A STUDY OF SAFETY AND SECURITY OF PEDESTRIANS TRAVELLING TOWARDS THE BELLVILLE, CLAREMONT AND MITCHELLS PLAIN PUBLIC TRANSPORT INTERCHANGES IN THE CAPE TOWN MUNICIPAL AREA

By

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A thesis presented in fulfilment of the requirements for the degree of Master of Engineering in Civil Engineering in the Faculty of Engineering at Stellenbosch University

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March 2020

DECLARATION

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ENGLISH ABSTRACT

Poor levels of safety and security have continued to increase, the state of public transport continues to deteriorate, while 5.2 million commuters are challenged by this daily. The implementation of NMT does not only include enough infrastructure but must consider the safety and security of pedestrians through understanding the daily challenges and risk encountered by the commuters within the Western Cape. The purpose of the study was to investigate the condition of the current NMT facilities and how commuters perceive levels of safety when travelling towards Bellville, Mitchells Plain and Claremont public transport interchanges.

Literature reviews were conducted, comparing various examples of developing countries that experienced high traffic crashes and pedestrian fatalities like South Africa. These examples illustrated the importance of implementing adequate NMT facilities and the role the end-user plays in the success of the facility.

Crash data and criminal data was analysed as contributing factors to pedestrian safety and security risks. A pedestrian environmental assessment was done to determine the state of NMT, and the questionnaire survey was distributed to commuters travelling to the PTI to provide their perception and daily experience. The data reveals many factors affecting pedestrians with regards to exposure to criminal activity and crashes but also the views and opinions of the commuters. Furthermore, an analysis of variance (ANOVA) was completed to determine the variation in the means for each public transport interchange. Using the evaluated data an action plan with countermeasure was completed recommending proven methods of improvement for the pedestrian environment.

The data evaluated revealed that the relevant NMT facilities are present at each PTI however, due to poor maintenance the facilities have deteriorated. It is concluded that commuters experience a poor level of safety and security when travelling towards PTI's. High level of criminal activity and crash risks exists around the PTI's. In addition, commuters believe that the presence of the police has little to no effect on their safety and security. The Analysis of Variance showed that commuters are travelling in constant fear, irrespective of which PTI they travel to.

Overall it was concluded that low levels of safety exist, and commuters do not feel safe. Although adequate infrastructure is provided, the safety and security of pedestrians should be prioritized.

AFRIKAANSE OPSOMMING

Lae vlakke van veiligheid en sekuriteit het steeds toegeneem, die toestand van openbare vervoer gaan steeds agteruit, terwyl 5,2 miljoen pendelaars daagliks hierdeur geraak word. Die implementering van NGV bevat nie net die voorsiening van genoeg infrastruktuur nie, maar moet ook die veiligheid en sekuriteit van voetgangers oorweeg deur die daaglikse uitdagings en risiko's wat pendelaars in die Wes-Kaap ondervind, in ag te neem. Die doel van die studie was om die toestand van die huidige NGV-fasiliteite te ondersoek, en hoe pendelaars die veiligheidsvlakke ervaar wanneer hulle na Bellville, Mitchells Plain en Claremont se openbare vervoer-wisselaars reis.

Literatuuroorsigte is gedoen, waarin verskillende voorbeelde van ontwikkelende lande wat hoë verkeersongelukke en sterftes by voetgangers soos in Suid-Afrika ondervind, vergelyk is. Hierdie voorbeelde illustreer die belangrikheid van die implementering van voldoende NGV-fasiliteite en die rol wat die eindgebruiker speel in die sukses van die fasiliteit.

Ongeluks en kriminele data is ontleed as bydraende faktore tot die veiligheid en sekuriteits risiko’ss van voetgangers. 'n Omgewingsevaluering van voetgangers is gedoen om die toestand van NGV te bepaal, en die vraelys is aan pendelaars wat na die PTI reis, versprei om hul persepsie en daaglikse ervaring te verskaf. Die data toon baie faktore wat voetgangers beïnvloed ten opsigte van blootstelling aan kriminele aktiwiteite en ongelukke, maar ook die pendelaars se opinies en sienings. Verder is 'n ANOVA analiese voltooi om vas te stel of daar 'n afwyking was tussen die gemiddel vir elke PTI. Met behulp van die geëvalueerde data is 'n aksieplan met teenmaatreëls voltooi wat beproefde metodes vir verbetering van die voetgangersomgewing aanbeveel.

Uit die data wat geëvalueer is, blyk dit dat die betrokke NGV-fasiliteite by elke PTI aanwesig is, maar weens swak onderhoud het die fasiliteite agteruitgegaan. Daarom is die gevolgtrekking dat pendelaars 'n lae vlak van veiligheid en sekuriteit ervaar wanneer hulle na PTI's reis. Daar is 'n hoë vlak van kriminele aktiwiteite en ongeluksrisikos rondom die PTI's. Boonop meen pendelaars dat die polisie se teenwoordigheid weinig tot geen invloed op hul veiligheid en sekurituit het nie. Die ontleding van variasie het getoon dat pendelaars in voortdurende vrees reis, ongeag na watter PTI hulle reis. Daar is lae veiligheidsvlakke, en pendelaars is nie veilig nie.

Die gevolgtrekking is gemaak dat lae veiligheidsvlakke bestaan en dat pendelaars nie veilig voel nie. Alhoewel, voldoende infrastruktuur voorsien word, moet voorkeur gegee word aan veiligheid en sekuriteit van voetgangers.

ACKNOWLEDGEMENTS

Throughout the writing of this thesis, I received a great deal of support and assistance. Compiling this thesis has been both insightful and challenging. I would like to thank the following people for their contributing role that has led to the success of this document:

My supervisor, Prof Sinclair for the support and guidance;

All the voluntary fieldworkers that assisted in the distribution and collection of the questionnaires;

All the participants that completed the questionnaires;

To my colleagues for allowing me to share my thoughts and ideas with them,

To my family for the support throughout the process especially to my brother, Wayne Van der Merwe for reading my research; and

Lastly to my loving husband, Emile Petersen, for the immense amount of support, effort and motivation I received every step of the way, from the day I started this journey to the end. Thank you for assisting me throughout my research.

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1. CHAPTER 1: INTRODUCTION

1.1 Background

"We've been building 40m² homes, 40km from where people work, where they spend 40% of their income on transport and probably live in communities where 40% of people are unemployed." (Viruly, 2017)

Traffic crashes, as a category, is the leading cause of non-natural causes of death in the world. The World Health Organization rated South Africa as one of the countries with the poorest road safety record in terms of road traffic crashes. South Africa recorded approximately 31.9 fatalities/100 000 people in comparison to a much lower rate recorded in other developing countries. The average fatality rate in Africa is 24.1 fatalities/100 000 people and the global average is 18 fatalities/100 000 people (WHO, 2015).

Pedestrians in South African account for a large percentage of commuters and the probability of pedestrians being involved in a Non-Motorised Transport (NMT) crashes are highly likely. Arrive Alive statistics recorded 5339 pedestrian deaths on South African roads in 2017 (Arrive Alive, 2018). The World Bank classified South Africa as a middle-income country (The World Bank, 2018). According to the WHO low to middle-income countries accounts for 93% of deaths caused by road traffic crashes, with pedestrian crashes making up 26% (WHO, 2018).

The unregulated public transport system consumes 40% of commuter's household income while commuters still face daily struggles of congestion and safety and security risks. The daily competition for space in Cape Town between pedestrians and motor vehicles, due to an influx in motor vehicles, has become a source of frustration and led to avoidable pedestrian fatalities (Mokitimi & Vanderschuren, 2016; Orcutt, 2012).

People struggle to move around Cape Town due to the uneven distribution of basic services and activities created during the apartheid era. The poor spatial planning inherited from this era has continued to expand, experiencing significant increases in population and housing developments in these areas.

Environments were created where commuters are faced with either multimodal travelling, extensive walking distances, high levels of exposure to safety and security threats or a combination of all these factors. In addition to these challenges, the

infrastructure provided lacked: continuous sidewalks, adequate pedestrian crossings and enough lighting (Murguia, n.d.; Levulyte, et al., 2017; Arrive Alive, 2018; Transport Matters, 2014). Public transport remains necessary to these inhabitants and there has been very little response from the new democratic government to achieve the mobility needs of these commuters (Teffo, et al., 2019).

For most of the population, public transport and/or walking are the only available modes of transportation. Commuters are faced with life-threatening situations in order to fulfil a basic need such as providing for their families and contributing to social, cultural and economic development (Mokitimi, 2015; Arrive Alive, 2019; SWOV, 2012). These commuters are known as vulnerable road users. Vulnerable road users are defined as road users who are not protected against the natural elements by an external shell compared to a road user protected by the shell of their vehicle (Levulyte, et al., 2017; SWOV, 2012).

The transportation modes available today includes trains, buses, Minibus taxis (MBT); and walking also forming an essential part of daily transportation (Mokitimi & Vanderschuren, 2016). Although research has shown a 0.5% increase in car ownership in South Africa since 2017 (Stats SA 2018) many still commute using the cheaper public transport option.

To alleviate the challenges faced by commuters the informal minibus taxi industry emerged opportunistically. The industry provided a unique service that reduced walking distances in the lower-income communities. Although different modes of transport were available, a lack of integration and the high cost of travelling contributed to fragmented public transport infrastructure (Orcutt, 2012).

The research topic covered within this thesis is, “Safety and Security of Pedestrians travelling towards Bellville, Claremont and Mitchells Plain’s Public Transport Interchange (PTI)”. The research will focus on acquiring knowledge about the vulnerable road users, the perception of the road user and the daily challenges faced like safety and security threats, road user behaviour and criminality within the traveller’s environment.

1.2 Scope of work

The research will focus on three PTI's, colloquially known as Taxi ranks, within the City of Cape Town (CoCT) municipal area. Each PTI was chosen based on a unique characteristic.

Bellville is the second busiest multimodal PTI in Cape Town after the Cape Town CBD PTI which was excluded from the study due to NMT upgrades at the beginning of 2019.

Claremont's has all the features of a shared space. Shared spaces are described as areas creating mutual awareness by deregulation traffic and introducing the integration of different modes based on mutual respect instead of physical separation barriers (NDA, 2012).

Mitchells Plain is a multimodal PTI that has the newest transport modes, i.e. the MyCiti BRT System.

Figure 1-1 below illustrates the location of the three PTI's relative to each other. The areas are labelled from one to three, Bellville, Claremont and Mitchells Plain respectively.

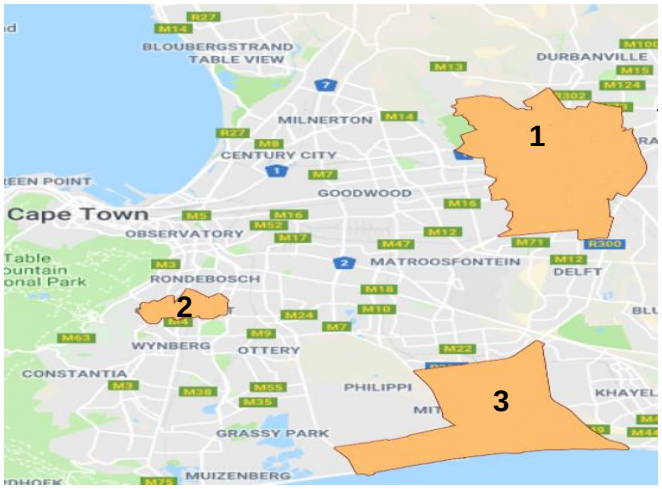


Figure 1-1: Location of research PTI's

1.3 Purpose of the study

This study investigates the safety and security risks faced by vulnerable road users when travelling towards a PTI and provides countermeasures that will enhance the pedestrian's experience.

1.4 Objectives

This thesis will aim to achieve the following objectives:

- To quantitatively and qualitatively evaluate the safety and security of pedestrians using differential and inferential evaluations.
- To determine the level of safety when travelling from home to the PTI.
- To determine concerns of pedestrians during their travels from surveys.
- Evaluate the state of NMT leading to and at the PTI
- To identify the red zones in terms of criminality and conflict situations
- To develop a local road safety plan to improve the pedestrian facility for vulnerable road users.

1.5 Assumptions and limitations of the study

1.5.1 Assumptions

- The assumption was made that more crashes occur on the links surrounding the PTI than at the intersection due to a lack of GPS co-ordinates.
- All commuter's trips were generated from home to work via the PTI or from work to home via the PTI.
- Commuters without driver's licenses are classified as captive users.

1.5.2 Limitations

- Criminal data could not be retrieved from the South African Police Service (SAPS) for the Mitchells Plain PTI, therefore, the Mitchells Plain PTI was omitted from the crash and criminal data analysis.
- An attempt was made to extract criminal data from the South African Police Service website from published statistics, however, the information was not detailed enough, and the information could not be identified as incidents that happened at the PTI only, therefore, this data could not be used.
- Limited information is found on pedestrian forgiving roadways in SA.

1.6 Research questions

The research attempted to answer the following questions:

1. What is the level of security experienced by pedestrians when travelling from home to the PTI and at the PTI's?
2. What is the state of NMT facilities at the various PTI's chosen as part of this investigation and how do these facilities differ?
3. Which is the biggest risk faced by pedestrians when using PTI's?
4. What are the major threats influencing pedestrian security when using public transport and when travelling to and from the PTI on foot?
5. What different methods can be used to reduce the level of conflict around the PTI?
6. What is the significance of the presence of NMT facilities in risk mitigation?

1.7 Organization of Thesis

The report has been completed in seven chapters that have been structured in the following order.

