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Factors Associated with Using GPS in Road Accidents at Cotonou in 2019

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Abstract

Introduction: Precise spatial location of accidents is relevant for accidentology researches or road safety investigations. **Objective:** The aim of this study is to investigate a number of factors associated with the geolocation of road accidents in the city of Cotonou in 2019. **Methods:** It was a cross-sectional, retrospective study with an analytical focus. **Results:** This study highlighted a prevalence of coordinates of the GPS reported at 41.63% in 2019 relating to the files of accidents on public roads during the period from April 18 to June 12, 2020. The work was carried out from 384 accident files examined in the 6 districts of Cotonou selected randomly. A logistic regression made it possible to sort out associated factors with using GPS in road accidents. The final model retained through the "ascending step by step" modeling was adopted. The average age of the responsible agents in charge of the observation was around 32 years (32.13 ± 3.17). Geolocation identified associated factors were: the level of instruction with odd Ratio 2 and its 95% confidence interval f [1.02 - 2.40], the means of conveyance odd ratio 2.56 and its 95% confidence interval of [1.21 - 5.41], the severity level of the accident with its odd ratio 4.59 and its 95% confidence interval of [2.82 - 8.32], and the type of day on which the accident occurred with odd ratio 0.56 and its 95% confidence interval f [0.437 - 2.553]. As for the quality of the reported GPS coordinates, 85% of them were good quality. **Conclusion:** The reduction of road accidents, given its serious nature and extent, requires strategies to promote geolocation of accidents to ensure better identification of risk areas and decision-making adapted to the accident phenomenon.

Keywords

Accidents, GPS, Geolocation

1. Introduction

According to the World Health Organization (WHO), over 1.2 million people die each year as a result of road crashes, and about 20 - 50 million victims suffer non-fatal injuries [1]. In 2018, road crashes were the 8th leading cause of death worldwide and the largest cause of death among children and youth aged 5 - 29 [1]. This is prevalent mainly in low-income countries where road traffic crash deaths are three times higher than in developed countries [2]. While having the least number of vehicles, Africa is the most affected continent with an estimated road traffic injury death rate of 26.6 per 100,000 population [3]. Out of fifteen countries worldwide with the highest number of road deaths, a dozen is on the African continent [3]. No African country has succeeded in reducing road traffic deaths [2]. The world Health Organization has been critical of the quality of the prevention strategies implemented and especially of the data used to develop these strategies [2]. Apart from completeness and exhaustiveness, data developed by most African countries are not geolocalized, despite the WHO recommendation on geolocalization of accidents in order to develop prevention strategies considering cultural specificities [4]. Monitoring and collection of reliable data is therefore essential not only to assess and measure the incidence of accidents but also in targeting interventions taking into account their geographical distribution. In Benin, the implementation of this WHO recommendation is hampered by the spontaneous use of GPS coordinates by police units and by the quality of the data on road accidents collected and reported. As a result, current national statistics are based on a poor system of reporting standardized accident forms, which tend not to be geolocated [5].

In view of these alarming situations that could affect the quality of the data collected and reported at the national level, it has become important to determine, through this research, the associated factors for the geolocation of road accidents and to help improving the quality of GPS coordinates reported in Cotonou in 2019.

The outcomes of this work will enable the identification of high-risk areas and the formulation of a strategic plan.

2. Study Design

2.1. Type of Study

- This was a cross-sectional, retrospective study with an analytical focus.
- **Population:**

- **Primary targets:**

The sample population is made up of all the accident files recorded in the six (06) districts randomly selected from the thirteen (13) districts of Cotonou.

The process of drawing lots was as follows:

We wrote on a piece of paper Cotonou's 13 districts and we drew 6 districts without discount.

- **Secondary targets:**

The source population for this target is all the staff members having observed accidents in the six (06) districts randomly selected.

➢ **Inclusion criteria:**

Primary targets:

✓ Was included the accident official reports.

✓ Report cards for the analysis of recorded accidents developed.

