



INVESTIGATION OF THE ROAD SAFETY MEASURES AROUND SCHOOLS IN ETHEKWINI

Centre for Transport Studies

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ABSTRACT

Globally, road traffic injury is a leading cause of death and disability in children aged 15 to 19 and the second leading cause of death in children between the ages 10 to 14 years. This thesis reviewed literature regarding the extent of road traffic injuries involving child pedestrians, the risk factors for child pedestrians and the effectiveness of interventions aimed at road safety improvement. eThekweni Metro was used as a case study for investigating the magnitude of road traffic crashes involving child pedestrians around primary schools. The schools with the highest road traffic crashes were used to investigate the road and environment contributory factors to crashes and finally the interventions in place at these schools to reduce road traffic injuries. The magnitude of crashes was quantified by using road accident data obtained from eThekweni Metro and the investigation of the interventions applied at the schools was conducted using Google Earth imagery, onsite inspections and administering a questionnaire to educators at the schools chosen for the case study.

Results suggest that, in eThekweni, 32% of pedestrian crashes involve children from 0 to 19 years. The 6 to 10 year age group has the highest risk of road traffic injury and boys are 20% more likely to be involved in a crash compared to girls. The top ten primary schools with the highest road traffic crashes are located in middle and low income areas in eThekweni, these are, Sydenham, Jacobs and Umlazi Township. Most crashes took place where three or more schools are located within a kilometre radius of each other. Child behaviour contributed to 77% of the road traffic crashes. Scholar transport driver behaviour was highlighted as a major contributor to crashes by the respondents and environmental factors that resulted in reduced visibility of the child pedestrian contributed to 6% of the crashes. The main cause of road traffic injury, 68%, was crossing the road when it was unsafe to do so. Most crashes took place away from the intersection (58%), under clear and dry weather conditions (95%) during daylight (87%), between 13h00 to 15h30 (41%). Mondays and Fridays had highest incidents of road traffic crashes compared to other days of the week. Forty five percent (45%) of crashes took place on Class 5 local roads but all top ten schools with the highest road traffic crashes are located within a kilometre of a Class 3 distributor road or a class 4 collector road and these higher order roads have the highest crashes per road associated with the primary schools in their vicinity. Traffic calming, in the form of speed humps are only provided on roads where school entrances are located and are not provided on other roads even the roads with the highest road traffic crashes. Pedestrian crossings that direct pedestrians to a safe crossing location, road signs and road markings that warn drivers about the school are also generally not provided.

The study revealed that road safety education is not formally provided in the school's curriculum, it is taught as part of the Life Skills subject. The content and type of training is decided upon by the Life Skills teachers. Practical training is only provided at two of the schools, in all other schools, road safety education is taught and tested in a classroom environment.

The author recommends that further studies be conducted on child pedestrian road safety around schools to obtain a full understanding of the road and environmental risk factors, that the municipality adopts the school zone concept and develops a policy for road safety interventions within the school zones. The municipality must also constantly monitor road traffic crashes involving child pedestrians, collect necessary data and test the effectiveness of measures applied to reduce the risks for child pedestrian crashes, investigate the possibility of providing grade separated pedestrian crossing facilities on higher order roads within a kilometre radius of the schools, initiate a scholar transport driver training programme and to assist the schools in the provision of road safety education by providing facilities where practical road safety training can be taught.

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CHAPTER 1: INTRODUCTION

1.1 Background

1.1.1 The road safety pandemic

The Global Burden of Disease Centre, ranks road traffic injury as the ninth cause of unintended death, globally (WHO 2015). The population groups that are affected the most by this pandemic, are from low and middle-income countries, mainly the Eastern Mediterranean and African regions. The African region has a mortality rate of 26.6 fatalities per 100 000 population compared to the global average of 17.5 fatalities per 100 000 population. The most vulnerable road users are pedestrians, motorcyclists and cyclists (WHO 2008). Studies show that men are three times more likely to be involved in crashes, compared to females (WHO 2015).

South East Asian and African regions are the most highly impacted by road traffic injuries and account for two thirds of road traffic injuries across all regions. The African region has the highest child road traffic fatality rate; at 19.9 per 100 000 population (Arendse et al., 2012); compared to the global average of 10.7 per 100 000 population. This rate is nearly twice as high as the global rate. The road traffic injury statistics are serious cause for concern and indicate that African countries should elevate the issue of road traffic Injury to a similar status as all other causes of death and come up with intervention measures of reducing Road Traffic Injury (RTI), especially for the most vulnerable road users, young children. Unfortunately, the WHO predicts that the fatality rate due to RTI is going to increase in developing countries, while in developed countries, the fatality rate will see a decrease. Europe, a developed continent, for example, has indicated a decline of RTI in children over the past two decades (Vaganay et al., 2003).

In South Africa, road traffic injury was identified by the South African Burden of Disease studies as the second leading cause of death in South Africa; it accounts for 26.7% of all deaths, due to RTI (Van Niekerk 2004). Literature reveals that the South African mortality rate (due to road traffic injury) is double that of the world's average mortality rate (Normal et al., 2007). South Africa's most vulnerable road users are (in order of vulnerability) pedestrians, passengers, drivers and, lastly, cyclists. The reason for the deviation in the number of deaths of cyclists on the road is that cycling is very low in South Africa due to unsafe cycling conditions and lack of a cycling culture. In South Africa, pedestrians account for 52% of all road traffic injuries (Normal et al., 2007). Pedestrians from black African and Coloured populations are most at risk in South Africa due to their increased exposure to the road environment as pedestrians (Van Niekerk et al., 2004). The gender profile of road traffic injuries in South Africa is aligned with the global trend and this indicates that 74% of road traffic injuries involve South African males.

The KwaZulu Natal province has the second highest road fatality rate due to road traffic injury in the country at 19.6%, following the Gauteng Province with 20.5% (RMTC 2016). eThekweni municipality is the biggest metropolitan area in KwaZulu Natal. The metropolitan's 2014 to 2015 road traffic crash data indicate that pedestrians are involved in 67% of road traffic injuries, but unlike the global and national statistics; 19.2% of the injuries are obtained by drivers, who are more at risk than passengers at 14%. Males in eThekweni take a similar share of road traffic injuries as the national statistics at 74%.

1.1.2 The extent of road traffic crashes in children

Road traffic injury is a major issue globally and has a notable contribution to the global mortality rate. Undoubtedly, anything that is a threat to mankind deserves a closer investigation especially if the threat is posed to children. Thirty percent (30%) of all deaths in children between 0 to 19 years are due to road traffic injuries, this makes road traffic injury (RTI) a leading cause of death and disability in young children aged 15 to 19 and the second leading cause of death in children between the ages 10 to 14 years (WHO 2008). In low to middle income countries, between 30% and 40% of all road traffic injuries in children involve child pedestrians and 21% of those injuries result in death (WHO 2008). Children from low income areas are five times more likely to be involved in road traffic crashes, compared to those from high income areas (WHO 2015). Children are most vulnerable as pedestrians, passengers and as young drivers, respectively. They are exposed to road traffic injury while using public or private motor vehicles, as motorcyclists or as cyclists (Ebel 2010; WHO 2008; Arendse et al., 2012; Wazana et al., 1997).

Africa has the highest child road traffic fatality rate; which is 19.9 per 100 000 children per year (WHO 2008). The analysis of the South African statistics provided by the Road Traffic Management Corporation in 2015, indicates that the most affected child road users are in the age group 0 to 19 years old; and the most exposed road users are pedestrians at 25.7%, drivers at 19.2%, and cyclists at 7.5%. Arendse et al. (2012), concurred in their assessment with the RTMC (2015) and noted that the most vulnerable age groups for road traffic injuries are 5 to 9 years and 10 to 14 years age group.

Global statistics indicate that road traffic injury involving children is something that can no longer be ignored. Children depend on adults to provide them with a safe and secure environment. It is worrying that the basic human instinct of protecting the young and vulnerable is being neglected, or worse - ignored. It is evident that an unsafe environment that leads to premature death of the most precious population group, namely the children has been allowed to develop. From the data available from eThekweni Municipality, local trends indicate that child pedestrians are also significantly affected by road traffic injuries. This road user group accounts for 16% of all road traffic injuries. This research focused on investigating the extent of road traffic injuries in one of the most vulnerable road user groups, child pedestrians in eThekweni Municipality. The research used primary schools in eThekweni

as case studies to understand the causes of road traffic crashes involving child pedestrians, as well as the risk factors for child pedestrians.

1.1.3 Motorisation

The rapid increase of motorisation has been cited by many authors as the biggest contributor of the increase of road traffic crashes in the world. Although Africa has the lowest number of registered vehicles compared to other regions in the world, the African region still has the highest road traffic crashes, compared to all other regions in the world (Peden et al., 2013). The calculation of the African road traffic injury rate per 100 000 vehicles (using rates provided by www.wikipedia.org accessed on 10 October 2017), revealed that Africa's rate of road traffic injury is 3.6 times that of the global average. High income countries seem to have found a way to decrease road traffic crashes, using various interventions to an extent that motorisation is no longer a significant contributor to fatalities in their populations (WHO 2015).

However, the situation is different in low and middle-income countries. The main reason for the high instances of road crashes in middle to low income countries is that rapid motorisation is coupled with the lack of good and comprehensive traffic laws that deal with the major risks as well as the protective factors of road traffic crashes. Where traffic laws do exist, the enforcement of the laws is a problem (Peden, et al., 2013). Africa also lags behind in the implementation of intervention measures to make motor vehicles and infrastructure safe for all users (WHO 2015). In some instances, infrastructure, such as bus terminals, bus stops, parking facilities and dedicated pedestrian facilities such as, sidewalks and pedestrian crossings and pedestrian bridges are not provided. The lack of interventions to curb road traffic injuries associated with rapid motorisation, is also highlighted by Islam & Hadhrami (2012) and Soehodho (2007). Figure 1 shows the crash rate per 1 000 vehicles in eThekweni, from 2000 to 2009.

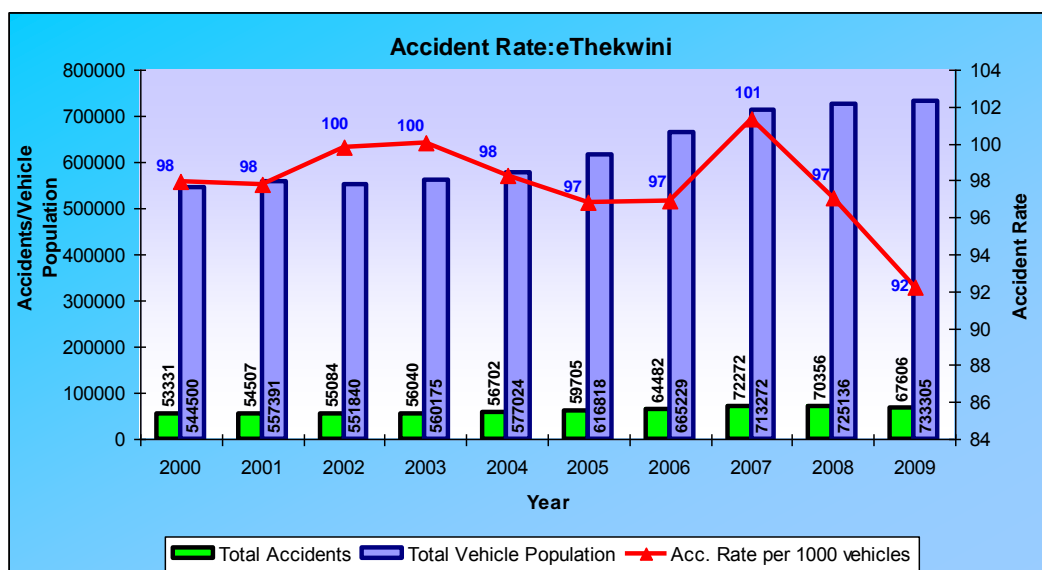


Figure 1: Crash rate per 1000 vehicles for year 2000 to 2009 in eThekweni Urbanisation

1.1.4 Urbanisation

The economic growth of a country comes with urbanisation. Urbanisation is good if it is well controlled, it provides, not only access but also choices for employment, education, health care and other resources that are usually scarce in rural areas. The threat of urbanisation to road safety is when it is not controlled. Statistics indicate that children from urban areas are five times more likely to be involved in road traffic crashes, compared to children from the rural areas (Petch et al., 2000). The rise of informal settlements, often located in non-ideal areas, results in the rise of road traffic crashes.

In South Africa, rapid urbanisation is cited as a significant cause to road traffic injuries (Van Niekerk et al., 2004). People move from rural areas and settle in informal settlements located in urban areas where most job opportunities are accessible. Since the informal settlements are not subjected to proper urban design, some are located close to high order roads where pedestrian access is restricted. The informal settlers have no option but to cross very dangerous roads at non-designated pedestrian crossing areas. Furthermore, people from rural areas are not generally exposed to complex road networks and in some cases, they have little or no exposure to commonly used traffic control measures found in urban areas, this lack of knowledge contributes to the high road traffic injuries (Van Niekerk et al., 2004).

1.1.5 Risk factors

Factors that contribute to road traffic injury are divided into four main categories, these are road factors, environmental factors, motor vehicle factors and human factors (WHO 2008). The main causes of road traffic injury in South Africa are cited in literature as unsafe road environments, lack of enforcement of traffic laws and driver behaviour. Jobanputra and Vanderschuren (2012) cite that the human factor is the main contributor to road traffic injury (83%) compared to vehicle factors (9%) and road factors (8%).

Child pedestrian risk factors

Child risk factors that contribute to road traffic crashes include the child's physical attributes, such as the height and physical stature; age, gender, education, physical defects, behaviour or social adjustment and socio-economic status. Literature reveals that child behaviour is affected by the child's development, including cognitive, emotional and personal attributes (Wazana et al., 1994; WHO 2008; Congiu et al., 2008; Arendse et al., 2012). The risk factors for child pedestrians are explored in detail in this thesis.

Road and environmental factors

Road factors are those associated with the road design, the condition of the road surface including pavements, sidewalks, pedestrian crossing facilities, the type and condition of the traffic control devices, such as traffic signals, road signs and road markings. Other road factors that contribute to road traffic crashes include the type of intersection, road classification and number of lanes. Traffic calming

and parking are two road factors that are particularly important in reducing road traffic crashes involving child pedestrians. These measures are applied respectively to reduce traffic speeds and to increase the driver's view of the road and children which can be easily concealed by a parked vehicle (Yoo et al., 2009). Environmental factors are those specific to the road traffic crash, they include lighting conditions, weather conditions, and location of road traffic crash, that is, midblock versus intersection. The road environment investigation within the school zones in this research focused on investigating the child pedestrian risk factors identified in Chapter two, that pose a risk to child pedestrians within the school zone.

1.1.6 Interventions to reduce road traffic crashes

Interventions required to address road safety and to reduce road traffic crashes include: (Towner et al., 2005; Retting et al., 2011):

- The provision of road safety education;
- Application of engineering measures;
- Enforcement of traffic rules; and
- Motor vehicle design changes.

This research focused on two interventions that address road safety interventions for children; the provision of road safety education and the application of engineering measures. An in-depth assessment of the two selected interventions is included in Chapter three of this thesis.

Road safety education

There is huge debate on whether road safety education is an effective intervention for road safety, particularly for children. Various authors argue that road safety education can be used to increase the knowledge about road traffic rules and road safety in general, but education does not necessarily result in the change of behaviour in children when they are faced with a real-life road traffic situation.

Engineering measures

Road traffic crashes are preventable. The departure point for proactive intervention, for decreasing road traffic crashes, is by ensuring proper planning and design of road system networks. If, from the onset, the planning and design of the road system network ensures equitable provision of good quality and accessible road infrastructure, for both motorised and non-motorised modes, and coupled with the provision of good traffic control management and control measures, road traffic crashes will be significantly reduced. One of the most successfully utilised engineering measures for the reduction of the frequency and severity of road traffic crashes is traffic calming. Traffic calming is used to resolve the major contributor to road traffic crashes, namely traffic speed. The installation of speed humps, for example, results in a 50% decrease of traffic speed (FHWA 2006). Furthermore, a mere 10% decrease in traffic speed and traffic volume, results in a 37.8% decrease in fatalities (Peden et al., 2008). This research explored the various types of traffic calming and their effectiveness in reducing the frequency

and severity of road traffic crashes. The research also looked at the various approaches to traffic calming and their merits. The approaches investigated are reactive versus proactive approaches as well as spot versus area-wide traffic calming approaches. In instances where traffic calming is used as a reactive measure, the research further explored common practices for determining whether traffic calming is required.

1.2 Research objectives

It is evident that road safety has become a major issue and that it deserves the same level of attention as other leading causes of death in children and the youth. The objective of this research was to review literature aimed at answering the following research questions:

- What is the global magnitude of road traffic injuries involving child pedestrians?
- What are the causes and risk factors for road traffic crashes involving child pedestrians?
- What intervention measures are used to reduce road traffic injuries involving child pedestrians, and the effectiveness of these intervention measures?

eThekwini Municipality was used as a case study for the research and was used to answer the following research questions.

- What is the magnitude of road traffic crashes involving primary school pedestrians around schools in eThekwini Municipality?
- Which primary schools in eThekwini Municipality have the highest road traffic crashes?
- What are the road and environmental risk factors for child pedestrians at these schools?
- What are the recorded causes of the road traffic crashes at these schools?
- What engineering and road safety educational measures have been applied or implemented at the schools with the highest road traffic crashes in eThekwini Municipality?

The approach to the research was to conduct a literature review on the international trends of road traffic crashes involving child pedestrians; followed by an investigation of the trends of road traffic crashes within eThekwini Municipality. Road traffic crash data provided by the eThekwini Municipality's Road Safety Department was used to identify the schools to be included in the study. Literature on the causes of Road Traffic Crashes (RTC) and risk factors for child pedestrians were investigated. Thereafter, the findings from the literature review revealed that road factors and environmental factors play critical roles in contributing to road traffic crashes. These factors were also investigated in the selected study areas, by analysing the school zones of the identified schools using Google Earth and onsite inspections. The human factor was investigated by analysing the road traffic crash data for the causes of road traffic crashes. A further literature review was conducted on the intervention measures for reducing road traffic crashes. The assessment of the measures provided in the study areas were completed by using Google

Earth and onsite inspections, while the educational measures were confirmed by conducting interviews with senior management of the identified schools. The research approach is shown on Figure 2.

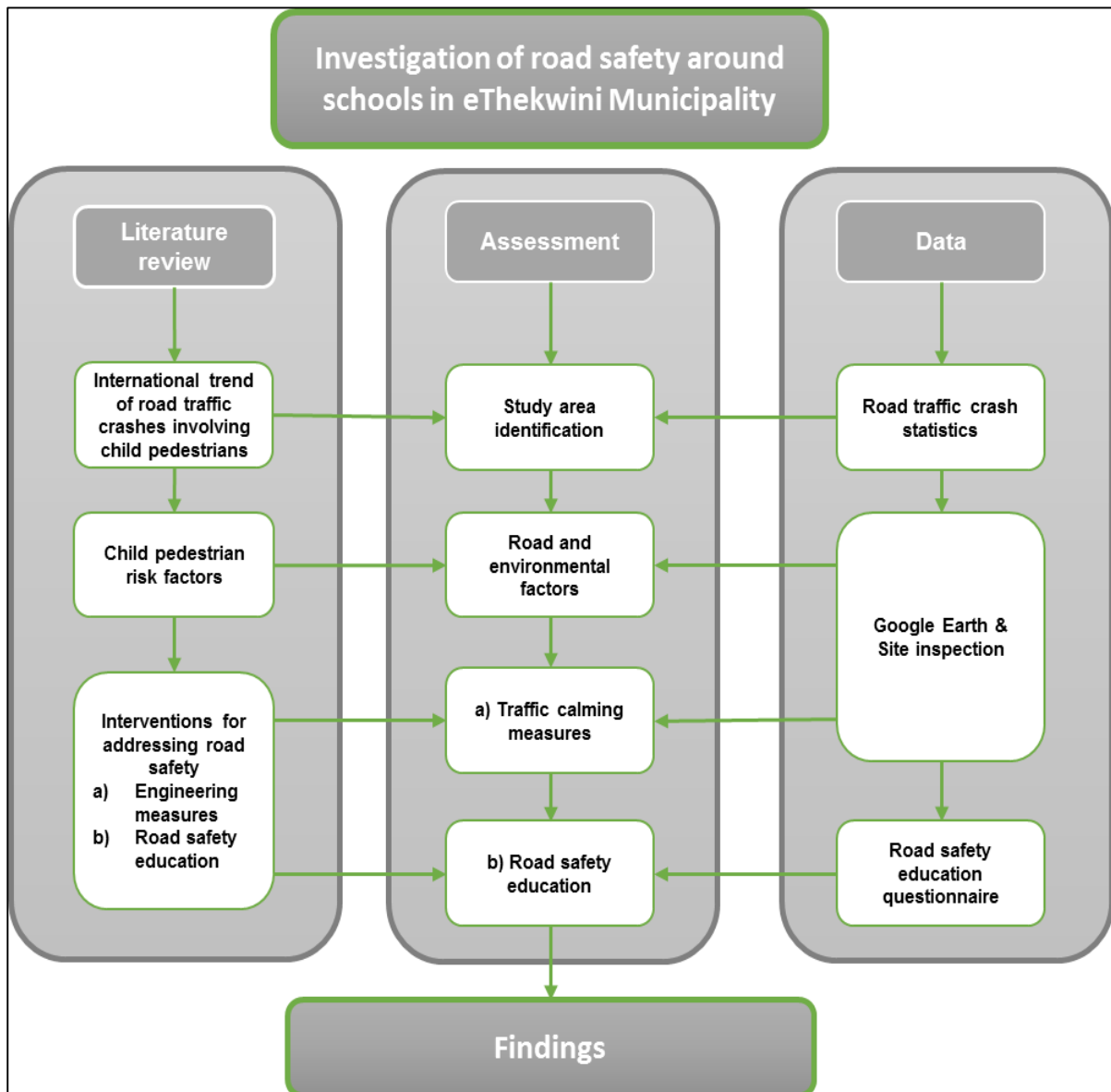


Figure 2: Research structure and approach

1.3 Definitions

Road traffic crash (RTC)

“A road traffic crash is an accident, event, collision or crash between two or more vehicles, a vehicle and a train, a vehicle and a cyclist, a vehicle and a pedestrian, a vehicle and an animal, a vehicle and a fixed object, such as a bridge, building, tree, post, etc., or a single vehicle that overturned on or near a public road. A road traffic crash is a single road traffic incident, regardless of the number of vehicles or persons involved in any particular crash.” (RTMC, 2015)

Road traffic injury (RTI)

Road traffic injury is an injury resulting from a road traffic crash. Injuries are classified as slight, severe or fatal. Slight injury is the road traffic injury that might, or might not, result in hospitalisation. If hospitalisation is required, the person is released within a day or two. Severe injury is an injury that results in a longer period of hospitalisation. The victim usually requires specialised medical care. Severe injury, might or might not, lead to disability. Fatal injury is a road traffic injury that results in death. (RTMC, 2015)

Child

The world report on child injury prevention describes a child as a person under the age of seventeen (WHO 2008).

School zone

The Oxford dictionary defines a zone as “An area or stretch of land having a particular characteristic, purpose, or use, or subject to particular restrictions” (<https://en.oxforddictionaries.com/definition/zone> accessed on 23 November 2017). Wikipedia.org, accessed on 14 October 2017 describes the school zone as an area close to the school or crosswalk leading to the school where child pedestrian traffic is expected. The researcher’s definition of a school zone is a kilometre radius around the school where child pedestrian traffic is expected.

Hazardous location

A hazardous location is the section of road that has significantly more incidences of road traffic crashes, compared the norm (Elvik 2008).

1.4 Research scope and limitations

1.4.1 Road traffic injury risk factors

Out of the four factors that contribute to road traffic injury, i.e., road factors, environmental factors, motor vehicle factors and human factors, this research focused on investigating road factors, environmental factors and human factors. Motor vehicle factors were not investigated. With regard to the human factors aspect, the investigation was limited to child behaviour, as opposed to driver behaviour.

1.4.2 Limitation of road safety intervention measures

The study intentionally limited the investigation of the intervention measures for increasing road safety to that of engineering measures and road safety education. Intervention through enforcement of traffic rules and amendment of the vehicle design were not included in this research.

1.4.3 Limitations due to sampling method

The research was conducted in eThekweni Municipality. The study was limited to primary schools and further limited to primary schools with the highest road traffic crash statistics, involving child pedestrians. The transferability of the results from this study, is therefore limited.

1.5 Report structure

This thesis consists of six chapters. The introductory chapter provides the research background which provides the motivation for the study. The background provides a detailed report on the first research question which investigates the global statistics of road traffic injury and provides insight on the magnitude of the road traffic injuries with regard to children. The chapter continues to introduce the remaining research questions that look at the causes and risk factors for child pedestrians and the intervention measures for reducing road traffic crashes. Chapter 2 provides a detailed investigation of the causes of RTC involving children as well as the risk factors for child pedestrians; while Chapter 3 provides a detailed investigation of the intervention measures used globally to reduce road traffic crashes. The chapter also reviews literature on the debate regarding the effectiveness of road safety education for children, the types of teaching methods and their effectiveness, whether or not road safety is included in the primary school's curriculum in most countries in the world and the responsibility for road safety in these countries.

Chapter 4 provides the methodology used in conducting the research and provides details of the data collection process, data analysis methods and identification of the study areas used as case study for this research. Chapter 5 presents results of the identified road and environmental risk factors for child pedestrians, the recorded causes of the road traffic crashes, and the engineering and road safety educational measures applied at the schools with the highest road traffic crashes. The research conclusions and recommendations are included in Chapter 6.

CHAPTER 2: CHILD PEDESTRIAN RISK FACTORS

Introduction

Chapter 1 highlighted the statistics on the contribution of road traffic injury to children fatalities. This chapter undertakes to understand factors that make child pedestrians most susceptible to road traffic injuries. Factors that contribute to road traffic injuries are divided into four categories, (WHO 2008; WHO 2015; Wazana et al., 1997; Vaganay et al., 2003; Botha 2005).

- Road factors;
- Motor vehicle factors;
- Human factors; and
- Environment factors.

The percentage contribution, of each factor, to road traffic crashes is cited by Botha 2005 as road factors (5% to 20%), vehicle factors (15% to 30%), human factors (60% to 90%) and environment factors (3% to 5%). It is evident that the human factor is a major contributor to road traffic injuries (Jobanputra et al., 2012). The road user group under investigation in this research, is the child pedestrian. This research focused on investigating the child's physical and behavioural attributes that contribute to road traffic injuries, as well as the road and environmental factors that result in crashes involving child pedestrians. Other human factors, such as drivers and the vehicle factors were not investigated in detail in this research.

