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Pedestrian Motor Vehicle Accidents and Fatalities in Botswana-An Epidemiological Study

Thuso Mphela[1]*, *Thamani Mokoka*[2] and *Kefalotse Dithole*[3]

[1] Department of Management, Faculty of Business, University of Botswana, Gaborone, Botswana, [2] Department of Road Transport and Safety, Ministry of Transport and Communication, Gaborone, Botswana, [3] Department of Nursing, Faculty of Health Sciences, University of Botswana, Gaborone, Botswana

According to WHO, more than 300,000 pedestrian deaths were recorded globally, accounting for 22% of total road user fatalities in 2019. In 2017, Botswana pedestrian fatalities were considerably high at 32% of the total road accident fatalities recorded. This paper investigated causes, distribution, risk, and offers potential solutions to pedestrian accidents and fatalities in Botswana. Secondary data extracted from different sources were analyzed through descriptive statistics and stepwise regression modeling was performed to determine significant explanators of pedestrian fatalities. The results show that the "car" vehicle type is responsible for 55% of pedestrian collisions. There is a higher chance of pedestrian fatality when collision is with a lorry with a trailer. On the other hand, driver negligence is also blamed for 55% of pedestrian accidents. Ninety percent (90%) of pedestrian fatalities happen away from road junctions. Truck, fuel imports and nighttime accidents were identified as significant regressors for pedestrian fatalities. Overall, pedestrians are six times more likely to perish in a collision than their counterparts. Adopting sustainable road infrastructure patterns that promote pedestrian safety will foster mode split. Improving road lighting and infusing pedestrian safety into driver training curriculum, while strengthening road traffic law enforcement, will lead to improved pedestrian safety. Future studies should disaggregate pedestrian safety analysis to account for location-specific variations.

Keywords: road traffic accidents, pedestrian safety, driver negligence, sustainability, epidemiology, nighttime accidents, regression modeling, truck

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***Correspondence:**
Thuso Mphela
mphelat@ub.ac.bw

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INTRODUCTION

Globally, the annual road traffic carnage is estimated to have grown from 1.2 million to 1.3 million (World Health Organization, 2015). The World Bank (2017) reports that ∼20–50 million people are seriously injured annually. In 2019, WHO estimated that more than 300,000 pedestrian deaths were recorded globally, a 22% share of total road user fatalities (WHO, 2018). Consequently, pedestrian accidents are becoming an important challenge in many countries (Mamun et al., 2020). Earlier research in Botswana, showed that between the years 2000 and 2004, most of the casualties were reported to be related to pedestrian accidents; mostly affecting 30% of children under the age of 15 years while high fatality (47.50%) occurred among the early to middle age group of 15–43 years (Mupimpila 2008). In 2017, 142 out of 444 fatalities in Botswana were pedestrians accounting for 32% of the total fatalities, which is higher than the global average of 22% (Government of Botswana, 2018).

Cochoy et al. (2015) argue that city planners need to consider pedestrian logistics in the design of cities, even though this is often neglected. Also, care must be taken to incorporate how pedestrians transport their items and themselves for future sustainability of cities to be realized. Wei and Lovegrove (2012) opine that governments, communities, businesses, and the public must innovate to find solutions for the increased burden of road accidents on vulnerable road users (VRUs), especially pedestrians. Their study on Ontario, Canada revealed that not only did the Dutch Sustainable Road Safety (SRS) Program improve community mobility, mode splits and energy consumption resulting in less emissions, but it also led to improved road safety. Pedestrian accidents have unique consequences and have a particularly high-risk profile (Zhang et al., 2014). Despite carrying the largest burden of road fatalities per capita, studies on pedestrian accidents in Africa are scant. A recent scoping of literature by Bonnet et al. (2018) revealed only four publications on pedestrian safety interventions covering Tanzania, Nigeria and South Africa. Interventions included reflective jackets that were given to school children, pedestrian bridges that were constructed, calming measures instituted, and road safety education given to pedestrians. The authors included literature from the 1950s. Our study is premised on the argument that pedestrian safety is a critical ingredient and an outcome of sustainable cities and communities. Therefore, this study seeks to investigate the occurrence, causes, distribution, risk, and advance potential panaceas to pedestrian motor vehicle accidents and fatalities in Botswana. The study identifies salient factors affecting pedestrian fatality rates. When designing road traffic safety interventions, it is important to consider context as African countries present divergent administrative and legal regimes (Bonnet et al., 2018). Our study is unique in two ways; first, it is the first attempt in Botswana to profile pedestrian accidents and secondly, it seeks to explain the occurrence of pedestrian fatalities as explained by multiple factors such as road infrastructure, exposure, motor vehicle characteristics and time of the day.

LITERATURE REVIEW

Pedestrians bear a huge burden of road traffic accidents (Sarikhani et al., 2017). Unfortunately, evidence shows that local transport authorities statistics underestimate and under-report pedestrian collisions (Stutts and Hunter, 1998). Abegaz et al. (2014) argue that under-reporting on road crashes statistics is a general challenge for low- and middle-income countries. One of the major contributing factors to this phenomenon is the lack of resources (Rolison et al., 2018). This leads to weak and absence of evidence-based policy on road safety resulting in unsuccessful interventions. Bonnet et al. (2018) argue that insufficient resources allocated to research in the subject cannot generate new knowledge. Therefore, the dire shortage of studies that evaluate road traffic injuries in sub-Sahara Africa as espoused by the call for increased research during the Decade of Action for Road Traffic Injuries by WHO (Vissoci et al., 2017) can only mean that the continent will take much longer to find solutions.

