Article

Pedestrian Neglect of Highway Footbridges and Safety Countermeasures: A Case Study from Ghana

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Abstract

In Africa, pedestrian deaths count for the majority of road traffic deaths, mainly resulting from bad crossing habits, including the neglect of footbridges. However, pedestrian behaviour remains understudied in Africa. In this article, we investigate the reasons for the non-use of footbridges along a major highway in Accra, Ghana, and test possible interventions. Using an intercept survey, we sampled 320 pedestrian violators by means of a questionnaire and structured interviews. Two decision trees were analysed using the chi-squared automatic interaction detection algorithm. The results indicated that men and students are more likely to disregard footbridges compared to other pedestrians. The length of the footbridge was cited as the main reason for non-compliance at designated crossings. Nonetheless, 93% of the respondents showed intentions to use the footbridges premised on some interventions. Pedestrian safety would be improved if shorter access points, adequate lighting and visibility are provided for footbridges and other road-crossing facilities. In this study, we propose countermeasures and reinforce the need for engineers and urban planners to carefully consider human behaviour in the design of urban road infrastructure.

Keywords: pedestrian safety; pedestrian-crossing behaviour; footbridge non-use; road-crossing structures; Ghana

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Introduction

In Africa, pedestrian deaths count for 40% of all road traffic deaths (World Health Organization, 2018). In Ghana, road-crash reports indicate that, between 2015 and 2019, there were 13 982 pedestrian crash casualties and 73.48% were as a result of bad road-crossing habits. The disregard for footbridges significantly accounts for this problem (Marisamynathan & Vedagiri, 2018; Ujjwal & Bandyopadhyaya, 2021). The ways in which to ensure the safety of pedestrians and to reduce footbridge non-use have therefore been of global concern (Rahimian, O'Neal, Zhou, Plumert, & Kearney, 2018).

The footbridge is an important safe road-crossing structure for pedestrians. However, there are many reports of pedestrians crossing the road without using footbridges. Past studies identified the location of the footbridge as one reason for its non-use (Oviedo-Trespalacios & Scott-Parker, 2017; Stefanova, Oviedo-Trespalacios, Freeman, Wullems, Rakotonirainy, Burkhardt, & Delhomme, 2018). Similarly, it has been identified that when pedestrians are in a hurry, the probability of ignoring the footbridge is high (Hasan, Oviedo-Trespalacios, & Napiah, 2020). Moreover, some pedestrians have voiced that they are less likely to use a footbridge if they perceive it as insecure (Dada, Zuidgeest, & Hess, 2019). Some pedestrians naturally fear the height of bridges or have some physical disabilities which affect their use of footbridges (Oviedo-Trespalacios & Scott-Parker, 2017). Interestingly, Truong, Nguyen, Nguyen and Vu (2019) realised that the higher the footbridge, the less likely it will be used. Poorly maintained street-crossing facilities such as fading paint marks, and missing barricades and pedestrian crossing marks can discourage the use of road-crossing facilities.

However, the literature has seen little research from sub-Saharan Africa regarding the reasons for non-use of footbridges, although they are common to many sub-Saharan African cities (Dada et al., 2019; Ojo, Appiah, Obiri-Yeboah, Adebanji, Donkor, & Mock, 2022). These studies involved pedestrians without focusing on the violators. It is, however, important to sample violators, ie non-users and seldom users for a better understanding of why they do not use footbridges. This will also help policymakers to make regulations for this category of road users. Between 2001 and 2020, the human development index (HDI) for Ghana increased by 1.32% and the current score is 0.63 (United Nations Development Programme [UNDP], 2020). It is expected that with this increase, perceived societal responsibility and safety attitudes would also increase. Given the high rate of pedestrian violations, it is important to do more empirical studies to help enhance safety tantamount to HDI growth.

In this article, we investigate the non-use of six footbridges along a major highway in Ghana, West Africa. We (1) investigate why pedestrians ignore the footbridges, (2) investigate the most plausible countermeasure from the pedestrians' perspective, and (3) recommend countermeasures to enhance usage.

