

Effect of Physical Street Characteristics on the Safety of Child Pedestrians in Kawangware Ward

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Abstract

Streets are known as the veins of a city. With the growth of cities, emphasis is moving from building large roads to creating streets that support quality places (NACTO, 2016). Child pedestrians from deprived areas such as informal settlements are particularly at risk (Clarke & Draisin, 2023). This study sought to establish whether there is a relationship between the physical characteristics of the streets of an area and the safety of school-going child pedestrians and was undertaken in Kawangware ward, Nairobi City County in Kenya. Data was collected by use of standardized questionnaires and an observation checklist. The questionnaires were issued to a sample of teachers and guardians representing children while the observation checklist was used to collect data on the physical characteristics of Gitanga street in Kawangware. Quantitative analyses were applied and it was found that not only do physical characteristics affect safety, but some are more critical to safety than others.

Keywords

Physical Street Characteristics, Safety, Child-Pedestrians

1. Introduction

Streets are known as the veins of a city. With the growth of cities, emphasis is moving from building large roads to creating streets that support quality places (NACTO, 2016). Physical street characteristics, described as the distribution of features that are visible and can be touched (Wang et al., 2022), are crucial in determining the quality of a place. Such characteristics include street width, street furniture, pedestrian infrastructure such as sidewalks, traffic calming infrastructure and street material.

Together with other challenges, traffic violence and inequity within cities should be addressed in the design of streets, prioritizing safety and liveability as opposed to the traditional design for car use (NACTO, 2016). Safety on roads is a key consideration in the Sustainable Development goals. This has been occasioned by the increase in road traffic deaths around the globe.

Road traffic deaths globally were estimated at 1.19 million in the year 2021 and remain the leading killer of children and youth aged 5 to 29 years (WHO, 2023a). Pedestrians, and cyclists account for more than half of these deaths (WHO, 2023a).

In Africa, the number of road traffic deaths recorded in the year 2023 shows an increase of 17% since the year 2010 compared to the decrease of road traffic deaths in the European region during the same period of time (WHO, 2023b). Pedestrian road traffic deaths account for 27% of the total deaths in Africa while at the same time, most of the total population are pedestrians (WHO, 2023b). Albeit all this, African countries and other middle and low-income countries continue to build systems of mobility for vehicles with little to no regard for people or safety (WHO, 2023b).

In Kenya, reported road traffic fatalities have been on an upward trend, with 2022 having a record 4690 deaths and 21,757 casualties (NTSA, 2023). Of these fatalities, pedestrians were noted as one of the most vulnerable groups, accounting for 35% of these deaths (NTSA, 2023).

In the city of Nairobi particularly, 2.27 million trips are made by walking every day (Odhiambo, 2021). Despite the large population of pedestrians, Nairobi's Street and road development has largely been centered on motorized transport with little to no investment in non-motorized transport infrastructure and still with little regard for safety. According to Odhiambo (2021), in the CDKN report on non-motorized transport in Nairobi, the age group mostly affected by road traffic accidents is the productive age group of 20 - 44 years. That said, children, remain one of the most vulnerable groups of pedestrians (WHO, 2013). This is evident from the success of the Netherlands in reducing road traffic injuries and fatalities by among other measures, paying particular attention to the special needs of children (WHO, 2013). Cognizant of the vulnerability of child pedestrians, the National Transport and Safety Authority in 2022, championed a nationwide campaign to equip children with safety gear and knowledge of highway codes.

Despite extensive measures put in place to educate and ensure that both motorists and pedestrians are aware of their role in maintaining their own safety, the number of accidents continues to rise. In 2022, the fatalities as a result of road accidents stood at 4690, a 2.5% increase from 2021 which recorded 4579 fatalities (NTSA, 2023). Out of this, 1682 were pedestrians. This indicates that the measures put in place such as educating the public on road safety, increasing road signage and enforcement of policy, are not effectively addressing the ongoing problem.

This is more evident with school children whose safety varies greatly due to

their stature both physically and mentally. According to Ciesla (2021), factors such as lack of cognitive ability to apply knowledge about road safety in practice, lack of proper assessment of other road users' behaviour, little concentration and short height contribute to children's vulnerability to road traffic dangers.

Child pedestrians from deprived areas such as informal settlements are particularly at risk (Clarke & Draisin, 2023). About 50 percent of the world's urban informal population comprising children, (Clarke & Draisin, 2023) and their main mode of transportation is walking, largely due to financial inability to use other options. With a large number of school-going children, especially from the low-income areas being pedestrians, there is a need to investigate whether the street characteristics of an area can contribute to the safety of school-going children who walk to and from school. Kawangware in particular, presents a unique setting. It houses various types of villages; its informal settlement extends to planned areas and peri-urban areas.