Chapter 1 introduces the study that was conducted, outlining the topic background and relevance, the scope of the investigation, the purpose of the study, the objectives, the assumptions and limitations as well as the research questions.

Chapter 2 provides a broad-spectrum literature review regarding the safety and security of pedestrians. International literature was reviewed from developing and developed countries based on the changes made to improve the NMT conditions. Furthermore, national literature was reviewed focusing particularly on the Cape Town area to understand the gaps within the NMT network.

Chapter 3 elaborates on the methodology used in this research thesis to process the various data set received and collected. It explains the ethical clearance process, the criminal and crash data analysis and the training that was done with the volunteers before the questionnaires were distributed and completed by commuters. The chapter also explains the methods used to analyse the data to obtain the results.

Chapter 4 elaborates on the three-study areas, namely Bellville, Claremont and Mitchells Plain. The chapter provides a layout of the various PTI's and the key findings from the site investigations.

Chapter 5 provides a complete data analysis on the crash and criminal data collected for the Bellville and Claremont PTI's as well as the survey that was distributed at the PTI's. The data was displayed graphically to identify statistical trends. Furthermore, the pedestrian environment assessment results were explained and recorded in this chapter.

Chapter 6 provides a layout of the countermeasures that can be used to improve the pedestrian environment based on the results collected throughout the investigation.

Chapter 7 provides feedback to the research questions asked in Chapter one.

Chapter 8 closes the research report by providing a summary of the report findings and providing the answer to the research questions. The recommendations will be provided based on the findings and future proposed implementation.

2. CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Safety and security of pedestrians are specifically important challenges in a developing country which has an elevated pedestrian fatality rate. Creating a mindset shift from a vehicle focused society to one that prioritizes pedestrians would encourage the use of facilities over motor vehicle use. Providing adequate facilities will facilitate the interaction between different groups of people from various walks of life, the interaction between modes of transport and prioritizing NMT. Many would realize the sustainability impacts of this cultural shift breaking the stigma between public transport and poverty.

For years, developed countries have enjoyed functional, safe NMT networks. The developing world has started exploring the idea of NMT. Whereas, the developed world model retrofitted within the South African context would cause more harm. Understanding the underlying needs of the South African road user and the challenges faced is pivotal to this investigation.

The relevance of the research lies in the improvements required to provide equal, safe, affordable and accessible facilities to all vulnerable road users who are fully dependent on the system. Most commuters in low-income communities do not have a choice in their selected transportation mode. However, the involvement of policymakers plays a critical role in rectifying the system.

2.2 Safety and Security of pedestrian

The concept of safety and security can easily be mistaken for the same thing. However, the concepts are closely linked to one another, but each has its own set of different characteristics. Safety and security are therefore defined below to demonstrate their significance in this section of the literature.

<u>Safety:</u>

The aspect of being secure against the unintended threat, being protected against threat or conditions likely to cause harm or danger, risk or injury because of crashes

<u>Security:</u>

Protection against deliberate threat like criminal activity which could inflict harm to oneself.

Focusing on the improvement of infrastructure is not the only consideration when protecting vulnerable road users. The knowledge of how to use the facilities, consulting with the end-user and understanding their ability to use the facility and understanding the perception of the commuter when travelling is critical to accomplish deliverables (Hodgson, et al., 2004).

2.3 Pedestrian infrastructure

"Pedestrian infrastructure provides safety, mobility and healthier communities" (FHWA, 2019). Infrastructure is built and intended to enhance and ease the commuter's journey when travelling (The National Academy of Sciences and Engineering, 2006). NMT infrastructure is highly effective when used and implemented correctly (DoT, 2009). Implementation and management of the infrastructure are vital to ensure that the facilities are well maintained and achieve the design life. Maintaining these facilities contributes to the safety, reduction in pedestrian-vehicle crashes and a reduction in pedestrian injury (FHWA, 2019; Ryosuke, et al., 2018).

Ensuring that the infrastructure is functional, it must provide safety benefits for all road user. Functional infrastructure further mitigates the safety risks which may occur due to defects. Defects may be manageable for an average pedestrian but can reduce the level of service substantially for a special need's users (Hodgson, et al., 2004).

Innovative Transport Systems provided a list of key features that would enhance the safety and security of pedestrians and influences pedestrian interaction with one another and with the infrastructure (Hodgson, et al., 2004; FDA, 2009).

Infrastructural features that improve the pedestrian experience includes:

- Pedestrian environment: Clean, green, attractive, safe

2.4 The vulnerable road user

A vulnerable road user is anyone using the roadway with direct exposure to risk and who lacks external protection. Inability to execute a certain task is another characteristic of a vulnerable road user. Women, children elderly and special need users are characterized as vulnerable road users (SWOV, 2012).

Statistics from the WHO showed that the most common age group involved in fatal pedestrian traffic crashes are road users between the ages of 15-29 (WHO, 2017). According to the South African National Household Survey, this age group is categorized as the youth in society (STATSSA, 2017). Stats SA confirmed that 55.2%

of the individuals that fall within the 15-29 age bracket are unemployed. These individuals are also listed as the most active road users and potential economic contributors in South Africa (WHO, 2017; Statistics South Africa, 2019). The commuters with the highest unemployment rate and who are the most active road users fall within the same age group. It is assumed that people within this age group are actively searching for jobs or travelling to educational institutions, increasing the probability of crashes within this age group. Although vulnerable road users are clearly defined, the context of the most active users should also be considered. An all-inclusive solution should be developed which all road users form part of in an effort to reduce road traffic deaths. (Statistics South Africa, 2019; Elhamy, 2012; Levulyte, et al., 2017).

- Pedestrian network: Sidewalks, dropped kerbs, pedestrian crossings
- Urban forms: Physical characteristics of the surrounding environment, the configuration of settlements
- Land use: Industrial area, retail activities, residential zone
- Traffic and security of pedestrians: street furniture, the manoeuvrability of people using wheelchairs, people who are reliant on tactile paving and push buttons(ITS, 2015; Murguia, n.d.).

One of the research critical variables focuses on the movement of commuters between home and the PTI. The NMT Facility Guidelines 2015 provides recommendations on improving security in urban spaces (Department of Transport, 2015). A safe space should have: clear lines of sight through areas (to avoid dead zones), alternative routes available to be used (to avoid unsafe areas), sufficient lighting on pathways, reduce areas/barriers (where criminals can hide) and NMT facilities should be protected from motorized transport. However, the spatial planning of communities does not always contain safe space features (Department of Transport, 2015).

Good infrastructure with poor safety and security because of a lack of enforcement adds to the commuter's daily struggle. This system flaw incubates behaviour patterns. Behaviour patterns are dictated by social and cultural pressures and contribute largely to the success of NMT. Finding the balance between infrastructure, law enforcement and safety and security may contribute to solving various shortcomings.

2.5 Pedestrian factors

Pedestrian movement can be distinguished by key factors such as personal choice and physical vulnerability. Pedestrian movement is difficult to predict because unlike other modes it does not always follow pre-set lines (Bezbradica & Ruskin, 2019; Akcelik, 2001; WHO, 2013). Most pedestrian-vehicle accidents are caused by pedestrians (Henry, 2013). Fortunately, the pedestrian cannot be held completely accountable. Different factors influence pedestrians such as mood, attitude and their perception of distance to the destination, availability of NMT facilities, perception of time, personal security, traffic, urban form, pedestrian environment, comfort and even the weather (Hodgson, et al., 2004; Murguia, n.d.).

Pedestrians evaluate their routes based on features like the lengths and the visual connectivity between points. The most popular route is generally the most congested but could also be perceived as a safer option (Bezbradica & Ruskin, 2019). The road users are influenced by human error, physical limits, system accountability, ethical values of road safety and societal safety (WHO, 2013). The pedestrian depends on more than just the infrastructure, psychological factors play a role as well (The National Academy of Sciences and Engineering, 2006). Without realizing the complexity of the thought process behind walking, pedestrians subconsciously make these connections before commuting and during their journey.

Physical attributes that contribute to vehicle crashes were are listed below.

- Improper land use in which modes of transport are required to interact with one another without proper guidance (PAWC, 2002; CoCT, n.d.).
- Incorrect allocation of NMT space where enough space is not allocated for another mode of transport and these modes start encroaching on the designated pedestrian space. Pedestrians are forced to walk in the roadway or weave between vehicle parked on walkways to avoid pedestrian conflicts and due to inadequate facilities (CoCT, n.d.).
- Unclear pedestrian signages and road markings or the lack of markings (NHTSA, 2017). Incorrectly marked facilities create an environment in which the pedestrian is responsible for making decisions to carry out challenging activities without all the information required (Henry, 2013). In this scenario, the pedestrian may perceive a safe crossing which may not be the

perception of the motorist. Drivers do not expect the pedestrian and since the road is not designed to compensate for human error there is limited time to react (Arrive Alive, 2018).

- Pedestrians crossing the street while a vehicle is executing a left-hand turn: The signal gives the pedestrian right of way but the left turning filter arrow is also giving vehicle right of way. This arrow operates on the bases that there is no vehicle-vehicle conflict but rarely considers the chance of pedestrian-vehicle conflict. The motorists that are turning left are generally not looking left but rather looking right, to ensure the intersection is clear to execute the left turn. Pedestrians may enter the intersection and must move swiftly across the road to avoid colliding with vehicles and in some instances, they may even enter the roadway while being distracted.
- Distractions by electronic devices (WHO, 2013): Electronic devices distract pedestrians from decisions that need to be made and observing the required information if the situation changes. A New York study was conducted where pedestrians who were involved in traffic crashes were interviewed. Eight percent (8%) of pedestrians and cyclists were injured while using electronic devices (Henry, 2013; Flegenheimer, 2013). In addition to the above, modern technology like quiet vehicles are likely to cause 40% of crashes between vehicles and pedestrians. (NHTSA, 2017).
- Pedestrians wearing dark clothing: “Nearly 50% of all pedestrian accidents happen on weekends and 70% happen at night. (Henry, 2013)”During dusk and dawn pedestrians are incredibly hard to see especially when wearing dark clothing. In addition, poor street lighting attributes to poor visibility of pedestrians. This increases the likelihood of crashes occurring.

According to the National Highway Traffic Safety Administration (NHTSA), two reasons for pedestrian crashes are alcohol abuse and arterial road crossing. However, this will not be elaborated on, as these factors are not relevant to this research (NHTSA, 2017; Henry, 2013).

2.6 South African Historic context

South Africa (SA) is known to have one of the highest road traffic crash fatality rates in the world. Pedestrian fatalities account for 35-40% of all road crashes (Arrive Alive, 2018). Statistics show that the numbers are elevated in lower and middle-income communities. These communities can be identified around Cape Town, created during the apartheid era. Today, the communities exist and continue to increase in population size (Arrive Alive, 2018; Writer, 2016; Automobile Assocation, 2003; Fourie & Verster, 2018).

The basic modes of travelling in the past have remained unchanged. People continue to use a combination of walking, minibus taxi, bus, commuter trains and to lesser extent trucks and motor vehicles (CimateTechWiki, 2018; Mokitimi & Vanderschuren, 2016). Gradually, all modes of transportation have become a site of popular struggle and tension (Thomas, 2016).

Although 30% of South Africans has access to car most of the population rely on public transport and walking (STATS SA, 2013; Teffo, et al., 2019). South Africans that rely on public transport have been classified as either choice or captive users. The term captive users are used to describe commuters that do not have an alternative mode of transport and has been captured by the public transport system. Unfortunately, captive users face an unsafe, unreliable and costly system.

2.7 Crash Fatality rates

Historic data suggests that for every fatality recorded, 4.6 serious injuries and 14.9 slight injuries are recorded (SaferSpaces, 2019) According to the Road Traffic Management Corporation (RTMC), 90% of crashes are as a result of lawlessness and are preventable. The RTMC published a list of the nine most common causes of accidents. These are distractions, drunk driving, speeding, reckless driving, pedestrians, weather, unmaintained infrastructure, tyres and brakes (RTMC, 2017). In addition, an article published which explored the good, the bad and the ugly of South African fatal road accidents, listed the causes contributing to fatal crashes as sharp bends, poor visibility, slippery road surface, stray animals[1], poor lighting, road works, poor or inadequate road markings and blind corners (Fourie & Verster, 2018). The high number of crashes is estimated to cost the country 142.95 billion Rands per annum.

[1] More pertaining to rural roadways which is not investigated in this research,

In 2003, the Automobile Associations (AA) presented a submission at the Transport Portfolio Committee and Mincom on road safety in South Africa. The AA predicted that road traffic crashes would be the third leading cause of death in the world and that the South African statistic would double by 2020 (Automobile Assocation, 2003). In 2016, the fatality prediction for 2020 had already been surpassed, four years before the expected deadline. South Africa recorded a death rate higher than double the predicted crashed (RTMC, 2017; Automobile Association, 2018). The Road Traffic Management Corporation (RTMC) recorded 14071 road fatalities, in 2016, a 9% increase in fatalities from 2015 to 2016 (RTMC, 2017).

The Department of Environmental Affairs has partnered with other government departments in an attempt to improve the social, economic and environmental development in communities with high crash rates. Implementing initiatives such as promotion of NMT, sustainable and safe cycle lanes and continuous footpaths aims to raise awareness of the importance of these features to ensure safe mobility for all. These initiatives are ongoing and aim to be implemented by 2021 (DoE, 2018).

2.8 Gini Coefficient

The Gini Coefficient is a statistical measure used to evaluate the economic inequality of a country. The coefficient ranges from 0 to 1, where 0 represents complete equality and 1 representing perfect inequality (Chappelow, 2019). Currently, South Africa has the highest Gini coefficient equalling 0.63, therefore indicating that the country has the highest level of inequality in the world. A high Gini Coefficient indicates an unequal distribution of the economy's wealth between the rich and poor and that a higher number of citizens are living below the poverty line. The coefficient has been steadily increasing[2] resulting in a bigger inequality gap (World Bank Group, 2019; Niselow, 2019).