There is a myriad causes of pedestrian accidents, ranging from air temperature (Parvareh et al., 2018), roadway, environmental, human (drunkenness and jaywalking) (Kim et al., 2008). Pedestrian collisions caused by distraction by the use of electronic gadgets through calling, texting or listening to music (given the high penetration of these gadgets) are becoming prevalent and relevant for policy makers (Schwebel et al., 2012). Distracted pedestrians are more likely to be hit by cars than undistracted ones while crossing the road (Schwebel et al., 2012; Byington and Schwebel, 2013). This is because pedestrians are likely to miss safe windows to cross the road. They tend to look away from the road instead of doing the basic road safety protocols like looking left and right less. Ropaka et al. (2020) observed similar behaviors under high pedestrian traffic—that distracted pedestrians also had higher near miss exposure increased with the pedestrian volumes.

In responding to pedestrian carnage, jurisdictions have adopted different approaches. New Jersey revised its law to criminalize pedestrian death caused by careless drivers, especially those that are distracted by the use of cellphones while driving (Clennan, 2020). Training and rehabilitating drivers can also be effective. Ābele et al. (2019) conducted a simulated intervention that involved training young drivers in an effort to improve their hazard perception in pedestrian-related situations. They concluded that trained drivers' hazard perception improved, while drivers also became more aware of their limited inexperienced driver skills, showing a lower self-assessment of hazard perception after the intervention. The result was that drivers became more cautious in subsequent simulated driving experiments.

Pedestrian safety interventions can significantly alter the pedestrian road crossing behavior (Aldayes and Mobrad, 2020; Mamun et al., 2020). Mamun et al. (2020) found a significant association between demographic characteristics and compliance levels. For example, pedestrians under the age of 25 were more likely to comply better after the intervention than other groups, while married pedestrians were more compliant than their unmarried counterparts. An initiative by the Bicycle and Pedestrian Subcommittee of the Transportation Planning Board (TBP) called "street smart" ran a campaign which intended to improve pedestrian and cyclist's safety on the USA roads that saw a decline of 50 and 21% on pedestrian collisions and fatalities, respectively (Aldayes and Mobrad, 2020). In areas where the road safety awareness messages were combined with engineering interventions (redesigning of pedestrian access roads), pedestrian collisions declined by as much as 79%. In Toronto, Canada a quasi-experimental study by Fridman et al. (2020), where a posted speed limit was reduced from 40 to 30km/h, led to a 28% decrease in pedestrian road accidents compared to roads that were left at 40 km/h. However, Matsui and Oikawa (2019) found that pedestrian collisions that happen at low speeds tend to be more fatal than those happening at high speeds at signalized intersections during daytime. The authors argue that this may be explained by the fact that in Japan cars and pedestrians move simultaneously when the traffic light is green, creating a potential conflict of movement. Pedestrian accidents are highly likely to occur in the outskirts than urban areas due to high vehicle speeds and lack of safety provisions for pedestrians (Sheykhfard and Haghighi, 2020). We can conclude that this provides evidence that regulating speed alone may not be sufficient if other road design factors are not accounted for. Perhaps some of the most successful road safety interventions worth mentioning would be Helsinki and Oslo cities in Norway, that reported no pedestrian deaths on their roads in 2019 consistent with the country's "vision zero" strategy. The strategy intends to eliminate crashes that lead to fatalities and serious injuries. In Helsinki, the interventions included among other things, improvement of street environment, reduction of speed limits and emergency response services (SmartCitiesWorld, 2020).

A transition to sustainable land use and transportation patterns will lead to significant improvements in road safety in neighborhoods and provide impetus for environmental sustainability proponents (Wei and Lovegrove, 2012). The authors conclude that the built environment that encourages bicycling, walking and is transit-friendly will significantly reduce auto dependence. A study by Marshall (2012) that examined a New Urbanism development of Stapelton in Denver, Colorado also evaluated the road infrastructure network design and resulting safety. The results showed that a significant number of drivers exceeded the posted speed limits because of road infrastructure patterns, increasing accident risk. A Malaysian study by Musa et al. (2020) shows that heavy investment in road infrastructure does not improve risk for pedestrian accidents if traffic management and road safety monitoring are deficient. The same authors advocate for improvement in public transportation systems as it reduces congestion and provides more choices for road users. The more telling statistic is the conclusion by Marshall (2012), which shows that 92% of the people in the Stapelton locality preferred to drive instead of cycling or walking (alternative modes). This emphasizes the argument that speed has a direct impact on pedestrian safety, at the same time influencing perception on safety. It is logical that more people in Stapelton choose to drive than in other localities because they do not feel safe. Cumulatively, this evidence suggests that the developing countries such as Botswana should learn from the risks that come with road infrastructure patterns when they construct their roads and learn from developed countries. Further, that the expansion of road infrastructure, without consideration of safety factors can only increase road traffic and VRU risk exposure.

RESEARCH METHODS AND DESIGN

This cross-sectional study uses Botswana road crashes statistics from 2014 to 2018. General pedestrian accident data was extracted from the annual Transport and Infrastructure Statistics reports prepared by Statistics Botswana. Data on pedestrian accidents by type of vehicle, time of the day according to severity, and accidents by gender and age are not publicly available. Therefore, case data was requested from the Botswana Police Traffic Division. The latter is the most reliable source of data on road traffic accident statistics and the main source of this data for Statistics Botswana.

The data was cleaned using basic descriptive statistics on excel. Inconsistencies in the data were resolved with the Botswana Police Service Traffic Division. Generally, frequencies and percentages were calculated, either to evaluate the contribution of each vehicular type to pedestrian accidents or to establish the gravity of pedestrian accidents by the time of day. Specifically, ratios were used to determine the level of risk of a fatal accident associated with a given type of vehicle. Data analysis was performed on excel spreadsheets. Further, interviews were conducted with key informants to corroborate the findings. Using Statistical Package for Social Sciences (SPSS) version 27, stepwise regression models were computed to determine significant explanators of pedestrian fatalities. To compute these models a 10-year dataset from 2008 to 2017 was used. National accident mapping was performed using ArcGIS Desktop: Release 10.5 software (ESRI, 2011).