2. Street Characteristics

Streets, according to NACTO (2013), are the lifeblood of our communities, accounting for about eighty percent of all public spaces in cities. Therefore, streets play a vital role in city life in general. To create a liveable city, urban planners need to understand street characteristics (Wang et al., 2022).

According to Wang et al., (2022) street characteristics refer to the physical and visual attributes of urban streets. He further categorizes these characteristics as aesthetic elements, functional elements, perceptual elements, and spatial elements (Wang et al., 2022). Norsima et al., also describe street characteristics as the physical elements that contribute to the overall appearance and function of a street. They categorize the characteristics into physical components and functional aspects. This paper will delve squarely into the physical street characteristics.

2.1. Physical Characteristics

Physical characteristics comprise the physical layout, design, and distribution of features that are visible and can be touched (Wang et al., 2022). Streets have various physical characteristics that differ from place to place, making some locations more suitable for pedestrianism than others. Speck (2012) describes five features that ensure that walkability is stifled and unsafe. One of these five is fattened roads. He coined a term—skinny streets and describes them as better for making a city more walkable. In this description, he does not just refer to the street in totality but specifically the part used for vehicular transportation. He outlines the lane width in particular as a factor that influences how safe a walk can be and how effective it is in protecting the pedestrian.

In her investigation on lane widths' impact on road safety, Hamidi et al. (2023) found that narrower lanes can lead to reduced vehicle speed and increased driver caution increasing the safety of pedestrians. She also noted that wider lanes encourage speed and reduce perceived safety. All these measures were found to go

hand in hand with the provision of pedestrian infrastructure and facilities to enhance safety further.

The various studies on narrowing of road length extensively mention the increase in the width of pedestrian footpaths. [Chen et al. \(2020\)](#) identified that an optimal balance between the vehicle lane and pedestrian path is needed for a fixed urban space. In reference to earlier studies, [Chen et al. \(2020\)](#) noted that footpaths when well designed can reduce vehicle-pedestrian conflict and crashes. It also improves pedestrian accessibility and provides both a safe and comfortable walking environment ([Chen et al., 2020](#)).

[Gekire et al. \(2021\)](#) described the role of street furniture as crucial in enhancing pedestrian safety. Street furniture provides a more inviting and comfortable environment for pedestrians by defining pedestrian spaces, encouraging social interaction and creating barriers to separate vehicular traffic. [Sewandono & Kuper \(2022\)](#) also reiterated that street furniture is crucial in pedestrian safety. Aside from providing clear pathways and designated areas for rest and social interaction, street furniture when well designed, also enhances visibility and awareness therefore increasing safety for pedestrians.

The design and placement of street furniture is critical when considering the safety of pedestrians. If poorly placed, street furniture can cause obstructions along walkways, thus creating hazards for pedestrians ([Sewandono & Kuper, 2022](#)). Additionally, the poor placement of street furniture may lead to cluttered sidewalks, visibility impediments and an eventual increased risk of accidents. Poor management of furniture such as trash receptacles may lead to overflowing litter, increasing safety concerns for pedestrians ([Sewandono & Kuper, 2022](#)).

The materials used on the street surfaces and on street furniture can be a great contribution to various aspects of pedestrian activity. [Elhamy \(2012\)](#) explored three aspects of the use of materials on three distinct safety elements. The first is the use of textured materials on pavements or walkways to improve traction and thus avoid slipping. The second is the use of thermoplastics or high-quality paint on crosswalks to ensure the durability of the markings even after harsh weather. The third aspect he studied was LED lights or bright materials used on sidewalks and crosswalks to enhance visibility at nighttime.

Traffic calming infrastructure refers to physical features that are installed to reduce both the speed and amount of traffic passing through an area making roads safer for all road users.

[Elhamy \(2012\)](#) noted that measures such as street closures, speed humps, chicanes, and diverters, can effectively improve safety for pedestrians and reduce vehicle speeds in neighbourhood streets. That study emphasizes the integration of both the design of these measures and additional enforcement of traffic laws to ensure their success.

In a study on the effects of traffic calming measures in different urban areas, the cities of Bilbao, Burgos, León, and Vitoria were studied. It was found that the most effective traffic calming measures observed were raised crosswalks, lane nar-

rowing, and radar speed cameras. Some of the measures observed solicited compliance from drivers while others like speed cameras only prompted temporary compliance. The study however, concluded that the traffic calming measures are effective in speed control (Gonzalo-Orden et al., 2018).

2.2. Safety

Safety can be defined as a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community (WHO, 1998).

This study focuses on road safety in particular. Road safety can be perceived, based on perceptions or real, based on previous crash data. Hamim & Ukkusuri's study looks into the perceived road safety of pedestrians as influenced by street features. A contrast of the perceived safety of the pedestrians and the actual road carnage data was done revealing that there is a relation between perceived and actual safety (Hamim & Ukkusuri, 2023).