First world countries have a Gini coefficient of 0.24 – 0.25. An example of a first-world country is Denmark. Denmark has seen an improvement in its Gini Coefficient from 0.28 in 2006 to 0.25 in 2015.

2 A Gini coefficient of 0.61 was recorded in 1961.

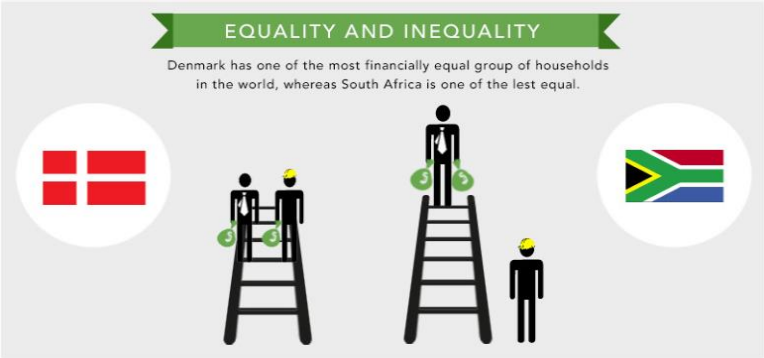


Figure 2-1: Comparison of inequality between 1st world and 3rd world country

Figure 2-1 illustrates the income disparity between management and employees. The variation in wage determines which step you are on. The South African ladder shows that the higher up the ladder you are, the more wealth you obtain (higher income) and the lower down the ladder you are, you do not share in the wealth (low income). However, when looking at the Denmark model there is a more equal distribution of wealth.

Statistics show that 5.2 million South African public transport users (STATSSA, 2017) are categorized within the bottom earner bracket. An analogy is made between a CEO classified as a top earner and general worker classified as a bottom earner in South Africa.

Fin24 reported that South Africa's top CEO earns a salary of approximately R 450 000 per month with an expected annual increase of 4.9%. The National Minimum Wage Act stated that the South African labour force[3] receives remuneration of R 3 500 per month based on the number of hours worked (The Presidency, 2018). The variation in daily income shows that the top earners receive an average of R 3 000 per day in comparison to bottom earners who earn R160 per day at R20 per hour (Niselow, 2019). The top earner has the leisure of choosing different modes of transport and likely has a personal or company vehicle whereas the bottom earner is reliant on public transport facilities.

Figure 2-2 below shows the budget of an average bottom earner. The largest portion of income is allocated for living expenses and the second largest for transportation costs. Based on these figures people are forced to use the public transport system or

[3] Labour force refers to he blue colour work force including farm workers, forestry workers, domestic workers, welfare sector and care workers

walk as a priority might be placed on other household expenses. According to Figure 2-2 more than 16% of their household income is spent on basic travel needs (Writer, 2017; STATS SA, 2013; Masiteng & Schmidt, 2015).

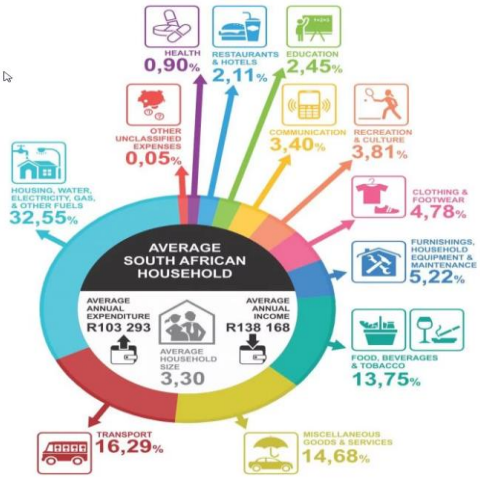


Figure 2-2: Average SA household wage breakdown

A costing analysis was done to determine actual cost incurred when travelling from the outlying areas to the Bellville PTI. Table 2-1 shows a breakdown of the route chosen for this calculation. The chosen route is as follows:

Leg 1: Delft[4] to Bellville PTI Leg 2: Bellville PTI to Cape Town CBD PTI

Table 2-1: Average commuter cost from Delft to the Cape Town CBD via Bellville PTI

Location	Cost (one-directional)	Cost (Round trip)
Delft to Bellville	R 8.00	R 8.00 * 2 = R 16.00
Bellville to Cape Town	R 17.00	R17.00 * 2 = R 34.00
Total cost per day		R50.00
Total cost per week		R50.00 * 5 = R250.00
Total cost per month		R250.00 * 4 = R1000.00
% of Income		R1 000.00/R3 500.00 = **28.6%**

[4] Delft: A low income community located in the Northern Suburbs of Cape Town developed during the Apartheid era

At month end commuters are spending close to R1000.00 on travelling cost. Given the minimum wage, the total spent on transportation is close to 30%

This historical context continues to play a big role in inequality, which is prevalent in the activities seen at the PTI where commuters travel for long distances from outlying communities. The ever-increasing inequality gap cycle continues as intergeneration mobility is low, indicating that inequalities are passed down from generation to generation with little change over time resulting in a lag on the inclusiveness of consumption growth (World Bank Group, 2019).

2.9 International infrastructure

Developed countries experience radical change and developing countries are prone to an imbalance in MNT facilities. The European Commission adopted an approach to pedestrianize some streets where traffic flow would not be severely affected allowing priority to the more sustainable modes of transport such as pedestrians, cyclist and public transport (Wallstrom, n.d.). For years, developed countries had operational NMT facilities while developing counties have looked at the world trying to retrofit the infrastructure. The imbalance in infrastructure has created additional traffic demand and an increase in the road space required.

Copenhagen, Denmark is an example where pedestrians were prioritized. Today the city has over 96000 square meters of car-free space where 33% is allocated to roadways for vehicle movement and 67% to the pedestrian area. Countries such as Finland, England and Germany moved to prioritise pedestrian as well, reducing the number of individual vehicles and improving the number of public transports trips (Wallstrom, n.d.).

A case study was done by the European Commission (EC) showing an international increase in car ownership over the past 30 years. However, the imbalance of infrastructure in lower-income and middle-income countries continues to increase. Today, the reality is that an increase in vehicles results in a decrease in short distances being walked (Asia, 2018).

Third world countries like India, Bangladesh, Mexico, and Colombia were used as examples to which South Africa could be compared, in terms of characteristics of the NMT facilities and infrastructure conditions.

2.10 Infrastructure Improvements in Asia

2.10.1 Healthy India - Calcutta, India

According to an article published by the Daily Nation, Kolkata formerly known as Calcutta is the most congested city in the world (Mutavi, 2017). India experiences extremely high volumes of pedestrians that walk and cycle. These account for one-third of the trips generated around the country (Asia, 2018). In 2016, India recorded 15 800 pedestrian deaths are mostly due to exposure to risk when crossing the road in urban and rural areas (Kumeresh, et al., 2019). Research showed that India had very little infrastructure that supported pedestrian activity and no appropriate legislation that governed the behaviour of pedestrians and NMT on the roads (Asia, 2018).

After experiencing a consistently high fatality rate, India started developing an initiative called “Healthy India”. The Healthy India initiative illustrates and promoted the importance of roadway behaviour. Principles like using proper facilities when crossing the roadway, obeying the signals, motorists being banned from driving on the footpaths and increase in pedestrian awareness formed part of the campaign. Healthy India improved pedestrian facilities by providing:

- Continuous pathways - wide enough to support pedestrian traffic
- Adjoining footpaths to be marked - to maintain the continuous paths
- Providing pedestrian holding area at intersections - to wait before crossing
- Providing 5m wide pedestrian crossings
- Installing rumble strips - to reduce speed

In addition to the high number of pedestrian trips completed in India, the United Nations (UN) provided worldwide statistics that recorded 37% of all trips completed in 2005 worldwide was done by walking.

2.10.2 Safety, Priority, Accessibility, Comfort and Enjoyment in Chennai, India

The City of Chennai in India introduced policies to reclaiming the road space from chaotic traffic and created wider, continuous and accessible footpaths to prioritize people over the vehicle. As part of the reclaiming initiative, the Chennai Corporation allocated 60% of the transport budget to create safe pedestrian networks and to ensure the facilities were sustained and well maintained. The Chennai Corporation aimed to provide enough infrastructure and to ensure that 80% of its streets equipped with

continuous walkways resulting in the elimination of pedestrian deaths. A policy was implemented to improve the mobility for the people to access to markets, recreational activities and allowed space for street vending (Transport Matters, 2014). The corporation also highlighted the importance of street management and the role it plays in the community with outreach and educational programmed to get people involved and build awareness.

The Institute for Transportation and Development hosted a conference in India where Transport Matters presented a conference proceeding about the S.P.A.C.E concept. Guidelines were published that determine the requirements for NMT planning. The focus of the S.P.A.C.E. concept encompassed Safety, Priority, Accessibility, Comfort and Enjoyable. The objective of S.P.A.C.E. provides the facility with the necessities to make the facility that attracts road users, maintaining each road user's safety and security and allowing a high level of comfort when using the facility (Vedant, 2014).

Figure 2-3 below was extracted from the Transport Matters conference proceeding where the presenter explored the level of NMT in the different countries showing the wide pathways as prescribed by Transport Matter to reclaim the space. The image highlights the importance of people and the low vehicle priority with full functionality (Vedant, 2014).

Figure 2-3: Ideal NMT road cross-section

2.10.3 NMT changing in Dhaka, Bangladesh

In Dhaka, Bangladesh 80% of the trips completed were done by walking or by some form of public transport. Research showed that 70% of the road space is allocated to private vehicles (Asia, 2018) although a higher number of trips are completed by

walking. Like South Africa, Bangladesh has a wide variety of NMT modes. Figure 2-4 below. Shows the local vehicle used in Bangladesh daily includes:

Figure 2-4: Different modes of transport used in Bangladesh

Figure 2-5 below illustrates the percentage of trips generated per mode for certain activities. The graph showed that 46% of home-work trips are completed by public transport and another 27% by rickshaws. Overall, the majority of the trips generated are done using public transport and Rickshaws. In each purpose-based trip, private vehicles make up the smallest percentage of the mode however, the largest portion of the infrastructure is allocated to motor vehicles (Hasan, 2014).

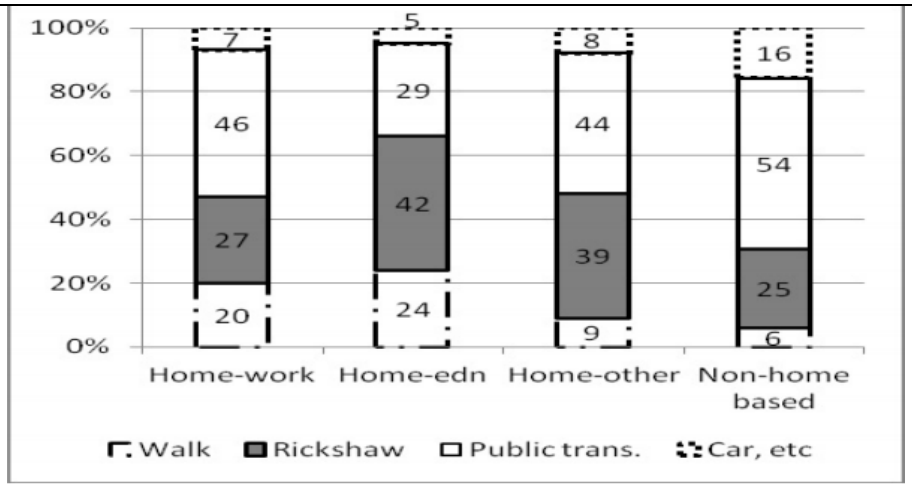


Figure 2-5: Modal share in each purpose based on the trips

A presentation presented by Uddin Hasan about the status of NMT facilities in Dhaka provides a list of features that contributed to negatively affecting pedestrian travelling.

- Vendors encroaching and illegally occupying 40% of the sidewalk even though 70% of the roads have no sidewalks
- Cars are parked on the sidewalk,
- Dust bins are placed next to the sidewalk with dirt flowing over onto the sidewalk
- Open sewers can be seen in the middle of the walkways.
- Vehicles blocking the pedestrian crossing
- Overpasses that are overcrowded
- Excessive height of overpasses

(Hasan, 2014)

A lack of these facilities requires pedestrians to manoeuvre through conflict points and experience high risks of exposure to harm.

2.10.3.1 Rickshaw as a transport mode

Rickshaws are the most used mode of transport specifically by woman and children. Since Dhaka is a predominantly Islamic country, culture prohibits females from travelling with men in crowded public transport, therefore, woman and children use the Rickshaws more regularly.

Hasan provides further evidence of the advantages of NMT. 76% of short trips are completed by Rickshaw which has exceptional environmental benefits like no carbon emissions, no fossil fuels and no noise pollution. (Bari & Efroymson, 2005)

The Bangladeshi government recommended a ban of Rickshaws on certain corridors. The suggestion was supported by the World Bank and then later, after observing the negative socio-economic impact on all road users, especially vulnerable road users the World Bank withdrew their support. The government proposed regulating the Rickshaw industry by licensing the rickshaws, providing separate dedicated lanes for the mobility and colour coding rickshaw friendly areas.

To prevent and restrict scattered and haphazard movement, Figure 2-6 below shows how the government made enough space to accommodate the Rickshaw mode of transport within the roadway.

