crash in the cities of Parakou (cOR: 1.7; CI95%: 1.1-3.0) or Porto-Novo (cOR: 2.4; CI95%: 1.6-3.7) were factors associated with the severity of injuries at univariate analysis (All $p < 0.05$) (table 5).

In the multivariate analysis, a night-time crash between 8pm and 12am (aOR: 1.7; CI95%: 1.1-2.5), main roads (aOR: 2.4; CI95%: 1.6-3.5) and private trips (adjusted OR: 2.3; CI95%: 1.4-3.8) were risk factors for serious injury at multivariate analysis (Table 5).

Discussion

The present study compares patients who sustained severe injuries following a road crash (cases) with those who sustained less severe injuries (controls). The results show that the time of the crash (8 pm to 12 am), type of road (interstate road and national road) and the reason for the trip (private) were independently associated with the severity of the injury.

The risk of a serious crash was higher at night between 8 pm and 12 am (aOR: 1.7; CI95%: 1.1-2.5). This association between time of crash and injury severity was also found in Brazil and

Ethiopia (14, 15). Several other research studies found that road crashes resulted in more serious and fatal injuries at night (14, 16, 17). A previous study in Benin using police data found that road crashes were more deadly at night (18). This could be explained by several factors including driving under the influence at night, non-compliance with traffic laws due to low police presence on the roads, and low street lighting. The latter hypothesis is supported by two studies that found, respectively, that the severity of injuries is almost three times higher on roads without lighting at night and that public lighting could prevent road crashes, injuries and deaths (19, 20).

Main roads (interstate roads and national roads) were the highest risk factor for serious injury (aOR: 2.4; 95% CI: 1.6-3.5). This was also found in research conducted by Asare et al. where national roads were a risk factor for serious crashes (21). A study in the United States found that crashes among electric motorbike riders were more severe on roads than on side roads (22). The higher severity of crashes on main roads could be explained by speeding, non-compliance with traffic regulations and poor police enforcement.

The results of the study also show that private trips were more risky than professional trips (aOR: 2.3; CI95%: 1.4-3.8). Similar findings were made by Boufous et al. who showed that car drivers on private trips were more likely to be seriously injured than those on professional trips (23). Similarly, research has found that tradespeople on private trips are more likely to have a crash than those on professional trips (24). Lengerrand et al. in contrast found that managers had a higher crude crash risk than unskilled workers, but this was no longer significant in the final model (25). The severity of the crashes among private users in the context of this study could be explained by the lack of knowledge of traffic regulations among motorcyclists and the high age of most of the vehicles on the road.

The comparison between cases and controls showed that less than 45% of cases had worn their protective equipment during the crash vs. more than 57% of controls. This result was higher

than the 42.3% and 29.4% of motorbike users wearing their protective equipment in studies conducted in Tanzania and Jamaica (26, 27). Another study by Setty et al. in India found a protective equipment wearing prevalence of 34.5% among motorbike riders, which is still low compared to the present results (28). This prevalence of wearing protective equipment in Benin could be explained by the existence and effective enforcement of the helmet law for motorbike drivers with permanent police enforcement, which is not yet the case for seat belts for motorists. The crude risk of serious injury was high for riders who did not have their protective equipment on at the time of the crash (cOR: 1.9; CI95%: 1.1-3.1). However, this study did not identify protective equipment as a factor associated with injury severity in the final model, unlike the study by Baru et al. (14) and Meng et al. who noted that the severity of injuries to passengers in private cars was related to seat belt use, among other factors (29). The present research did not find a significant difference between socio-demographic variables and injury severity. Similar findings were made by Tumwesigye et al. in Uganda where socio-demographic variables were not significant in the multivariate model (30). On the other hand, some authors have observed significant differences for socio-demographic variables in studies on the severity of road crashes (31-33).

The main limitation of this study is that the behavioural variables were collected on the basis of patients' self-reports. These patients were informed at the time of data collection that the present research had no legal implications, which facilitated the exchanges.

Conclusions

This study identified the time of crash between 8 pm and 12 am, interstate national roads, national roads and private trips as risk factors for serious road crash injuries in Benin. The improvement of public lighting, the obligation of a driving licence for motorcyclists, raising user awareness about compliance with traffic rules, coupled with police controls on the main roads, especially at night, will help reduce the severity of crashes in Benin.