Definition of Accident Severity in Botswana

According to MVAF (2012: 21-22), Botswana classifies accidents severity on three levels as follows;

Fatalities: any person who dies in a road traffic accident within 30 days of the traffic accident.

Serious injuries: any person who is injured and who was hospitalized for a period of more than 24 h, for example a person who suffered fracture, severe cuts, internal injuries, and others.

Minor injuries: any injury of a minor character not requiring medical treatment, for example, lesser wounds, minor cuts, and bruises. These people are normally treated at emergency centres.

An interview with the Botswana Police Service Road Traffic Division revealed a number of concerns regarding accuracy of road traffic statistics, especially with regards to classification of minor or serious injuries. They cited many instances where they classified cases as minor or major only for them to be upgraded or downgraded accordingly by respective health centers. They argue that the police officers assess severity with their naked eyes, therefore only visible injuries can be picked. However, in some instances these changes of classification are communicated to the police for update. The downside is that there is weak communication between the health professionals and the police when dealing with road accident cases, leading to inaccurate statistics. To circumvent this situation, the Government is upgrading the data-capturing software called Microcomputer Accident Analysis Package (MAAP) to iMAAP, with a new key feature being integration, so that there is real time communication between the police and the health professionals attending to the road traffic accident victims. The original MAAP was a product of the 1983 agreement to improve road safety in the country between the Government of Botswana and the Swedish International Development Authority (SIDA).

Ethical Consideration

This research is based on publicly available secondary data with no human subjects involved. Further, the study does not pose any harm to any person's character, business or organization. However, the researchers take personal responsibility of the outcome of the results.

TABLE 1 | Pedestrian accident severity by police region.

District	2014			2015			2016			2017			2018			Total
	Fatal	Serious	Minor	Fatal	Serious	Minor	Fatal	Serious	Minor	Fatal	Serious	Minor	Fatal	Serious	Minor	
Francistown	3	19	57	7	16	82	5	21	87	7	16	70	3	8	46	447
Gaborone	7	45	220	23	44	254	14	42	263	17	43	257	17	36	223	1,505
Gaboronw West	26	59	249	22	71	245	26	54	250	32	63	239	27	47	249	1,659
Kanye	8	14	39	8	19	47	4	5	16	10	25	45	13	20	44	317
Kasane		5	4	1	8	2	7	19	61		3	9	1	6	10	136
Kutlwano	8	23	70	5	21	56		5	4	4	23	57	6	13	40	335
Letlhakane	4	7	12	8	9	16	4	20	53	4	12	9	4	5	13	180
Lobatse		12	34	6	13	23	1	7	14	7	8	22	6	7	23	183
Maun	6	28	54	4	19	56	6	17	25	4	21	44	6	15	56	361
Ghanzi	1	4	7	1	5	7	6	8	27	3	6	13	4	6	13	111
Molepolole	13	16	51	8	15	50	6	9	54	14	21	72	10	17	55	411
Mochudi	4	14	43	8	15	40	7	18	42	10	11	41	7	10	34	304
Mahalapye	7	4	26	7	18	19	11	24	53	8	7	32	6	10	24	256
Selibe Phikwe	4	12	37	4	18	39	2	9	23	3	11	22	2	9	26	221
Serowe	2	16	59	7	15	64	10	18	67	17	22	68	9	13	54	441
Tsabong	1	2	11	1	3	5	2	5	10	2	2	12	5	3	13	77
Total	94	280	973	120	309	1,005	111	281	1,049	142	294	1,012	126	225	923	6,944

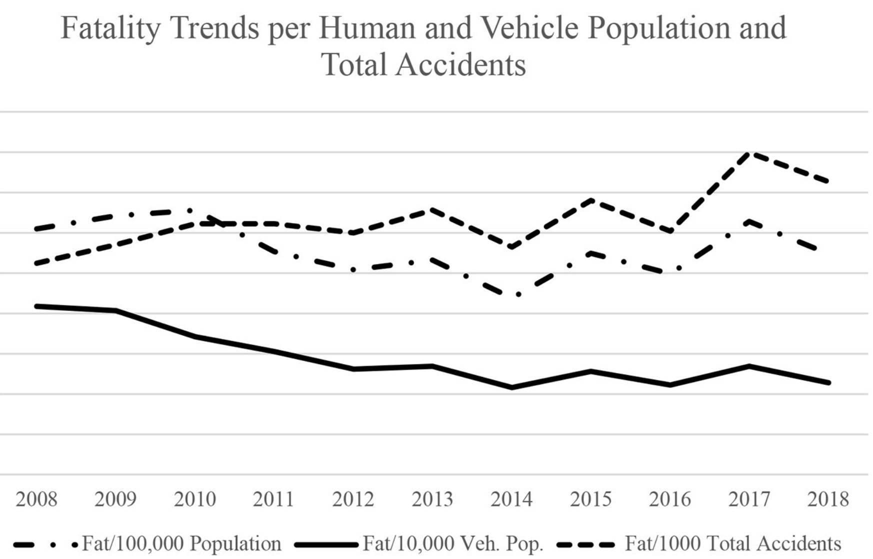

FIGURE 1 | Fatality trends per human and vehicle population, and total accidents. Source: Authors.

RESULTS

Demographic Data

Gaborone is the capital city of Botswana, with a population estimated to grow beyond 313,000 by 2026, while Francistown, which is second city is estimated to host just above a third of that population (Statistics Botswana, 2015). According to the pedestrian accident severity by police region statistics presented in **Table 1**, Gaborone cumulatively bears almost half the national pedestrian accidents over the 5 years from its police districts that include Gaborone, Gaborone West and Kutlwano. Tsabong police district is the least affected, with the maximum pedestrian fatalities only reaching 5 in 2018. These numbers are reflective of the regional population densities. Botswana is sparsely populated in the west, where Gantsi and Tsabong are. By extension, there is subdued economic activity and transport modal conflicts. When comparing the 5 years at country level, 2017 recorded the highest number of pedestrian fatalities at 142. In 2018, Serowe experienced the most decline in pedestrian fatalities, a reduction of almost half from the previous year. From 2014 to 2015, pedestrian fatalities increased by a factor of three in both

TABLE 2 | Pedestrian accident causes.