Figure 2-6: Dedicated rickshaw lane

2.11 South America

2.11.1 The Guadalajara, Mexico BRT System

The Minister of Health reported that in 2008, 17 000 people were killed and a further 600 000 were injured because of road traffic crashes with the average ages of victims being between 15 and 29 years old (WHO, 2008). Mexico is one of ten countries included in the program funded by Bloomberg Philanthropies known as “Road Safety in 10 countries”. This initiative gave rise to the development of the Macrobus BRT system.

The Guadalajara Macrobus began operations in March 2009 (Hidalgo, 2010) integrating light rail and the feeder services. Stations were constructed with level

boarding platforms and wide pedestrian crossings at the signalized intersections. The system gained large user acceptance with 7.8 out of 10 commuters using the service. The Macrobus addressed key factors like service quality, travel times, reliability, comfort, cost and external factors like a lower level of accidents and congestion relief (Hidalgo, 2010). Before the Macrobus system was implemented in Guadalajara, like the previous examples, the number of traffic crashes was much higher.

Figure 2-7 below depicts a graph extracted from a case study which determined the effectiveness of an integrated transport system. The graph displays data collected in Guadalajara showing that crashes reduced by 50% once the Macrobus was fully operational (Duduta, 2012).

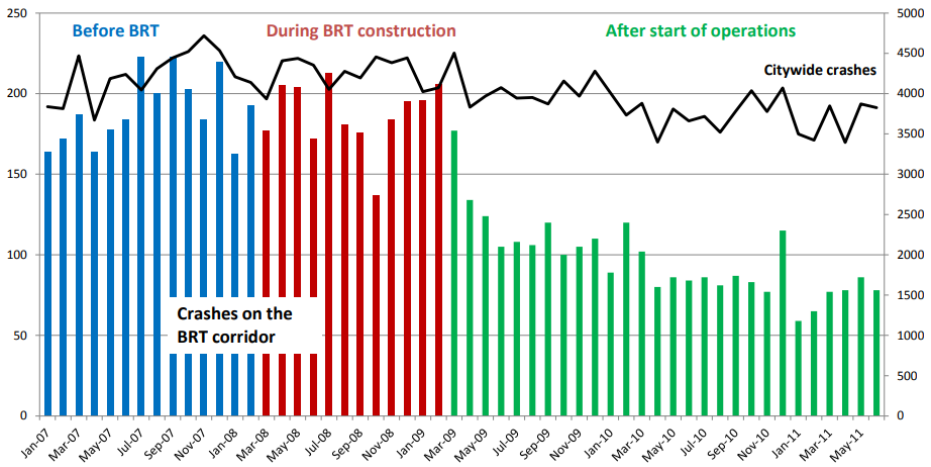


Figure 2-7: Effectiveness of an integrated transport system

Figure 2-7 below, shows a comparison between the number of crashes and passenger output using the first pilot Bus rapid transit (BRT) lanes. The graph on the left compares the crashes between mixed traffic to 1 BRT lane. The crashes reduced by almost 99%.

The passenger output increases substantially when looking at the number of passengers moved in two mix lanes of traffic compared to 1 BRT lane.

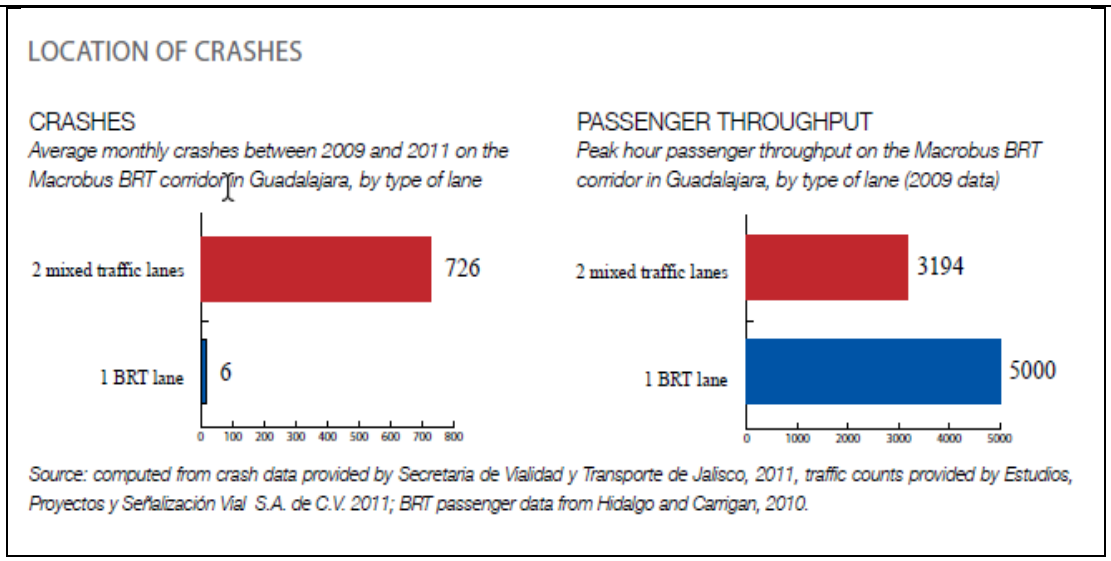


Figure 2-8: Number of crashes vs the passenger output during BRT lane pilot

Although the BRT network was not fully constructed, the implementation of an incomplete system did not cause major disruptions. The graphs show the improvement of the system. This indicates that the pedestrian's perception and buy-in are critical to the success of the infrastructure. Before the construction was complete people used the system because of safety and security advantages and well as other outputs experienced like comfort and reduced travel time.

The phased implementation allowed the focus to be shifted to critical aspects. The key lessons learned during the process were:

- The BRT was a successful project with relatively low cost, high quality and good performance.
- An improvement could be seen in the infrastructure in terms of good pavement layers, strong NMT separation and a good operational plan.
- Performance of the system could be monitored easily and from this information, the improvement could be suggested to enhance the reliability and comfort of the BRT system. (Hidalgo, 2010)

The advantages of the system included easy access, short waiting intervals, seamless integration with other transport modes, improved safety and security and affordability (Hidalgo, 2010).

2.11.2 TransMilenio - Bogota, Columbia

The mayoral administration was responsible for the transformation of Bogota between 1992 and 2006 which led to a dramatic decrease in traffic fatalities. Since the second

term began the goal was to build on the existing infrastructure and consolidate the success of improving road safety. The promotion of mobility included the development of the TransMilenio system that would integrate bike paths through the city and pedestrian footways (Mosequera, et al., 2012; Vergel-Tovar, et al., 2018). Integrating the network with bicycles and pedestrians would encourage a reduction in air pollution, noise pollution, traffic congestion and vehicle dependence (Mosequera, et al., 2012). Since the system was rolled out in various phases, a large portion of the countries investment was allocated for the reclamation and improvements of NMT facilities.

The first phase converted space previously used for parking by private vehicles into pedestrian and bicycle facilities (Vergel-Tovar, et al., 2018; Mosequera, et al., 2012). The second phase required a complete relook at the street design to include bus lanes, mixed traffic lanes, sidewalks and cycle lanes. The final phase integrated the railway, while BRT maintained the expansion of NMT. The majority of the NMT is separated from the motorized transit and today 25% of the TransMilenio system forms part of the shared road section.

Bogota, Columbia is an outstanding example of a well-integrated network. The model is used to emphasize the shift from vehicle orientated roadways to pedestrian orientated spaces prioritizing NMT accessibility and mobility. Bogota has more than 7 million inhabitants, 28% of the population lives in poverty and approximately 20% of the population owns cars (Mosequera, et al., 2012). Columbia recorded more than 7000 road traffic fatalities before the implementation of TransMilenio. Once the system was operational, crash statistic reduced by half.

In Guadalajara and Bogota, the introduction of bus corridors saw a significant reduction in crashes once the bus corridor was completed (Duduta, et al., n.d.).

2.12 African Infrastructure Review

2.12.1 Reduced NMT facilities in Egypt

An article published in the International Journal of Transportation Science and Technology reported that traffic crashes are the largest preventable, public health and injury problem (Elhamy, 2012). Egypt is ranked in the top ten countries for road traffic fatalities with Cairo being ranked the second-highest congested city in Africa (Mutavi, 2017). Egypt recorded over 7000 traffic fatalities of which 20% accounting to pedestrian fatalities. (Elhamy, 2012). Elhamy, the author of the article published in the

International Journal of Transportation Science and Technology, stated that traffic crashes are the world's largest preventable public health and injury problem.

"To simply design and create a street environment that is interactive, the definitive separation between moving traffic and pedestrians, easy and safe to cross and to achieve a balance between various modes of transport within the shared space, makes a street pedestrian-friendly"(Elhamy, 2012).

Providing enough facilities for both vehicles and pedestrians can result in a large conflict zone. Overcrowding and dense sidewalks provide an ideal environment for criminal activity and could lead to accidents.

Although high volumes of vehicles and pedestrians were experienced in Egypt, vehicles were prioritized. High volumes of vehicles were being experienced and resulting in high levels of congestion in the city. To alleviate the congestion, the pedestrian facilities were reduced to increase space for vehicles.

The Egyptians reduced the sidewalk width to improve vehicle flow, reducing the NMT facility to widen the roadway. After the sidewalk reduction, it was found that due to the high volumes of pedestrians the sidewalks were congested resulting in the pedestrian overflow spilling into the streets. This created an increased number of pedestrian-vehicle conflict points. Pedestrians would be exposed to risk for longer periods because of a long crossing distance. (Elhamy, 2012)

To compensate for the reduced sidewalk a host of methods were used to improve pedestrian accessibility and mobility like motor speeds were reduced, reducing pedestrian exposure, improving traffic law compliance (Fathy, 2010) and lastly eliminating behaviour that will lead to crashes (Elhamy, 2012).

2.12.2 Share the Road - Nairobi, Kenya

Kenya, located in East Africa, is the second most congested city in the world according to an article published in the Daily Nation. In Africa, the top 6 cities with the worst traffic are Nairobi followed by Cairo in Egypt and then South African cities, Pretoria, Johannesburg, Cape Town and Durban respectively (Mutavi, 2017).

The International Road Assessment Programme (iRAP) in Nairobi conducted a study on the infrastructure of pedestrian facilities in developing countries. From the 95% of roads that were assessed, only 20% made provision for footpaths even though high pedestrian volumes were observed (Watson, n.d.).

Nairobi, Kenya was the first African country to adopt the pilot “Share the Road” in March 2015 due to the levels of congestion (PPMC, 2014). 47% of the Nairobi population walk as their main mode of transport (World Highway, 2016). As part of the pilot project, the Nairobi governments converted the roadway cross-section to 3-meter-wide sidewalks on both sides of the road and 3-meter-wide two-way segregated bus lanes (Murguia, n.d.). The project helped Kenya realize how NMT facilities can be included in the road network and the benefits thereof especially with a working public transport system (Anon., 2018).

Nairobi embraced the “Share the Road” concept which demonstrated that the NMT policy can be used to redress the investment challenges and act as a catalyst to provide safe infrastructure for pedestrian with long term benefits to the environment, safety and accessibility. “Share the Road” promoted a modal shift from vehicle priority to pedestrian’s priority, reduced carbon emissions and increased protects vulnerable road users from high-speed traffic allowing an increase in affordable access to vital services and employment (PPMC, 2014).

Separating different modes of transport would mitigate the safety risk (Murguia, n.d.; Commission, 2019) and reduce conflict substantially. Understanding desired paths and the environment is vital in conflict reduction. Optimizing the infrastructure design encourage good road user behaviour improves the safety and effectiveness of the facility (Transport, 2006).

2.12.3 NMT Improvements in Windhoek, Namibia

Windhoek, like South Africa, experiences high pedestrian volumes as well as high pedestrian fatalities (GIZ, 2016). The high pedestrian volumes were affected by the available infrastructure. Poorly maintained infrastructure resulted in a low level of service placing pedestrians at a disadvantage. The citizens demanded improvement to the facility within a short period of time. This forced the implementation of safe, quality infrastructure that met the current and future demands of pedestrians (CoW, 2013). The City of Windhoek (CoW) acknowledged the simplicity of the approach but also the crucial elements that defined the pedestrian network, the routing system and the impact that on the environment, the economy and mobility of citizens (Riehle, n.d.).

Many commuters travelled more than 2 kilometres and after gathering the information the CoW focused on evaluating the origin and destination as part of the evaluation. CoW evaluation was aimed at defining the desired route to provide routes with

characteristics that offered coherence, consistency and comprehensiveness for a direct and safe route (Riehle, n.d.).

The origin-destination study evaluated pedestrian needs in terms of the range of users who needed to be considered. Generally, infrastructure is designed for the lowest level user. To provide an all-inclusive solution, all-access barriers limiting mobility and accessibility were removed (Riehle, n.d.). Provisional features for the present and the future user were considered including completeness, easy access, connectivity, directness, low conflict, appropriate vehicle speeds close to NMT environments, the comfort of all road users and a safe and secure environment (Riehle, n.d.).

Another part of the investigation focused on public transport, accident hotspots, existing informal pathways and other barriers. The concept of pedestrians walking along the route with the least detours and the informal pathways was a large contributor to the route evaluation. The Windhoek PTI's resembles similar problems experienced in South Africa. Due to the lack of sustainable urban transport, poorer Namibians were spending up to 25% of their income to meet their mobility needs (Riehle, n.d.).

Improvement of pedestrian facilities should not overshadow the urgent need to provide efficient public transport. In 2014, a 20-year plan was launched to help decision-makers to develop an affordable, accessible, attractive and efficient public and NMT system. Records showed that the public transport system was lacking an all-day bus service, interchange connecting different routes of the system and vehicle capacity to satisfy the peak hour demand.

