UHASSELT

KNOWLEDGE IN ACTION

School of Transportation Sciences

Master of Transportation Sciences

Master's thesis

ROAD CROSSING BEHAVIORS OF SCHOOL CHILDREN. THE CASE OF DAR ES SALAAM, TANZANIA

Thomas Njanda

Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences

SUPERVISOR :
Prof. dr. Ariane CUENEN

SUPERVISOR :
Dr. Geophrey MBATTA

2024
2025

UHASSELT

KNOWLEDGE IN ACTION

www.uhasselt.be
Universiteit Hasselt
Campus Hasselt:
Martelarenlaan 42 | 3500 Hasselt
Campus Diepenbeek:
Agoralaan Gebouw D | 3590 Diepenbeek

UHASSELT

KNOWLEDGE IN ACTION

School of Transportation Sciences

Master of Transportation Sciences

Master's thesis

ROAD CROSSING BEHAVIORS OF SCHOOL CHILDREN. THE CASE OF DAR ES SALAAM, TANZANIA

Thomas Njanda

Thesis presented in fulfillment of the requirements for the degree of Master of Transportation Sciences

SUPERVISOR :

Prof. dr. Ariane CUENEN

SUPERVISOR :

Dr. Geophrey MBATTA

Preface

This thesis marks the completion of a meaningful academic and professional journey in the field of transportation sciences, pursued through the joint Master of Transportation Sciences program offered by Hasselt University and Ardhi University under the VLIR-UOS project. The research presented here reflects my growing interest in the field of mobility, safety, and child welfare within the complex urban settings of developing cities.

The inspiration for this study came from recurring observations of school children navigating dangerous road environments in Dar es Salaam. These scenes sparked a deep concern about the safety of young pedestrians, and motivated me to explore the behaviors, risks, and environmental factors that shape children's road-crossing decisions. I was particularly interested in understanding how infrastructural and traffic conditions influence their vulnerability and what interventions might lead to safer mobility for them. However, conducting this study had its own challenges. One significant challenge was the long and uncertain wait for research permits to access school zones for data collection. This process delayed fieldwork and required persistent coordination with multiple institutions. Despite these obstacles, the experience strengthened my resolve and taught me valuable lessons in resilience, planning, and ethical research engagement.

I would like to express my sincere gratitude to my supervisors, Prof. Dr. Ariane Cuenen from Hasselt University and Dr. Geophrey Mbatta from Ardhi University, for their steady support, critical guidance, and thoughtful feedback throughout this work. I am also thankful to VLIR-UOS for sponsoring my studies and to the institutions that facilitated my data collection, Tanzania National Roads Agency (TANROADS), the Tanzania Police Force, the Dar es Salaam Regional Office, and the primary schools that generously allowed my research within their environments. Lastly, I would like to thank my precious wife for her unwavering support during the entire period that I was conducting this research.

Abstract

Road traffic injuries represent a significant public health challenge globally, with children among the most vulnerable groups, particularly in developing countries like Tanzania. Despite various educational interventions aimed at improving children's awareness of safe road use, pedestrian injuries remain common around school zones. This study sought to bridge the gap between knowledge and actual behavior by assessing school children's awareness of road crossing safety, observing their real-world behaviors, and analyzing the key individual and environmental factors influencing these behaviors. The research was conducted across six primary schools in Dar es Salaam, where road traffic conditions vary substantially and pose different levels of risk to school-aged pedestrians.

The objectives of the study were to: (i) assess school children's awareness of road crossing safety; (ii) analyze road and traffic characteristics within school zones; (iii) investigate actual road-crossing behavior; and (iv) examine the factors influencing such behaviors. Data were collected through three approaches: questionnaires administered to 600 students to assess their road safety awareness; direct observations of 600 school children during actual road crossings; and assessment of the surrounding traffic environment, including measurement of vehicle speed using a radar gun and structured observation of road characteristics such as number of lanes, presence of pedestrian infrastructure, signage, and traffic volume.

Statistical methods included descriptive analysis, chi-square tests, and binary logistic regression to determine the influence of key predictors, such as gender, group size, traffic volume, vehicle speed, number of lanes, and adult accompaniment, on specific crossing behaviors. Results revealed a high level of road safety awareness among students, particularly among older children, with minimal gender differences in knowledge. However, actual crossing behaviors varied widely, with unsafe actions such as running, diagonal crossing, and ignoring zebra crossings more common in areas with fast traffic and wide roads. Boys were more likely to engage in risky behaviors than girls, and adult accompaniment consistently contributed to safer road-crossing practices. Logistic regression confirmed that environmental factors, especially traffic speed and road characteristics, and adult supervision were the most significant predictors of child pedestrian behavior.

Generally, the findings of this study indicate that while primary school children in Tanzania demonstrate high levels of road safety awareness, especially in understanding safe behaviors such as stopping, scanning, and using designated crossings. There is still, a significant gap between knowledge and practice. Observed unsafe road crossing behaviors were influenced by a combination of individual, social, and environmental factors, with adult accompaniment emerging as a strong predictor of safer behavior. Environmental conditions like high traffic volume and vehicle speed increased risky behaviors, while inconsistent road safety infrastructure across school zones further contributed to unsafe crossings. The absence of significant gender differences in awareness is encouraging, but behavioral trends among boys and peer groups suggest targeted interventions are still needed. These findings underscore the need for a shift from awareness creation to behavior reinforcement, supported by consistent infrastructure improvements, adult supervision, and community-wide engagement to ensure lasting road safety among children.

Table of Contents

List of figures

List of tables

List of appendices

Abbreviations

ITF	International Transport Forum
PO-RALG	President's Office - Regional Administration and Local Government
RSE	Road Safety Education
RTI	Road Traffic Injuries
TANROADS	Tanzania National Roads Agency
TARURA	Tanzania Rural and Urban Roads Agency
UNECE	United Nations Economic Commission for Europe
UNICEF	United Nations Children's Fund
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1. Background

Road traffic crashes are a major global public health issue, claiming approximately 1.19 million lives annually and causing serious injuries to 20 to 50 million people (UNICEF, 2020; WHO, 2023). A significant portion of all road crashes occurs to vulnerable road users, pedestrians, cyclists, and elders to be specific (Cloutier et al., 2020). Among the pedestrians, children face a disproportionately high risk of traffic-related injuries and fatalities (Cloutier et al., 2020). Each day, an estimated 500 children lose their lives on the roads, equivalent to one child being killed every four minutes (UNICEF, 2020). In 2016 alone, the global number of pedestrian fatalities among individuals aged 0–20 years was estimated to be around 72,000 (Cloutier et al., 2020). Although these global statistics are alarming, there is a significant difference when comparing the developing and developed countries.

The rate of child road traffic injuries and fatalities is significantly higher in developing countries, where 97% of all child road traffic deaths occur (UNICEF, 2022). In some developing countries, child road traffic death rates can be up to 30 times higher when compared to countries with the lowest child road traffic death rate (UNICEF, 2022). Africa, which consists largely of developing nations, has the highest child road traffic death rate, reaching up to 31.5 deaths per 100,000 children (ITF, 2022; WHO, 2021). Despite global efforts to enhance child road safety, Africa recorded the lowest reduction in child road traffic deaths between 2019 and 2020 (WHO, 2021). Studies indicate that limited efforts have been directed towards improving road safety in school zones, leaving children at increased risk of crashes (ITF, 2022).

In Tanzania, road traffic injuries among children present a serious and growing public health concern. School-aged children face significant risks as pedestrians, especially during their daily commutes. It is estimated that 21% of all road traffic injuries occur to children under age of 15 years, with 93% of those injuries occurring while walking (Zimmerman et al., 2012). Most of road traffic incidents take place during school commutes and involve motorcycles or private cars (Poswayo et al., 2018). These associated risks are attributed by road infrastructures lacking basic safety features, such as pedestrian crossings, speed control measures, and clear signage, exposing children to speeding vehicles and unsafe crossing conditions (Akasreku et al., 2023). Also, drivers and motorcyclists often fail to yield or obey traffic laws near schools which further increasing the risk of child pedestrian injuries (Moshiro et al., 2021). Although the mentioned risks are faced all road users, children are particularly more vulnerable to them.

One of the primary reasons children's vulnerabilities to road crashes is their physical characteristics. Their small stature makes them less visible to drivers, and as they are not as tall as adults, their view can be easily obstructed (Damsere-Derry et al., 2017; Morrongiello et al., 2016). Another reason is that children lack the cognitive maturity to accurately judge vehicle speed, distance, and safe gaps in traffic, making it difficult for them to navigate roads safely. Additionally, their unpredictable movements increase their vulnerability (Damsere-Derry et al., 2017; Thompson et al, 2005). Research also suggests that children frequently engage in risky pedestrian behaviors (Thompson et al., 2005), these unsafe behaviors significantly contribute to the occurrence of child pedestrian crashes. To reduce the risk of pedestrian crashes, many countries have

introduced road safety education (RSE) programs aimed at improving children's awareness and pedestrian behavior.

Similar to other countries, RSE is incorporated into the primary school curriculum in Tanzania to improve children's awareness of traffic dangers (Perego et al., 2019; Poswayo et al., 2019). Various road safety programs have been introduced by schools and NGOs, focusing on pedestrian safety including classroom-based instruction, practical road-crossing training, and community engagement programs (Poswayo et al., 2019). The assumption behind these initiatives is that educating children about traffic rules and road safety from an early age can help them develop safe behaviors, enabling them to navigate roads more cautiously and reduce their risk of accidents (Alonso et al., 2016; Odame et al., 2024). To assess the effectiveness of these education programs, scholars around the world have examined the awareness of RSE among children in different countries (Odame et al., 2024), but such research remains limited in Tanzania.

Although RSE is widely provided to school children, studies highlight that the effectiveness of RSE programs largely depends on how well they align with the actual behaviors that children exhibit in real-world traffic environments. Hence, understanding these behaviors is essential before designing or implementing any educational interventions (Bartholomew et al., 2011; Grayson, 1981). Observational studies show that children frequently neglect fundamental safety actions, such as checking for oncoming traffic or using designated crossing points, despite being aware of traffic rules (Rosenbloom et al., 2008; Schwebel et al., 2018; Zeedyk et al., 2002). Risky behaviors, such as crossing for convenience rather than safety (Ampofo-Boateng et al., 1993), and the inability to accurately assess vehicle speed or identify safe crossing locations (Meir et al., 2015; Underwood et al., 2007), underscore a persistent gap between knowledge and practice. While such global insights offer valuable guidance, studies specifically investigating the behaviors of Tanzanian school children remain scarce. This points to deeper gaps in localized training and risk perception. Without a detailed understanding of how Tanzanian children behave in their specific traffic contexts, it remains difficult to develop interventions that are both relevant and effective for reducing pedestrian injury risks.

Nevertheless, studies indicate that pedestrian behavior, including that of school-aged children, varies significantly depending on the surrounding road and traffic conditions, the available pedestrian infrastructure, and demographic characteristics such as age and gender (Escobar et al., 2021). These environmental and contextual variables play a crucial role in influencing how children behave in traffic, regardless of the RSE they may have received. For instance, observation of traffic before crossing increases in high-risk environments, such as roads with higher traffic volume or faster-moving vehicles, suggesting that perceived danger may enhance caution among children with adequate cognitive functioning (Barton & Morrongiello, 2011). Similarly, unsafe crossing behaviors differ according to the nature of traffic and gender, emphasizing how traffic characteristics interact with behavioral tendencies (Riaz et al., 2022). Although such insights are essential for tailoring road safety initiatives to real-world scenarios, there is limited empirical data examining these relationships in Tanzania.

1.2. Problem statement

Road accidents claim millions of lives worldwide each year, with pedestrians, particularly children, being among the most vulnerable groups. Children’s vulnerability to road traffic injuries stems from their physical and cognitive limitations resulting to their tendency to engage in unsafe road behaviors, such as crossing

where there is no pedestrian crossing and running while crossing hence increasing their risk to road crashes. In the effort to make children practice safe road crossing behaviors in Tanzania, RSE is provided to school children.

Despite the provision of RSE to school children in Tanzania, children still face high road risks primarily due to their behaviors. There is limited literature on children's awareness of safe road crossing practices. Even less is known about their actual road-crossing behaviors and the factors that influence these behaviors in real traffic environments. There is a need to conduct a study to fill this gap by examining not only what children know, but also how they act and what shapes their decisions when crossing the road. Such an understanding is essential for designing interventions to reduce road traffic crashes involving school children, that are both effective and responsive to the lived experiences of children in the Tanzanian context.

1.3. Research objectives

1.3.1. Main Objective

To explore school children's understanding of road safety and how their crossing behaviors are shaped by different factors in Dar es Salaam.

1.3.2. Specific Objectives

1. To examine the road crossing safety awareness among school children in Dar es Salaam.
2. To analyze the road and traffic characteristics of roads passing in school zones in Dar es Salaam.
3. To investigate children's behaviors when crossing the road in school areas to identify the key unsafe crossing practices.
4. To investigate the factors influencing children's road crossing behaviors in Dar es Salaam.

1.4. Research Questions

1. How well do school children understand road crossing safety rules and practices?
2. How is the road and traffic nature of the roads passing school zones in Dar es Salaam?
3. What do children pedestrians do when they cross the roads in school areas in Dar es Salaam?
4. What are the factors that influence children's road crossing behaviors in Dar es Salaam?

1.5. Significance of the Study

This study provides insights into school children's understanding of safe road-crossing practices. By assessing their level of awareness, the study helps to reveal how well children grasp essential road crossing safety principles. This is crucial in evaluating the effectiveness of the RSE currently provided in schools and identifying areas where improvements are needed.

In addition to awareness, the study explores how children behave when crossing roads in actual traffic environments. It captures the common crossing practices, both safe and unsafe, adopted by children in school areas. This behavioral analysis offers a practical understanding of the risks children face on the road and highlights areas where their safety is most compromised.

Moreover, the study examines the key factors influencing children's road-crossing behaviors. These include individual, social, road, and traffic-related characteristics that shape decision-making during road use. Understanding these influences is vital for designing targeted policies and interventions aimed at reducing child pedestrian injuries and fatalities in urban areas like Dar es Salaam.

CHAPTER TWO

LITERATURE REVIEW

2.1. Traffic injuries among school children in Dar es Salaam.

The problem of traffic crashes is not new in Dar es Salaam, as road traffic injuries have long been recognized as a major public health issue in the city. However, despite growing concerns, limited studies have explored the specific patterns and risk factors affecting children's safety on the roads.

A case-control study conducted by Moshiro et al. (2021) in Dar es Salaam, Tanzania, examined the patterns and risk factors of childhood injuries, including road traffic injuries, falls, burns, and cuts. The findings highlighted several socioeconomic and environmental factors contributing to childhood injuries, such as poor child supervision, overcrowding, low household income, and young maternal age. One of the key findings was the high prevalence of motorcycle-related road traffic injuries among school children, which aligns with the increasing use of motorcycles as a primary mode of transportation in urban Tanzania. The study emphasized the need for improved road infrastructure and stricter enforcement of traffic laws to address this growing concern. This study provides insight to the existence of the traffic injuries among children but it does not delve deep to uncover the associated causes of these traffic injuries.

Another study conducted by Akasreku et al. (2023) examined road traffic injuries among school children in Dar es Salaam, Tanzania, highlighting key risk factors and safety challenges in school zones. The study found that children face significant dangers while crossing roads due to high vehicle speeds, lack of pedestrian infrastructure, and risky road user behavior. The research revealed that many school zones lacked designated pedestrian crossings, speed control measures, and proper signage, making it difficult for children to navigate roads safely.

One of the major findings of the study by Akasreku et al. (2023) was that most road crashes involving school children occurred near major roads with high traffic volumes and speeds. In these areas, drivers frequently failed to yield to pedestrians, forcing children to take unsafe crossing decisions. The absence of speed humps, pedestrian crossings, and enforcement of traffic laws contributed to the high incidence of road traffic injuries. Additionally, the study found that road user behavior, particularly among drivers and motorcyclists, played a significant role in school zone safety. Many drivers did not reduce speed near schools, and motorcycles were frequently observed weaving through traffic and using pedestrian walkways, increasing the risk for children. The study suggested that enhanced law enforcement, public awareness campaigns, and improved infrastructure could significantly reduce the risks faced by school children.

Additionally, Poswayo et al. (2018), conducted a study to assess the impact of infrastructure and educational interventions on reducing road traffic injuries among school-aged children in Dar es Salaam. She found that school-aged children in Dar es Salaam continued to experience a high and increasing burden of road traffic injuries in environments without safety interventions. The injury incidence among children rose from 1.49 to 1.87 per 100 person-years, with a significant portion of these injuries occurring during school commutes. Children were frequently injured as pedestrians, particularly by motorcycles and private cars, which were responsible for the majority of reported cases. Notably, injuries sustained while going to or from school increased to 1.08 per 100 person-years, highlighting the routine danger faced by children in traffic

environments. These findings reflect the real situation many children encounter daily exposure to unsafe road conditions, lack of child-friendly infrastructure, and limited protection from fast-moving vehicles, underscoring a critical public health challenge that requires urgent and focused attention.

Additionally, Zimmerman et al. (2012) conducted a community-based survey of 6,001 individuals in Tanzania, children under 15 years old accounted for 21.4% of all non-fatal road traffic injuries R with an incidence of 16.7 per 1,000 person-years in the 0–4 age group and 22.1 in the 5–14 age group. Most of these injuries occurred among male children (38.5% in 0–4 and 51.7% in 5–14). Children experienced an average of 25–34 disability days when injured, and 93% were injured as pedestrians. Half of all child road traffic injuries took place on highways, while small side streets accounted for 35.7% (15 out of 42 cases), indicating unsafe road environments. Playing was a common context for injury (8.2%), and most injuries were minor (86%), though 14% were classified as major, involving more than 30 days of disability. It was noted that, about 21.4% of the child road traffic injuries occurred while commuting to or from school.

2.2. Children as vulnerable road users

Vulnerable road users generally include pedestrians, bicyclists, motorcyclists, children, the elderly, and disabled (Abdulazeez et al., 2024). Children's vulnerability as road users stems from two key factors: first, their physical vulnerability as they are small and are still developing physically (Trifunovi´c, 2017), and, their functional vulnerability, which refers to their stages of cognitive and perceptual development, with many skills such as ability to estimate the vehicle speed and the distance they are from the vehicle (Thornton, 1999) and paying attention (Benjaminsen, n.d.) that are considered essential for safe traffic participation not fully developed until young adulthood (Peden et al., 2004). Traffic hazards to children stem from vehicles and road environments designed by adults for adults. Child pedestrians are less likely than adults to be seen from the driver's seat; younger children, particularly, are less likely to be fully aware of the dangers or be able to judge the speed and distance of an approaching vehicle; as pedal cyclists and novice drivers or riders, their skills are less developed; and particularly as adolescents, they may engage in risk-taking as part of their path to independence (UNECE, 2018). For all these reasons, WHO's Ten Strategies to Keep Children Safe on the Road encourage adults as road users, vehicle designers and road and urban planners, to fully and continually consider the vulnerabilities of children to road traffic injuries (UNICEF, 2023).

In addition, WHO outline that children need specific attention because if they are involved in a road traffic crash, they are more susceptible to more serious head injuries due to having heads softer than adults. Younger children may make weak judgement due to difficulties in interpreting sights and sounds, nevertheless they can't be attentive for a long time which makes it even more difficult to cope with many challenges at the same time (WHO, 2015). Another challenge with children is that, as they grow older when becoming adolescents then tend to take more risks, compromising their own safety on the road (WHO, 2015).

2.3. Road Safety Education and Awareness Among School Children

RSE refers to the deliberate effort to inform and empower road users, particularly vulnerable groups like children, with the knowledge, values, and skills needed to navigate traffic safely (Goddard et al., 2020; Wilde, 2001). It aims to shape attitudes and develop competencies that reduce road-related injuries and fatalities by cultivating safe decision-making in traffic environments. RSE not only includes formal

teaching in classrooms but also encompasses interactive and experiential learning such as road-crossing simulations, visual scanning tasks, and community-based campaigns. The fundamental rationale behind RSE lies in the assumption that young road users lack the cognitive maturity, knowledge, or experience to behave safely in complex traffic situations, and that educating them can significantly reduce their exposure to harm (Raftery & Wundersitz, 2016).

The significance of RSE has become increasingly apparent given the high incidence of traffic-related deaths involving children in developing countries (WHO, 2020). Children on foot, who form a large proportion of school commuters, are particularly at risk, due to their physical vulnerability and limited understanding of road dynamics (Kilbey et al., 2011; Ngunde et al., 2019). Rapid urbanization and increasing vehicular traffic further exacerbate these risks (González-Sánchez et al., 2021). Studies suggest that children below the age of ten are especially prone to traffic injuries, given their developmental limitations, smaller stature (which affects visibility), and often unsupervised journeys to school (Lee et al., 2018; Sangowawa et al., 2012). These conditions create an urgent need to embed RSE systematically within school systems, not as an ad hoc initiative, but as a critical part of children's right to safe mobility and education (Ackaah, 2010; Goddard et al., 2020).

In many developing countries, including Tanzania, RSE is nominally integrated into the basic school curriculum, often as part of civic or social studies, but its delivery remains inconsistent and underdeveloped (Biassoni et al., 2020). While policies may exist on paper, the actual implementation is hindered by a lack of teaching resources, limited teacher training, and poor alignment with practical road safety needs. As reported in similar contexts, some schools lack even the basic instructional materials for road safety, and there is little evidence that exam bodies systematically test road safety knowledge in subjects like civic education (Amoako-Sakyi, 2017; Raftery & Wundersitz, 2016). This limited instructional depth often leaves children without the necessary experiential learning opportunities to internalize safe road behavior. As Wilde (2001) notes, RSE must go beyond mere awareness, it must cultivate mature, actionable decision-making skills among children navigating real traffic environments.

Biassoni et al. (2020), in their study conducted in Arusha, Tanzania, examined the road-crossing behavior and visual scanning patterns of 303 school children aged 8 to 18 using static images of traffic scenes. The children were asked to identify safe crossing locations and explain their reasoning, while researchers recorded their eye movements. The study found that younger children predominantly applied role-learned rules like "look right–look left–look right," often failing to detect peripheral hazards such as approaching cyclists or obstructed visibility. Older students showed more flexible and informed visual scanning behaviors, considering contextual traffic risks more effectively. However, the researchers noted that systematic visual exploration was inconsistent across all age groups, suggesting a significant gap between classroom-based knowledge and real-world application. These findings underscore the critical need for practical, context-sensitive RSE that includes visual training and decision-making tasks, especially in countries like Tanzania where infrastructure and traffic conditions present heightened risks for young pedestrians.

2.4. Children road crossing behaviors

Understanding children's behavior is crucial to developing effective safety strategies (Grayson, 1981). Observational studies indicate that children often neglect critical safety steps, such as checking for oncoming traffic before crossing (Rosenbloom et al., 2008; Zeedyk et al., 2002). Despite awareness of

safety rules, many children fail to apply them consistently in real-world settings (Ampofo-Boateng & Thomson, 1991).

Ampofo-Boateng and Thomson (1991) investigated children's perception of safety and danger on the road, highlighting that children often struggle to accurately assess risks due to limited cognitive and perceptual abilities. Their study found that children's traffic scanning skills were underdeveloped, making them more vulnerable to accidents. Expanding on this, Zeedyk et al. (2002) examined what children do when crossing roads, rather than what they are taught to do. Zeedyk et al. (2002) revealed that despite educational messages emphasizing the need to "stop, look, listen, and think," children often fail to consistently apply these safety behaviors, leading to risky pedestrian decisions. Similarly, Underwood et al. (2007) explored how age and gender influence children's perceptions of road risks, finding that children, particularly boys, exhibit greater risk-taking tendencies and struggle to gauge vehicle speed and distance accurately.

Another study done by Meir et al. (2015) further examined children's ability to identify hazardous traffic situations using a virtual reality environment. Their findings emphasized that many young pedestrians lack the necessary hazard perception skills to make safe crossing decisions. Collectively, these studies highlight key behavioral factors, including inattentiveness, distractions, and poor hazard perception, that contribute to child pedestrian accidents, underscoring the need for targeted RSE and intervention programs.

It has been also proven that children look for convenience rather than safety when crossing the road. Ampofo-Boateng et al. (1993) conducted a developmental and training study investigating children's ability to identify safe routes for road crossing. Their research examined how children of different ages assessed road-crossing locations and found that younger children often struggled to recognize safe crossing points, instead opting for the most convenient and direct routes. The study emphasized the role of cognitive development and experience in shaping children's pedestrian behaviors.

Additionally, studies employing unobtrusive video recordings have also identified key behavioral norms among child pedestrians, shedding light on frequent violations of pedestrian safety practices. Schwebel et al. (2018) conducted a case study in Changsha, China, observing street-crossing behaviors outside a primary school. Their study documented frequent risky actions, such as crossing outside designated areas and failing to look for oncoming traffic, emphasizing the gap between taught pedestrian rules and real-world application. This study highlights the need for targeted interventions to reinforce pedestrian safety norms, particularly addressing the observed inconsistencies between knowledge and behavior in children's road-crossing practices.

In Tanzania, limited studies have been done regarding children's pedestrian behaviors, for example, Perego et al. (2019) conducted a study analyzing children's pedestrian behaviors and road safety awareness in Tanzania. The research highlighted significant gaps in RSE, with many children failing to scan their surroundings properly before crossing. The study found that 90% of participants (aged 8–18) focused only on specific areas of the road, ignoring potential hazards from other directions. This behavior was attributed to inadequate road safety training and possible cultural fatalism regarding road accidents. Although this study give important insights on the Tanzania's context, this study was conducted in-class hence missed the chance to capture the behaviors in the actual world. Nevertheless, there is no literature on how road crossing behaviors of school children is attributed by different factors in Tanzania

2.5. Factors influencing child pedestrian behaviors

Various studies have identified multiple factors that influence child pedestrian behavior, including peer influence, parental supervision and accompanying, gender, traffic characteristics, and crossing conditions such as traffic volume. These factors play a significant role in determining children's safety when navigating roads.