Year	Cause of accident	Fatal	Serious	Minor	Total	Percentage
2014	Driver fatigued or asleep	0	0	1	1	0.07
	Drivers influence of drinks or drugs	6	23	32	61	4.53
	Unlicensed driver	6	11	28	45	3.34
	Driver excessive speed (Over speeding)	2	3	3	8	0.59
	Driver overtaking improperly	1	0	0	1	0.07
	Driver u – turning	0	0	1	1	0.07
	Driver reversing negligently	2	9	62	73	5.42
	Driver failing to comply with traffic sign/signal	1	0	7	8	0.59
	Driver cyclist error	0	1	0	1	0.07
	Driver losing control	3	9	15	27	2.00
	Driver following too close from behind	0	0	1	1	0.07
	Driver any other negligence	39	164	604	807	59.91
	Pedestrian crossing without care	18	32	136	186	13.81
	Pedestrian walking or standing on road	2	0	4	6	0.45
	Pedestrian playing on road	0	2	8	10	0.74
	Pedestrian slipping or falling when crossing	0	0	1	1	0.07
	Pedestrian under influence of drinks or drugs	13	19	37	69	5.12
	Pedestrian holding on to a vehicle	0	0	1	1	0.07
	Pedestrian any other negligence	1	4	26	31	2.30
	Passenger any other negligence	0	0	1	1	0.07
	Animal dog on road	0	1	0	1	0.07
	Other obstructions	0	0	1	1	0.07
	Veh defect tyre burst	0	0	1	1	0.07
	Veh other defects	0	2	2	4	0.30
	Roads potholes	0	0	1	1	0.07
	Total	**94**	**280**	**973**	**1,347**	**100.00**
2015	Drivers influence of drinks or drugs	12	11	31	54	3.80
	Driver physical defective	0	0	1	1	0.07
	Unlicensed driver	2	15	48	65	4.57
	Driver excessive speed (Over speeding)	3	4	9	16	1.13
	Driver overtaking improperly	0	1	3	4	0.28
	Driver swerving to the left/right carelessly	0	0	1	1	0.07
	Driver u – turning	0	0	4	4	0.28
	Driver reversing negligently	1	12	44	57	4.01
	Driver failing to comply with traffic signs	3	3	12	18	1.27
	Driver cyclist error	0	0	5	5	0.35
	Driver turning without care	0	0	1	1	0.07
	Driver losing control	8	7	18	33	2.32
	Driver negligence of PSV driver	0	0	2	2	0.14
	Driver any other negligence	61	171	545	777	54.64
	Pedestrian crossing without care	18	49	189	256	18.00
	Pedestrian walking or standing on road	0	1	8	9	0.63
	Pedestrian playing on road	0	0	3	3	0.21
	Pedestrian under influence of drinks/drugs	8	10	35	53	3.73
	Pedestrian sleeping on the road	0	1	1	2	0.14
	Pedestrian any other negligence	4	12	43	59	4.15
	Obstruction other obstructions	0	0	1	1	0.07

(Continued)

TABLE 2 | Continued

Year	Cause of accident	Fatal	Serious	Minor	Total	Percentage
	Veh Defect other defects	0	0	1	1	0.07
	Total	**120**	**297**	**1,005**	**1,422**	**100.00**
2016	Drivers influence of drinks or drugs	6	7	33	46	3.19
	Driver physical defective	0	1	0	1	0.07
	Driver unlicensed driver	4	15	29	48	3.33
	Driver excessive speed (Over speeding)	6	2	5	13	0.90
	Driver overtaking improperly	0	2	5	7	0.49
	Driver swerving to the left/right carelessly	0	0	1	1	0.07
	Driver u – turning	0	0	1	1	0.07
	Driver reversing negligently	1	10	42	53	3.68
	Driver failing to comply with traffic signs	0	0	5	5	0.35
	Driver cyclist error	0	0	1	1	0.07
	Driver turning without care	0	0	1	1	0.07
	Driver losing control	2	6	17	25	1.73
	Driver any other negligence	53	155	610	820	56.90
	Pedestrian crossing without care	28	48	183	259	17.97
	Pedestrian walking or standing on road	3	0	9	12	0.83
	Pedestrian playing on road	1	2	8	11	0.76
	Pedestrian slipping or falling when crossing	1	1	0	2	0.14
	Pedestrian under influence of drinks /drugs	3	19	32	54	3.75
	Pedestrian holding on to a vehicle	1	0	3	4	0.28
	Pedestrian sleeping on the road	0	1	0	1	0.07
	Pedestrian any other negligence	2	12	57	71	4.93
	Obstruction other obstructions	0	0	1	1	0.07
	Veh Defect tyre burst	0	0	1	1	0.07
	Veh Defect other defects	0	0	4	4	0.28
	Weather heavy rain	0	0	1	1	0.07
	Total	**111**	**281**	**1,049**	**1,441**	**100.00**
2017	Drivers influence of drinks or drugs	9	15	34	58	4.01
	Driver unlicensed driver	5	17	51	73	5.04
	Driver excessive speed (Over speeding)	4	1	5	10	0.69
	Driver overtaking improperly	0	1	4	5	0.35
	Driver swerving to the left/right carelessly	0	0	1	1	0.07
	Driver u – turning	0	0	1	1	0.07
	Driver reversing negligently	3	6	46	55	3.80
	Driver failing to comply with traffic signs	0	0	8	8	0.55
	Driver turning without care	0	0	4	4	0.28
	Driver losing control	6	9	31	46	3.18
	Driver negligence of PSV driver	0	0	1	1	0.07
	Driver any other negligence	65	166	562	793	54.77
	Pedestrian crossing without care	31	47	186	264	18.23
	Pedestrian walking or standing on road	1	2	3	6	0.41
	Pedestrian playing on road	0	0	4	4	0.28
	Pedestrian slipping or falling when crossing	0	0	1	1	0.07
	Pedestrian under influence of drinks/drugs	16	22	33	71	4.90
	Pedestrian holding on to a vehicle	0	0	1	1	0.07
	h	0	0	2	2	0.14
	Pedestrian any other negligence	2	8	28	38	2.62