260 **List of abbreviations**

261 AIS: Abbreviated Injury Scale

262 ARES: Académie de Recherche et d'Enseignement Supérieur

263 CNSR: Centre National de Sécurité Routière

264 ReMPARt: Recherche Multidisciplinaire pour la Prévention des Accidents de la Route.

265 CNHU-HKM: Centre National Hospitalier et Universitaire Hubert Koutoukou Maga

266 CHUD-BA: Centre Hospitalier Universitaire et Départemental du Borgou-Alibori

267 CHUD-OP: Centre Hospitalier Universitaire et Départemental de l'Ouémé-Plateau.

268 WHO: World Health Organization

269

270 **Declarations**

271 **Ethics approval and consent to participate**

272 This study is part of a doctoral thesis. The Ethics Committee of the University of Parakou
273 (Benin) approved the protocol describing this study. At recruitment, participants were informed
274 of the purpose of the study and their right to accept or not to participate in the study without
275 compromising their right to care. They could also withdraw from the study at any time.
276 Participation in the cohort was conditional on the patient or a relative signing a free and
277 informed consent form. Patient privacy and confidentiality were observed at all stages of this
278 study; data was treated confidentially. In addition, the principles of the Declaration of Helsinki
279 were also respected (34).

280 **Consent for publication**

281 Not applicable

282

Availability of data and materials

The data from this cohort are available at the Multidisciplinary Research Unit for the Prevention of Public Road Accidents (URMAVP) based at the Regional Institute of Public Health in Ouidah (Benin). E-mail: urmavp@gmail.com

Competing interests

The authors state that there is no competing of interest.

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Author's contribution

DD, YGA and BHDS set up the cohort TraumAR. DD and YGA designed the study. EMO, YC and AL helped design the study. DD, YGA, AK, and BHDS analyzed the data. DD wrote the draft of the article. All authors reviewed the article and approved its final version.

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Figure Captions

Fig. 1 Case and control selection process

Fig. 2 Map showing the roads and hospitals of the initial cohort data collection, Benin, 2019-2020

Table 1 Sociodemographic characteristics of cases and controls, 2019-2020, Benin

Table 2 Behavioral factors of cases and controls, 2019-2020, Benin

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

Table 4 Factors related to the history, habits and life style of cases and controls, 2019-2020, Benin

Table 5 Factors associated with injury severity in patients, univariate and multivariate analysis

Table 1 Sociodemographic characteristics of cases and controls, 2019-2020, Benin

Variables	Severity of injury (%)		p-value
	Case (199)	Control (398)	
Marital status			0.704
Single	32.2	35.4	
Married or engaged	62.3	58.8	
Divorced or widowed	5.5	5.8	
Professional status			0.618
No occupation	9.1	7.3	
In employment	70.8	74.4	
In training	20.1	18.3	

Table 2 Behavioral factors of cases and controls, 2019-2020, Benin

Variables	Severity of injury (%)		p-value
	Case (199)	Control (398)	
Protection equipment			0.025
Yes	44.8	57.2	
No	55.2	42.8	

Distraction during the crash 0.023

Yes 12.9 23.8

No 87.1 76.2

Fatigue/ drowsiness during crash 0.419

Yes 16.2 12.8

No 83.8 87.2

Compliance with road signs (282) 0.825

Yes 98.7 99.0

No 1.3 1.0

407

408

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

Variables	Severity of injury (%)		p-value
	Case (199)	Control (398)	
Type of user			0.073
Pedestrians	24.1	17.3	
motorcyclists	69.9	78.4	
other road users	6.0	4.3	
Time of the crash			0.009
12 pm-6 am	5.0	6.0	

7 am-7 pm	57.8	68.9	
8 pm-12 pm	37.2	25.1	
Perceived visibility level			0.860
Good	72.6	74.1	
Poor	12.2	12.3	
Acceptable	15.2	13.6	
Type of road			P < 0.001
Main roads ^a	56.8	35.9	
Other roads ^b	44.2	64.1	
Crash location			0.252
Intersection	7.5	8.8	
Off intersection	83.4	85.6	
Parking area	9.1	5.6	
Perceived pavement condition			0.641
Good	77.9	79.9	
Poor	18.6	17.8	
Under construction	3.5	2.3	
Type of crash			0.138
None	9.6	12.3	