Perceived Safety

Perceived safety can be referred to as an individual's subjective assessment of their safety in a given environment (Wangzom et al., 2023). This may differ from actual safety risks. In the case of active travel, perceived safety is essential in making the decision to walk to a destination or use other means. Being subjective, perceived safety depends on various factors. In the street context, factors such as the built environment, social setting, and the general maintenance of the area have a huge impact on the eventual perceived safety (Wangzom et al., 2023).

The use of surveys, focus groups, and Likert scale assessments can be employed to measure perceived safety (Amiour et al., 2022). Visual assessments can also elicit valid responses that can indicate a person's perceived safety (Wangzom et al., 2023). The understanding of perceived safety helps inform urban planning decisions that enhance safety. It is perceived safety that influences parents to allow for walking as a mode of transport for their children and thus reduces vehicular traffic (Wangzom et al., 2023; Amiour et al., 2022).

Actual Safety

Actual safety, sometimes referred to as objective safety is real traffic safety represented by the actual number of risks of collision, fatalities and injuries caused by road traffic (Amiour et al., 2022). Data such as police and hospital reports regarding traffic incidents is used in determining actual safety. This data is crucial in making urban planning decisions. Mitigation measures can be implemented in areas prone to collisions and accidents. Warnings such as markings of blackspots can be used to elicit proper traffic behaviour from the public, encouraging people to move with caution.

Children's Safety

Children are less able to assess distance, speed and sound, thus are at a higher risk as pedestrians (Clarke & Draisin, 2023). This is compounded by their often short stature which further reduces their field of vision. This field of vision is es-

sential in experiencing space and thus altering perceived safety, as discussed by Gehl in his book *cities for people* (Gehl, 2010).

Because of their small stature, children are less likely to be seen by motorists, less likely to see beyond obstructing objects to allow assessment of the safety level and much more likely to get serious head injuries if hit by a vehicle (Clarke & Draisin, 2023). Seventy to ninety percent of children walk to and from school in Africa, yet there are insufficient sidewalks along our roads (Clarke & Draisin, 2023).

It is imperative that on the onset of planning, we rethink and rebuild cities from the perspective of children (Clarke & Draisin, 2023). This will create safer cities for all demographics. Cities such as Fortaleza in Brazil were able to increase street safety through their Streets for Kids program. This was achieved through removing and narrowing travel lanes, building refuge islands and curb extensions, focusing on play spaces for children (Clarke & Draisin, 2023).

Child Pedestrians' Behaviour related to Street Infrastructure

Street infrastructure availability, condition and obstruction are key determinants of children's behaviour while using streets. Osuret et al. (2024) found that a key factor such as the presence of an obstruction along the crossways used by children could result in the unsafe behaviour of crossing outside crosswalks. Riaz et al. (2022) noted a difference between raised and flat crosswalks in enhancing safety for children by eliciting different behaviour. Crosswalks that were clearly marked also enhanced safe behaviour from children compared to those that were not.

Obstacles along walkways often cause children to walk along roadways instead. It also may cause distraction as they walk, deterring the children from assessing oncoming traffic (Riaz et al., 2022).

Running across a street was another behaviour induced by street infrastructure. Riaz et al. (2022) found that two-way traffic roads often elicited running behaviour due to an increase in uncertainty and a lack of coordinated perception of oncoming traffic from both ways. One-way traffic often improved looking behaviour because it simplified where the children had to look (Riaz et al., 2022). Properly designed road layouts, coupled with traffic calming measures greatly improve visibility and assist children in their looking behaviour. Elements such as street lighting and clear road signs also assist in looking behaviour (Riaz et al., 2022).

3. Methods

The study employed a quantitative approach to determine the relationship between street characteristics and safety. With the use of a standardized questionnaire, assessment of the respondents' opinions on the effect of physical characteristics on safety was undertaken. This data collection tool comprised questions that required ranking and others that utilized a likert scale to capture the respondents' general understanding of street physical characteristics, problems that affect safety

on the streets, and suggestions on solutions.

Sampling Design

The study adopted purposive sampling focusing on teachers and guardians to children. Each guardian or teacher was a representation of a child in Kawangware. The total population of children aged 3 - 17 within Kawangware is 11,317 (KNBS, 2019). Using Nassiuma's (2000) formula a sample size was calculated.

$$n = \frac{N \cdot C^2}{C^2 + (N-1)e^2}$$

where n = sample size

N = Target Population

C = Coefficient of Variance

e = standard error

With a $C = 0.21$ and an $e = 0.02$ our sample size was determined at 109.2. The study managed to get 110 respondents.

