Pedestrian risk perception of marked and unmarked crosswalks in Kumasi, Ghana

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ABSTRACT

Pedestrians constitute the majority of all urban road crashes in Ghana, yet there is inadequate supply of pedestrian facilities, and road-user behaviours have been cited as a major contributing factor to the high crash rates. This study seeks to investigate how pedestrians perceive risk at different crosswalks. The study adopted a mixed-method approach, where secondary crash data for 30 selected crosswalks was correlated with corresponding primary data that consisted of pedestrian surveys. The crash data from 2011 through 2014 was obtained from the database of the Building and Road Research Institute of the Council for Scientific and Industrial Research (CSIR-BRRI) in Kumasi, and supplemented with a survey of 900 pedestrians. The results revealed that pedestrians perceived marked crosswalks to be safer than unmarked crosswalks, but this is contrary to the crash records. Also, most of the crashes were registered for crosswalks located across multilane highways. In light of these results, it is recommended that the safety features of crosswalks be re-examined, while restricting indiscriminate crossing by channelling pedestrians to designated protected crossing points, installing traffic control devices and other speed-calming devices at identified high-risk crosswalks, and signalising crosswalks that are located on multilane roads. It is also recommended to intensify road safety campaigns and public education on safe road-crossing practices, while enforcing traffic safety laws to influence road-user behaviours.

Keywords: risk perception, pedestrian safety, crosswalks, mid-block, zebra crossing, stated preferences

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INTRODUCTION

Road-traffic injuries are a leading cause of death throughout the world, causing over 1.35 million fatalities annually (World Health Organization, 2018), with some 90% of these deaths occurring in low- and middle-income countries, which account for only 50% of motor vehicles in the world (World Bank, 2017). African countries particularly record a disproportionate number of the fatalities relative to their lower levels of motorisation, with nearly 44% of the deaths involving pedestrians and cyclists (World Health Organization, 2018). Traffic injury has been a public health problem, and also a development issue with economic consequences, because the younger, working-age population is disproportionately affected (World Bank, 2017). Considering the unacceptably high rates of road-traffic fatalities and their negative economic impacts, especially in low- and middle-income countries, the United Nations, in a 2010 resolution, declared the period from 2011 to 2020 as the Decade of Action for road safety, and singled out "changing road user behaviour" as a critical component of the holistic safe systems approach to achieving their road safety goals (World Health Organization, 2015). The focus on road-user behaviour underscores the significant role that human factors play in road safety.

In Ghana, like many African countries, urban commuters depend largely on public transport due to relatively low levels of private auto ownership (Kumar, Kwakye, & Girma, 2004; Salifu, 2004b; Kumar & Barrett, 2008). The proliferation of informal public transport and unplanned pick-up/drop-off points scattered throughout the cities mean that many urban dwellers must walk and, in many cases, cross several streets, roads, and even motorways as part of their daily travel. This generates large volumes of pedestrians that are exposed to vehicular traffic. The result is a high number of pedestrian crashes, which account for some 46% of all traffic fatalities in Ghana (Afukaar, Antwi, & Ofosu-Amaah, 2003). A 2010 safety study in Ghana found that pedestrians are involved in about 60% of all urban road crashes in Ghana and that 70% of pedestrian fatalities occurred at roadway crossings (Damsere-Derry, Ebel, Mock, Afukaar, & Donkor, 2010). Ackaah and Adonteng (2011) found that children (aged 15 years and below) and the elderly (above 55 years) are over-represented in pedestrian fatalities in Ghana, with inadequate provision of pedestrian facilities in road designs, excessive vehicular speeds and night-time conspicuity being identified as primary contributing factors to these deaths. Failure to comply with posted speed limits has led to the construction of many speed humps in settlement areas, as part of efforts to reduce pedestrian fatalities in the country. Additionally, numerous state-sponsored road safety campaigns and educational programmes have been carried out over the years to improve road-user behaviours in Ghana. For instance, a road-crossing education programme has recently been organised by the National Road Safety Authority, in collaboration with other stakeholders, to educate school children on safe road-crossing practices (Vivo Energy Ghana, 2019). Nevertheless, the high rate of pedestrian casualties that still prevail in Ghanaian cities calls for continued research for a better understanding of the problem. Previous traffic safety studies in Ghana have addressed various aspects of the problem (Salifu, 1993; Afukaar et al., 2003; Damsere-Derry et al., 2010; Obeng, 2013; Ojo, Adetona, Agyemang, & Afukaar, 2019). However, none of these studies has compared pedestrian safety at marked and unmarked crosswalks.

Pedestrian risk-taking behaviour at a crosswalk may be influenced by their perception of the safety of the facility. A pedestrian that perceives the crosswalk as a safe pedestrian right-of-way may be willing to take more risk, while a pedestrian who perceives the crossing to be dangerous may be more cautious when crossing. This means that a false perception of the safety of pedestrian crossing facilities can have fatal consequences. The objective of this study, therefore, was to investigate how pedestrians perceive the safety of different crosswalks in Kumasi, Ghana. A mixed-method approach was adopted in the study, where crash data for some selected crosswalks was correlated with pedestrian surveys carried out at those same crosswalks. This approach can help to understand how pedestrian perceptions of risk can contribute to crash occurrences and injury severity at crosswalks. Ultimately, the findings of the study can be used to inform decision-making in the design and provision of pedestrian crosswalks in a way that meets the expectations of pedestrians, to derive the optimum safety benefits. Furthermore, the findings will help in targeted road-user education and safety campaigns, to influence road-user attitudes towards pedestrian safety.

PREVIOUS WORKS

Human factors account for over 90% of road-traffic crashes (Treat, Tumbas, McDonald, Shinar, Hume, & Meyer, 1977; Singh, 2015; United States Department of Transportation, 2017) – hence, changing road-user behaviours and risk perceptions is paramount to mitigating crashes. Changing pedestrian behaviour could be a critical factor in reducing pedestrian fatalities. Lund and Rundmo (2009) argued that it is possible to change the attitudes of people by influencing their risk perceptions, because attitudes, risk perception and behaviour are all related to each other. They defined risk perception as "the subjective assessment of the probability of experiencing a negative event" such that the traffic risk perception of a pedestrian relates to being struck and injured (or killed) by a vehicle. While studying driver behaviour in Iran, Habibi, Haghi and Maracy (2014) observed that a driver's risk-taking behaviour can be a significant factor that influenced crash occurrence. By extension, it can be argued that a pedestrian's risk-taking behaviour could be an important contributing factor in crashes involving at-fault pedestrians. Risk perception may be influenced by a variety of factors, including sub-regional characteristics like safety culture. For instance, Lund and Rundmo (2009) observed that culture contributes to major differences between Ghanaian and Norwegian road users in the perception of risks like traffic safety risks. This implies that road safety countermeasures need to be designed to account for location-specific dynamics, such as cultural differences, general perceptions of risk, and other regional factors that may be drivers of risky road-user behaviours. Indeed, it is well documented that understanding localised and cultural influences is essential to a Safe System approach to reducing the occurrence and severity of road crashes (e.g., Adanu, Penmetsa, Wood, & Jones, 2019)