Secondary targets:

Be a police officer who has made at least one accident report since joining the Precinct.

➢ **Non-inclusion and exclusion criteria:**

Primary targets:

✓ Accident report not yet prepared.

✓ Accident Analysis official Report Form not yet prepared.

✓ Unreadable accident analysis form.

Secondary targets:

Be a police officer with no prior record of accidents since joining the Precinct.

Was excluded for this study any unreadable accident report.

2.2. Sampling

Methods and techniques for sampling of Official Statements of Offence (OSI) and reporting officers in Cotonou in 2019. Table 1 gives the synthesis of methods and techniques for sampling.

3. Data Processing

3.1. Data Treatment and Analyzing

3.1.1. Quality Assurance

Data processing was both manual and computerized. A check of all tools was done to ensure the quality of completion. This check consisted of going through the completed questionnaire by any interviewer and filling in missing information or correcting outliers before releasing the interviewed patient. It enabled the correction of any recording errors on the data collection sheets. Using Epi info version 7 software, a data entry mask was created. The data were entered using this software and then transferred to Stata11.0 for analysis. This transfer was done in order to test the adequacy of the final model obtained after the analysis. The control and cleaning of the data were ensured.

Table 1. Methods and techniques for sampling.

Targets	Method	Technic
Primer	Probabilistic	Random selection of 06 districts and random selection of 64 accident files among the recorded accidents in these districts
Second	Non probabilistic	Reasoned choice

- **Data treatment and Analysis**

Data entry was done using EPI INFO 7.2.1.0 software. Data consistency was corrected, identified outliers were removed. The analysis was conducted by STATA software version 11.0.

3.1.2. Descriptive Analysis

- **Variables description**

Quantitative variables were presented as mean ± standard deviation when normally distributed and as medians followed by the interquartile range when the distribution is not normal.

The qualitative variables were presented as numbers and frequencies.

3.1.3. Univariate Analysis

Each independent variable was crossed separately with the dependent variable. The significant independent variables were identified at the 20% threshold with the dependent variable (geolocation: 1 = Yes; 0 = No).

- **Interactions**

Relationships between predictors were sought to account for them in the final model. Thus, they were crossed with each other to identify those that had a significant relationship at 5% level.

3.1.4. Multivariate Analysis

The dependent variable is crossed with the independent variables together. Following a step-by-step bottom-up method, the final model is built. The adequacy of the model is checked by means of HoswLemeshow test. The model is adequate if the p-value is greater than 5%. The Odds ratios of the variables retained in the final model are presented and their 95% confidence intervals. The odds ratios were then interpreted according to whether these variables are risk factors or protective factors, and whether geolocation is a factor.

3.2. Ethical Concerns

All respondents were informed of the nature and objectives of the study. In addition, the following ethical rules were observed:

Free and informed consent was obtained from the police commissioners before the survey was conducted. The police units interviewed were informed of the use that is made of the information collected.

Anonymity: The interviews and questionnaires were conducted anonymously. No names were disclosed during the study.

Confidentiality: the information obtained is used only within the strict boundaries of this work and no one was negatively affected by the use of collected data.

4. Results

4.1. Sample Description

4.1.1. Distribution of Accident Files According to Behavioral Factors

Of 384 files, most of the police officers who conducted the investigations had

mastered the use of the GPS device (87.05%), while a minority (12.95%) had not. The most recorded accidents were material (46.28%), light bodily injury (29.43%).

The details are given in the Table 2 and Table 3.

Table 2. Behavioral features of police officers who witnessed accidents at Cotonou in 2019.

Variables	GPS data		Headcount	%
Handling GPS	**No**	**Yes**		
No	53	2	55	12.95
Yes	175	154	329	87.5
Selection due to gravity				
Material accidents	147	32	179	46.28
Minor injury accidents	74	38	112	29.43
Serious non-fatal accidents	7	77	84	22.84
Fatal accidents	0.0	7	7	1.44
Selection due to the involvement of two-wheelers alone				
Yes	86	63	149	93.41
No	4	6	10	6.59
Selection due to involvement of light vehicle only				
Yes	190	154	354	99.49
No	1	0.0	1	0.51

Table 3. Behavioral features of police officers who observed accidents in Cotonou in 2019.