2.1 Human Factors

Driver behaviour has been cited in literature as a significant contributor to road traffic accidents. The driver factors include disregard of traffic laws such as speeding, not using safety equipment such as seat belts and child seats for children, drunken driving, drug abuse, poor eye sight, fatigue, inexperienced drivers, age, disease and disability. Young drivers and male drivers are more likely to be involved in road traffic crashes (Petridou & Moustaki 2000). Petridou and Moustaki (2000) cited that human driver behaviour factors that contribute to RTI could be classified as follows;

- a) "Those that reduce capability on a long-term basis (inexperience, aging, disease and disability, alcoholism, drug abuse);
- b) Those that reduce capability on a short-term basis (drowsiness, fatigue, acute alcohol intoxication, short term drug effects, binge eating, acute psychological stress, temporary distraction);
- c) Those that promote risk taking behaviour with long-term impact (overestimation of capabilities, macho attitude, habitual speeding, habitual disregard of traffic regulations, indecent driving

behaviour, non-use of seat belt or helmet, inappropriate sitting while driving, accident proneness; and

- d) Those that promote risk taking behaviour with short-term impact (moderate ethanol intake, psychotropic drugs, motor vehicle crime, suicidal behaviour, compulsive acts)”.’

2.2 Risk factors for child pedestrians

The human factor in this instance, the child factor, is one of the major contributors to road traffic injuries. Obtaining an in-depth understanding of these child factors moves us closer to resolving the issue of road traffic crashes involving child pedestrians.

Child factors that contribute to road traffic crashes are the child’s physical attributes, such as height, child’s physical stature (and where it exists, a physical defect), age, gender, socio economic status and behaviour. Behaviour is the major contributor to child road traffic injuries. Child behaviour depends on the child’s development which is linked to age. Cognitive, attentional and perception skills improve as children grow older. Emotional and personal skills are also contributing factors to child behaviour, but these are children’s individual characteristics and are not linked to age. Wazana et al., 1997 ranked the key child attributes that contribute to road traffic crashes in descending order as the following:

- Age;
- Behaviour;
- Race; and
- Gender.

Child pedestrians are most at risk while attempting to cross a road. The road is considered as a complex environment for a child, although crossing a road is easily perceived as an easy task by adults, but in fact, it is not, especially for young children. Pedestrians require several skills to negotiate the roads safely, these skills include: (Thomson et al., 1996)

- Detecting the presence of traffic and road hazards or risks;
- Making a visual judgement of the gap in traffic before crossing;
- Receiving and processing information from all directions of traffic; and
- Perceiving danger and deciding on how to react.

At a young age, children lack the cognitive, attentional and perceptual skills to navigate roads and road traffic safely (Wazana et al., 1994, WHO 2008, Congiu et al., 2008; Arendse et al., 2012). Children that are most at risk are those that have not had adequate exposure to road traffic environments (Congio et al., 2008). The following sections investigate, in detail, the factors that increase the risks of child pedestrians to be involved in road traffic crashes.

2.2.1 Socio economic factors

The WHO (2015) report alerts that children from low to income countries are five times more likely to be involved in a road traffic crash, compared to those from high income areas. Fourie et al., (2005) argue that the reason for this is that children from low income areas spend a larger amount of time navigating the road environment, as they walk to school, or use public transport. Even in low and medium income countries, the countries themselves are further divided into communities that are better off compared to others. Children from communities with higher socio-economic status are less likely to be involved in road traffic crashes, compared to children from poor communities. This is mainly due to their reduced exposure to risk as they do not have to walk to and from school daily (WHO 2008).

South Africa is a unique case in that, during the apartheid era, some population groups could not equitably participate in the South African economy. The legacy of apartheid still exists to this day. Black African and Coloured population groups are the most socio-economically challenged populations in South Africa. It is no surprise that children from these population groups are the most impacted by road traffic injuries (Van Niekerk et al., 2004).

2.2.2 Physical attributes

Height is one of the physical attributes that increases the risk of a child to road traffic injury. From a child's perspective, the height limits the child's view of the road environment. To a driver, children do not stand out on the road, when compared to adults. This is especially the case for drivers of low vehicles. The risk is further increased, if both the driver and child's views are further obstructed by physical obstacles on the road, such as on-street parking (WHO 2008; Arendse et al., 2012). The removal of on-street parking in the school zone is one of the intervention measures for increasing road safety around schools. Other physical limitations that increase the risk of road traffic injury for children are linked to the under development of sensory functions, such as sight and sense of hearing. Peripheral vision and the ability to detect and process sounds from various directions are functions that are acquired with age.

2.2.3 Age and gender

Studies have shown that there is a correlation between road traffic injury with a child's age and gender (Wazana et al., 1997). Children between 6 and 19 years are more at risk to road traffic injury compared to younger children between 0 to 6 years, this is because, children get more exposure to road traffic, when they start attending primary school from ages 5 to 14 years. Furthermore, as children grow older, parents are more willing to let them travel longer distances from home by themselves instead of being accompanied by an adult and they themselves become more independent and want to travel on their own (Congiu et al., 2008). Petch et al., (2000) reports that most road traffic crashes involving children under 5 years old take place close to their home, while most road traffic crashes in children older than 11 years old take place further away from home. In South Africa, the most vulnerable age groups to

road traffic injuries are 5 to 9 years and 10 to 14 years old (Arendse et al., 2012) Hence, this study focused on primary school children. The analysis of the national statistics provided by RTMC in 2015 also confirms that children between the ages of 5 to 9 years have the highest fatality rate of all children between 0 to 19 years.

Studies indicate that boys are more at risk of being involved in road traffic crashes compared to girls (Wazana et al., 1997). The reason for this difference is cited in literature that boys have a higher risk-taking behaviour, compared to that of girls (WHO 2008; Wazana et al., 1997). The South African statistics indicate that young boys are twice as likely to be involved in road traffic injuries compared to girls (RMTC, 2015).

2.2.4 Cognitive attributes

A child's cognitive skills include their ability to solve problems, their memory level and language development. Children between ages 5 to 7 years have low cognitive skills (Thomson et al., 1996), they are unable to concentrate on two things at the same time and are unable to make an accurate assessment of the road environment for potential danger. A child's perception and judgement is also under developed at a young age and they find it difficult to process a lot of information within a short space of time. Skills required for detecting a gap between vehicles, vehicle distance, speed, and assessing whether there is enough time to cross the road safely before taking the action, are not sufficiently developed at a young age. For example, most child crashes involve the "dart and dash" crashes where a child thinks that by running quickly across the road they will avoid the hazard (WHO 2008; Congiu et al., 2008; Arendse et al., 2012). Furthermore, children tend to ignore (or are unable to detect) things that are not in their line of sight, for example, blind spots and vehicles approaching from the opposite direction. Cognitive skills improve from 11 years, children older than 11 years are able to concentrate more, are not easily distracted, can easily switch attention from one task to the other and are better at making decisions when faced with multiple stimuli. When crossing the road, older children can accurately scan the environment for danger and can change their behaviour to avoid the danger (WHO 2008; Congiu et al., 2008; Arendse et al., 2012). The practice applied by primary schools globally, is to provide school patrollers that assist young children to cross roads safely.

2.2.5 Emotional and personal attributes

Children, like all human beings exhibit personal attributes that might not be linked to age. Some children are hyperactive, impulsive, have a low attention span and are easily distracted, some are natural risk takers. Children with such attributes are more at risk of road traffic injuries due to their behaviour on the road (WHO 2008; Chingiu et al., 2008). The WHO (2008) report suggest that in some cases, especially in children of ages between 9 and 14, risk taking is done deliberately as part of thrill seeking venture or as part competition amongst peers, fortunately, this type of behaviour reduces with age.

2.3 Motor vehicle factors

The vehicle type, design and state of maintenance are some of the major contributors to the number and severity of road traffic crashes. The type and design of motor vehicle contributes to the severity of road traffic accidents involving pedestrians. Heavy vehicles such as trucks and sport utility vehicles (SUV) have a higher rate of fatal injuries compared to all other passenger vehicles (Kim et al., 2008). Vehicle manufactures have been urged to review the design of the vehicles and in particular, the front bumper and bonnet as studies show that using softer material on the vehicle bonnet reduces the severity of lower body injuries and head injuries if a victim's head hits the front bonnet during the collision (WHO, 2008). Young children have a higher fatality rate when involved in a road traffic crash because in a crash, a child is hit on the upper body where vital organs are located and in some cases, the child victim could be hit on the head depending on the victim's height. Head injury increases the chance of the crash resulting in a fatality (WHO, 2008).

Studies indicate that the use of un-roadworthy vehicles also contribute significantly to RTCs. Moodley and Allopi (2008) highlight defective tyres as the main contributor to road vehicle accidents followed by mechanical failure.

2.4 Road and environmental factors

The road environment is part of every human being's general environment and forms part of how human beings interact with the world. Children are exposed to the road environment whilst conducting their everyday activities, whether it be around their homes, whilst playing, walking or cycling, around the schools and around recreational facilities and as passengers in motor vehicles and while in the company of adults conducting their day to day activities (Congiu et al., 2008; Dragutinovic & Twisk 2006). The type of environment that exposes children to traffic injury include: (WHO 2008; Petch et al., 2000)

- Lack of open spaces or playgrounds for children to play;
- On-street parking;
- High traffic volumes and speeds;
- Roads that are straight and those that allow high volumes of through traffic;
- Street frontage access;
- Lack of dedicated pedestrian infrastructure;
- Street vending; and
- Lack of safe public transport.

It was mentioned in Section 2.2 that a child's development determines how it can successfully and safely interact with the environment it is exposed to. The road environment can be a deadly place for young and under developed children. It is, therefore, important that child factors be taken into consideration in the design of the built environment that children are exposed to. The South African statistics provided by RTMC 2015 indicate that road environment factors contribute to 8% of all road

traffic fatalities. The built environment factors that increase the risk of road traffic injuries are divided into two categories.

The *first* category includes those factors that are influenced by the choice of road and environment design. The *second* category are those environment factors that are usually unique to the situation or environment where the road traffic crash took place, they are influenced by external factors, such as state of infrastructure maintenance, weather and lighting conditions. A summary of Category one road factors that increase the risk of road traffic crashes are listed hereunder, (Kim et al., 2008):

- Poor road design;
- Road class - which influences the number of lanes, type of intersection and direction of traffic;
- Lack of provision of good quality and accessible pedestrian facilities, such as pedestrian crossings and sidewalks;
- Lack of good traffic control measures, such as traffic signals, traffic signs, road markings, channelling devices and variable message signs; and
- Lack of provision of measures that deal with high traffic speeds and volumes, such as traffic calming and the reduction of posted speed limits.

A summary of Category two environmental factors follow hereunder:

- Condition of the road surface;
- Presence of on-street parking and street vendors;
- Lighting conditions;
- Weather conditions; and
- Location of road traffic crash, that is, midblock versus intersection.

According to Wazana et al., (1997) the physical environment risk factors that increase the likelihood for child pedestrian injuries are, in descending order:

- Volume of traffic;
- Speed limits;
- Predominant type of dwelling or land use;
- Absence of play areas due to the lack of open spaces;
- Location on roads which also affect road classification;
- Protection provided around the play areas;
- Extent of on-street parking;
- Vehicle speed;
- Shared driveways;
- Types of road;

- Time of day;
- Weather; and
- Lighting.

The road environmental factors are discussed in more detail in the following sections.

2.4.1 Geometric Design

The road alignment plays a role in the number and severity of road traffic crashes. Most crashes take place on roads with a straight alignment compared to curved roads, because straight roads provide good sight distances for drivers and therefore encourage speeding. Roads on steep gradients have been found to have higher frequency and severity of road traffic injuries, compared to flat roads because there is a tendency for speeding when motor vehicle drivers travel downhill (Kim et al., 2008). Furthermore, the frequency of crashes involving child pedestrians is high on through roads with high traffic volumes, and on children's trip attractors and generators, such as schools, recreational areas, libraries (Elvik et al., 2004; Kim et al., 2008; Petch et al., 2000).

2.4.2 Road Class

Studies indicate that road class also contributes to the severity and frequency of road crashes. Local streets in residential areas have more road traffic crashes involving child pedestrians than other road classes (Petch et al., 2000). One of the reasons for the high crash rate in local streets, is poor land use planning (WHO 2008). Children find themselves playing on the streets where open spaces are not provided and this increases the risk of road traffic injuries (Petch et al., 2000). Another reason is that most trip generators and attractors for children, such as schools, play grounds, recreational areas are located in residential areas.

Higher order roads are more associated with the severity rather than frequency of road traffic crashes. This is, due to the high traffic volume and speeds associated with higher order roads. The effect of traffic speed and volume on road traffic crashes is discussed further on Section 2.3.6.

In South Africa, higher order roads have a higher contribution to road traffic injuries compared to other countries, this is linked to the spatial structure inherited from the apartheid era that resulted in poorer populations' residential areas located far from the economic hubs and educational institutions. Pedestrians, therefore, interact with high order roads as they travel to and from work or school. Socio-economic factors also play a role in the contribution of higher order roads and road traffic crashes. Children get exposed to higher order roads as they travel from their play areas or places of residence in the townships to 'better' schools located in remote suburbs. Figure 3 shows the contribution of each road class to road traffic crashes involving children under 14 years in eThekweni from the year 2010 to 2014 (eThekweni Municipality, unpublished).

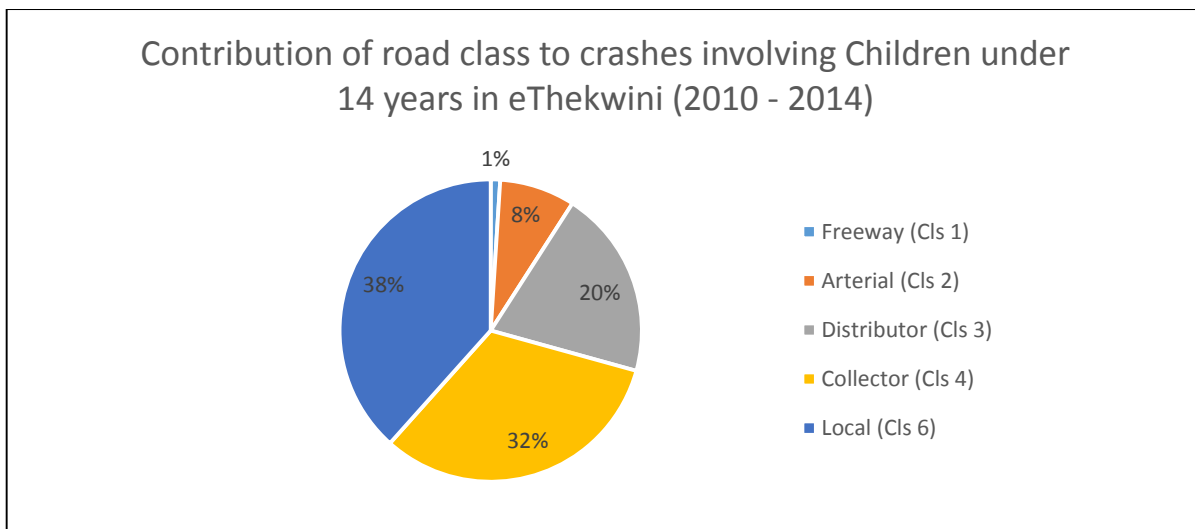


Figure 3: Contribution of road class to crashes involving Children under 14 years in eThekwini (2010 -2014)
 Source: eThekwini Municipality road traffic crash statics

2.4.3 Location of road traffic crashes

Studies reveal that a large proportion of child pedestrian crashes take place while a child is crossing the road, more than 80% are associated with a child not crossing the road at a designated crossing area (Kim et al., 2008; Petch et al., 2000, Retting et al., 2003). The frequency of road traffic crashes at un-signalised intersections is higher compared to signalised intersections (Petch et al., 2000). The reason is that children at a young age do not understand the rules of the road, such as the “right of way”. Furthermore, these findings confirm that young children lack the critical skills of crossing the road particularly if they are presented with a complex road environment, with multiple stimuli and have to make a correct judgement of traffic speeds and direction. Figure 4 contains crash statistics from eThekwini, collected from 2010 to 2014, that indicate that most crashes involving children take place on the road compared to the sidewalk or shoulder of the road (eThekwini Municipality, unpublished).

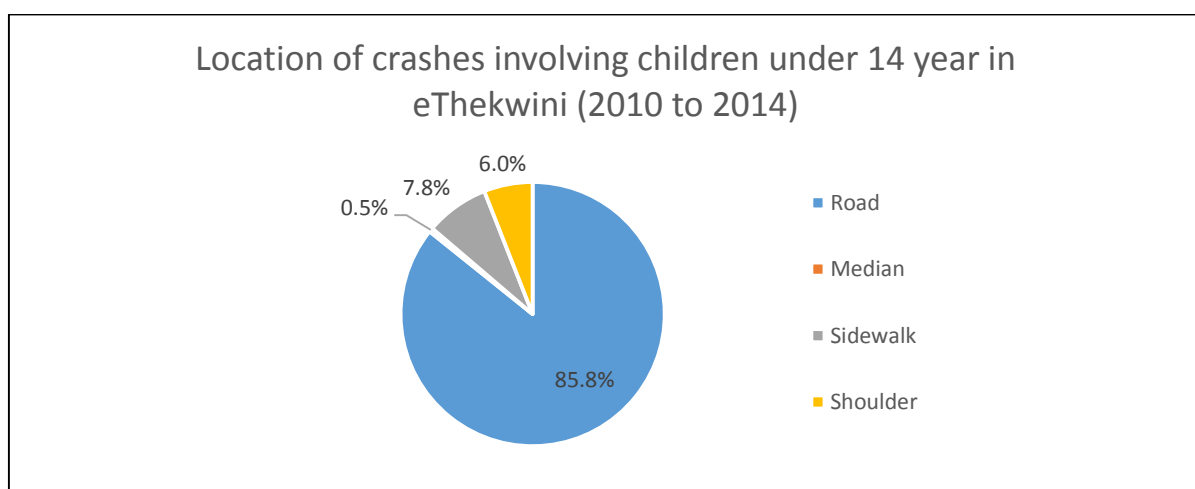


Figure 4: Location of crashes involving children under 14 years in eThekwini (2010 – 2014)
 Source: eThekwini Municipality road traffic crash statistics, unpublished.

2.4.4 Pedestrian Facilities

In South Africa, the provision of adequate infrastructure for pedestrians has been ignored even though the statistics show that walking is a dominant mode of transport among the poor population (Jobanputra 2013). The increase in road traffic crashes has necessitated a review of the provision of infrastructure for non-motorised modes of transport in 2003, therefore the country issued a first guideline to the design of non-motorised infrastructure. Dedicated infrastructure for non-motorised transport, such as walking and cycling includes sidewalks, dedicated road crossing facilities, footways and cycling paths. Sidewalks and cycle lanes are useful in separating pedestrians and cyclists from motor vehicles, their provision reduces the exposure of pedestrians and cyclists to motor vehicles and thus reduces the rate of road traffic crashes (Retting et al., 2011). Knoblauch et al. (1987) found that residential roads without sidewalks have twice as many road crashes involving pedestrians compared to those with sidewalks.

A pedestrian crossing demarcates the area at which pedestrians and cyclists are allowed to cross the road. Pedestrian crossings are meant to increase the driver's expectation of pedestrians and cyclists and ensure that drivers are not taken by surprise by the sudden appearance of a pedestrian or cyclist on the road. A pedestrian crossing can either be located at the intersection or away from the intersection. These crossings can be in the form of painted lines, textured paving or raised crossings. Raised crossings have a dual purpose of acting as traffic calming measures. Unfortunately, studies reveal that pedestrian crossings are not effective in reducing road traffic crashes involving pedestrians especially on roads with high traffic volumes (Zegeer et al., 2001; Erkman 1997).

2.4.5 On street Parking

The presence of on-street parking is particularly problematic to child pedestrians and increases the risk of crashes involving child pedestrians (Stevenson et al., 1995). A study in the UK revealed that 28% of child pedestrian crashes take place in locations with on-street parking (Petch et al., 2000). A 10% take up of on-street parking increases the risk of road traffic injury in child pedestrians by more than three times (Wazana et al., 1997). Older children are less likely to be involved in crashes where there is on-street parking compared to younger children, this is because older children are taller, and therefore, have a better view of the road over the parked vehicles compared to younger shorter children (Petch et al., 2000). Elvik et al., (2004) and Kim et al. (2008) found that roads with public transport stops have higher crashes compared to routes without public transport. The reasons are the following:

- Temporarily a high volume of pedestrians on the side of the road after disembarkation;
- Children's view of the road is obstructed by taller children; and
- Adults and the public transport vehicle itself that might not have left the bus stop.

Furthermore, children lack the training and skills of waiting for the right time to cross the road and choosing the correct location to cross the road.

2.4.6 Traffic speed and volume

High traffic speed and volume are one of the main contributors to frequency and severity of road traffic crashes (Petch et al., 2000; Peden et al., 2008). Roberts et al., (1994) and Stevenson et al. (1995) concluded that the probability of a child being involved in a road traffic crash increases with the increase in traffic volume and speed. A slight change in speed results in a huge change in the severity of road traffic crashes. A 10% decrease in speed and traffic volume, for example, results in a 37.8% speed and 6.5% volume decrease in fatalities. Figures 5 and 6 indicate the results from crash studies conducted by Davis in the the year 2001 and more recently between 2004 and 2007. The studies graphically represent the percentage probability of a pedestrian being fatality injured as a function of impact speed of a motor vehicle (Rosén et al., 2011). The fatality risk curves indicate that the risk of death after a crash increases with vehicle speed. The fatality risk increases sharply after vehicle speeds of 40km/h are reached. Wazana et al. (1997)'s concludes that a child is more than three times likely to be injured if the speed limit is set above 40km/h. The results from the crash studies reinforce the fact that posted speed limits, especially in residential areas, where most child pedestrian fatalities take place, should be kept at most 40km/h, to minimise fatalities in case of a crash.

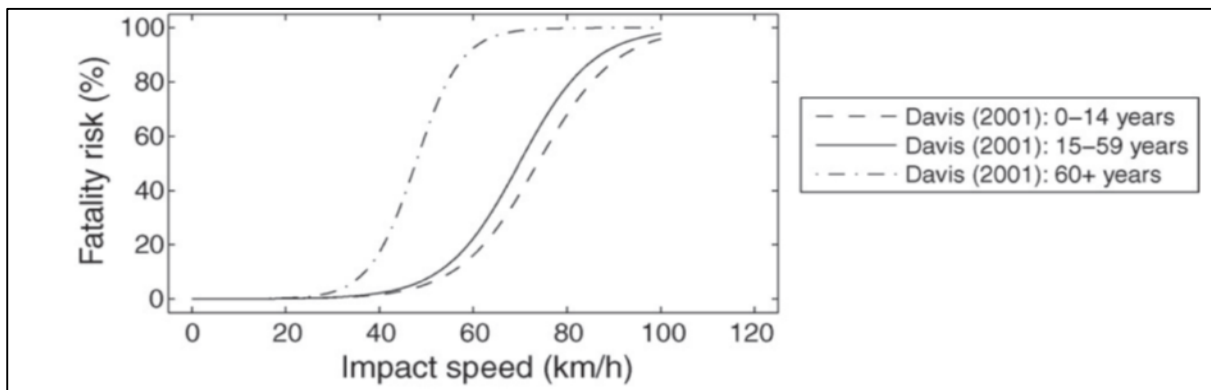


Figure 5: Fatality risk based on studies conducted in 2001

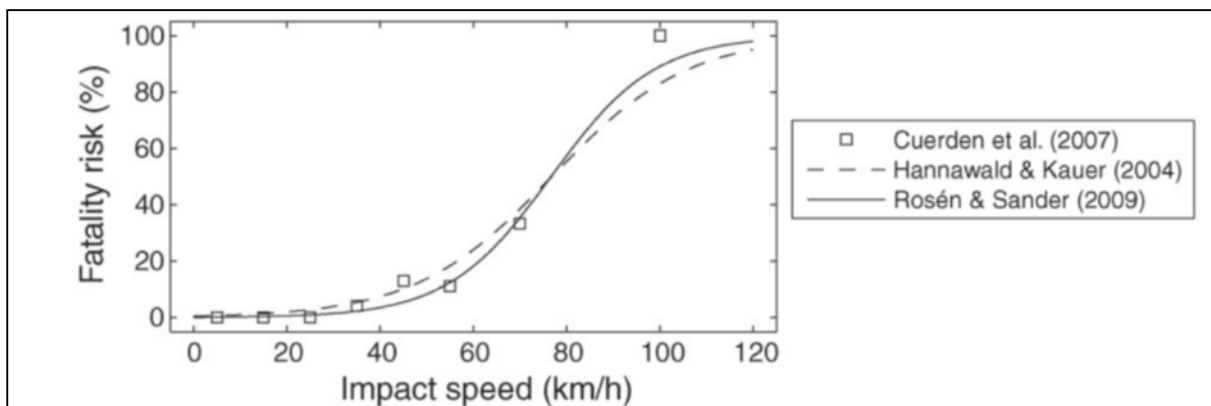


Figure 6: Fatality risk based on studies conducted between 2004 and 2007

The contribution of speed to fatalities, due to crash injury cannot be over emphasised. Unfortunately, only eleven countries in Africa have set a speed limit to less than 50km/h in urban areas (Peden et al., 2008). It is, therefore, not surprising that the fatalities linked to road crashes are very high in Africa.

Traffic volume is also found to be a significant contributor to road traffic crashes and this poses a risk to child pedestrians. In fact, Wazana et al. (1997), list high traffic volumes as the highest contributor to road traffic injuries in child pedestrians. Studies by Petch et al. (2000) show that doubling the traffic volume results in double the rate of road traffic crashes. The reason for the high road traffic crashes involving child pedestrians is that, on high volume roads, there is a high frequency of vehicles, this poses a risk to child pedestrians since they lack the skill to assess the gap between traffic in order to cross the road safely.

Traffic volumes are particularly problematic in and around the school zones. The number of scholars being picked-up and dropped-off at school by private vehicles has increased in recent years. The increase in the number of vehicles during school pick-up and drop-off times has introduced a further risk for child pedestrians (Hillary et al., 2007). The road infrastructure along schools has not kept up with this change. Facilities, such as off-street parking and vehicle turning facilities are often not provided at schools. Attempts to solve the problem have been made by some schools where safety officers or scholar patrollers have been introduced to guide scholars while crossing the road during the morning and afternoon pick-up- and drop-off times.