Methodology

Preliminary Works and Data Collection

The study began with problem identification along the highway corridors using field enumerators and surveyors. All procedures were performed in compliance with the relevant laws. The on-site officers of the Ghana Highway Authority and the Motor Traffic and Transport Department were informed of the field investigation. On 30 October 2020, video observation of the footbridges, a headcount of pedestrians crossing the street, and a count of pedestrians crossing the footbridges were conducted. This covered the morning and afternoon peak hours (06:30–08:30 and 15:30–17:30). Overall, 72 600 pedestrians were counted during the four-hour observation at all footbridges: 46 680 (64%) crossed the street without using the footbridge (non-users/violators) and 25 920 (36%) used the footbridge when crossing the street. Subsequently, on 9 March 2021, surveyors measured the geometric dimensions of the footbridges (Appendix A) and the streets underneath. The geometric features of the footbridges were obtained (Table 1) and the respective study locations on the highway are shown in Figure 1. The street underneath has a lane width of 3 m. The average distance between the six footbridges on the highway is 743.2 m.

Table 1: Geometric attributes of the footbridges and the streets underneath

Footbridges and Streets Underneath	**MAF1**	**MAF2**	**MAF3**	**MAF4**	**MAF5**	**MAF6**	**Average**
Characteristics of the footbridge							
Length (m)	58.3	62.7	62	67.2	55.9	61.7	61.3
Width (m)	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Number of stairways	0	3	0	0	1	0	–
Number of disabled ramps	2	2	2	2	2	2	2
Number of risers per stairway	0	49	0	0	23	0	–
Length of disabled ramp (m)	135	140.1	139	144	163	145.3	144.4
Height (m)	8	8.6	8.7	8.6	8.6	8.9	8.6
Characteristics of street underneath							
Width of road lane (m)	3	3	3	3	3	3	3
Directions	2	4	2	2	3	3	3
Near intersection or not	No	Yes	No	No	Yes	Yes	Yes
Type of intersection	No	Cross	No	No	T	T	–
Number of lanes east	0	4	0	0	0	4	–
Number of lanes west	0	4	0	0	4	0	–
Number of lanes north	10	9	9	10	10	10	–
Number of lanes south	10	9	9	10	9	10	–
Traffic lights	No	Yes	No	No	Yes	Yes	3

Footbridges and Streets Underneath	MAF1	MAF2	MAF3	MAF4	MAF5	MAF6	Average
Distance to intersection(m)	0	67.7	0	0	72	204	–
Other characteristics							
Distance between footbridges (m)	Ref.	703	573	894	714	832	743.2

MAF = Madina-Adentan Footbridge; T = T-shaped intersection; Ref. = reference

Figure 1: A satellite image showing the footbridges along the highway

Questionnaire Design

It is noteworthy that during the preliminary field inspection, the majority of pedestrians (64%) did not use the footbridge. The purpose of this study was therefore to determine why the pedestrians were not using the footbridges. Consequently, regular users were excluded from the questionnaire design. This makes the context of our intercept study different from previous studies (Dada et al., 2019; Ojo et al., 2022).

The pedestrians who crossed the road at the street level without using the footbridges were categorised into two dichotomous groups: those who never used the footbridge (non-users) and those who used the footbridge irregularly (non-regular or seldom users). These two dependent variables were coded as seldom usage (0) and non-usage (1). Following previous studies (Hasan et al., 2020; Oviedo-Trespalacios & Scott-Parker, 2017; Stefanova et al., 2018; Truong et al., 2019), it was assumed that seldom usage and non-usage were dependent on the following independent variables: the location of the footbridges, the complexity of the design (length), habits of pedestrians, safety attitudes of pedestrians, regulation enforcement, time-saving element, the height of the footbridges, and the age, gender and occupation of pedestrians.

The questions posed to the participants required Yes (1) or No (0) answers, except for age, gender and occupation. Age was coded as below 18 (0), 18–29 (1), 30–45 (2), 46–59 (3) and 60 plus (4). Gender was coded as male (0) and female (1). Hasan et al. (2020) identified that when pedestrians are in hurry the probability of ignoring the footbridge is high. It should be noted that transportation is a derived demand. People go out for a purpose; this purpose therefore influences their time consciousness which in the long run can determine whether they use a footbridge or not. To incorporate this, the occupation of pedestrians was coded as formal sector (0), artisan (1), trader (2), truck pusher (3), and student (4).