Variables	GPS data		Headcount	%
Behavioral features of police officers who observed accidents in Cotonou in 2019	**No**	**Yes**		
Heavy vehicle alone	30	24	54	
Yes	14	16	30	
No				
Selection according to the type of day the accident occurred				
Weekend	110	39	149	38.10
Holiday eve	25	2	27	7.28
No special day	89	110	199	54.62

4.1.2. Distribution of Accident Cases According to Legislative and Technological Factors

The majority of officers who observed accidents (95.87%) found it easy to use the GPS, even though there were no measures in place to force them to use it. The synthesis of distribution is given in Table 4.

4.1.3. Distribution of Accident Records by Socio-Economic Factors

A total of 384 road accident files were examined. The mean age of the investigating officers was 32 years (32.13 ± 3.17), most of them were men (99.08%) with a secondary education (94.15%) and most of them travelled to the scene of the accident by motorcycle. he synthesis of this is given in Table 5.

Table 4. Legislative and technological features of road accidents recorded by police officers in Cotonou in 2019.

Variables	GPS data		Headcount	%
Existence of restrictive measures for the use of GPS during the observations	**No**	**Yes**		
Yes	1	0.0	1	0.46
No	227	155	382	99.54
Ease of handling				
No	15	2	17	4.13
Yes	213	153	366	95.87

Table 5. Socio-economic features of road accidents recorded by police officers in Cotonou in 2019.

Variables	GPS data		Headcount	%
Gender of the reporting officer	**No**	**Yes**		
Male	225	156	381	96.42
Female	3	0.0	3	3.57
Level of education				
Primary and secondary	226	138	364	94.15
Advanced	2	8	20	5.85
Transport means				
Motorcycle	226	119	335	86.86
Vehicles with more than 3 wheels	12	37	49	13.14
Officer's rank				
Police Brigadier	7	20	27	6.80
AP1	155	109	264	67.62
AP2	66	27	93	25.57
Training and post-training follow-up				
Yes	229	155	384	99.77
No	1	0	1	0.23

Distribution of accident records by climatic and atmospheric factors.

The majority of accidents recorded occurred in normal weather conditions. Table 6 gives the synthesis of distribution by climatic and atmospheric factors.

4.1.4. Prevalence of GPS Coordinates in Cotonou in 2019

Among the 384 accident files examined, 156 had GPS coordinates for the geolocation of accidents, *i.e.* a prevalence of 41.62% with a confidence interval of [29.76 - 54.91].

Explanatory factors for the geolocation of accidents in Cotonou.

After the bivariate analysis, the significant variables at the 20% level are as follows:

Table 7 presents the bivariate analysis between geolocation and sociodemographic behavioral features of traffic accident officers in Cotonou in 2019.

The crashes recorded by police officers with a higher level of education were twice as likely to be tagged with GPS coordinates as those with a primary and secondary level of education (OR = 2.38 with 95% CI = [1.65 - 3.44]). Accidents involving vehicles with more than 3 wheels were twice as likely to be geolocated as accidents involving motorcycles. Fatal crashes are 5 times more likely to be geotagged than other injury crashes. Crashes that occurred on days with no special circumstances (no weekend, no market day etc.) are more likely to be geolocated than those on days with special circumstances (weekend, market day and holiday).

Table 8 presents the final logistic regression model of factors associated with geolocation of road accidents in Cotonou in 2019.

Accidents recorded by police officers with higher levels of education were twice as likely to be tagged with GPS coordinates as those with primary and secondary education adjusted for the other variables (OR = 2 with 95% CI = [1.02 - 2.40]. Accidents with vehicles with more than 3 wheels were twice as likely to be geolocated as accidents with motorcycles. Fatal accidents were 4 times more likely to be geolocated than other light injury accidents adjusted for other variables. Crashes occurring on days with no special circumstances (no weekends, no market days, etc.) are more likely to be geolocated than those occurring on

Table 6. Climatic features of road accidents recorded by police officers in Cotonou in 2019.