2.4.7 Weather and Lighting

Studies indicate that inclement weather, in general, reduces the rate of road traffic crashes. The reason for the decrease in crashes is that drivers and pedestrians are likely to be more cautious in bad weather. Drivers are likely to slow down, due to poor visibility and reduced skid resistance of the road surface. Studies in New York City revealed that most of the road traffic crashes involving children took place in dry, clear weather conditions. The results from this study are shown on Table 1 and 2 (DiMaggio et al., 2002)

	Age 5 to 9 Years	Age 10 to 14 Years	Age 15 to 19 Years
Dry	81.5	79.3	73.2
Wet	11.2	14.4	16.7
Unknown	7.3	6.4	10.1

Table 1: Percentage of road traffic crashes linked to road surface conditions (NYC 1991-1997) Source: DiMaggio et al., 2002

	Age 5 to 9 Years	Age 10 to 14 Years	Age 15 to 19 Years
Clear	74.1	71.5	66.2
Cloudy	12.4	13.2	11.7
Rain/snow/sleet/fog	6.2	9.0	12.1
Other/unknown	7.4	6.3	10.0

Table 2: Percentage of road traffic crashes linked to weather conditions (NYC 1991-1997) Source: DiMaggio et al., 2002

Studies show that most road traffic crashes involving children take place during daylight (Arendse et al., 2012, DiMaggio et al., 2002)

2.5 Chapter summary

Child behaviour is the highest contributor to road traffic injuries involving child pedestrians. The behaviour depends on their development which is linked to age. The key developmental characteristics are cognitive, perceptual and attentional skills. Physical development, such as height and sensory nerves are also critical as they increase the ability of the child to possess sufficient skills to navigate a complex road environment and make important decisions when attempting to cross the road. It is therefore important that children younger than six years old are not allowed to navigate the road environment on their own because they are not sufficiently developed to act safely in the road environment.

The road and environmental factors highlighted as risk factors for child pedestrians are high traffic speeds and volumes, on street parking, lack of provision of pedestrian facilities, such as sidewalks, pedestrian crossings, lack of open spaces for children to play, high order roads with high traffic speeds and traffic volumes, weather and lighting. The complete removal of road and environmental factors should be relatively easy but requires a complete change in the approach to planning and design of the built environment.

CHAPTER 3: ROAD SAFETY INTERVENTIONS FOR CHILDREN

Introduction

Towner et al., (2005), Rose (2000), Retting et al., (2003) asserted that the interventions required to address road safety and to reduce road traffic crashes involving children, can be divided into four categories, these are;

- Education;
- Engineering measures; and
- Enforcement of traffic rules.
- Modification of vehicle design

Other campaigns include encouragement and evaluation as additional measures to increase road safety for child pedestrians.

Education measures could be a variety of teaching methods to increase awareness about road safety as well as attempts to reinforce good behaviour of children on the road.

Engineering measures involve the proactive or reactive design and manipulation of the built environment to make it safe for children.

Enforcement measures are applied to ensure compliance with the road traffic rules; particularly those traffic measures that are applied to reduce the risk of road traffic crashes.

Motor vehicle modification measures are those aimed at the modification of motor vehicle design, in particular, the use of softer material on the vehicle bonnet as studies indicate that this measure reduces the severity of lower body injuries and head injuries if a victim's head hits the front bonnet during the collision.

Encouragement is a measure applied to encourage school children to use more sustainable modes of transport, such as walking and cycling to school. This type of measure reduces traffic congestion in the school zone caused by motor vehicles dropping off and picking up scholars in the morning and afternoon.

Evaluation is the process applied to check the effectiveness of the strategies applied to increase road safety at particular schools. The evaluation allows for continuous improvement of the road safety interventions.

This research used primary schools as case studies for investigating road traffic injuries involving child pedestrians. The interventions investigated in this research are road safety education and engineering measures that have been cited in literature as being successful in reducing road traffic injuries in the school zone.

This chapter is divided into two sections. Section 3.1 investigates the effectiveness of road safety education in children, as a measure of reducing road traffic injury. Thereafter, it then reviews literature that provides information on the types of training that was found to be most effective as well as the approaches taken by major countries in the world, in allocating the responsibility of road safety education and the role that parents, schools and communities should play in providing road safety education.

Section 3.2 focuses on the utilisation of engineering intervention measures to reduce road traffic crashes. This section commences by exploring the existing types of traffic calming and proceeds to review literature that provides the evidence of the effectiveness of each type. The chapter concludes by presenting the widely used approaches to traffic calming and the associated merits thereof.

3.1 Road safety education

3.1.1 Aim and effectiveness of road safety education in children

Research shows that children are exposed to the road environments from a very young age and that they require education and skills to navigate road environments safely. Therefore, road safety education should be part of a child's life from a very young age (Chongiu et al., 2008; Dragutinovic and Twisk, 2006).

The aim of road safety education is to increase the knowledge about road safety and to influence the behaviour of children in and around the road (Thomson et al., 1996). The key objective is to ensure that children know and understand road traffic rules and how to behave safely around the road from an early age. Congiu et al. (2008) recommends that children under 10 years should not be allowed to use the road unaccompanied, and that road safety education in young children should focus on developing skills associated with safe road crossing. There are a number of authors that assert that education is not a proper intervention for children, for example, Retting et al. (2003), Tester et al. (2004), Zeedyk et al. (2010) warn that increasing road safety knowledge does not necessarily change the child's behaviour on the road. On the other hand, others, Thomson et al. (1996) and Van Niekerk et al. (2004) argue that road safety education in children can help increase their road crossing knowledge and change their behaviour and that a child's behaviour can be raised if appropriate road safety training is provided.

It is evident that there is disagreement regarding the effectiveness of road safety education in reducing child pedestrian road traffic crashes (Thomson et al., 1996). Various authors argue that the differences result from the fact that, firstly, there are various approaches of assessing the effectiveness of the educational programs and, therefore, it is difficult to draw similar conclusions of their effectiveness. Although road safety education has been widely accepted as a road safety intervention, in most cases assessment and evaluation of such educational programs are not done; hence, there is insufficient evidence to strongly support the effectiveness of this intervention (Dragutinovic and Twisk 2006;

Towner et al., 2005; Zeedyk et al.,2010). Numerous experiments have been conducted to assess the effectiveness of this intervention. Literature in this regard is presented below.

3.1.2 Content of road safety education

Thomson et al. (1996) advise that the critical skills that should be included in road safety education are those that are required to increase children's knowledge about road safety and ultimately change their behaviour, these are (Thomson et al., 1996):

- Where to cross the road;
- How to cross at intersections of different types;
- How to cross safely in areas where there is a presence of on-street parking; and
- How to recognise dangerous areas where crossing should not be attempted.

3.1.3 Teaching methods

Road safety can be taught either in a classroom environment using various teaching tools, such as books, computer programs, videos or practically on the roadside (Fourie et al., 2005). The effectiveness of a teaching method depends on the training medium and training period. Some teaching methods are more effective with some children compared to others. Therefore, it is best to utilise multiple mediums of education (Fourie et al., 2005). The period of exposure to road safety education is also very important. It has been found that repetitive exposure is more effective compared to once-off training (Fourie et al., 2005; Thomson et al., 1996; Congiu et al., 2008).

Classroom based training

Classroom based training involves teaching done only in a classroom environment using teaching aids, such as books, computer programs and videos. Classroom training on road safety can provide knowledge about the road environment, traffic rules and how to behave in the road environment. Literature reveals that classroom based road safety education is less effective when compared to practical training (Thomson et al., 1996; Thomson 1997; Rothengatter 1981; Dragutinovic and Twisk 2006). Classroom based training is best used as a foundation for practical training (Towner, 2005).

Practical training or roadside training

Adult guided practical training on the roadside, supported with peer discussions about road safety, have been found to be more effective in improving road safety (Thomson et al., 1996; Thomson 1997; Rothengatter 1981; Dragutinovic and Twisk, 2006). Studies show that individual practical training yields better results, compared to group training (Dragutinovic and Twisk, 2006).

The advantage of practical training over classroom teaching is that, during practical training, the child's behaviour can be assessed and corrected immediately, whilst class room training only tests the knowledge about road safety (Thomson, 1997). Practical training can be started as early as primary school level, because this type of training is more about 'show and tell' concept that children from an

early age are already familiar with. Practical training is beneficial in that it, (Thomson 1997; Rottengatter, 1981):

- Increases the visual timing judgement in children therefore children can judge the gap between traffic crossings and take appropriate action of either to wait or to cross.
- Reduces the impulsiveness of children around the road environment. Children are better able to assess the risk before crossing the road.
- Improves route planning. Children learn to identify and to choose safe routes (the perceived challenges with practical training are that it is resource intensive).

A study conducted by Thomson et al. (1996), on the provision of road safety through practical training, revealed a significant increase in a child's judgement of dangerous crossing conditions, crossing at intersections and where there is on-street parking. The study concluded that children who received fewer training sessions showed less improvement in behaviour. The observed short coming from the training was that, although children knew how to act on the road, that is, to look out for traffic before crossing the road, in most cases, children started looking out for traffic after they have already entered the road. This behaviour clearly indicates the under development in synchronising the decision making and then taking relevant action.

Computer based training

Computer based training involves the use of computer programs to teach road safety to children. Computer based teaching, just like class room based training, should be supported with practical training, especially for younger children who need to make a connection between real life situations and the virtual world, created by computer programs (Rothengatter 1981; Dragutinovic and Twisk 2006). A study conducted by Rothengatter (1981) on children of age groups 5 to 6, 7 to 8 and 9 to 10 revealed that computer based training supported with practical training resulted in improved judgement of the gap in traffic which is required to cross the road safely in children of all ages. In 6-year-old children, the training improved the judgement in the selection of safe routes, while the effect of training on 8-year-old and 10-year-olds doubled their ability to identify dangerous routes. Rothengatter's study confirms the phenomenon that younger children have poor cognitive skills compared to older children and are unable to make good decisions when faced with a complex situation.

3.1.4 Responsibility for road safety education

Road safety education for children can be provided by parents, schools, volunteers, government organisations, non-profit organisations, road safety professionals, youth groups and anyone who is interested in making a difference in reducing road traffic crashes involving children.

Community involvement

Literature reveals that road safety education is more effective if the whole community is involved (Dragutinovic and Twisk, 2006). There is evidence that shows that community involvement in road

safety has the potential to reduce road safety crashes. Howat et al. (2001) asserts that the most effective way to involve the community is by establishing committees that deal specifically with road safety issues. The committees could be responsible for road safety education, identifying road safety issues in their community and liaising with government authorities and schools to ensure that the issues are appropriately addressed. The key to the success and sustainability of community involvement in road safety is that road safety should give the level of status and priority that it deserves within the community and that communities themselves, should be capacitated and appropriately resourced to perform this function (Howat et al., 2001).

Parent involvement

Parents have a huge influence on child behaviour, because children learn by observing their parents' behaviour and are, therefore, likely to imitate that behaviour (Green et al., 2008; Wood et al., 2003; Fourie et al., 2005). Training is most effective if administered by adults, especially parents (Dragutinovic and Twisk, 2006; Fourie et al., 2005). Parents, just like communities, should be capacitated to take on the responsibility of becoming educators by receiving training on how to educate their children about road safety. Educational aids, such as training manuals should also be provided. An experiment in Thomson (1997) indicated that utilising trained parents with no qualifications in transport as educators yielded the same results as using highly qualified individuals.

One well known method of providing road safety training to children using parents as educators of road safety to their children and other people's children is through traffic clubs. Parents belonging to a traffic club are provided with teaching tools and training material. The targeted age group for the clubs is usually children from 3 to 7 years' old (Dragutinovic and Twisk, 2006).

School involvement

Globally, the role of schools in the provision of road safety education differs. In some countries, road safety is included in the school curriculum and in others, it is not formally included in the school's curriculum. In France for example, road safety education is included as a subject in the school's curriculum and is tested just like other subjects and a certificate is awarded at the end of the training. (Dragutinovic and Twisk 2006). In countries such, as Spain, Scandinavia, some eastern European countries, Australia and New Zealand, road safety education is incorporated in the curriculum but is not treated as a separate subject and is not formally tested (Dragutinovic and Twisk, 2006). In South Africa, road safety education is not formally included in the school's curriculum. The Provincial Government is tasked with road safety education but the responsibility is usually left to the individual schools or the local authorities (Fourie et al., 2005). Teachers decide on the content, methods of evaluation and the extent and frequency of education. This approach is not ideal because literature indicates that there needs to be consistent teaching over a number of years before an educational program yields fruitful results.

3.2 Engineering measures

The built environment is listed as one of the three main contributors to road traffic crashes. Proper planning and design of a road system network is at the centre of the prevention of road traffic crashes. It seems obvious that the built environment must be designed in such a way, that the contribution of the built environment to road traffic injuries, is eliminated, and that the provision of good quality and accessible road infrastructure is done equitably, across all modes.

In Chapter 2, road factors are highlighted as one of the factors that contribute to high road traffic crashes involving child pedestrians. Road factors that increase the risk of crashes include, (Kim et al., 2008):

- Poor road design;
- Lack of provision of good quality and accessible pedestrian facilities (pedestrian crossings and sidewalks); and
- Lack of good traffic management and control measures (traffic calming measures that deal with high traffic speeds and volumes).

The most effective engineering measures for reduction of road traffic crashes are: (Retting et al., 2003)

- Provision of separate infrastructure for pedestrians;
- Provision of measures that reduce vehicle speed, such as the reduction of posted speed limits and provision of traffic calming; and
- Removal of on-street parking to increase the visibility of pedestrians.

Many authors agree that using engineering measures is the most effective way of reducing road traffic crashes involving children (Retting et al., 2003; Tester et al., 2004). In South Africa, there is little, if any, proactive use of engineering measures to ensure road safety, in most cases engineering measures, especially traffic calming, is only considered as a reactive measure after an issue has been identified (Jobanputra, 2013).

Traffic calming is one of the most successfully utilised engineering measure for reducing the frequency and severity of road traffic crashes. The success of traffic calming is attributed to the fact that it has been found to successfully resolve the major contributor to road traffic crashes, traffic speed and volume. The types of traffic calming measures, and their effectiveness, are discussed in Section 3.2.3 in this chapter.

3.2.1 Posted speed limits

The reduction of traffic speeds around schools is required, because at lower speeds, a driver has a better chance of perceiving and reacting to the unpredictable behaviour of children timeously. Figure 7 depicts the stopping sight distance of vehicle in relation to the speed and indicates that vehicles travelling at higher speeds require a longer stopping distance.

It seems obvious that if speed has been a major contributor to road traffic crashes, simply reducing posted speed limits should resolve the problem. However, studies show that reducing posted speeds does not stop drivers from speeding (Tameside Metro, 2007; Afukaar, 2003). Therefore, the reduction of posted speeds should be accompanied by enforcement measures, as well as the installation of additional speed reduction measures, such as traffic calming. Enforcement measures such as using speed cameras, have been found to be effective in the reduction of motor vehicle operating speeds (Afukaar, 2003; Retting and Farmer, 2003; Elvik 2012).

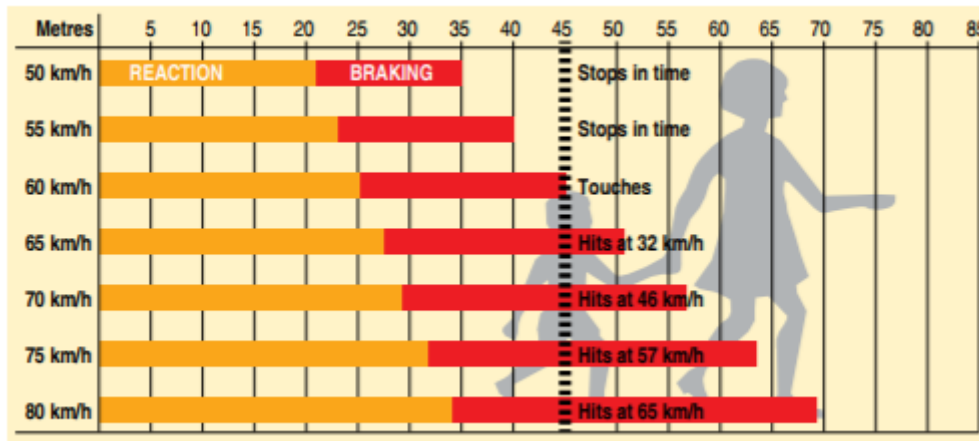


Figure 7: Stopping sight distance in relation to speed. Source (www.tccs.act.gov.au, accessed on 3 November 2017)

Posted speed limits around schools vary from country to country and range from 30km/h to 50km/h. It is important that compliance with the speed limit within the school zone be enforced especially during the morning and afternoon peak hours. The afternoon peak should be extended by 3 or 4 hours, because this is when some children engage in extramural activities.

In South Africa, a study conducted in the City of Tswane where the speed limit around schools was reduced to 30km/h revealed that the reduction of the speed limit in a school zone resulted in a lower rate of road traffic crashes (Lambert and Fenter, 2015).

To ensure compliance with the speed limit within the school zone, speed limits should be monitored as well as enforced in the morning, at one hour before school, and in the afternoon, after school, up to 3 or 4 hours. The extended after school monitoring is required because this is when some children engage in extramural activities.

3.2.2 Elimination of on-street parking around schools

The risk that on street parking poses on children was discussed in Chapter 2. Retting et al. (2004) assert that on-street parking presents the highest risk to child pedestrians and that the elimination and enforcement of a no parking zone around schools is required to increase the safety of school children.

3.2.3 Traffic calming

Chapter 2 highlighted that traffic speed is one of the major contributors to the frequency and severity of road traffic injuries. The application of traffic calming has been cited in literature as one of the most effective measure for reducing traffic speeds and volume. A study conducted in the US reveals those children that live within a block of speed humps are two times less likely to be involved in a road traffic crash (Tester et al., 2004). Another five-year study by German Federal Government found that traffic calming reduced vehicle speeds by 50%. Speed reduction, through traffic calming, can be achieved by using either vertical or horizontal deflection measures.

Vertical deflection measures

Vertical deflection measures include speed humps, speed bumps, speed tables, raised pedestrian crossings, raised intersections and textured road paving, speed cushion and rumble strips.

Horizontal deflection measures

Horizontal deflection measures include chicanes, neck downs, refuge islands, extended kerbs and turning treatment, traffic circle, roundabout, chokers, road diets and bike lanes.

Other traffic measures include FHWA 2013; Jobanputra 2010):

- Reduction and enforcement of posted speed limits;
- Speed alerts and warning signs;
- Landscaping;
- Perceptual design;
- Complete or partial road closures through bollards or boom gates to create non-motorised transport zones;
- Diversions; and
- Discouraging through traffic by including many dead ends and cul de sacs in areas where claimed traffic is desired (neo-traditional design); (FHWA 2013; Jobanputra 2010).

This research investigated the most commonly used vertical deflection measures and measures that reduce traffic volume.

One of the major advantages of traffic calming measures is that most of them do not require enforcement. For example, drivers are forced to lower their speed in order to reduce the discomfort caused by vertical deflection of negotiating a speed hump. The downside of traffic calming is that, if not applied correctly, the measure can interfere with road operations. Traffic calming can result in a shift of traffic from roads with traffic calming to adjacent roads, where the measures are not applied, this can result in high traffic congestion and a reduced level of service of the road. Before application, the impact on the road network in the vicinity of the application site should be assessed. Traffic calming

is most effective in lower order roads, such as residential roads with low traffic volume and where priority is given to access rather than mobility (FHWA, 2006). Another general concern about traffic calming is that the measures might delay emergency vehicles but this was disproved by studies conducted in Berkley and Palo over a 5-year period that concluded that traffic calming did not reduce the response time of emergency vehicles (FHWA, 2006).

To overcome some of the challenges caused by traffic calming, care should be taken to ensure that the right measure is installed at the right place. Physical dimensions, construction, location and spacing are the most important factors that need to be taken into consideration when applying the traffic calming measures.

The physical dimensions of speed humps should allow a vehicle to pass through comfortably when travelling at the design speed. If constructed too high, the speed hump results in an uncomfortable ride, even when negotiated at the design speed and can cause damage to vehicles with low suspension. On the other hand, very low speed humps result in the driver tendency of speeding over the humps, because this reduces the discomfort felt when negotiating the speed hump at lower speeds (DOT 1997). Another critical element is that traffic calming measures, if not constructed correctly, can cause drainage problems (DOT1997). Care should be taken to leave a gap between the kerb and speed hump to allow for drainage, this gap is also used by cyclists to reduce the discomfort of riding over a speed hump.

The spacing of traffic calming measures should be considered carefully as this has an effect on vehicle speed (FHWA, 2008). The spacing should ensure that the desired operating speed could be achieved. If spaced too far apart, motor vehicles get a chance to speed between the calming devices, if spaced too close, the measure can drastically reduce the vehicle speeds which might result in traffic congestion.

Other transport benefits of traffic calming, besides traffic speed and volume reduction, are that a calmed environment encourages walking and cycling, and, therefore ensures equitable use of road space by all modes of transport that is motorised and non-motorised.

3.2.4 Types of traffic calming and their effectiveness

The widely used types of traffic calming measures within a school zone are vertical deflection measures, these are speed humps, speed bumps, speed tables and raised pedestrian crossings and volume reduction measures, such as road closures. These measures are discussed in detail hereunder.

Speed hump, speed bump and speed table

A speed hump is a raised pavement which creates a ‘hump’ on the road. Speed humps have a round top configuration and extend from kerb to kerb but are usually cut back from the kerb to allow for drainage and to provide a passage for cyclists. A speed table is similar to a speed hump but has a flat top. A speed bump has a shorter cross section compared to a speed table.

Speed humps are the most effective and widely traffic calming measures for reducing traffic speeds (DOT, 1997; FHWA, 2008). Their popularity is attributed to that they are relatively cheap to install and are self-enforcing. Various international studies tested the effectiveness of speed humps, for example, a study in Zimbabwe found that speed humps reduced road crashes by 70% and speed tables reduced road crashes by 5.9% (Pardon and Average, 2012). Findings from studies conducted in the US revealed speed humps resulted in a 53% to 60% reduction in road traffic crashes involving child pedestrians (Tester et al., 2004).

A comparison between speed humps and speed tables reveals that speed tables are less effective in the reduction of vehicle speed compared to speed humps due to their larger cross section and flatter top. Therefore, speed tables should be used as speed reduction measure where a milder reduction of speed and volume is required, for example in higher order roads, such as collectors (Leonardi, 2007).

Raised pedestrian crossings and intersections

Raised pedestrian crossing and intersections are usually constructed to be as wide as the crossing area and extend from one edge to the other edge of the road. Raised crossings have a flat top to ensure that the surface is comfortable for pedestrians. A study conducted in Tanzania over a 3-year period found that raised pedestrian crossing were associated with a high reduction of road traffic crashes (De Langen et al., 1999). Jabaputra, 2013's assessment of the raised pedestrian crossings effectiveness concluded that the measure results in a speed reduction of up to 50% and a reduction of traffic volume by between 10 to 15% (Jobanputra, 2013). Another observation by De Langen et al., (1999) was that, raised crossings introduced a culture for motor vehicles to stop at dedicated pedestrian crossings.

A comparison of raised pedestrian crossings with painted crossings and signalised intersections, revealed that raised crossings are much safer compared to the other two measures because the vertical deflection forces drivers to lower their speed unlike the painted crossings.

A further comparison of the raised crossing with speed humps revealed that raised pedestrian crossings performed better over time, compared to speed humps, due to the method and type of material used in construction. Speed humps are usually constructed using asphalt which eventually flattens out after a long period of use, raised pedestrian crossings are usually constructed using robust and long-lasting road paving which lasts longer.

The slope, height and design characteristics of the raised pedestrian crossing play a huge role in its effectiveness. Choosing the correct dimensions for different road applications will result in the achievement of the desired reduction in speed.

Neck downs

Neck downs reduce the overall width of the road and force drivers to slow down, they also reduce the crossing length for pedestrians and cyclists which reduces their exposure to danger.

Refuge islands

Refuge islands are created in the middle of the road that usually has more than two lanes. The refuge islands provide an area for pedestrians to wait before crossing the next set of traffic lanes, it therefore reduces the total length that a pedestrian should cross in one time.

Turning radii treatment

Turning radii treatment involves the reduction of the turning radii at intersections. The reduction creates a very tight turning move for vehicles which forces the driver to reduce the vehicle speed.

Chicanes and extended kerbs

Chicanes are measures applied on straight and flat roads to interfere deliberately with the horizontal alignment of the road, to include diversion from a straight line and to reduce driver sight distance. The horizontal deflection provided by chicanes force drivers to slow down. Studies in the Seattle, USA indicated that two-way chicanes reduced vehicle speed by (28%), traffic volume by 48%, frequency, and severity of injury (Malek and Walgren). One of the disadvantages of chicanes is that they are relatively more expensive to implement, compared to speed humps, respectively (Malek and Walgren).

3.2.5 Summary of traffic calming application and effectiveness

In a before and after study (Table 3) conducted in eThekweni Municipality by Reddy 2013, to determine the effectiveness of traffic calming in KwaMashu township and Chatsworth township, revealed that the application of traffic calming in a form of speed humps was successful in reduction of road traffic crashes involving pedestrians. The study determined the effectiveness in reducing the severity of crashes and the reduction of crashes caused by road and environmental factors, such as time of day, lighting conditions and road conditions, the results from the study are shown on Table 3.

	Chatsworth		KwaMashu	
	Pre	Post	Pre	Post
Total PVCs, N	553	455	163	96
Outcome, n (%)				
Fatal	22(4)	7(1.5)	2(1.2)	1(1)
Serious	123(23.9)	101 (22.2)	37 (22.7)	29(30.2)
Slight	331 (59.9)	291 (64.0)	121 (74.2)	64 (66.7)
Non-injury	68 (12.3)	56 (12.3)	3 (1.8)	2 (2.1)
Time, n (%)				
Day	367 (66.4)	326 (71.6)	90 (55.2)	59 (61.5)
Night	124 (22.4)	79 (17.4)	45 (27.6)	25 (26)
Twilight	62 (11.2)	50 (11)	28 (17.2)	12 (12.5)

Period, n (%)

Peak (6 - 8 am)	83 (15)	68 (14.9)	18 (11)	5 (5.2)
Peak (4 - 6 pm)	93 (16.8)	76 (16.7)	22 (13.5)	15 (15.6)
Off-peak	377 (68.2)	311 (68.4)	123 (75.5)	76 (79.2)

Road condition, n (%)

Wet	35 (6.3)	16 (3.5)	0 (0)	4 (4.2)
Dry	517 (93.5)	419 (92.1)	158 (97)	90 (93.8)

PVCs = pedestrian-vehicle collisions.

Table 3: Before and after study traffic calming study conducted in eThekweni municipality; Source: - Reddy 2015

Table 5 shows the various types of traffic calming measures, and their impact in the reduction of traffic speeds and volumes when applied to arterial and local roads (Jobanputra, 2010).