The final part of the questionnaire consisted of questions about the possible interventions or countermeasures. We posed seven questions with Yes or No answers. The variables were enhanced comfort, shorter stairways, affixing CCTV cameras, fencing, public education, alerting posters or signposts, and imposition of monetary fines for violators. Examples of the questions include: "Would a shorter stairway encourage you to use the footbridge?" and "Would you use the footbridge if a CCTV camera is installed?" Yes and No were coded as 1 and 0 respectively on the interventions.

Data Collection

The intercept study was composed of two approaches: (1) a random interview of pedestrians who crossed the road at the road level without using the footbridge, and (2) a survey of pedestrians who either crossed the road at the road level without using the footbridges (non-users) or identified as non-regular users of the footbridges (seldom users). The random interviews involved 20 pedestrians who crossed the road at the road level. Interviews give a detailed understanding of road users' opinions which help to control their behaviours (Huemer & Vollrath, 2011).

For the intercept survey, five surveyors administered the questionnaire at both ends of the road where non-users were most likely to cross the road. These locations were selected since regular users were not our target group. The surveyors approached the respondents with greetings in the local dialect. The purpose of the intercept survey was then explained to them. They were told the ultimate purpose of the survey was to provide recommendations to city authorities on their problems regarding the footbridges. This way they were willing to cooperate with the surveyors. This technique was largely successful although some pedestrians did not cooperate with the surveyors. Overall, 330 responses were collected over three days out of which 320 were validated (ie had complete responses). Past studies used smaller samples (Hasan & Napiah, 2018; Razi, 2017); this sample size is therefore adequate for decision-making.

Data Analysis

The data set was divided into two types of respondent using the split data function in SPSS 24 to understand the various responses that came from seldom users and non-users. Next, two decision trees were analysed. A decision tree is a data and decision classifier that has a tree-like structure. It is a non-parametric data-analysis tool suitable for data sets such as ours in which normality and linearity are not always given (Hasan et al., 2020). It has been previously applied in traffic psychology studies (Bordarie, 2019; Li, Oviedo-Trespalacios, & Rakotonirainy, 2020). The author employed the chi-squared automatic interaction detection (CHAID algorithm (Kass, 1980) to break down the independent variables in the tree into statistically significant ones similar to past studies. The decision tree also breaks down the probabilities and outcomes of every decision among the proposed interventions.

Results

Characteristics of Participants

The survey realised 236 (74%) seldom users of the footbridge out of the 320 samples and 84 pedestrians who have never attempted to use the footbridge (Table 2). Regarding their socio-demographic features, 53% of the participants were between the ages of 18 and 29. Out of this, 121 participants (71%) confirmed to be seldom users whereas the rest have never used the footbridge. Also, some 22% of the participants were between 30 and 40 years old (78% are seldom users). Those below 18 constitute 21% and comprised 76% seldom users. Generally, among the age groupings, at least 70% of each category are seldom users. Notably, these pedestrians have no physical impairments constraining their use of the footbridges. There were 166 male participants (52%) and 154 female participants. This is similar to a previous study in Ghana in which 59.6% of non-users were male (Ojo et al., 2022). However, women were more likely to be seldom users (78%) as compared to men who were 70% seldom users.

Table 2: Categorisation of participants

Measures	**Variables**	**All of the Respondents (%)**	**Seldom Users (%)**	**Non-Users (%)**
Age	Below 18	67 (21)	51 (76)	16 (24)
	18–29	171 (53)	121 (71)	50 (29)
	30–45	69 (22)	54 (78)	15 (22)
	46–59	9 (3)	7 (78)	2 (22)
	60 plus	4 (1)	3 (75)	1 (25)
Gender	Male	166 (52)	116 (70)	38 (30)
	Female	154 (48)	120 (78)	46 (22)
Occupation	Formal sector	36 (11)	31 (86)	5 (14)
	Artisan	60 (19)	40 (67)	20 (33)
	Trader	104 (33)	75 (72)	29 (28)

Measures	Variables	All of the Respondents (%)	Seldom Users (%)	Non-Users (%)
	Truck pusher	4 (1)	3 (75)	1 (25)
	Student	116 (36)	87 (75)	29 (25)
Seldom user	Non-regular user	236 (74)	–	–
Non-user	Never used	84 (24)	–	–