	GPS data		
Atmospheric condition of the accident	**No**	**Yes**	**Headcount**
Normal	220	155	375
Rain	4	1	5
Storm	4	0.0	4
Total	**228**	**156**	**384**

Table 7. Bivariate analysis between geolocation and sociodemographic, behavioral features of traffic accident officers in Cotonou in 2019.

Variables	GPS data		Total	OR	IC 95%	P-Value
	No	Yes				
Level of education						
Primary and secondary	226	138	364	1		
Advanced	2	18	20	2.38	[1.65 - 3.44]	
Transport means						
Motorcycle	216	119	335	1		
Vehicle with more than 3 wheels	12	37	49	2.13	[1.61 - 2.81]	0.000*
Grade of the reporting officer						
Police officer (Brigadier)	7	20	27	1		
AP1	155	109	264	0.56	[0.39 - 0.79]	0.000*
AP2	66	27	93	0.39	[0.25 - 0.62]	0.000*
Selection due to gravity						
Material accidents	147	32	179	1		
Minor injury accidents	74	38	112	0.56	[0.39 - 0.79]	0.000*
Serious non-fatal accidents	7	77	84	0.39	[0.25 - 0.61]	0.000*
Fatal accidents	0	7	7	5.59	[2.94 - 10.66]	0.000*
Selection by type of day						
Weekend	110	39	149	0.29	[0.18 - 0.45]	0.000*
Holiday eve	28	02	27	0.06	[0.01 - 0.28]	0.000*
No special day	89	110	199	1		
Ease of handling						
No	15	2	17	1		
Yes	213	153	366	3.55	[1.30 - 9.73]	0.014*

PO: Police Officer; OR: Odds Ratio.

special days (weekends, market days, and holidays adjusted for other variables).

4.1.5. Fitness of the Final Model

The adequacy of the final model was verified by the Hosmer-Lemeshow test. In this test, the model is adequate if $p > 0.05$. The following hypotheses were posed:

H0: the model is adequate H1: the model is not adequate for a risk $\alpha = 0.05$ we obtained a $p = 0.07$ $p > 0.05$; the null hypothesis H0 was accepted and we concluded that the model was adequate.

The significant variables in our final model allowed us to reconstruct the conceptual framework for this study. The final conceptual framework for the research study of factors associated with the geolocation of traffic accidents is presented in Figure 1.

Table 8. Final logistic regression model of factors associated with geolocation of road accidents in Cotonou in 2019.

Variables	OR	IC 95%	P-Value
Level of education			
Primary and secondary	1		
Advanced	2	[1.02 - 2.40]	0.000*
Transport means			
Motorcycle	1		
Vehicle with more than 3 wheels	2.56	[1.21 - 5.41]	0.013*
Selection due to gravity			
Material accidents	1		
Minor injury accidents	0.56	[0.39 - 0.79]	0.000*
Serious non-fatal accidents	1.39	[0.25 - 2.61]	0.000*
Fatal accidents	4.59	[2.82 - 8.32]	0.000*
Selection by type of day			
Weekend	0.56	[0.437 - 2.553]	0.425
Holiday eve	0.02	[0.007 - 0.320]	0.000*
No special day	1		