Type	Application		Impacts	
	Arterial	Local	Volumes	Speeds
Speed hump	-	✓	Volumes	Yes
Speed table	-	✓	Possible	Yes
Raised crosswalk	✓	✓	Possible	Yes
Raised intersection	With caution	✓	Possible	Yes
Textured pavement	✓	✓	Possible	Yes
Speed cushion	With caution	✓	Possible	Yes
Rumble strips	-	✓	No	Yes
Traffic (mini) circle	✓	✓	Possible	Yes
Roundabout	-	-	Not likely	Yes
Chicanes	✓	✓	Yes	Yes
Realigned intersection	✓	✓	Possible	Yes
Tight radii	✓	✓	Possible	Yes
Neckdowns	✓	✓	Possible	Yes
Centre island narrowing	✓	✓	Possible	Yes
Chokers	✓	✓	Possible	Yes
'Road diets'	✓	✓	Yes	Yes
Bike lanes	✓	✓	Possible	Possible

Speed Limits	✓	✓	Yes	Yes
Type	Application		Impacts	
	Arterial	Local	Volumes	Speeds
Speed alerts, enforcement	✓	✓	No	Yes
Perceptual design	✓	✓	Possible	Yes
Warning signs	✓	✓	No	Yes
Full closure	-	✓	Yes	Yes
Half closure	✓	✓	Yes	Yes
Diagonal diverters	✓	✓	Yes	Yes
Lateral shift	✓	✓	No	Yes
Median barriers	✓	-	Yes	Yes
Neo-traditional design	✓	✓	Yes	Yes

Table 4: Traffic calming measures, application and impacts; Source Jobanputra et al., 2010

3.2.6 Approaches to traffic calming implementation

Reactive and proactive approaches to traffic calming

The common approaches that are used in establishing whether traffic calming is required or not in a location are either a reactive or a proactive approach. In the reactive approach, traffic calming measures are only provided after a need is identified, that is after crashes have already taken place. The process involves the follow up assessment of the identified hazard, whereas a proactive approach to traffic calming means that the local transport department conducts a needs assessment for traffic calming, through road safety audits on existing or new roads and provides the necessary measures, before a problem arises. Proactive measures are crash prevention measures, while reactive approaches are treatment or reduction measures (Mustafa 2008; Ewing 1999; JWG 1994).

Spot versus area wide approach

The traffic calming improvement can be a spot improvement or an area wide improvement. Spot improvement focuses on one road while area-wide approach focuses on a wider area with multiple streets in a community or area of study. Various cities and countries use one or combinations of the above approaches. The most successful approach according to Ewing (1999) is the proactive area-wide approach.

Common practices for determining whether traffic calming is required

The common practices used in establishing whether traffic is required or not in a location are warrants, guidelines, priority rating, public involvement and public petitions and ballots (Ewing, 1999).

a) Warrants

Warrants are minimum requirements that should be met before a traffic calming intervention is implemented (Ewing 1999). The minimum requirements may include the number of vehicles, vehicle speed, number of pedestrians and number of crashes.

b) Guidelines

Guidelines are similar to warrants in that criteria are used to evaluate if a traffic calming intervention is required. However, unlike warrants, where the criteria and intervention are prescribed and rigidly implemented without any questions; guidelines are put in place to guide the decision maker on the type of intervention that may be required (Ewing 1999).

c) Priority rating

Priority rating systems rank projects in order of their priority and a budget is set aside for priority projects. Each project's rating is calculated by adding points that the project scores under each defined factor such as vehicle speed, vehicle and pedestrian volume and crashes. The points are summed up to obtain a rating. Each project requires a minimum score set in the city's rating system to qualify for physical traffic calming. For projects that do not achieve a minimum score, other interventions are put in place such as public awareness campaigns. The UK has put in place a traffic calming scheme assessment framework, where assessment factors are selected and given weightings. In designing a priority rating scheme, it is important to include factors that at least provide an indication of the scale of the problem, the benefits or dis-benefits that will arise from the implementation. If incorrectly chosen for the prioritisation process, areas deserving prioritisation might be missed and not prioritised, (Ewing, 1999).

d) Public involvement

The advantages of public involvement in deciding areas where traffic calming is required are that it provides confidence in the community that their requests are being heard and the community needs matter to the authorities. The disadvantages, on the other hand, are that the public participation process tends to be long and require large resources to get everyone's views. Furthermore, the public's outcry could be due to one isolated incident, which does not necessarily mean that traffic calming is required (Ewing, 1999).

e) Public petitions and ballots

Petitions are signed by the community to indicate their support or lack thereof for traffic calming. The advantage of petitions is that they indicate the extent to which the community is in support of the motion. The disadvantage of petitions is that people might feel obliged or coerced to sign a petition for various reasons. In order to obtain a true reflection of the public views, petitions are usually followed by ballots, if both processes indicate a strong support for traffic calming, measures are implemented.

3.3 International best practice for road safety around schools

USA - Minnesota School Zone Safety

The Minnesota commissioner of transport published laws that prescribe the minimum requirements for school zone road safety. The commissioner recommends the following interventions:

(<http://www.dot.state.mn.us/speed>, accessed on 3 November 2017).

- Reduction of speed limit to no more than 48km/h
- Provision of school zone road signs to alert drivers that they've entered a school zone;
- Provision and up keep of all road markings such as marked pedestrian crossings;;
- Narrower streets with good sight distances;
- Provision of fencing in strategic positions to channel pedestrians to dedicated pedestrian crossings and to discourage jay walking;
- Provision of continuous sidewalks on both sides of the road;
- Provision of school patrol to assist children in crossing roads within the school zone;
- Elimination of on street parking;
- Careful design of traffic control devises to ensure that signal timing caters for additional time taken by younger children to cross the road; and
- Conducting regular hazardous location investigations and recording incidents within the school zone to provide information on the cause of crashes and effectiveness of applied road safety measures.

USA - New Jersey School zone safety

The New Jersey School Zone Design Guide prepared for the New Jersey Department of Transport by the RBA Group Fitzgerald & Halliday Inc in November 2014 highlights the following requirements for the school zone:

(<https://www.state.nj.us/transportation/community/srts/pdf/schoolzonedesignguide2014.pdf>, accessed on 8 November 2017)

- Setting speed limits of not more than 40km/h and ensuring enforcement of speed limits through heavy traffic fines;
- Provision of school zone road signs, signage and road makings to alert drivers about the schools;
- Provision of road signs that warn drivers about the location of pedestrian crossings;
- Provision of strategically positioned and marked pedestrian crossings supported with road signs;
- Removal of on street parking particularly close to pedestrian crossings and intersections;
- Developing a school route plan with consistent school zone safety measures;

- Provision of trained scholar patrol to assist children in crossing the road;
- On wide roads, provision of road safety measures that decrease the crossing length such as, kerb extensions, refuge islands, medians, and reducing the kerb radii;
- On high order roads, provision of grade separated pedestrian infrastructure such as pedestrian bridges or underpasses;
- Provision of well maintained, accessible, continuous sidewalks with adequate widths. Sidewalks should be protected by either fencing, or provision of buffer zones such as planting trees; and
- Provision of suitable traffic calming measures.

Australia School Zone Road Safety

The Traffic Management and Safety: A Practical Guide for Schools published by the ACT Government in Australia highlight the following as critical measures to be applied in the school zone:

(https://www.tccs.act.gov.au/_data/assets/pdf_file/0013/811003/ACT-A-Practical-Guide-for-schools-Final.pdf, accessed on 3 November 2017)

- Setting and enforcing speed limits of 40km/h in the school zone during school hours;
- Provision of school zone road signs;
- Provision of strategically located, marked and signed pedestrian crossings including signalised crossings, marked zebra crossings, refuge islands;
- Provision of fencing or guardrails along the road to restrict crossing and non-designated areas;
- Provision of safe walking and cycling facilities;
- Provision of safe and strategically positioned bus stops, drop off and pick up areas;
- Designating pick up and drop off points away from the school to decrease congestion in the school zone; and
- Provision of suitable traffic calming measures.

The Ideal School Zone

The Guidelines for road safety around schools published by the Northern Territory Government in Australia describes an ideal school zone in their guidelines for road safety around schools as the one that has the following:

(https://nt.gov.au/_data/assets/pdf_file/0017/163223/guidelines-for-road-safety-around-schools.pdf, accessed on 8 November 2017)

- The school's main entrance should be located on a local class five road;
- The school should have off street parking for parents and teachers;
- On street parking should be eliminated and enforced;

- Roads around the school to be restricted to one-way roads and pick up and drop off should be separated and located on one-way roads;
- Turning facilities after pick up and drop off should be provided away from the school to prevent unnecessary turning manoeuvres;
- Pedestrian and cycling paths should be separated and any conflicts with traffic removed;
- Refuge islands to be provided close to the school on higher order roads located close to the school;
- Bus stops should be located on the school side sufficiently away from the school's main entrance to reduce conflict with high scholar traffic at entrance;
- Schools sporting facilities should be located adjacent to the school to reduce travelling and road crossings to reach these areas;
- Road marking and signage to increase visibility of school entrances;
- Traffic speeds should decrease to 40km/h and also enforced;
- School signage, such as warning signs should be provided to alert drivers about the school;
- No stopping should be allowed opposite the school;
- Pedestrian crossings should be located strategically close to the school and along child traffic desire lines; and
- Where necessary, roads adjacent to the school should be, closed and adequate turning facilities provided.

3.4 Chapter summary

The literature study indicates that there are some gains from providing road safety education to young children, but the effectiveness is limited by their development. The education does not necessarily result in sustained behaviour. The use of engineering measures to modify the built environment and exposure of children to the risk of traffic injury, appears to be a better strategy. Traffic calming is one of the most successfully utilised engineering measure for reducing the frequency and severity of road traffic crashes. The success of traffic calming is attributed to the fact that it has been found to successfully resolve the major contributor to road traffic crashes, traffic speed and volume. Proactive, area-wide approach to traffic calming is the best approach for schools because it is a risk mitigation and preventative measure. The area wide application ensures that the environment around the school is adequately assessed and interventions are applied.

The ideal school zone road safety features includes measures that reduce traffic speeds, removal of on street parking, removal or reduction of conflict between pedestrians and vehicles, the use of road markings, road signs and warning signs to alert drivers about the school zone and provision of adequate and safe infrastructure, such as parking, turning facilities and bus stops.

CHAPTER 4: METHODOLOGY

Introduction

The purpose of this research was to investigate the magnitude of road traffic crashes involving child pedestrians, around primary schools, in eThekweni. Additionally, to identify the top ten at risk primary schools and use these extreme cases to understand the common risk factors associated with the road traffic crashes. Finally, to investigate the interventions applied within the school zone and compare the interventions with international best practice. The methodology for completing this research is shown on Figure 8.

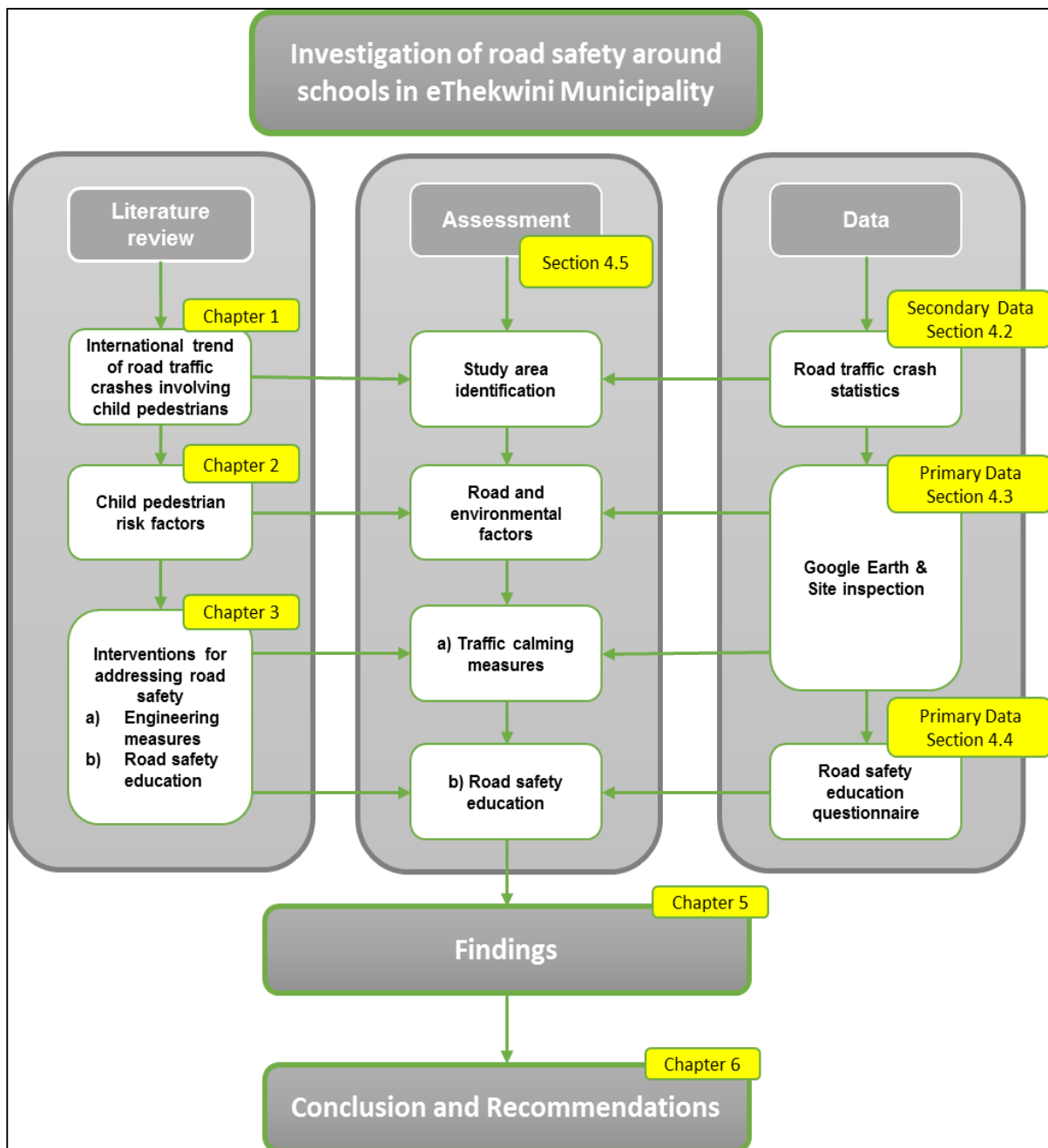


Figure 8: Research methodology diagram

The research commenced by reviewing literature on the international trend of road traffic crashes involving child pedestrians in Chapter one; the risk factors for child pedestrians and the causes of Road Traffic Crashes (RTC) in Chapter 2. Thereafter, literature on the intervention measures for reducing road traffic crashes was reviewed in Chapter 3.

The road crash statistics from eThekweni municipality were used to identify primary schools with the highest road traffic crashes as the study areas for this research. The road and environmental risk factors in the study area and the engineering measure applied at the schools were then identified by analysing the school zones of the identified schools using Google Earth and onsite inspections. The assessment of the educational measures were confirmed by conducting interviews with senior management of the identified schools. The results from the assessment are included in Chapter 5 of this thesis.

4.1 Mixed method study

This research used a combination of qualitative and quantitative methods of research. Mixed methods are used where a combination of methods is found to be the best way of providing answers to the research question. The purpose of the quantitative component of this study was to identify primary schools with the highest road traffic crashes using road traffic crash data, to analyse the data and identify the common risk factors for child pedestrians. The purpose of the qualitative component of the research was to complement the quantitative study by collecting data on the observations, opinions and factual information about the common causes of road traffic crashes, and the effectiveness of the applied measures. The onsite observations were also conducted to supplement information on the road environment factors that contribute to road traffic crashes within the school zone.

4.2 Secondary data – Road traffic crash statistics

Secondary data refers to existing data collected by others for research or non-research purposes (Hox et al., 2005). The advantage of using secondary data sets is that if the information is already available, this reduces the cost and time of doing the research. The main disadvantage of using secondary data sources is that data is usually collected for a different purpose and might not be tailored to answer some of the research questions. Fortunately, the municipality confirmed that the data is collected with the same purpose as that of this research.

The secondary data source with road crash statistics was obtained from eThekweni Municipality's Road Safety Department. The data was retrieved and analysed to identify the top ten primary schools with the highest road traffic crashes, child pedestrian risk factors, specifically, the cause of accident, accident severity, and location of accident, road class, age and gender, time of day, day of the week, weather condition and lighting condition. The results are presented in Chapter 5.

4.2.1 Secondary data quality verification

The quality of the data was verified by investigating the methods that the municipality uses for data collection, verification and recording. The consultation with the municipality revealed that the data is collected from the road crash reports obtained from either the South African Police Services (SAPS) at all 52 police stations in eThekweni and seven Metropolitan Police (Metro Police) Stations in eThekweni. The Accident Reports are then scanned and saved on the database. The accident data is then captured onto the “Impact Data Entry Traffic Accident System” – an online database system developed by the municipality over the years. Approximately 1 700 forms are collected each week, resulting in an average of 7 300 forms per month, of which 15% are duplicates.

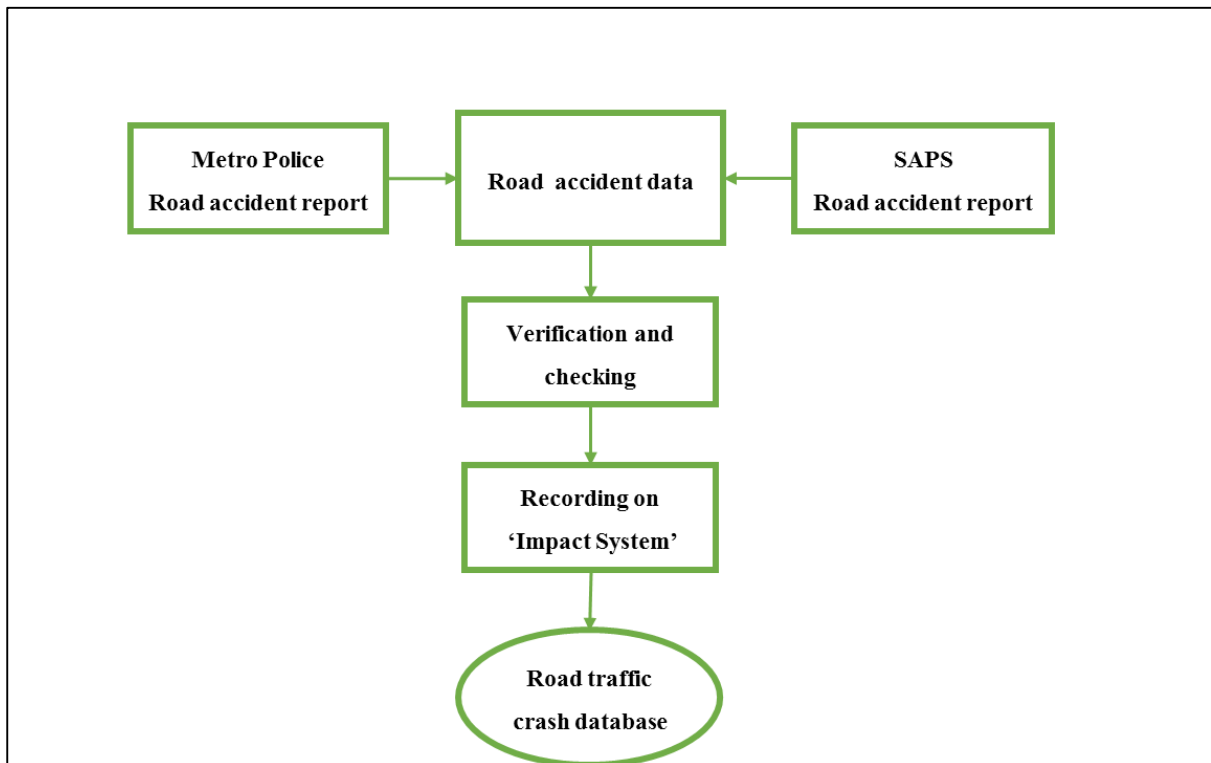


Figure 9: Process for creation of the eThekweni Municipality road traffic crash database

Data cleaning is done by checking the data for completeness and removing duplications that arise, due to the two data sources. A typical road crash report contains information on the crash type, brief description of cause of the crash, crash location, particulars of the vehicles, passengers, pedestrians, cyclists or drivers involved in the crash, road and environmental conditions, such as weather and lighting. Figure 9 indicates the data collection flow diagram.

4.2.2 Data shortcomings

The municipality highlighted the following short comings from the data collection process:

- a) Forms are often poorly completed with a number of fields with critical information left blank, i.e. the location of the accident, the identity numbers of the victims, degree of injury, usage of seatbelts or helmets for cyclists and motorcyclists and drunken driving; and
- b) The municipality does not receive copies of severe and fatal crash reports where dockets are opened. These accident reports are usually kept by the investigating officers. In 2013, for example, SAPS recorded 794 fatal crashes, but the municipality only received 490 forms (62%).
- c) The municipality confirmed the well-known fact that the road traffic injuries are under reported, especially in developing countries, (WHO 2008). Sometimes the municipality is made aware of the incident, but the data cannot be captured into the database without the road accident forms that provide important information about the crash.

The mitigation measure was to source and analyse data that was collected over a 4-year period, 2012 to 2016.

4.2.3 Sampling method

The sampling method used for this study is purposeful criterion sampling. Purposeful sampling is regarded as a non-probability sampling method where a sample is purposefully handpicked rather than randomly selected (Sandelowski 2000; Alvi 2016, Etikan et al., 2015). Criterion sampling is choosing a sample according to their scores on a predefined instrument or according to the predefined criteria (Sandelowski, 2000; Alvi, 2016). The criteria used in this research is the number of road traffic crashes. The top ten schools that have the highest road traffic crashes were chosen as the sample. The initial data analysis revealed that most schools with RTC were located in clusters that are within 300m of each other, with the exception of one primary school.

Due to the type of sampling method chosen for this research, the results are not generalizable. Sandelowski (2000) asserts that criterion sampling is beneficial where research is done with the ultimate goal of conducting intervention trials and seeing if the interventions are successful or not. In this research, data was collected with the objective of investigating the common risk factors between the schools with the highest RTC, and interventions applied at the schools to reduce road traffic crashes. The aim of the research is not to generalise the results, but to identify risk factors that are common in schools with the highest road traffic crashes.

Sandelowski (2000) also advises that, for triangulation purposes, it is best to supplement data collected using criterion sampling by conducting interviews or observations. This research administered structured interview surveys on the sampled study areas and conducted on-site observations to ensure triangulation.

4.2.4 Study area identification

Road traffic crash data involving child pedestrians was retrieved from the database using the following steps:

- Crashes involving pedestrians were selected;
- Persons of ages 0 and 14 years were selected;
- A 500m radius around each primary school was drawn and road traffic crashes falling within this radius were selected;
- Schools were ranked according to the number of RTC; and
- Top ten schools with the highest RTC were selected as case study areas.

4.3 Primary data collection

Primary data refers to the data collected specifically for the topic under research to answer some or all the research questions (Hox et al., 2005). King (1994), states that a qualitative research interview is most appropriate “Where a quantitative study has been carried out, and qualitative data are required to validate particular measures or to clarify and illustrate the meaning of the findings” (King, 1994). The investigation focused on the road environment within the school zone including traffic calming measures, pedestrian infrastructure, that is, sidewalks and pedestrian crossings, road geometric layout, road class, posted speed limits and land use.

4.3.1 Onsite inspections & Google Earth desk top study

An in depth, hazardous location investigation of the school zone was conducted using two methods. The first method was a desktop study using Google Earth. A bird’s eye view of the school zone was useful in providing information about the road network, the road alignment, position of the primary school relative to other schools, the land use around the school, the proximity of the school to major intersections.

Onsite inspections were conducted at all schools to identify road and environmental risk factors for child pedestrians. The inspections provided information about the traffic calming measures around the school, pedestrian facilities, such as sidewalks, pedestrian crossings, and the state of the road including road markings, the provision of road traffic signs, the road’s vertical alignment including the gradient. The inspections were also useful in providing the ‘feel’ for the road environment, sight distances, traffic speeds and volumes, pedestrian traffic and, lastly, obstructions around the road environment.

4.3.2 Structured interviews

The purpose of the interview survey was to collect data on the observations and opinions of the senior school leadership about road safety around their schools and the facts about the road safety education offered at the school. The reason for selecting structured interviews as an addition data collection measure was that:

- Because interviews allow for probing for answers by the interviewer, the researcher was going to obtain valuable information that could be missed through onsite inspections and Google Earth desktop studies.
- The selected sample was small enough to conduct interviews.

4.3.3 Designing a survey questionnaire

The questionnaire was designed to contain a combination of open ended and closed ended questions. The questionnaire included questions about the educator's estimation of the number of crashes involving children at the school, the locations where most crashes took place, the opinion of the cause of the crashes, the type of road safety measures around the school, their opinion on the effectiveness of the measure and the additional measures required to reduce crashes. Information on whether road safety was included in the school's curriculum and other means that the education is provided, the method of teaching and evaluation was also included in the questionnaire.

In open ended questions, respondents were asked to provide their opinions, observations and to provide yes or no responses but also to elaborate on their answers. Closed ended questions requested respondents to select the best fit answer from options provided in the questionnaire.

4.3.4 Selecting respondents

Principals and other senior management of the schools were used as key informants. The reasons for selecting school's senior management were that they are senior leaders of the school and were perceived to possess information relevant to the research. The questionnaire included a consent form which clarified the research objectives and clauses that ensured respondents about their voluntary participation and confidentiality of the responses.

4.3.5 Selecting interviewers

In order to reduce the bias of the researcher, interviews were conducted by three different interviewers. As noted earlier, the interview was guided by the questionnaire which contained both open ended and closed ended questions. The interviewers were instructed to probe the respondents for additional information on all questions included in the questionnaire.

4.4 Chapter Summary

This research used a combination of qualitative and quantitative methods of research because this combination was found to be the best way of providing answers to the research question. The magnitude of road traffic was obtained using data from eThekweni Municipality and the investigation of the interventions applied at the schools was conducted using Google Earth imagery, onsite inspections and administering a questionnaire to educators at the schools chosen for the case study.

CHAPTER 5: CASE STUDY IDENTIFICATION, DATA ANALYSIS AND RESULTS

Introduction

This research undertook to:

- Identify primary schools with the highest road traffic crashes in eThekweni Municipality;
- Analyse the road traffic crash data to identify the recorded causes and risk factors associated with the road traffic crashes around the identified schools;
- Analyse the school zones as hazardous locations to identify road and environmental risk factors for child pedestrians; and
- Investigate the existing road safety education and engineering intervention measures applied at the study schools.

This chapter presents the results of the investigation. Section 5.1 presents data on the primary schools with the highest road traffic crashes in eThekweni and ranks the schools according to the number of road traffic crashes and highlights the results of the injury severity. Section 5.2 presents the results from the analysis of recorded causes and risk factors of the road traffic crashes. Section 5.3 provides an analysis of the socio economic factors and the land use around the schools under investigation. Lastly, Section 5.4 presents results on the school zone analysis and highlights information regarding the road design factors, the provision of pedestrian facilities and traffic calming measures.