Pedestrian injury has been a global safety concern for many years (Di Stasi, Megías, Cándido, & Maldonado, 2015), and the 40% pedestrian fatality rate in Africa (Odero, Khayesi, & Heda, 2003; Chen, 2010) is exceptionally high when compared with the 15% rate on US roads (National Highway Traffic Safety Administration, 2015). The pedestrian safety problem in Africa is more of an urban, and invariably a developmental, problem (Damsere-Derry et al., 2010; World Bank, 2017). Like in other parts of the world, pedestrian safety in Africa, and indeed road safety in general, has a socioeconomic dimension that must be understood as part of efforts to reduce traffic fatalities. Chimba, Kutela, Ogletree, Horne, and Tugwell (2014) observed that poverty and its associated dependency on walking and public transit has caused African American and Latino populations in America to be overly exposed to the risk factors and thus disproportionately represented in pedestrian crashes compared to their Caucasian counterparts. A similar phenomenon is observed in many parts of Africa, where endemic poverty forces many people to walk in mostly unregulated mixed traffic conditions. In fact, the relationship between exposure to road crashes and poverty in Africa has been described as a matter of social justice (Azestop, 2010). The large presence of pedestrians in the midst of rising vehicular activities in cities raise the exposure rates – hence the high pedestrian safety risks (Zegeer & Bushell, 2012). Also, unsafe pedestrian behaviours such as the improper crossing of roadways, inattentiveness and failure to obey traffic signs and regulations can significantly increase the crash risk for pedestrians, and the mere addition of a crosswalk may not be enough to influence pedestrian crossing behaviour (Zegeer, Stewart, Huang, & Lagerwey, 2002).

Various risky road-user behaviours that contribute to high traffic crash rates and pedestrian casualties in Ghana have been identified. Drivers' reluctance to yield at zebra crossings and alcohol impairment, especially among truck drivers and private car drivers, have been identified as significant risky behaviours (National Road Safety Commission, 2012). Pedestrian non-compliance at zebra crossings, wearing headphones, talking on a cellphone, eating, drinking, smoking or talking while crossing the street, and jaywalking, night-time walking, street hawking and pedestrian alcohol impairment have also been identified as risky pedestrian behaviours that significantly affect pedestrian crash rates and severity (Damsere et al., 2010; Ojo et al., 2019). Herrero-Fernández, Macía-Guerrero, Silvano-Chaparro, Merino, & Jenchura (2016) argued that "risky pedestrian behaviour is associated with risk perception and acceptable risk" and this varies across population groups. The profiles of pedestrian crash victims are found to differ by age and gender (Campbell, Zegeer, Huang, & Cynecki, 2004; Obeng, 2013). In a household survey carried out in Dar es Salaam, Tanzania, it was observed that both males and females have a strong perception that traffic injuries are the result of driver recklessness and drunk driving (Astrom, 2006). By assigning the causal responsibility of crashes to drivers, it is quite possible for pedestrians to be more cognisant of driver behaviours while crossing the road. Indeed, Tom and Granié (2011) found that there are differences in the gaze patterns of the genders before and during crossing. The study observed that while women focused on other pedestrians, men focused on the vehicles.

A number of safety research works have focused on pedestrian behaviours and preferences in relation to roadway features. For instance, Berhanu (2004) documented the positive effects of a range of pedestrian facilities on crash frequency and severity in Addis Ababa, while Anciaes and Jones (2018) estimated pedestrian preferences for different types of crossing facilities in three English cities. Sisiopiku and Akin (2003) also carried out an observational study of pedestrian behaviours at different types of urban crosswalks, where they found that unsignalised midblock crosswalks were the preferred crossing points, and that pedestrians showed high levels of compliance at such crossings. An examination of historic crash data provides information on crash frequency, severity, and other direct crash characteristics that are recorded at the scene of the crash. This information does not, however, include indirect factors like road-user perceptions that contributed to the crash, hence limiting a full understanding of the nature of safety problems (Kononov, Allery, & Znamenacek, 2007). Meanwhile, pedestrians often have to make trade-offs between safety and convenience before crossing the road and this largely depends on their risk perceptions (Sharples & Fletcher, 2001; Rankavat & Tiwari, 2016). Often, pedestrians looking for more direct and quickest routes, are willing to take the extra risk of crossing at unapproved locations, instead of walking a little further to a designated crossing point (Demiroz, Onelcin, & Alver, 2015). Proximity of the crossing to the pedestrian's origin and destination, the presence of functioning traffic control, vegetation and concrete barriers were found to have positive effects on pedestrian safety, by restraining pedestrians and channelling them to cross at designated crossing points (Sisiopiku & Akin, 2003). A wide range of methods have been used to study pedestrian road-crossing behaviour, including: experiments (Granié, Brenac, Montel, Millot, & Coquelet, 2014), GIS analysis (Lassarre et al., 2012), pedestrian tracking, self-completed questionnaires (Bernhoft & Carstensen, 2008), video surveys (Sisiopiku & Akin, 2003) and personal interviews (Guo et al., 2014). In this study, a mixed approach was adopted to understand the relationship between pedestrian risk perceptions of crosswalks and the historical crash records of those crosswalks.

METHOD

STUDY AREA

The study was carried out in Kumasi, the second largest city in Ghana. The city is centrally located between the southern and northern regions of the country, so it is an important centre for commercial and industrial activities. The roads are mostly two-lane roads with a few multilane arterials with raised medians. Marked crosswalks are dotted across the metropolitan area, serving as designated crossing points, but many of the markings are faded almost beyond recognition, and some of these can virtually be considered as unmarked. Three speed categories are broadly used in Ghana: 100 km/h on expressways, 80 km/h on intercity highways and 50 km/h in settlements, so many of the roads in Kumasi fall under the 50 km/h speed limit. Figures 1 and 2 provide illustrative examples of typical crosswalks in the study area. Figure 1 shows a 4-lane divided urban facility with a marked zebra crossing, and this is the major form of crosswalk marking in the city. The raised medians serve as refuge for pedestrians to wait and find acceptable gaps in the opposing traffic stream. Figure 2 shows the picture of a faded crosswalk, and these are also common in the city.

Figure 1. Median Serving as a Refuge

Figure 2. Faded Marked Crossing

As shown in Figure 3 below, a few of the crosswalks are signalised, and some are also fitted with traffic-calming measures like speed ramps, as shown in Figure 4. However, the crosswalks in this study do not have any controls.

Figure 3. Signalised Crosswalk

Figure 4. Marked Crossing with Speed Ramps

THE KUMASI CRASH DATA

A mixed-method approach was adopted in the study, where secondary crash data for 30 crosswalks were correlated with primary data obtained from pedestrian surveys that were carried out at the selected crosswalks.