2.5.1. Gender

Gender has been identified as a factor that may influence children's pedestrian behavior, though findings across studies vary in strength and context. Research from both developing and developed countries suggests that boys may be more likely to engage in unsafe or impulsive behaviors while crossing roads compared to girls (Riaz et al., 2022; Schwebel et al., 2018). This disparity has been attributed to developmental differences, social norms, and behavioral tendencies such as greater risk-taking among boys (Underwood, 2007).

Schwebel et al. (2018) conducted a detailed observational study outside a primary school in Changsha, China, assessing child pedestrian behavior in a busy traffic environment. Their findings revealed that male children were significantly more likely, among other unsafe behaviors, to run across the road than female children. Specifically, being male increased the odds of running by approximately 122% (OR = 2.22; $p = 0.001$), a behavior associated with greater pedestrian risk. This gender-based difference may reflect higher impulsivity or a stronger inclination toward risk-taking in boys.

Additionally, Riaz et al. (2022) conducted a study that focused specifically on schoolchildren's pedestrian behavior and its relation to gender. While there were no significant differences in overall crossing behavior between boys and girls at each school site, a notable difference emerged in one key behavior: stopping at the curb before crossing. Boys were significantly less likely to stop at the curb, an important safety measure, compared to girls, $\chi^2(1) = 4.155$, $p = 0.042$. It was showed that girls had 1.91 times higher odds of exhibiting this safer behavior. These findings support the notion that while general crossing behavior may not vary dramatically by gender, specific high-risk actions tend to be more prevalent among boys.

2.5.2. Peer Influence

Peer influence significantly shapes children's pedestrian behaviors. Preffer and Hunter (2013) examined how children's crossing decisions were affected by the presence of peers. Their study found that children were more likely to engage in riskier crossings when accompanied by peers, particularly under social pressure to keep up with a group. Similarly, Tolmie et al. (2005) conducted an experimental study where children participated in group discussions before making pedestrian decisions. While peer discussions sometimes improved risk assessment, they also led to overconfidence, causing children to make unsafe crossing decisions in real traffic conditions.

Additionally, peer influence can vary based on the composition of the group. Research suggests that younger children in mixed-age groups are more likely to follow the decisions of older children, sometimes adopting riskier behaviors as a result (Morrongiello & Barton, 2009). On the other hand, when children are in groups with similarly aged peers, they may engage in competitive behaviors that increase their likelihood of crossing unsafely. Social dynamics such as peer encouragement or dares can further contribute to risky

pedestrian behavior, emphasizing the need for targeted interventions that address peer-related decision-making in road safety programs.

2.5.3. Parental accompanying

Parental supervision strongly influences pedestrian safety. Barton and Schwebel (2007) tested how the presence of an adult affected children's crossing decisions in both real and simulated environments. They found that children who crossed with an adult demonstrated better traffic scanning behavior, checked both directions more frequently, and made safer crossing choices. However, children who walked alone often misjudged vehicle speed and distance, leading to more dangerous crossing attempts. Morrongiello and Barton (2009) further explored the role of supervision, analyzing how different types of parental intervention, such as verbal warnings versus physical guidance, affected safety. Their results indicated that while verbal instructions made children more cautious, direct physical intervention (such as holding hands) was the most effective in preventing unsafe crossings.

Beyond the immediate effects of supervision and accompanying, long-term parental guidance plays a crucial role in shaping children's pedestrian habits. Parents who frequently discuss road safety and model safe behaviors contribute to their children's development of independent pedestrian skills. However, research also suggests that overly restrictive supervision may delay children's ability to assess and respond to traffic risks on their own (Schwebel et al., 2018). Striking a balance between guidance and independent decision-making is essential for fostering responsible pedestrian behaviors.

2.5.4. Age

Studies on cognitive development indicate that younger children lack essential crossing skills, such as risk assessment, visual scanning, and compliance with traffic laws (Rosenbloom et al., 2008; Zeedyk & Kelly, 2003). These skills improve with age and experience. Children aged 6 to 10 years have limited attentional capacities, making them more vulnerable, particularly when distracted (Schwebel et al., 2018). Research also shows gender differences in risky behavior, with boys displaying greater confidence and underestimating risks compared to girls (Granié, 2007).

Furthermore, as children grow older, their ability to judge vehicle speed and distance improves, leading to safer road-crossing behaviors. However, adolescents may exhibit increased risk-taking behaviors due to heightened impulsivity and peer influence. Developmental studies indicate that while older children have improved cognitive abilities for risk assessment, they may still engage in dangerous crossings when distracted by mobile devices, conversations, or environmental stimuli. This underscores the need for age-specific educational programs that evolve with children's cognitive and perceptual development.

A study done by Biassoni et al. (2020) in Arusha, Tanzania to investigate children's visual exploration patterns and road-crossing behaviors found that younger children tend to follow a rigid "look left-right-left" pattern, often neglecting peripheral hazards, whereas older children adopt a more flexible gaze that includes side areas where other road users, such as cyclists and pedestrians, may emerge. Although this study provide insight in the influence of age on scanning for potential hazards, it does fully represent the real situation

because the students where given a set of pictures to scan the right place to cross. There is still a need to conduct a study of this nature in real situation s where many factors come into play.

2.5.5. Traffic Characteristics

Barton & Morrongiello (2011) conducted a research study examining the impact of traffic environment and executive functioning on children's pedestrian behaviors. Their findings indicated that while higher traffic volume remains a significant predictor of pedestrian behavior, the study highlighted that higher volumes of traffic and greater speed and efficiency in attention were linked to more observation of traffic before crossing, meaning that children are more likely to cross the road safely when it is more dangerous.

A study by Riaz et al. (2022) on the street-crossing behavior of primary school children with adult supervision highlighted that unsafe road-crossing behaviors, such as not stopping at the curb, not looking for traffic, running while crossing, distractions, and not using the crosswalk, varied by gender and the type of street (one-way or two-way). However, while Riaz et al. (2022) provided insight into variability due to traffic type, they did not explore other parameters such as vehicle speed and traffic volume.

2.6. Children road crossing behavior-prediction Models

The modeling of pedestrian behavior is an important tool in better understanding the influential factors, as it enables the analysis of a large number of scenarios and potentially dangerous interactions, without affecting the actual system and endangering the safety of pedestrian movements (Deluka-Tibljaš et al., 2022).

The analysis of pedestrian traffic safety is a very complex task, because many factors have an impact on pedestrian behavior. Modeling of pedestrian behavior is an important tool in better understanding influential factors, as it enables the analysis of a large number of scenarios and potentially dangerous interactions, without affecting the actual system and endangering the safety of pedestrian movements (Deluka-Tibljaš et al., 2022).

A study by Riaz et al. (2022) utilized binary logistic regression analysis to examine child pedestrian crossing behavior, considering various independent variables such as gender, school location, and the presence of an accompanying adult. This model was selected due to its ability to predict the probability of a specific event occurring when the dependent variable is dichotomous. The analysis involved computing frequencies and percentages of coded behaviors, followed by Pearson chi-square tests to determine significant differences among groups. Additionally, the Hosmer–Lemeshow test was employed to assess the model's goodness of fit, ensuring its reliability in predicting child pedestrian behavior patterns. The study further emphasized the importance of interrater reliability, using Cohen's kappa and percent agreement to validate observational consistency. Despite its strengths, the study had several limitations. First, limited data collection duration of data collection also raises concerns about the generalizability of findings across different times and conditions. Additionally, while behavioral observation is beneficial, it lacks insights into underlying factors such as traffic volume, vehicle speed and peer influence. Also, this study was done in a developed country, Belgium, so it may not fully represent the context in the developing countries like Tanzania.

Scholars like Gitelman et al. (2019) have modelled child-pedestrian behaviors at crosswalks of urban intersections, aiming to characterize their behavior patterns and identify risk factors that may lead to injury. In their study, they used multivariate logistic regression models to identify factors associated with crossing on red and with non-checking vehicle traffic at unsignalized crosswalks. The results showed that in addition to the age of children, different attention distractors have a significant impact on children's unsafe road crossing behaviors. Although this study gives insight about modelling child pedestrian behaviors, its focus is at the intersection which may not fully represent children road crossing behaviors at the mid-block sections.

The research by Pinna & Murrau (2018) examined the relationship between age and pedestrian speed, specifically considering pedestrian movement on sidewalks under real conditions. It focuses on individuals walking within a pedestrian flow, where interactions with others influence their speed. The analysis reveals that the relationship between speed and age is not linear; instead, a polynomial model incorporating mean individual pedestrian speed, mean walking speed, and age class provides a more accurate representation of pedestrian behavior. However, the study has certain limitations. It was conducted in a restricted area (a city downtown) and only during weekends, which may not fully capture variations in pedestrian behavior across different environments and time periods. Additionally, while the model effectively explains the influence of age and walking speed, it does not account for other potential influencing factors such as peer influence, road and traffic characteristics, or gender. Nevertheless, the study was done for all range of pedestrian age but did not focus on school children only.

CHAPTER THREE

THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1. Key conceptual terms underpinning the study

The main concepts in this study include road safety awareness, RSE, road crossing behavior, traffic characteristics, and school area or school zone.

3.1.1. Road Safety Awareness

Road safety awareness refers to the level of understanding, perception, and mindfulness that individuals, have regarding traffic dangers and the importance of protective behaviors on roads. Among children, this awareness is shaped not only by direct experiences and social interactions but also by formal and informal educational efforts (Perego et al., 2019). In contexts such as Tanzania, road safety awareness among school children has been shown to be low, with many unable to identify hazards beyond their immediate visual focus, which increases their exposure to risk (Biassoni et al., 2020; Perego et al., 2019). This limited awareness often stems from inadequate training at both school and community levels. Road safety awareness is therefore not just a knowledge issue, it reflects a broader socio-environmental engagement with road safety as a public concern.

3.1.2. Road Safety Education

RSE is a structured effort aimed at equipping road users, especially vulnerable populations like school-aged children, with knowledge, skills, and values necessary for safe participation in traffic environments (Raftery & Wundersitz, 2016; Wilde, 2001). It involves both classroom-based instruction and experiential learning methods such as road-crossing simulations and visual scanning exercises (Biassoni et al., 2020). The foundation of RSE lies in the understanding that children, due to developmental and cognitive limitations, often lack the maturity to accurately assess traffic risks (Ampofo-Boateng & Thomson, 1991). However, implementation in many developing countries remains inconsistent due to resource constraints and lack of practical emphasis in curricula (Amoako-Sakyi, 2017; Goddard et al., 2020).

3.1.3. Road Crossing Behaviors

Road crossing behaviors describe the set of actions and decisions pedestrians make when navigating across roads, which can be categorized as either safe or unsafe. Safe behaviors include practices such as stopping at the curb, looking both ways, and using designated crossing points, while unsafe behaviors include darting into traffic, failing to look for vehicles, and crossing at unmarked locations (Schwebel et al., 2018; Zeedyk et al., 2002). Research shows that while children are often taught to follow safety rules, many fail to consistently apply them in real-life scenarios due to developmental constraints and distractions (Ampofo-Boateng et al., 1993; Meir et al., 2015). Moreover, children may prioritize convenience over safety when selecting crossing points, highlighting the need for repeated, context-specific training (Biassoni et al., 2020; Perego et al., 2019). These behaviors are shaped not just by individual understanding, but also by demographic, social and traffic conditions surrounding the child.

3.1.4. Road and traffic Characteristics

Traffic characteristics refer to the specific features of vehicular movement and road conditions that influence pedestrian safety. These include vehicle speed, traffic density, driver behavior, road infrastructure, and the presence or absence of pedestrian-friendly amenities like zebra crossings and sidewalks (Schwebel et al., 2018). In the context of school environments, high traffic volumes and speeding are particularly dangerous as they reduce driver response times and increase the severity of potential collisions (WHO, 2015). Additionally, children often struggle to judge speed and distance accurately, further amplifying their risk in high-traffic areas (Thornton, 1999; Underwood et al., 2007).

3.1.5.School Area / School Zone

A school area or school zone refers to the geographical zone surrounding a school, typically characterized by high pedestrian activity from students during morning arrival and afternoon dismissal times, covering an area within 500 meters from the school gate (Harrison, 2013). These zones are expected to have enhanced safety measures such as lower speed limits, signage, and traffic calming infrastructure to protect vulnerable road users like children, as it is believed, school children are primarily more involved in these school zones (Harrison, 2013; UNECE, 2018). However, in many low-income countries, school zones lack basic safety infrastructure, leaving children to navigate complex and hazardous road environments (Biassoni et al., 2020; Perego et al., 2019). Well-designed school zones can play a pivotal role in reducing road traffic injuries among children by creating safer walking environments

3.2. Theoretical Framework

This theoretical framework provides a foundation for understanding children's road-crossing behavior in school zones by focusing on the various factors that influence their pedestrian decisions. Integrating insights from road safety and behavioral theories, this framework guides the analysis of individual, social, road and traffic characteristics shape children's crossing practices and contribute to road safety risks. As Bhattacherjee (2012) suggests, theories help to systematically explain behaviors by linking abstract concepts to real-world phenomena, thereby enabling a structured approach to studying complex interactions such as those affecting child pedestrian safety.

3.2.1. Ecological Systems Theory

The Ecological Systems Theory, developed by Urie Bronfenbrenner (1979), provides a useful framework for understanding the multifaceted influences shaping children's road crossing behavior. The theory states that there are levels which shape human behavior based on the interaction. The levels are the micro, meso, exo, macro, and chrono levels. The theory highlights how children's decisions are influenced not only by individual traits but also by environmental and systemic forces.

At microsystem, children's pedestrian behavior is directly shaped by daily interactions within their family, school, and neighborhood. Parental supervision and school-based RSE form the child's primary sources of knowledge and guidance on how to cross roads safely (Biassoni et al., 2020). However, children frequently demonstrate limited visual scanning behaviors and tend to rely on rote-learned rules rather than adaptively responding to dynamic traffic conditions (Perego et al., 2019). This reflects both developmental limitations and a lack of immediate environmental supports, such as pedestrian signage or marked crossings. Additionally, children often focus narrowly on small sections of the road, ignoring wider traffic dynamics,

an attentional pattern tied to cognitive development and inadequate local infrastructure (Biassoni et al., 2020).

Mesosystem level examines the interconnections between microsystems, such as the relationship between home and school. When parents and teachers offer consistent messaging about road safety, children are more likely to internalize safe behaviors. However, if children observe adults (including parents or other community members) violating pedestrian rules, such as crossing unsafely or ignoring traffic signals, these conflicting cues can weaken the effects of formal safety education (Zeedyk et al., 2002). Such inconsistency between what children are taught and what they observe in their environment undermines their ability to form coherent safety strategies, increasing risk-taking behaviors.

At exosystem level, broader environmental and institutional settings, though not directly experienced by children, still exert powerful influence. For instance, parental work schedules may limit opportunities for adult supervision during commuting times. Similarly, urban planning decisions and road design often fail to consider children's unique needs, placing them in unsafe traffic environments (WHO, 2015). The absence of pedestrian infrastructure such as sidewalks, speed bumps, and school-zone signage reflects an adult-centric urban model that overlooks child safety (WHO, 2015).

The macrosystem encompasses overarching societal norms, legal systems, and cultural attitudes toward road use and child independence. In many developing contexts, including parts of Africa, pedestrian safety is deprioritized in transport planning, and the enforcement of traffic regulations remains weak (WHO, 2015). Cultural acceptance of informal mid-block crossings and limited emphasis on child-centered safety policies contribute to the normalization of risky behaviors and systemic exposure to harm.

3.3. Conceptual Framework for the Study

This study conceptualizes children's road-crossing behavior as influenced by factors like child characteristics, road & traffic characteristics, and environmental & social influences. These factors as can be seen on figure 2, collectively shape children's behavior when crossing roads, which in turn affects the occurrence of road crashes. Understanding these influences is essential for designing effective interventions to enhance child pedestrian safety.

3.3.1. Child Characteristics

Child characteristics refer to individual attributes that influence how children perceive and interact with road environments during crossing. These traits determine the child's ability to recognize risk, make decisions, and behave safely while navigating midblock roads. In this study, three aspects of child characteristics are considered critical: gender, risk perception, and RSE. Each plays a role in shaping the likelihood of safe or unsafe crossing behavior, and they are important to examine when analyzing pedestrian behavior among school children.

Gender is a relevant factor because children may differ in how they behave on the road depending on whether they are male or female. Boys are more likely than girls to cross without stopping at the curb, suggesting a tendency toward less cautious behavior (Riaz et al., 2022). These behavioral differences may

relate to social norms or developmental traits and contribute to variation in exposure to danger while crossing.

Risk perception relates to how children interpret and respond to the presence of danger in a road environment. Younger children often have limited ability to detect vehicle speed, recognize obstructed views, or assess the right time to cross. Many apply rote rules such as “look right–look left–look right” but fail to adapt to complex traffic contexts like hidden cyclists or unclear road edges (Biassoni et al., 2020). As such, the maturity of a child's risk perception has a direct influence on whether their crossing behavior is safe or unsafe.

RSE provides children with knowledge and skills to navigate traffic situations more safely. RSE includes classroom lessons, hands-on training, community campaigns, and visual scanning tasks. Its aim is to strengthen a child's ability to make decisions in real traffic settings, not just to recite rules (Goddard et al., 2020; Wilde, 2001). In many low-income settings, including Tanzania, RSE is introduced through school subjects like civics, but the instruction is often superficial and lacks practical application. There are limited learning materials, minimal teacher training, and little alignment with local traffic realities (Amoako-Sakyi, 2017; Raftery & Wundersitz, 2016). Without applied learning, children may understand basic concepts but remain unable to transfer that knowledge to real-world road situations (Biassoni et al., 2020).

These child-specific factors, gender, and exposure to RSE are essential in understanding how children behave at midblock crossings. Studying them provides insight into why some children take appropriate precautions while others take unnecessary risks, thereby influencing the development of targeted interventions.

3.3.2. Road & Traffic Characteristics

Road and traffic characteristics refer to the physical design and operational dynamics of road environments that influence how road users behave, particularly child pedestrians. These characteristics shape the level of safety, visibility, and decision-making opportunities available to children as they attempt to cross roads. Understanding these factors is essential in analyzing midblock road-crossing behavior, as they present both risks and cues that affect children's judgment and timing during crossing. This study focuses on four key aspects: number of lanes, presence of pedestrian crossings, traffic volume, and vehicle speed. Each of these factors plays a distinct role in influencing how children assess and respond to road-crossing situations.

The number of lanes on a road determines the complexity and duration of a crossing task. Roads with multiple lanes increase the distance children must cover and require them to evaluate more vehicle movements, hence different width of the road may affect the crossing behavior (Riaz et al., 2022). Riaz et al. (2022) found that unsafe crossing behaviors such as not stopping at the curb or running while crossing varied by whether the road was one-way or two-way. One-way streets can mislead children into thinking traffic is less dangerous due to fewer directions of vehicle flow. However, such streets often encourage higher vehicle speeds and introduce more turning movements at intersections, leading to increased pedestrian-vehicle conflicts (Federal Highway Administration, 2018; Walker et al., 2000).

Additionally, the presence of designated pedestrian crossings, especially midblock crossings, can offer safer crossing options for children. These crossings give priority to pedestrians, requiring vehicles to yield when both enter the area simultaneously (Apardian & Alam, 2017). Further, infrastructure such as elevated crosswalks enhances visibility and encourages drivers to reduce speed. Also, elevated crossings contribute positively to reducing accidents involving children (Bhuiyan, 2019; Pawar & Patil, 2015).

Traffic volume is another critical element. Higher volumes may initially seem more dangerous; however, research by Barton and Morrongiello (2011) indicates that children exposed to busier traffic tend to engage in more frequent traffic scanning and cautious behavior. In other words, when the traffic environment is visibly risky, children are more likely to adjust their behavior accordingly. This suggests that traffic density can serve as both a hazard and a behavioral cue.

Lastly, vehicle speed significantly influences children's safety. Higher speeds reduce the time drivers have to react and increase stopping distances. In environments where drivers travel at greater speeds children may face heightened risks and perform unsafe behaviors, especially if they are unable to accurately estimate vehicle approach speed or distance (Wang et al., 2019).

In summary, road and traffic characteristics, including number of lanes, type of crossing infrastructure, traffic volume, and vehicle speed, constitute a crucial component of this study. These factors affect not only the physical risk but also how children perceive and respond to their environment, thereby shaping their crossing behavior in measurable ways.

3.3.3. Social Influences

Social factors refer to the influence that individuals or groups exert on the behavior, perceptions, and decisions of others within a shared environment. In the context of children's road-crossing behavior, social factors may include the presence of peers, family members, or other adults, and the nature of interactions that occur in such settings. These factors are important because children do not make crossing decisions in isolation; instead, their choices are often shaped by those around them, whether through direct supervision, social pressure, or observed behavior.

In this study, two key social factors are considered: peer influence and parental supervision. These are particularly relevant for understanding how children behave in mid-block crossing situations, where traffic control mechanisms may be absent and decisions must be made quickly and independently.

Peer influence refers to the impact that other children or adolescents may have on a child's behavior, either directly through encouragement and group dynamics, or indirectly through social expectations. The presence of peers has been shown to affect the level of caution children exercise when crossing the road. According to Preffer and Hunter (2013), children accompanied by peers are more likely to engage in unsafe crossing behaviors, especially when under pressure to keep pace with the group. In this sense, peer presence may increase impulsiveness and reduce individual attention to traffic conditions.

In group settings, children may also develop a false sense of security or overconfidence. Tolmie et al. (2005) found that group discussions among peers, although sometimes beneficial in promoting risk awareness, can

also lead to poor judgment in real crossing scenarios. In addition, Morrongiello and Barton (2009) point out that younger children may imitate the behavior of older peers, sometimes engaging in unsafe practices such as crossing without checking for traffic. These findings suggest that peer influence is a critical component in shaping children's decisions and behaviors at mid-block crossings, and therefore warrants close attention in road safety analysis.

Parental accompanying or supervision, on the other hand, involves the presence and involvement of an adult usually a parent or caregiver in guiding or controlling a child's behavior. This factor plays a significant role in ensuring safety and reducing risk. Barton and Schwebel (2007) demonstrated that children accompanied by adults tend to make safer crossing decisions, characterized by proper scanning of the road and cautious movement. The physical presence of an adult not only offers immediate protection but also sets a behavioral standard that children may internalize over time.

However, the nature of accompanying matters. Morrongiello and Barton (2009) note that while verbal instructions can encourage careful behavior, physical contact such as holding hands is more effective in preventing unsafe actions. In some cases, the pattern of adult supervision varies by gender. As observed by Zeedyk & Kelly (2003) and Barton & Schwebel (2007), adults are more likely to hold hands with girls than with boys, despite the fact that boys are generally more prone to impulsive and unsafe behaviors in traffic. Moreover, adults do not always seize the opportunity to teach children safe crossing habits. Zeedyk & Kelly (2003) observed that many adults failed to guide children in checking for oncoming traffic, missing critical moments for safety education.

Taken together, these social factors, peer influence and parental accompanying, are integral to understanding children's road-crossing behavior in the urban context. They not only affect immediate decision-making but may also shape long-term habits and risk perception. Their inclusion in this study is therefore essential in analyzing the behavioral dimensions of child pedestrian safety at mid-block crossings.

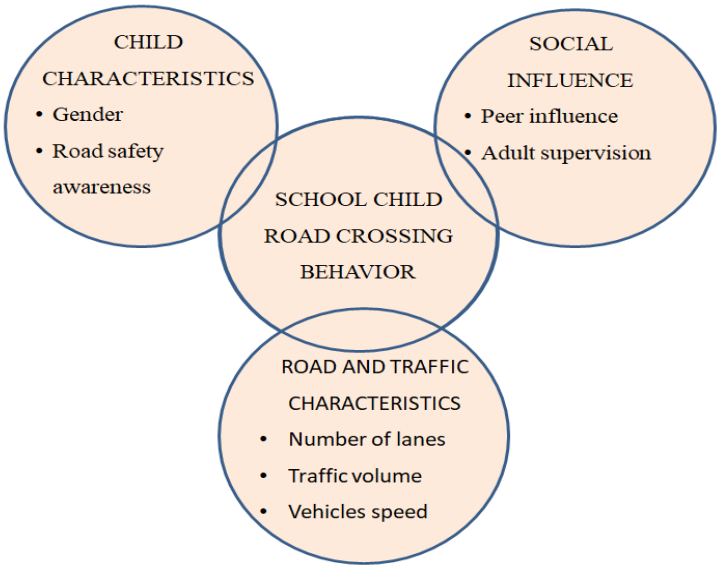


Figure 1: Conceptual framework (Author, 2025)

CHAPTER FOUR

METHODOLOGY

4.1. Research strategy

This study employed a case study research strategy using a mixed-methods approach, utilizing only quantitative data, hence a quantitative approach will be used. A case study strategy allows the integration of various data collection and analysis techniques to generate comprehensive insights into complex issues (Creswell, 2015). Nevertheless, the case study strategy is suitable when the research involves "how" and "why" questions, focuses on real-world contemporary phenomena, and allows the researcher access to actual behaviors and processes (Yin, 2018). This strategy was selected based on the nature of the research problem and the research questions of the study. Dar es salaam was selected as the case study due to its complex traffic nature which will allow to capture more information regarding the study matter.