5.1 Top ten schools with highest road traffic crashes

There are 750 schools in the eThekweni Municipal area. The road traffic crash statistics indicate that over a period of four years, commencing in 2012 to 2016, 668 primary schools recorded road traffic crashes. The total recorded road traffic crashes around primary schools with the highest road traffic crashes is 285. The number of child pedestrians involved in the road traffic crashes at these schools is 576. The severity of the injuries resulting from the recorded crashes ranged from no injury, 257, slight injury, 247, serious injury, 61 and fatal injury 11. The primary schools with the highest number of road traffic crashes are shown on Figure 10.

The road traffic crash data from the top ten schools indicate that only 2% of injuries resulted in death, 11% resulted in serious injury and the majority of the crashes result in slight injury, 43% and no injury, 45%. The percentage split of the severity of injuries is shown in Figure 11.

Figures 17 to 20 indicate the location and severity of crashes relative to the schools. Figure 17, 18 and 20 indicate that road crashes are dispersed around the schools and are not concentrated on one road. On the other hand, Figure 19, shows a clear pattern that indicates that most crashes around Inkonkoni primary schools take place on Sibusiso Mdakane Drive.

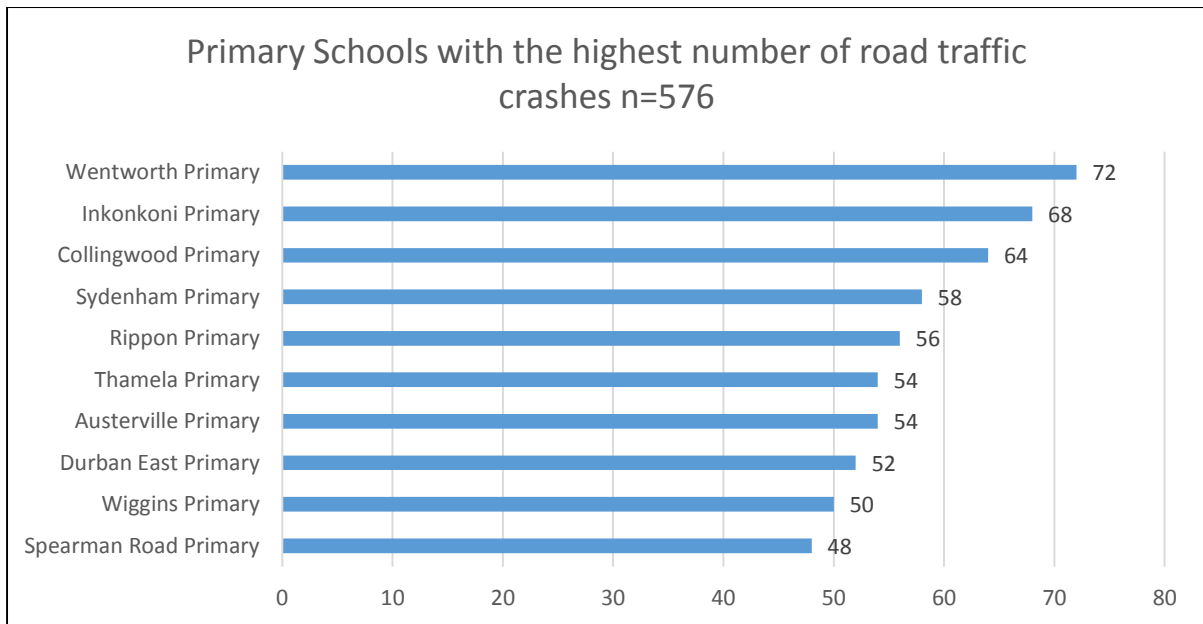


Figure 10: Top Ten Primary Schools with Highest Road Traffic Crashes in eThekweni (2012-2016)

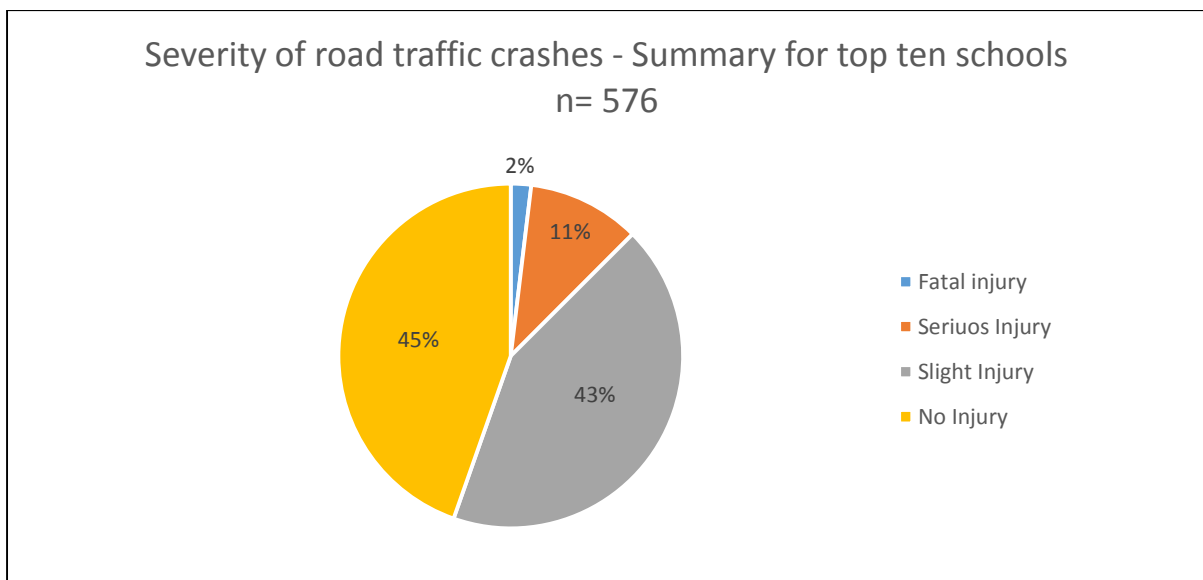


Figure 11: Severity of road traffic crashes involving Primary School children (2012 -2016).

The data reveals a pattern where the highest road traffic crashes are observed in areas with more than three schools within a one kilometre radius of each other. This pattern was observed in Jacobs as well as in Sydenham, refer to Figures 12 to 14. The first cluster of schools is located in Jacobs, in the South Durban Basin. The schools are Wentworth Primary School, which has the highest crash incidents of all primary schools in eThekweni, Collingwood Primary School, which has the third highest crashes, and Austerville Primary School, which has the seventh highest road traffic crashes as well as Durban East Primary School, with the eighth highest road traffic crashes in eThekweni.

The second cluster of primary schools with the highest crashes is located in Sydenham, Durban. These schools are Sydenham Primary School, which has the fourth highest rate of crashes, Rippon Road Primary School, fifth highest and Spearman Road Primary School, which has tenth highest road traffic

crashes. Clayton Primary School that is located within a 1km radius of the Sydenham, Rippon and Spearman Road that also has a significant number of road traffic crashes and falls in the top twenty schools with the highest road traffic crashes in eThekweni and was included in the area assessment for Sydenham Primary Schools.

Umlazi Township has 2 out of 10 schools with the highest RTC, the schools are Inkonkoni Senior Primary School, which has the second highest RTC and Thamele Primary School which has the same number of crashes as Austerville Primary School, and these schools are listed as the fifth and sixth highest schools. Wiggins Primary School is the only school that is from Wiggins that falls within the top 10 schools with the highest RTI and is ranked ninth out of the ten primary schools. An in depth assessment of the road and environmental risk factors for child pedestrians were done on three areas; primary schools located in Sydenham, Jacobs and Umlazi. Wiggins's primary school was not included in the assessment.

Three areas were identified for an in-depth investigation in this research;

1. Jacobs : Wentworth, Austerville, Collingwood and Durban East Primary Schools
2. Sydenham: Sydenham, Rippon Road, Clayton, Spearman Road Primary Schools
3. Umlazi: Thamele and Inkonkoni Primary Schools

5.2 Socio-economic factors and land use

5.2.1 Study area one – Jacobs in the South Durban Basin

The South Durban basin is a large industrial area in the South of Durban. Among the 5000, businesses located in this area are large petrochemical refineries, a paper mill and motor manufacturing companies. The area has 22 000 households and a population of 200 000 residents (www.statssa.gov.za accessed on 10 October 2017). The population mainly consists of Coloureds, Indians and Black Africans. The area is classified as a medium to low income area. Four out of the ten primary schools with the highest road traffic crashes are located in Jacobs, in the South Durban Basin, these are Wentworth, Austerville, and Collingwood and Durban East Primary Schools. The schools are within 300m of each other, as shown in Figure 12.

5.2.2 Study area two – Umlazi township, Durban South

Umlazi Township is one of the largest townships in eThekweni and is located in the South of Durban. The township is classified as a low to medium income area and has 105 000 households and a total population of more than half a million (www.statssa.gov.za accessed on 10 October 2017). Over 90% of Umlazi residents are Black Africans. The township is predominantly a residential area. Two primary schools with the highest road traffic crashes are located in Umlazi Township, these are Inkonkoni and Thamele Primary School. Figure 13 is an aerial map that shows the location of the two primary schools in relation to each other.



Figure 12: Aerial view of the Jacobs Primary Schools.



Figure 13: Aerial view of the Umlazi Primary Schools.

5.2.3 Study area three – Sydenham, Durban central

Sydenham is a residential area located close to the Durban central business district. The area predominantly consists of Indians 80%, Black African 13%, Coloured 7% and less than 1% White populations (www.statssa.gov.za accessed on 10 October 2017). Sydenham is regarded as a middle to low income area but has been in news in the past year where residents were complaining about informal settlements that are being built in open spaces in this area causing the area to deteriorate from medium to low income area. Sydenham consists of three out of ten primary schools with the highest road traffic crashes, these are Sydenham Primary School, Rippon Road Primary School and Spearman Road Primary School. The investigation of the area indicates that there is another school Clayton Primary School that is located within a 1km radius of the Sydenham, Rippon and Spearman Road schools. The road traffic crash statistics reveal that this school also has a significant number of road traffic crashes and falls in the top twenty of the 668 schools with road traffic crashes in eThekweni. The aerial view of the Sydenham schools is shown in Figure 14.

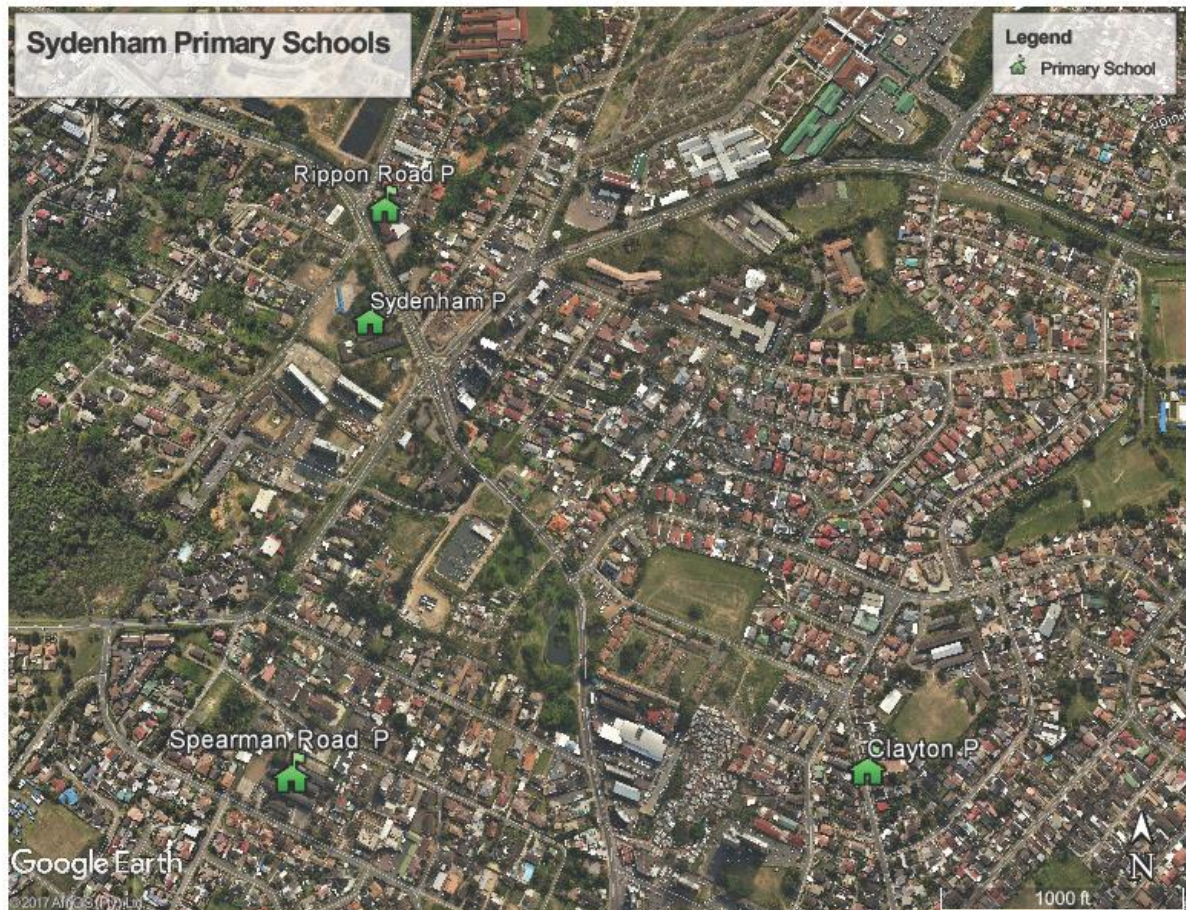


Figure 14: Aerial view of the Sydenham Primary Schools

5.3 Risk Factors

5.3.1 Crash Location

The data indicates that 58% of the road traffic crashes in the study areas took place away from an intersection, the remainder, 42%, took place at an intersection of which, 21% were at a T-junction and 20% took place at a cross intersection and only 1% took place at a staggered intersection. The results indicate that the intersections have a significant contribution to crashes and pose a risk to child pedestrians. The area based analysis results follow the same trend that indicates that most road traffic crashes take place when a child pedestrian is crossing the road away from the intersection. The location of crashes for the top ten primary schools and the area based analysis are shown on Figures 15 and 16 respectively. The results from the GIS analysis of location of crashes are shown of Figures 17 to 20.

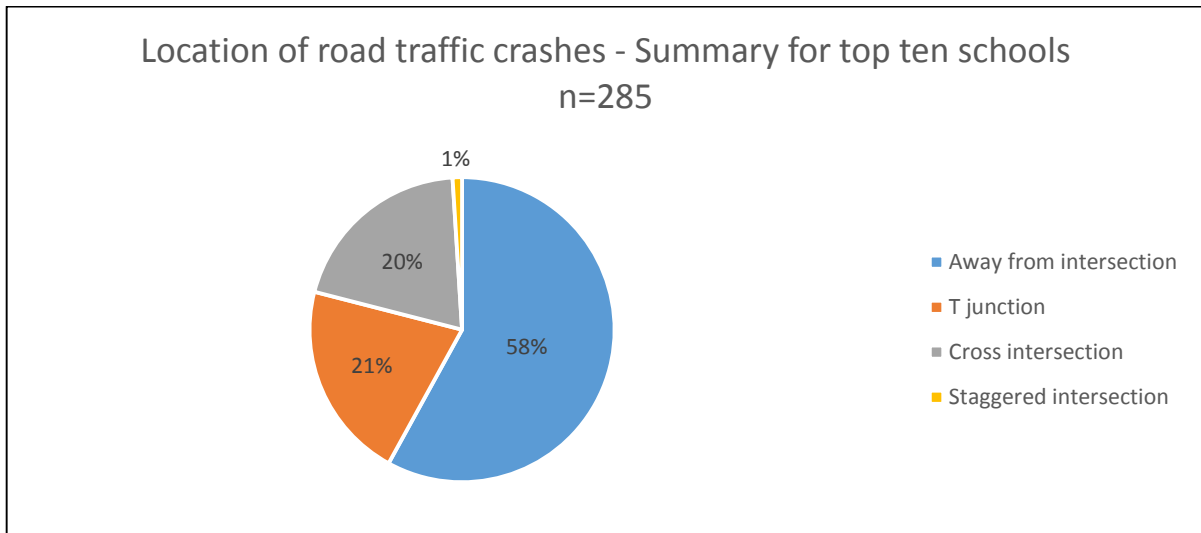


Figure 15: Location of Road Traffic Crashes – Summary for top ten schools (2012 -2016)

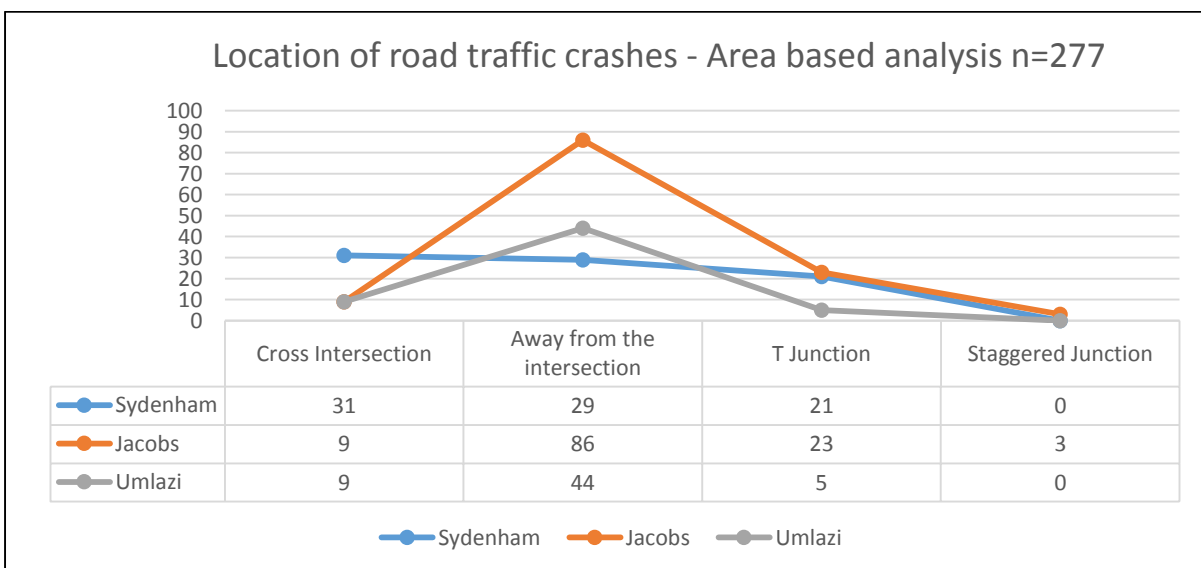


Figure 16 Location of road traffic crashes – Area based assessment (2012-2016)



Figure 17: Severity and location of road traffic crashes for Durban south Primary Schools



Figure 18: Severity and location of road traffic crashes for Sydenham Primary Schools



Figure 20: Severity and location of road traffic crashes for Thamela Primary School

5.3.2 Cause of crashes

There were 285 road traffic crashes recorded in the schools with the highest road traffic crashes over a period of four years. The data reveals that most crashes were caused by child behaviour associated with crossing the road when it was unsafe to do so, 69% and playing or fighting on the road, 8%. Therefore, child behaviour contributed to 77% of the road traffic crashes. Driver behaviour contributed to 17% of crashes, the recorded behaviour was speeding, 4%, and making an unsafe manoeuvre, 13%. The cause of six percent, 6%, of the crashes was recorded as driver not seeing the pedestrian, the visibility of the pedestrian can be obscured by a number of environmental factors, such as, on street parking, obstructions on the side of the road, vehicular traffic, lighting and weather conditions. The percentage split of the cause of crashes is shown on Figure 21. The conclusion that can be drawn here is that human behaviour contributed to 94% of the crashes and environmental factors only contributed to 6% of all crashes. The graphical representation of the cause of road traffic crashes on all areas follow the same trend with the highest cause of crashes linked to child behaviour of entering the road when it was unsafe to do so. Jacobs shows a significant number of the cause linked to “the driver did not see the pedestrian” and “playing or fighting on the road”. The possible reasons were informed by key informant interviews that revealed that, 80% children from the Sydenham schools come from Umlazi, and are brought in by scholar transport. Scholar transport often arrives late in the afternoons, therefore children end up playing on the road to overcome boredom. The area based analysis is shown on Figure 22.

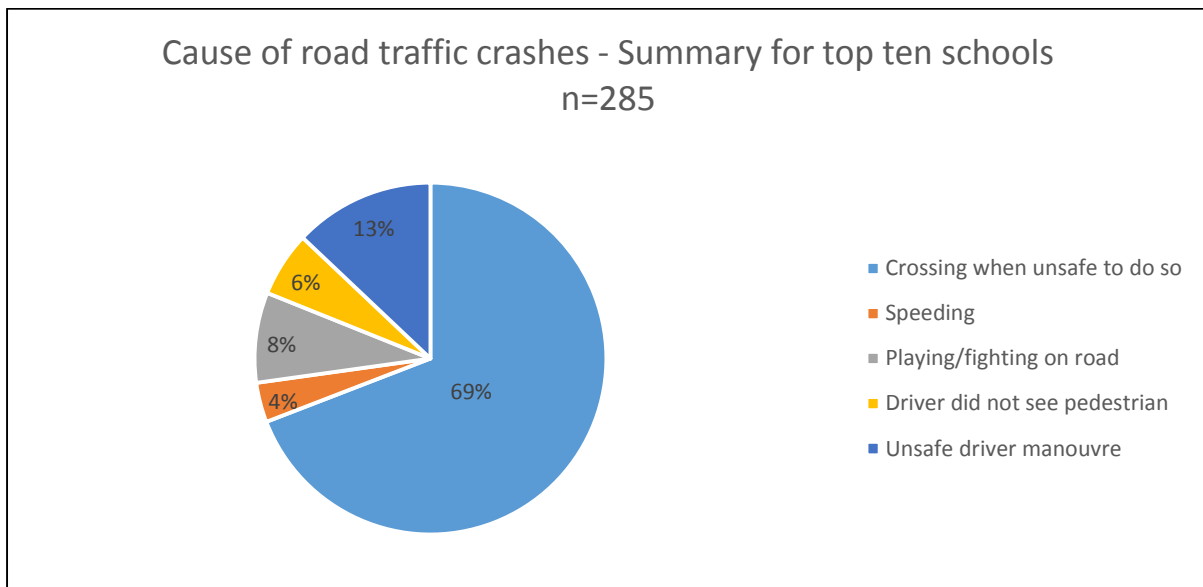


Figure 21: Cause of road traffic crashes – Summary for top ten schools (2012-2016)

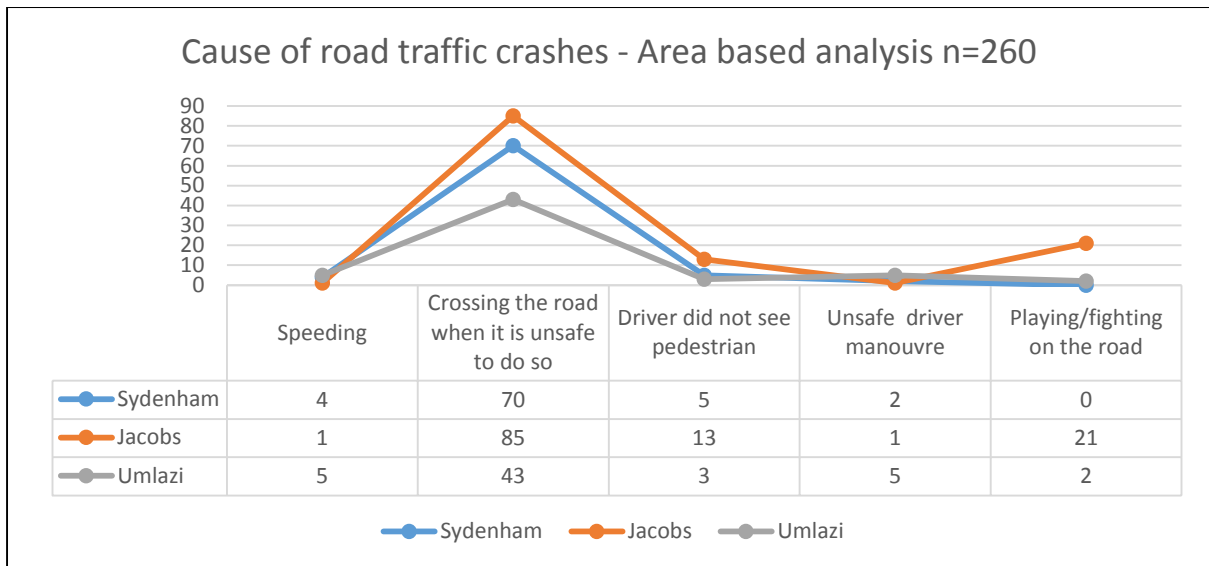


Figure 22: Cause of road traffic crashes - Area based assessment (2012-2016)

5.3.3 Day of the week and time of day

The data indicates that most crashes at Sydenham schools took place on Mondays and Fridays. In Jacobs schools, the beginning of the week; Monday and Tuesdays, had the highest crashes, while in Umlazi schools show a peak of crashes on Tuesdays and Fridays. All schools show an increase on crashes on Monday and Fridays. There is a clear trend of an increased number of crashes in the morning and afternoon peak periods for all schools, this is consistent with the start and end of school day. The afternoon peak, between 13h00 to 15h30, has most crashes this is due to the fact that school children are released at the same time after schools whereas, in the morning, children’s arrival is distributed. The data representing traffic crashes per weekday and time of day is presented in Figures 23 and 24 respectively.