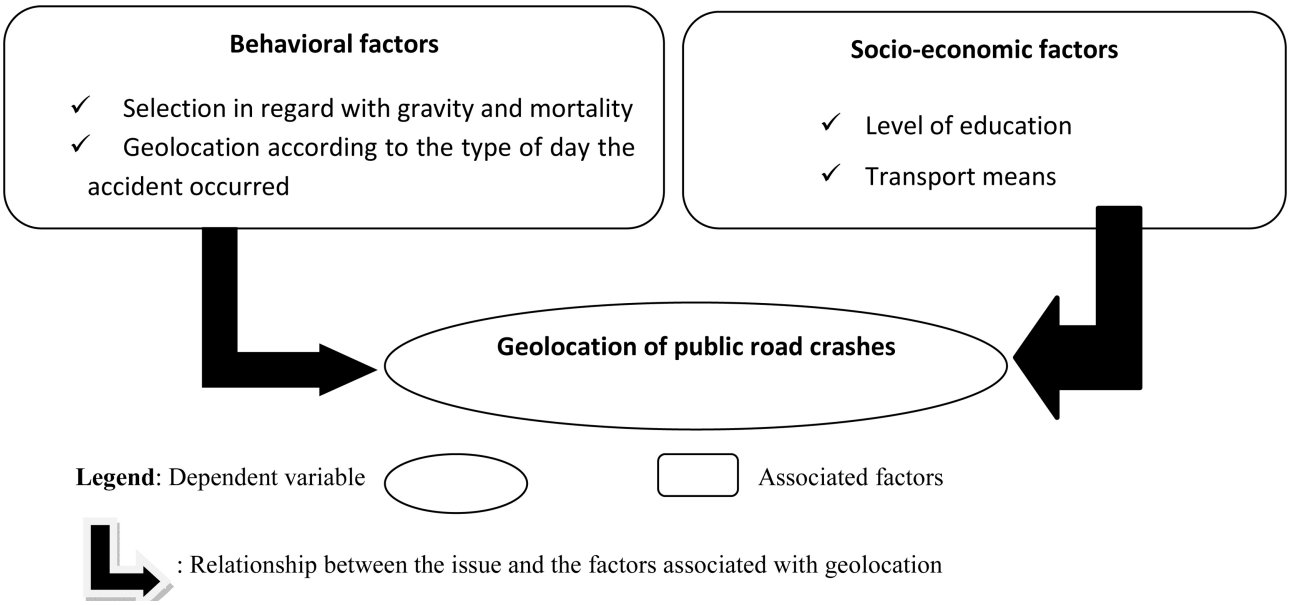

Figure 1. Final conceptual framework for the study of factors associated with geolocation of traffic accidents.

4.2. Geographic Coordinates Quality of the Accident Reports

The representation of accidents recorded with GPS is as follows in Figure 2.

By enlarging the map above, we can see that some crash points were off the road despite the 7 m margin related to the GPS accuracy. These poorly represented accident points are 15 out of a total of 156 geolocated accidents, so