The purpose of going to the roadside (occupation) is an important indicator of use intentions. The results indicated that the majority are students (116; 36%), of which 25% have never used the bridge. The next larger group is traders (104; 33%) of which 28% have never used the footbridge. Interestingly, this occupational category in the Ghanaian context is more likely to engage in daily roadside activities. This group comprises hawkers, roadside food vendors and other small-scale traders. Notably, the formal sector workers such as bankers, teachers and public servants only constituted 11% of the participants. Perhaps this is because they are more likely to cross the street at most twice a day, ie going to work in the morning and returning in the evening. However, they recorded the highest percentage of seldom users (86%). This suggests that with educational interventions, they may become regular users.

Participants' Reasons for Non-Use

There are various reasons for pedestrians' seldom or complete non-use of footbridges as presented in Table 3. For seldom users, the safety of the bridge, height, length and location were the topmost inhibitors to their usage. Conversely, non-users chose safety, habitual dislike for footbridges, the location, and a waste of time as their principal reasons for non-compliance.

Table 3: Overview of responses

Variables Reasons for Non-Use	Seldom Users		Non-Users	
	Yes (%)	No (%)	Yes (%)	No (%)
The location of the bridge is not good	167 (71)	69 (29)	58 (69)	26 (31)
The bridge is too long	171 (72)	65 (28)	51 (61)	33 (39)
I just do not like using footbridges	47 (20)	189 (80)	60 (71)	24 (29)
The bridge is not safe for me to use	209 (89)	27 (11)	70 (83)	14 (17)
I do not use it because there is weak regulation	162 (69)	74 (31)	47 (56)	37 (44)
I think crossing the bridge wastes my time	121 (51)	115 (49)	58 (61)	26 (31)
The height of the footbridge is not convenient for me	174 (74)	62 (26)	52 (62)	32 (38)

Figure 2 shows the significant contributors to non-use according to the decision-tree analysis. The tree comprises the root node (user type) and eight other nodes. The chi-square test identified habit, age, length of the footbridge and occupations as the significant factors that influence the frequency of use. Habit is the most likely cause (χ^2 = 73.861) showing just beneath the root node. On the left side are 213 participants who are habitually not anti-footbridge. Age was significant among non-users and seldom users of this category. On the right side are 107 participants who confirmed that they are anti-footbridges (habit). For this category, the length of the footbridge is the next important reason for non-use. Similarly, occupation was the next significant contributor to non-use.