The pedestrian crash data was obtained from the National Road Traffic Crash Database at the Building and Road Research Institute of the Council for Scientific and Industrial Research (CSIR-BRRI) in Kumasi, for the period 2011 to 2014. The crash data from the CSIR-BRRI is compiled from police reports, and the database is subject to some level of under-reporting resulting from non-reporting (where the crash is not reported to the police and so not included in the official statistics) and under-recording (not all the data can be retrieved from the police). The level of under-reporting of road-traffic crashes has been studied in Ghana (Salifu & Ackaah, 2011), but has not been accounted for in this study, as this study focuses more on factors contributing to pedestrian crashes, rather than overall national statistics. Thirty pedestrian crash locations were selected across the city for this study, based on exposure and utilisation, as represented by high pedestrian and vehicular traffic volumes. The sites included eight residential, three industrial and nineteen mixed land uses. Fourteen of the sites were unmarked, sixteen were marked, and a total of 2 359 pedestrian crashes were recorded for all 30 sites over the four-year period. Most of the land development in Ghanaian cities does not conform to any strict zoning laws, so most of the study sites were rather classified as mixed land use, consisting of a mix of commercial and residential units.

PEDESTRIAN SURVEY AND FIELD MEASUREMENTS

Thirty (30) pedestrians were interviewed at each of the 30 selected crossing points, to obtain their views on safety through a structured questionnaire interview that was administered by trained enumerators. The pedestrians were asked to rate their perceived safety when crossing the road, using a five-point scale ranging from very unsafe to unsafe, neutral, safe and very safe. The crosswalk type was indicated as marked or unmarked, and the gender, age, trip purpose and frequency were all recorded for each response. Respondents were randomly selected after crossing the roads and were given the questionnaires or assisted in filling them in after reading the informed consent. Any pedestrian that crossed the road was selected for the interview, as long as the interviewer was free to proceed. When pedestrians crossed as a group, only one respondent was selected from the group to avoid group bias, because they still interacted while filling out the forms. No efforts were made to limit the investigation to any particular demographic group like age, gender, income, etc. Instead, pedestrians were sampled based on their willingness to be interviewed, provided they confirmed that they were 18 years or older. Respondents below the age of 18 were only interviewed if they were accompanied by an adult. A total of 900 pedestrians were interviewed. For a population of over 100 000 and research designed to provide a precision level of at least ±5% on the estimates at a 95% confidence level and 0.5 degree of variability, a minimum sample of 400 is adequate (MaCorr Research Solutions, 2013). Other field measurements included the weather and geometric characteristics at the interview locations, to identify other factors that may correlate with high crash frequencies. The roadway data included lane width, median width and type, number of lanes and shoulder width. The weather and environmental data included the time of day and weather. Vehicle spot speeds were also recorded using radar guns, to verify vehicle speed-limit compliance for the crosswalk locations.

Descriptive statistics of the historic crash data and the field survey were carried out to understand the features of the data. Pearson correlation was conducted to understand the relationship between crash factors and the severity of pedestrian injuries. Additionally, Chi-Square tests were conducted to understand the associations between pedestrians' safety perceptions of the crosswalks, and the pedestrians' demographics, travel characteristics, and crosswalk characteristics.

RESULTS

ANALYSIS OF CRASH DATA

Detailed records of individual crash observations could not be obtained for the study, so aggregate crash records for each of the sites were pooled together in Table 1. As shown in the table, nearly 34% of the traffic crashes on the study roads involved pedestrians. This is a lower proportion than the 60% pedestrian crashes reported in Damsere-Derry et al. (2010), and the 46% pedestrian casualties reported by Afukaar, Antwi, & Ofosu-Amaah (2003). About a third of these crashes resulted in fatalities and 54% led to serious injuries. Fifty-eight percent (58%) of the casualties were males and 42% were females. The age group from 16 years to 45 years were involved in 69% of the crashes, and the single age group mostly affected was the group of 16 to 30 years, accounting for 42% of the crashes.

Table 1: Descriptive Crash Statistics

Variables	Proportion
Pedestrian crashes	0.34
Pedestrian victim gender: Males/Females	0.58/0.42
Pedestrian victim age: 1-15/16-30/31-45/46-60/60 or more	0.16/0.42/0.27/0.09/0.06
Pedestrian action: No action/Crossing road/Walking along road/Walking along edge/On footpath/Other	0.11/0.57/0.11/0.02/0.03/0.16
Injury severity: Fatal/Serious/Slight	0.27/0.54/0.19
Median type: Unmarked/Marked/Raised	0.03/0.23/0.75
Crosswalk location: Residential/Mixed land use/Industrial	0.267/0.633/0.1
Crosswalk marking: Marked/Unmarked	0.53/0.47
Average length of crosswalks (m)	7.52
Average width of crosswalks (m)	4.99
Crosswalks located on divided highways	0.833
Average shoulder width (m)	2.15
Lighting conditions: Day: clear / Night – no light /	0.65/0.21/0.03/0.10

Night – light off / Night – light on	
Median type: Marked/Raised/Unmarked	0.267/0.700/0.003
Intersection type: Midblock/Signalised/Unsignalised	0.833/0.067/0.100
Speed ramps present/Posted speed present	0.067/0.1
Crashes by day of week: Sun/Mon/Tue/Wed/Thu/Fri/Sat	0.13/0.16/0.13/0.10/0.15/0.17/0.15
Average pedestrian volume at crosswalk	931
Vehicle involved in crash: Car/Bus/HGV/Minibus/Pickup/Motorcycle/Tractor	0.47/0.04/0.07/0.21/0.04/0.15/0.02

About 57% of all pedestrian crashes occurred while the pedestrian was crossing the road, either at an approved crosswalk or jaywalking. This compares with 60% reported in Damsere-Derry et al. (2010). For all crashes that occurred at crosswalks, 53% occurred at marked crosswalks and 47% occurred at unmarked crosswalks. Also, 70% of crashes occurred on roads that have raised medians, and 65% of the crashes occurred in broad day light. Forty-seven percent (47%) of these were caused by cars and 21% by minibuses, which are informal public transport vehicles, locally known as “trotro”. The analysis of the data in Table 1 shows that 6% more crashes occurred on the marked crosswalks than on the unmarked crosswalks. The difference is even higher for fatal crashes, as shown in Figure 5, because about 60% of the fatal midblock crashes occurred at marked crosswalks.