(Continued)

TABLE 2 | Continued

Year	Cause of accident	Fatal	Serious	Minor	Total	Percentage
	Animal dog on road	0	0	3	3	0.21
	Veh defect tyre burst	0	0	1	1	0.07
	Veh defect other defects	0	0	2	2	0.14
	Total	**142**	**294**	**1,012**	**1,448**	**100.00**
2018	Drivers influence of drinks or drugs	8	9	30	47	3.69
	Driver physical defective	0	0	1	1	0.08
	Driver unlicensed driver	4	10	21	35	2.75
	Driver excessive speed (Over speeding)	4	1	6	11	0.86
	Driver overtaking improperly	1	0	6	7	0.55
	Driver swerving to the left/right carelessly	0	0	1	1	0.08
	Driver reversing negligently	3	6	26	35	2.75
	Driver failing to comply with traffic sign or signal	0	0	5	5	0.39
	Driver cyclist error	0	0	2	2	0.16
	Driver turning without care	0	0	4	4	0.31
	Driver losing control	5	3	13	21	1.65
	Driver any other negligence	71	137	552	760	59.65
	Pedestrian crossing without care	14	33	170	217	17.03
	Pedestrian walking or standing on road	3	3	18	24	1.88
	Pedestrian playing on road	0	0	7	7	0.55
	Pedestrian slipping or falling when crossing	0	3	1	4	0.31
	Pedestrian under influence of drinks/drugs	4	12	26	42	3.30
	Pedestrian holding on to a vehicle	0	1	0	1	0.08
	Pedestrian sleeping on the road	0	0	1	1	0.08
	Pedestrian any other negligence	9	6	31	46	3.61
	Veh defect other defects	0	1	2	3	0.24
	Total	**126**	**225**	**923**	**1,274**	**100.00**

Gaborone and Serowe. When pedestrian severity is compared against others, 8.54% of pedestrian collisions are fatal while motorists' fatality rate is only 1.53%. Therefore, pedestrians are more than 6 times likely to die from a collision than vehicle occupants.

When we consider the rate of pedestrian fatalities over a 10-year period from 2008 to 2018, the trend shows that fatalities per 10,000 vehicle population have been on the decline (see **Figure 1**). In fact, it halved by 2018 from 4.17 to 2.28 demonstrating that the rate of fatalities is growing at a slower pace than the population of vehicles in the country. Conversely, the rate of pedestrian fatalities per 100,000 population shows a declining trend until 2014, almost mimicking the fatalities per 10,000 vehicle population, only to rise steadily until peaking at 6.27 in 2017, where it almost reached the 2010 peak before declining sharply into 2018. The pedestrian fatalities per 1000 total accidents assumes a generally growing trend, moving from 5.24 to 7.27 over the period under consideration. Its growth mirrors that of fatalities per 10,000 vehicle population, only in a different direction. This evidence shows an inverse relationship between pedestrian fatalities and vehicle population, while there is a positive relationship between pedestrian fatalities and the total number of accidents.

Comparing Botswana With Other Countries

In China there are more pedestrians that die on the roads than motorists, with cyclists and pedestrian suffering more deaths in rural areas, while the picture in the USA is the opposite (Zhang et al., 2010). Despite accounting for the largest number of road fatalities globally, China only passed the first law on road traffic safety in 2003 (O'meara, 2020). As a proportion of population, Botswana registered 26, China 17, South Africa 22, India 16, while the USA is 13 road traffic fatalities per 100, 000 in 2019. The world average was 17 (World Bank, 2021). India, like China, has experienced continued growth in road traffic crashes and fatalities, as a result of the continued expansion of road infrastructure and increase in motorized vehicles. This has led to 60–90% of road fatalities being VRUs (Mohan et al., 2009). In India, the bus and truck population is of the same magnitude as the cars.

Causes of Pedestrian Accidents

Table 2 provides a comprehensive breakdown of causes of accidents that involved a pedestrian. Botswana categorizes causes of pedestrian accidents by ascribing them to the dominant party. Categories include driver, pedestrian, vehicular and road surface defects. On average driver negligence (which is categorized as other) accounts for more than 55% of the pedestrian accidents that occurred over the 5-year period. Of those distinctively categorized, "driver reversing negligently," "driver under the influence of drugs," and "unlicensed driver," are the leading contributors to pedestrian accidents. In 2014, "pedestrian crossing without care" resulted in 13.8% of the accidents that involved pedestrians, while the following 4 years recorded a minimum of 17% of the total pedestrian accidents caused by pedestrians crossing the road without care. The second contributing factor of accidents caused by pedestrians is "pedestrian under influence of drinks /drugs" recording a minimum of 3.30% and high of 5.12%. However, the trend has been generally declining over the years. Pedestrian accidents caused by vehicular defects and road surface are quite negligible. Spatially, the evidence provided also shows that on average, 80% of pedestrian accidents occur away from road junctions, consistent with other studies in Benin, Ghana and Hawaii (Kim et al., 2008; Ojo et al., 2019; Glèlè-Ahanhanzo et al., 2021), while accidents happening at stop signs or working traffic signals peaked at 20% in 2017. These statistics grew continually from 14% in 2014 before declining to 16% in 2018. However, over 90% of fatalities occur away from road junctions and signals. Overall, more than 70% of pedestrian accidents are caused by drivers.