Fixed obstacle ^c	7.5	4.5	
Moving vehicle	80.4	77.9	
Pedestrian animals or projectiles	2.5	5.3	
Driver			0.032
Yes	63.5	74.4	
No	36.5	25.6	
Reason for trip			0.006
Private	78.4	67.6	
Professional	21.6	32.4	
Commune of the crash			p<0.001
Cotonou	34.2	49.0	
Parakou	19.1	18.1	
Porto-Novo	46.7	32.9	

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

Table 4 Factors related to the history, habits and life style of cases and controls, 2019-2020, Benin

Variables	Severity of injury (%) or (mean $\pm$ sd)		p-value
	Case (199)	Control (398)	
History of chronic disease			0.871
Yes	18.7	18.2	

No	81.3	80.8	
History of crash			0.450
Yes	34.3	38.7	
No	65.7	61.3	
Driving experience (years)	17.3 (14)	15.3 (10)	0.776
use of psychoactive products			0.725
Yes	59.3	57.8	
No	40.7	42.2	

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416 Table 5 Factors associated with injury severity in patients, univariate and multivariate analysis

Variables	Crude OR (IC à 95%)	Adjusted OR (IC à 95%)
Protection equipment		
Yes	1	
No	1.9 (1.1-3.1)**	
Distraction during the crash		
Yes	1	
No	1.8 (0.9-3.9)	
Time of the crash		
12 am-6 am	0.9 (0.4-2.3)	1.2 (0.5-2.8)
7 am-7 pm	1	1
8 pm-12 am	1.6 (1.1-2.4)**	1.7 (1.1-2.5)**

Type of road

main roads ^a	2.3 (1.5-3.3)***	2.4 (1.6-3.5)***
other roads ^b	1	1

Driver

Yes	1
No	2.4 (1.4-4.3)**

Reason for trip

Private	2.4 (1.5-3.8)***	2.3 (1.4-3.8)**
Professional	1	1

Commune of the crash

Cotonou	1
Parakou	1.7 (1.1-3.0)**
Porto-Novo	2.4 (1.6-3.7)***

* p < 0.1; ** p < 0.05; *** p < 0.001.