4. Study Area

The section of Gitanga Road that is within Kawangware Ward serves as the main street in the ward. It cuts through almost in the middle and leads to the Kawangware market which is a key component of the Kawangware economic landscape. The street is the main transport route into Kawangware. It also uniquely serves as the main route used by the Kenya Bus Services, whose headquarters are along the neighbouring Kawangware road. Aside from its strategic position, its importance as a gateway into Kawangware for most public transportation led to its consideration for this study. The study utilized an observation checklist to collect data on the street characteristics of the street along Gitanga Road.

Physical Characteristics

The street along Gitanga Road within Kawangware Ward is 1.43 kilometers long. It spans from just slightly before the Congo stage to the junction where it meets Kawangware road. It has a two-lane roadway with a width of 6 meters (3 meters for each lane) and the provided walkways' width varies within different sections of the street. It was observed that some sections have a walkway on one side while others have one on both sides. The street has no provision for a cycle lane or path. Most motorcycles and bicycles were observed utilizing both the road and the walkway. Illegal street parking was observed along walkways and on the road as seen in **Figure 1**.

The observed street material finish was tarmac. Some sections had extensive damage and an evident lack of maintenance rendering the material unrecognizable as seen in **Figure 1**. The Street Furniture observed was street lighting, billboards and signage. There was an evident lack of street benches, bus stop shelters, trash receptacles and landscaping elements. Street Furniture such as signage was observed as obstructive especially in areas with a large concentration of these. The

street lights observed were 83 in number. Some were operational but many were either vandalized or faulty. Traffic calming infrastructure observed were bumps. These were fairly distributed.

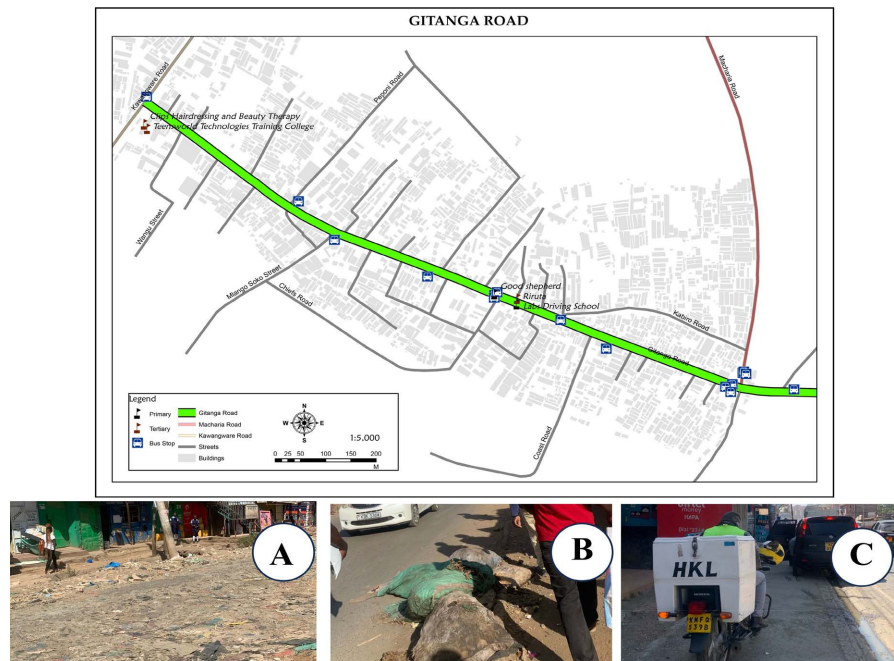


Figure 1. Physical Street Characteristics. (A) Lack of maintenance of street leads to unrecognizable material finish. Source. Author; (B) Observed trash alongside walk. No trash receptacle observed. Source. Author; (C) Parking along the sidewalk observed. Source. Author.

5. Data Analysis and Discussions

5.1. Descriptive Analysis of Physical Street Characteristics

The analysis of the physical street characteristics ranking demonstrated that respondents had strong preferences for priorities among the variables as seen in **Table 1**. Sidewalks are seen as the highest safety mechanism ($M = 2.20$, $SD = 0.86$), followed by elevations at crosswalks ($M = 3.38$, $SD = 1.80$) and street lighting ($M = 3.76$, $SD = 1.62$). Middle support was found with features like bumps ($M = 4.33$, $SD = 2.20$) and wider roadways ($M = 4.35$, $SD = 1.49$), and lower support with variables like benches ($M = 4.96$, $SD = 1.57$) and road roughness ($M = 5.12$, $SD = 1.80$). This supports a prominent effort to prioritize the infrastructure that the respondents felt most indicated safe walking and crossing (sidewalks and crosswalks) versus more peripheral features like benches and road surfaces indicating less influence on child pedestrian safety.