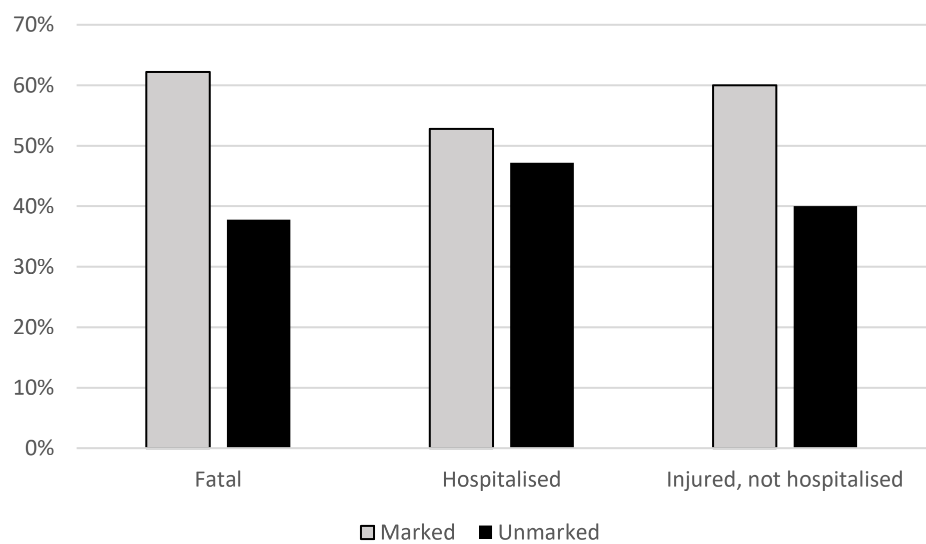

Figure 5: Crash Severity by Midblock Crosswalk Type

Further, 60% of the non-hospitalised crashes (i.e. less severe crashes) also occurred at marked crosswalks, an indication that marked crosswalks are much more dangerous than unmarked crosswalks, as these locations experienced most of the crashes. Considering median types, more crashes occurred on roads with raised medians, as shown in Table 1. Those roads are arterials that pass through mixed land-use areas, with heavy pedestrian activities. Also from Table 1, it is clear that industrial and residential land-use areas recorded lower numbers of pedestrian crashes, but crashes occurring in residential areas were more likely to be fatal. About 80% of all pedestrian crashes occurred at midblock crosswalks, indicating that intersections were relatively safer for pedestrians. However, crashes that occurred at unsignalised intersections were more likely to be fatal.

ANALYSIS OF FIELD STUDIES

Table 2 gives a description of the interview statistics and further descriptions are given in Figures 6 to 8. There were 394 males among the respondents and 506 females. With regard to age, 124 of the respondents were under 18 years, 179 were 18-25 years, 332 were 26-35 years, 242 were 35-59 years and 22 were 65 years or older. A total of 46% of respondents considered the crosswalks to be unsafe, while 19% thought they were very unsafe. So, together, 65% of the respondents had a perception of unsafe crosswalks. About 13 of the responses were neutral.

Table 2: Descriptive Statistics for Pedestrian Interviews

Variables	**Proportion**
Safety perception: Safe/Neutral/Unsafe	0.22/0.13/0.65
Unsafe: Males/Females	0.66/0.64
Safe: Males/Females	0.22/0.21
Neutral: Males/Females	0.12/0.15
Unsafe: Under 18/18-25/26-35/36-59/60 or more	0.50/0.65/0.70/0.67/0.55
Safe: Under 18/18-25/26-35/36-59/60 or more	0.33/0.22/0.20/0.17/0.23
Neutral: Under 18/18-25/26-35/36-59/60 or more	0.28/0.13/0.10/0.14/0.23

The neutral option was given in the interview to have a leeway for respondents who just could not form any opinion on their safety perception, in order to lessen the number of erroneous responses. There were 17 marked crosswalks and 13 unmarked crosswalks that were studied, and Figure 6 shows their average utilisation.

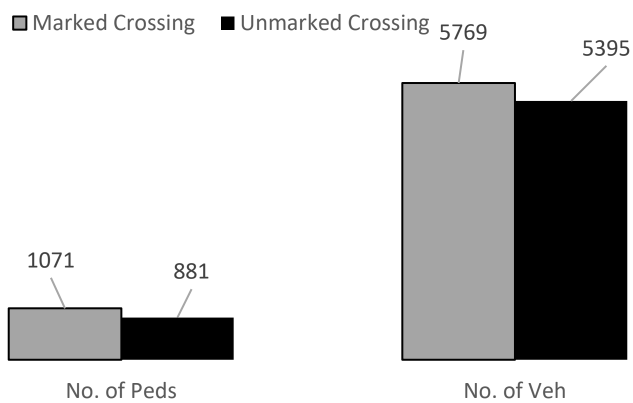

Figure 6: Pedestrians and Vehicles per Crosswalk

The average number of pedestrians was similar for both marked and unmarked crosswalks, and so was the average traffic volume across the two categories of crosswalks, implying that the rate of utilisation was similar for both crosswalk categories. The pedestrian exposure rates were also similar for both facilities, as it can be observed from Figure 6 that there were 5.4 vehicles/pedestrian on the marked crosswalks and 6.1 vehicles/pedestrian on the unmarked crosswalks. That is to say that, on average, a pedestrian crossing any of the marked crosswalks would be exposed to 5.4 vehicles, while a pedestrian crossing an unmarked crosswalk would be exposed to 6.1 vehicles. So, both crosswalk types had similar usage and similar exposure rates. Still, most of the respondents had the perception that unmarked crosswalks were more unsafe than marked crosswalks. The data analysis show that about 58% of the respondents perceived marked crosswalks to be unsafe (Figure 7), while 91% perceived unmarked crosswalks to be unsafe.

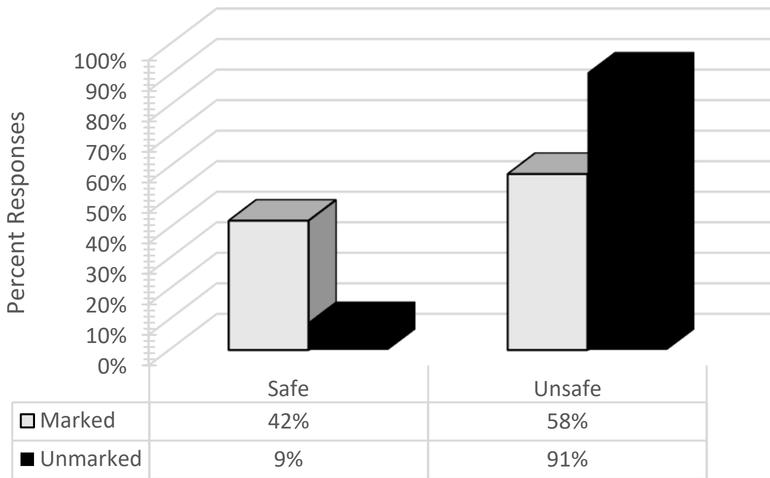

Figure 7: Safety Perception by Crosswalk Type

Spot speeds measured at the study locations showed a wide range, with a minimum speed of 22 km/h and a maximum speed of 83 km/h. The mean spot speed was 52 km/h, which is around the posted speed limit of 50 km/h on the roads, but nearly 30% of the vehicles were speeding over 10 km/h above the posted speed limit, thus making the roads unsafe for pedestrians.