The quantitative approaches used in this study enabled a detailed and systematic investigation of children's road-crossing behaviors and the various factors influencing them. By employing structured observation and statistical analysis, the study was able to quantify behavioral patterns, assess associations with variables such as gender and environment, and draw objective conclusions based on measurable data. Quantitative research is particularly suitable when the goal is to examine relationships among variables and to generalize findings from a sample to a population (Creswell). Similarly, Kothari (2004) emphasizes that quantitative methods allow for precision, replicability, and statistical validation, making them ideal for studies that seek to analyze behavioral trends across a defined group. In this context, the quantitative approach proved effective in revealing not only how children behave when crossing roads but also how these behaviors relate with other factors.

4.2. Selection criteria for case study schools

This study was conducted in Dar es Salaam as it is the Tanzania's most motorized city, which features a wide range of road infrastructures with varying levels of complexity (TANROADS, 2024). The city is home to 953 primary schools, of which 419 are publicly owned (PO-RALG, 2024). Some of these schools were located near roads with different traffic characteristics, including trunk, regional, collector and access roads, some of which are paved while other are unpaved (TARURA, 2022; TANROADS, 2024).

For the purpose of this study, only publicly owned primary schools were considered. This was because children attending private schools were typically transported using school buses, which significantly reduced their likelihood of independently crossing roads around school areas. Consequently, such schools were deemed inapplicable for analyzing pedestrian crossing behaviors and were excluded from the study.

To ensure a comprehensive understanding of children's road-crossing behavior in school environments, a set of criteria was developed to guide the selection of case study schools. These criteria were carefully aligned with the overall objectives of the study to ensure that the selected sites provided relevant, diverse, and representative insights. Each criterion is outlined and explained in detail below.

i. Proximity of schools to trunk roads

The selection of schools for this study considered their proximity to major trunk roads, specifically targeting schools situated within 500 meters of a trunk road, a zone commonly referred to as the school zone. This proximity ensured that the selected schools were directly exposed to the dynamics of high-speed and high-volume traffic environments. Trunk roads were purposefully chosen because they pose greater risks to child pedestrians due to the frequency and intensity of vehicle movement, which heightens both the likelihood and severity of road traffic injuries (Stoker et al., 2015). Furthermore, schools located near these roads often require children to engage in midblock crossing behavior due to the absence of designated crossings, which is associated with a higher probability of fatal outcomes compared to intersections (Siddiqui et al., 2006). Selecting such a challenging environment aligns with the principle of pushing cases to their most extreme or information-rich settings, as recommended by Patton (1987), Flyvbjerg (1999), and Seawright and Gerring (2008), in order to generate deeper insights into pedestrian risk and behavior under conditions of heightened vulnerability.

ii. Necessity of midblock crossing

Another selection criterion was the necessity of midblock crossing. Schools were selected based on whether their surrounding road environments compelled children to cross at midblock locations rather than designated intersections. This was important because midblock crossings typically lack formal pedestrian infrastructure such as traffic signals or marked crosswalks, making them significantly riskier than crossing at intersections (Siddiqui et al.,2006). This elevated risk is largely attributed to the absence of vehicle-to-vehicle conflicts at midblock segments, which encourages drivers to increase their speed, thereby reducing their ability to react to pedestrian movements. By selecting school locations where midblock crossing is necessary, the study aimed to observe children's behavior in high-risk, unregulated environments, providing a more accurate assessment of pedestrian vulnerability in real-world school zone conditions.

iii. Number of students

To ensure adequate observation for achieving the required sample size and enabling reliable behavioral analysis, the study selected schools with the highest student populations among those located within 500 meters of trunk roads. A larger student body increases the frequency and diversity of pedestrian activity, thereby enhancing the opportunity to observe a wide range of road-crossing behaviors. To maximize the variability of road and traffic characteristics, two schools with the highest number of students were selected from each of the following trunk road types: two-lane two-way roads, (one lane per direction) dual carriageways (two lanes per direction), and multi-lane roads (three lanes per direction). This variation allowed the study to capture behavioral responses across different traffic conditions. Moreover, high-enrollment schools were intentionally chosen for their potential to provide information-rich cases, which are considered essential in case-oriented research (Patton, 1987). By focusing on these dense school zones, the study ensured both analytical depth and a broader representativeness of the road-crossing challenges faced by school children. Student enrollment data were retrieved from the President's Office – Regional Administration and Local Governments (PO-RALG) database.

From the first and second criteria, 38 schools qualified out of 419 schools, and after using the third criterion to further narrow down the schools, 6 qualified which are Mzinga and Mtambani primary school which are close to Bagamoyo and Kilwa road (as can be seen on figure 5) respectively (one lane per direction), Mbagala and Mtoni primary school which are close to Kilwa road as can be seen on figure 6 (two lanes per

direction) and Kibamba and Upendo primary school which are close to Morogoro road as can be seen on figure 7 (three lanes per direction) as located in figure 4 and described in table 2.

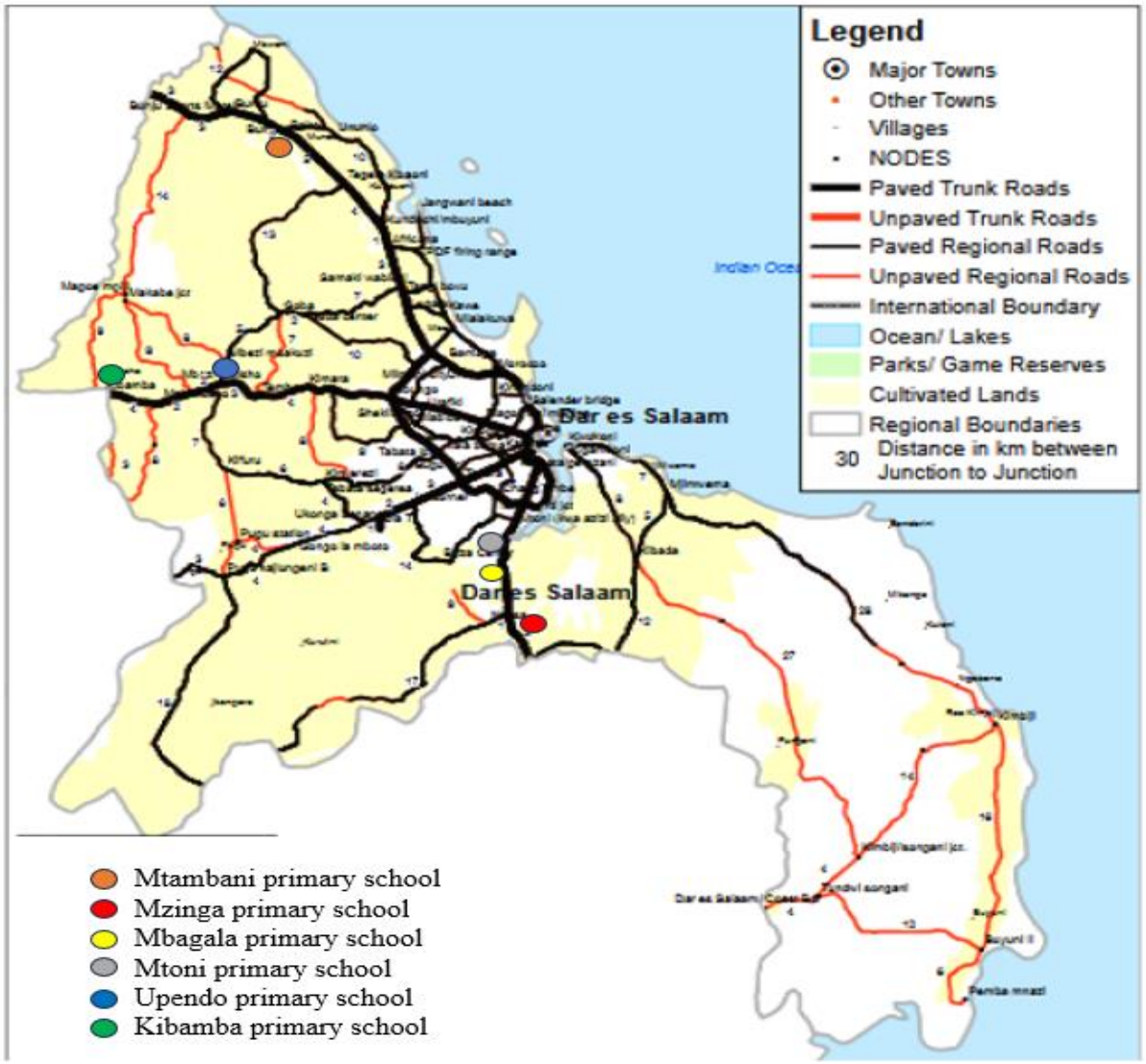


Figure 2: Map of Dar es Salaam showing the selected schools for case study

Table 1: Characteristics of roads passing the selected school

Name of school	Name of the road passing by	Number of lanes per direction
Mtambani	Bagamoyo road	1
Mzinga	Kilwa road	
Mbagala	Kilwa road	2
Mtoni		

Kibamba	Morogoro road	3
Upendo		

Figure 3: One lane per direction road passing close to Mzinga primary school (Author, 2025)

Figure 4: Two lanes per direction road passing close to Mbagala and Mtoni primary school (Author, 2025)

Figure 5: Three lanes per direction road passing close to Upendo and Kibamba primary school (Author, 2025)

4.3. Sample size

A representative sample was used to capture the characteristics of each selected school. The sample size for this study was determined to support subsequent binary logistic regression analysis, with the aim of examining the influence of selected factors on children's road-crossing behavior. The model includes one binary dependent variable (crossing behavior: safe vs unsafe) and four independent variables, with data collected from six different school zones.

To ensure the sample size was adequate for detecting statistically meaningful effects, an a priori power analysis was conducted using G*Power software under the Z-test family, selecting the logistic regression test. Several key parameters guided this analysis:

i. Effect size (odds ratio) = 2.0: This value corresponds to a medium effect size based on commonly accepted benchmarks (Cohen, 1988; Faul et al., 2009). It reflects the assumption that the odds of safe crossing behavior are twice as high for one group compared to another, a plausible expectation in behavioral safety research (Biasson et al., 2008).
ii. Alpha error probability = 0.05: This conventional threshold indicates a 5% risk of rejecting the null hypothesis when it is true (Type I error), commonly used in social and behavioral sciences to balance the risks of false positives and missed detections (Creswell & Creswell, 2018).
iii. Power (1–β error probability) = 0.80: A power of 0.80 means there is an 80% chance of correctly detecting a true effect (Cohen, 1988). This level is widely accepted as sufficient to reduce the risk of Type II errors.

iv. Number of predictors = 6: Although the primary model includes four key independent variables, additional site-level or demographic covariates may be introduced, warranting this conservative estimate to avoid underpowering the model.
v. Assumed probability of outcome ($Pr(Y = 1 \mid X = 1)$) = 0.3–0.5: This range reflects realistic expectations based on prior research in road safety and pedestrian behavior, where risky behaviors may account for 30% to 50% of observed cases, depending on context (Rosenbloom et al., 2008).
vi. R^2 of other predictors = 0: This conservative assumption indicates no overlap in predictor variance, ensuring the required sample size is not underestimated.

Based on these specifications, the minimum required sample size from G power software to detect a medium effect was estimated at 472 to 500 participants. A total sample size of 600 children, 100 observations per each of the six study sites, was therefore selected and their summary of the observed students can be seen on table 3. This not only exceeds the minimum requirement to maintain adequate statistical power but also provides room for handling potential data loss and supports subgroup analysis across different school environments. The balanced distribution across sites further ensures regional representation and variability in road and traffic characteristics.

Table 2: Demographics of the questionnaire participants (Author, 2025)

	Observed students		Questionnaire participants							
			Female				Female			
	Male	Female	Age				Age			
			< 9	10	11	>12	<9	10	11	>12
Mzinga	52	48	6	18	17	9	8	13	19	10
Mtambani	51	49	11	10	14	15	8	15	16	11
Mtoni	45	55	5	18	17	10	9	21	12	8
Mbagala	52	48	9	9	10	22	5	10	19	16
Kibamba	48	52	8	14	21	7	11	14	16	9
Upendo	46	54	7	12	16	15	6	14	17	13

4.4. Data collection methods

To address the research questions comprehensively, quantitative data were collected using a range of appropriate methods to ensure a thorough analysis. The methods included individual survey, observation, measurements, and photographic documentation which used different data collection tools as shown in table 4. Each method is carefully selected to capture different aspects of the study, providing a well-rounded understanding of the subject matter and enabling triangulation of data for increased reliability and validity in the findings.

4.4.1. Observation

Detailed field observations were conducted at six purposively selected primary schools located near trunk roads in Dar es Salaam. The primary objective of the observation was to systematically document the road-crossing behaviors of school children during their commute to school, as well as to record physical road features that might influence pedestrian safety. Observations were carried out during morning hours, specifically between 6:30 AM and 8:00 AM, which corresponds with the peak time for school arrivals. This timing was selected to capture naturalistic behaviors during actual crossing scenarios. Each school was observed for two consecutive school days, allowing for variability in conditions such as weather, traffic flow, and supervision.

A non-participant, concealed observation approach was employed to ensure that the presence of researchers did not influence or alter the children's natural behavior. Observer were positioned at a discreet distance, allowing for a clear view of the road and crossing activity without drawing attention. No interaction occurred between the observers and the school children or guardians during data collection.

The unit of observation was individual school children engaging in road-crossing behavior. For children crossed in a group, data like gender and number of vehicles passed before crossing were collected with reference with the child arrived first at the crossing area. Each observed crossing was documented for actions such as stopping at the curb, scanning for oncoming traffic, use of pedestrian facilities (if any), direction of the student while crossing (whether direct or diagonal), running or walking, whether the child was crossing while distracted and whether the school child was accompanied by an adult and the number of students in case of a group crossing. In line with the school children crossing behaviors observation, the observer had a field assistant who documented the number of vehicles passed while the school child was waiting for a gap to cross the road. In addition, contextual features of the road were recorded using a structured observation checklist, which included items such as the presence or absence of zebra crossings, signage and traffic speed calming measures.

At each observation site, the observer waited and documented a total of 100 crossings of the school children some being alone while others either in a group of school children or accompanied by an adult. All observations were recorded manually in real time using standardized forms to ensure consistency across all sites. To enhance reliability, the same trained observer team was used throughout the study. Data were later coded and analyzed to identify patterns in behavior, risky practices, and environmental factors contributing to pedestrian exposure to danger.

4.4.2. Questionnaires

Structured individual surveys were conducted with school children to assess their awareness, perceptions, and understanding of road crossing behaviors. The questionnaire was carefully designed to be simple and age-appropriate, ensuring that it matched the cognitive and reading abilities of the target respondents. According to Kothari (2004), it is essential to design research tools that consider the characteristics of the respondents to ensure validity and reliability of responses. In this case, the simplicity of the questionnaire was especially important given that participants were children. The survey focused on key areas such as

how students determine when and how to cross the road, their understanding of traffic rules, their perception of safe crossing locations, and their awareness of potential road hazards.

To ensure the students could read and comprehend the questions independently, the survey was administered only to students from Standard 4 to Standard 7, as children in lower grades may not yet possess adequate reading ability. The questionnaires were administered after the completion of observations at each school, ensuring that the survey did not influence the students' natural behavior during observation.

Figure 6: School children filling the questionnaires (Author, 2025)

A total of 100 students per school were surveyed, with an equal number of 50 boys and 50 girls. Participants were randomly selected during tea and religious break sessions, which allowed access to students from various standards in a shared space, enhancing the diversity and representativeness of the sample. To prevent copying and ensure the integrity of individual responses, students were seated at a distance from one another during the survey administration. The use of pre-designed, structured questionnaires helped maintain consistency in data collection across all six study sites. Researchers explained the purpose of the study to the participants and obtained verbal assent, maintaining ethical standards throughout the process.

4.4.3. Measurements

Measurements were taken to quantify key safety indicators, particularly the waiting time (patience) of students before crossing and the speed of motor vehicles near school zones. Waiting time was defined as the duration each student spent standing at the roadside before initiating a crossing. This was measured using stopwatches by trained field assistants who conducted the timing concurrently with the behavioral observation sessions. In cases where a group of students crossed together, the child who arrived first at the

roadside was considered for the waiting time measurement. This approach ensured consistency and minimized bias in data collection.

For vehicle speed, measurement was carried out using handheld radar speed guns. At each school site, the first 30 vehicles passing the crossing point from 7:00 AM onward were targeted for speed measurement. This specific time frame was chosen to correspond with the morning school arrival period, when traffic volumes are typically high and student pedestrian activity is concentrated. The radar device was positioned discreetly to avoid influencing driver behavior. This method enabled the collection of standardized speed data across all sites, facilitating comparisons and analysis. By capturing both student waiting times and vehicle speeds, the study generated important quantitative evidence on how traffic flow dynamics relate to crossing behaviors, allowing for the identification of critical risk patterns and potential road safety interventions.

4.4.4. Photographic documentation

Photographs were taken to visually document student crossing behavior and environmental factors that contribute to unsafe road crossings in school zones. These images captured key elements such as midblock crossing locations, absence of designated pedestrian crossings and road infrastructure conditions. The photographic documentation served as a visual record that complements other collected data, providing clear evidence of the risk's children face. These images are also valuable for communicating findings to policymakers, educators, and other stakeholders, ensuring a better understanding of the challenges in improving school zone safety.

Table 3; Data collection methods and tools (Author, 2025)

Method	Tool
Individual survey	Questionnaire
Observation	Observation checklist
Time measurements	Stopwatch
Speed measurements	Speed gun

4.5. Data analysis

The collected data underwent a comprehensive quantitative analysis to assess school children awareness on safe road crossing, road crossing behavior, and factors contributing to the prevalence of these behaviors factors. The analysis focused on descriptive statistics on the awareness and observed behaviors, and behavioral modeling using key independent variables. R studio was used for statistical analysis, ensuring robust data processing and visualization.

Descriptive statistics were applied to summarize school children's road safety awareness, key behavioral and traffic characteristics observed in school zones. This analysis included bar charts representing the percentage on safe crossing on different scenarios for the case of awareness and bar charts representing crossing behaviors such as whether students waited before crossing, scanning for oncoming traffic, whether

crossed the road while running, their choice of crossing locations (e.g., designated or undesignated), whether they were distracted while crossing and whether they crossed diagonally. These descriptive insights helped establish baseline conditions and highlight recurring safety concerns in school environments. In addition to the descriptive analysis statistical tests like chi-square was conducted for the categorical and continuous data respectively.

To complement behavioral data, traffic characteristics were also analyzed. For each observed child, traffic volume was computed by counting the number of vehicles that passed during the child's waiting time before crossing. This provided a personalized exposure level for each crossing event. Additionally, 85th percentile of vehicle speed for each observation site which is a common indicator used in traffic safety studies was determined using a cumulative frequency curve (ogive). The point at which 85% of the speed values fell below was identified on the curve to represent the 85th percentile speed. This value was used to characterize the prevailing speed conditions for each road segment near the schools. These analyses allowed for a more precise understanding of the traffic environment children faced during crossings.

In order to better understand the factors influencing student crossing behavior, binary logistic regression analysis was conducted using key independent variables observed during fieldwork. These variables included the gender of the student, group size, traffic volume, 85th percentile vehicle speed, number of lanes per direction, and whether the student was accompanied by an adult. A binary logistic regression model was used to assess how each of these variables affected the likelihood of unsafe crossing behaviors which included stopping and scanning for traffic before crossing, crossing while running, crossing while distracted, crossing diagonally and not using pedestrian cross. The analysis helped quantify the role of road infrastructure and traffic conditions in shaping children's crossing decisions, offering data-driven evidence to guide future safety interventions and urban design improvements. The relationship between the probability of unsafe crossing behavior and the independent variables follows the binary logistic regression model which is as follows:

$$Y = \ln \frac{P}{1-P} = \epsilon + \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \ldots. B_n X_n$$

Where:

The left-hand side represents the log-odds of an unsafe crossing occurring.

ϵ represents the error term.

The coefficients (β_1, β_2, β_1, β_2,....) indicate the strength and direction of the effect of each variable on the probability of an unsafe crossing.

CHAPTER FIVE

RESULTS

5.1. Safe road crossing awareness; results of questionnaire

The results on awareness of safe road crossing revealed noticeable variations across age groups, with older children generally demonstrating a better understanding of key safety principles compared to younger ones. Differences in awareness were also revealed across specific aspects of crossing behavior. For instance, more children were familiar with the need to use designated pedestrian cross than the importance of stopping and scanning before crossing. These variations in understanding are detailed in the following subchapters

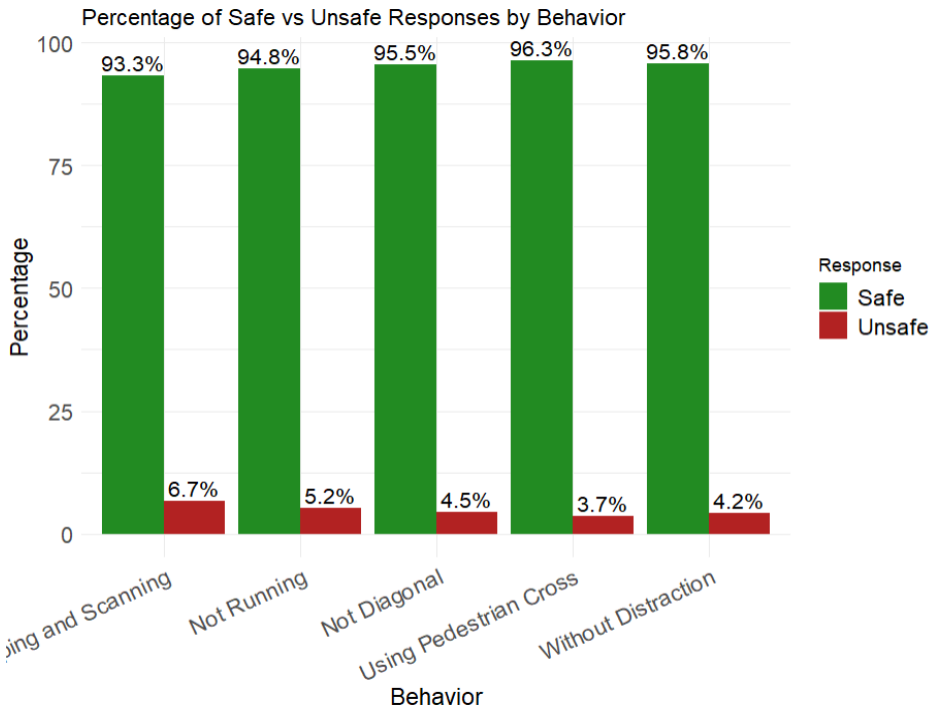


Figure 7: Bar chart of the results of awareness for each behavior (Author, 2025)

5.1.1. Stopping and Scanning Before Crossing

In assessing awareness of school children regarding the need to stop and scan before crossing the road, results showed that 560 out of 600 respondents (93.3%) demonstrated awareness of this critical safety behavior, while only 6.7% responded unsafely as it can be seen on figure 9. This high level of awareness suggests that the practice of stopping and visually scanning for traffic is a well-understood and consistently followed precaution among the surveyed children. Given that this action is a foundational aspect of pedestrian safety training, the result reflects positively on the effectiveness of current RSE programs.

When the data was disaggregated to the respondents age groups, the results revealed a clear upward trend as age increased as it can be seen on figure 10. Among students aged 9 years or below, only 83.9% demonstrated awareness of this crucial behavior, representing the lowest level of compliance across all age categories. Conversely, the highest proportion was found among students aged 12 years or above, where 96.6% reported stopping and scanning before crossing. Students aged 10 and 11 showed intermediate but still high levels of awareness, with 91.6% and 96.2%, respectively. This pattern reflects a strong age-related improvement in the adoption of safe pedestrian practices.

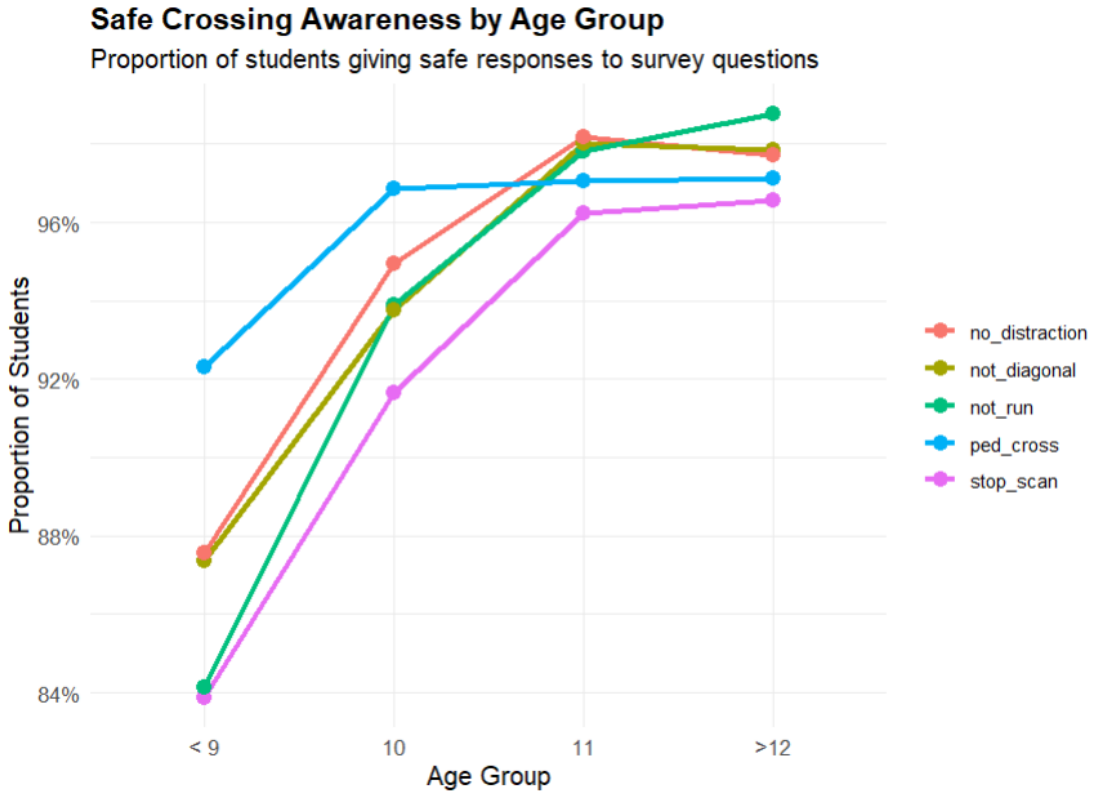


Figure 8: Safe crossing awareness by age of school children (Author, 2025)

To statistically verify whether this variation in awareness was significant, a chi-square test for independence was conducted. The test produced a chi-square statistic of X^2 (N = 600) = 19.02 with 3 degrees of freedom, and the resulting p-value was less than 0.01. A chi-square value of this magnitude indicates a large deviation between the observed and expected frequencies under the assumption of no association. Since the p-value is far below the conventional threshold of 0.05, the result is considered statistically significant. This means that the difference in awareness levels across age groups is unlikely due to chance, and suggests that age is a significant factor in determining whether students are aware of this specific safety behavior. The implication of the high chi-square value is that younger children may be more vulnerable due to underdeveloped cognitive processing or limited exposure to RSE, while older students may benefit from experience or structured training.