Considering improving the PTI, the "Move Windhoek" concept, created in 2013, is in the process of developing modified bus routes and operational plans to provide a better bus service while integrating the taxi industry as well. The focus, however, remains pedestrian safety (SUTP, 2018).

2.13 National Infrastructure

2.13.1 The State of Infrastructure in Cape Town, South Africa

South African National Household Travel Survey 2017 showed that 5.2 million people commute with public transport and 63% of these trips are generated from home-work travels or walking as their primary mode of transportation (STATSSA, 2017; Arrive Alive, 2019; Mokitimi & Vanderschuren, 2016). In 2016, South Africa was rated as the third worse congested country on the African continent, with Cape Town contributing to the congestion index with an average travel time of 44.15 minutes (Mutavi, 2017).

The spatial divide created by the apartheid legacy prevents inclusive development and has been exacerbated by the poor road accessibility. This has been fuelling the daily hardships for thousands of South African residents especially in poorer communities (CoCT, n.d.; Smith, 2017). The move towards integration in term of rapid public transport has been introduced but is not operating at the expected level (Morapedi & Makhari , 2016).

2.13.2 Modes of transport in South Africa

Many different modes of transport can be found in South Africa. The most common mode is the minibus taxi. Although buses, trains and bus rapid transit are available, most commuters choose to travel with MBT because of their fast and effective driving methods.

Walking is the cheapest mode of transportation and even though a commuter may never intend to walk, each journey starts and ends with walking whether you travel by public transport or personal motor vehicle. Mokitimi elaborates on walkability describing how friendly, safe and accessible walks are in the community (Mokitimi, 2015). The route of walkability is created from the patterns of the desire lines that can be seen in high pedestrian volume areas. Within the South African context, the desire line forms part of a planned route to avoid the criminality experience or they may contribute to a time or distance reduction.

The National Household Travel Survey (NHTS) provides a breakdown of the amount of time spent travelling by commuters. The NHS shows that some commuters in the rural area walk more than 60 minutes to access the nearest public transport facility and 10 minutes in an urban area (STATS SA, 2013). Stats SA provided a comparison between down the user percentage per mode in 2013 and 2017. The use of taxis increased from 59% to 68.8%, busses from 16.6% to 20.1% and rail from 5,7% to 9.9% (STATS SA, 2013). South Africa has approximately 14.2 million households and 10.1 million households depend on travelling with public transport (Bickford, 2013; STATSSA, 2017; Lehohla, 2015)

Table 2-2 below shows the number of trips generated, in the Western Cape, per week across the different forms of public transport (STATS SA, 2013).

Table 2-2: Weekly trips generated in Western Cape per the mode of public

Mode	Western Cape
Train	1 817 000
Taxi	1 821 000
Bus	1 820 000

The vast South Africa population depends on the public transport system daily to work and contribute to the economy. On average, one trip can take up to 56 to 60 minutes to complete in one direction (TDA, 2019). Integrated transportation planning in South Africa should become a deliberate process (Thomas, 2016).

2.13.3 Bus Rapid Transit

The 2010 FIFA Soccer World Cup saw considerable changes in the South African road infrastructure. A major factor that was discussed was the integration plan of the public transport modes being controlled and monitored by one central authority. Modes including the BRT and minibus taxi (MBT) would receive government-subsidized (Van Zyl, 2009).

The Cape Town BRT system better known as the MyCiti was implemented in August 2009. Initially, the MyCiti aim was to upgrade the CBD, Cape Town International Airport, Atlantis, Century City and Montague Gardens. These upgrades were greatly successful. After the MyCiti had been operational for almost 10 years and the city improved integration by adding more routes although the remaining public transport requires attention. The statistics revealed that in 2017/2018, the bus service transported 1.6 million people per month equating to a daily volume of 51000 commuters, however, the taxi industry transports more than 350 000 commuters per day.

2.13.4 Minibus Taxi's

The minibus taxi industry was established in late 1970 to meet the demands of a growing South African workforce. The taxi industry provided an accessible and inexpensive way to travel on flexible routes that reduced walking distances to government-funded transportation like the Golden Arrow bus service and Metrorail train service (IOA, 2013). MBT became the backbone of the South African public transport industry and this is likely to remain the case (Diaz, 2015). Today many South African still rely on the MBT to complete daily tasks.

Although the industry was never formalized, a spike of gang violence and taxi wars have become a routine part of the taxi industry. Since the industry is not regulated and operates on a cut-throat business model operator battle to operate within the conditions of the law. The taxi drivers are given unrealistic trip and financial targets that have been exacerbated through competition between the MBT's, negatively affecting commuters (IOA, 2013). The industry then faces economic and social pressures (Diaz, 2015). The safety and security of passengers using the mode are directly affected.

To improve vehicle safety, the South African government made attempts to remove ageing fleets from the SA roads. The Taxi Recapitalization Program was created to improve safety although service delivered remains unchanged (Diaz, 2015). As of December 2015, it was recorded that more than 1 million vehicles fell within the criteria for recapitalization but only 61 254 were removed from the road network which was well below the expected number (Fourie & Verster, 2018; GCIS, 2017).

According to Stats SA, the top three causes of unnatural death in descending order are external causes of accidental injury, assault and transport accidents (Lehohla, 2012; Hunter, 2018). Verster and Fourie reported on the top three vehicles involved in traffic crashes on South Africa roads and found that almost half the fatalities that occurred in 2015 were caused by motor vehicles, the second-highest vehicle type recorded was bakkies and the third vehicle type was MBT's (Vertser & Fourie, 2018). It was found that 3 out of the 36 daily fatalities were MBT related. The public raised concerns about MBT being unsafe and operated in an offensive way but this matter has not been fully addressed by the Government. The reality that the public faces are compromising their safety and security for accessibility and cost-effectiveness or finding an alternative (Kani, 2018).

2.13.5 Pedestrian Desired routes

"When the cities lack the path pedestrian needs, people vote with their feet" (Bramley, 2018).

Desire lines are described as the informal pathway formed by pedestrians when moving naturally. In South Africa, a substantial amount of desired route has been formed as everyday commuters travelling from and to the PTI. The desired routes are formed when origin and destination[5] points do not follow a designated NMT path and generally, the desire routes are shorter than the conventional route.

Pedestrian generally choose the route with the shortest time or the route with the most direct path (Hodgson, et al., 2004; Liao, et al., 2016; Riehle, n.d.). Research further states that time may be the single most important factor when a pedestrian is making their route choice. The desire lines can assist in determining the new path. (Department of Transport, 2015).

Evaluating the position of NMT may be more successful when the origin and destination evaluation is included as well as a layout of the desired line around the destination. This information would guide engineering solutions in terms of the position, gradient and level of security for the end-users during the design process.

A study was conducted at Universities in the United States of America where pathways were deliberately not constructed. As soon as the new building was constructed, the university would allow the student to move around freely with no designated facilities to establish their desired paths. Figure 2-9 shows an aerial view of the University after the desired lines were formed by the students.

A similar method can be used during engineering design. Over years desired lines have been formed and this could assist with determining origins, destinations and preferred route. The patterns formed, can be used as a stencil to construct NMT facilities.

[5] Origin – Destination refers to the start and end of a commuter's journey

Figure 2-9: Desire pathways formed by students at the Michigan State University

2.13.6 South African Policy

The DoT provided guidelines for the pedestrian network that prescribed acceptable walking radii to access public transport facilities. The guideline distances were 300m to access public transport stops and 500m for commuter rail stations. However, it was found that commuters travel up to 1.3km to access public transport in the urban environment (Hodgson, et al., 2004; Labuschagne & Ribbens, 2014; Thomas, 2016; Department of Transport, 2016). During the site visit, the researcher noted that the walking distance within the PTI exceeds 50m. It was established that no residential area is located less than 50m from the PTI either. A gap was identified because the specified distance and the actual distance did not correspond. Obtain end-user "buy-in" is critical to the understanding of the environment and the implementation of the minimum standards (Labushchagne, 2011).

The conference proceedings published by Pillay and Seedat elaborates on the public transport strategy and the action plan visualized for 2020. Some of the key factors mentioned in the proceeding included:

- Integrating all modes of public transportation using the Integrated Rapid Public Transport Services Network Model.
- Ensuring sustainable, equitable and uncongested mobility which will contribute to liveable cities especially for citizens who do not have access to cars and are reliant on a third-class public travel option.
- Phasing out the apartheid legacy with the implementation of Integrated Rapid Transport service in the smaller districts and the more rural areas.

(Pillay & Seedat, 2007)

Although the plan has been carefully thought out and strategy planned completed for 2007 to 2020, very little has been materialized since there is only one year left before the deadline of 2020.

South Africa developed many regulatory systems to promote and encourage NMT (Mokitimi, 2015). The section below will review key points of the policy that directly and indirectly impact the safety and security of the commuter.

2.13.7 The White Paper on National Transportation Policy

"Provide safe, reliable, effective, efficient, and fully integrated transport operations and infrastructure which will best meet the needs of freight and passenger customers at improving levels of service and cost in a fashion which supports government strategies for economic and social development whilst being environmentally and economically sustainable"

(NDoT, 2017).

The White Paper policy strives to support the goals of the reconstruction and development program to meet the basic needs of growing the economy, developing resources and participate in decision making (NDoT, 2017).

The vision is to meet vulnerable road users' needs by providing:

- Safe, secure, reliable, efficient and sustainable transport.
- The infrastructure that is affordable, sustainable and has qualitative values for the users.
- Improvements to limit walking distance to less than one km per direction, from residential areas to the PTI.
- NMT facilities that attract commuters.
- Improved integration with respect to information, scheduling and routing.

(NDoT, 2017)

With the stated vision, the road traffic and safety policy go hand in hand. The function of the road traffic policy is to ensure road traffic control, enhance road users' knowledge, skills and attitudes of all road users and to provide a support function. The

goal is to ensure improvement in road traffic safety and enhance discipline (NDoT, 2017).

2.13.8 Department of Transport

The DoT outlines the strategic objectives that will be implemented to develop and improve the system for both rural and urban passengers. The improvements are aimed at addressing accessibility, public authority and planning, and regulation (Department of Transport, 2015).

Currently, South Africans are not able to utilize safe, secure, easily accessible and high-quality NMT services. The DoT explains how an unintegrated network and inconsistencies in the facilities affect residential areas. The aim was to developed a more sustainable approach to MNT facilities. This approach would be used to address the safety and sustainability of the NMT users as well as rebalancing of the PT network and of the daily experiences.

The department's review of the NMT policy developed in 2007 entailed rollouts of various NMT facilities around South Africa. The objects were to promote accessibility, urban mobility and improvement to NMT. The downfall of this is that there have been many strategies compiled in the past 20 years and none have materialized to a point that the DoT could qualify significant results (DoT, 2017).

One of the key features reviewed by the DoT that is consistent with this researcher's theory is the road safety challenge in NMT. The number of fatalities and the percentage of registered vehicles in South Africa is disproportionate. Increased poor driver behaviour, high speeds and lack of infrastructure have been identified as features that have become increasingly common and difficult to control. The DoT is aware that this challenge is complex and requires multidisciplinary approaches (DoT, 2017).

The DoT's key policy focus area, going forward will incorporate regulation, institutional arrangements and governance, integrated transport and land use planning, funding, social health and economic opportunities, road safety, and environmental sustainability. The question remains how this will be accomplished when for more than 20 years the recurring issue of road traffic fatalities remain (DoT, 2017).

2.13.9 National Road Safety Strategy

The National Road Safety Strategy aims to eliminate fatalities and serious injuries on South African roads by 2030 using a system that anticipates human error (DoT, 2016).

Before this strategy, three different strategies were implemented for the periods; 1996-2000, 2001 - 2005 and 2006 - 2015 (AA, 2006). These all included; strategic focus, intervention measures, delivery successes and shortcomings. The common factors that repeatedly appear in the documentation are; road environment safety, pedestrian safety, driver fitness and road safety management all of which are directly influenced by human behaviour. The DoT investigated underlying philosophies that are used internationally to determine the best practice strategies.

Success in implementing the model is highly affected by human factors because the system accommodates various human behaviour while considering the different situations encountered and this, in turn, provides a certain daily behaviour. Humans will make mistakes and incorporating room for error results in a reduction in conflicts while not exceeding the limit of human tolerance.

This safety strategy has been researched by evaluating seven countries to have the best practices from around the world to be implemented into the zero vision. The factors listed below formed part of the criteria; road safety management, road safety education, awareness around road safety, innovative solutions to address road safety, road users, road design, engineering and environment, and road safety excellence in the low to middle-income bracket (DoT, 2016).

As participants of the United Nations Decade of Action (UNDA) for road safety, the DoT has undertaken different features that contribute to implementing the strategy. There are two pillars that are most relevant to this research.

The first pillar elaborates the Safer Roads and Mobility aspect - where the key focus is to make the road safe against human error. This requires intelligence and a forgiving road environment which minimizes the exposure and identifies hazardous locations to alert NMT users of the danger.

The second UNDA pillar, Safer Road User, provides a framework geared towards developing comprehensive programs to improve road user's behaviour and attitude. According to the RTMC, human factors contributed to 91% of fatal crashes in 2017 compared to 78% in 2016 (RTMC, 2017). The link displayed between these two factors shows the extent of the human factor in Transportation (DoT, 2016).

2.13.10 Moving towards Transit Orientated Developments

Cities are moving towards developing Transit Orientated Development (TOD). TOD is defined as a relatively dense and pedestrianized mixed-use development precinct with quality public space and immediate access to high-frequency public transit (Department of National Treasury, 2017; Hale, 2007).