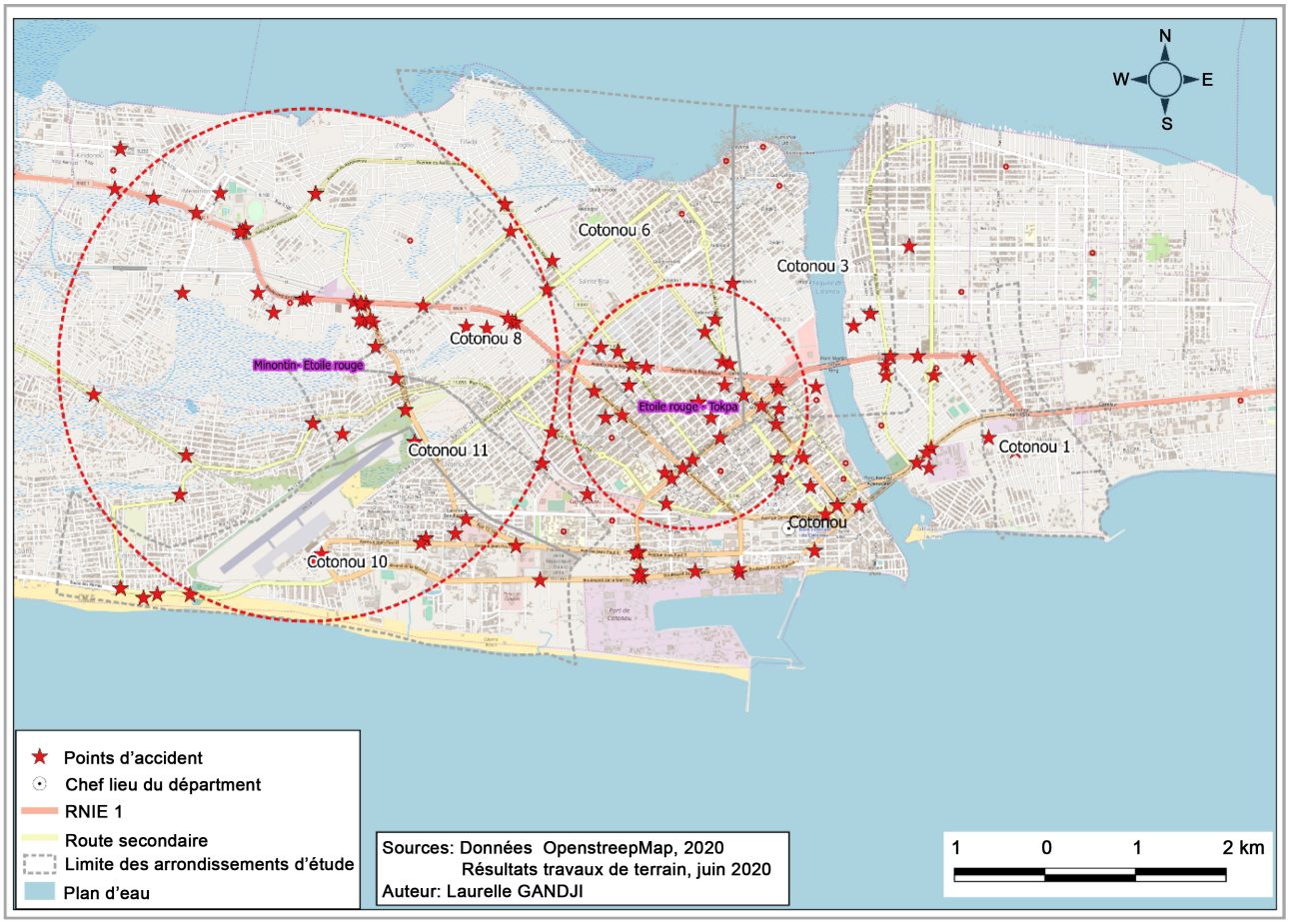

Figure 2. Map of geolocated accidents that occurred in Cotonou during the period January to July 2019. Source: Opemstreep map data, 2020 Fieldwork results, June 2020.

the percentage of poorly represented accidents in our sample is 9.62% with a confidence interval ranging from 5% to 14.25%.

Observing the resulting map also revealed that most of the road accidents occur after the crossroads "Etoile-rouge". Thus, the road network (National Interstate Highway Number 2 and urban roads) extending from the Etoile-Rouge intersection to Tokpa has a high density of accidents compared to the road network extending from Menontin to the Etoile-Rouge intersection.

5. Discussion

5.1. Achievement of Objectives

The aim of this work was to study the factors associated with the geolocation of public road accidents in Cotonou in 2019. The major outcomes of this study are as follows.

- the prevalence of accidents that were geolocated in 2019 was 41.62%.
- factors associated with the geolocation of public road accidents were: the level of education, the means of travel, the level of severity of the accident and the type of day on which the accident occurred.

- The quality of the coordinates provided: about 15% of the coordinates collected during the accident reports in Cotonou are of poor quality (85% are of good quality).

We thus consider that the objectives of the study have been achieved.

5.2. Quality and Validity of Data from the Study

In order to achieve our objectives, the study was conducted cross-sectionally. Among other things, this study will enable us to calculate the rate of use of GPS in public road accidents. The sampling method was probabilistic and the technique of random choice. Our study was cross-sectional and analytical. The probabilistic method and the random sampling technique were used. This approach was possible thanks to the processing of 384 files randomly selected in the 06 districts (1, 3, 6, 8, 10, 11) of recorded accidents. The size of our sample was calculated using the Schwartz formula.