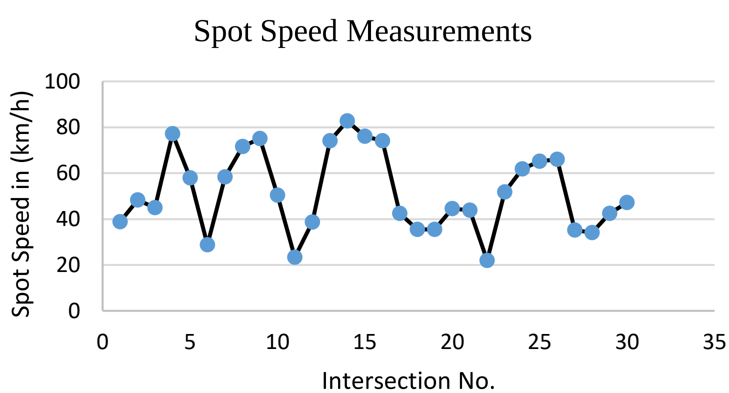

Figure 8: Spot Speed Measurements

STATISTICAL ANALYSIS

Table 3 shows Pearson correlations between the severity of pedestrian injuries and different crash factors. Due to the limited number of crosswalks selected for this study, most of the correlation coefficients were not statistically significant. However, the signs (positive or negative) of the coefficients provide interesting findings.

Table 3: Correlation of Crash Factors and Pedestrian Injury Severity (p-values in parenthesis)

Variable	Category	Fatal injury	Serious injury	Minor injury
Causal vehicle type	Car	-0.213 (0.259)	0.201 (0.287)	0.003 (0.989)
	HGV	0.558 (0.001)	-0.343 (0.064)	-0.228 (0.226)
	Tractor	0.225 (0.231)	-0.183 (0.334)	-0.039 (0.838)
	Bus	0.001 (0.995)	0.155 (0.413)	-0.188 (0.321)
	Minibus	-0.195 (0.302)	0.174 (0.358)	0.014 (0.9415)
	Motorcycle	-0.142 (0.454)	-0.095 (0.618)	0.277 (0.138)
	Pickup	-0.098 (0.606)	-0.166 (0.381)	0.312 (0.093)
Pedestrian action	No action	0.132 (0.487)	0.107 (0.574)	-0.281 (0.133)
	Crossing road	0.219 (0.245)	0.112 (0.556)	-0.387 (0.035)
	Walking on road	-0.242 (0.198)	-0.044 (0.817)	0.331 (0.074)
	Walking along edge	-0.268 (0.152)	0.114 (0.549)	0.171 (0.366)
	On footpath	-0.054 (0.777)	-0.012 (0.950)	0.076 (0.690)
Lighting conditions	Daylight	0.111 (0.559)	-0.135 (0.477)	0.034 (0.858)
	Night – no lights	0.001 (0.996)	-0.095 (0.618)	0.113 (0.552)

	Night – lights off	-0.054 (0.777)	0.095 (0.618)	-0.052 (0.785)
	Night – lights on	-0.122 (0.521)	0.260 (0.165)	-0.172 (0.363)
Geometric features	Crosswalk length	-0.015 (0.937)	0.101 (0.595)	-0.104 (0.584)
	Shoulder width	0.036 (0.850)	0.069 (0.717)	-0.125 (0.510)

For instance, crashes involving Heavy Goods Vehicles (HGVs), tractors, and buses resulted in more fatalities than those involving cars, minibuses, and motorcycles. Crashes involving pedestrians who were crossing the roads and those in which the pedestrian performed no action (i.e., was stationary) were more likely to be fatal. Also, crashes that occurred during daylight and at night where there were no street lights, were more associated with fatal injury. Increased length of the crosswalk had a negative correlation with fatalities while shoulder width was found to be positively correlated with fatal injury.

Table 4: Crosswalk Characteristics and Pedestrian Injury Severity

Variable	**Category**	**Fatal injury**	**Serious injury**	**Minor injury**	**p-value**
Crosswalk location	Industrial area	1 (2.2%)	10 (11.2%)	3 (10.0%)	0.029*
	Mixed land use	25 (55.6%)	61 (68.5%)	22 (73.3%)	
	Residential	19 (42.2%)	18 (20.2%)	5 (16.7%)	
Crosswalk type	Marked	28 (62.2%)	47 (52.8%)	18 (60.0%)	0.538
	Unmarked	17 (37.8%)	42 (47.2%)	12 (40.0%)	
Divided highway	Yes	40 (88.9%)	73 (82.0%)	27 (90.0%)	0.415
	No	5 (11.1%)	16 (18.0%)	3 (10.0%)	

Intersection type	Mid-block	38 (84.4%)	71 (79.8%)	23 (76.7%)	0.866
	Unsignalised (T-junction)	4 (8.9%)	8 (9.0%)	4 (13.3%)	
	Signalised (T-junction)	3 (6.7%)	10 (11.2%)	3 (10.0%)	
Lighting	Lighted	33 (73.3%)	60 (67.4%)	20 (66.7%)	0.750
	Not lighted	12 (26.7%)	29 (32.6%)	10 (33.3%)	
Median type	Marked	9 (20.0%)	20 (22.5%)	4 (13.3%)	0.740
	Raised median	35 (77.8%)	67 (75.3%)	26 (86.7%)	
	Unmarked	1 (2.2%)	2 (2.2%)	0 (0.0%)	
Number of lanes	One	7 (15.6%)	26 (29.2%)	10 (33.3%)	0.401
	Two	35 (77.8%)	58 (65.2%)	19 (63.3%)	
	Three	3 (6.7%)	5 (5.6%)	1 (3.3%)	

Tables 4 presents the results of the Chi-Square analysis of the associations between crosswalk characteristics and the severity of crashes. The results show that the only variable that has a significant relationship with injury severity is crosswalk location [χ^2(4, N = 164) = 10.81, p < 0.05]. No significant association was found for injury outcomes and crosswalk type, highway type, intersection type, lighting conditions, median type, and the number of lanes. The results of the Chi-Square test for pedestrian safety perceptions and pedestrian demographics and travel characteristics, and safety perceptions and crosswalk characteristics are presented in Tables 5 and 6, respectively.

Table 5: Pedestrian Safety Perceptions of The Selected Crosswalks

Variable	Category	Pedestrian safety perception			p-value
		Safe	Neutral	Unsafe	
Age of responder	< 18	41 (21.2%)	21 (17.5%)	62 (10.6%)	0.004*