Additionally, when disaggregating the data by gender, the results showed a remarkably consistent pattern between male and female students. Both groups demonstrated identical awareness levels, with 93.3% of boys and 93.3% of girls reporting that they stop and scan for vehicles before crossing the street. This high

level of uniformity suggests that pedestrian safety messages related to this behavior have been equally distributed and well received across genders within the school environments sampled. The resulting chi-square statistic was X^2 (N = 600) = 0, with 1 degree of freedom, and the p-value was 1.00. This outcome indicates a perfect alignment between the expected and observed frequencies, providing no evidence of a statistical association between gender and this safety behavior. In simpler terms, the likelihood that any differences between boys and girls occurred by random chance is 100%, meaning no actual difference exists in the data. This uniformity in gender-based responses is encouraging. It reflects the effectiveness of RSE that has managed to reach students regardless of gender. Furthermore, it emphasizes the value of reinforcing universal messages around pedestrian safety in mixed-gender settings, ensuring that all students are equally prepared to navigate traffic environments safely.

The ability to stop and scan is one of the foundational elements of pedestrian safety training, as it allows the child to assess incoming traffic from both directions. The children's strong performance on this question suggests that this message has been clearly communicated and well understood. Although there is difference in performance across different age groups, the fact that both boys and girls performed equally well highlights a uniform level of RSE or awareness within the school environments and the younger students will get more knowledgeable about safe road crossing as they continue to get the education. Such results which were also documented by Odame et al. (2024) indicate the importance of reinforcing this behavior through regular reminders and road safety drills.

5.1.2. Running or walking across the road

In assessing awareness of school children regarding the importance of walking and not running while crossing the road, results showed that 569 students (94.8%) understood the importance of walking carefully, while 31 students (5.2%) still indicated unsafe behavior. This indicates a strong level of comprehension and adherence to pedestrian rules aimed at minimizing impulsive or reckless movements while crossing. It further suggests that the message of controlled crossing has been successfully communicated, though continued reinforcement may be necessary for the remaining minority.

When the data were grouped and analyzed by age groups, the results displayed a noticeable and progressive increase across age categories. Among students aged 9 years or below, the awareness level of not running while crossing was the lowest, with 84.1% of respondents indicating that they are aware of avoiding running during road crossing. As age increased, the proportions improved steadily: 93.9% for those aged 10, 97.8% for those aged 11, and reaching a peak of 98.8% among students aged 12 or above. These results suggest that as children grow older, their understanding and internalization of appropriate road safety behaviors become more pronounced, likely due to cognitive development, repeated exposure to road safety messaging, or practical experience.

The chi square test yielded a value of X^2 (N = 600) = 27.27 with 3 degrees of freedom, and a p-value of less than 0.01. This very low p-value provides strong evidence against the null hypothesis, confirming that the observed differences are not due to random chance. The magnitude of the chi-square statistic also indicates that the variation in awareness is substantially greater than what would be expected if age had no influence. In simpler terms, the result suggests that age is significantly associated with children's awareness of the need not to run when crossing the road. This finding reinforces the importance of focusing RSE more intensively on younger students. Their comparatively lower compliance highlights the need for child-friendly teaching tools, supervised crossing routines, and behavioral modeling by adults and older peers.

In addition to analysis by age groups, the data when disaggregated by gender revealed nearly similar levels of awareness between male and female students. Specifically, 94.7% of boys and 95.0% of girls reported that they understand it is not safe to run while crossing the road, indicating only a marginal difference of 0.3 percentage points between genders. This near parity in responses reflects an encouraging consistency in how RSE is being received by both boys and girls. When a chi-square test was performed, the resulting chi-square value was X^2 (N = 600) = 0, with 1 degree of freedom, and a p-value of 1.00. This outcome shows no statistical difference in awareness of this behavior between genders indicating that there is a 100% probability that any observed differences occurred purely by chance. Similar to the stopping and scanning awareness. this uniformity across gender which is also documented by Alonso (2018) and Indhumanthy & Thenmozhi (2016) is evidence of parity, suggesting that both male and female students are receiving equally effective messaging around the importance of not running while crossing, and are integrating that knowledge into their behavior.

5.1.3. Diagonal against straight crossing awareness

In assessing awareness of school children concerning the danger of crossing the road diagonally rather than perpendicularly, results showed that 573 children (95.5%) were aware that, crossing straight and not diagonal is the safe behavior and selected the picture on the right side of figure 11, while 4.5% responded that crossing diagonally was safe by selecting the picture on the left side on figure 11, signifying that they are unaware of the risk coming with diagonal crossing. The high rate of correct responses signals strong knowledge of the increased exposure to risk which is associated with crossing diagonally.

On the other side, the results revealed a steady upward trend in safe behavior response with increasing age. The lowest proportion of correct responses was observed among children aged 9 or under the age of 9, where 87.4% reported they know, they should avoid crossing diagonally. This awareness improved significantly with age: 93.8% among 10-year-olds, 98.0% among 11-year-olds, and 97.9% among students aged 12 or older than 12. These findings suggest that older children are more attuned to the dangers of crossing diagonally, possibly due to greater exposure to formal road crossing safety instructions and cognitive maturity.

To determine whether the differences in awareness across age groups were statistically significant, a chi-square test of independence was conducted. The chi square test to determine whether the differences in awareness across age groups were statistically significant yielded a value of X^2(N = 600) = 16.585, with 3 degrees of freedom, and a p-value of less than 0.01. This low p-value indicates strong statistical evidence against the null hypothesis that awareness of this behavior is independent of age, confirming that age and awareness of diagonal crossing are significantly associated, these findings highlight the necessity of reinforcing safe crossing behaviors, especially avoiding diagonal paths, at younger ages, where such understanding is not yet fully internalized.

Additionally, when awareness of not crossing diagonally was analyzed by gender, the proportions were relatively close but showed a slight difference. Among male students, 94.0% reported they avoid crossing diagonally, compared to 97.0% of female students. Although the difference may suggest slightly greater adherence to this safety behavior among girls, it is statistically insignificant because chi-square test result yielded a chi-square value of X^2 (N = 600) = 2.48, with 1 degree of freedom, and a p-value of 0.12. This p-value means that there is 11.52**%** probability that the difference noted could have happened by chance, suggesting that there is no strong evidence of a gender difference in this behavior. While there appears to

be a trend toward greater awareness among females, the data do not support the conclusion that gender is a significant factor in determining whether a student crosses diagonally or not. These results which are consistent with Alonso (2018) imply that interventions aimed at discouraging diagonal crossing can effectively target both boys and girls without needing to tailor content differently. Continued emphasis on using direct and shortest paths when crossing the road remains critical across all groups.

Figure 9: Pictures shown to students to choose safe crossing regarding diagonal crossing (Author, 2025)

5.1.4. Choosing the correct crossing zone

In assessing awareness of school children on the importance of using designated pedestrian crossings, a key safety measure that reduces vehicle-pedestrian conflict, results showed that 578 out of 600 respondents (96.3%) correctly identified the safe response by selecting the safe crossing area (b) as can be seen on figure 12, with only 3.7% indicating unsafe responses by selecting (a) and (c). Respondents were most aware about this safe practice more than any other safe practice, this is possibly due to the fact that pedestrian crossing zones are normally marked on the road surface which reinforce safe crossing awareness through environmental cues.

Results also revealed high levels of compliance across all age groups, though with slight variation. The lowest awareness was found in children under the age of 9 or below, where 92.3% indicated that they understand the importance of using pedestrian crossings. This figure rose slightly among older children: 96.9% for 10-year-olds, 97.0% for 11-year-olds, and 97.1% among those aged 12 or above. While the overall percentages are impressively high, the relatively small increase with age suggests that this is a well-internalized awareness even among younger children.

The results of a chi-square test of independence conducted were X^2 (N = 600) = 4.67 with 3 degrees of freedom, and a p-value of 0.1977. Since this p-value is well above the conventional 0.05 threshold, the result is not statistically significant. This means that while small differences exist across age groups, they are not large enough to conclude that age has a meaningful effect on the likelihood of using a pedestrian crossing. The chi-square statistic (4.67) reflects only a modest level of deviation from what would be expected by chance alone. These findings suggest that awareness of this behavior is likely influenced more by other factors than by age-based cognitive differences.

When analyzed by gender, the proportions of students who reported using pedestrian crossings were again high and relatively close between the two groups. Among female students, 95.3% reported they use pedestrian crossings, compared to 97.3% of male students. This slight difference indicates a small

advantage in awareness among boys, though both genders demonstrate high levels of safe behavior. To determine whether this gender-based difference was statistically significant, result showed a chi-square value of X^2 (N = 600) = 1.18, with 1 degree of freedom, and a p-value of 0.2774 indicating no significant association between gender and awareness of using pedestrian crossings. This outcome suggests that pedestrian crossing awareness is uniformly strong across both boys and girls. The relatively consistent high percentages, which was also observed by Indhumanthy & Thenmozhi (2016) further underscore the success of general road safety campaigns or the presence of designated crossings around schools that encourage safe practices regardless of demographic group.

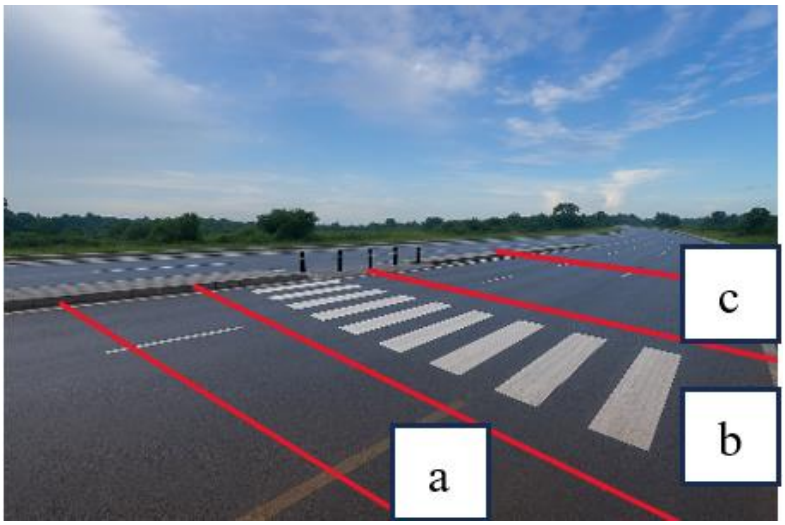


Figure 10: Picture shown to students to choose safe crossing area (Author, 2025)

5.1.5. Recognizing the risk of distraction

In assessing awareness of school children on avoiding distractions such as playing, phone use, conversations, or looking away while crossing, results showed that 575 out of 600 (95.8%) were aware that such behaviors are unsafe and selected the picture on the right side of figure 13, while 25 (4.2%) still responded unsafely by selecting the picture on the left side of figure 13. This demonstrates a strong general understanding of the importance of full attention during road crossing. Nonetheless, the small fraction of unsafe responses underlines the need for continued reminders about the risks posed by distraction, especially in high-traffic environments

The data were analyzed by age groups and results revealed a notable improvement with age. The lowest awareness was observed among students of the age of 9 or below, with 87.6% indicating they understand the need to avoid distractions while crossing. This figure increased steadily with age: 94.9% for 10-year-olds, 98.2% for 11-year-olds, and 97.7% for students of age 12 or above. These findings suggest that as children grow older, they become more aware of the safe practice regarding attention while crossing the road and are likely to better manage cognitive focus during road use, likely due to both developmental maturity and increased exposure to safety messaging. A chi-square test of independence to assess whether the differences in distraction avoidance were statistically associated with age yielded a chi-square statistic

of X^2 (N=600) = 14.002 with 3 degrees of freedom, and a p-value of less than 0.01. This p-value is well below the conventional threshold of 0.05, indicating a statistically significant association between age and awareness of distraction-free crossing. In practical terms, the chi-square value of 14.002 reflects a meaningful deviation from random variation, suggesting that age contributes substantially to students' attentiveness at the time of road crossing. This result reinforces the importance of age-appropriate training that considers cognitive development when teaching safe crossing practice

Moreover, the analysis by gender revealed consistently high levels of awareness regarding distraction avoidance among both male and female students. Female students reported a 95% rate of crossing without distraction, while male students showed a slightly higher rate at 96.7%. This minor difference suggests that both genders are similarly equipped with knowledge or habits that promote focused road behavior. A chi-square test to determine if gender had a statistically significant relationship with this behavior produced a chi-square statistic of X^2 (N=600) = 0.67 with 1 degree of freedom, and a p-value of 0.41. Since this p-value is well above the 0.05 threshold, the difference between males and females is not statistically significant. This implies that any observed differences in behavior could easily be attributed to chance rather than a systematic gender-based pattern. These results, as also documented by Odame et al. (2024) indicate a uniformly high level of awareness about the risks of distraction while crossing the road across genders, underscoring the success of general education strategies that reach boys and girls equally. It also emphasizes that future interventions to reduce distraction risk may benefit more from targeting younger children rather than segmenting by gender.

Figure 11: Pictures shown to students to choose safe crossing (Author, 2025)

5.2. Road and Traffic Characteristics in the School Zones: result of observation and measurement

This section presents the observed and calculated characteristics of the road and traffic environment surrounding six school zones. Key parameters examined include vehicle speed, number of lanes, presence of medians, pedestrian crossing facilities, signage, traffic calming measures, road condition, roadside features, and the presence of crossing guards. The results highlight differences across locations that may influence the safety and ease with which children navigate traffic near their schools. Each parameter is discussed below, with emphasis on variations that may impact pedestrian behavior and risk exposure.

5.2.1. Vehicles speed

In investigating the differences in vehicle speeds across six school zones, the spot speed study revealed substantial variation in the 85th percentile speeds. Mzinga recorded the lowest 85th percentile speed at 23.1 km/h, followed closely by Mtambani at 26.4 km/h. These sites, both located on single-lane roads, reflect relatively calmer traffic conditions, possibly due to constrained road width or naturally moderated driver behavior. In contrast, higher 85th percentile speeds were noted at Mtoni (32.8 km/h) and Mbagala (35.5 km/h), both situated on two-lane roads. The highest speeds were observed in Kibamba and Upendo, where 85th percentile speeds reached 52.6 km/h and 55.3 km/h respectively. These two sites featured three-lane roadways, supporting the trend that vehicle speeds tend to increase with road width. The 85th percentile speed, commonly used to represent the behavior of the majority of drivers under free-flow conditions, serves as a key indicator of the prevailing traffic environment and potential pedestrian risk in school zones. A Kruskal–Wallis test showed that there was a statistically significant difference in vehicle speeds among the six school zones, $\chi^2(5) = 165.77$, $p < 0.01$.

5.2.2. Road cross-section

In investigating the road cross-section characteristics, which in this context were focused on the number of lanes and the presence of a central median, varied across the six school zones and play a direct role in determining the level of risk faced by child pedestrians. Observations confirmed that Mzinga and Mtambani had single-lane roads in each direction. These narrower roads generally require shorter crossing distances and may present fewer traffic conflict points, potentially making them less hazardous for children attempting to cross. In comparison, Mtoni and Mbagala featured two-lane roads, while Kibamba and Upendo had the widest roads with three lanes in one direction. These wider roads significantly increase the distance and time required for children to cross, thereby raising their exposure to moving vehicles and the potential for unsafe interactions, especially during peak school hours. The presence of central medians, which can serve as pedestrian refuge points, was observed only at Mtoni, Mbagala, Kibamba, and Upendo. Mzinga and Mtambani, which had narrower roads, did not have medians

5.2.3. Pedestrian crossing facility

In investigating the presence and condition of pedestrian crossing facilities, observation revealed that all six school zones were equipped with some form of designated pedestrian crossing facility. This indicates a positive recognition of pedestrian needs in school environments across all sites. However, the mere presence of a crossing facility does not necessarily translate to safety unless it is clearly marked, properly located, and respected by motorists. At Mzinga, although the pedestrian cross is strategically positioned to serve the largest number of crossing school children, the markings are faint and merely visible. All other locations studied had visible and well maintained pedestrian cross marking. It was also noted that there is an overpass to cross the road passing near Upendo and Kibamba primary schools but they are located far that the place where school children would conveniently cross.

Figure 12: Faint pedestrian cross at Mzinga (Author, 2025)

5.2.4. Traffic calming measures

With respect to the traffic calming measures to ensure that vehicles slow down when passing the school zones, observation findings showed that only Mtoni had an active traffic calming measure in place in the form of a road hump. No other schools, Mzinga, Mtambani, Mbagala, Kibamba, or Upendo had any visible traffic calming infrastructure. There were also traffic police close to the Upendo primary school enforcing the speed limit adherence however the posted speed limit is 50km/hr which is still higher than the recommended speed limit of 30km/hr around school zones. Traffic calming measures such as speed humps, raised crossings, and rumble strips are proven interventions that can reduce vehicle speed and improve pedestrian safety.

5.2.5. Road signage

In investigating the presence of road signs around school zones, visual assessments indicated inconsistency in the presence and quality of road signage across school zones. Mzinga had the most comprehensive signage, with clear indicators of a school zone, pedestrian crossing, and nearby road humps. Mtoni also had multiple signs, including the road hump sign, and pedestrian cross sign, reinforcing the presence of both a crossing and traffic calming measures. However, Mtambani had no visible signage related to school children or pedestrian activity, there was however a post standing which meant there was once a sign but it is no longer there, which could pose a serious safety concern. At Mbagala, Kibamba, and Upendo, only basic pedestrian crossing signs were noted. The presence of clear and highly visible signage is essential for alerting drivers to reduce speed and exercise caution, particularly in areas where children are known to cross regularly.

5.2.6. Other features near the crossing area

With respect of other features which could potentially change the traffic complexity near the crossing areas, observations recorded that Mzinga, Mtambani, Mbagala, and Kibamba all had bus stops in close proximity to the school crossings. While these may facilitate school transport access, they can also obstruct visibility

and introduce additional pedestrian-vehicle conflict points. Mtoni and Upendo did not have any notable features such as public transport infrastructure near the crossing area.

5.2.7. Road Condition

A visual inspection of the road surfaces revealed that Mzinga was the only school zone with noticeable pavement defects, including potholes, edge deterioration, and cracks. While such conditions are generally undesirable, they were observed to influence driver behavior by prompting vehicles to slow down significantly when approaching the crossing area. In some cases, this reduction in speed resulted in drivers coming to a complete stop, increasing the likelihood of yielding to school children attempting to cross. In contrast, the remaining school zones, Mtambani, Mtoni, Mbagala, Kibamba, and Upendo, had smooth and well-maintained road surfaces. Although smooth pavement improves vehicle movement and comfort, it was found that it encourage higher speeds because there is no traffic calming measures or clear pedestrian visibility features.

5.2.8. Presence of crossing guard

Observation of school crossing personnel revealed varied practices across the sites. Mzinga relied on informal crossing assistance provided by older school children and local good samaritans. Mbagala had a crossing guard, while Upendo had a designated traffic warden, both of which contribute positively to pedestrian control and safety. It was noted that although these locations had people to help school children However, Mtambani, Mtoni, and Kibamba had no observed crossing assistance, which may put children at greater risk during busy periods. The presence of a trained and visibly equipped crossing guard can serve as a critical safety layer, especially in areas with high traffic volumes or poor infrastructure.

5.3. School children road crossing behaviors: results of observation

This subchapter presents the results and analysis of observed behaviors of school children as they crossed roads near the selected six primary school locations in Dar es Salaam. It highlights how children responded to real traffic conditions, focusing on behaviors such as pausing, scanning, running, distracted crossing, diagonal crossing, and use of pedestrian crossings. The results reveal patterns of safe and unsafe behavior, with variations across locations and road environments, as detailed in the sections that follow.

5.3.1. Children's Road-Crossing Behaviors by Location

The first stage of analysis examined the frequency of specific road-crossing behaviors exhibited by children across the six observation sites. The figure below illustrates the percentage of children who demonstrated key safe crossing practices.

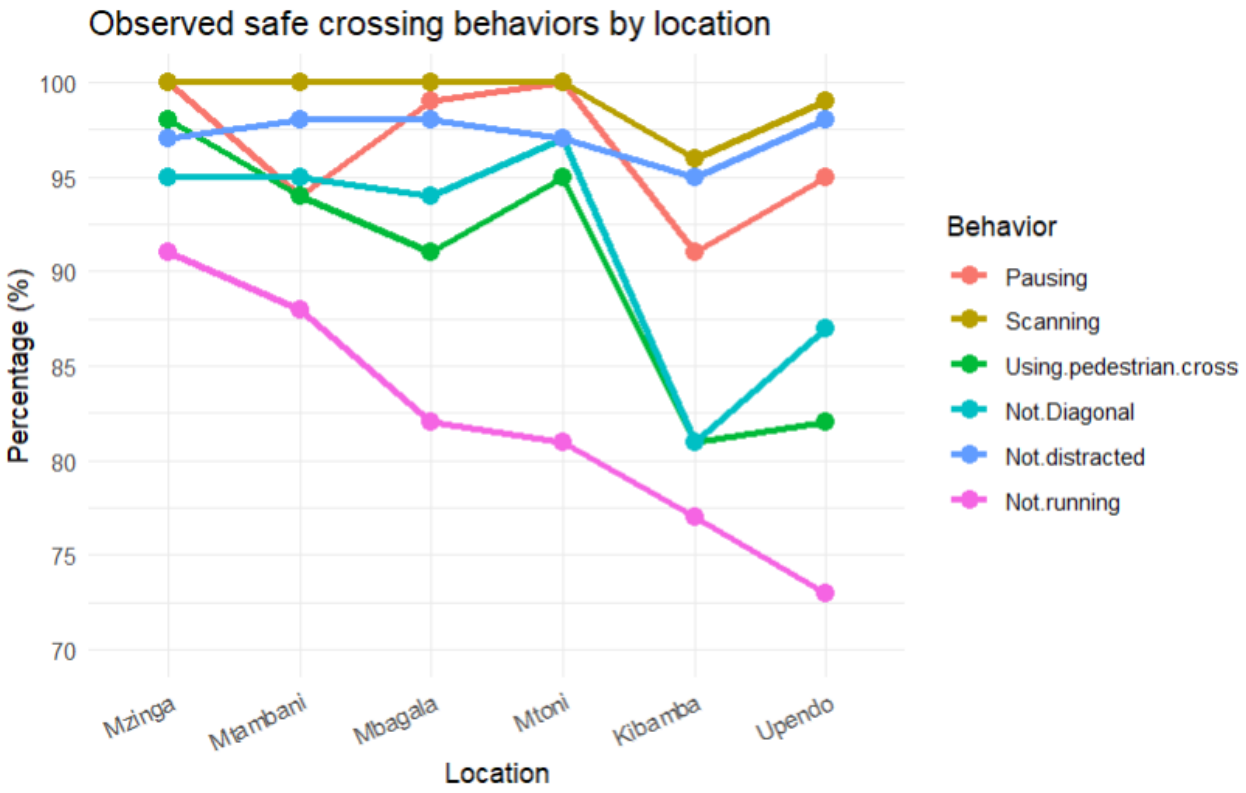


Figure 13: Line chart of observed safe crossing behaviors by location (Author, 2025)

In the analysis of behaviors by locations, the results show adherence to safe behaviors was high across most locations, particularly in Mzinga and Mtambani, where more than 88% of children were compliant in all observed behaviors. For example, at Mzinga, 100% of the children were seen scanning before crossing and pausing, suggesting possible influence of environmental or infrastructural cues. In contrast, Upendo recorded some of the lowest levels of safe behavior, with only 73% of children not running and 82% using pedestrian cross, potentially indicating gaps in safety awareness or infrastructure support. The prevalence of these behaviors was also documented in previous studies done by Biassoni et al. in 2020, Jiang et al. 2021 and Riaz et al. in 2022. The following images depict real-life instances of crossing behaviors observed at different sites, offering qualitative insight into the challenges and risks faced by school children in navigating busy roads.