The questionnaire was administered in the local language or in French depending on the respondent. Logistic regression was used to search for the association with a p-value ≤ 0.05. In order to better explain the studied phenomenon, we conducted interviews with the police officers. For data analysis, we used multiple logistic regression at the 5% threshold. The type of study chosen could not identify the real factors associated with the use of GPS in crashes. The temporal sequence between exposures and events is difficult to establish in cross-sectional studies, which might have been possible with a longitudinal study. However, this study provided results that can be used to conduct interventions for this target and could serve as a basis for further studies on a national scale.

Like any cross-sectional study, our study could also be subject to selection and information bias. Selection bias could be related to the likelihood of nonresponse or refusal to participate in the survey.

The data used in our study were obtained in a cross-sectional manner by document and questionnaire analysis. Several pieces of information called upon the memory of police officers. These items could introduce information bias. However, we tried to minimize these biases by:

- trying to ask the questions in stages and asking for the same information from multiple viewpoints, overlaying them to see discrepancies and re-specifying information as needed;
- briefing interviewers on the tools and;
- pre-testing tools to adapt them and ensure a common understanding of their content by all interviewers.

In addition, all the free and informed consent of the respondents and the various ethical provisions were taken during the collection. In light of all this, we believe that our results are valid and reliable.

5.3. Limits of the Study

The best way is to take all the accidents that were recorded in 2019, but given the time available for collection, we had set up a sample.

5.4. Comparison of the Findings of This Study with Other Researches

At the end of this study, the frequency of information on the coordinates of accidents in Cotonou is estimated at about 42% of cases.

This proportion in Cotonou was relatively encouraging when one considers that the use of GPS coordinates to locate accidents was at the beginning of its expansion throughout the world, but was not yet systematically available. Nevertheless, it is lower than that reported by El-Mansouri and Fournier, which was 70% [6]. It must be recognized, however, that not all districts have the same frequency of accidents. This point was also made in the study by Sounkayna and Fournier [6]. Regarding the quality of GPS coordinates, 85% were of good quality in Cotonou. This contradicts the results of the Cooperative Research in Road Safety of the University of Sherbrooke, according to which more than 70% of the GPS coordinates recorded during accidents are not exploitable [7].

This study found that most of the officers who perform these observations have a high school education, although this does not influence the report by GPS as much as those with a higher education level. The higher the level of education, the more likely it is that the officer is able to use the GPS. Most of them were first- and second-class police officers, but it was the brigadier police officers who were more able to report by GPS. The means of travel used to access the scene of the accident is a determining factor in the taking of GPS coordinates. These officers have been trained and are regularly monitored even after training in the proper use of GPS. In the majority of cases the accidents causing property damage were found without GPS coordinates. In contrast, it can be seen that as soon as the accident is fatal, it is more likely to be geotagged than a simple material accident (**Table 8**). This could be understood from the point of view of the importance of the accident which would be linked to multiple legal proceedings. Our study found that accidents that occurred on days with no special circumstances had a higher chance of being geotagged than those that occurred on market days, holidays and weekends. This can be explained by the fact that the days without any particularity are mainly the days when the police officer is not overwhelmed with tasks and can therefore validly execute all the procedures related to accident reports.

6. Conclusions

The percentage of accidents recorded with GPS in Cotonou in 2019 was 41.62% with an estimate IC 95% of [29.76 - 54.91]. The factors identified as being associated with this geolocation were the level of education, the means of travel, the level of severity of the accident and the type of day on which the accident occurred. The initial hypothesis that behavioral, socio-economic, legislative and technological factors explain the geolocation of road accidents in Cotonou in 2019 is therefore confirmed. As for the quality of the GPS coordinates provided, 85% of the coordinates collected were of good quality.

Reducing road accidents requires strategies to promote the geolocation in order to better identify risk areas and to make decisions adapted to the accident phenomenon.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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