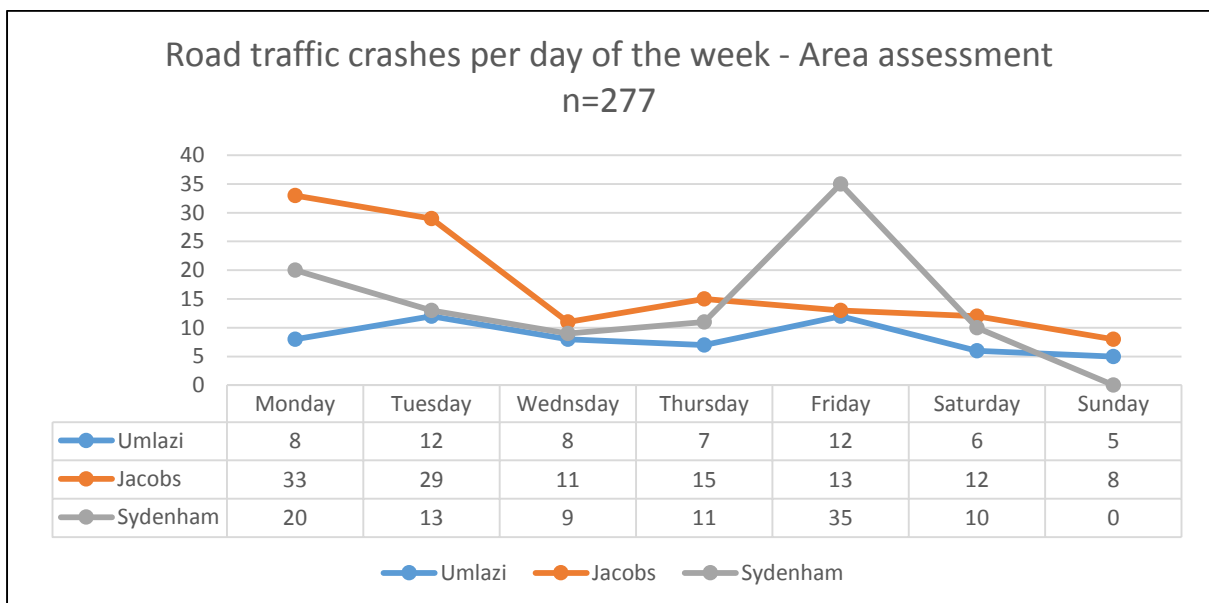


Figure 23: Road traffic crashes per day of the week (2012 -2016)

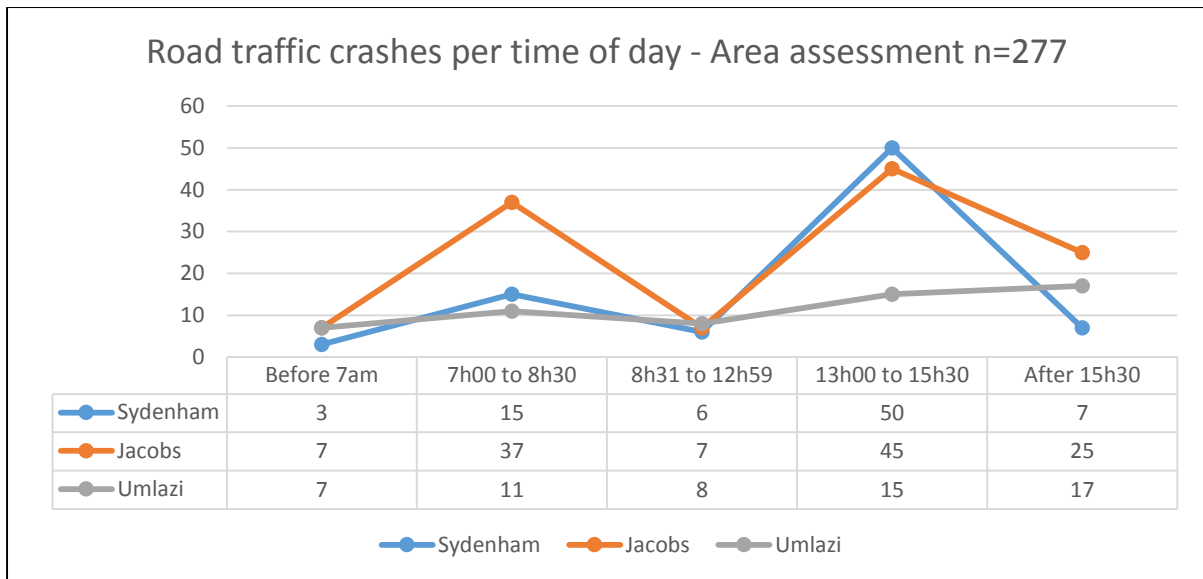


Figure 24: Road traffic crashes per time of day – Area assessment (2012-2016)

5.3.4 Age and gender

The assessment of the age and gender profile was done for all road traffic crashes taking place within a 3 km radius of all schools in eThekweni. The results indicate that out of the 823 road traffic crashes recorded around the schools, the 5 to 9 year-old age group had the highest number of road traffic crashes and that boys were more likely to be involved in road traffic crashes when compared to girls. The results are in line with the 2015 RTMC which indicates that children between the ages of 5 to 9 years have the highest fatality rate of all children. The graphical representation of the road traffic crashes per age and gender are shown on Figures 25 and 26 respectively.

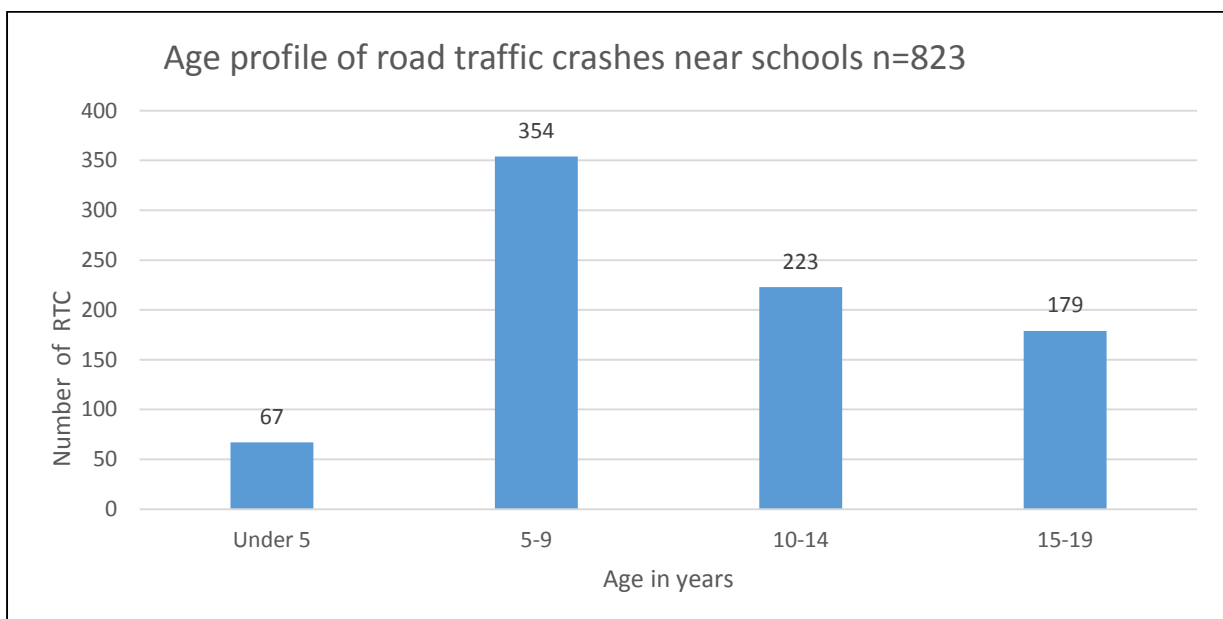


Figure 25: Age groups with the highest road traffic crashes (2012-2016)

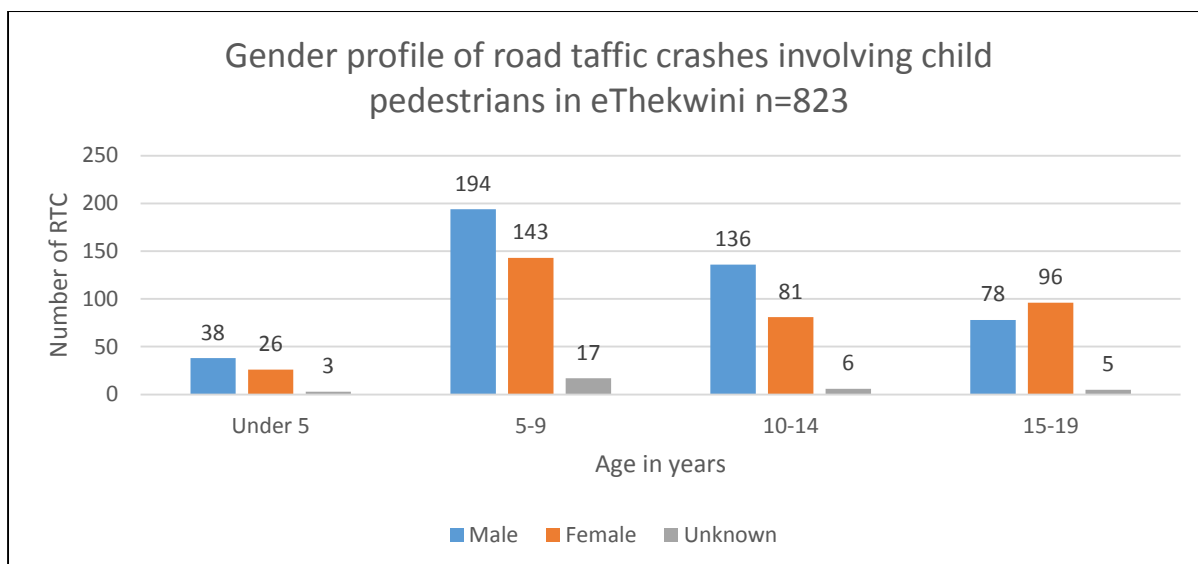


Figure 26: Road traffic crashes and gender (2012 -2016)

5.3.5 Road class

Class 5 roads are local or residential roads that predominantly perform an access function as opposed to a mobility function and therefore provide access to residential properties. Collector and distributor roads are found in residential areas and their main function is to collect traffic from the lower order roads, Class 5 local roads, and feed to higher order arterial roads. Table 6 includes the roads with the highest road traffic crashes in the top ten primary schools and their classification. The data shows that, in Umlazi and Sydenham, Class 3 and Class 4 roads are individually responsible for the highest number of crashes compared to Class 5 local roads. A significant contribution of crashes by Class 4 roads is also noted in Jacobs. The main reason for this is that, all schools in the top ten, are located within a kilometre distance from the higher order roads.

Road name	Location	Road class	Number of crashes
Austerville Drive	Jacobs	Collector Class 4	35
Rippon Road	Sydenham	Distributor Class 3	25
Sibisiso Mdakane Road	Umlazi	Collector Class 4	24
Moses Kotane	Sydenham	Distributor Class 3	21
Silvertree Road	Jacobs	Local Class 5	16
Goede Hoop Street	Jacobs	Local Class 5	16
Maurice Gumede Drive	Umlazi	Collector Class 4	11
Sbu Magwanyane Drive	Umlazi	Distributor Class 3	9
Griffiths Mxenge Highway	Umlazi	Distributor Class 3	5

Table 5: Classification of roads with highest road traffic crashes (2012-2016)

The combined assessment, on the other hand, indicates that, Class 5 roads, are collectively responsible for most crashes, and most crashes in Jacobs take place on Class 5 roads. The results, shown in Figure 27 are consistent with literature that reveals that most crashes involving child pedestrians take place on local roads. The results from the area assessment are shown on Figure 28.

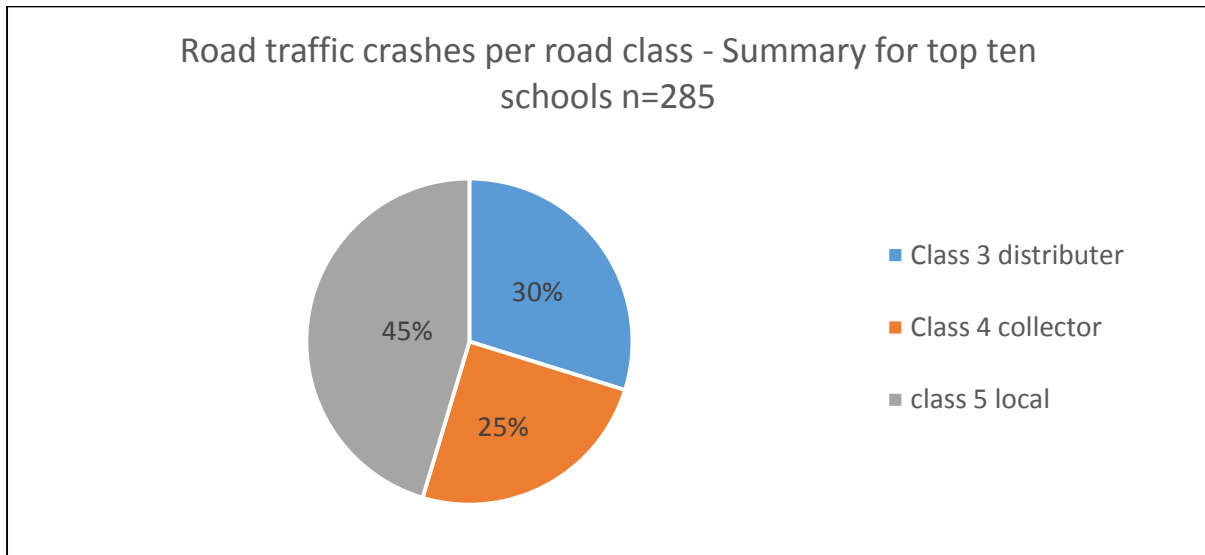


Figure 27: Road traffic crashes per road class – Summary for top ten schools (2012-2016)

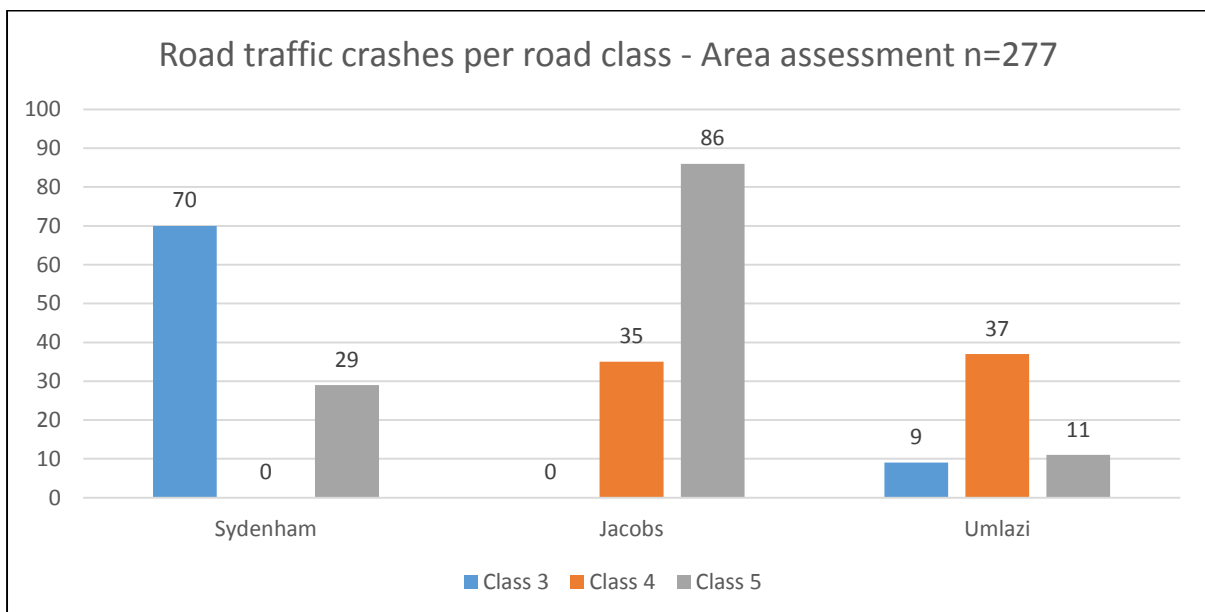


Figure 28: Road traffic crashes per road class - Area assessment (2012 -2016)

5.3.6 Road type

The analysis of the data shows that 88% of the road traffic crashes took place in roads with a single carriageway, Figure 29, and the remainder occurred on roads with dual carriageway. This is in line with the results of Table 6, since typically, collector, distributor and local roads are single carriageway roads

with one lane in each direction. The area assessment indicates follows the same trend with most crashes taking place on single carriageway roads, refer to Figure 30.

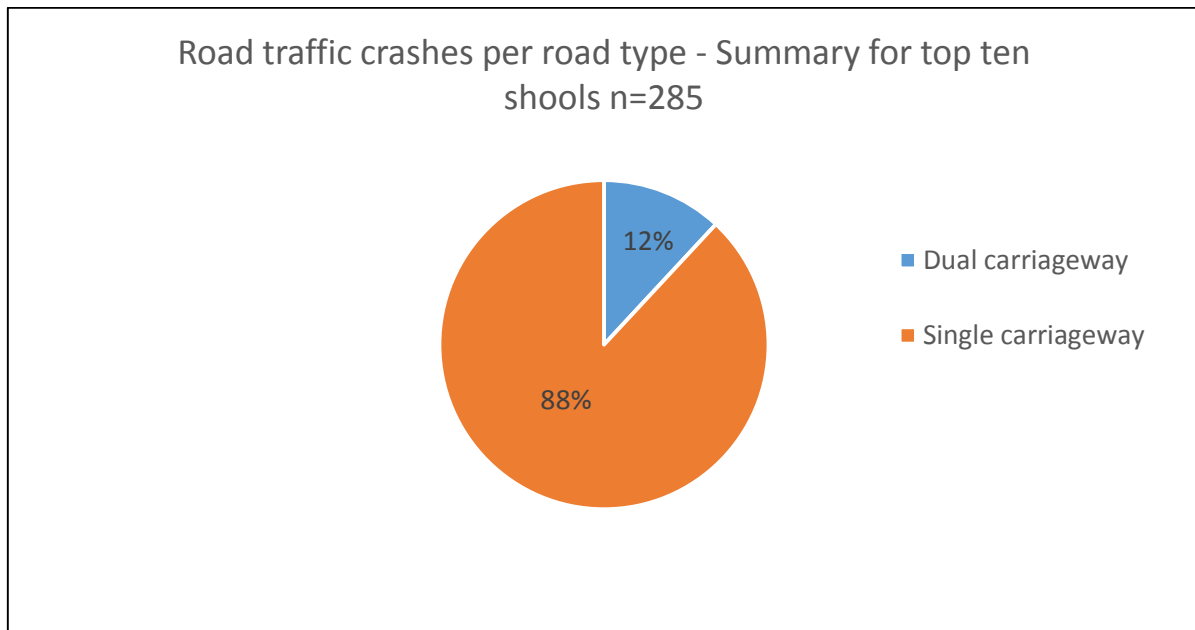


Figure 29: Road traffic crashes per road type (2010 – 2016)

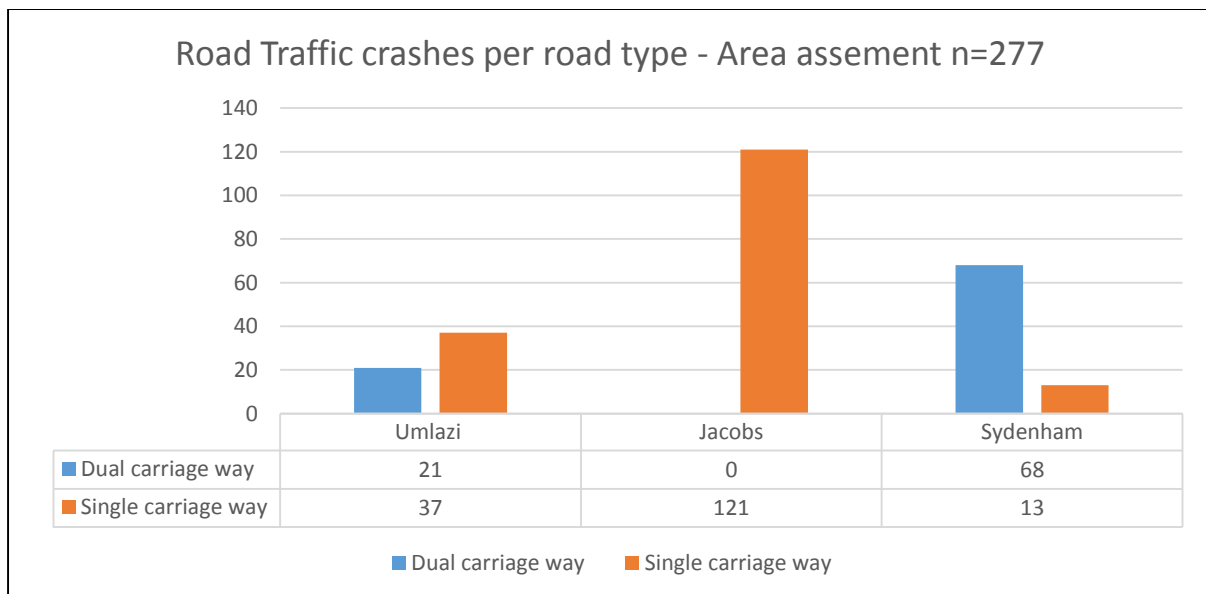


Figure 30: Road traffic crashes per road type - Area assessment (2012 -2016)

5.3.7 Weather and lighting

The data indicates that 87% of the crashes took place during day light, 8% took place during dusk or dawn and only 5% took place at night. The results are consisted with the fact that most child pedestrian traffic in the school zone is observed during day time and less at dusk, dawn and night time. The data on lighting condition for all top ten schools and per area investigated is shown on Figure 31 and Figure 32 respectively.

Ninety five percent (95%) of crashes took place in dry weather conditions and 5% took place when it was either raining (4%) or overcast (1%). The results for top ten school assessment and area based analysis are shown of Figure 33 and 34 respectively.

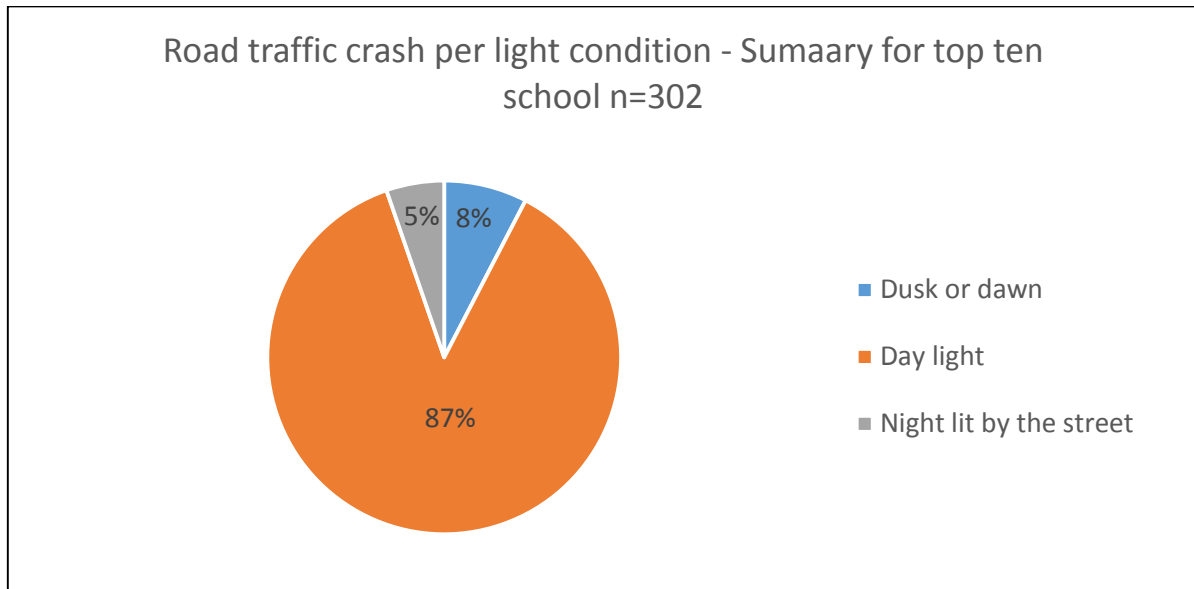


Figure 31: Status of lighting during a road traffic crash – Summary for top ten schools (2012-2016)

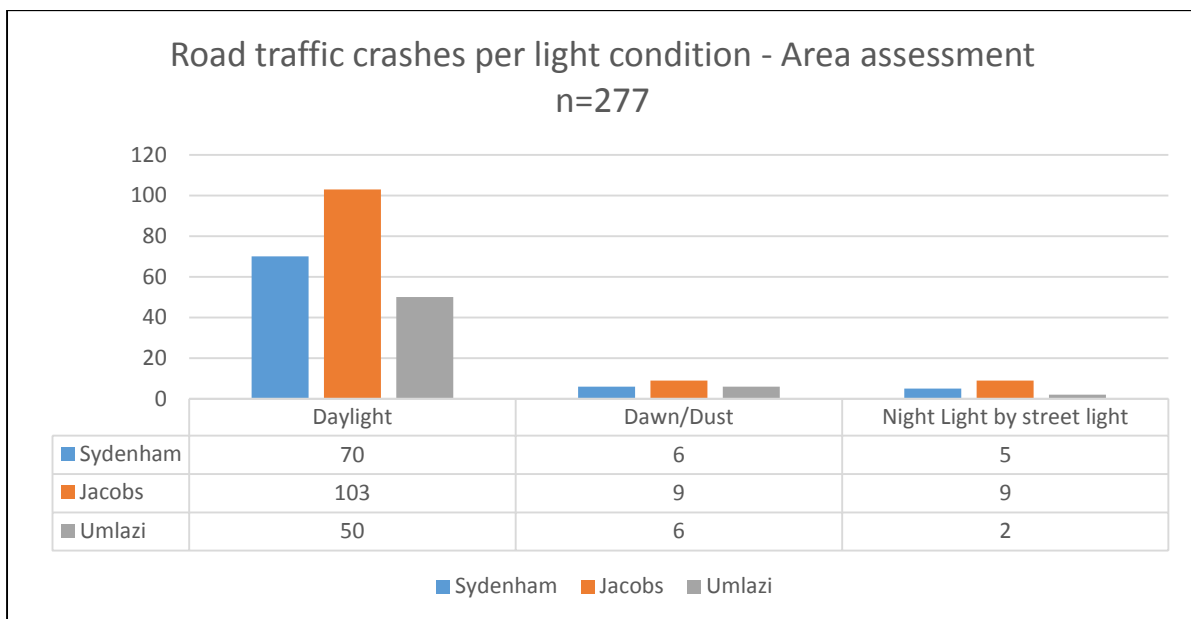


Figure 32: Road traffic crashes per lighting condition - Area assessment (2012-2016)