Pedestrian Accidents by Type of Vehicle

Table 3 presents a record of pedestrian accidents according to type of vehicle. "Car" is the vehicle type that causes most of the pedestrian accidents annually. At an aggregate level, almost 55% of pedestrian accidents are ascribed only to cars over the 5-year period. "Pick-up" and "mini-bus" are the subsequent largest contributors to total pedestrian accidents with 15.67 and 7.16%, respectively. The mini-bus dominates intra-city and short distance inter-city public transport, and particularly known for nuisance drivers, while "tractor" and "animal-drawn vehicle" have the least proportion of pedestrian accidents, followed by "lorry with trailer," "motorcycle," and "bicycle." However, this must be understood from the view that these vehicular types of population are relatively low. Of the least accident-prone vehicle types, only the motorcycle has registered fatalities.

The analysis was taken further to determine fatal pedestrian accidents as a proportion of the total number of pedestrian accidents per vehicle type. This would reveal which vehicle types are more likely to result in the loss of pedestrian lives as opposed to others. For example, cars take a huge proportion of total number of pedestrian accidents and claim more pedestrian lives than any other vehicle type at aggregate level. However, **Table 4** shows that "car" is the 7th most fatal vehicle type, ranking even lower than motorcycle which recorded only 3 fatalities over the five-year period under study. "Lorry with trailer" is the most fatal vehicle type followed by "bus" and "lorry." A pedestrian accident caused by a lorry with a trailer is 1.7 and 5 times likely to be fatal than one caused by a bus and car, respectively.

Pedestrian Road Accidents by Time of the Day

In **Table 5**, pedestrian accidents are presented by the time of the day at 2-h intervals. Isolating hours of the day allows us to

TABLE 3 | Casualty injury by vehicle type.

Year	Casualty	Vehicle type														Total	Percentage
	Injury	Bicycle	Motorcycle	Car	Taxi	4-wheel drive	Pick-up	Light duty vehicle	Lorry	Lorry with trailer	Minibus	Bus	Tractor	Animal drawn	Other		
2014	Fatal	0	0	48	0	1	25	3	1	2	6	2	0	0	6	94	1.36
	Serious	3	3	133	4	7	53	20	9	0	9	2	1	0	36	280	4.04
	Minor	0	3	523	22	20	168	47	16	4	57	6	3	3	101	973	14.04
2015	Fatal	0	1	61	0	5	22	6	5	3	4	2	-	0	11	120	1.73
	Serious	0	1	156	7	3	53	9	8	1	16	0	-	4	39	297	4.28
	Minor	6	6	539	21	20	167	27	17	0	78	7	-	5	112	1,005	14.50
2016	Fatal	0	0	57	0	2	24	2	4	2	7	4	0	-	9	111	1.60
	Serious	0	0	157	4	4	45	12	7	1	20	1	2	-	28	281	4.05
	Minor	3	2	573	32	20	150	15	13	1	115	9	2	-	114	1,049	15.13
2017	Fatal	-	0	72	0	4	24	3	6	3	11	3	-	0	16	142	2.05
	Serious	-	0	167	3	7	40	4	8	4	15	1	-	3	42	294	4.24
	Minor	-	9	582	13	22	144	23	8	3	83	4	-	3	118	1,012	14.60
2018	Fatal	0	2	68	2	5	21	2	3	1	5	0	0	0	17	126	1.82
	Serious	1	2	114	6	11	35	1	9	1	14	4	2	2	23	225	3.25
	Minor	3	5	547	27	33	115	20	11	3	56	3	0	2	98	923	13.32
Total		16	34	3,797	141	164	1,086	194	125	29	496	48	10	22	770	6,932	100.00
Percentage		0.23	0.49	54.77	2.03	2.37	15.67	2.80	1.80	0.42	7.16	0.69	0.14	0.32	11.11	100.00	

determine variations in the distribution of accidents and what time of the day we are likely to experience more accidents than others. Evidence shows that most pedestrian accidents occur during the 6 a.m.−8 a.m., 4 p.m.−6 p.m., and 6 p.m.−8 p.m. intervals. The latter interval experiences most accidents registering 18% of the total pedestrian cases. Not surprisingly, accidents are prevalent during these 6 h of the day since they are the most active in terms of movement. The most productive society in school going children and workers commute to and from their schools and employment places during these hours. The 6 p.m.−8 p.m. interval proves to be the most fatal of the 12 intervals, recording an average of over 26% pedestrian fatalities over the 5-year period. This could be explained by challenges in visibility in the evenings (Zhang et al., 2014) and high speeds when traffic has dissipated on most urban roads. The 4 p.m.−8 p.m. block accounts for 35% of the total pedestrian fatalities.

TABLE 4 | Fatalities as a ratio of total number of pedestrian accidents by vehicle type.

Vehicle Type	Fatalities/total accidents
Lorry with trailer	0.38
Bus	0.23
Lorry	0.15
Pick-up	0.11
4-wheel drive	0.1
Motorcycle	0.09
Car	0.08
Light duty vehicle	0.08
Other	0.08
Minibus	0.07
Taxi	0.01
Bicycle	0
Tractor	0
Animal drawn	0

Pedestrian Fatalities Model

The study also endeavored to determine the salient explanators of pedestrian fatalities. In the first model, the "fatalities count" was treated as a dependent variable, regressed against twelve independent variables comprising road conditions, road infrastructure in kilometers, motor vehicle characteristics, fuel imports (used as a proxy variable for exposure) and accident statistics by time of the data. For the latter, time of day was divided into two—day and night. When running the stepwise regression model, two significant models emerged, one with only one and the other two explanatory variables (see **Table 6**). Both models returned the vehicle type "truck" as a significant explanatory variable, while the second model also had "fuel imports," albeit with a negative coefficient. However, the explanatory power of fuel imports is negligible. The second model has a significantly higher adjusted R^2 (0.652) than the first model that recorded 0.384, evidence that the former model is much stronger at explaining pedestrian fatalities. ANOVA statistics shows that both models are significant at <0.05.