5.2. Physical Safety Perceptions

With respect to the items we measured, participants thought physical features were important for child pedestrian safety, as they rated them positively (i.e.,

Table 1. Physical characteristics ranking.

| Characteristic | Mean Rank | SD |
|-------------------|-------------|----------|
| Rough roads | 5.117117117 | 1.797669 |
| Benches | 4.963963964 | 1.572074 |
| Wide Roadways | 4.349056604 | 1.486719 |
| Bumps | 4.330188679 | 2.20269 |
| Street Lighting | 3.756521739 | 1.620003 |
| Raised Crosswalks | 3.379310345 | 1.796882 |
| Sidewalks | 2.201754386 | 1.863387 |

rated the items above a neutral level) as seen in **Table 2**. The rated feature perceived to afford children safety is walkways that separate the children from traffic ($M = 6.25$, $SD = 1.21$), which received the most positive rating overall. Adequate street lighting also received a high rating overall ($M = 6.15$, $SD = 1.20$). Safe crossings where children cross with raised crossways, also received a high overall rating ($M = 5.59$, $SD = 1.21$) while good visibility for all forms of road marking even in the dark ($M = 5.97$, $SD = 1.27$) was also identified as important. Poor sidewalks ($M = 4.24$, $SD = 1.79$) received a comparatively low rating overall, as did wide roads ($M = 4.86$, $SD = 1.89$), suggesting they were seen as having less value to child pedestrian safety. The response indicated that participants valued features that support visibility; separate children from the roadway; and controlled crossings (e.g., crosswalks) over other features as important ways of facilitating the safety of school aged pedestrians.

Table 2. Physical safety perceptions.

| <i>Descriptive Statistics</i> | | |
|---|-------|----------------|
| | Mean | Std. Deviation |
| 5.1 I feel school children are safer while crossing streets with one lane compared to crossing streets with two lanes. | 5.336 | 1.819 |
| 5.2 I feel school children are safer walking along wide roads compared to narrow roads | 4.864 | 1.889 |
| 5.3 I feel school children are safer walking along walkways that do not have obstructions. | 5.955 | 1.547 |
| 5.4 I feel school children are safest walking along streets that have dedicated lanes for bicycles and motorcycles. | 5.773 | 1.560 |
| 5.5 I feel school children are safe walking along walkways that are well separated from the road. | 6.245 | 1.205 |
| 5.6 I feel school children are safe walking along a street with sufficient lighting even at night. | 6.145 | 1.195 |
| 5.7 I feel school children are not safe on streets where the street benches, flower pots and trash receptacles obstruct the walkway. | 5.182 | 1.725 |
| 5.8 I feel school children are safer walking on a rough walkway than on a smooth walkway | 4.236 | 1.786 |
| 5.9 I feel school children are safer walking along a road made of rough material that slows cars down than along smooth material that cars move very fast | 5.127 | 1.503 |

Continued

| | | |
|---|-------|-------|
| 5.10 I feel school children are safer walking beside a road whose markings are visible even in the dark than along a road without clear markings. | 5.973 | 1.274 |
| 5.11 I feel school children are safer crossing a road at a raised crossway than crossing at a flat crossway. | 5.591 | 1.206 |
| 5.12 I feel school children are safe walking along a road that has many bumps, humps or tables | 5.000 | 1.608 |

5.3. Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis for the physical safety construct indicated that most of the items were loading significantly onto the latent factor. The strongest indicators as seen in **Table 3** were identified as varying degrees of separation from the road/increased distance to cars (Estimate = 1.34, SE = 0.18, $z = 7.61$, $p < 0.001$, 95% CI [0.99, 1.68]), unobstructed walkable passages (Estimate = 1.22, SE = 0.18, $z = 6.99$, $p < 0.001$, 95% CI [0.88, 1.57]), and, sufficient illumination from streetlights (Estimate = 1.08, SE = 0.16, $z = 6.96$, $p < 0.001$, 95% CI [0.77, 1.38]). Somewhat further down the rankings, raised crossways (Estimate = 1.05, $p < 0.001$), and visible road markings (Estimate = 1.13, $p < 0.001$) also demonstrated statistically strong and significant loadings. Conversely, wide roads (Estimate = 0.35, SE = 0.16, $z = 2.13$, $p = 0.033$) and rough walkways (Estimate = 0.35, SE = 0.16, $z = 2.19$, $p = 0.028$) had relatively weak, but significant proportions in the final loading. In sum, the results indicated that separation from traffic, adequate lighting, and clear road markings are the 3 most salient indicators of physical safety for child pedestrians.