	18-25	39 (20.2%)	23 (19.2%)	117 (19.9%)	
	26-35	66 (34.2%)	34 (28.3%)	233 (39.7%)	
	36-59	42 (21.8%)	37 (30.8%)	163 (27.8%)	
	>59	5 (2.6%)	5 (4.2%)	12 (2.0%)	
Gender of responder	Female	83 (43.0%)	58 (48.3%)	253 (43.1%)	0.558
	Male	110 (57.0%)	62 (51.7%)	334 (56.9%)	
Other mode of travel	None	61 (31.6%)	34 (28.3%)	142 (24.2%)	0.038*
	Bicycle	0 (0.0%)	0 (0.0%)	2 (0.3%)	
	Bus	0 (0.0%)	2 (1.7%)	4 (0.7%)	
	Drop off by friend's car	0 (0.0%)	2 (1.7%)	4 (0.7%)	
	Own Car	3 (1.6%)	4 (3.3%)	6 (1.0%)	
	Taxi	10 (5.2%)	5 (4.2%)	61 (10.4%)	
	Trotro	119 (61.7%)	73 (60.8%)	368 (62.7%)	
Trip distance	Less than a mile	92 (47.7%)	42 (35.0%)	254 (43.3%)	0.115
	1 mile-2 miles	67 (34.7%)	55 (45.8%)	248 (42.2%)	
	2 miles-5 miles	34 (17.6%)	23 (19.2%)	85 (14.5%)	
Use of crosswalk in a week	Once	21 (10.9%)	12 (10.0%)	70 (11.9%)	0.871
	Twice	13 (6.7%)	11 (9.2%)	34 (5.8%)	
	3 times	14 (7.3%)	6 (5.0%)	42 (7.2%)	
	4 times	19 (9.8%)	18 (15.0%)	76 (12.9%)	

	6 times	30 (15.5%)	16 (13.3%)	91 (15.5%)	
	7 times or more	96 49.7%)	57 (47.5%)	274 (46.7%)	
Trip purpose	Leisure	3 (1.6%)	3 (2.5%)	14 (2.4%)	0.000*
	School	51 (26.4%)	28 (23.3%)	62 (10.6%)	
	Shopping	14 (7.3%)	9 (7.5%)	49 (8.3%)	
	Work	120 (62.2%)	77 (64.2%)	452 (77.0%)	
	Worship	5 (2.6%)	3 (2.5%)	10 (1.7%)	

* Significant at 95% confidence level

From Table 5, a significant association is observed between perception of crosswalk safety and:

- the respondent's age [χ^2(10, N = 900) = 25.90, $p < 0.05$],
- respondents who used other modes of transport to complete the trip [χ^2(12, N = 164) = 21.93, $p < 0.05$], and
- the purpose of the respondent's trip [χ^2(8, N = 900) = 35.67, $p < 0.05$].

These findings show that younger and older pedestrians perceive the safety of the crosswalks differently. Similarly, those who complete their entire trip on foot and those who use the crosswalks to cross to the other side in order to use other transport modes, perceive the safety of the crosswalks differently. Also, it was found that the purpose of the pedestrian's trip had a significant effect on how they perceived the safety of the crosswalks they use. The safety perception of crosswalks did not significantly differ based on respondent gender, trip distance, and number of times they use the particular crosswalk in a week. While the reasons behind these observed associations are not obvious, it is possible that the risk perceptions of pedestrians who use the crosswalks more frequently and have done so for a longer period of time, were influenced by their experiences. For instance, pedestrians who have used the crosswalks for a longer time and have not witnessed any negative outcomes are more likely to rate those crosswalks as safe, irrespective of the crosswalk characteristics and conditions. With respect to crosswalk characteristics, there is significant relationship between respondents' safety perception and:

- the number of pedestrian crashes previously recorded at the crosswalk [χ^2(4, N = 900) = 34.30, $p < 0.05$],

- the crosswalk type [$\chi^2(2, N = 900) = 134.94, p < 0.05$],
- the crosswalk location [$\chi^2(4, N = 900) = 18.98, p < 0.05$], and
- the intersection type [$\chi^2(4, N = 900) = 31.50, p < 0.05$].

No significant association was found between the respondents' perception of safety and crosswalk lighting conditions, the median type, and whether the highway is divided or not.

DISCUSSION

The results from the crash data and field surveys are discussed here to draw similarities and differences where they exist. The pedestrian survey data showed that marked and unmarked crosswalks had similar rates of utilisation and exposure, and the perception among pedestrians was that unmarked crosswalks were more dangerous than marked crosswalks. However, this perception is contrary to the crash data, which shows that not only did more crashes occur on marked crosswalks, but more fatal crashes occurred at the marked crosswalks, making marked crosswalks more dangerous than unmarked crosswalks. In fact, 53% of the crashes were recorded on marked crosswalks, compared to 47% on unmarked crosswalks. This is consistent with the existing literature which shows that most pedestrian crashes in Ghana, including the most fatal ones, occur at zebra crossings (Ojo et al. 2019). Another study published in the *American Medical Association Journal* concluded that marked crosswalks increase the risk of pedestrian collisions with vehicular traffic (Koepsell, Lon, Marsha, Anne, David, Jess, & Matthew, 2002). Meanwhile, Chu (2004) also confirmed the assertion that pedestrians have a false sense of security when crossing the road at unsignalised, marked crosswalks (Chu, 2004).

This study has shown that pedestrians in the age bracket from 16 to 30 years suffered the most casualties, and crosswalks located on roads with raised medians accounted for 70% of pedestrian crashes over the study period. These are multilane urban arterials with normally moderate to high traffic volumes and speeds. It would be expected that the raised medians could serve as refuge zones for pedestrians and promote safety, but the results showed otherwise. The study also supports earlier research findings that pedestrian crashes in Ghana can be attributed to excessive speed (Damsere-Derry et al. 2010). The results provide evidence for the reasoning that pedestrian crosswalks on divided roads should be signalised (Olszewski et al., 2015). The posted speed limits for these urban facilities is 50 km/h, but the measured spot speeds from all the study sites showed a wide range from 22 km/h to 83 km/h. It is important to note that Kumasi serves as transit point for most vehicles travelling between southern Ghana and northern Ghana, and the main arterial highway passes through the city. This necessitates high speeds and high traffic volumes on the divided multilane corridor that was included in the study. Incidentally, this highway corridor passes through heavily populated neighbourhoods with substantial commercial activities. Many studies from different countries have identified speed as one of the most significant factors that influence crash frequency and severity (Damsere-Derry, Afukaar, Donkor, & Mock, 2007; World Health Organization, 2018). In a study of vehicle speeds in Ghana, average speeds of 87 km/h were measured in built-up areas along the Accra-Kumasi highway (Damsere-Derry et al., 2007), and these speeds were found to be 57% higher than the posted speed limits. Meanwhile, research has shown that "reducing speed by a few km/h can greatly reduce the risk of and severity of crashes" (International Transport Forum, 2018). Roadway lighting conditions affect the visibility of both drivers and pedestrians (Beyer & Ker, 2009; Wanvik, 2009), and the existing research also shows that poor lighting conditions significantly increases the severity of crashes (Salifu, 2004a; Wang, Haque, Chin & Goh, 2013). However, the results of this study show that the majority of the pedestrian crashes occurred in broad day light. The fact that most of the pedestrian crashes at the crosswalks happened in daylight perhaps contributed to the insignificant association between crosswalk lighting and safety perception.

CONCLUSIONS AND RECOMMENDATIONS

The objective of this study was to investigate how pedestrians in Kumasi perceive crosswalk safety. The findings of this study indicate a clear disconnect between pedestrian perception and the crash reality. While pedestrians considered unmarked crosswalks to be more dangerous, the crash records showed that marked crosswalks were more dangerous for pedestrians. While the majority of the fatal crashes occurred at marked crosswalks, most of the crashes that occurred at unmarked crosswalks were less severe, though one can conclude from this study that both marked and unmarked unsignalised crosswalks are unsafe crossing points for pedestrians.