When running another multiple regression model as shown in **Table 7**, the pedestrian fatality count variable was converted to "fatalities/1000" of human population in the country to determine if this could improve the model. The stepwise regression model returned only "night accidents" as the significant explanator of pedestrian fatalities. At significance level of <0.01, the model had an R^2 and an adjusted R^2 value of 0.640 and 0.596 respectively. When we compare the three models, the second model of the fatalities count models has a better explanatory power (72.9%) and higher adjusted R^2 value than the other two.

Previous Pedestrian Safety Interventions

The researchers also sought to establish the interventions adopted at national level to curb the occurrence of pedestrian accidents and mitigate their epidemiological effects on welfare, in general. Following the United Nations Declaration on the Decade of

TABLE 5 | Casualty injury by time of the day.

Time	2014			2015			2016			2017			2018			Total	Percentage
	Fatal	Serious	Minor	Fatal	Serious	Minor	Fatal	Serious	Minor	Fatal	Serious	Minor	Fatal	Serious	Minor		
00–02	6	14	19	9	14	28	2	12	25	7	17	26	7	10	19	215	3.10
02–04	4	2	11	7	3	19	3	10	16	4	6	13	6	3	12	119	1.72
04–06	2	4	18	3	9	7	8	9	12	4	3	17	5	4	15	120	1.73
06–08	6	22	111	9	17	127	14	30	139	10	26	133	8	24	125	801	11.56
08–10	8	12	53	3	10	52	4	13	67	5	10	60	4	9	69	379	5.47
10–12	4	14	79	2	22	83	4	13	96	5	13	97	10	15	56	513	7.40
12–14	2	27	119	5	26	92	4	15	90	8	28	96	5	23	105	645	9.30
14–16	9	25	107	4	25	113	5	20	116	7	26	107	6	20	96	686	9.90
16–18	7	41	198	10	45	186	8	44	192	16	49	168	14	21	151	1150	16.59
18–20	26	60	142	38	58	173	28	61	181	38	59	155	27	50	152	1248	18.00
20–22	11	35	64	21	42	75	12	37	73	20	37	77	15	20	68	607	8.76
22–24	9	24	52	9	26	50	19	17	42	18	20	63	19	26	55	449	6.48
Total	94	280	973	120	297	1,005	111	281	1,049	142	294	1,012	126	225	923	6,932	100

TABLE 6 | Pedestrian count regression model.

		Coefficients[a]									
Model		Unstandardized coefficients		Standardized coefficients	*t*	Sig.	Correlations			Collinearity statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	88.965	10.025		8.874	0.000					
	Trucks	0.001	0.000	0.673	2.571	0.033	0.673	0.673	0.673	1.000	1.000
2	(Constant)	109.027	10.625		10.262	0.000					
	Trucks	0.001	0.000	0.762	3.823	0.007	0.673	0.822	0.752	0.972	1.029
	Fuel Import	−3.791E-9	0.000	−0.534	−2.677	0.032	−0.406	−0.711	−0.526	0.972	1.029

[a]*Dependent Variable: Pedestrian Fatalities.*

TABLE 7 | Pedestrian fatalities/1,000 regression model.

		Coefficients[a]									
Model		Unstandardized coefficients		Standardized coefficients	*t*	Sig.	Correlations			Collinearity statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	−0.055	0.030		−1.870	0.098					
	Night Acc.	1.523E-5	0.000	0.800	3.775	0.005	0.800	0.800	0.800	1.000	1.000

[a]*Dependent Variable: Fat/1000.*

Action for Road Safety, 2011–2020, Botswana developed a National Road Safety Strategy (NRSS) 2011–2020, which was launched on the 16th of November 2013. The aim of the strategy was to improve road safety in general. Subsequently, some of the interventions that were put in place over the years to improve pedestrian safety on national roads include:

a) Construction of overpass pedestrian bridges on roads that have high traffic volume.
b) Designated marked pedestrian crossings, some of which are traffic signal controlled.
c) Installation of road signals to alert motorists that pedestrians are crossing.
d) Implementation of lower speed limits and speed bumps in built up areas where pedestrians are likely to cross the roads.
e) Road safety education done at schools to sensitize pupils on pedestrian safety.

Notably, a "Safer Roads to Schools" campaign themed 'Too Young to Die' was launched by a partnership of different stakeholders. The campaign intended to make it safer for kids to cross the roads through reduction of speed, particularly around schools. When the Department of Road Transport and Safety and its stakeholders reflected on the NRSS in 2018, the review revealed fragmentation of efforts and parallel programs that were not aligned to the strategy. Interventions were sporadic, uncoordinated and retrogressive (Aldayes and Mobrad, 2020), leading to a negligible impact. The insignificant effect on pedestrian accidents statistics at national level supports this view. However, an interview with the DRTS revealed that in 2018, a decision was made to integrate operations and align interventions at national level.