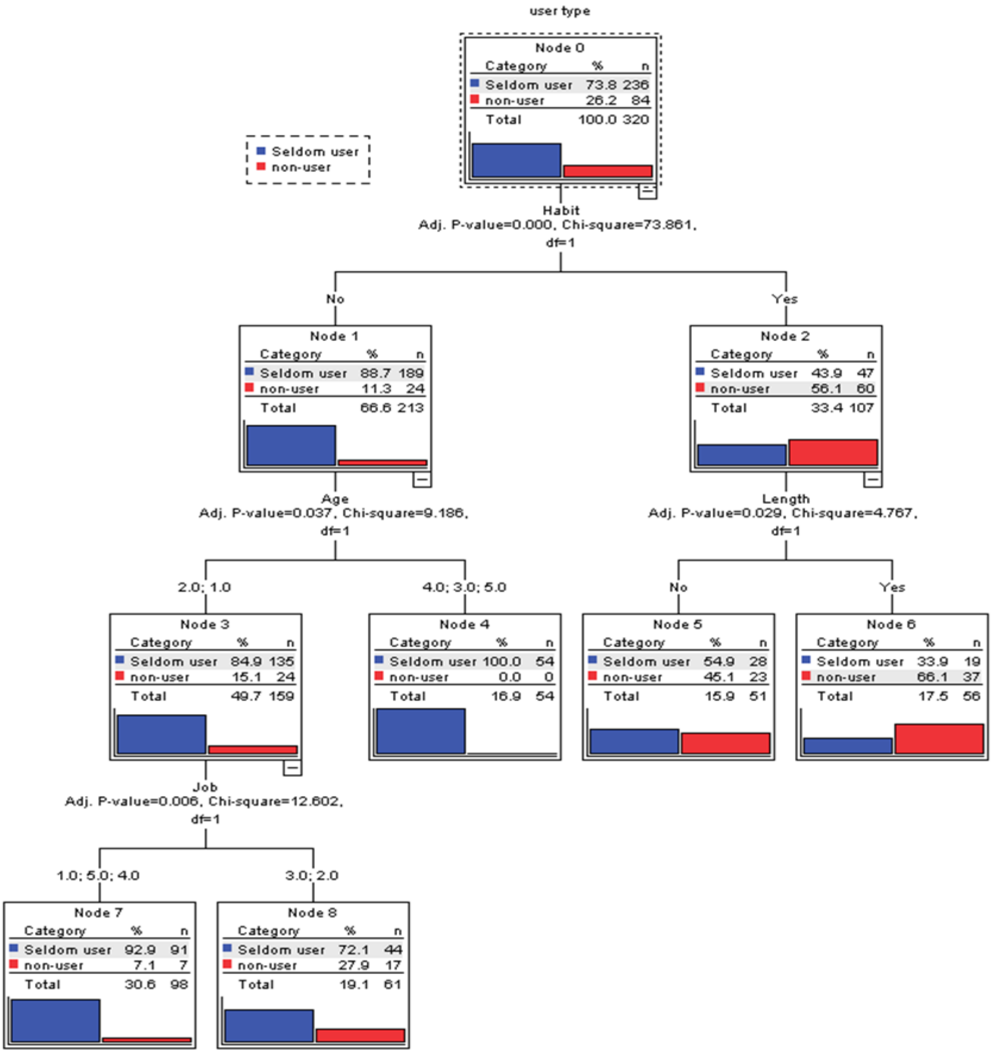

Figure 2: Decision tree showing the significant reasons for non-use of the footbridges

Decision Tree for Proposed Interventions

Table 4 presents the outcomes for both seldom users and non-users. The first question solicited responses to ascertain whether pedestrians will use the footbridges or not by merely seeing an attempt to implement a countermeasure. Approximately 219 seldom-user participants (93%) indicated that they would use the footbridge if they saw interventions. Similarly, 79 (94%) participants who have never used the footbridge showed positive intent to use it if they see interventions. This suggests there are strong intentions to use the footbridges when some interventions are implemented.

Table 4: Participants' responses to the proposed interventions

Variables **Usage Decisions**	**Seldom Users**		**Non-Users**	
	Yes (%)	**No (%)**	**Yes (%)**	**No (%)**
I will use the footbridge if certain measures are put in place	219 (93)	17 (7)	79 (94)	5 (6)
Shorter Access Point				
Would a shorter stairway encourage you to use the footbridge?	206 (87)	30 (13)	59 (70)	25 (30)
CCTV				
Would you use the footbridge if a CCTV camera is installed?	193 (82)	43 (18)	65 (77)	19 (23)
Fencing				
Would you use the footbridge if it is fenced?	211 (89)	25 (11)	67 (84)	17 (20)
Public Education				
Would more public education encourage you to use the footbridge?	222 (94)	14 (6)	75 (89)	9 (11)
Poster				
Would an alerting poster or signpost encourage you to use the footbridge?	200 (85)	36 (15)	64 (76)	20 (24)
Fines				
Would you use the footbridge if a fine is imposed for non-users?	211 (89)	25 (11)	70 (83)	14 (17)

To know which interventions the participants would prefer, the second decision tree (Figure 3) tested six interventions aimed at improving the use of the footbridges. The chi-square test indicated that only the provision of a shorter stairway has the potential of improving usage ($\chi^2 = 23.164$). If this measure is implemented, 265 respondents (about 82.8%) are likely to use the footbridge, with only 55 likely to remain non-compliant.