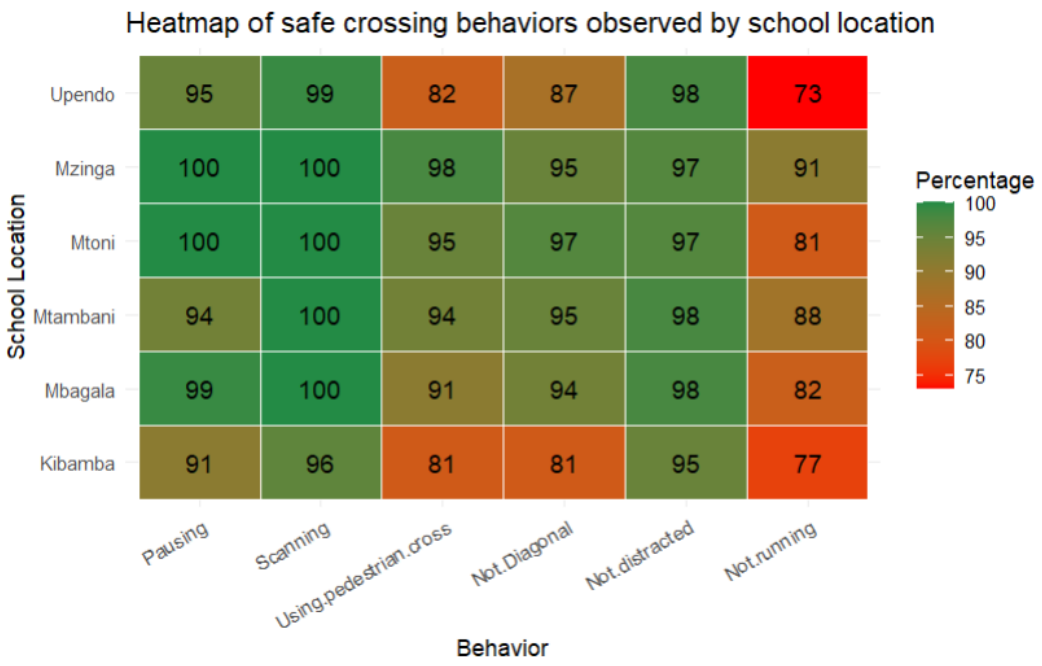


Figure 14: Heatmap of observed safe crossing behaviors by location (Author, 2025)

Figure 15: Children safely crossing the road at Mzinga (Author, 2025)

Figure 16: Children running and diagonally crossing the road at Upendo (Author, 2025)

The analysis of the behaviors by observation location revealed distinct patterns in children's safe crossing behaviors across the six school locations, Mzinga, Mtambani, Mtoni, Mbagala, Kibamba, and Upendo. Results showed overall high adherence to safe road-crossing practices, with most locations reporting percentages above 90% for several key behaviors. Notably, Mzinga and Mtambani consistently demonstrated the highest levels of compliance across all observed behaviors, while Kibamba and Upendo exhibited lower adherence in certain aspects, particularly in avoiding running and in using designated pedestrian crossings. Visualizations such as heat maps and line charts illustrated these variations clearly.

5.3.1.1. Pausing before crossing

With respect to pausing before crossing, results showed a generally high level of compliance across all six school zones. Children in Mzinga and Mtoni demonstrated full adherence, with 100% of observed students pausing before entering the road. Similarly, Mbagala recorded 99%, while Upendo and Mtambani showed slightly lower yet still commendable rates of 95% and 94%, respectively. Kibamba recorded the lowest pausing rate at 91%, which, although still high, represents a slight deviation from the otherwise consistent trend. A chi-square test was performed to assess whether these differences in pausing behavior across schools were statistically significant. The test yielded a chi-square statistic of $X^2 = 0.72$ with 5 degrees of freedom and a p-value of 0.9818. This high p-value indicates that the differences are not statistically significant, meaning that the variation observed is likely due to chance. Thus, it can be concluded that pausing behavior is consistently practiced across all school locations, reflecting a generally successful internalization of this safety message.

5.3.1.2. Scanning for traffic before crossing

When analyzing the behavior of scanning before crossing, a similarly strong pattern of adherence emerged. Mzinga, Mtoni, and Mbagala each recorded perfect compliance, with 100% of children looking both ways

before crossing the road. Mtambani and Upendo followed closely at 100% and 99%, respectively, while Kibamba had a slightly lower but still strong performance at 96%. The consistency of high percentages suggests that scanning has become a well-established behavior across the locations. This observation was confirmed by the chi-square test, which produced a remarkably low chi-square value of $X^2 = 0.13$ with 5 degrees of freedom and a p-value of 0.9997. The extremely high p-value confirms that the differences observed among locations are not statistically significant and that children across all zones have a uniformly high adherence to the behavior of scanning for traffic before crossing. This finding reflects effective reinforcement of a critical road safety behavior and aligns with existing safety training campaigns.

5.3.1.3. Use of pedestrian cross when crossing the road

Regarding the behavior of using pedestrian crossings, the results show slightly more variation than in pausing or scanning. The highest adherence was recorded in Mzinga, where 98% of children used pedestrian crossings, followed by Mtoni at 95% and Mtambani at 94%. Mbagala reported a lower rate of 91%, while both Kibamba and Upendo had the lowest rates, tied at 81% and 82%, respectively. These figures indicate a need to improve infrastructure availability or educational outreach in certain areas. Nevertheless, a chi-square test showed $X^2 = 2.78$, df = 5, and a p-value = 0.7336, meaning that the variation is statistically insignificant. This means that while some schools recorded lower rates, these differences are not strong enough to indicate a meaningful pattern across locations. Still, schools with lower usage may benefit from infrastructure improvements such as visible crosswalks or signage to further encourage this behavior.

5.3.1.4. Not crossing diagonally

For the behavior of not crossing diagonally, which reduces exposure time on the roadway, high levels of adherence were also recorded. Mtoni and Mtambani led with 95%, while Mzinga was close behind with 95%. Mbagala followed with 91%, whereas Upendo recorded 87%. Kibamba showed the lowest level of compliance at 81%. Despite this spread, the chi-square test result of $X^2 = 2.09$, degree of freedom = 5, and a p-value = 0.8361 indicated that these differences are not statistically significant. The overall consistency of high scores, even in the lowest-performing school, indicate that that most children understood the value of crossing directly rather than diagonally. Continued reinforcement of this behavior, possibly through road markings and instructions at crossing points, could further reduce the already minimal variance observed.

5.3.1.5. Avoiding distraction while crossing

Analysis of the not being distracted while crossing behavior showed similarly high levels of safety adherence. Mtambani and Upendo topped the list with 98% of children showing no distraction while crossing. Mbagala and Mtoni followed with 94% and 97%, respectively, while Mzinga reported 97%. Kibamba, although lowest, still had a solid 95% compliance rate. These high percentages across all sites demonstrate a strong understanding among children of the dangers of distractions, such as making conversations, mobile phone use or playing, while crossing roads. The chi-square test confirmed the lack of statistically significant differences across the locations, yielding $X^2 = 0.07$, degree of freedom = 5, and a p-value = 0.9999. This extremely high p-value strongly suggests that the adherence to this behavior is uniformly high, and any observed differences are random rather than location-based.

5.3.1.6. Not running while crossing

Lastly, the results of not running while crossing behavior revealed a wide variation among the six behaviors. Mzinga reported the highest compliance at 91%, while Upendo and Kibamba recorded the lowest

percentages at 73% and 77%, respectively. These lower figures suggest potential concerns related to urgency, excitement, or lack of supervision. However, even with this apparent variability, the chi-square analysis showed $X^2 = 2.73$, degree of freedom = 5, and a p-value = 0.7413, indicating no significant differences between locations.

5.3.2. Road crossing behaviors by gender

In analyzing the data of observed behaviors with respect to gender, the results of the gender-based analysis indicate that, across most observed pedestrian behaviors, there were no statistically significant differences between male and female students as it can be displayed on figure 18. In the behavior of pausing before crossing, nearly equal proportions of students in both groups exhibited safe behavior, with 96.2% of males and 96.7% of females pausing before stepping onto the road as can be seen on figure 19. The chi-square test yielded a value of $X^2 = 0$ with a p-value of 1, confirming that there is no meaningful difference between the two genders in this aspect of crossing behavior. Similarly, in the behavior of scanning for traffic, 99.0% of males and 99.3% of females demonstrated the expected caution. Although a Fisher's Exact Test was applied due to low expected counts in some cells that could render the chi square test not reliable, the result from Fisher's test again showed no significant difference (p = 1.0), indicating that both boys and girls are equally likely to look out for traffic before crossing.

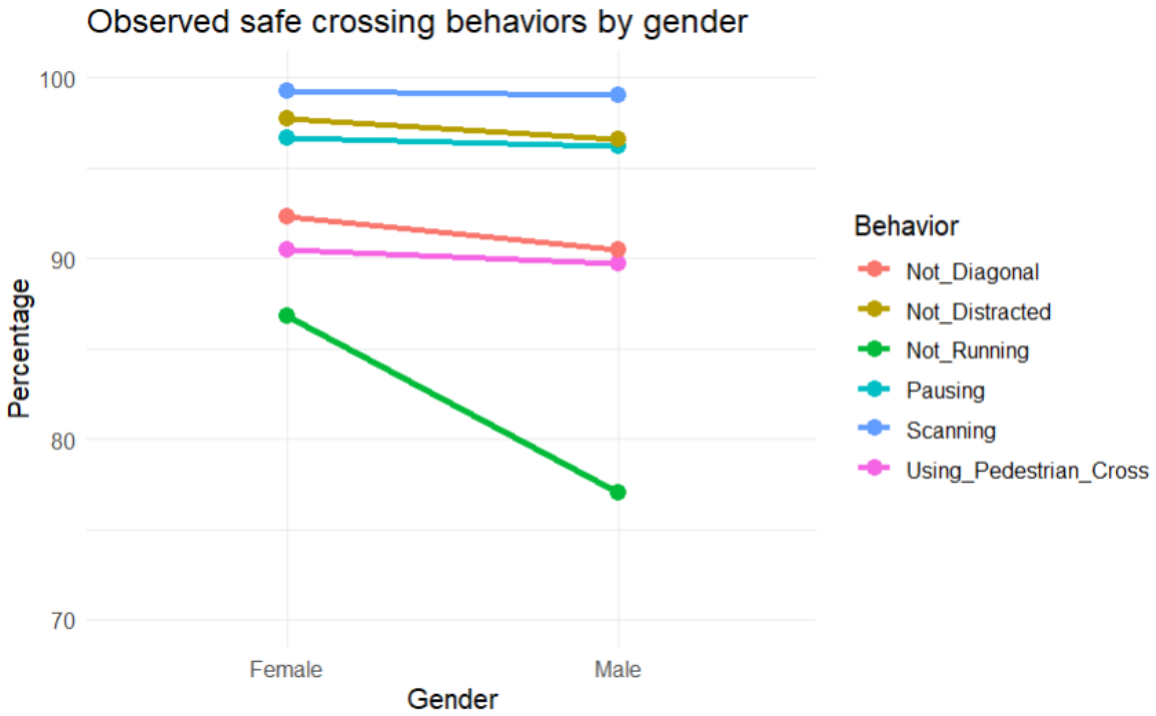


Figure 17: Line chart of observed safe crossing behaviors by gender (Author, 2025)

The analysis of the behavior of using pedestrian crossings revealed that 89.7% of male students and 90.5% of female students adhered to this recommended practice. The statistical test for difference in this behavior yielded a chi-square value of $X^2 = 0.075$ with a p-value of 0.784, providing further evidence that there is no gender-based disparity in this behavior. A similar trend was observed in the behavior of avoiding diagonal crossing, where 90.5% of males and 92.3% of females crossed the road in a straight path rather

than diagonally. Again, the chi-square test produced a non-significant result ($X^2 = 0.343$, $p = 0.558$), reinforcing the finding that both genders display comparable adherence to safe crossing practices in terms of movement direction.

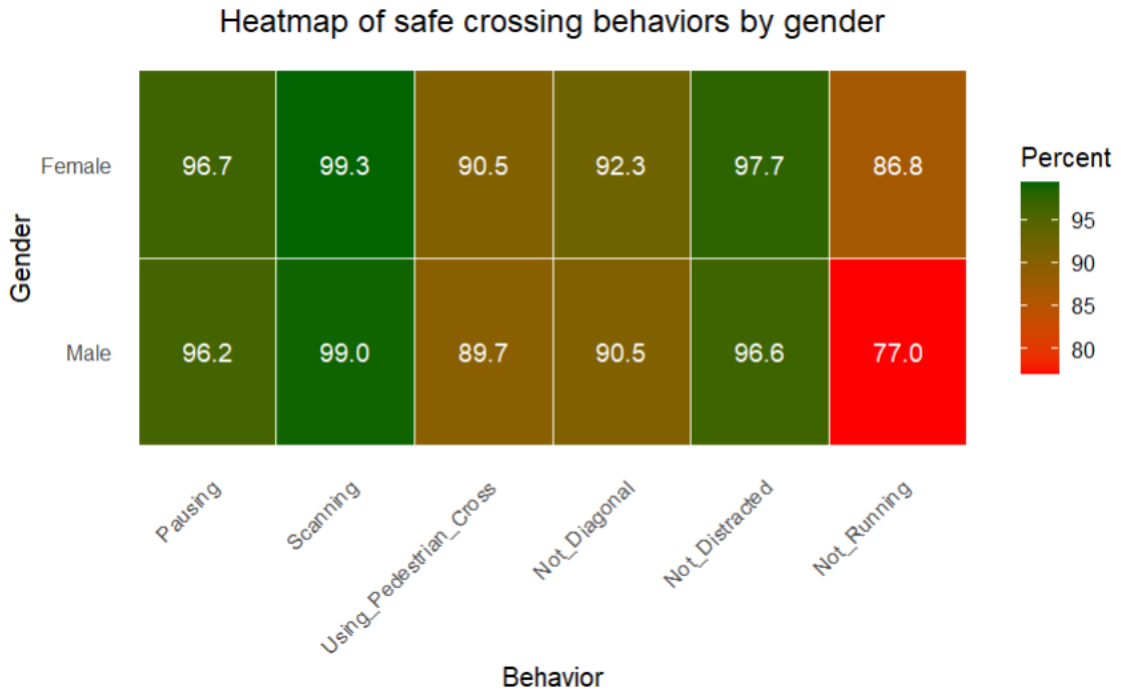


Figure 18: Heatmap of observed safe crossing behaviors by gender (Author, 2025)

Another critical behavior analyzed was remaining undistracted while crossing, which included not playing, not using phones or engaging in conversation during road crossing. This behavior was safely observed in 96.6% of males and 97.7% of females. The statistical comparison showed no significant difference ($X^2 = 0.242$, $p = 0.623$), again suggesting that both boys and girls are similarly cautious in maintaining attention while crossing. This consistency across behaviors highlights that safe pedestrian practices are generally well internalized among students, regardless of gender.

However, a statistically significant difference emerged in the behavior of not running while crossing the road. Only 77.0% of male students were observed walking across the road, compared to 86.8% of female students. The chi-square test for this behavior produced a value of $X^2 = 8.789$ and a p-value of less than 0.01, indicating a significant gender disparity. This suggests that male students are more likely to run while crossing, a behavior that may be associated with reduced attention to traffic and increased exposure to risk. In contrast, the higher proportion of female students who walked calmly across the road reflects greater caution and potentially a higher awareness of pedestrian safety.

In these results while the majority of safe crossing behaviors were exhibited at high levels among both male and female students, the behavior of not running while crossing stood out as an area of significant difference. This finding which show poor adherence by male students, which was also observed by Riaz et al. (2022) and Zeedyk et al. (2002) is explained by the belief that male children tend to be more confident hence show riskier behaviors (Granie 2007; Underwood, 2007). The result implies that male students may

require more focused intervention in road safety programs, particularly in promoting calmer, more deliberate crossing practices.

5.3.3. Road crossing behaviors by number of lanes

In analyzing observed behaviors data concerning the number of lanes carrying traffic in one direction, the results of revealed clear trends in how road width corresponds with safe crossing practices among school children. Across the six behaviors analyzed, differences in adherence were evident, particularly between one-lane and three-lane roads noted by general decrease in safe practice as number of lanes increased as it can be seen on figure 20.

For pausing before crossing, as shown on figure 21, the highest adherence was observed on two-lane roads, where 199 out of 200 children (99.5%) paused before crossing, while the lowest was on three-lane roads with 186 out of 200 (93.0%). This behavior showed a decreasing trend with increasing number of lanes, and results of chi square test showed that the difference was statistically significant ($\chi^2 = 12.73$, $p < 0.01$). On the other hand, the behavior of scanning for traffic was performed by all 200 children (100%) on both one-lane and two-lane roads but slightly declined on three-lane roads to 195 out of 200 (97.5%). Although the observed difference was small, results of chi square test showed that it was statistically significant ($\chi^2 = 10.084$, $p = 0.00646$). Due to low expected counts in some cells particularly the absence of unsafe observations in the one-lane and two-lane groups, Fisher's Exact Test was also performed to complement the chi square test, confirming the result with a p-value of 0.01194.

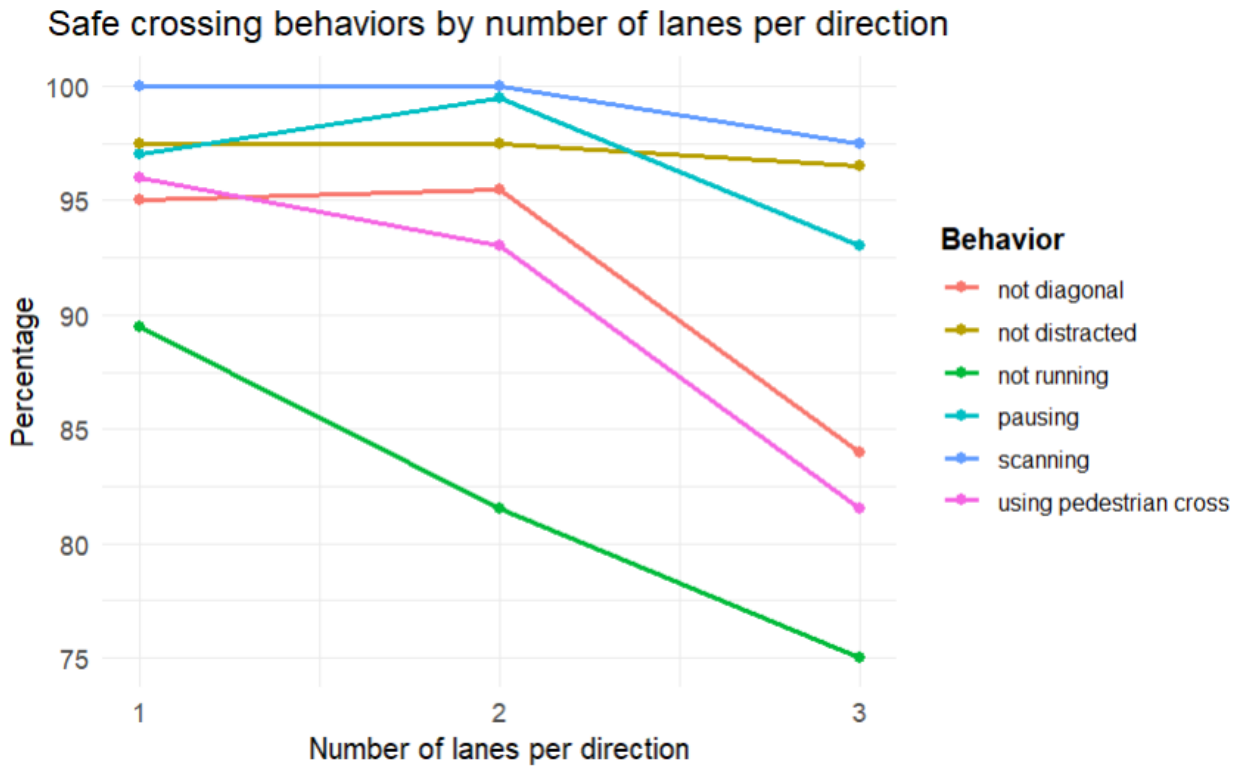


Figure 19: Line chart of observed safe crossing behaviors by number of lanes (Author, 2025)

Another behavior, the use of pedestrian crossings showed the highest adherence on one-lane roads with 192 out of 200 children (96.0%) using them, compared to the lowest on three-lane roads with 163 out of 200 (81.5%). This consistent decline across increasing road width was statistically significant according to the chi square test ($\chi^2 = 26.429$, $p < 0.01$). For the behavior of diagonal crossing avoidance, the highest percentage was observed on two-lane roads with 191 out of 200 children (95.5%) avoiding diagonal paths, while the lowest was on three-lane roads with 168 out of 200 (84.0%). This also followed a decreasing trend and results of chi square test showed that it was statistically significant ($\chi^2 = 21.729$, $p < 0.01$).

While most of behaviors show high variation across different number of lanes, the behavior of distraction avoidance remained high across all lane groups with minimal variation. The highest was 195 out of 200 children (97.5%) on one- and two-lane roads, and the lowest was 193 out of 200 (96.5%) on three-lane roads. The results of chi square test showed that difference was negligible and not statistically significant ($\chi^2 = 0.484$, $p = 0.7849$) meaning that the observed differences are statistically due to chances and not influenced by the number of lanes. For the behavior of not running while crossing, the highest adherence was on one-lane roads with 179 out of 200 (89.5%), and the lowest was on three-lane roads with 150 out of 200 (75.0%), showing a clear decreasing trend and a statistically significant difference ($\chi^2 = 14.295$, $p < 0.01$).

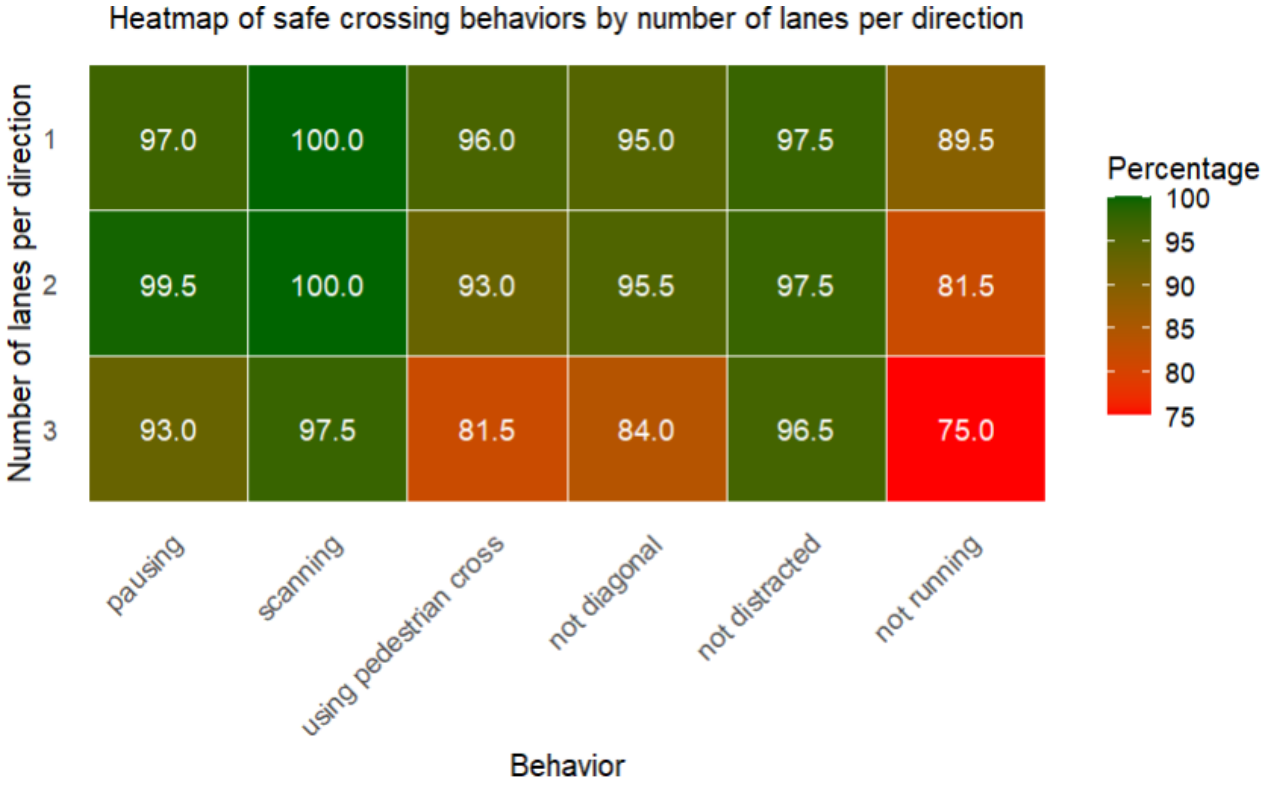


Figure 20: Heatmap of observed safe crossing behaviors by number of lanes (Author, 2025)

Overall, the results demonstrate that five out of the six observed behaviors, pausing before crossing, scanning for traffic, using pedestrian crossings, avoiding diagonal crossing, and not running while crossing, showed statistically significant differences across roads with different numbers of lanes per direction. In each of these cases, the lowest levels of safe behavior were consistently recorded on three-lane roads,

indicating a general decline in adherence to safe crossing practices as road width increased with the exception of only distraction avoidance. These findings which show as number of lanes increases children are more prone to unsafe behaviors, which were also documented by Riaz et al. (2022) highlight a consistent pattern where wider roads typically involve longer crossing distances, heavier traffic flow, and potentially higher vehicle speeds, all of which may create a greater sense of urgency or perceived danger among children which may result to unsafe behaviors for example running (Schwebel et al, 2018).

Figure 21: A child not using a pedestrian cross on a one lane per direction road (Author, 2025)

Figure 22: A child not using a pedestrian cross on a three lane per direction road (Author, 2025)

5.3.4. Overall road-crossing behavior by location

To explain the general safety of school children's road-crossing habits, an overall behavior indicator was developed by combining six key sub-behaviors: pausing before crossing, scanning the road, avoiding distractions, crossing without running, avoiding diagonal crossing, and using a pedestrian crossing when available. A child's overall crossing behavior was considered safe only if all six behaviors were demonstrated correctly. If the child failed to perform even one of these behaviors, their overall crossing behavior was classified as unsafe. This approach reflects the principle that road safety is cumulative, each behavior contributes to reducing risk, and a single lapse can place a child in danger.