Three essentials factors of TOD are; high-frequency transit that links areas to one another, mixed land-use development which includes a combination of shops and offices and public spaces where commuters can move freely. The TOD concept is based on designs from Europe and Australia and is based on integrated development with; transport infrastructure, community services, and employment as well as a policy that facilitates various forms of TOD based on high capacity public nodes (Hale, 2007).

National Treasury hosted a workshop, in 2017, focused on TOD outlining the different elements of the framework which had a physical and implementation component. The physical component comprised of people, places and connections. The implementation component comprised of partnerships, planning, and analysis (Department of National Treasury, 2017). Although all the characteristics cannot be implemented in Cape Town, reducing the travel distance which is directly proportional to the travel time will provide relief of congestion and allow less time and cost spent on travelling.

South African standard principals include the promotion of NMT, planning mix land-use and creating compact commutes with increased mobility. The transport component was elaborated on, to providing the citizen with clean, safe and reliable transport which allows commuters to travel to different places and attracts more users (Department of National Treasury, 2017; Bickford, 2013). The benefits of introducing TOD to South Africa include:

- South Africa has a significant base of public using the public transport system and TOD would be ideal to provide a more integrated network.
- The riders are generally economically disadvantaged however with TOD, the walking distance would be reduced and the cost may reduce as one mode will not hold the monopoly.
- Providing high-quality transit may attract an economically diverse ridership reducing the number of private vehicles on the road network.

- TOD may be a path to developing socio-spatial transformation, but the focus will need to be shifted intentionally to an all-inclusive TOD system allowing the economically challenged to participate.

(Hale, 2007; CoCT, n.d.)

The success of the implementation would depend on identifying and engaging with key stakeholders such as politicians, government agencies, transit system operators and the community; as well as the end-user (Hale, 2007).

The spatial planning found in suburbs within the Cape Town area does not allow public transport, specifically bigger transport modes, easy access. A feeder model can be used for movement within the development with the larger vehicles moving towards the most popular destination. This would create order, decrease walking distance and the high safety and security exposure risk to a door-to-PTI service. There would be fewer vehicles on the major routes with law enforcement regulating the flow and the transport operators controlling the operation.

2.14 Shared Space AND Right of Way

A shared space is defined as a low-speed road that is designed to be used by pedestrians, cyclists and low-speed motor vehicles (Murgula, n.d.; Royce, 2017; Kos, et al., 2013). Navigation of the space is based on agreement rather than physical separation of the modes (Williams & Ruetener, 2016) particularly in spaces with high volumes of pedestrians (Kos, et al., 2013). The concept aims to enhance safety for all road users using the same space (Murgula, n.d.).

South Africa has many shared mobility spaces varying in quality and age. Rory Williams (2016) presented a presentation about shared mobility spaces at the 2016 Mobility Indaba. Williams (2016) reviews the share mobility spaces concept which can readily be seen within the Cape Town CBD (Williams & Ruetener, 2016). Figure 2-10 shows four shared spaces found in the Cape Town CBD. The variation in activity distribution can easily be seen as each shared space has a different combination of activities. One of the shared spaces formed was labelled as an unintentionally shared space because although minimum shared space features were available, the activities generated and the interaction between the various modes had shared space characteristics.

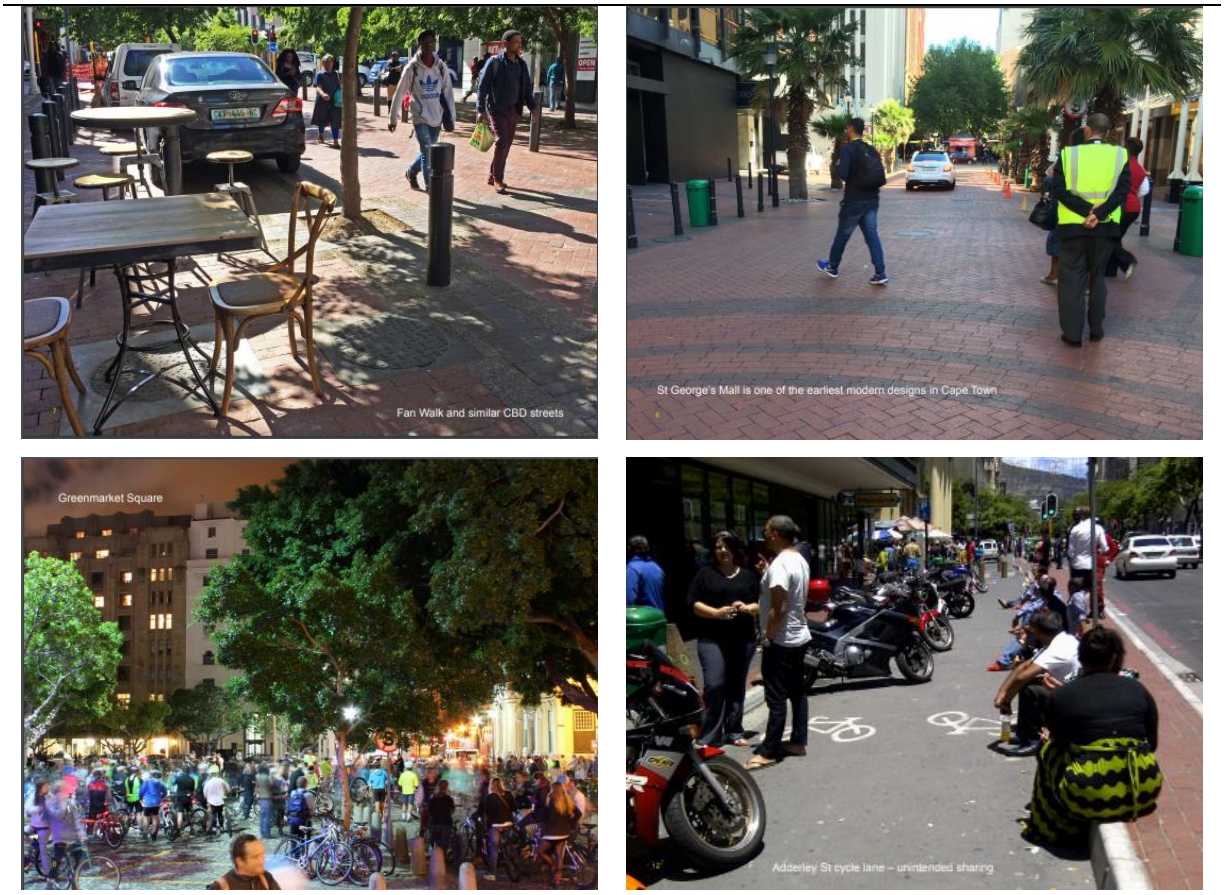


Figure 2-10: Shared spaces in Cape Town

The shared space consists of parking's bay on either side of the roadway, designated pedestrian and cycling lanes and the area is completely covered in paving bricks. Bollard's have been strategically placed at entrances and exits that cross the pedestrian crossing, but all road users negotiate through the area. Vendors are positioned along the pathway selling refreshments to road users. Signal controls are located at the entrance and exit of the shared space with minimal speed controls in between. Since the entire area is a low-speed zone, pedestrians have enough time to manoeuvre safely. Although the square meter of the shared space is small, the concept has been accepted. One feature that is not seen at these shared spaces are the ROW for public transport.

To develop successful shared spaces, the focal features are movement, inclusiveness, accessibility, functionality, sustainability safety and security (Williams & Ruetener, 2016). The conventional road model prioritized vehicles, however, society has started accepting the concept of shared space.

The conventional model used to define the hierarchy of the roadway compared to the sustainable approach which has been the model that society is moving towards and

accepting. A European example where the shared space concept was implemented showed reductions in accidents by 17%, speed between 19-39%, vehicle traffic by 9-34% and the area experienced less noise and air pollution. (Kos, et al., 2013)

Figure 2-11 below depicts the attributes that form a good shared space. The four key features are comfort, activities, social ability and access and linkage to ensure an inclusive space.

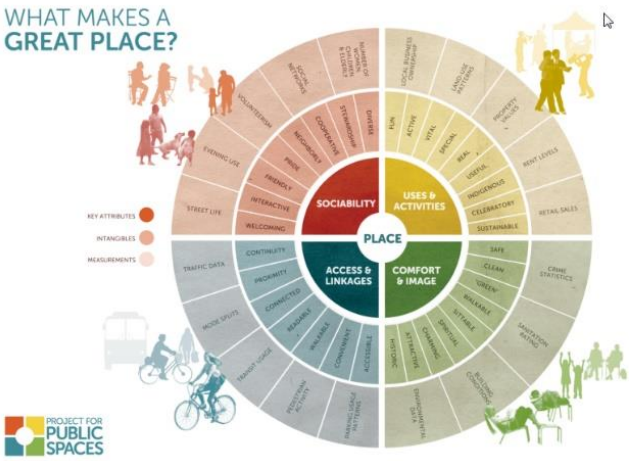


Figure 2-11: Attribute of a conventional shared space

Using this concept to upgrade and improve the PTI and the corridors leading to the PTI would benefit the commuters and improve the user's perception and enhance safety and security.

Using the model below illustrated in Figure 2-12, as a guideline, the priority will move from vehicle to pedestrian but will still provide public transport with the required ROW.

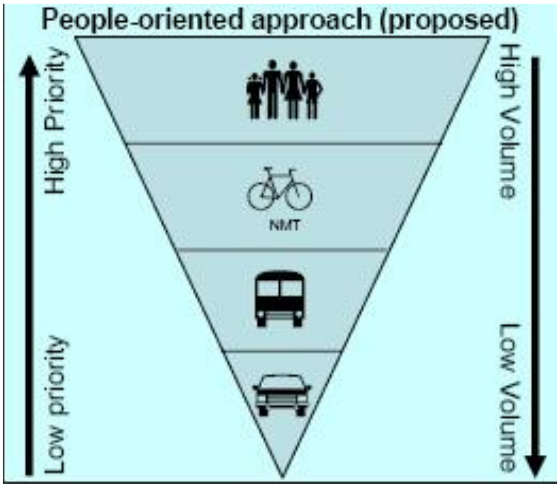


Figure 2-12:The hierarchy of transportation nodes

Initially, implementation of the model may cause higher levels of frustration and poor compliance as it adjusts to the new hierarchy. However, the benefits of the space such as the reduction in speed, better integration of modes, increase visibility or light segregation will become evident (Williams & Ruetener, 2016; WHO, 2013).

During the Mobility Indaba, Williams introduces an evaluation method called the SMART [6]tool. The SMART tool can be used to evaluate the utilization of NMT paths, facilities, and open spaces (Williams & Ruetener, 2016). Together with the SMART tool, the DoT developed methods to enhance shared spaces in the South African context. The three concepts were: pedestrian priority and developing a sustainable approach to urbanization, making space for pedestrians and ROW in terms of universal access (Department of Transport, 2016). All these concepts are focused on enhancing the pedestrian experience and improving the levels of service.

A study was completed in Auckland, New Zealand which evaluates a street that was highly motorized compared with a street that had been converted into a shared space. The transformation entailed redesigning the roadway and providing facilities like benches, road furniture, traffic calming measures, additional signage, minimal signal controls and safe zones on either side of the street. The conversion provided a higher

[6] SMART is an assessment tool which makes use of local and international Best Practice to evaluate NMT paths, facilities and Open Spaces.

level of service to pedestrians instead of motorists (Karbdacharuk, et al., 2015; Kos, et al., 2013).

The study also included a Likert scale method survey where the road users provided feedback regarding the changes. The aim of the survey was to determine the attitudes of road users. When asked to rate the space, 94% of participants perceived the change as positive with similar results recorded for the economic and location criteria. The conclusion from the survey indicated that safety was perceived as the most important aspect and the new shared space displayed this (Karbdacharuk, et al., 2015).

Without complete reconstruction, a combination of the methods can be used to improve the area leading towards and at the PTI. Acquiring community buy-in would be pivotal to the maintenance and longevity of the infrastructure. Providing the community with a safe space that will benefit generations to come would enhance the area and encourage the use of public transport. Providing NMT facilities will promote the mode of transport and the facility can be used as an educational hub to the community surrounding the shared space regarding the advantages of NMT.

2.15 NMT Challenges in Cape Town

The Southern African Transport Conference held in Pretoria, South African in 2014 covered a range of topics regarding the pinch points of the end-users' journey. The challenges faced by the NMT user in Cape Town include:

- Inadequate and lacking infrastructure for moving along the roadside
- NMT infrastructure is not continuous
- Land use and transport planning does not always take NMT needs into account
- Limited funding for maintenance of NMT facilities thus not user-friendly
- Deficient intermodal transport planning practices
- A lack in sense of security for NMT users and
- Universal designs are not applied, i.e. universal access, traffic density, and volumes restrict shared road use.

(Labuschagne & Ribbens, 2014; WHO, 2014; Von Der Heyden, n.d.; Arrive Alive, n.d.).

In addition to the above challenges, South Africans do not have the lack of choice of public transport mode, the condition of the vehicles and the poor NMT facilities (Von Der Heyden, n.d.). Pedestrians are forced to walk in the street because inadequate space is provided on the sidewalks. Sidewalks are overcrowded with the high volume of pedestrians using the facility. In addition, the sidewalk is shared with the cyclist, road furniture and services that create a safety hazard (Von Der Heyden, n.d.). According to the CoCT, effective public lighting is critical to facility usability and increasing the level of safety in terms of deterring crimes (Weyers, n.d.). This increased the unattractiveness for the commuters and instils fear into the commuters that must use the facility.

During protesting and taxi violence out-burst commuters are forced to use their own vehicles. Although additional costs are incurred, no alternative model is available. The repercussions of less operational public transport and more personal vehicle increase the level of congestion (Ligege & Nyarirangwe, 2015; Cooke, et al., 2017; Cooke, et al., 2017).