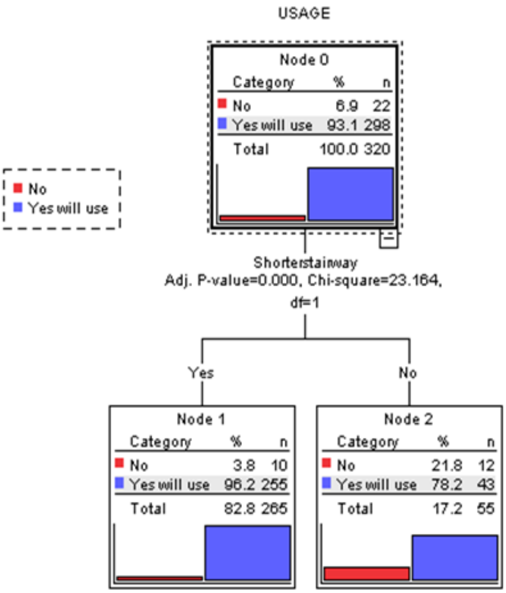

Figure 3: Decision tree showing the significant intervention to enhance usage

Outcomes of the Interviews

Structured interviews as validation tools were used to confirm some of our main findings. The 20 pedestrians who were interviewed gave their reasons for non-use, transcribed as follows:

> The footbridge is too long, especially the stairway. Also, because it is closer to the market, most of us carry loads on our heads and would prefer crossing by the street because it is shorter and easier. It takes a few minutes to cross at the street level compared to using the bridge. We prefer to wait for five minutes by the street to cross at the onset of the red light. Further, it takes much energy to use the footbridge due to the height and length. People of old age cannot climb it. Besides, there are reports of theft cases on the footbridge during night-time. The lighting is poor at night, which makes it unsafe to use it after 9 p.m. This also discourages usage. We also feel the distance between the footbridges is too long. If we want to cross the road to buy something from a shop across the street, we need to walk very far to access the footbridge. This takes too much effort.

Shorter stairs, cases of theft and lighting challenges were expressed by some of the interviewees. The participants gave some propositions on interventions aimed at dealing with such major concerns as follows:

> Authorities should provide shorter stairs for us since it takes too much energy to climb the stairs. They should strictly deny pedestrians from crossing the street by installing high wire mesh at the road median of the street. The police must strictly enforce

> restrictions. Police presence in the daytime and patrols in the night-time will curb theft cases and increase usage. We also want better lighting at night.

Discussion

Intriguing outcomes have been found in the present study that investigated the non-use of six pedestrian footbridges in Ghana. The study adds to the literature on safe mobility in the Global South including Ghana's urbanised areas. It is found that pedestrians who always ignore the studied footbridges confirmed having a dislike towards footbridges. This extends the findings of past studies in the Honduras (Landa-Blanco & Ávila, 2020), Canada (Cambon de Lavalette, Tijus, Poitrenaud, Leproux, Bergeron, & Thouez, 2009) and Turkey (Räsänen, Lajunen, Alticafarbay, & Aydin, 2007) which reported that the non-use of footbridges was habitual. However, in the present study, it is not a significant reason attributed to non-use among seldom users. This emphasises the present study's novel data-collection approach that excluded regular users from the sample.

General public education on the health benefits of walking and the advantages of footbridges could encourage usage (Barajas, Beck, Cooper, Lopez, & Reynosa, 2019). Public education can also mitigate issues about the length of the footbridge. Notably, these findings relate specifically to the access points of the footbridge and the time it takes a pedestrian to cross (Anciaes & Jones, 2018; Razi, 2017; Shaaban, Muley, & Mohammed, 2021). As indicated in the methodological section, only two out of the six footbridges have stairways. The other four footbridges are accessible only by disabled ramps, which have an average length of 144.4 metres. The participants perceive that even those with stairway access have too long stairways; pedestrians have to climb 49 steps for a single stairway. The decision trees show that the best approach to entice usage is the construction of shorter stairways. This was equally voiced in the pedestrian interviews. The first option is to provide an escalator as proposed in studies from Malaysia and Turkey (Hasan et al., 2020; Räsänen et al., 2007). However, in Ghana, investments in outdoor escalators seem impossible given the costs involved. The second option is to provide wooden or concrete access points to augment the current stairways and ramps. Admittedly, this would need more engineering evaluations of the structures. Although the disabled ramps are long, they may be useful for people with physical disabilities.

Specifically for the four footbridges without stairways, we recommend an immediate structural evaluation to provide extra access points. Some footbridge guidelines recommend that for a single-flight stairway of a footbridge, the number of steps should be at most 13 (Highways England, 2020). Furthermore, the participants voiced the average distance between the footbridges (743.2 m) as a reason for non-use. Residents who live about 400 to 500 m to the footbridges along the streets must walk a very far distance before they can access a footbridge to cross the highway. The general implication is that footbridge construction in urban areas should have simple but effective designs that would encourage usage.