The results of overall safe crossing behavior across the six school locations showed a clear variation in performance as displayed on figure 24, reflecting differences in how children adhered to safety practices in different environments. The highest level of safe behavior was recorded in Mzinga, where 86 out of 100 children (86%) exhibited safe crossing practices. In contrast, the lowest was observed in Kibamba, with only 63 out of 100 children (63%) demonstrating safe behavior. This 23-percentage point gap highlights a substantial difference in pedestrian safety compliance across sites. Other locations such as Mtambani, Mtoni, and Upendo fell in the mid-range, suggesting that while some environments support safer behaviors, others may require greater attention. The trend observed points to location-based disparities that may be influenced by varying school zone conditions, traffic patterns, or environmental cues.

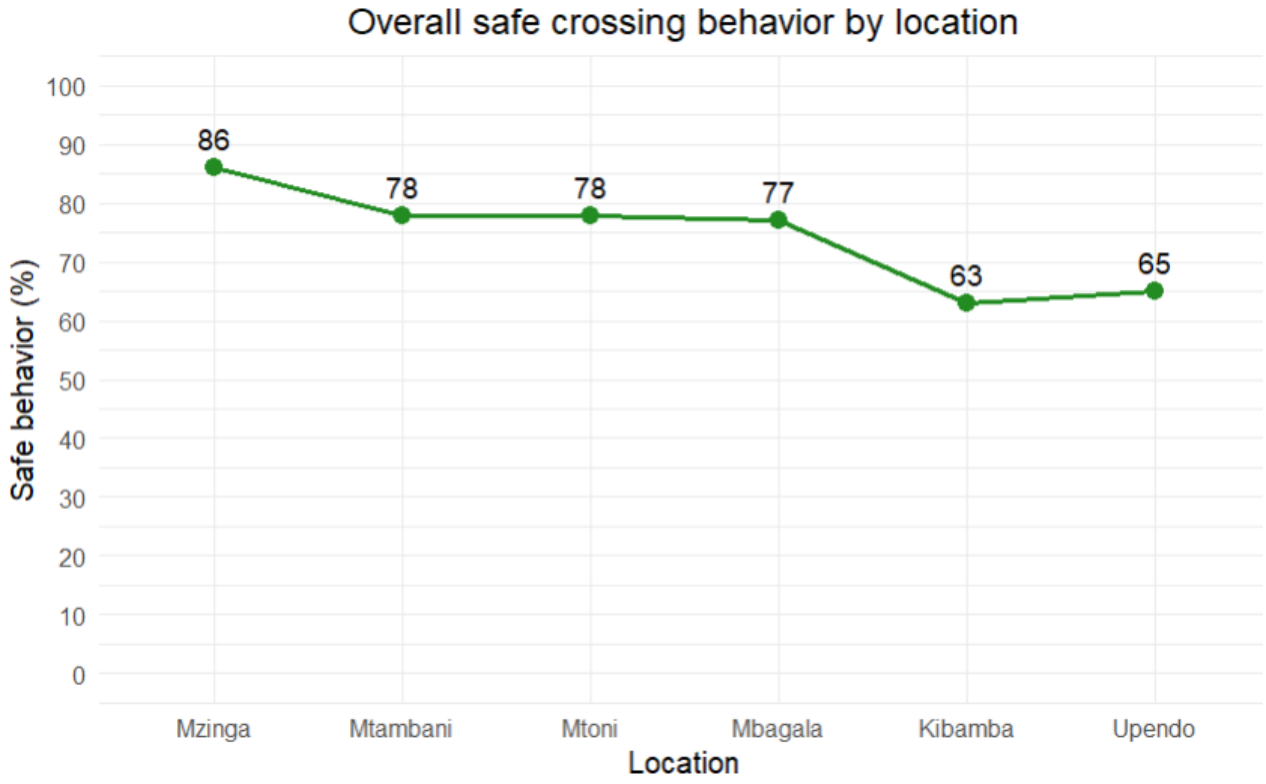


Figure 23: Line chart of overall safe crossing behaviors by location (Author, 2025)

The results of Pearson's Chi-square test to statistically assess these observed differences and association between location and overall safe crossing behavior yielded a significant result, $\chi^2 = 20.292$, $p = 0.0011$,

indicating that the variation in safe behavior across the six locations was not due to chance. This finding confirms that the distribution of safe and unsafe behaviors is significantly associated with location, meaning that the likelihood of a child crossing safely differs depending on the school zone. Location like Mzinga and Mtambani could benefit from calmer traffic environment but Upendo and Kibamba which are adjacent to a multilane may suffer from higher traffic and high-speed vehicles.

5.3.5. Overall crossing behavior by gender and number of lanes

In assessing the relationship between overall safe road-crossing behavior and road complexity, focusing on the number of lanes per direction and disaggregating results by gender. The results showed that children's safe crossing behavior significantly declines as the number of lanes per direction increases. Specifically, the highest level of safe behavior was recorded on 1-lane roads, where 164 out of 200 children (82%) crossed safely as can be seen on figure 25. This proportion dropped to 150 out of 200 (75%) on 2-lane roads and further declined to 128 out of 200 (64%) on 3-lane roads. Again as witnessed on the individual behaviors in the previos subchacpter, this trend suggests that wider roads pose greater challenges to child pedestrians (Schwebel et al., 2018), possibly due to longer crossing distances, faster vehicle speeds, and more complex traffic environments that increase the difficulty of making safe crossing decisions. A Pearson's Chi-square test revealed a significant association between road width and safe crossing behavior, $\chi^2(2) = 18.476$, $p = 9.727e\text{-}05$. This indicates that the likelihood of children engaging in safe crossing behavior is not evenly distributed across road types and is strongly influenced by the number of lanes.

On the other hand, the results of observations of crossing behavior by gender revealed that female children exhibited overall a higher rate of safe crossing behavior compared to their male counterparts, with 77% of females crossing safely versus 71% of males as can be seen on figure 26. This difference suggests that, in general, female children may be slightly more cautious or better at following safe pedestrian practices. However, a Pearson's chi-square test with Yates' continuity correction to determine whether this observed difference was statistically meaningful indicated no statistically significant relationship, $\chi^2(1, N = 600) = 2.50$, $p = 0.114$. This means that the difference in safe crossing proportions between males and females could be attributed to random variation rather than a true underlying effect of gender on pedestrian safety. Previous studies, such as that by Underwood (2007) also found that male school children are more likely to cross the road unsafely, the observation that is attributed by over confidence and risk-taking nature of males.

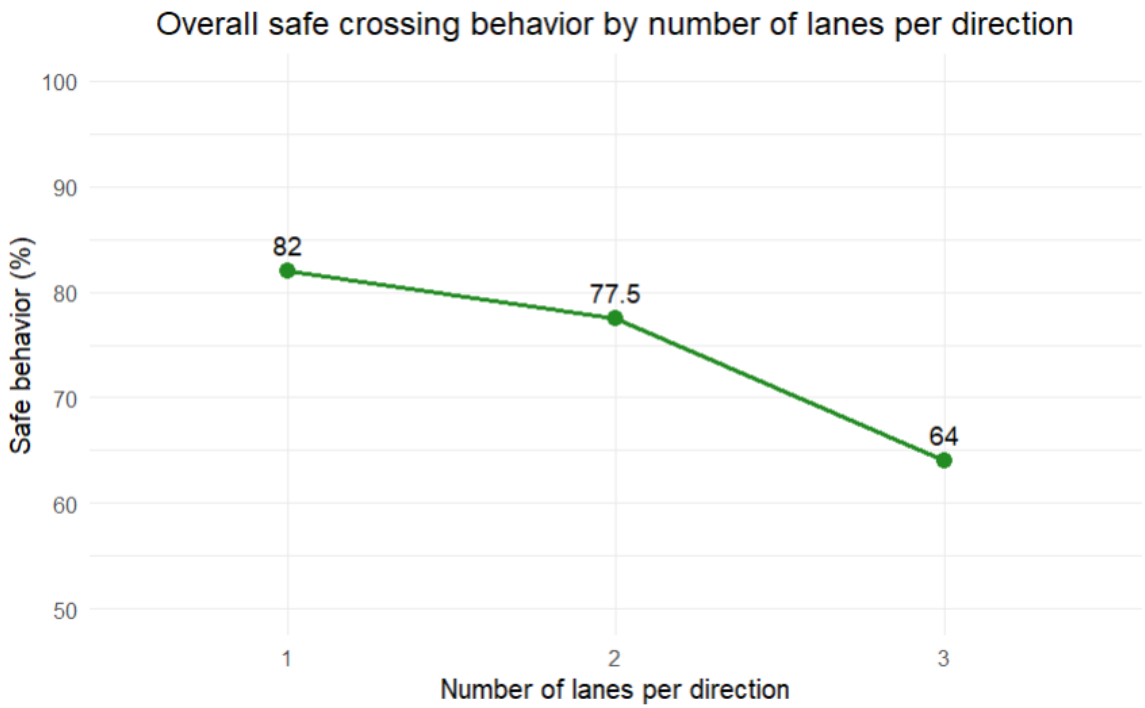


Figure 24: Overall crossing behaviors by number of lanes (Author, 2025)

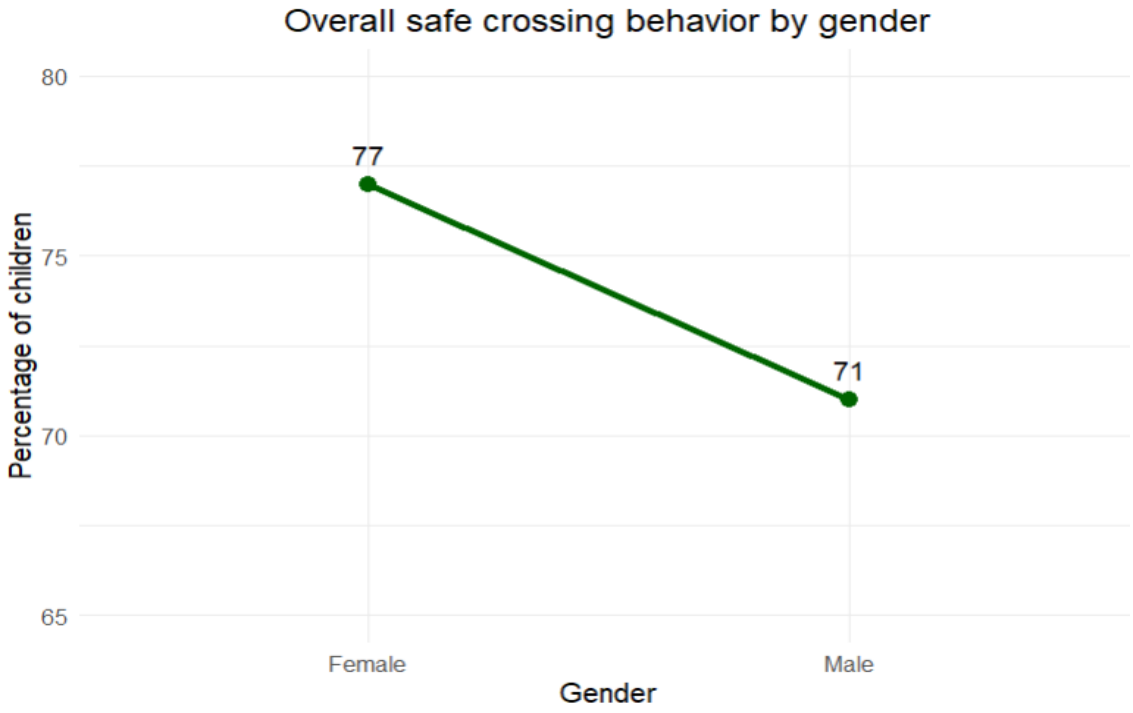


Figure 25: Overall crossing behaviors by gender (Author, 2025)

5.5. Factors influencing road crossing behavior among school children

In this subchapter, the results of a binary logistic regression analysis to uncover the influence of various individual and traffic factors on school children's road crossing behavior. The dependent behaviors investigated include pausing before crossing, scanning, running, distracted walking, diagonal crossing, and zebra crossing use while the independent variables (predictors) entered into the models were: gender, number of accompanying children, traffic volume which in this context is defined as number of vehicles passed while waiting per unit waiting time, 85th percentile speed, number of lanes, and whether the child was accompanied by an adult. The influence of these variables on each specific pedestrian behavior is discussed in the subchapters below.

5.5.1. Factors affecting school children's pausing behavior

The result of the binary logistic regression model to examined the relationship between the predictors and the likelihood that a school child pauses before crossing the road as can be seen on table 5 showed that, only the intercept was statistically significant at the 95% confidence level (p = 0.0104). While all the predictors, even at 90% confidence level, were not significantly influencing the tendency of school children to pause before crossing the road.

Table 4: binary logistic regression results for pausing behavior

Predictor	Estimate	Std. Error	z value	p-value
(Intercept)	4.215	1.644	2.564	0.010 **
Gender (Male)	0.296	0.533	0.556	0.578
Children	-0.186	0.186	-1.000	0.318
Volume	0.183	20.13	0.009	0.993
Speed	-0.113	0.076	-1.481	0.139
Lanes	0.899	1.058	0.849	0.396
Accompanied (Yes)	21.94	11450	0.002	0.999

*Note: Significance codes – ***p < 0.001, **p < 0.01, *$p < 0.05$

5.5.2. Factors affecting school children's scanning behavior

In determining the factors affecting school children's scanning behaviors, the results of binary logistic regression as can be seen on table 6 showed that none of the predictors were significantly affecting the scanning behavior, however, the number of children crossing together was found to be statistically significant at the 90% confidence level (p = 0.0913). Specifically, the estimate for the number of children variable was negative (Estimate = -1.028), suggesting that the presence of more children is associated with a decreased likelihood of scanning before crossing. While speed approached significance at 90% confidence level (p = 0.1025), its effect was not strong enough to meet the 90% but it has a positive influence meaning

that at higher speed children are more likely to scan for oncoming traffic. On the other hand, the traffic volume showed to have no influence all to this behavior (p = 0.997)

Table 5: Logistic Regression Results for Scanning Behavior

Predictor	Estimate	Std. Error	z value	p-value
(Intercept)	74.39	23000	0.003	0.997
Gender (Male)	1.247	1.318	0.946	0.344
Children	-1.028	0.609	-1.688	0.091 *
Volume	0.059	18.22	0.003	0.997
Speed	0.921	0.564	1.633	0.103
Lanes	-40.78	7667	-0.005	0.996
Accompanied (Yes)	20.38	16280	0.001	0.999

*Note: Significance codes – ***p < 0.001, **p < 0.01, *$p < 0.05$

5.5.3. Factors affecting school children's running behavior

In investigating the factors affecting the children's running behavior, the result of the regression analysis as can be seen on table 7 showed several significant predictors of running behavior. Notably, male children were more likely to run across the road than female children. Specifically, being male increased the odds of running by approximately 122% (OR = 2.22; p = 0.001). Additionally, the presence of other children when crossing (number of children variable) also significantly increased the likelihood of running (p = 0.041). Children in groups were about 11% (OR = 1.11) more likely to run than those not in groups. This slight increase could be attributed to peer influence, where children imitate the actions of their peers or attempt to keep pace with them.

Moreover, the result showed that traffic volume had a significant effect (p = 0.005), although the coefficient was small (OR ≈ 1.0008). While this might appear negligible, it indicates that even slight increases in traffic volume can make children feel more pressure to run across the road to avoid being caught in moving traffic. Similarly, the number of lanes was also statistically significant (p = 0.046), for each additional lane, the odds of a child running increased by 182% (OR ≈ 2.83). Most strikingly, the results showed that school children being accompanied by an adult significantly reduced the odds of running (p < 0.001). Children accompanied by an adult were 96% less likely to run across the road (OR ≈ 0.04), indicating a strong protective effect.

Table 6: Logistic Regression Results for Running Behavior

Predictor	Estimate	Std. Error	z value	p-value
(Intercept)	-4.750	0.699	-6.794	<0.001 ***
Gender (Male)	0.797	0.246	3.240	0.001 ***
Children	0.106	0.052	2.047	0.041 *
Volume	0.0008	0.0003	2.833	0.005 **
Speed	0.0089	0.032	0.278	0.781
Lanes	1.040	0.521	1.996	0.046 *
Accompanied (Yes)	-3.185	0.490	-6.496	<0.001 ***

*Note: Significance codes – ***p < 0.001, **p < 0.01, *$p < 0.05$

5.5.4. Factors affecting distraction while crossing

In investigating the factors affecting distraction behaviors while crossing, the results of regression analysis as can be seen on table 8 showed that, the only statistically significant predictor of distraction (at the 95% confidence level) is the intercept (p = 0.003). This suggests that when all other variables are held at their reference values, the baseline probability of a child being distracted is notably low. None of the individual predictors had a statistically significant effect on distraction behavior, even at 90% confidence level (all p-values > 0.1). For example, although being accompanied showed a large negative coefficient (Estimate = -17.58), this variable was highly unstable due to an extremely large standard error (1183), indicating it is not reliable or meaningful.

Table 7: Logistic Regression Results for Distraction Behavior

Predictor	Estimate	Std. Error	z value	p-value
(Intercept)	-3.966	1.357	-2.923	0.003 **
Gender (Male)	0.349	0.506	0.690	0.490
Children	0.032	0.113	0.282	0.778
Volume	-0.00019	0.00063	-0.301	0.764
Speed	-0.00691	0.06396	-0.108	0.914
Lanes	0.507	1.014	0.500	0.617
Accompanied (Yes)	-17.580	1183.000	-0.015	0.988

*Note: Significance codes – ***p < 0.001, **p < 0.01, *$p < 0.05$

5.5.5. Factors affecting diagonal crossing behavior

In investigating the factors affecting diagonal crossing behaviors, the results of logistic regression analysis as displayed on table 9 showed that, three predictors stand out in influencing diagonal crossing behavior. First, being accompanied by an adult is a strong negative predictor (OR = 0.09, $p < 0.01$), meaning that children who are accompanied are significantly less likely to cross the road diagonally by 91%. Second, traffic volume also showed a significant negative association with diagonal crossing (OR = 0.99, $p = 0.018$), indicating that higher vehicle volumes tend to discourage children from choosing diagonal routes. Lastly, the intercept is statistically significant ($p < 0.01$), pointing to a very low baseline probability of diagonal crossing when all other factors are held at their reference levels. On the other hand, gender of the crossing school child had the most insignificant influence ($p = 0.68$) while the remaining variables, including number of children crossing together, vehicle speed, and number of lanes, did not show statistically significant effects on diagonal crossing behavior even at 90% confidence level ($p > 0.1$).

Table 8: Logistic regression results for diagonal crossing

Predictor	Estimate	Std. Error	z value	p-value
(Intercept)	-4.413	0.897	-4.919	< 0.001***
Gender (Male)	0.128	0.312	0.409	0.683
Children	0.111	0.079	1.401	0.161
Volume	-0.00096	0.00040	-2.368	0.018*
Speed	0.048	0.044	1.091	0.275
Lanes	0.291	0.696	0.418	0.676
Accompanied (Yes)	-2.409	0.540	-4.464	< 0.001*

*Note: Significance codes – ***p < 0.001, **p < 0.01, *$p < 0.05$

5.5.6. Factors affecting crossing at zebra cross behavior

In investigating the factors affecting the behavior of using pedestrian cross, the results of logistic regression indicate that four variables significantly predict the likelihood of children using zebra crossings. Firstly, the variable of being accompanied by an adult is a strong positive predictor (OR = 9.45, $p < 0.01$), implying that adult supervision greatly increases the chances of children using designated crossings by 9.45. Secondly, traffic volume also shows a positive association (OR = 1.001, $p = 0.013$), suggesting that higher vehicle density motivates children and their guardians to seek safer crossing points and for each unit increase in traffic volume the chance of a crossing school child to use the pedestrian cross is increased by 0.1%. Conversely, vehicle speed is negatively associated with zebra crossing use (OR = 0.913, $p = 0.031$) meaning that for every 1 km/h increase reduces odds by 8.7%. Additionally, the model's intercept was found to be significant ($p < 0.01$), indicating a high baseline probability of zebra crossing use when all predictors are at their reference categories. On the other hand, variables such as gender, number of children, and number of lanes were not statistically significant in this model, suggesting that these do not meaningfully influence the decision to use zebra crossings in this dataset.

Table 9: Logistic regression results for zebra crossing behavior

Predictor	Estimate	Std. Error	z value	p-value
(Intercept)	4.475	0.877	5.104	< 0.001*
Gender (Male)	0.035	0.297	0.117	0.907
Children	-0.021	0.088	-0.241	0.810
Volume	0.001	0.0004	2.494	0.013*
Speed	-0.091	0.042	-2.151	0.031*
Lanes	0.327	0.645	0.507	0.612
Accompanied (Yes)	2.246	0.454	4.943	< 0.001*

*Note: Significance codes – ***p < 0.001, **p < 0.01, *$p < 0.05$

5.5.7. Factors affecting overall unsafe crossing behavior

In investigating the factors affecting overall unsafe crossing behaviors, the results of the regression analysis as displayed on table 11 showed that several predictors are statistically significant at the 95% confidence level, for example, being accompanied by an adult was found to be a strong negative predictor of unsafe crossing behavior (OR = 0.43, p < 0.01). This result indicates that children under adult supervision are significantly less likely to cross roads unsafely, specifically, being accompanied reduces odds of crossing the road unsafely by 95.7%.

While the accompaniment showed the negative influence toward unsafe crossing, traffic volume emerged as a significant positive predictor (OR = 1.001, p = 0.03), suggesting that as the number of vehicles increases, children become more prone to cross unsafely. Although the traffic volume is a significant predictor due to its odd ratio being very close to one (1.001) it only increases the chances of unsafe crossing by 0.1% pe unit increase in the traffic volume. Additionally, vehicle speed showed a significant positive association with unsafe crossing behavior (OR = 1.063, p = 0.03), implying that faster-moving traffic increases the likelihood of risky decisions. Precisely, for each increase of 1km/hr on the road, the odds of school children crossing unsafely are increased by 6.3%.

Table 10: Logistic regression results for overall unsafe crossing

Predictor	Estimate	Std. Error	z value	p-value
(Intercept)	-4.044	0.620	-6.520	< 0.001***
Gender (Male)	0.403	0.217	1.858	0.063
Children	0.078	0.047	1.667	0.096
Volume	0.0005	0.0003	2.174	0.030*
Speed	0.061	0.027	2.234	0.026*

Lanes	0.166	0.419	0.395	0.693
Accompanied (Yes)	-3.158	0.380	-8.302	< 0.001***

*Note: Significance codes – ***p < 0.001, **p < 0.01, *$p < 0.05$

Moreover, gender, specifically being male, was not statistically significant at the 0.05 level but showed a marginal effect (OR = 1.497, p = 0.063), indicating that male school children have 49.7% higher odds of exhibiting the outcome compared to female school children. Just like the gender variable, the number of children crossing together also showed a marginal association (OR = 1.081, p = 0.096), with larger groups appearing to slightly increase the likelihood of unsafe crossing. The intercept in the model was also highly significant (p < 0.01), indicating a very low baseline probability of unsafe crossing when all predictors are at their reference levels. This underscores the importance of the identified predictors in influencing crossing behavior, as deviations from the baseline appear to be meaningfully explained by their presence. Other predictor, the number of lanes, showed no significant influence to the overall unsafe crossing (p = 0.693).

CHAPTER SIX

DISCUSSION

6.1. Discussion of findings on road safety awareness (Objective 1)

This study assessed the level of awareness among school children regarding various aspects of safe road crossing. The findings reveal a generally high level of awareness across all measured behaviors, suggesting that RSE has been effective to a large extent. However, age emerged as a significant determinant of awareness in several aspects, while gender differences were minimal and statistically insignificant. These results emphasize the importance of age-tailored interventions and support the continued rollout of inclusive RSE across primary school levels (Biassoni et al., 2020; WHO, 2020; Wilde, 2001).

The results showed that 93.3% of children were aware of the need to stop and scan before crossing, a behavior widely regarded as a foundational pedestrian safety practice. The statistically significant association between age and awareness ($\chi^2(3, N = 600) = 19.02$, $p < 0.01$) indicates that awareness increases with age, likely due to cognitive development and repeated exposure to safety education. This supports findings by Biassoni et al. (2020) and Odame et al. (2024), which highlighted developmental maturity as a key factor in the application of visual scanning strategies during road crossing. The ability to scan traffic from both directions before stepping into the road is crucial for risk avoidance and hazard recognition (Kilbey et al., 2011). Therefore, the increase in awareness with age may reflect both maturing executive functioning and the cumulative effects of schooling or informal learning (Goddard et al., 2020). These results underscore the importance of incorporating visual scanning simulations and teacher-led road crossing drills, especially for younger age groups (Raftery & Wundersitz, 2016).

Similarly, 94.8% of children reported awareness of the importance of walking, not running, while crossing the road. Again, awareness increased with age ($\chi^2 = 27.27$, $p < 0.01$), suggesting that older children are more capable of regulating impulsive behavior, a trend consistent with studies such as Lee et al. (2018) and Goddard et al. (2020). Running across the road exposes children to unexpected traffic conflicts and reduces their ability to make adjustments in dynamic environments (Ngunde et al., 2019). Therefore, this behavior is especially dangerous for younger children who may act impulsively. The sharp improvement in awareness among older students suggests that behavior modeling and structured reinforcement play a critical role (Sangowawa et al., 2012). These findings point to the need for sustained engagement with younger pupils using practical tools such as storytelling, animated content, or supervised crossings to internalize the importance of controlled movements in road environments.