2.16 Criminality

340 000 instances of theft occur in South Africa annually, equating to 933 thefts daily which translates to 40 cases hourly (Writer, 2016). Criminal activity affects all South African especially when walking to the PTI. The journey becomes more challenging when the lack of required facilities like sidewalks, lights, and remote extended walking distances form part of the commute.

Wright and Ribbens (2016) elaborate on the significant safety threats experienced from criminal activity and believe that criminal behaviour has a direct impact on road safety, (Arrive Alive, 2019; Wright & Ribbens, 2016). Crime readily occurs at the PTI, along the route towards the PTI and when commuters least expect it.

Criminal activities are more likely to occur in a densely populated area, where high volumes of people are present or where the socio-economic status is questionable (Crime Registrar, 2017/2018). These characteristics are consistent with those of a PTI. Common robbery is one of the criminal activities which can easily be executed in this environment (Wright & Ribbens, 2016). The Africa Check crime fact sheet revealed that on average, 146.4 common robberies were recorded daily in 2016 (Africa Check, 2017). Common robbery at overcrowded PTI's and commuters being attacked while walking from or towards the PTI is common (Wright & Ribbens, 2016).

The South African Police Service (SAPS) Annual Report showed that common robbery mostly occurs on weekends, although consistent throughout the week. These trends develop as a result of the receipt of wages and weekly grocery runs (Crime Registrar, 2017/2018).

SAPS reported that crimes where weapons such as firearms and knives were used, accounted for 88% of the instruments used when performing a crime (Crime Registrar, 2017/2018). Africa Check concurred this statistic recorded a daily average of 386.2 incidents of robbery with aggravated circumstances in 2016 to 2017 (Africa Check, 2017). Furthermore, Stats SA published a reported titled crime against women in South Africa that found that woman are deprived of participating in certain activities including the use of public transport due to the fear of crime (STATS SA, 2018). Women also feel unsafe walking during the day and at night. Generally, females are more likely than males to use public transport, however, in the last 10 years, a significant amount of woman have received driver's licenses (Statistics South Africa, 2013).

Crime Stats Simplified released a list with the ten worse precincts in Cape Town with the largest number of reported crimes. The top two areas are found in the Cape Town Municipality, namely Cape Town CBD (16246) and Mitchells Plain (15205) (Crime Stats SA, 2019). Mitchells Plain forms part of the investigation area for this research.

2.17 Dangerous Driver Behaviour

At a defensive driving day training, an advanced driving instructor was asked to identify characteristics of bad driving habits and the effects of driver's behaviour on the road. Advanced drivers, specializing in driver training and defensive driving techniques listed a few bad driving habits that could contribute to poor roadway manner (AA, 2017).

Typical poor driver habits contributing to crashes include; insufficient following distance, not positioning oneself for maximum control of the vehicle, not looking far enough ahead, resting the arm on the window sill, using a cell phone whilst driving, running a red light, driving in the emergency lane, overtaking on barrier lines, slouching behind the wheel and gearing down when slowing down. Most of these habits delay the reaction time required to react to an emergent situation (AA, 2017).

Safe driving requires the use of both hands as well as mental and physical skills. The set of behaviour described above is highly dangerous to pedestrians especially as they cannot predict the drivers next action (AA, 2017). AA reported that the biggest failure to safe driving is having an incorrect mindset before stepping into the vehicle. Many

drivers do not undergo formal training and fail to complete pre-trip checks on their vehicles. As insignificant as this may seem, it could be life-saving for both the driver of the motor vehicle and the other road users using the facility. Often pedestrians and drivers communicate by means of eye contact or hand gestures. The communication helps both road users formulate a reaction and alerts the other of what to expect (Sucha, et al., 2017).

The RTMC showed statistics, listing the most common day, time of day and time of year for crashes to occur (RTMC, 2018). According to the report:

- The most fatal accident happens on Friday, Saturday and Sunday
- The most common time for crashes to occur is between 6 pm and 8 pm

  (RTMC, 2018; Hippo, 2018)

The RMTC further reported that the contributing factors to these crashes were human factors, vehicle factors and environmental factors. Research shows despite the high number of human factors towards crashes there is very little published on driving behaviour in South Africa (Africa, 2019).

2.18 Pedestrian behaviour

Pedestrians are known to be the biggest causes of accidents as their movements are highly unpredicted. Most pedestrian crashes occur while crossing the road (WHO, 2013). Engineering design aims to provide an efficient crossing facility that is well-positioned and that prioritizes the balancing of pedestrian movements (Levulyte, et al., 2017). Although signalised crossing is provided, many pedestrians tend to cross the roadway through traffic gaps or at a point where many pedestrians have crossed repeatedly.

Research Gate published research that created a prediction model based on how pedestrians behave in a social setting. The model showed pedestrian behaviour in a social setting where influencing factors such as physical constraints, pedestrian environment, communication and social interaction with other road users (Moussaid, et al., 2010). In addition to the above-mentioned factor, it is believed that the pedestrian attitude will lead to a negative or positive outcome. Conforming to subjective norms like social pressures and the beliefs of the people associated with them are generally factors that influence pedestrian behaviour (Olawole, 2017). An outcome from the

model indicated that pedestrians never walk alone indirectly resulting in constant social pressure along their journey (Moussaid, et al., 2010).

A case study was done in Athens comparing observed pedestrian behaviour to the declared pedestrian behaviour. The survey covered three crossing patterns namely:

- crossing the road with signal and signalized pedestrian crossing
- crossing minor roads without marked pedestrian crossing
- crossing major arterials with signal-controlled crossings

(Papadimitriou, et al., 2016).

Understanding exposure to crashes and injury risk is needed as this can save and protect many pedestrians. Using the latest technology and innovative engineering solutions is necessary for these improvements (WHO, 2013). In most scenarios' pedestrians are unprotected when interacting with traffic. The most important factor in pedestrian fatalities is post-crash care. (Levulyte, et al., 2017). Levulyte et al, elaborate on the reconstruction of the crash where the 3 critical stages are evaluated: pre-crash, crash and post-crash and the impact it can have on saving a pedestrian (Levulyte, et al., 2017).

2.19 Universal access

In 2011, the Census Household Survey recorded that 7.5% of the South African population is disabled with 5.4% of the Western Cape's population is disabled (Lehohla, 2011). Statistics show an increase in disabled individuals during the period from 2011 to 2013. The National Household Travel Survey reported that 9.5% of the Western Cape's workforce is disabled (STATS SA, 2013).

Navigating the streets and public transport network in the City of Cape Town can be challenging - especially for Special Needs Users (SNU) (Tukushe, 2014). More people are aware of and sensitive to SNU. Mobility should be available to any road users.

Designs limited facilities for SNU creating a gap in SNU's participation in society because of constricted accessibility. SNU's have no choice but to rely on able-bodied persons for assistance when wanting to use the transportation system. The repercussions of SNU's not being able to access basic transportation facilities deprived them of equal access to education, health care, and social opportunities (Tukushe, 2014). SNU would be considered as part of the most vulnerable road user category.

There are various kinds of road users that use UA. The most common are visually impaired users and physically impaired users. In the same way that each impairment is different, each “solution” must be applicable to the “desired improvement” and not retrofitted into the facility. (Frieslaar, et al., 2015)

The gap had to be filled to ensure that no vulnerable road user is left behind. To improve on the various special needs facilities each need was evaluated individually.

The main challenge for **physically impaired** pedestrians is the accessibility of a wheelchair, which coincidently caters to strollers as well. By overcoming this and providing a safe crossing environment will also act as a traffic calming measure. In areas with high pedestrian volumes e.g. bus stops safety precautions such as separation barriers must be incorporated in UA.

The main challenges for **visually impaired** users are navigating through pedestrian phases - in traffic cycles, directional changes - at intersections, clear makings and adequate lighting.

Providing these facilities enhances safety and security as well as the user's experience. In recent years there has been a global increase in innovation and research to meet the needs of differently-abled individuals. Countries like Germany and Australia have implemented methods to assist road users to identify where to cross safely. This was done by means of audible messages that provide location and instructions to assist in crossing the road. These are some of the methods that should be incorporated into design and engineering practice as a standard consideration.

South Africa’s biggest drive for UA implementation was rolled out with the BRT network, although this is well received, the majority of NMT users are not able to use the BRT as it only serves a selected few neighbourhoods. The intention was to include better-integrated transport system into these residential areas with a BRT system however the older transport facilities such as the taxi ranks around the Western Cape have not been upgraded.

Lessons can be learnt from the European innovation and from the BRT implementation. Simple design flaws can be avoided like that unsymmetrical drop kerbs installations or incorrect placement of tactile blocks. For physically impaired users the gradient might be too steep for safe wheelchair access.

Ultimately, the design should satisfy the needs of SNU by including equitable facilities, providing improved access opportunities, enhancing the quality of life, ensuring continuity and building an inclusive city with equal opportunity for all citizens (Tukushe, 2014). This criterion might seem minor to an able-bodied person, but it is extremely challenging and risky for a differently-abled person.

2.20 FOUR E's

2.20.1 Education

"The DoT and DoE emphasized a long-term road safety strategy that will include road safety education" (Department of Transport, 2015; DoE, 2019). In 2006, an announcement was made that pupils will study road safety as part of the schooling curriculum, receiving road safety education as part of the schooling system is believed to be one of the most effective ways to relay the seriousness of the road safety matter to the youth. (Arrive Alive, 2018)

Arrive Alive stated that children and young people have high involvement in road crashes. Incorporating road safety education into the curriculum will develop knowledge, skills, and attitude to enable an improvement for all road users in the future (Arrive Alive, 2018). Although the youth is being educated, there is still a large knowledge gap in the NMT commuter group, as the working-class spans over a wide age range (STATS SA, 2013). A lack of inability to identify road signs and signals might be the reason for the high number of crashes.

A literature review done by Dragutinovic and Twisk elaborates on effective methods incorporating road safety into the education curriculum. The report states that road safety education should be contextualized, and education should emphasize the daily activity of a learner, so the process can be internalized. The road safety material should be authentic and include practical exercises as it may be difficult for the learner to put into action what they have learned whereas it is easier to read books or play games which can be used to enhance learning in the classroom. A contributor to the learner's behaviour is the influence of the community since they determine what is socially acceptable (Dragutinovic & Twisk, 2006; iRAP, 2010).

The following aspects are provided by RTMC partnered with Arrive Alive as educational shortcomings within the South Africa context (RTMC, 2017):

- Obeying traffic signals.

- Warning about the dangers of distraction when walking
- Walking in the road and not on the sidewalk
- Crossing the road at an undesignated area
- Not looking both ways when crossing
- Do not walk and stop halfway across the road
- Never assume that you have been seen and make eye contact with the driver

2.20.2 Engineering

Engineering plays a vital role in the functionality of the NMT facility. Part of the engineering responsibility is to identify the problem and ask the correct questions. Providing a facility that is suitable to the client, the end-user and the environment. Engineering planning and design should make road use efficient and safe for all road users especially NMT users.

Apart from traffic calming and speed management to ensure the implementation of safe, speed limits plays an important role as part of engineering. Setting and enforcing speed limits are the most effective methods of reducing road traffic injuries according to the WHO (WHO, 2018). Combining the traffic calming measure with speed management would reduce road crashes between 2 – 3%.

These responsibilities include accessing the risk, identifying the high-risk location, identify common problems and recommend countermeasures.

Engineering contribution focusses on:

- Road planning and placement of facilities like traffic calming features or posted speed limits
- Separation of different modes in terms of low speed and high-speed road users
- Improving shared space
- Provision for continuous footpath with the correct dimensions for all NMT users
- Effective lighting and strategic placement thereof

- Placement of correct road markings such as zebra stripes with stop lines to alert vehicles of the NMT facility
- Limiting speed through traffic design like roundabouts
- Implementation of traffic calming measures to reduce speed and influence driver behaviour (Arrive Alive, 2018)
- Posted speed limits adjusted according to weather, traffic condition and time of day

When these features are correctly placed, it encouraged road users to conscientiously make decisions and changed behaviour allowing road users to shift their mindset from a motorized focus roadway to a shared space (Arrive Alive, 2018).

Engineers provide solutions in different forms to mitigate the risk and recommend countermeasures. An evaluation tool was created specifically for South Africa known as the Pedestrian Environment Assessment Tool (PEATS). The model was created using the Australian Systematic Pedestrian and Cycling Environmental Scan, the Scottish Walkability Tool and the Pedestrian Environment Quality Index and examples (Albers, et al., 2010).

PEATS is vital to this research project to identify the shortcoming of the facilities by investigating the road-side environment using different criteria. All the engineering-focused solutions were evaluated and broken down into sections for which countermeasures could be provided. Peats considered intersection safety, traffic movements, street design, perception of safety, land use and road conditions. All these factors were considered during this investigation (Albers, et al., 2010).

2.20.3 Enforcement

Regulatory framework (legislation) is set up to ensure that a system works well and that all users can use the facility. For pedestrian safety to be prioritized and to decrease the number of fatalities, all road users must know and understand the laws, how it is implemented and compliance. Arrive Alive gave a list of laws that they deem critical in the pedestrian safety aspect namely; compliance with a legal speed limit, drinking and driving regulations, red light signal compliance and pedestrian traffic control signals (Arrive Alive, 2018).

The Netherlands is a good example of enforcement where a common method of enforcement are by-laws, mobility policies, speed control, vehicle, and parking

restrictions were policing. The police are responsible to enforce new regulations, traffic control and the police officers are properly trained to address these scenarios (Servaas, 2000). For each level of intervention, a list of requirements was given to achieve these intervention goals.