The findings in this study provide a good background for the evidence-based implementation of pedestrian crash countermeasures at the selected crosswalks in the Kumasi metropolis, and lessons learned from this study may be extended to other locations with similar characteristics in Ghana. The need to re-examine the safety features of crosswalks and to redesign them to accommodate the high pedestrian volumes in the metropolis has the potential to reduce pedestrian crashes and fatalities. Restricting indiscriminate crossing by channelling pedestrians to designated protected crossing points may lead to improved safety outcomes. Where appropriate, traffic control devices and other speed-calming devices can be installed at identified high-risk crosswalks to regulate the flow of traffic at those locations. The signalisation of crosswalks that are located on multilane roads could potentially yield significant pedestrian safety benefits. It is also important to intensify road safety campaigns and public education on safe road-crossing practices, while enforcing traffic safety laws to influence road-user behaviours, particularly considering that many of the pedestrians who were interviewed viewed some high-risk crosswalks to be safe.

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REFERENCES

Ackaah, W., & Adonteng, D. O. (2011). Analysis of fatal road traffic crashes in Ghana. *International Journal of Injury Control and Safety Promotion*, *18*(1), 21-27.

Adanu, E., Penmetsa, P., Wood, D., & Jones, S. (2019). Incorporating Systems Thinking Approach in a Multilevel Framework for Human-Centered Crash Analysis. *Transportation Research Interdisciplinary Perspectives*, *2*, 100031.

Afukaar, F., Antwi, P., & Ofosu-Amaah, A. (2003). Pattern of Road Injuries in Ghana: Implications for Control. *International Journal of Safety Promotion 10* (2003), 69-76.

Ameratunga, S., Hijar M., & Norton R. (2006). Road-traffic injuries: confronting disparities to address a global-health problem. *Lancet, 367,* 1533-40.

Anciaes, P. R., & Jones, P. (2018). Estimating preferences for different types of pedestrian crossing facilities. *Transportation Research Part F*, *52*, 222-237.

Astrom, J. S. (2006). Signatures of four generations of road safety planning. *Journal of Eastern African Research and Development*, *l20*, 186-201.

Azestop, J. (2010). Social justice approach to road safety in Kenya: Addressing uneven distribution of road traffic injuries and deaths across population groups. *Public Health Ethics, 3*(2), 114-127.

Berhanu, G. (2004). Models relating traffic safety with road environment and traffic flows on arterial roads in Addis Ababa. *Accident Analysis and Prevention, 36*, 697-704.

Bernhoft, I. M., & Carstensen, G. (2008). Preferences and behavior of pedestrians and cyclists by age and gender. *Transportation Research Part F*, *11*, 83-95.

Beyer, F. R., & Ker, K. (2009). Street lighting for preventing road traffic injuries. *Cochrane Database of Systematic Reviews, 1*(1). doi:10.1002/14651858.CD004728.pub2

Campbell, B. J., Zegeer, C. V., Huang, H. H., & Cynecki, M. J. (2004). *A review of pedestrian safety research in the United States and abroad*. US Department of Transportation, Federal Highway Administration, Publication no. FHWA-RD-03-042.

Chen, G. (2010). Road traffic safety in African Countries – status, trend, contributing factors, countermeasures and challenges. *International Journal of Injury Control and Safety Promotion*, *17*, 247-255.

Chimba, D., Kutela, B., Ogletree, G., Horne, F., & Tugwell, M. (2014). Impact of abandoned and disabled vehicles on freeway incident duration. *Journal of Transportation Research*, *50*, 109-116.

Chu, X. (2004). A reality-based approach to stated-preference surveys. Paper submitted to the Transportation Research Board Annual Meeting, Washington D.C.

Damsere-Derry, J., Afukaar, F., Donkor, P., & Mock, C. (2007). Study of vehicle speeds on a major highway in Ghana: Implication for monitoring and control. *Traffic Injury Prevention*, *8*(2), 142-146, doi:10.1080/15389580601100944

Damsere-Derry, J., Ebel, B. E., Mock, C. N., Afukaar, F., & Donkor, P. (2010). Pedestrian injury patterns in Ghana. *Accident Analysis and Prevention*, *42*(4): 1080-1088.

Demiroz, Y. I., Onelcin, P., & Alver, Y. (2015). Illegal road crossing behavior of pedestrians at overpass locations: Factors affecting gap acceptance, crossing times and overpass use. *Accident Analysis and Prevention*, *80*, 220-228.

Di Stasi, L. L., Megías, A., Cándido, A., & Maldonado, A. (2015). The influence of traffic signal solutions on self-reported road-crossing behavior. *The Spanish Journal of Psychology*, *17*(103), 1-7. doi.org/10.1017/sjp.2014.105

Granié, M.-A., Brenac, T., Montel, M.-C., Millot, M., & Coquelet, C. (2014). Influence of built environment on pedestrian's crossing decision. *Accident Analysis and Prevention*, *67*, 75-85.

Guo, H., Zhao, F., Wang, W., Zhou, Y., Zhang, Y., & Wets, G. (2014). Modeling the perceptions and preferences of pedestrians on crossing facilities. *Discrete Dynamics in Nature and Society, 2014*, 1-8. Retrieved from https://www.hindawi.com/journals/ddns/2014/949475/.

Habibi, E., Haghi, A., & Maracy, M. R. (2014). Investigating the predictive of risk-taking attitudes and behaviors among Iranian drivers. *Journal of Education and Health Promotion*, *3*, 19. doi:10.4103/2277-9531.127599

Herrero-Fernández, D., Macía-Guerrero, P., Silvano-Chaparro, L., Merino, L., & Jenchura, E. C. (2016). Risky behaviour in young adult pedestrians: Personality determinants, correlates with risk perception, and gender differences. *Transportation Research Part F: Traffic Psychology and Behavior, 36*, 14-24.

International Transport Forum/OECD. (2018). *Speed and crash risk*. Paris: OECD Publishing. Retrieved from: https://www.itf-oecd.org/sites/default/files/docs/speed-crash-risk.pdf.

Koepsell, T., Lon, M., Marsha, W., Anne V. M., David, B., Jess, K. & Matthew, P. (2002), Crosswalk markings and the risk of pedestrian-motor vehicle collisions in older pedestrians. *Journal of American Medical Association, 17*, 2136-2143.

Kononov, J., Allery, B., & Znamenacek, Z. (2007) Safety planning study of urban freeways: proposed methodology and review of case history. *Transportation Research Record*: *Journal of the Transportation Research Board, No. 2019*, 146-155.

Kumar, A., & Barrett, F. (2008). Stuck in traffic: Urban transport in Africa. Africa Infrastructure Country Diagnostic, World Bank, pp. 1-85.