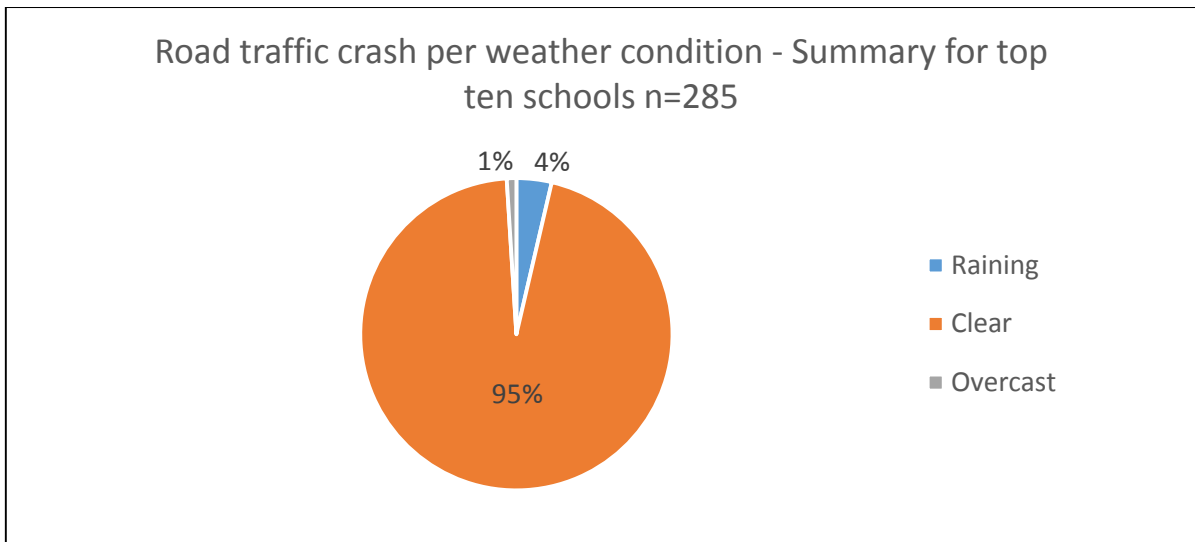


Figure 33: Road traffic crashes and weather condition- Summary for top ten schools (2012-2016)

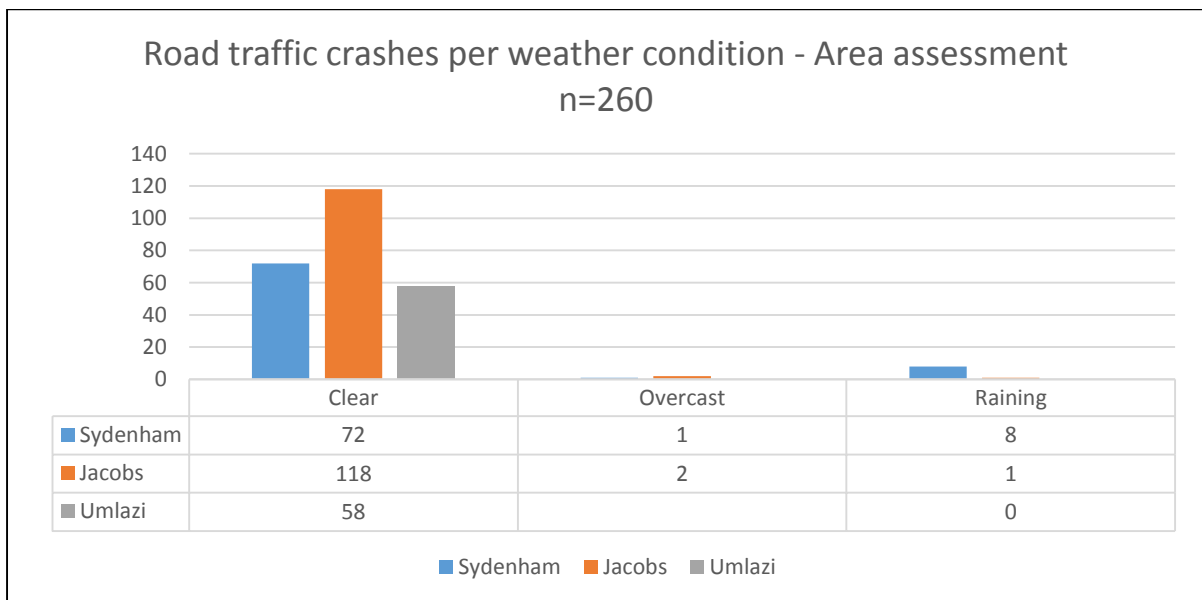


Figure 34: Road traffic crashes per weather condition - Area assessment (2012 – 2016)

5.4 Road and environmental factor investigation

5.4.1 Jacobs Primary Schools

5.4.1.1 School zone description

Wentworth Primary School has the highest road traffic crashes of all primary schools in eThekweni. A Google search and onsite inspection revealed that the school is bound by two local Class 5 roads, Timmerman Road and Jonas Road, both roads are dead end roads that provide access to the school and adjacent properties. Austerville Drive forms the third and final boundary of the school but the school property does not have direct access to Austerville Drive. The road traffic crash data indicates that most road traffic crashes, (39%) associated with this school took place on Austerville Drive, followed by

Goedehoop 11% and Croton Road 8%. Only two road traffic crashes were recorded to have taken place on Timmerman Road, no crashes took place on Jonas Road. Goede Hoop Street and Croton Road are located approximately 300m from the school.

Collingwood Primary School has the third highest road traffic crashes of all primary schools in eThekweni. The school is bound by Goede Hoop Street, Austerville Drive (2km) and Croton Road (1.3km). Access to the school is located on Goede Hoop Street. The data reveals that just like Wentworth Primary School, most, 34%, road traffic crashes for Collingwood Primary School took place on Austerville Drive and Goede Hoop Road had the second highest road traffic crashes.

Austerville and Durban East Primary Schools have the sixth and the eighth highest road traffic crashes of all primary schools in eThekweni respectively. The schools are located within the same block which is bound by Class 5 local roads i.e. Silvertree Road (0,8km), Tifflin Road (0,6km), Richard Winn Road (0,4km) and Victor Lawler Road (0,4km). The statistics indicate that most road traffic crashes associated with these schools took place on Austerville Drive (27%) which is located 300m from the school, followed by Silvertree Road (23%) where the entrances to the two schools are located, and Goede Hoop Street (15%) which is located within 280m from the school respectively.

5.4.1.2 Design factors of roads with highest crashes

Three roads are associated with the highest road traffic crashes recorded around the Jacobs Primary Schools. These roads are Austerville Drive, Silvertree Road and Goede Hoop Street. The road design factors associated with these roads are discussed hereunder and the number of road traffic crashes is shown in Figure 35.

Austerville Drive has the highest road traffic crashes associated with the identified primary schools in Jacobs. The road is a class four connector through road and is approximately 2km in length. The road pavement is well maintained. The road has a large horizontal curve in the vicinity of the school which reduces the sight distance for both the drivers and the pedestrians. There are large trees and shrubs growing along the verge of the road which may also contribute to reduced visibility of pedestrians along the road side. The road does not provide for on-street parking and no vehicles were observed parked on the road in the vicinity of the school.

Goede Hoop Street has the second largest number of crashes associated with Jacobs Primary Schools. The road is a Class 5, local road, and is 0,4km long, the road is a straight road with a short horizontal curve close to the three-way, un-signalised intersection with Austerville Drive. The road verges are clear of vegetation and obstructions. The geometric design provides drivers with a long sight distance which might encourage speeding on this road. There is no provision for on street parked and no vehicles were observed parked on the street. The road has a significant number of driveways that provide access

to individual properties. The driveways present conflict points between the pedestrians and motor vehicles as they drive in and out of the road.

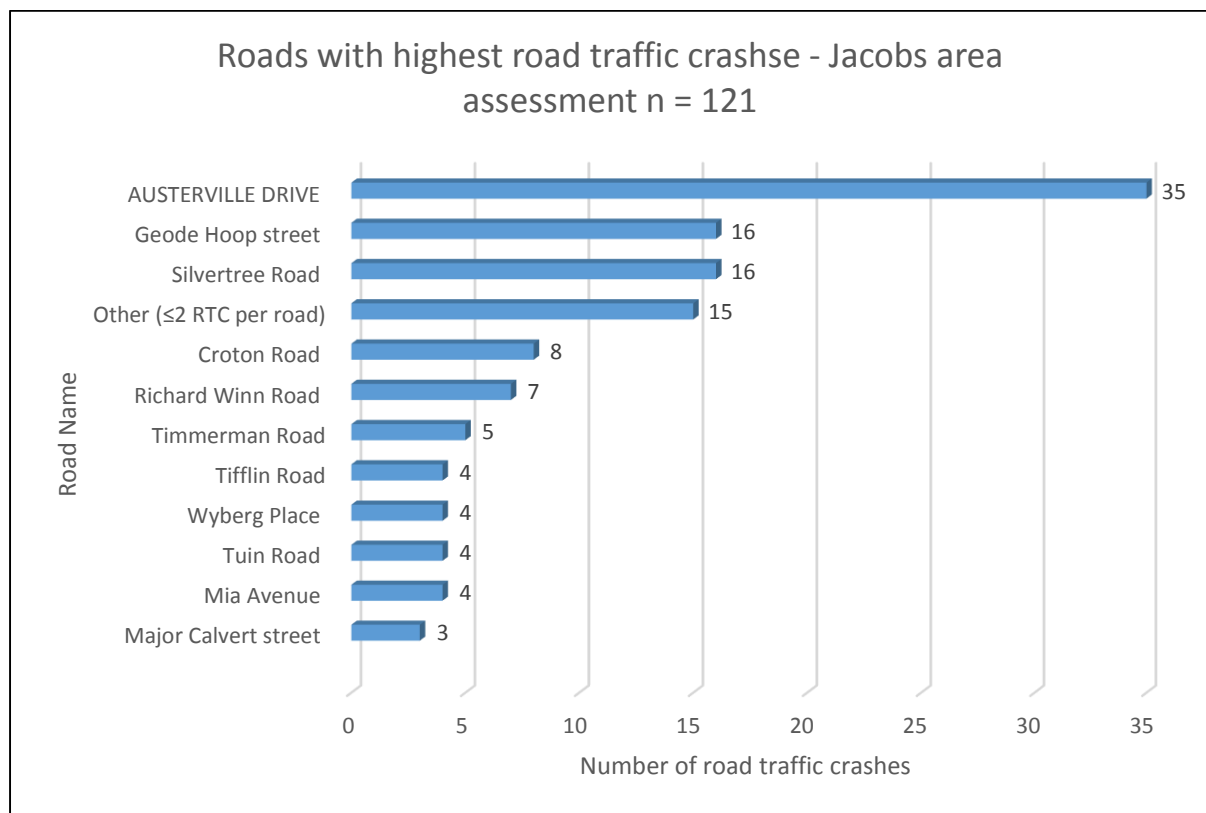


Figure 35: Roads with highest road traffic crashes – Jacobs (2012-2016)

Silvertree Road has the third highest road traffic crashes associated with Jacobs Primary Schools. The road is Class 5 local road and is 0,8km long. Six hundred meters (600m) of the total 800m meters of this road is straight. A gentle horizontal curve is located on the south side of the road close to the Durban East Primary School. The straight section of this road provides long sight distances for the drivers which might encourage speeding but also provides long sight lines for the pedestrians that allows for the safe crossing of the road. The road verges are clear of vegetation and obstructions.

5.4.1.3 Traffic speed and volume

The posted speed limit on Austerville Drive, Goede Hoop Street and Silvertree Road is, 60 km/h, 40km/h and 40km/h respectively. The 60km/h speed limit on Austerville Drive is inconsistent with the recommended traffic speed of 40km/h of roads within the school zone.

5.4.1.4 Pedestrian facilities

All roads around the schools have sidewalks, either on one side, or on both sides of the road. Austerville Drive, Goede Hoop Street and Silvertree Road have sidewalks on both sides. Pedestrian crossing

facilities are not provided on all roads around the school including the school entrances. The only painted crossing is provided on Austerville Drive close to Wentworth Primary School.

5.4.1.5 Traffic calming

Traffic calming, in the form of speed humps, is provided on all roads around the schools except on Jonas road.

5.4.2 Umlazi Primary Schools

5.4.2.1 School zone description

Inkonkoni Primary School

Inkonkoni Primary School is located in V section of Umlazi Township. The school has the second highest road traffic crashes involving primary school children in eThekweni. The school is bound by Nkonkoni Drive and Uve Road. The school is located at approximately 200m from Sbusiso Mdakane highway where 67% of the road traffic crashes associated with this school took place, and 500m from a major signalised cross intersection where Sibusiso Mdakane Road intersects with Griffiths Mxenge Highway. The Sibusiso Mdakane and Griffiths Mxenge intersection is one of the busiest intersections in Umlazi Township.

Sibusiso Mdakane Road is classified as a Class 4 collector road. The road is approximately 8km long and is a major route for public transport. The remainder of the road traffic crashes took place on Veni Yeni Drive (2.6km), a class four collector road and Prince Mcwayizeni Road (2,9km) another class four, collector road. All three roads that contribute to the highest road traffic crashes for Inkonkoni Primary School, are class four collector roads. The roads are single carriageway with one lane in each direction, although some sections of Sibusiso Mdakane have three lanes. The geometry of the Sbusiso Mdakane Road is windy and consists of a large number of horizontal curves and vertical curves, this is due to the hilly terrain but the section of Sibusiso Mdakane Drive closest to the school is relatively straight. The land use in the vicinity of the schools consist of residential areas, shopping areas, other businesses and two famous township tourist destinations, Max's lifestyle and Eyadini Lounge are located within 300m of the school. The land use attracts vehicular and pedestrian traffic that primary school children might find hard to navigate. Roads with highest number of road traffic crashes associated with Inkonkoni Primary Schools are shown on Figure 36

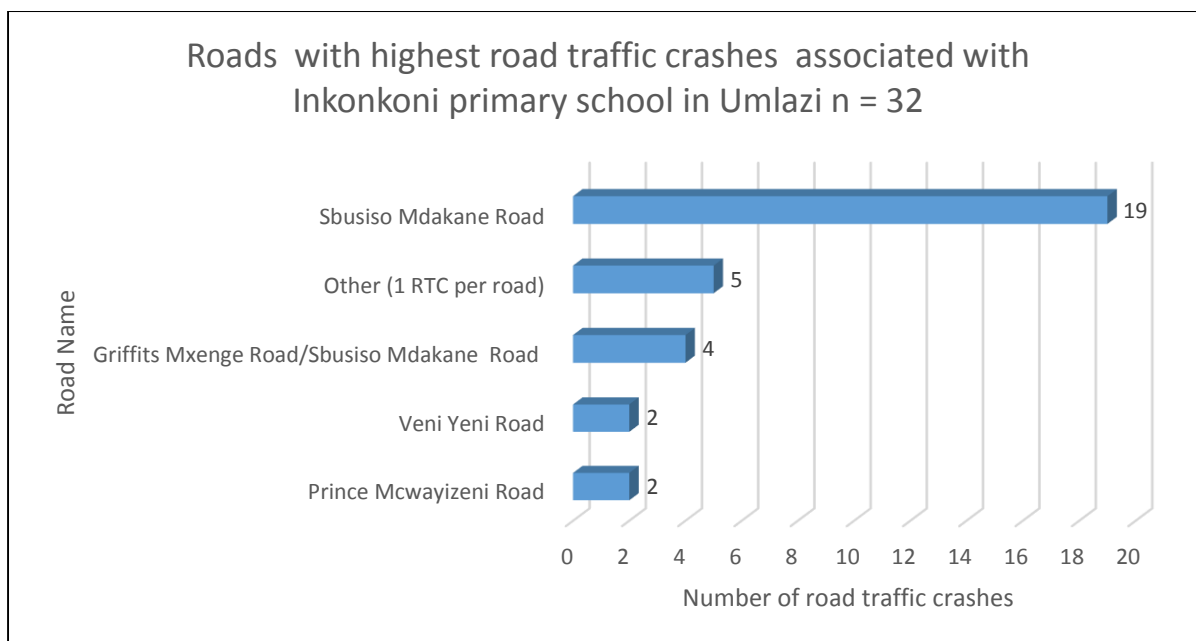


Figure 36: Roads with highest RTC associated with Inkonkoni Primary School (2012-2016)

Thamela Primary School

Thamela Primary School is located in Umlazi U section. The school has the sixth highest road traffic crashes of all primary schools in eThekweni. The school is bound by Thamela Circle (1,1km) a Class 5 local road and two Class 3 distributor roads Maurice Gumede Drive (2,3km) and M35 Sbu Magwanyane Drive (14km). Most road traffic crashes associated with this school, 39%, take place on Maurice Gumede Drive, followed by Sbu Magwanyane Drive 32% and lastly 11% take place on Malukazi Drive (1km) a Class 5 local road situated across Sbu Magwanyane Drive, the remainder (18%) take place on roads located further away from the school. The Maurice Gumede Drive and Sbu Magwanyane Drive cross intersection is located within 250m of the school. The intersection is signalised and has painted pedestrian crossings. Another major intersection between high order roads, is located within 200m of the school, is between Sbu Magwanyane Drive and Malukazi Drive. This intersection is a three-way un-signalised intersection. The school is also located behind one of the major supermarkets which also contains a number of convenience shops and a hardware. This environment attracts pedestrian and vehicular traffic close to the primary school and creates a complex road environment for children.

Sbu Magwanyane Drive and Maurice Gumede Drive have the highest number of road traffic injuries associated with Thamela Primary School, the data is shown on Figure 37.

Sbu Magwanyane Drive is a 3-lane road with two lanes for the westbound traffic and one for east bound traffic. The section of road along the school lies on a gentle horizontal curve. Maurice Gumede Drive has a hair pin horizontal curve in the school's vicinity. The curve is likely to contribute to the reduction of speed by drivers when negotiating this curve but may contribute to shorter sight lines for pedestrians wanting to cross the road.

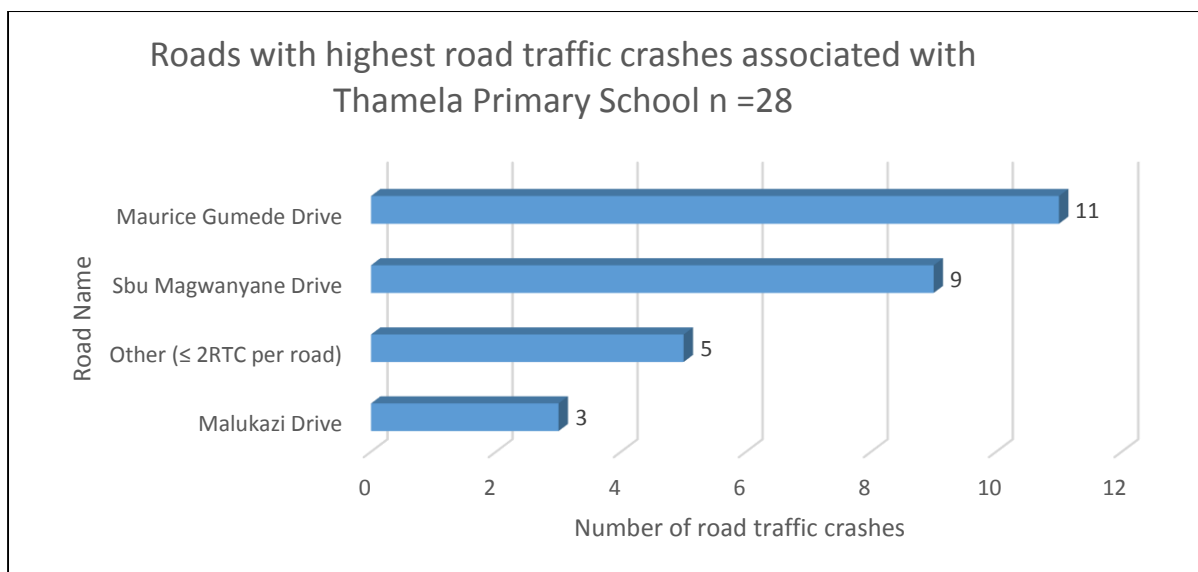


Figure 37: Roads with highest RTC associated with Thamela Primary School (2012-2016)

5.4.2.2 Speed limit and traffic volumes

Sibusiso Mdakane and Maurice Gumede Drive are Class 4 collector roads with a posted speed limit of 60km/h. Griffiths Mxenge and Sbu Magwanyane are Class 3 distributor roads with posted speed limits of 60km/h. The high speeds, high traffic volumes and the complex road environment that includes a signalised cross intersection or an un-signalised three-way intersection presents a very complex environment for child pedestrians which results in road traffic crashes.

5.4.2.3 Pedestrian facilities

Sidewalks are provided only on one side of the road on Uve Road and Nkonkoni Drive, Sibusiso Mdakane Drive, Prince Mcwayizeni and VeniYeni Roads. There were no dedicated pedestrian crossings observed on all roads around the school. A painted pedestrian crossing is located between the intersections of Maurice Gumede Drive and Malukazi Drive with Sbu Magwanyane Drive.

5.4.2.4 Traffic calming

Traffic calming, in the form of speed humps, is only provided on roads adjacent to the schools; Uve Road, Nkonkoni Drive, Thamela Circle, Veni Yeni Road and Maurice Gumede Drive. Traffic calming is not provided on the roads associated with the highest road traffic crashes for Nkonkoni Primary and Thamela Primary School.

5.4.3 Sydenham Primary Schools

5.4.3.1 School zone description

Sydenham Primary School and Rippon Road Primary School are situated within 150m of each other on opposite sides of Clare Road, a 4,2km Class 3 distributor road. Sydenham has the fourth highest number of road traffic crashes followed by Rippon Road Primary School with the fifth highest number of road

traffic crashes of all primary schools in eThekweni. Four intersections fall within 250m of the school properties where Clare Road intersects with Burnwood Road (1km) a Class 4 collector road, Crouch Road (0,4km) a Class 5 local road, Avis Road and Rippon Road (0,6km) a Class 3 distributor road. The Clare and Rippon road intersection is a major 4-way signalised intersection. All other intersections are three way un-signalised intersections except for the Crouch – Clare Road intersection. The school entrance is located on Eskdale Road, Class 5 local road.

The data reveals that most crashes (37%) associated with Sydenham Primary school take place on Rippon Road, followed by an equal number on Clare Road and D’Aintree Road at 21%. Sixty-five percent (65%) of all road traffic crashes took place at the intersection. This result is expected due to the close proximity of the schools with closely spaced signalised and un-signalised intersections, this creates environment that is very complex for young children to navigate safely.

Spearman Road Primary School has the tenth highest road traffic crashes of all primary schools in eThekweni and is located along Spearman Road. The school falls within a block of roads that consists of Class 5 local roads Spearman Road (0,8km), Shoul Avenue (0,2km), Keal Road and Kearey Road. The block consists of residential areas with minor convenient shops. The road traffic crash data reveals that most crashes, 48%, associated with this school take place on Moses Kotane Road (4km) a Class 3 distributor road located approximately 400m from the school. Moses Kotane is a dual carriageway with two lanes in each direction. Moses Kotane intersects with Spearman Road via a three way un-signalised intersection. The second highest contributor to road traffic crashes for this school is Rippon Road which is also classified as a Class 3 distributor road. Sixty three percent (63%) of all crashes on Rippon Road took place at an intersection.

Clayton Primary School is number twenty on the list of schools with the highest road traffic crashes in eThekweni. It was included as a study area because it is located within a 1 km radius of the top ten schools with crashes in Sydenham. Clayton Primary School is situated along Clayton Road (1km) Class 5 local road, Mallinson Road (0,6km) another Class 5 local road, Moses Kotane Road and Felix Dlamini (4,6km) both classified as Class 3 distributor roads. There is a major signalised cross intersection located 250m from the school where Moses Kotane Road intersects with Felix Dlamini Road. Such environment is very complex for child pedestrians to negotiate. The data reveals that 71% of all crashes associated with this school take place on Moses Kotane Road and that 76% of these take place at the signalised intersection. The land use around the school is commercial with small and medium businesses. The environment around the school is buzzing with pedestrian and motor vehicle traffic, informal trade and on street parking.

The statistics reveal that most accidents associated with the cluster of schools in Sydenham are Rippon Road, Moses Kotane, D’Aintree and Clare Road respectively. The number of crashes associated with the case study schools in Sydenham are shown on Figure 38.

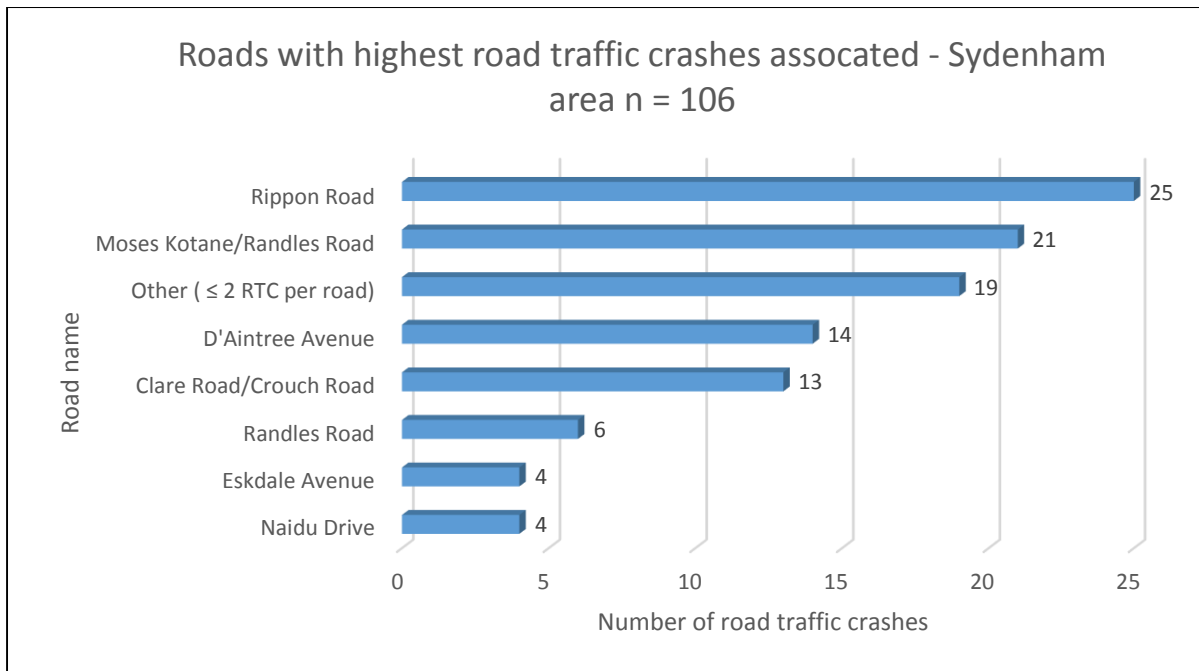


Figure 38: Roads with highest RTC associated with case study schools in Sydenham (2012-2016)

5.4.3.2 Road geometric design

The geometric design of the roads with the highest road traffic crashes is acceptable and provides acceptable sight distances for both drivers and pedestrians. The hazards associated with the roads are the closely spaced large and complex four-way intersections.

5.4.3.3 Pedestrian facilities

Sidewalks are provided on both sides of all roads in the vicinity of the schools. Painted pedestrian crossings are not provided on all roads except at signalised intersections. The sidewalks close to the schools are often obstructed with vehicular and pedestrian traffic on Moses Kotane Road and Felix Dlamini Road.