In addition, the age of a pedestrian and the purpose of travel (occupation) have a strong link with the non-use of the footbridge (Kim & Ulfarsson, 2019). These findings relate to the location of the bridges and the load or luggage a pedestrian carries. The participants criticised the location of the footbridges. Perhaps positioning a footbridge at intersections, rather than a few metres from intersections, could solve this problem. In some modern designs in countries such as China, a spherical-shaped footbridge is provided at intersections. Similar to the issues on the length of the footbridges, the position of the bridges and diversification of crossings (both underpasses and overpasses) are therefore imperative. These implications apply to other road infrastructure for active mobility.

Lighting conditions and visibility are very important for road-crossing facilities, especially when there is a history of theft at night-time, as reported in the interviews. It is prudent to provide some streetlights for all the footbridges to enhance the safety and easy mobility of pedestrians. The provision of adequate lighting at those designated crossings is a significant requirement. Some studies found that the lack of lighting of road infrastructure contributes to pedestrian violations (Joewono, Vandebona, & Susilo, 2015; Kwayu, Kwigizile, & Oh, 2019). CCTV installations can augment lighting by providing more visibility to protect pedestrians, especially at night-time. To enforce these measures, the traffic police can strictly prohibit pedestrians from crossing the street with the use of posters; however, more public education is needed here. Currently, the road median has no barricade so pedestrians can cross at any section of the road. The participants proposed using a wire mesh to partition the road median as a physical impediment to the illicit crossing. Although this idea has merit, we recommend the planting of ornamental plants at the road median consistent with the importance of greening road medians that recent publications have emphasised (Black, Tara, & Pakzad, 2016; Herawaty & Shirly, 2017; Im, 2019). This would not only impede pedestrian illicit crossing but would also beautify the highway and provide other environmental benefits. It takes less than two years for these plants to fill the median, after which the public can enjoy the fruitage of these plantations.

Conclusion

In this article, we used the intercept methodology and the CHAID algorithm to investigate the non-usage of six pedestrian footbridges along the Madina-Adentan stretch of Ghana’s N4 highway. Growing pedestrian collisions and fatalities at crossings in most African cities necessitated the current study to investigate attitudes towards road crossings and the use of structures to aid urban planning and improve pedestrian safety. The study is also beneficial to safety institutions and urban planners as it provides commonalities and differences among pedestrian groups and interventions relevant to Africa.

Men and students were more likely to be non-users compared to other groups of road users. This is because of typically higher aggression and risk-taking behaviours recorded among these groups. The main reasons for non-use were the length of the footbridge, personal dislike of footbridges, age and occupation of the road user as the common travel purpose. Other reasons ascertained from the interviews were poor lighting in the evening, the distance between the footbridges and the weak enforcement of usage by relevant authorities, including the traffic police. To enhance usage, the most significant intervention is to provide shorter stairways for enhanced access. Positioning the footbridge at intersections, improving the design engineering, and diversifying crossings are also imperative. Other recommendations include the installation of streetlights for all of the footbridges, the installation of CCTV, growing horticultural plants at the road median, and public education campaigns by leading authorities. However, the routine maintenance of footbridges must be prioritised, given Ghana's poor records in facility management. Fortunately, 93% of the pedestrians showed positive switching intentions towards usage premised on interventions. Also, the pro-footbridges group maintained positive attitudes towards compliance and was more likely to continue using these pedestrian-crossing structures.

The study has some limitations regarding the sample size and this potentially affects the generalisation of our findings. Intercept surveys by their nature are difficult to administer because they do not have pre-solicited appointments. The participants, therefore, do so willingly and in accordance with their schedules. This makes it difficult to get large sample sizes, however, our final sample size was comparatively representative. In the future, country-by-country comparisons will be necessary given the high rate of pedestrian mortalities in Africa. Also, engineers and urban planners can research solutions to making urban mobility safer in locations with high violations.

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Appendix A1: Footbridges and Their Coordinates

(a) Firestone bus stop (812946/627661)

(b) Madina Zongo Junction (813161/628329)

(c) Madina Royco (813362/628863)

(d) Adenta Assemblies (813298/629749)

(e) Adenta SDA (813289/630459)

(f) West Africa Senior High School (813326/631286)