Awareness of the danger of diagonal crossing was also high, with 95.5% of students recognizing the importance of crossing perpendicularly. A significant relationship between age and awareness was observed ($\chi^2 = 16.59$, $p < 0.01$), further supporting the trend that safety knowledge improves with age. These results align with Sangowawa et al. (2012), who reported that younger children often struggle to assess risk associated with complex traffic scenarios such as crossing at an angle. Diagonal crossing increases both exposure time and unpredictability for approaching vehicles, and is thus a key hazard to mitigate. That younger students showed lower awareness of this risk highlights the need to target this behavior through active demonstration on school premises or through mock simulations. Practical demonstrations and visual training, rather than abstract teaching, may be especially effective for embedding this concept in early learners (Biassoni et al., 2020; Wilde, 2001).

The practice of using designated pedestrian crossings received the highest level of awareness (96.3%), yet interestingly, the age differences were not statistically significant ($\chi^2 = 4.67$, $p = 0.20$). This suggests that environmental cues like road markings may play a greater role than age-based learning in shaping behavior (WHO, 2020). Such cues likely reinforce formal education, helping even younger children internalize this particular behavior early on. These findings are consistent with Indhumanthy & Thenmozhi (2016) and Raftery & Wundersitz (2016), who argue that infrastructure design and visible signage play a crucial role in shaping pedestrian habits among children. The near-universal awareness of pedestrian crossings implies that this is one of the most successful areas of road safety communication. It also demonstrates the value of school zones having clearly marked crossings, which visually guide children toward safe behaviors regardless of formal instruction (Ackaah, 2010).

Lastly, awareness of the need to avoid distractions while crossing was also high (95.8%), with significant variation by age ($\chi^2 = 14.00$, $p < 0.01$). This result reinforces the idea that cognitive maturity enhances attention control and risk perception, enabling older children to maintain focus while navigating traffic (Odame et al., 2024). These results support the conclusions of Alonso (2018) and Odame et al. (2024), who highlight attentional development as central to pedestrian safety among youth. Distractions such as playing, using phones, or engaging in conversations can impair visual attention and delay reaction time (Ngunde et al., 2019). While the high level of awareness is encouraging, the findings also emphasize that interventions for younger children should focus on habit formation and behavioral modeling. Teachers and parents should be actively involved in reinforcing distraction-free crossing through repeated messaging and supervised practice (González-Sánchez et al., 2021). Addressing distractions through age-appropriate strategies can substantially reduce risk, especially in busy urban environments.

Across all behaviors, no statistically significant differences were observed by gender, as confirmed by chi-square results (all $p > 0.05$). This finding indicates that road safety messages are reaching both male and female students with similar efficacy, reflecting gender-equitable delivery of safety education within schools. The consistency with prior research (e.g., Alonso, 2018; Biassoni et al., 2020) highlights the value of maintaining uniform training while reinforcing messages early and often, especially for younger learners. Gender parity in awareness is a positive outcome, demonstrating that interventions do not need to be gender-specific but rather should focus on early cognitive development and context-based learning (Indhumanthy & Thenmozhi, 2016). This insight simplifies curriculum development and supports inclusive, whole-class approaches to road safety training.

6.2. Discussion on road and traffic characteristics at school zones (Objective 2)

The characteristics of the road and traffic environment surrounding the six school zones in Dar es Salaam reveal substantial disparities in how infrastructure either mitigates or exacerbates risks for child pedestrians. These differences offer critical insight into the observed crossing behaviors and highlight systemic inconsistencies in urban safety planning. Vehicle speed, road geometry, pedestrian facilities, traffic control measures, and crossing supervision each play a nuanced role in shaping children's road-crossing experiences and decisions.

A central finding from the speed study was the wide range of 85th percentile speeds observed across the sites, from 23.1 km/h at Mzinga to 55.3 km/h at Upendo. This variation followed a clear trend, with higher speeds consistently recorded on wider roads with more lanes, particularly at Kibamba and Upendo, where three-lane roads allowed for faster, less restricted vehicle movement. The relationship between road width

and speed is well established in road safety literature, as wider roads create a perception of openness and control, prompting drivers to increase speed (OECD, ITF, 2012, Trifunović, 2017). For child pedestrians, who often struggle to judge vehicle speeds and distances (Ampofo-Boateng and Thomson, 1991), high-speed traffic significantly raises the danger of mistimed crossings. Furthermore, Wilde (2001) argues that when environments become more hostile or unpredictable, children adjust by either hesitating dangerously or rushing to cross, behaviors clearly seen in the running and diagonal crossing patterns noted in the behavioral observations.

The road cross-section further compounds the challenge. Children faced greater exposure in locations like Kibamba and Upendo, where the crossing distance across three lanes increased both the time spent on the carriageway and the number of potential vehicle conflict points. Longer exposure increases the cognitive and physical demands on children, who may struggle to maintain vigilance throughout the crossing (Peden et al., 2004). The limited presence of central medians, absent at the narrower roads of Mzinga and Mtambani, reduced opportunities for staged crossing and safe refuge, particularly at high-volume sites. As Biassoni et al. (2020) explain, physical design features such as medians or pedestrian islands are essential not just for safety but for psychological comfort, especially for young road users.

Despite the universal presence of designated pedestrian crossing facilities, their condition and location varied in ways that reduced their effectiveness. At Mzinga, for instance, the crosswalk markings were faded and barely discernible. This undermines both child confidence and driver compliance, as poorly marked crossings are more likely to be ignored (Perego et al., 2019). In contrast, other schools like Mtoni and Mbagala had more visible and maintained crossings, offering a safer alternative. Still, infrastructure alone is insufficient when design ignores human behavior. The pedestrian overpasses at Upendo and Kibamba were sited far from the children's natural crossing points, rendering them underutilized. This mismatch between infrastructure placement and pedestrian desire lines reflects a broader issue in urban planning, with facilities that are technically correct but behaviorally irrelevant (Biassoni et al., 2020).

Traffic calming infrastructure was notably lacking in nearly all zones. Only Mtoni had a physical calming device in the form of a road hump, while the rest had no apparent speed-reduction measures in place. This absence is particularly alarming in high-speed environments like Upendo, where even the presence of a traffic officer was insufficient to counteract the risks posed by a posted limit of 50 km/h, well above the recommended 30 km/h for school zones (WHO, 2020). The presence of calming measures such as raised crossings, rumble strips, or narrowing devices has been shown to significantly lower speeds and increase driver attentiveness, especially in areas frequented by vulnerable users (Odame et al., 2024; Thornton, 1999). Their absence, therefore, is not a neutral design decision, it actively contributes to a less safe environment for children.

Complementing this, the analysis of road signage revealed inconsistent patterns. Mzinga and Mtoni had relatively robust signage, including school zone indicators and pedestrian crossing warnings. These act as critical visual cues for drivers, prompting them to reduce speed and heighten awareness (Odame et al., 2024). In stark contrast, Mtambani had no functional signage, with a rusting pole indicating where a sign once stood. Such degradation not only fails to inform drivers but signals neglect, an implicit message that pedestrian safety is not prioritized in that space. The absence of visible signage, particularly in child-dense areas, undermines the broader traffic ecosystem meant to protect vulnerable users (WHO, 2015).

Environmental complexity was further heightened by the proximity of bus stops to crossings in four of the six zones. While bus stops enhance accessibility, they also introduce new risks such as obstructed visibility, increased vehicle movements, and erratic pedestrian flows. Children navigating these spaces must manage sudden obstructions and shifting traffic patterns, often beyond their developmental capacity (Schwebel et al., 2012). As Wilde (2001) notes, unpredictability in the environment increases the cognitive load on young pedestrians, often pushing them toward impulsive or unsafe decisions.

Interestingly, road surface condition, typically considered a vehicle safety issue, also emerged as a factor in pedestrian risk. At Mzinga, deteriorated pavement forced vehicles to reduce speed, inadvertently making it safer for children to cross. Although this cannot be promoted as a formal strategy, it echoes Wilde's (2001) theory of risk compensation, whereby drivers adapt to perceived hazards by adjusting behavior. In contrast, the smooth and well-maintained pavements at other locations enabled higher vehicle speeds in the absence of calming measures or visual friction, thereby creating unintentionally hazardous conditions for children.

The presence, or absence, of crossing supervision further amplified these infrastructural disparities. While Upendo had a traffic officer and Mbagala had a crossing guard, other zones such as Mtambani, Mtoni, and Kibamba lacked any form of supervision. The difference this makes is profound. Studies by Alonso (2018) and WHO (2015) highlight that adult presence, especially trained crossing guards, not only improves child behavior at crossings but also increases driver compliance with pedestrian right-of-way. In locations without this layer of behavioral guidance, children are left to negotiate complex environments independently, often resulting in erratic or unsafe crossings.

In sum, the road environments of the six school zones show a fragmented safety landscape. Each missing or degraded element, whether signage, supervision, speed control, or pedestrian facilities, does not just represent a technical gap but increases the cognitive and physical burden on school children. As Wilde (2001) emphasized, road users do not operate in isolation but adapt to the perceived risks and affordances of their surroundings. For children, whose perceptual, attentional, and decision-making abilities are still developing (Ampofo-Boateng and Thomson, 1991; Biassoni et al., 2020), these inconsistencies can be the difference between safety and harm. The findings clearly underscore the urgent need for an integrated, child-sensitive approach to road design and enforcement in school zones, one that considers not only infrastructure but how it is perceived and used by its most vulnerable users.

6.3. Children's road crossing behaviors in school areas (Objective 3)

This study also analyzed key unsafe crossing practices among school children in Dar es Salaam. Through structured observations conducted across six school zones, several insights emerged regarding the prevalence and nature of both safe and unsafe road-crossing behaviors.

A majority of the children demonstrated high compliance with fundamental safety behaviors, particularly pausing before crossing and scanning for traffic, with adherence levels exceeding 90% in nearly all locations. These two behaviors appear to be the most well-internalized among children and are likely the result of early-age RSE and the intuitive nature of these actions. They are simple, require no physical infrastructure, and can be practiced in virtually any traffic situation. These findings align with Biassoni et al. (2020), who argue that consistent exposure to RSE fosters positive pedestrian behaviors in children. The results also reflect Wilde's (2001) Risk Compensation Theory, which posits that individuals adjust their behavior based on their perception of risk, suggesting that children may recognize traffic danger and instinctively pause and scan to minimize it. Despite this strong compliance with basic safety checks, several

unsafe crossing behaviors were prevalent and context-dependent, including running across roads, crossing diagonally, and not using designated pedestrian facilities (zebra crossings). These behaviors introduce significant risks and reflect deeper behavioral and contextual influences.

Running across roads was one of the most common unsafe behaviors, particularly in Kibamba (77%) and Upendo (73%), where traffic environments were more intense. This tendency is consistent with literature noting that children often lack mature impulse control and tend to act impulsively when exposed to high-risk or stressful environments (Ampofo-Boateng & Thomson, 1991; Zeedyk et al., 2002). In such contexts, children may run not out of ignorance but out of urgency, anxiety, or peer pressure, a behavior often observed in crowded or wide roads where crossing seems intimidating. This is further supported by Underwood (2007), who noted that boys in particular are more likely to engage in risk-taking behavior such as running, driven by both temperament and social conditioning.

Another unsafe practice involved children failing to use zebra crossings, even in areas where such infrastructure was available. In Upendo and Kibamba, fewer than 83% of observed children used zebra crossings. Field notes suggest that children may avoid these facilities due to poor visibility, faded markings, or inconvenient placement, factors that reduce their perceived utility. Additionally, lack of driver compliance with pedestrian right-of-way discourages children from relying on crossings. This observation supports findings by Trifunović (2017) and WHO (2020), who argue that infrastructure alone is not sufficient; without proper maintenance, enforcement, and driver education, its effectiveness diminishes significantly.

Diagonal crossing, another unsafe behavior, was notably common in Kibamba and Upendo. This practice increases the time children spend exposed to traffic and complicates drivers' ability to predict pedestrian movement. Diagonal crossing likely results from children taking the shortest route to their destination, especially in environments with informal drop-off points, missing fencing, or lack of footpaths. This behavior reflects both practical decision-making (seeking efficiency) and insufficient road-use guidance, consistent with Trifunović's (2017) assertion that unsafe behaviors often arise from infrastructure gaps rather than ignorance of rules.

The combined measure of overall safe crossing behavior, where a child was required to correctly perform all six observed behaviors, revealed significant variation across the six study sites. Mzinga recorded the highest overall safe behavior rate (86%), whereas Kibamba recorded the lowest (63%). The statistically significant association between location and overall behavior ($\chi^2 = 20.292$, $p < 0.01$) suggests that environmental features, such as road width, traffic speed, and visibility of signage, have a direct effect on pedestrian behavior. Indeed, Mzinga and Mtambani, both of which are characterized by single-lane roads and calmer traffic conditions, recorded fewer unsafe behaviors, suggesting that traffic environment plays a critical role in shaping pedestrian decision-making.

While children in Dar es Salaam generally understand and attempt to practice safe road crossing, their behavior is highly influenced by environmental conditions, supervision, and social context. Unsafe behaviors persist not solely due to lack of knowledge, but due to practical constraints, fear, and adaptive responses to traffic complexity. These findings underscore the need for a holistic approach to child pedestrian safety that goes beyond education to include infrastructure improvement, adult supervision, and community-level enforcement of road safety norms.

6.4. Factors influencing children's road crossing behaviors in Dar es Salaam (Objective 4)

The regression analysis confirmed that children's road crossing behavior in Dar es Salaam is not random but is influenced by multiple individual and contextual factors. These results highlight that behavior in traffic environments is shaped by the interplay of perceptual development, environmental constraints, and social influence, rather than knowledge alone (WHO, 2020; Wilde, 2001). The significance of factors such as adult supervision, traffic characteristics, group dynamics, and road design underscores the complex nature of pedestrian safety among school children.

Adult accompaniment emerged as the most consistent and powerful predictor of safer road crossing behavior. Children accompanied by an adult were significantly less likely to engage in unsafe behaviors such as running or diagonal crossing and were far more likely to use zebra crossings. For instance, adult accompaniment reduced the odds of running by 96% and increased the likelihood of zebra crossing use by nearly tenfold. This finding echoes the observations of Alonso (2018) and Wilde (2001), who emphasize that adult presence not only provides direct supervision but also offers psychological comfort that mitigates panic and impulsive decision-making. Adults often act as surrogate risk assessors, guiding children in timing their crossings and reinforcing proper behavior through modeling and instruction (Biassoni et al., 2020). In urban African contexts such as Dar es Salaam, where road signage and pedestrian infrastructure may be limited, this guidance becomes even more critical (Odame et al., 2024).

Traffic volume and vehicle speed also showed important, though nuanced, effects. Higher traffic volume and faster vehicle speeds were both positively associated with unsafe behaviors like running and overall unsafe crossing. At the same time, they increased the likelihood of using pedestrian crossings, revealing a behavioral paradox. Children under pressure from congested roads may resort to running or crossing unsafely to avoid prolonged exposure to traffic, a phenomenon noted in prior studies (Ampofo-Boateng & Thomson, 1991; Odame, 2024). Yet when pedestrian crossings are available, these same children may gravitate toward them as safer alternatives in chaotic traffic environments. As Biassoni et al. (2020) point out, children's cognitive limitations affect their capacity to accurately judge vehicle speed and distance, leading to poor crossing timing. Trifunović (2017) further explains that increased traffic density reduces perceived crossing opportunities, encouraging hurried or misjudged behavior. The current study confirms these insights, showing that with every 1 km/h increase in vehicle speed, the odds of unsafe crossing rose by 6.3%.

Gender differences were especially pronounced in running behavior. Male children were more than twice as likely to run across roads compared to females (OR = 2.22, $p < 0.01$). This aligns with developmental findings that boys often engage in higher-risk behavior, are more impulsive, and are more physically active in public settings (Biassoni et al., 2020; Underwood, 2007). While gender was not a significant predictor of overall unsafe behavior, its influence on specific behaviors suggests that risk profiles are at least partially shaped by gendered socialization patterns. Odame et al. (2024) recommend that interventions take gender into account, as boys may require more targeted strategies to mitigate impulsivity and promote reflective behavior in traffic contexts.

Number of school children crossing together, represented by the number of children crossing together, showed a modest but statistically significant impact. It increased the odds of running and had a marginal effect on overall unsafe behavior. This may reflect social facilitation or herd behavior, where children imitate their peers or rely on group momentum rather than individual assessment of traffic conditions.

Perego et al. (2019) explain that in group settings, especially unsupervised ones, individual attention to environmental cues diminishes, increasing the risk of unsafe actions. Similarly, Biassoni et al. (2020) observe that group behavior often leads to a breakdown in traffic vigilance among children, particularly if no adult is present. In Dar es Salaam, where many children walk in informal groups without adult supervision, this peer influence can become a critical factor in shaping unsafe practices.

The number of lanes, as an indicator of road width, was another relevant predictor. Children were nearly three times more likely to run across wider roads, which may be interpreted as an urgency response, perceiving the crossing task as more demanding and time-sensitive. However, the number of lanes was not significantly associated with overall unsafe behavior, suggesting that infrastructure alone does not dictate risk. Rather, children's crossing behavior on multi-lane roads is more strongly influenced by perceived difficulty and time pressure than by formal training or education (Trifunović, 2017; Wilde, 2001). This again highlights the importance of context: in environments where traffic flow is continuous and unregulated, such as many school zones in Dar es Salaam, children may feel compelled to run, even if they recognize it as unsafe.

Collectively, these findings affirm the need for multifaceted safety interventions that go beyond awareness campaigns. While knowledge of road safety is important, as shown in earlier chapters, behavior is strongly influenced by situational pressures and developmental constraints. RSE must therefore be reinforced through environmental and social changes, such as ensuring the presence of guardians during school travel, calming traffic near school zones, and promoting structured group crossings. The Safe System approach, which shifts responsibility from the child to the system, is highly applicable in this context (WHO, 2020). Strategies such as reducing vehicle speed near schools, improving signage and road markings, and enforcing safe crossing zones can reduce exposure to risk and align the road environment with children's developmental capabilities (Biassoni et al., 2020; Trifunović, 2017).

Generally, children's crossing behaviors in Dar es Salaam are influenced by a combination of supervision, traffic conditions, peer dynamics, and infrastructure. The protective effect of adult accompaniment, the dangers posed by high traffic speeds, and the behavioral influence of peers all reinforce the notion that road safety cannot rest solely on the child. These insights should inform targeted interventions, policies, and urban planning strategies aimed at reducing pedestrian injury risks among children.

6.5. Reflection of the finding to the theoretical framework

The observed crossing behaviors among children, along with the awareness levels and environmental characteristics surrounding the school zones, clearly reflect the layered influences described in Bronfenbrenner's Ecological Systems Theory. At the microsystem level, the study showed that children accompanied by adults consistently demonstrated safer crossing behaviors. This illustrates the immediate and powerful role of parental or adult presence in shaping behavior. While children generally displayed high awareness of safe practices such as pausing, scanning, and using pedestrian crossings, this knowledge did not always translate into safe actions, particularly in environments that lacked supportive infrastructure or clear visual cues. The disconnect between what children know and how they behave in real traffic situations highlights the limitations of cognitive development when not supported by their immediate environment, such as through visible signs, designated crossings, or adult guidance.

At the mesosystem level, the interaction between different spheres of influence such as home, school, and community was reflected in the inconsistencies between safety instruction and actual practice. Although

some schools had visible road signs and designated crossing guards, others lacked any formal pedestrian guidance. In such settings, children were often observed running, crossing diagonally, or acting impulsively, especially when in groups or without adult supervision. These behaviors likely arise from peer influence and observational learning, where children model what they see rather than what they are taught. When children witness adults or peers engaging in unsafe road behaviors, the mixed messages they receive can erode the effectiveness of safety education. This inconsistency between message and practice creates confusion and weakens the internalization of safe habits.

The findings also demonstrate the influence of broader systemic and societal factors described in the exo-system and macrosystem levels. Road design elements such as high vehicle speeds, multiple lanes, and lack of pedestrian infrastructure were common in several school zones, creating hazardous environments for children. In places where traffic calming measures or enforcement officers were absent, vehicle speeds were significantly higher, increasing the likelihood of unsafe behavior among children. Moreover, decisions related to infrastructure placement, such as distant pedestrian overpasses, indicate planning approaches that do not account for the unique needs of children. These realities reflect wider societal values and priorities, where child pedestrian safety receives limited attention in transport planning and policy enforcement. As a result, children are frequently placed in environments that require decision-making skills beyond their developmental capacity, reinforcing the theoretical claim that behavior cannot be separated from the broader systems in which it occurs.

6.6. Reflection of the findings to the conceptual framework

The findings of this study strongly align with the conceptual framework, demonstrating that children's road crossing behavior is shaped by an interplay of child characteristics, road and traffic factors, and social influences. The analysis revealed that although many children displayed awareness of safe practices, such as scanning and using pedestrian crossings, their actual behaviors were not always consistent with this knowledge. This discrepancy is closely related to the individual-level factors highlighted in the framework. For example, gender emerged as a significant determinant of certain behaviors, with male children being more likely to run across roads. This supports earlier assertions that boys may be more prone to risky or impulsive behavior due to socialization patterns and developmental traits. Risk perception was also evident in how children responded to traffic volume and speed. The increased use of pedestrian crossings in high traffic areas suggests that some children perceived greater risk and acted accordingly, while others responded with unsafe behaviors like running, indicating uneven development of risk assessment skills. These behavioral patterns reflect the framework's emphasis on how gender and risk perception influence children's decisions in real traffic environments.

The study further supports the role of road and traffic characteristics as critical external determinants of behavior. Roads with more lanes and higher vehicle speeds were associated with increased running and overall unsafe behaviors. At the same time, children were more likely to use zebra crossings in environments with heavier traffic or where infrastructure was visibly supportive. This duality reflects the idea that physical road environments can serve both as hazards and behavioral cues. As the conceptual framework suggests, the number of lanes and traffic dynamics affect both the complexity of crossing tasks and children's judgments during these moments. Moreover, the presence or absence of pedestrian facilities, traffic calming features, and signage significantly influenced behavior across locations. Where such features were lacking, children showed higher instances of unsafe behavior. These findings reinforce the conceptual

understanding that road design not only determines physical exposure to vehicles but also conditions the strategies children use to navigate crossings.

Social influences were especially prominent in the study's findings, with adult accompaniment consistently emerging as a strong protective factor. Children who were accompanied by adults were significantly less likely to engage in unsafe behaviors, including running or diagonal crossing, and more likely to use pedestrian crossings. This aligns directly with the conceptual framework's assertion that supervision plays a vital role in promoting safety. The data also reflected the influence of peer presence. Children crossing in groups were more likely to run and, in some cases, less likely to scan, suggesting peer dynamics can reduce individual caution. These findings support the framework's inclusion of peer influence and adult supervision as key social variables that mediate children's crossing behavior. Collectively, the observed behaviors and their associated influences validate the conceptual structure of this study, demonstrating how child traits, environmental features, and social interactions converge to determine the nature and safety of children's road crossing decisions.

6.7. Limitations of the study and suggestions for future studies

This study focused on assessing road safety awareness in relation to road crossing behavior only; therefore, the findings should not be generalized to reflect broader aspects of school children's road safety awareness. Furthermore, while observational data were collected from randomly selected school children, the questionnaires were limited to pupils in standard Four. This decision was based on the fact that children at this level are capable of reading and have already been exposed to RSE, which is introduced from standard three. Another limitation concerns the observational method. Since the study prioritized a non-intrusive approach to avoid influencing children's natural crossing behaviors, the observers did not engage in direct interaction with the children. As a result, it was not possible to determine the exact age of the children observed while crossing. This restricted the ability to analyze behavioral differences based on age, even though such differences may be significant between younger and older children.

For future studies, it is recommended that researchers consider approaches that enable the estimation or documentation of the children's ages without disrupting their behavior. This would allow for more age-specific analysis of crossing behaviors. Additionally, future research should explore psychological and environmental factors influencing children's decisions while crossing, particularly in relation to scanning and distraction, which were not significantly associated with explanatory variables in this study. Longitudinal studies are also suggested to evaluate the long-term effectiveness of RSE programs and infrastructural improvements on behavioral change. Advanced tools such as GPS tracking, wearable sensors, or eye-tracking technologies could also be employed to gain real-time insights into children's crossing decision-making processes and design more targeted interventions.

6.8. Policy recommendation

Based on the findings of this study, several policy recommendations are proposed to enhance school children's pedestrian safety. Firstly, the presence of adult supervision near schools and busy roads should be prioritized. The study found that children accompanied by adults were significantly less likely to engage in unsafe crossing behaviors such as running and diagonal crossing, and were more likely to use zebra crossings. Policymakers and school authorities are therefore encouraged to implement initiatives such as

deploying school crossing guards, assigning designated pedestrian escorts, or organizing volunteer patrols during school commute hours. These strategies not only provide immediate protection but also promote long-term safe crossing habits among children.

Secondly, effective traffic-calming measures should be introduced in school zones. This includes installing speed bumps, pedestrian overpasses, signalized crossings, and clearly visible signage to reduce vehicle speed and volume, two factors found to influence children's road crossing behavior. Well-marked and strategically located zebra crossings should be implemented and regularly maintained in areas frequented by school children. Lastly, continued investment in RSE is crucial. Age - based and continuous RSE programs should be integrated into school curricula, combining classroom-based instruction with practical, supervised crossing exercises. It is also important to involve parents and caregivers in safety education efforts, so they can serve as consistent role models and reinforce safe road behaviors both at home and during daily commutes.

CHAPTER SEVEN

CONCLUSION

The findings of this study offer a strong and optimistic outlook on road safety awareness among primary school children in Tanzania, with consistently high response accuracy across verbal and image-based assessments, and a well understanding of safe road crossing behaviors such as stopping, scanning, avoiding distractions, and using designated crossings. The absence of significant gender differences suggests that RSE has been effectively delivered, while the observed trend of increasing awareness with age highlights the role of cognitive development in shaping safe behavior. These results affirm the success of current awareness initiatives but also point to the next critical step, which is moving from knowledge dissemination to behavior reinforcement. With children already demonstrating high awareness, future interventions should focus on building habits through repeated practice, integration into daily routines, and real life simulations under adult supervision. Additionally, sustained reinforcement through curriculum integration, visible school zone signage, and active involvement of parents and community leaders is essential to ensure that this awareness is not only maintained but translated into consistent, safe behavior.