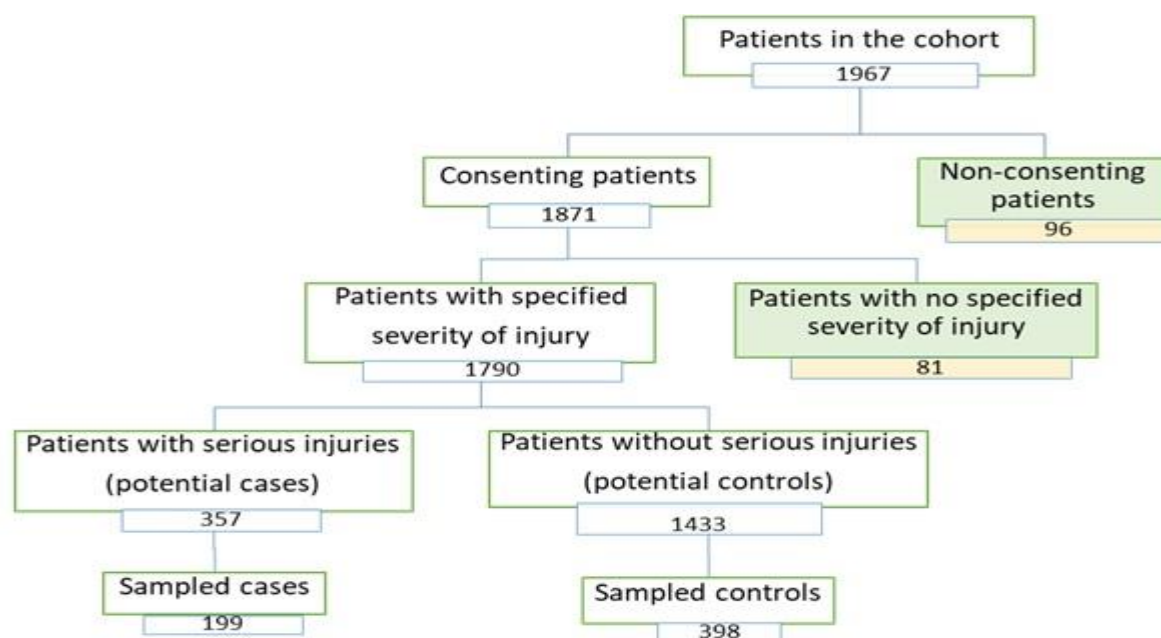


Fig. 1 Case and control selection process

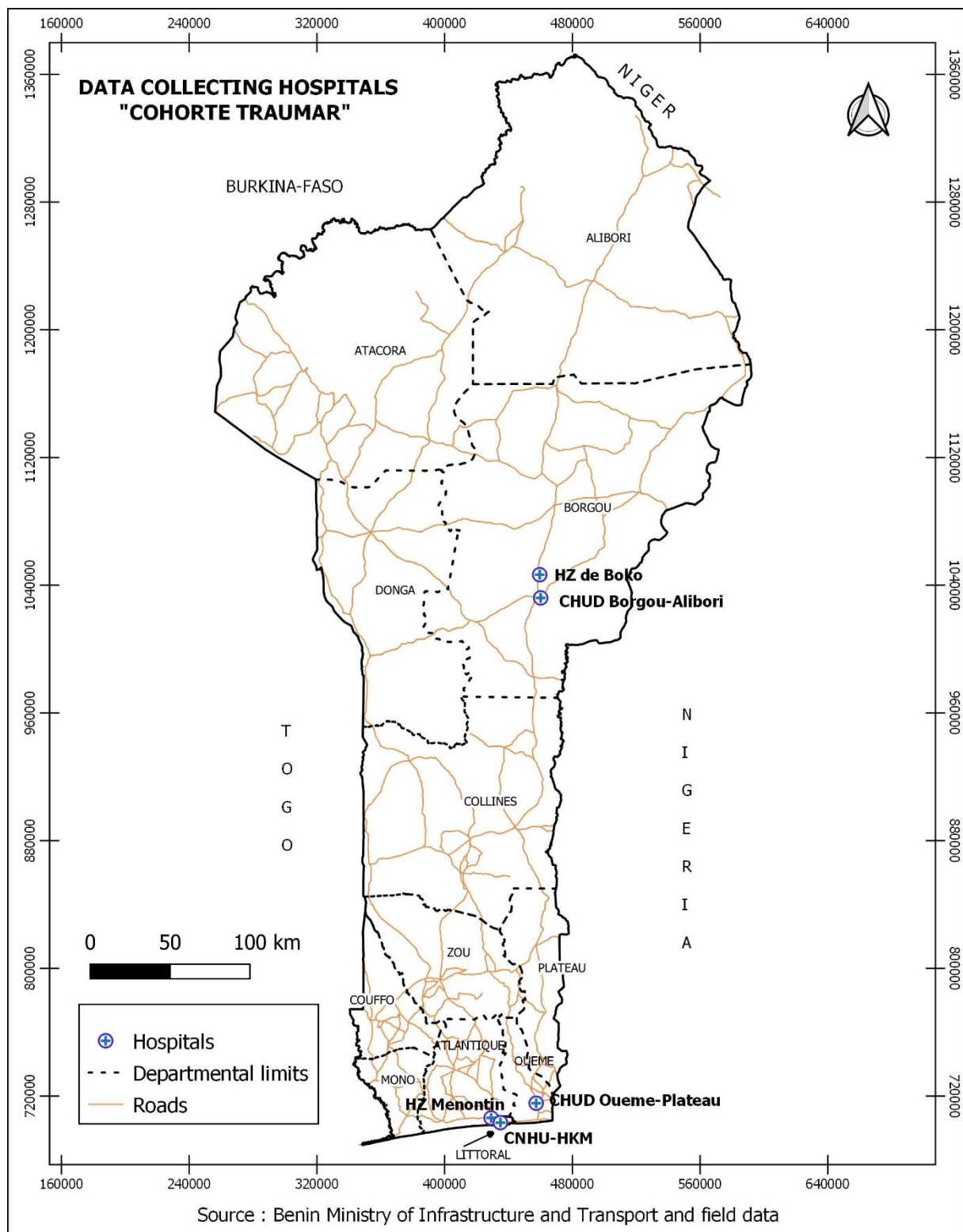


Fig. 2 Map showing the roads and hospitals of the initial cohort data collection, Benin, 2019-2020