5.4.3.4 Traffic calming

Speed humps are only provided on roads adjacent to the schools where the school entrances are situated. There was no traffic calming provided on the roads with the highest road traffic crashes Rippon Road, Clare Road and Moses Kotane Road.

5.4.4 Summary of road and environmental assessment

A summary of the road and environmental factors of the roads with the highest road traffic crashes for the Jacobs, Sydenham and Umlazi areas is provided on Table 7.

5.5 Results from key informant interviews

5.5.1 Cause of crashes - Road and environmental factors

Jacobs Primary Schools

- The respondents complained that the roads adjacent to the schools are very narrow, there is high congestion in the peaks during pick up and drop off times caused by scholar transport and neighbourhood traffic.
- Speed was only highlighted as a problem on Silvertree Road and Austerville Drive due to spacing of speed humps.
- Vehicular and pedestrian traffic congestion was highlighted as an issue on Croton Road and Goede Hoop Street. Both roads are public transport routes, traffic includes buses, minibus taxis and general traffic.

Sydenham Primary Schools

- Clare Road was mentioned as problematic because it is the main road that leads to the city centre and is the main public transport route. The perception was that most crashes took place on Clare Road.
- Sydenham Primary School complained about a busy bus stop located right next to the school entrance. The high pedestrian traffic causes congestion.
- Clayton Primary School highlighted that the road that services the school is very narrow for two lanes and should be changed to a one way.

Umlazi Primary Schools

- Thabela Primary School is on the main road, where there is business and cars are always speeding. Inkonkoni is located close to busiest intersection and mixed land use.

5.5.2 Cause of crashes - Child behaviour

- Child behaviour was also highlighted as an issue, respondents noted that children do not take care to wait until the vehicle pulls away before crossing since the parked vehicle obstructs the view of the road. Furthermore, children run across the road without checking for passing motor vehicles.
- A principal of one of the primary schools in Jacobs indicated that scholars, particularly older boys, engage in a dangerous game to see who can cross between speeding traffic, disregard instructions from the scholar patrol, and usually cross away from the areas guarded by the scholar patrol.
- The respondents noted that often, the scholar transport arrives late after school. Whilst waiting, children occupy themselves by playing games and sometimes play on the road, this increases chances of a road traffic crash;

- In Umlazi Primary Schools, respondents noted that the schools are located very close to high order roads, but the intersection, where children can cross safely, is located a kilometer away from the schools therefore children still opt for crossing away from the intersection which increases the risk of a road traffic crash.

5.5.3 Traffic calming measures

- Respondents from the Jacobs Primary Schools were satisfied with the speed humps installed as a traffic calming measure around the schools.
- At Sydenham Primary School, the respondents highlighted that traffic calming is not provided on most roads around the school, especially the most congested roads and the ones perceived to be hazardous for primary school children. When asked about the existing traffic calming infrastructure, one principal, commented and said “we have nothing here”

Road name	Road class	Length	Speed limit	Number of crashes	Traffic calming	Sidewalks	Pedestrian crossing	Hazard
Austerville Drive	Class 4	1 900m	60km/h	35	Yes	Yes	Only one close to Wentworth Primary School	Through road, public transport route with high traffic volume
Rippon Road	Class 3	587	60km/h	25	No	Yes	No	High order road with high traffic volume, sidewalks are congested with street vendors, large number of small and medium grocery shops and commercial properties.
Sibisiso Mdakane Road	Class 4	7 967m	60km/h	24	No	Yes	Only at intersection	Main public transport route with high vehicular and pedestrian traffic due to mixed land use, high traffic speeds and volume, intersection with Griffiths Mxenge Highway has high vehicular and pedestrian traffic, high number of t- intersections close to Inkonkoni Primary School
Moses Kotane Road	Class 3	3 948 m	60km/h	21	No	Yes	Only at intersection	High order road with large traffic volume, major public transport route, consists of a large four-way intersection with Randles Road, located close to Rippon Road and Sydenham Primary Schools

Sivertree Road	Class 5	817m	40km/h	16	Yes	Yes	No	Very narrow road, services three adjacent schools and residents, tight horizontal curve close to the schools
Goede Hoop Street	Class 5	406m	40km/h	16	Yes	Yes	No	Very narrow road, services Collingwood Primary School and residential properties, consist of high number (7) tee intersections that provide access to residential properties.
Maurice Gumede Drive	Class 4	2 256	60km/h	11	Yes	Yes	No	Large horizontal curve close to Thamela Primary School, services a large supermarket and businesses located close to the school which attract large pedestrian and vehicular traffic.
Sbu Magwanyane Drive	Class 3	14 224m	100km/h	9	No	Yes	No	High order road with high traffic speeds and volume. Road intersects with Maurice Gumede Drive where there is high pedestrian and vehicular traffic from the supermarket and other businesses are located.
Griffits Mxenge Highway	Class 3	19 850m	100 km/h	5	No	Yes	Only at intersection	High order with high traffic speed and volume, dual carriageway with two lanes in each direction. All crashes took place at intersection with Sibusiso Mdakane Road

Table 6: Summary of road factors for roads with highest road traffic crashes associated with case study Primary Schools in eThekweni

- In Umlazi primary schools, the teacher's perception is that traffic calming is inadequately provided on the roads around the school, especially because the schools are located close to roads with high traffic speeds and volume. Thabela Primary School highlighted that it is not only the children that are at risk, the teacher had witnessed crashes involving older people as well. The school's intervention was to employ scholar patrol to assist children to cross the road, since this intervention the number of crashes involving children from their school has reduced.

5.5.4 Scholar patrol

All schools highlighted the importance of scholar patrol in assisting children cross the roads especially in the school zone. All schools have engaged the services of scholar patrols either formally or in some instances the community or school security guards where available, even the teachers perform this duty because this service is not provided by the Department of Transport or the Department of Education. Rippon Road Primary School reported that Metro Police provide the scholar patrol service at the schools during the morning and afternoon peaks on occasion. Thabela primary school noted that they have seen a large reduction of fatalities since the measure was put in place.

5.5.5 Pedestrian infrastructure – sidewalks

- The general comment was that although sidewalks are available, they are often congested with pedestrian traffic. In Sydenham the respondents attributed the congestion to be due to the fact that, schools are located close to each other, during the morning and afternoon peak periods, the sidewalks cannot accommodate the number of scholars and there is usually a spill over to the roadway, and that the roads around the school are major transport routes and sidewalks are very congested with pedestrian traffic.
- The lack of public transport laybys was highlighted as a problem because scholar transport vehicles and other public transport vehicles stop or park on the sidewalk and cause obstruction to the sidewalk.
- Street vending located on sidewalks was highlighted as an issue as it causes obstruction to the sidewalk.

5.5.6 Pedestrian infrastructure - Marked pedestrian crossings

The respondents noted that marked pedestrian crossings are not provided around the schools. A zebra crossing that was provided at Collingwood Primary School has since faded and is no longer visible. The main issues highlighted by the respondents were that:

- The lack of provision of a pedestrian crossing mean that there is no predetermined safe crossing location that will help guide the children to cross in a dedicated area.
- Scholar patrols have to choose a suitable location on their own to guide children in crossing the road and that they are usually not suitably qualified to do so.

- The marked crossings would be used by teachers during practical road safety training to teach the scholars about safe road crossing behaviour.

5.5.7 Road signs and warning signs around school

The respondents advised that warning and roads signs aimed at alerting drivers about the schools is not adequately provided, the maintenance is poor and sometimes not provided at all, the only consistently provided signs are those warning drivers about the presence of speed humps.

5.5.8 Recommendations from the case study schools were:

The recommendations from the case study schools were:

- Provision of state paid scholar patrol at the school has to find money from their limited resources to employ the scholar patrols.
- Provision of enforcement during morning and afternoon peak to discourage unsafe driver behaviour of scholar transport drivers, illegal parking and vending.
- In Jacobs, the pedestrianisation (closure to motorised transport) of Silvertree Road to motorised traffic or conversion to a one-way street.
- Provision of a dedicated drop off area, (taxi rank) away from the narrow roads adjacent to the school.
- Provision of marked pedestrian crossings, road signage and warning signs.
- Reduction of speed hump spacing to effectively decrease traffic speeds, especially on Austerville drive.
- Increase of the frequency of road safety campaigns.
- Schools to be provided with road safety teaching aids such as posters, banners, fliers and gaming material.
- In Sydenham, the widening of Clare Road to ease traffic congestion particularly around the school where two lanes merge into one lane.
- In Sydenham, the widening of Clayton Road or conversion into one-way street. Access to Clayton Road from Brickfield Road to be restricted.
- In Umlazi, provision of traffic calming and road safety measures on the roads with high traffic crashes associated with the schools.

5.6 Results from key informant interviews on road safety education

5.6.1 Inclusion of road safety education in the school's curriculum

The key informants advised that road safety education is taught in the classroom as part of Life Orientation. There is no guide on how road safety should be taught or tested. The frequency and content are decided by the Life Orientation teacher. Practical training is not provided by the school. Testing of knowledge is done as part of Life Skills curriculum, only written tests are administered.

5.6.2 Type of training

In most primary schools, road safety is taught in a classroom environment. Testing of knowledge is done as part of Life Orientation curriculum, only written tests are administered. Only two schools reported that practical training is conducted in the school's playground. One school in Sydenham reported that technical training is provided by for example requesting scholars to draw different road signs and explain their use. Thamela Primary School reported that senior primary scholars are tested through the normal tests and exams format, whilst the lower grades are tested through practical training.

5.6.3 Road Safety Campaigns

The key informants confirmed that the schools participate in road safety campaigns provided through a joint collaboration between eThekweni Transport Authority, South African Police Services (SAPS), eThekweni Metropolitan Police Services, the eThekweni Fire Department, Passenger Rail Agency of South Africa (PRASA) and the municipality. In Jacobs school stakeholders located in the Durban South basin, such as Engen and Sapref and Mondi participate on the road shows. In other schools, road safety campaigns are conducted by Non-Government Organisations (NGO). One school reported that they conduct their own road safety campaign in the school.

5.7 Chapter Summary

In eThekweni, 32% of pedestrian crashes involve children from 0 to 19 years. The 6 to 10 year age group has the highest risk of road traffic injury and boys are 20% more likely to be involved in a crash compared to girls. The top ten primary schools with the highest road traffic crashes are located in middle and low income areas in eThekweni, these are, Sydenham, Jacobs and Umlazi Township. The majority of the road traffic crashes resulted in no injury, 45%, or slight injury, 43%. Eleven percent (11%) of the crashes resulted in serious injury, and only 2% resulted in a fatality. This study revealed seven of the top ten schools are located in two clusters with the schools in the cluster located within kilometre of each other.

Human behaviour

Child behaviour contributed to (77%) of the road traffic crashes. The behaviour included, crossing the road when it was unsafe to do so, 69% and playing or fighting on the road, (8%). Driver behaviour contributed to (17%) of the road traffic crashes through speeding, 4, and making unsafe driving manoeuvres, (13%). In total, human behaviour contributed to (94%) of the road traffic crashes. Furthermore, scholar transport driver behaviour was highlighted as a major contributor to crashes by the respondents from primary schools selected for the investigation. The remaining (6%) of the road traffic crashes is recorded as "the driver did not see the pedestrian", this might be due to the road and environmental factors that reduced visibility of the child pedestrian or driver characteristics not elaborated on in this research.

Road and environmental factors

Most crashes took place away from the intersection (58%). This indicates that child pedestrians do not utilise the dedicated crossing facilities, this might be due to the fact that they are inadequately provided or that children lack the skills to identify midblock crossing as unsafe behaviour. Ninety five percent (95%) of crashes took place under clear and dry weather conditions and during daylight (87%). The trend for the time of day clearly indicated that the highest number of crashes took place in the morning peak between 7h00 and 8h30 am, at the start of school day; and in the afternoon between 13h00 to 15h30 (41%), at the end of the school day. Mondays and Fridays had highest incidents of road traffic crashes compared to other days of the week. Forty five percent (45%) of crashes took place on Class 5 local.

Traffic calming and pedestrian facilities

Traffic calming, in the form of speed humps are only provided on roads where school entrances are located and are not provided on other roads even on the roads with the highest road traffic crashes. All top ten schools with the highest road traffic crashes are located within a kilometre of a Class 3 distributor road or a Class 4 collector road and these higher order roads have the highest crashes per road associated with the primary schools in their vicinity but traffic calming is not provided on most of these roads.

Pedestrian crossings that direct pedestrians to a safe crossing location, road signs and road marking that warn drivers about the school are also generally not provided.

Road Safety Education

Road safety education is provided through the Life Skills or Life Orientation subjects in all primary school grades. The method of teaching and testing of knowledge was confirmed by all but two schools as classroom based teaching and testing. Only two schools indicated that practical training is offered at their school. The curriculum is not prescribed for the teachers by the Department of Education. Life Skills teachers decide on the content, type and extent of road safety education. All schools reported that government, non-governmental organisations and private companies conduct road safety campaigns at their schools, these range from one to three times a year.

CHAPTER 6: SUMMARY OF KEY FINDINGS AND RECOMMENDATIONS

6.1 What is the global magnitude of road traffic injuries involving child pedestrians?

This study revealed, that the fatality rate, due to road traffic injuries of children, is unacceptably high, and in fact, is the leading cause of death and disability in children between the ages 15 to 19. It is also the second leading cause of death in children between the ages 10 to 14 years. The most affected countries are low and medium income countries including African countries. Africa has the highest child road traffic fatality rate at 19.9 per 100 000 children per year compared to the global average of 10.7 per 100 000 population. In eThekweni municipality, children account for 16% of all road traffic crashes. Children are most vulnerable as pedestrians, passengers and as young drivers respectively. They are exposed to road traffic injury while using public or private motor vehicles, as motorcyclists or cyclists.

6.2 What is the magnitude of road traffic crashes involving Primary School pedestrians around schools in eThekweni municipality?

The study revealed that the primary schools with the highest road traffic crashes are located in medium to low income areas of eThekweni in Jacobs, Sydenham and Umlazi. High crash incidents were observed in primary schools that are located in close proximity of each other, that is, within 1km of each other. This phenomenon was observed in the four primary schools located in Jacobs and in three primary schools in Sydenham.

6.3 What are the causes and risk factors for road traffic crashes involving child pedestrians?

There are four main categories of risk factors for child pedestrians, these are, road factors, environmental factors, human factors and the motor vehicle factors. Human behaviour is the leading cause of all traffic crashes. In this study, human behaviour contributed to 94% of the road traffic crashes.

Age and gender

A child's development is linked to their age. Skills required for appropriate and safe behaviour on the road are acquired with age. The key developmental characteristics that increase the ability of the child to possess sufficient skills to navigate a complex road environment and make important decisions when attempting to cross the road are cognitive, perceptual and attentional skills. Physical development, such as height and the development of sensory nerves are also critical. Height limits the visibility of the child to the driver and also limits the child's view of the road environment. Vision and hearing enables the child to look out and listen for traffic which is important for crossing the road safely.

Boys are more at risk of being involved in road traffic crashes compared girls due to their higher risk taking behaviour. The study revealed that boys were 20% more likely to be involved in a crash

compared to girls. One key informant highlighted that boys usually engage in unsafe risk taking behaviour on the road by playing dangerous games whilst crossing the road, furthermore some boys resisted being chaperoned by scholar patrol whilst crossing the road and choose to cross away from the scholar patrol.

Child behaviour

Child behaviour, classified under the human factor, is the leading cause of crashes involving young children. Young children find the road environment very complex to navigate safely and do not possess the critical skills required to deal with complex situations. Their cognitive, attentional and perceptual skills are simply not developed enough to enable them to perceive danger, make critical decisions and act accordingly when faced with multiple stimuli that is presented by the road environment. In this study child behaviour contributed to (77%) of the road traffic crashes. The behaviour responsible for the most crashes was found to be crossing the road when it was unsafe to do so, (69%) and playing or fighting on the road, (8%).

Driver behaviour

Driver behaviour is a significant contributor to road traffic accidents. The driver factors include disregard of traffic laws such as speeding, not using safety equipment such as seat belts and child seats for children, drunken driving, drug abuse, poor eye sight, fatigue, inexperience, age, disease and disability. In this research driver behaviour contributed to (17%) of the road traffic crashes through speeding, (4%), and making unsafe driving manoeuvres, (13%). Furthermore, scholar transport driver behaviour was highlighted as a major contributor to crashes by the respondents from primary schools selected for the investigation.

Road and environmental factors

Road and environmental factors are ranked as the least cause of traffic crashes. The road and environmental factors highlighted as risk factors for child pedestrians are high traffic speeds, on street parking, lack of provision of pedestrian facilities, such as sidewalks, pedestrian crossings, lack of open spaces for children to play, through roads with high traffic speeds and traffic volume. This study revealed that only 6% of the road traffic crashes might have resulted from the road and environmental factors. The cause is recorded as “The driver did not see the pedestrian” which might have been due reduced visibility of the child pedestrian due to parked vehicles, inadequate sight distance due to the road’s geometric design or obstacles on or along the side of the road.

Through roads, traffic speeds and volume

High traffic speed and volume are one of the main contributors to the frequency and severity of road traffic crashes. All top ten schools with the highest road traffic crashes are located within a kilometre of a Class 3 distributor road or a Class 4 collector road. These higher order, through roads, have high

traffic speeds and volume with posted speed limits greater than the 40km/h recommended for the school zones. The research revealed that Class 3 and Class 4 roads were individually, responsible for the highest number of road traffic crashes, particularly in Sydenham and Umlazi primary schools. These schools are located close to more than one higher order road. In Jacobs, Austerville road is the only high order road located close to the school and has the highest road traffic crashes recorded for each road in this area.

On street parking

The secondary data did not record the presence of on-street parking during the road traffic crash. On-street parking was not identified as an issue during the onsite inspections and the desktop assessment using Google Earth.

Pedestrian facilities - Sidewalks

Sidewalks were provided in all areas investigated in this research. Local Class 5 roads had a sidewalk on one side of the road, while higher order roads had sidewalks on both sides. The level of service during morning and afternoon peak periods was not assessed by the researcher but key informants, particularly in Jacobs, noted that the width of the sidewalks could not accommodate all scholars during peak hours. The key informants also highlighted that street vending and the absence of public transport laybys contributed to the congestion of the sidewalks. In Sydenham and Umlazi, the proximity of the schools to the retail and commercial land uses results in high pedestrian traffic which reduces the level of service of the sidewalks. The risk factor for children is that this creates a complex environment for them as they “get lost or swallowed” by the crowd.

Pedestrian facilities – Pedestrian crossings

In general, pedestrian crossings were not provided close to the schools investigated. Painted pedestrian crossings were not provided, even on roads leading to the school entrances. There was one painted crossing on Austerville Drive in Jacobs close to Wentworth Primary School and one on Griffiths Mxenge, in Umlazi, close to Thamele Primary School. The key risk factor for children is that, if not provided, children are unable to identify a safe crossing location due to the limitation in their development, scholar patrols are often not qualified themselves to identify a safe crossing location, if available, the pedestrian crossing facility could be used for practical road safety education.

Crash location

A large proportion of child pedestrian crashes take place while a child is attempting to cross the road. Fifty eight percent (58%) of crashes were recorded in this study as have taken place away from the intersection. This is not surprising because, firstly, dedicated midblock crossing facilities are inadequately provided, secondly, children lack the skills to identify safe crossing locations, are not developed enough to detect the presence of traffic and other road hazards or risks, make a visual

judgement of the gap in traffic before crossing, receive and process information from all directions of traffic, and perceive danger and decide on how to react.

Lack of open spaces for children to play

The research identified playing or fighting on the road as one of the child behaviour aspect that contributed to road traffic crashes. In Jacobs, the respondents highlighted that children wait on the side of the road for scholar transport, and if late, children end up playing on the road after school. Although, all schools have play grounds, the facilities are within the school boundary are further away from the waiting area and are not used by children waiting for scholar transport, there are no additional open spaces that are available for children waiting for transport after school.

Weather and lighting

Weather and lighting was not found to be an environmental risk factor for child pedestrian crashes in this study because 95% of crashes took place under clear skies and dry weather conditions and during daylight hours 87%.

Day of the week and time of day

The highest number of crashes were recorded on Mondays and Fridays compared to other days of the week on all schools. The trend for the time of day clearly indicated that the highest number of crashes took place in the morning peak between 7h00 and 8h30 am (24%), at the start of school day; and in the afternoon between 13h00 to 15h30 (41%), at the end of the school day.

Socio economic factor and land use

All top ten primary schools are located in middle and low-income areas. Schools in Sydenham and Umlazi are located close to busy retail and commercial areas and busy highways where there are high vehicular speeds and volumes accompanied by high pedestrian traffic.

6.1 What intervention measures are used to reduce road traffic injuries involving child pedestrians and what is their effectiveness?

The intervention measures investigated in this study were engineering measures, particularly, traffic calming and road safety educational measures.

Traffic calming

Many studies globally concur that traffic calming is an effective measure for reducing road traffic crashes. The most successfully used measures for reducing one of the major causes of road traffic crashes are speed humps. In this study, the environmental assessment revealed that traffic calming within the school zones was inconsistently applied at the schools used as case studies. In Jacobs's schools, traffic calming is applied on all roads around the school including the road with the highest

number of road traffic crashes; Austerville Drive. In Sydenham and Umlazi Primary Schools, on the other hand, traffic calming is provided on roads where the school entrances are located, but not provided on roads that are main contributors to road traffic crashes associated with these schools. The study revealed that no traffic calming is provided on Class 3 and Class 4 roads, even if they are responsible for the highest number of crashes associated with the school and are located within the school zone.

The ideal school zone road safety measures

The review of best practises for school road safety highlighted the importance of applying measures that alert drivers about approaching, entering and driving in the school zone. The ideal school zone road safety features include, measures that reduce traffic speeds, removal of on-street parking, removal or reduction of conflict between pedestrians and vehicles, the use of road marking, road signs and warning signs to alert drivers about the school zone and the provision of adequate and safe infrastructure for vehicles, such as parking, turning facilities and bus stops. In this study, road markings, road signs dedicated to warning drivers about the school zone were absent on all schools.

Educational measures

There is no consensus with regards to the effectiveness of road safety educational measures. Some studies assert that road safety education is only effective when done practically on the road side, while some authors argue that classroom lessons about road safety, result in having knowledge about road safety but does not translate into changed behaviour on the road. The study revealed that road safety education is not formally provided in the school's curriculum, it is taught as part of the Life Skills subject. The content and type of training is decided upon by the Life skills teachers. Practical training is only provided at two out of the ten schools, in all other schools, road safety education is taught and tested in a classroom environment. All schools reported that government, non-governmental organisations and private companies conduct road safety campaigns at their schools, the frequency ranges from one to three times a year.

6.2 Summary of key findings

There are six risk factors and causes of road traffic crashes involving child pedestrians identified in this study that were found to be common in all investigated areas and schools.

1. Child behaviour is the leading cause of crashes, the main cause of crashes was found to be - crossing the road when it is unsafe to do so.
2. The restless behaviour of scholar transport drivers.
3. Inadequate provision of safe public transport facilities, such as stopping areas, turning and ranking facilities for scholar transport, especially on narrow roads in Sydenham.

4. The presence of through, high order roads with high traffic speeds and volume close to the schools together with inadequate provision of safe midblock crossing facilities and lack of traffic calming measures.
5. Inadequate provision of safe midblock pedestrian crossing facilities on all roads within the school zone.
6. Schools zones are not easily identifiable due to lack of road signs, road marking and other measures that warn drivers about the school zone.

6.3 Recommendations

6.3.1 Interventions

The recommendations listed below are interventions required to address the six risk factors and causes of road traffic crashes identified in this research.

- **Child behaviour is the leading cause of crashes, the main cause is crossing the road when it is unsafe to do so.**

The author recommends that the Department of Education includes the provision of state paid scholar patrols for all primary schools in their policy and provide a budget for each school. The Department forms partnerships with accredited training service providers to train scholar patrols on road safety, how to identify safe crossing locations and how to better perform their job in assisting children to cross the road. The Department develops a road safety curriculum for primary schools and make it mandatory for Life Skills teachers and other teachers tasked with providing road safety education to obtain training on road safety. Provide teaching and knowledge testing aids and guidelines for teachers. Lastly, the Department makes a budget provision for the building of infrastructure to be used for practical training at each school.

- **The restless behaviour of scholar transport drivers**

The Department of Transport should partner with accredited training service providers to train scholar transport drivers about road safety and customer service especially focused on how to work with young children. The training course should be linked to the process of qualifying for the Professional Driver Permit (PRDP) and the process of applying for an operating license for scholar transport.

- **Schools zones cannot be easily identified**

The recommendation is that the Department of Transport working together with the Department of Education updates the legislation to adopt the school zone concept and demarcate areas around the schools as school zones, draft school zone road safety guidelines to be applied nationwide around all schools, include the requirement for application of school zone measures in the Integrated Transport Plan (ITP) and provide a budget to local municipalities for the implementation of the school zone

requirements. The guideline should contain specification that are in line with the global best practice of school zone road safety and should include the following as a minimum:

- Speed limit of not more than 30km/h;
- Pedestrian facilities;
- Traffic calming, including road closure or one way street treatment;
- Warning signs, road signs, road marking;
- Parking, turning facilities;
- Public transport facilities; and
- Non-motorised transport facilities

- **Inadequate provision of midblock crossing facilities on all roads within the school zone**

The adoption of the school zone treatment would also cover the requirement for the provision of safe midblock crossing facilities. Furthermore, and where practical, fencing, such as guiderails should be provided around the schools to discourage scholars from jay walking and channelizing them towards a crossing area.

- **Inadequate provision of safe stopping areas for scholar transport, especially on narrow roads**

The local municipality is responsible for provision of transport facilities within their jurisdiction. The provision of transport stopping and ranking facilities should be made a school zone requirement as stated above.

- **The presence of through, high order roads with high traffic speeds and volume close to the schools together with inadequate provision of safe midblock crossing facilities and lack of traffic calming measures.**

Higher order roads provide a mobility function compared to lower order roads, it is therefore understandable that traffic calming cannot be provided on all roads, especially higher order roads. The recommendation from the author is the that the Department of Transport includes, in the legislation, a requirement for the provision of grade separated pedestrian crossings on higher order roads located within a school zone or within a three kilometre radius of schools and then allocate a budget to local municipalities for the provision of the infrastructure.

6.3.2 Further studies and data collection

The author recommends that further studies be conducted on child pedestrian road safety around schools to obtain a full understanding of the road and environmental risk factors for child pedestrians, a constant monitoring of road traffic crashes involving child pedestrians, data collection. The study identified top schools with high incidents of road safety. The findings indicate that road traffic crashes involving child pedestrians are more prevalent where schools are located in clusters, that is, within a kilometre of each other. The two clusters identified are located in Sydenham and Jacobs. There is an opportunity for

ETA to use the Jacobs cluster of schools as a test site for the implementation of the recommendations listed above and to monitor the effectiveness of the applied interventions.

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