DISCUSSIONS

Whenever a conflict of movement that results in a collision between a pedestrian and a motorist occurs, it is almost certain that the pedestrian will emerge as the biggest loser. Morbidity and mortality suffered by these vulnerable road users should remain at the core of policy. To a greater degree in Botswana, drivers are more often than not culpable in pedestrian accident situations. This also begs the question, who should road safety interventions target—pedestrians or motorists? Our evidence shows that car as a vehicle type caused more pedestrian accidents and claimed more pedestrian lives than any other vehicle type. However, the most fatal vehicle types are lorry-with-trailer, bus and lorry. This may be explained by the size of these vehicles, which may increase their braking distance especially when moving at high speeds. Cars are mostly privately owned while the other vehicle types are business operated. Evidence from China, India and the USA demonstrates that building more road infrastructure and getting more cars on the roads only increases road traffic collisions and fatalities. Due to intensive commercial activity, trucks contribute significantly to fatalities especially on highways (Mohan et al., 2009). Our regression model shows the truck vehicle type as a significant explanatory variable to pedestrian fatalities. To reduce pedestrian accidents, road safety awareness should be created for drivers. The active participation of private businesses, especially logistics companies is recommended, more so that safer trucks will sustain their businesses. Driver training and driver road safety campaigns and interventions should emphasize pedestrian safety (Zhang et al., 2014).

A closer look at the pedestrian accident data in Botswana shows that the majority of pedestrian fatalities occur away from junctions, meaning that these collisions happen at high speed. Unfortunately, drivers also fail to comply with signalized pedestrian crossings. When the time of day is considered, only 3 out of the 12 intervals, representing 6 h of the day are problematic. These hours are commonly known as peak hours. The high prevalence of pedestrian accidents during these hours provides an opportunity for targeted interventions. Pedestrian road safety campaigns can be intensified during these hours. For example, partnerships with local radio stations can be forged to play road safety messages during these times (Aldayes and Mobrad, 2020). More importantly, a more rigorous profiling of these accidents should be undertaken. Vehicular object detection technologies should also be adopted. As much as it is important to empower the pedestrian to protect their own lives, invariably, road safety messages relating to their safety should also be shared with motorists. Pedestrian accidents interventions should take a multi-dimensional approach that involves, among others, policy, pedestrians, infrastructure design (Sarikhani et al., 2017). The third regression model we computed singles out the nighttime accidents to explain pedestrian fatalities. The use of reflective jackets (Bonnet et al., 2018) and brighter clothes, in general, should be encouraged for pedestrians who walk at night, while road lighting should be improved. However, there is need for caution. Marchant et al. (2020) found no improvement in road traffic collisions when streetlights were made brighter in the UK. Earlier studies by Jackett and Frith (2013) found a significant improvement in road safety when light was increased especially in poorly lit roads in New Zealand. The authors argue that there are thresholds, which is consistent with findings by Marchant and colleagues.

Botswana is weak on road traffic law enforcement. Despite having stricter road traffic laws, there has been negligible improvement in road safety (Mphela, 2011). While the reduction of posted speeds has led to improvements on pedestrian safety in other countries as reported by Fridman et al. (2020) and Marshall (2012), driver non-compliance remains a threat in Botswana. Improving law enforcement and nurturing driver compliance is ideal. Marshall (2012) notes that the mistake that was committed by the City of Denver was opening up the roads for higher speeds while leaving the traffic law enforcement division weakened. There is currently an intensive upgrade of road infrastructure along the main highways in Botswana cities, redesigning crossroads to minimize direct motor vehicle interactions and installation of new traffic signal equipment and camera systems. All these developments are built with easing of movement of cars in mind, with no plans to upgrade public transport systems and walkways. With the influx of gray imports mostly from Asia, car population will keep growing, exacerbating the situation (Mphela, 2020). It is clear that the conduct of policy is pro-auto use. The National Road Safety Strategy 2011 to 2020 of Botswana found that "land use policies allow major roads to run through high pedestrian areas" (Government of Botswana, 2011, p. 37), posing an immediate risk to pedestrians.

CONCLUSIONS

This study sought to investigate the occurrence, distribution, risk levels, and causes of pedestrian motor vehicle accidents and fatalities in Botswana. Literature across the continents of Africa, Europe, Asia, and America was reviewed and regression models computed that returned significant outputs. A number of possible solutions were advanced in the context of the evidence. Pedestrian accidents remain a major health problem globally. Unfortunately, Botswana's vulnerable road users are among the hardest hit. Cars are the largest, while the bicycle is the least contributor to pedestrian accidents and fatalities. Generally, motorists are mostly at fault. This provides compelling reasons for inclusion and emphasis on pedestrian safety in driver training curriculum. VRUs are most vulnerable during peak hours when conflict of movement is at its highest and during the night, when lighting is poor. However, pedestrian accidents are more prevalent in built-up areas and Gaborone, as the capital city, contributes almost half of the national pedestrian accident statistics. Intensifying road safety efforts, including the use of reflective jackets and improvement of lighting will lead to significant improvements in pedestrian safety. Previous and current efforts to curb pedestrian accidents have not led to any significant impact because they were not informed by the NRSS. Research on road traffic collisions is negligible, while quality useful research on road safety interventions is almost non-existent. There is need for countries to invest resources in meaningful research that will have greater impact on sustainability. Building more roads, while neglecting to integrate pedestrian road safety, is detrimental to sustainability efforts. Safer cities foster mode split. Road safety and sustainability are not mutually exclusive.

LIMITATIONS

The study represents the first effort on profiling road pedestrian accidents in Botswana, therefore, analysis is done at aggregate national level. This study would have gained more value from regional or local level analysis. Unfortunately, analysis at regional level in relation to population could not be undertaken because of misalignment between police districts and political administrative districts. Therefore, exact population could not be determined based on police districts. Future studies should comprehensively evaluate pedestrian road safety campaigns and interventions to determine their efficacy.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding authors.

AUTHOR CONTRIBUTIONS

TMp: conceptualized, drafted, and finalized the manuscript for submission. TMo: provided technical knowledge especially on pedestrian safety interventions and reviewed the manuscript for technical consistencies. KD: critically revised the manuscript for important intellectual content and final approval of the version to be published. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2021.666111/full#supplementary-material

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