Table 3. Physical characteristics.

| | | <i>Factor loadings</i> | | | | 95% Confidence Interval | |
|--------------------------|---|------------------------|------------|---------|--------|-------------------------|-------|
| Factor | Indicator | Estimate | Std. Error | z-value | p | Lower | Upper |
| Physical Characteristics | 5.1 I feel school children are safer while crossing streets with one lane compared to crossing streets with two lanes | 1.000 | 0.000 | | | 1.000 | 1.000 |
| | 5.2 I feel school children are safer walking along wide roads compared to narrow roads | 0.347 | 0.163 | 2.134 | 0.033 | 0.028 | 0.665 |
| | 5.3 I feel school children are safer walking along walkways that do not have obstructions | 1.222 | 0.175 | 6.989 | <0.001 | 0.879 | 1.565 |
| | 5.4 I feel school children are safest walking along streets that have dedicated lanes for bicycles and motorcycles | 1.116 | 0.165 | 6.745 | <0.001 | 0.791 | 1.440 |

Continued

| | | | | | | |
|---|-------|-------|-------|--------|-------|-------|
| 5.5 I feel school children are safe walking along walkways that are well separated from the road | 1.335 | 0.175 | 7.606 | <0.001 | 0.991 | 1.679 |
| 5.6 I feel school children are safe walking along a street with sufficient lighting even at night | 1.076 | 0.155 | 6.959 | <0.001 | 0.773 | 1.379 |
| 5.7 I feel school children are not safe on streets where the street benches, flower pots and trash receptacles obstruct the walkway | 0.872 | 0.129 | 6.771 | <0.001 | 0.620 | 1.125 |
| 5.8 I feel school children are safer walking on a rough walkway than on a smooth walkway | 0.354 | 0.161 | 2.194 | 0.028 | 0.038 | 0.671 |
| 5.9 I feel school children are safer walking along a road made of rough material that slows cars down than along smooth material that cars move very fast | 0.720 | 0.148 | 4.876 | <0.001 | 0.431 | 1.010 |
| 5.10 I feel school children are safer walking beside a road whose markings are visible even in the dark than along a road without clear markings | 1.132 | 0.164 | 6.902 | <0.001 | 0.810 | 1.453 |
| 5.11 I feel school children are safer crossing a road at a raised crossway than crossing at a flat crossway | 1.051 | 0.160 | 6.582 | <0.001 | 0.738 | 1.364 |
| 5.12 I feel school children are safe walking along a road that has many bumps, humps or tables | 0.798 | 0.144 | 5.520 | <0.001 | 0.514 | 1.081 |

5.4. Multicollinearity

VIF and tolerance values were calculated to check for multicollinearity among the predictor variables and are represented in **Table 4**. The VIF values for the physical

characteristics ranged from 4.70 (benches) to 9.12 (bumps), and the tolerances for the physical characteristics had ranges of 0.110 (bumps) to 0.213 (benches). Although none of the VIF values exceeded 10, bumps, sidewalks, rough roads, and raised crosswalks were the highest VIF values indicating moderate amounts of multicollinearity present. To conclude the results, all the physical characteristics showed moderate amounts of collinearity thus justifying proceeding with the regression analysis.

Table 4. Collinearity statistics for street physical characteristics.

| Predictor Variable | VIF | Tolerance |
|---------------------------------|------|-----------|
| Physical Characteristics | | |
| Physical_Benches | 4.7 | 0.213 |
| Physical_Bumps | 9.12 | 0.11 |
| Physical_Raised Crosswalks | 6.82 | 0.147 |
| Physical_Rough roads | 7.94 | 0.126 |
| Physical_Sidewalks | 7.74 | 0.129 |
| Physical_Street Lighting | 4.89 | 0.205 |
| Physical_Wide Roadways | 4.97 | 0.201 |

5.5. Equality of Variance

We examined the independence of residuals assumption from the safety indices using the Durbin-Watson statistic and autocorrelation tests as seen in **Table 5**. For the Physical Safety Index, the Durbin-Watson values (1.76 to 1.89) and the autocorrelation tests for both tests being non-significant ($p = 0.248$ and $p = 0.525$) provided little evidence for violations of independence.

Table 5. Durbin-Watson test for independence of errors.

| Model | Autocorrelation | Statistic | <i>p</i> |
|-----------------------|-----------------|-----------|----------|
| Physical Safety Index | 0.116 | 1.764 | 0.248 |
| | 0.032 | 1.887 | 0.525 |

5.6. Linearity Assumptions

Model 1. Physical Characteristics

The correlation between the Physical Safety Index and its predictors was evaluated through Pearson’s correlations and represented in **Table 6**. Significant positive correlations were found with the presence of sidewalks ($r = 0.694, p < 0.001$), raised crossings ($r = 0.447, p < 0.001$), and street lighting ($r = 0.308, p = 0.002$). Significant negative correlations were established with benches ($r = -0.517, p < 0.001$), rough roads ($r = -0.501, p < 0.001$), and wide roads ($r = -.571, p < 0.001$). Lastly, bumps had no significant correlation ($r = 0.077, p = 0.449$). These results suggest that perceptions of safety are positively related to the presence of side-

walks, raised crossings, and lighting and that perceptions of safety are negatively related to benches, rough roads, and wide streets.