On the other hand, road and traffic characteristics across the different school zones in Dar es Salaam have uneven road safety levels. While some zones benefited from features that promote safer crossings, such as lower vehicle speeds, narrower roads, and the presence of speed calming measures, others lacked essential infrastructure like visible pedestrian crossings, signage, and proper traffic control. High traffic volumes, and wide multi-lane roads were common in several locations, creating environments that increase the risk of unsafe road crossing, particularly for school children. This level of variation points to inconsistencies in how school zones are planned and protected across the city.

Children have shown a variety of unsafe road crossing behaviors which are attributed by a combination of individual, social, and environmental factors. Binary logistic regression analysis revealed that adult accompaniment was the most consistent predictor of safer behavior, significantly reducing risky actions like running, diagonal crossing, and overall unsafe crossing, while encouraging safer practices such as using zebra crossings. Environmental conditions, particularly high traffic volume and vehicle speed, were also strong influences, increasing the likelihood of unsafe behaviors and reducing proper crossing practices. Gender and peer group presence had more variable effects, with male children and those in groups more likely to engage in riskier behavior, such as running and reduced scanning. Meanwhile, some behaviors like pausing and distraction were not significantly affected by the measured predictors, suggesting the role of other psychological or situational factors. These insights highlight the importance of comprehensive road safety interventions that combine supervision, infrastructure design, traffic regulation, and targeted education to foster safer pedestrian behavior among children.

REFERENCES

Ackaah, W. (2010). Road traffic fatalities among children in Ghana. Injury Prevention, 16(1). http://dx.doi.org/10.1136/ip.2010.029215.254

Akasreku, B., Rwejumura, G., Maroko, A., Nyanza, R., Malekela, G., Kalolo, S., Yokeeswaran, U., Fiori, K. P., Abwe, F., & Teasdale, C. A. (2023b). Road traffic injuries in Tanzanian children and adolescents: A cross-sectional household survey. *Injury*, *54*(1), 160–167. https://doi.org/10.1016/j.injury.2022.11.052

Allahyari, T., Saraji, G. N., Adi, J., Hosseini, M., Iravani, M., Younesian, M., & Kass, S. J. (2008). Cognitive failures, driving errors and driving accidents. *International Journal of Occupational Safety and Ergonomics*, *14*(2), 149–158. https://doi.org/10.1080/10803548.2008.11076759

Alonso, F., Esteban, C., Useche, S., & Colomer, N. (2018). Effect of road safety education on road risky behaviors of Spanish children and adolescents: Findings from a national study. *International Journal of Environmental Research and Public Health*, *15*(12), 2828. https://doi.org/10.3390/ijerph15122828

Amoako-Sakyi, R. O. (2017). School path walkability and pedestrian crashes in the Cape Coast Metropolitan Area [Master's thesis, University of Cape Coast]. https://doi.org/10.1017/CBO9781107415324.004

Ampofo-Boateng, K., & Thomson, J. A. (1991). Children's perception of safety and danger on the road. *British Journal of Psychology*, *82*(4), 487–505. https://doi.org/10.1111/j.2044-8295.1991.tb02415.x

Ampofo-Boateng, K., & Thomson, J. A. (1991). Children's perception of safety and danger on the road. British Journal of Psychology, 82(4), 487–505. https://doi.org/10.1111/j.2044-8295.1991.tb02415.x

Apardian, B., & Alam, B. M. (2017). A study of effectiveness of midblock pedestrian crossings. *Interdisciplinary Journal of Signage and Wayfinding*, *1*(2), 26–59. https://doi.org/10.15763/issn.2470-9670.2017.v1.i2.a7

Bartholomew, L. K., Parcel, G. S., Kok, G., Gottlieb, N. H., & Fernández, M. E. (2011). Planning health promotion programs: An Intervention Mapping approach. John Wiley & Sons.

Barton, B. K., & Schwebel, D. C. (2007). The roles of age, gender, inhibitory control, and parental supervision in children's pedestrian safety. *Journal of Pediatric Psychology*, *32*(5), 517–526. https://doi.org/10.1093/jpepsy/jsm014

Barton, B.K.; Schwebel, D.C. (2007). The roles of age, gender, inhibitory control, and parental supervision in children's pedestrian safety. J. Pediatr. Psychol, 32, 517–526.

Bella, F., & Silvestri, M. (2015). Effects of safety measures on driver's speed behavior at pedestrian crossings. Accident Analysis & Prevention, 83, 111–124. https://doi.org/10.1016/j.aap.2015.07.016

Benjaminsen, C. (2016). How Attentive Are Children in Traffic? Norwegian SciTech News. https://norwegianscitechnews.com/2016/10/attentive-children-traffic/

Bhattacherjee, A. (2012). *Social Science Research: principles, methods, and practices.* 2nd Ed., University of South Florida, USA. http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=1002&context=oa_textbooks

Bhuiyan, N. (2019). Enhancing pedestrian safety in bangladesh. https://www.researchgate.net/publication/332057524_ENHANCING_PEDESTRIAN_SAFETY_IN_BANGLADESH

Biassoni, F., Perego, P., Sangiorgio, V., Bonalume, L., Valoti, G., Cecchini, M., & Tarantino, V. (2020). Evaluating school-aged children's ability to recognize safe street-crossing zones using a static visual tool: Evidence from Arusha, Tanzania. Sustainability, 12(24), 10534. https://doi.org/10.3390/su122410534

Biassoni, F., Perego, P., Sangiorgio, V., Bonalume, L., Valoti, G., Cecchini, M., & Tarantino, V. (2020). Evaluating school-aged children's ability to recognize safe street-crossing zones using a static visual tool: Evidence from Arusha, Tanzania. Sustainability, 12(24), 10534. https://doi.org/10.3390/su122410534

Charron, C., Festoc, A., & Guéguen, N. (2012). Do child pedestrians deliberately take risks when they are in a hurry? An experimental study on a simulator. *Transportation Research Part F: Traffic Psychology and Behaviour*, *15*(6), 635–643. https://doi.org/10.1016/j.trf.2012.07.001

Cloutier, M.-S., Beaulieu, E., Fridman, L., Macpherson, A. K., Hagel, B. E., Howard, A. W., Churchill, T., Fuselli, P., Macarthur, C., & Rothman, L. (2020). State-of-the-art review: Preventing child and youth pedestrian motor vehicle collisions: Critical issues and future directions. Injury Prevention. Access here

Collier, P., & Jones, P. (2017). Transforming Dar es Salaam into a City That Works. In Tanzania (pp. 86–104). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198704812.003.0004

Damsere-Derry, J., Palk, G., & King, M. (2017). Road accident fatality risks for "vulnerable" versus "protected" road users in northern Ghana. Traffic Injury Prevention, 18(7), 736–743. Access here

Deluka-Tibljaš, A., Šurdonja, S., Ištoka Otković, I., & Campisi, T. (2022). Child-Pedestrian traffic safety at crosswalks—literature review. *Sustainability*, *14*(3), 1142. https://doi.org/10.3390/su14031142

Demir, B., Özkan, T., & Demir, S. (2019). Pedestrian violations: Reasoned or social reactive? Comparing theory of planned behavior and prototype willingness model. Transportation Research Part F: Traffic Psychology and Behaviour, 60, 560–572. https://doi.org/10.1016/j.trf.2018.11.012

Dingus, T. A., Guo, F., Lee, S., Antin, J. F., Perez, M., Buchanan-King, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. *Proceedings of the National Academy of Sciences*, *113*(10), 2636–2641. https://doi.org/10.1073/pnas.1513271113

Edquist, J., Rudi-Brown, C. M. & Lenne, M. G. (2009). Road design factors and their interactions with speed and speed limits. Accidents research center, Monash University. https://www.monash.edu/__data/assets/pdf_file/0007/216727/Road-design-factors-and-their interactions-with-speed-and-speed-limits.pdf

Eliakunda, W., MAshoke, M., Leticia & Gurisha, Z. (2018). Vehicles accident in tanzania: causes and control challenges. International Journal of Business Management and Economic research.

Escobar, D. A., Cardona, S., & Hernández-Pulgarín, G. (2021). Risky pedestrian behaviour and its relationship with road infrastructure and age group: An observational analysis. *Safety Science*, *143*, 105418. https://doi.org/10.1016/j.ssci.2021.105418

Federal Highway Administration. (2018). Road Design: One-Way/Two-Way Street Conversions, in FHWA Safety; Federal Highway Administration: Washington, DC, USA.

Flannigan, S. A., & Khayesi, M. (2021). Content analysis of reported activities of the United Nations Road Safety Collaboration Members during the Decade 86 of Action for Road Safety 2011–2020. BMJ Open, 11(3), e042409. https://doi.org/10.1136/bmjopen-2020-042409

Gitelman, V.; Levi, S.; Carmel, R.; Korchatov, A.; Hakkert, S. Exploring patterns of child pedestrian behaviors at urban intersections. Accid. Anal. Prev. **2019**, 122, 36–47. [Google Scholar] [CrossRef]

Goddard, T., McDonald, A. D., Alambeigi, H., Kim, A. J., & Anderson, B. A. (2020). Unsafe bicyclist overtaking behavior in a simulated driving task: The role of implicit and explicit attitudes. Accident Analysis and Prevention, 144, 105595. https://doi.org/10.1016/j.aap.2020.105595

Granié, M.-A. (2007). Gender differences in preschool children's declared and behavioral compliance with pedestrian rules. *Transportation Research Part F: Traffic Psychology and Behaviour*, *10*(5), 371–382. https://doi.org/10.1016/j.trf.2007.02.002

Grayson, G. B. (1981). The identifiction of training objectives: What shall we tell the children? *Accident Analysis & Prevention*, *13*(3), 169–173. https://doi.org/10.1016/0001-4575(81)90003-8

Grayson, G. B. (1981). The role of perceptual and cognitive skills in the development of children's road safety. Transportation Research, 15F(5), 403–412.

Harrison, A. (2013). Road Safety: Insurers Show Accidents Near Schools. Available online: https://www.bbc.com/news/education-23899232

Indhumathy, P. B. & Thenmozhi. P. (2016). Assess the knowledge and practice on road safety regulations among primary school children in rural community. *International Journal of Medical Science*, *3*(8), 1–5. https://doi.org/10.14445/23939117/ijms-v3i8p101

ITF (2022), “The SARSAI programme in sub-Saharan Africa”, Case Study, ITF, Paris. Access here

ITF (2022), “The SARSAI programme in sub-Saharan Africa”, Case Study, ITF, Paris. Access here

ITF (2023), “Using Safety Performance Indicators to Improve Road Safety: The Case of Korea”, International Transport Forum Policy Papers, No. 126, OECD Publishing, Paris. https://www.itf-oecd.org/sites/default/files/docs/safety-performance-indicators-road-safety-korea_0.pdf

Kazuzuru, B. (2020). Factors Contributing to Road Traffic Accidents in Tanzania. The case of Morogoro Municipality and Dar es salaam City. World Wide Journal of Multidisciplinary Research and Development.

Kilbey, P., Wilson, D., Beg, O., Goodman, G., & Bhagat, A. (2011). Reported Road Casualties Great Britain. UK Department for Transport. http://www.dft.gov.uk

Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International.

Kumar, S.N. & Umadevi, G. (2011) Application of System Dynamic Simulation Modelling in Road Safety. 3rd International Conference on Road Safety and Simulation Purdue University Transportation Research Board, Indianapolis. Access here

Leden, L., Gårder, P., & Johansson, C. (2006). Safe pedestrian crossings for children and elderly. Accident Analysis & Prevention, 38(2), 289–294.

Lee, J., Kim, H. K., Yoon, Y., & Kim, K. (2018). Risk factors in children’s pedestrian safety: The role of roadside visibility and child development. Medical Studies, 2, 155–160.

Lukenangula, J. M. (2023). Peoples’ perspectives on the walking environment in rapidly growing cities: The case of Dar es Salaam City. African journal on land policy and geospatial sciences. https://revues.imist.ma/index.php/AJLP-GS/article/view/34447

Meir, A., & Oron-Gilad, T. (2020). Developmental and individual differences in pedestrians’ hazard perception: A simulated hazard perception task for children. Transportation Research Part F: Traffic Psychology and Behaviour, 72, 164–176. https://doi.org/10.1016/j.trf.2020.05.008

Meir, A., Oron-Gilad, T., & Parmet, Y. (2015). Are child-pedestrians able to identify hazardous traffic situations? Measuring their abilities in a virtual reality environment. *Safety Science*, *80*, 33–40. https://doi.org/10.1016/j.ssci.2015.07.007

Meir, A., Parmet, Y., & Oron-Gilad, T. (2013). Towards understanding child-pedestrians’ hazard perception abilities in a mixed reality dynamic environment. *Transportation Research Part F: Traffic Psychology and Behaviour*, *20*, 90–107. https://doi.org/10.1016/j.trf.2013.05.004

Mkalawa, C. C., & Haixiao, P. (2014). Dar es Salaam city temporal growth and its influence on transportation. Urban, Planning and Transport Research, 2(1), 423–446. https://doi.org/10.1080/21650020.2014.978951

Morrongiello, B. A., & Barton, B. K. (2009). Child pedestrian safety: Parental supervision, modeling behaviors, and beliefs about child pedestrian competence. *Accident Analysis & Prevention*, *41*(5), 1040–1046. https://doi.org/10.1016/j.aap.2009.06.017

Morrongiello, B. A., Barton, B. K., & Thomas, B. (2016). Supervising for safety: Effects of peer presence and child impulsivity on children's risk-taking behaviors. *Journal of Pediatric Psychology, 41*(1), 15-25.

Moshiro, R., F Furia, F., Massawe, A., & John Mmbaga, E. (2021). Pattern and risk factors for childhood injuries in Dar es Salaam, Tanzania. *African Health Sciences*, *21*(2), 817–825. https://doi.org/10.4314/ahs.v21i2.42

Ngunde, P. J., Akongnwi, A. C. N., Mefire, C. A., Puis, F., Gounou, E., Nkfusai, N. C., Nwarie, U. G., & Cumber, S. N. (2019). Prevalence and pattern of lower extremity injuries due to road traffic crashes in Fako Division, Cameroon. Pan African Medical Journal, 32, 53. https://doi.org/10.11604/pamj.2019.32.53.17514

Obeng-Atuah, D., Poku-Boansi, M., & Cobbinah, P. B. (2017). Pedestrian crossing in urban Ghana: Safety implications. Journal of Transport & Health, 5, 55–69. https://doi.org/10.1016/j.jth.2016.06.007

Odame, P. K., Sam, E. F., & Fiangor, A. (2024). Exploring the nature of road safety education in basic schools and school children's travel mode options in winneba, ghana. Ghana Journal of Geography, 16(1), 128–161. https://doi.org/10.4314/gjg.v16i1.5

Osuret, J., Van Niekerk, A., Kobusingye, O., Atuyambe, L., & Nankabirwa, V. (2023). Child pedestrian crossing behaviour and associated risk factors in school zones: A video-based observational study in Kampala, Uganda. Injury Prevention, 30(3), 216–223. https://doi.org/10.1136/ip-2023-044932

Pawar, D. S., & Patil, G. R. (2015). Pedestrian temporal and spatial gap acceptance at mid-block street crossing in developing world. Journal of Safety Research, 52, 39–46. https://doi.org/10.1016/j.jsr.2014.12.006

Peden, R. M., Scurfiled, D., Sleet, D., Mohan, A., Hyder, E., & Jarawan, C. (2004). World report on road traffic injury prevention. World Health Organization, Geneva; Switzerland.

Pembuain, A., Priyanto, S., & Suparma, L. (2019). The effect of road infrastructure on traffic accidents. Proceedings of the 11th Asia Pacific Transportation and the Environment Conference (APTE 2018). https://doi.org/10.2991/apte-18.2019.27

Perego, P., Biassoni, F., Sangiorgio, V., Valoti, G., & Tarantino, V. (2018). Teaching road safety in primary schools: An empirical study in Arusha, Tanzania. International Journal of Injury Control and Safety Promotion, 25(4), 386–393. https://doi.org/10.1080/17457300.2018.1458275

Pfeffer, K., & Hunter, E. (2013). The effects of peer influence on adolescent pedestrian road-crossing decisions. *Traffic Injury Prevention*, *14*(4), 434–440. https://doi.org/10.1080/15389588.2012.725259

Pinna, F.; Murrau, R. Age Factor and Pedestrian Speed on Sidewalks. Sustainability **2018**, 10, 4084. [Google Scholar] [CrossRef] [Green Version]

PO-RALG. *(2024). Primary Enrolment by Age and Sex, 2024. Tanzania.* https://www.tamisemi.go.tz/singleministers/basic_education_data_2023

Poswayo, A., Kalolo, S., Rabonovitz, K., Witte, J., & Guerrero, A. (2018). School Area Road Safety Assessment and Improvements (SARSAI) programme reduces road traffic injuries among children in Tanzania. Injury Prevention, 25(5), 414–420. https://doi.org/10.1136/injuryprev-2018-042786

Raftery, S. J., & Wundersitz, L. N. (2016). Road safety education: Directions for the future. Centre for Automotive Safety Research. https://www.researchgate.net/publication/306257099

Riaz, M. S., Cuenen, A., Polders, E., Akram, M. B., Houda, M., Janssens, D., & Azab, M. (2022). Child pedestrian safety: Study of street-crossing behaviour of primary school children with adult supervision. *Sustainability*, *14*(3), 1503. https://doi.org/10.3390/su14031503

Rosenbloom, T., Ben-Eliyahu, A., & Nemrodov, D. (2008). Children's crossing behavior with an accompanying adult. *Safety Science*, *46*(8), 1248–1254. https://doi.org/10.1016/j.ssci.2007.07.004

Sangowawa, A. O., Fatiregun, A. A., & Abiola, A. O. (2012). Children's vulnerability in traffic: Factors influencing safe road use in developing countries. Medical Studies, 2, 155–160.

Schwebel, D. C., Wu, Y., Swanson, M., Cheng, P., Ning, P., Cheng, X., Gao, Y., & Hu, G. (2018). Child pedestrian street-crossing behaviors outside a primary school: Developing observational methodologies and data from a case study in Changsha, China. *Journal of Transport & Health*, *8*, 283–288. https://doi.org/10.1016/j.jth.2018.01.005

Tabibi, Z., Pfeffer, K., & Sharif, J. T. (2012). The influence of demographic factors, processing speed and short-term memory on Iranian children's pedestrian skills. *Accident Analysis & Prevention*, *47*, 87–93. https://doi.org/10.1016/j.aap.2012.01.013

TANROADS. *(2024). Dar es salaam region roads network. Tanzania.* https://www.tanroads.go.tz/common/attachments/road_networks/kb9e20d5ea973ff389ad59bb6ccb62eb.pdf

TARURA. *(2022).* Hali za Barabara kwa Mikoa hadi June, 2022. Tanzania. https://tarura.go.tz/#/trr/regions-roads

Thomson, J. A., Tolmie, A. K., Foot, H. C., & McLaren, B. (1996). Child development and the aims of road safety education: A review and analysis. *Road Safety Research Report No. 1*, Department for Transport, UK.

Thornton, S., Pearson, A., Andree, K., Rodgers, N. (1999). Taking the child's perspective seriously. Psychologist, 12, 393–394

Tolmie, A., Thomson, J. A., Foot, H. C., Whelan, K., Morrison, S., & McLaren, B. (2005). The effects of adult guidance and peer discussion on the development of children's representations: Evidence from the training of pedestrian skills. *British Journal of Psychology*, *96*(2), 181–204. https://doi.org/10.1348/000712604x15545

Tolmie, A., Thomson, J., & Foot, H. (n.d.). Computer-based support for the training of children's pedestrian skills: Software design and evaluation of impact. *International Conference on Computers in Education, 2002. Proceedings.*, *1*, 515–519. Retrieved February 10, 2025, from https://doi.org/10.1109/cie.2002.1185994

Trifunovi´c, A.; Peši´c, D.; Ci˘cevi´c, S.; Anti´c, B. (2017). The importance of spatial orientation and knowledge of traffic signs for children's ˇ traffic safety. Accid. Anal. Prev., 102, 81–92.

Truong, L. T., Nguyen, H. T. T., Nguyen, H. D., & Vu, H. V. (2019). Pedestrian overpass use and its relationships with digital and social distractions, and overpass characteristics. Accident Analysis & Prevention, 131, 234–238. https://doi.org/10.1016/j.aap.2019.07.004

Underwood, J., Dillon, G., Farnsworth, B., & Twiner, A. (2007). Reading the road: The influence of age and sex on child pedestrians' perceptions of road risk. *British Journal of Psychology*, *98*(1), 93–110. https://doi.org/10.1348/000712606x104409

UNECE. (2018). World Forum for Harmonization of Vehicle Regulations. https://unece.org/fileadmin/DAM/trans/main/wp29/wp29regs/2018/ECE-TRANS-WP.29-343-Rev.26.pdf

UNICEF. (2020). Children's way to school - the journey of worry Children's way to school - the journey of worry. Vietnam. Access here

UNICEF. (2022). Technical guidance for child and adolescent road safety. UNICEF. Access here

UNICEF. (2023) child and adolescent road safety in East Asia and Pacific nations. https://www.unicef.org/eap/media/14126/file/unicef%20NY%20child%20and%20adolescent%20road%20safety%20in%20East%20Asia%20and%20Pacific%20nations.pdf

Vitalis, N., Runyoro, A.-A. K., & Selemani, M. (2022). Assessing factors for occurrence of road accidents in tanzania using panel data analysis: Road safety perspective. *Journal of Transportation Technologies*, *12*(01), 123–136. https://doi.org/10.4236/jtts.2022.121008

Wang, H., Gao, Z., Shen, T., Li, F., Xu, J., & Schwebel, D. C. (2019). Roles of individual differences and traffic environment factors on children's street-crossing behaviour in a VR environment. *Injury Prevention*, *26*(5), 417–423. https://doi.org/10.1136/injuryprev-2019-043268

Wang, H., Tan, D., Schwebel, D. C., Shi, L., & Miao, L. (2018). Effect of age on children's pedestrian behaviour: Results from an observational study. *Transportation Research Part F: Traffic Psychology and Behaviour*, *58*, 556–565. https://doi.org/10.1016/j.trf.2018.06.039

WHO. (2015). Ten strategies for keeping children safe on the road. https://iris.who.int/bitstream/handle/10665/162176/WHO_NMH_NVI_15.3_eng.pdf?sequence=1

Wilde, G. J. S. (2001). Target Risk 2: A new psychology of safety and health. PDE Publications.

World Bank. (2015). "Tanzania Policy Note," mimeo. World Bank: Washington, DC. https://www.monash.edu/__data/assets/pdf_file/0007/216727/Road-design-factors-and-their interactions-with-speed-and-speed-limits.pdf

World Health Organization (WHO). (2021). Global health estimates, 2019. WHO. Geneva.

World Health Organization (WHO). (2023). Global Status Report on Road Safety 2023. WHO. Geneva Access here

World Health Organization. (2018). Global status report on road safety 2018. WHO. https://www.who.int/publications/i/item/9789241565684

World Health Organization. (2020). Road traffic injuries: Children. https://www.who.int/news-room/questions-and-answers/item/road-traffic-injuries-children

Zeedyk, M. S., & Kelly, L. (2003). Behavioural observations of adult–child pairs at pedestrian crossings. *Accident Analysis & Prevention*, *35*(5), 771–776. https://doi.org/10.1016/s0001-4575(02)00086-6

Zeedyk, M. S., Wallace, L., & Spry, L. (2002). Stop, look, listen, and think? *Accident Analysis & Prevention*, *34*(1), 43–50. *https://doi.org/10.1016/s0001-4575(00)00101-9*

Appendix 1: Questionnaire

SAFE ROAD CROSSING AWARENESS QUESTIONS

Sex: □ Male □ Female

Age: Years ….

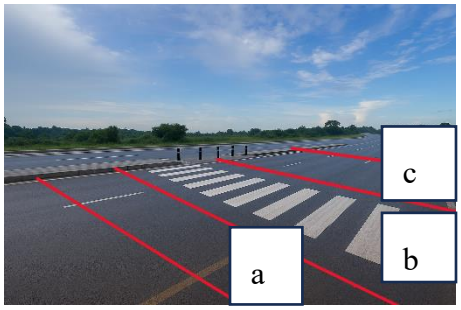
1. Before crossing the road, you need to stop, and look on the left and right. ( )
   a) True
   b) False

2. When crossing the road, you need to
   a) Run
   b) Walk ( )

3. In which of the following two pictures, a child is crossing safely? ( )

   a) b)

4. Which of the three zones (a, b, c) shown in the picture below is the safety to use when crossing the road? ( )



5. In which of the following two pictures, a child is crossing safely? ( )

   a) b)

Appendix 2; Observation checklist

OBSERVATION CHECKLIST

General information

Date:……..

Observer:……

Location:……...

Time:……..

Weather:……

Number of lanes to be crossed:

Presence of pedestrian cross:

Presence of median/ pedestrian island:

85th percentile speed:

School children information and behavior

S/N	Gender	No of school children crossing	No of pedestrians crossing	While waiting before crossing				While crossing					
				Pausing before crossing ✓ or ✗	Scanning oncoming traffic ✓ or ✗	Waiting time (seconds)	No of vehicles passed while waiting	Running ✓ or ✗	Diagonal crossing ✓ or ✗	Distracted ✓ or ✗	Supervised ✓ or ✗	Used pedestrian cross ✓ or ✗	Inadequate gap (near miss) ✓ or ✗