Kumar, A., Kwakye E. A., & Girma, Z. (2004). What works in private provision of bus transport services – case study of Accra and Addis Ababa. Cooperation for Urban Mobility in the Developing World (CODATU), pp. 1-13. Retrieved from https://www.codatu.org/wp-content/uploads/What-works-in-private-provision-of-bus-transport-services-case-study-of-Accra-and-Addis-Ababa-A.-KUMAR-E.A.-KWAKYE-Z.-GIRMA.pdf.

Lassarre, S., Bonnet, E., Bodin, F., Papadimitriou, E., Yannis, G., & Golias, J. (2012). A GIS-based methodology for identifying pedestrians crossing patterns. *Computers, Environment & Urban Systems, 36*(4), 321-330.

Lund, O. I., & Rundmo, T. (2009). Cross-cultural comparisons of traffic safety, risk perception, attitudes and behavior. *Safety Science*, *47*(4), 547-553.

MaCorr Research Solutions. (2013). Sample size methodology and optimization for market research surveys, MaCorr Research. Retrieved from http://www.macorr.com/sample-size-methodology.htm.

National Highway Traffic Safety Administration. (2015). Traffic safety facts: Summary of motor vehicle crashes. Revised February 2020. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=2ahUKEwj9-43fr6fpAhWimuAKHZ0tDd0QFjABegQIChAD&url=https%3A%2F%2Fcrashstats.nhtsa.dot.gov%2FApi%2FPublic%2FViewPublication%2F812376&usg=AOvVaw0zewC5MYJyiwZO5T9V2j6S.

National Road Safety Commission. (2012). A study to determine the magnitude of driving under the influence of alcohol and its impact on road safety in Ghana. Ministry of Transport Final Report. Retrieved from http://www.nrsc.gov.gh/images/ publications/NRSC_PUBLICATION.pdf.

Obeng, D. A. (2013). Characteristics of pedestrian accidents on trunk roads in Ghana. *International Journal of Engineering and Science, 5*, 46-54.

Odero, W., Khayesi, M., & Heda, P. M. (2003). Road traffic injuries in Kenya: magnitude, causes and status of intervention. *International Journal of Injury Control and Safety Promotion*, *10*(1-2), 53-61.

Ojo, T., Adetona, C. O., Agyemang, W., Afukaar, F. K. (2019). Pedestrian risky behavior and safety at zebra crossings in a Ghanaian metropolitan area. *Traffic Injury Prevention*, *20*(1), 1-4. doi: 10.1080/15389588.2018.1555372.

Olszewski, P., Szagala, P., Wolanski, M., & Zielinska, A. (2015). Pedestrian fatality risk in accidents at unsignalised zebra crosswalks in Poland. *Accident Analysis and Prevention*, *84*, 83–91.

Rankavat, S., & Tiwari, G. (2016). Pedestrians perceptions for utilization of pedestrian facilities – Delhi, India. *Transportation Research F, 42*(3), 495-499.

Salifu, M. (1993). Bicycle safety: sustaining mobility and environment. *International Association of Traffic and Safety Sciences Research*, *17*(2*)*, 60-66.

Salifu, M. (2004a). Accident prediction models for unsignalised urban junctions in Ghana. *International Association of Traffic and Safety Science (IATSS) Research*, *28*(1), 68-81.

Salifu, M. (2004b). Transport deregulation and sustainability of the urban bus transit initiative in Ghana, CODATU XI: World congress: Towards more attractive urban transportation.

Salifu, M., & Ackaah, W. (2011). Under-reporting of road traffic crash data in Ghana. *International Journal of Injury Control and Safety Promotion*, *19*(4), 331-339.

Sharples, J. M., & Fletcher, J. P. (2001). Pedestrian perceptions of road crossing facilities. Edinburgh: Scottish Executive Central Research Unit. Retrieved from www.gov.scot/resource/doc/156816/0042173.pdf.

Singh, S. (2015). Critical reasons for crashes investigated in the National Motor Vehicle Crash Causation Survey (Traffic Safety Facts Crash, Stats. Report No. DOT HS 812 115). Washington, DC: National Highway Traffic Safety Administration.

Sisiopiku, V. P., & Akin, D. (2003). Pedestrian behaviors at and perceptions towards various pedestrian facilities: an examination based on observation and survey data. *Transportation Research Part F*, *6*(4), 249-274. Retrieved from http://dx.doi.org/10.1016/j.trf.2003.06.001.

Tom, A., & Granié, M. A. (2011). Gender differences in pedestrian rule compliance and visual search at signalized and unsignalized crossroads. *Accident Analysis and Prevention*, *43*(5), 1794-801. doi: 10.1016/j.aap.2011.04.012

Treat, J. R., Tumbas, N. S., McDonald, S. T., Shinar, D., Hume, R. D., & Mayer, R. E. (1977). *Tri-level study of the causes of traffic accidents*. US Department of Transportation (Technical volume 1). Bloomingdale, IN: Institute for Research in Public Safety.

United States Department of Transportation. (2017). Automated Driving Systems 2.0: A vision for safety (Publication DOT HS 812 442). Washington DC. Retrieved from https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/ 13069a-ads2.0_090617_v9a_tag.pdf.

Van Houten, R., & Malenfant, J. E. L. (2004). Effects of a driver enforcement program on yielding to pedestrians. *Journal of Applied Behavior Analysis, 37*, 351-363.

Vivo Energy Ghana. (2019). Vivo Energy leads road safety education in basic schools. *Business Ghana* news item. Retrieved from https://www.businessghana.com/site/news /general /197560/Vivo-Energy-Leads-Road-Safety-Education-in-Basic-schools.

Wang, Y. Y., Haque, M. M., Chin, H. C., & Goh, Y. J. (2013). Injury severity of pedestrian crashes in Singapore. *Australasian Transport Research Forum 2013 Proceedings*, vol. 8.

Wanvik, A. (2009). Effects of road lighting: an analysis based on Dutch accident statistics1987–2006. *Accident Analysis & Prevention*, *41*(1),123-128.

World Bank. (2017). *The high toll of traffic injuries: Unacceptable and preventable*. Washington, DC: Word Bank. Retrieved from https://www.worldbank.org/en/programs/global-road-safety-facility/publication/the-high-toll-of-traffic-injuries-unacceptable-and-preventable.

World Health Organization. (2015). *Global status report on road safety*. Geneva: World Health Organization. Retrieved from www.who.int/violence_injury_prevention/road_safety_status/2015/en.

World Health Organization. (2018). *Global status report on road safety*. Geneva: World Health Organization. Retrieved from www.who.int/violence_injury_prevention /road_safety_status/2018/en/.

Zegeer, C. V., & Bushell, M. (2012). Pedestrian crash trends and potential countermeasures from around the world. *Accident Analysis and Prevention*, *44*, 3-11.

Zegeer, C. V., Stewart, R. J., Huang, H. H., & Lagerwey, P. A. (2002). Safety effects of marked vs. unmarked crosswalks at uncontrolled locations: Executive summary and recommended guidelines (FHWA-RD-01-075). Retrieved from https://rosap.ntl.bts.gov/view/dot/15480.