Table 6. Pearson's correlations-physical characteristics.

| | | | Pearson's r | <i>p</i> |
|----------------------------|---|----------------------------|-------------|----------|
| Physical_Safety_Index | - | Physical_Benches | -0.517 | <0.001 |
| Physical_Safety_Index | - | Physical_Bumps | 0.077 | 0.449 |
| Physical_Safety_Index | - | Physical_Raised Crosswalks | 0.447 | <0.001 |
| Physical_Safety_Index | - | Physical_Rough roads | -0.501 | <0.001 |
| Physical_Safety_Index | - | Physical_Sidewalks | 0.694 | <0.001 |
| Physical_Safety_Index | - | Physical_Street Lighting | 0.308 | 0.002 |
| Physical_Safety_Index | - | Physical_Wide Roadways | -0.571 | <0.001 |
| Physical_Benches | - | Physical_Bumps | -0.400 | <0.001 |
| Physical_Benches | - | Physical_Raised Crosswalks | 0.015 | 0.875 |
| Physical_Benches | - | Physical_Rough roads | -0.072 | 0.468 |
| Physical_Benches | - | Physical_Sidewalks | -0.285 | 0.003 |
| Physical_Benches | - | Physical_Street Lighting | 0.032 | 0.744 |
| Physical_Benches | - | Physical_Wide Roadways | 0.028 | 0.782 |
| Physical_Bumps | - | Physical_Raised Crosswalks | -0.520 | <0.001 |
| Physical_Bumps | - | Physical_Rough roads | 0.440 | <0.001 |
| Physical_Bumps | - | Physical_Sidewalks | -0.410 | <0.001 |
| Physical_Bumps | - | Physical_Street Lighting | -0.422 | <0.001 |
| Physical_Bumps | - | Physical_Wide Roadways | 0.004 | 0.968 |
| Physical_Raised Crosswalks | - | Physical_Rough roads | -0.583 | <0.001 |
| Physical_Raised Crosswalks | - | Physical_Sidewalks | 0.443 | <0.001 |
| Physical_Raised Crosswalks | - | Physical_Street Lighting | 0.147 | 0.133 |
| Physical_Raised Crosswalks | - | Physical_Wide Roadways | -0.421 | <0.001 |
| Physical_Rough roads | - | Physical_Sidewalks | -0.606 | <0.001 |
| Physical_Rough roads | - | Physical_Street Lighting | -0.545 | <0.001 |
| Physical_Rough roads | - | Physical_Wide Roadways | 0.168 | 0.093 |
| Physical_Sidewalks | - | Physical_Street Lighting | 0.288 | 0.003 |
| Physical_Sidewalks | - | Physical_Wide Roadways | -0.384 | <0.001 |
| Physical_Street Lighting | - | Physical_Wide Roadways | -0.210 | 0.033 |

5.7. Regression Analysis of Physical Safety Index

A multiple regression analysis was conducted to examine how each individual physical street feature predicted perceptions of physical safety for child pedestrians as seen in **Tables 7-9**. The regression model was significant and explained a relatively high amount of variance, $R = 0.916$, $R^2 = 0.84$, Adjusted $R^2 = .83$, $F(7,$

87) = 65.14, $p < 0.001$, indicating physical features explained 84% of the variance in perceptions of physical safety.

Among the predictors, sidewalks ($\beta = 0.720$, $p < 0.001$), bumps ($\beta = 0.723$, $p < 0.001$), raised crosswalks ($\beta = 0.513$, $p < 0.001$), and street lighting ($\beta = 0.381$, $p < 0.001$) were all significant positive predictors of physical safety suggesting higher anticipation for each individual feature was highly associated with greater perceptions of safety. In contrast, benches ($\beta = -0.025$, $p = 0.788$), physical rough roads ($\beta = 0.126$, $p = 0.301$), and wide roadways ($\beta = -0.007$, $p = 0.941$) were not significant predictors of physical safety.

The results highlight the importance of pedestrian-oriented traffic infrastructure—specifically sidewalks, bumps, crosswalks, and street lights—and its great influence on perceptions of physical safety, while features like benches, physical rough roads or assuaging the width of the road for child pedestrian safety in the current context were not consequential.

Table 7. Model summary—physical_safety_index.

| Model | R | R ² | Adjusted R ² | RMSE |
|----------------|-------|----------------|-------------------------|-------|
| M ₀ | 0.000 | 0.000 | 0.000 | 0.797 |
| M ₁ | 0.916 | 0.840 | 0.827 | 0.332 |

Note. M₁ includes Physical_Benches, Physical_Bumps, Physical_Raised Crosswalks, Physical_Rough roads, Physical_Sidewalks, Physical_Street Lighting, Physical_Wide Roadways.

Table 8. ANOVA.

| Model | | Sum of Squares | df | Mean Square | F | p |
|----------------|------------|----------------|----|-------------|--------|--------|
| M ₁ | Regression | 50.158 | 7 | 7.165 | 65.142 | <0.001 |
| | Residual | 9.570 | 87 | 0.110 | | |
| | Total | 59.728 | 94 | | | |

Note. M₁ includes Physical_Benches, Physical_Bumps, Physical_Raised Crosswalks, Physical_Rough roads, Physical_Sidewalks, Physical_Street Lighting, Physical_Wide Roadways.
Note. The intercept model is omitted, as no meaningful information can be shown.

Table 9. Coefficients.

| Model | | Unstandardized | Standard Error | Standardized | t | p |
|----------------|----------------------------|----------------|----------------|--------------|--------|--------|
| M ₀ | (Intercept) | 2.693 | 0.082 | | 32.928 | <0.001 |
| M ₁ | (Intercept) | -0.785 | 1.267 | | -0.620 | 0.537 |
| | Physical_Benches | -0.013 | 0.049 | -0.025 | -0.269 | 0.788 |
| | Physical_Bumps | 0.262 | 0.047 | 0.723 | 5.580 | <0.001 |
| | Physical_Raised Crosswalks | 0.237 | 0.052 | 0.513 | 4.572 | <0.001 |
| | Physical_Rough roads | 0.055 | 0.053 | 0.126 | 1.041 | 0.301 |
| | Physical_Sidewalks | 0.305 | 0.051 | 0.720 | 6.034 | <0.001 |
| | Physical_Street Lighting | 0.195 | 0.049 | 0.381 | 4.019 | <0.001 |
| | Physical_Wide Roadways | -0.004 | 0.052 | -0.007 | -0.074 | 0.941 |

6. Discussion

From the findings it is evident that physical characteristics of streets play a crucial role in the safety of child pedestrians. In particular, sidewalks, crosswalks and streetlighting seem to be the most important physical characteristics in determining the safety of children. An additional element to the features such as separation of walkways from roadways, raising of crosswalks and clear markings and illumination of other street features accounts for a greater perceived safety.

Street furniture, material finish and street width were however the least impactful on the safety of the physical characteristics of streets. This confirms the study on road widths by [Speck \(2012\)](#) and [Hamidi et al. \(2023\)](#) which highlight that wider roads are perceived as more unsafe as they can hold more traffic while narrow roads help in the reduction of vehicle speed and better concentration by the drivers.

Benches were seen as negatively impacting safety. [Sewandono & Kuper \(2022\)](#) study outlined some reasons as to why benches and other street furniture could impede safety along streets such as, being an obstruction thus causing cluttered sidewalks and impairing visibility. The findings from this study though not explicitly mentioning these reasons, support the possible negative impact street furniture can have on safety along streets.

Another characteristic that responded negatively was rough roads. The findings partly contradict the study on street materials by [Elhamy \(2012\)](#) which looked at street material in two parts; texture and illumination. Whereas bright markings on sidewalks had a high relation to safety perceptions, a textured material finish had a low relation to safety perception. The findings on bumps also contradicted studies in the literature review.

7. Study Limitations

- 1) The study focused on perceived safety rather than actual accident data.
- 2) The study's geographic focus was on a single ward thus making it difficult to generalize the findings.

8. Conclusion

The intentional design of physical street characteristics is crucial in enhancing safety along the streets, particularly for child pedestrians. Characteristics such as sufficient sidewalks, sufficient and raised crosswalks, bumps and adequate street lighting if provided will greatly enhance the safety of child pedestrians.

Policies such as the Nairobi Non-Motorized Transport Policy (2015) provide a base at the county level from which child-sensitive street design can be implemented by prioritizing walkways, raised crosswalks, and sufficient street lighting in school zones and residential areas. The findings would also lower risks for child pedestrians, particularly in informal urban areas, if integrated into the Kenya Urban Streets Design Guidelines and school zone safety initiatives.

These findings will also support national commitments under Kenya Vision

2030 and international objectives like the Sustainable Development Goals (SDGs) by fostering urban environments for children that are safer, more inclusive, and more accessible.

9. Recommendation

From the study, several recommendations can be made to enhance the safety of child pedestrians along streets, in particular the streets of Kawangware:

Regular maintenance of street lights to ensure they are functioning during the night time. Gitanga road was found to have a sufficient number of street lights but some were not functioning.

Provision of adequate sidewalks on both sides of the road and periodic maintenance along the sidewalk. The sidewalks observed had several obstructions and were therefore not sufficient for the large pedestrian traffic.

There are no marked crossings along Gitanga road, therefore the provision of well-marked crosswalks, preferably raised would greatly enhance safety for child pedestrians.

Conflicts of Interest

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

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