Without law enforcement reprimanding illegal activity, the PTI becomes a space where all users can misbehave without consequences including jaywalking, stopping in not stopping zone, cutting off traffic to allow passengers to disembark and disobeying control signals (Arrive Alive, 2018).

As part of enforcement, the research will provide a Local Road Safety Plan (LRSP). The LRSP will require the participation of many stakeholders to analyse, identify, prioritize and evaluate the framework to be implemented. LRSP strives to improve the local roads, specifically leading up to and surrounding the PTI as well as the PTI itself. Low-cost methods that are easily accessible and easy to implement forms the foundation of this plan. Prioritizing the more critical safety issues specifically feedback for the pedestrian survey will form the basis of the plan's compilation.

2.20.4 Encouragement

"Pedestrian safety is something that has to be entrenched in the mind of pedestrian from a young age" (Arrive Alive, 2018). All road users should be encouraged to obey the rule of the road. One could approach the matter by sharing information in schools informally, emphasizing the importance of crossing at designated NMT crossing facilities, safety awareness in schools or at PTI's and then promoting safety as "cool" (Arrive Alive, 2018).

The DoT encourages commuters to shift away from single-occupancy vehicles and developing a more desired pattern. Encouraging NMT is economical and this is crucial to a functional and prosperous economy. Apart from the economy, a sustainable environment positively impacts on congestion, minimized emissions and better air quality. The most important factor that should drive encouraging NMT, is the quality of life road users would acquire from a more active lifestyle. (DoT, 2017)

3. CHAPTER 3: METHODOLOGY

3.1 Introduction

The research method combined qualitative and quantitative research methods. The data sets were analysed using **inferential statistics** which was used to answer the research questions. The Analysis of Variance technique ANOVA was used to determine the correlation between the level of safety and perception of safety.

The study methodology evaluated the risk faced by pedestrians when travelling from their homes to the Public Transport Interchanges (PTIs) around Cape Town. The investigation sites were identified based on the unique Non-Motorized Transport (NMT) features which is a key contributor to the level of risk experienced. These PTI's was also selected to add variation to the research.

The information collected using this methodology was used to formulate the local road safety plan to improve the facility in terms of minimizing the risk, improving safety and security and the perception of the public transport system.

3.2 Data collection

The data analysed for the research was collected from a variety of sources at different times during the research period. A five-year evaluation period, from 2012 to 2017 was selected for the crash data and the criminal data. A five-year period was chosen to improve the accuracy of the data. According to the United States Census Bureau, sample sizes of 1-year, 3-years and 5-years can be used. The benefit of using 5-year or more include: largest data sample, most reliable in terms of identifying trends or errors and the 5-year data set is best used when accuracy is required (US Government, 2019).

3.3 City of Cape Town: Crash Data

Crash data was collected from the City of Cape Town's Transport Network Management Centre. The raw data was presented in a spreadsheet format and contained the following information: node location, crash date, day and time, crash type, alleged cause, the person involved as well as injuries suffered. The crash data was analysed using the **inferential statistic.** This analysis was used to determine key elements such as hazardous locations, in terms of the highest number of reported incidents, and if there are any trends at the PTI's in terms of time and day of the incident. While every reasonable effort was made to ensure the information provided

is accurate, the City does not accept legal liability for the accuracy, reliability or completeness of the information disseminated.

3.4 South African Police Service: Criminal Data

Unfortunately, due to concerns regarding the confidentiality of the data from SAPS, the Mitchells Plain criminal data could not be disclosed.

The criminal data was collected from the Criminal Information Management and Analysis Centre (CIMAC) department of the Bellville and Claremont police stations. Due to the sensitive nature of the information, precautions were taken to ensure that all the victim's personal information was removed from the data set and that none of the personal information reflects in this research. Like the crash data, the criminal data provided the researcher with the locations, crime dates and times as well as the nature of the crime.

The criminal data was used to determine the level of safety at the PTI based on the frequency of criminal activity. In addition, the data was utilised to identify typical characteristics of the PTI in terms of the time of occurrence, the type of crimes as well as general trends in the criminal activity.

3.5 Ethical clearance

As per Stellenbosch University's requirements, any research that uses questionnaires, as a form of data collection, must complete the ethics clearance process. Once the questionnaire was completed the researcher submitted it to the Ethics Board for their approval. They approved and the approval letter has been attached as Annexure A.

3.6 Questionnaire

A questionnaire was created as a qualitative measure to gain knowledge from the commuters about their perception and experience (Annexure C). A total of 300 questionnaires were distributed to random commuters at the various PTI's during morning and afternoon peak periods. Volunteer's acted as fieldworkers, distributing the questionnaires at the various PTI's. The volunteer's received training on the questionnaires based on the Ethics criteria. The questionnaire process, from the first date of distribution, took 4 weeks to complete.

The commuter could either complete the questionnaire during their journey or complete a questionnaire and return it to the field worker at a later stage. The questionnaire revealed general information like travel times, gender, age and the multiple-choice

questions which prompted responses with regards to safety and security, pedestrian behaviour and risk appetite. The questionnaire together with the crash data and criminal data would provide information to identify the problems and the needs of the facility.

After the data was received from the respondents, it was transferred to Survey Monkey for analysis. Survey Monkey's graphical representation of the survey information was used to discuss the trends found in the data.

3.7 Site visits

Site visits were conducted at the PTI's under investigation to examine features that were not identified by the questionnaire and collected data. In addition, the site visit was used as an opportunity to evaluate the pedestrian facilities available at each PTI.

The site visits were conducted on four different dates and can be seen in Table 3-1: Dates when site visits were conductedTable 3-1 below.

Site visits were completed during daylight hours since the PTIs are crime hotspots after dark. The researcher arranged supervised visits with a taxi owner to ensure the safety of the team. This limited the site visits to weekends during daylight hours. The preferred time to visit the site was at 9 am when the peak had just finished.

Table 3-1: Dates when site visits were conducted

SITE	DATES OF SITE VISITS			
	SITE VISIT			DISTRIBUTION
Bellville	28/04/2019	27/07/2019	02/09/2019	09/09/2019
Claremont	7/04/2019	17/07/2019	3/08/2019	12/09/2019
M. Plain	9/06/2019	27/07/2019	3/08/2019	09/09/2019

Each site visit served a different purpose. The first site visit was used to determine the layout of the PTI and to identify NMT features that were unique to each area. Photographs of the study areas were taken and have been added as supporting evidence throughout the report.

During the second site visit, an evaluation known as the Pedestrian Environment Assessment Tool (PEAT) was completed. This tool assessed the intersection safety, traffic, street design, perceived safety, land use and road conditions. The researcher used descriptions of the site as a preliminary application and then evaluated the specific factors deemed important to pedestrians (Albers, et al., 2010). Each variable was then rated as to whether it positively or negatively affected the pedestrians and a percentage of assessment was presented for each feature. A PEATS matrix was compiled to identify which facility has the most suitable pedestrian environment. The third site visit was used to finalise data collection and to ensure that all features were included.

The final date listed Table 3-1, was the date the first questionnaire was distributed. The fieldworkers completed the process within four weeks. The questionnaires were distributed during morning and evening peak. The fieldworkers only collected data during daytime hours. This was done as a safety precaution.

3.8 Sample selection

As per the general household survey, commuters are divided between the most common modes of transport as follows (STATSSA, 2017):

Table 3-2: No. of commuters travelling per mode in the Western Cape

MODE	TOTAL COMMUTERS (N)
Bus	812 000
Train	448 000
MBT	3 982 000
TOTAL	5 242 000

The sample size was determined using an online calculator from Qualtrics. The calculator allowed the researcher to input various parameters such as confidence level, population size, the margin of error and the output was an ideal sample size. For the study, the following parameters were used (Qualtrics, 2019)

Table 3-3: Study input parameters

PARAMETER	VALUES
Confidence Level	95%
Population Size	5 242 000
Margin of error	7%

Based on the input parameters the following output was obtained as can be seen below:

Confidence Level:

95%

Population Size:

3982000

Margin of Error:

7%

Ideal Sample Size:

196

The researcher distributed 300 questionnaires (100 per PTI), which exceeded the minimum of 196 questionnaires required as a representative of the chosen sample (Qualtrics, 2019).

Probability sampling was chosen to ensure that the overall representation of the group(s) of commuters was covered (Tool4dev, 2019). This method of sampling was chosen for practicality and due to limited time and resources.

3.9 ANOVA

Analysis of variance is a statistical method used to compare the means of different samples. The purpose of this analysis is to test the significant difference between the means and is also known to be an extension of the t-test and z-test. The questionnaire's answers were converted to numerical values using a scale from 1 to 5 which was then analysed.

3.10 Limited research

During the research, it was found that not many papers covered NMT in South Africa. Many of the papers looked at the safety of the NMT facilities only and not at the pedestrians at the PTI. The researcher attempted to fill this gap by gaining first-hand knowledge and experience from the commuters by distributing questionnaires at the different PTI's.

Unfortunately, the location of the crashes was not accurate as the GPS co-ordinates were not recorded when the crash was reported/recorded.

Training sessions were conducted with each of the volunteers to assist them with the data collection. The questionnaire was handed out in transit to avoid additional time being spent at the taxi rank. Only 10 questionnaires could be handed out per trip and this increased the number of volunteers used.

4. CHAPTER 4: RESEARCH DESIGN PTI OVERVIEW

4.1 Introduction

The research design provides an overview of the various PTI's that will form part of the investigation and the unique features that are influential to the safety and security of the pedestrians. Each PTI is reviewed individually to identify the crucial differences and issues that can be addressed as part of the local road safety plan. The section is divided into Bellville, Claremont and Mitchells Plain PTI's within the CoCT. Each PTI will be evaluated individually, based on the statistics, structure, location and pedestrian experience.

The Transport Development of Cape Town (TCT) categorizes the various PTI's within different corridors based on a primary accessibility grid assessment (Transport for Cape Town, 2013). Each corridor feeds from different sides of the City of Cape Town Municipal area, however, Bellville forms part of two of the four corridors, and the corridors are as follows:

- Western Corridor - Feeding the Simons Town and West Coast region.
- Southern corridor - Linking between Claremont, Wynberg and Somerset West.
- Eastern corridor - Linking between Mitchells Plain and Khayelitsha to Bellville.
- Urban corridor - Operating from Bellville, along Voortrekker road funnelling commuters from the Northern Suburbs to the CBD.

These PTI's is a representation of three of the four corridors identified by TCT. The PTI's were selected based on location and the number of pedestrians using the facility daily. The research focused on the interaction of pedestrians with the facility in its entirety to establish the problem within the facility.

Data was collected for each PTI that shows the pedestrian incidents, crash statistics and the crime statistics specific to the area. These data sets were selected to identify the risk at the PTI as well as the level of safety and security experienced by commuters when using the facility.

4.2 Investigation area

4.2.1 Bellville PTI

Bellville PTI was established as the second largest PTI in the CoCT. The PTI is multi-modal and is divided into three sections namely; the taxi rank, the railway station and the bus terminus. The PTI is in the centre of Bellville and has the Middestad Mall and many smaller vendors within a radius of 50m. Bellville is largely used as a transfer point between origin and destination. In recent years, Bellville has unfortunately experienced taxi violence which has forced the City to close and reopen the interchange several times.

As part of the investigation, the researcher has included all roads adjacent to the facility as these roads are used to access the PTI by commuters.

4.2.2 Bellville PTI layout

Figure 4-1 below shows an aerial view of the Bellville PTI. The image has been colour coded to indicate the different elements of the PTI. The green pins show the intersections and the orange lines indicate the links between the intersections being investigated. The three different sections have also been colour coded: Red-Taxi, Blue-Bus and Purple-Train.

Figure 4-1: Aerial view of Bellville PTI

Table 4-1 below lists the intersections that surround Bellville PTI and indicates how the intersections recurrently controlled.

Table 4-1: Intersection road names and intersection types surrounding the Bellville PTI

ROAD NAME	INTERSECTION
Robert Sobukwe Road and Tiener Meyer Bypass	3-leg Signalised
Robert Sobukwe Road and Belrail road	4-leg Signalised
Robert Sobukwe Road and Reed Street	One-way stop control
Belrail road and BPTI Entrance	Signalised
Belrail road and Church street	Signalised
Wilshammer Street and Charl Malan road	Un-Signalised pedestrian crossing
Charl Malan road	Un-Signalised pedestrian crossing

Bellville PTI has distinguishing features that have not been identified at the other PTI's. Bellville is the only PTI that has the entrance and exit adjacent to one another. This creates congestion and pedestrians and vehicle constantly mixed because all the facility uses one entrance and exit.

Bellville has 2 holding area's that are situated outside the main PTI. Unfortunately. these areas have become home to informal settlers. The boundary palisade fence surrounding the PTI is used as anchors for these dwellings.

4.2.3 Pedestrian movement

Figure 4-2 shows the dominant commuter routes at Bellville PTI. These routes were observed during the site visit and displayed on an aerial photo of the area. Since the PTI has a fence along the boundary pedestrians are forced to walk to the front of the PTI and enter from one direction.

Figure 4-2: Main pedestrian movement at Bellville

4.2.4 Claremont PTI

The Claremont PTI forms part of the Southern corridor and acts as a transfer to Lansdowne, Claremont and Wynberg. The PTI formed part of the investigation because it feeds a large part of the Cape Town Southern Suburbs. It is situated in a more lucrative area than Bellville or Mitchells Plain and the facility is unrestricted in terms of circumference fencing. Claremont is a multimodal PTI that provides access to MBT, Golden Arrow buses and rail services. The facility is surrounded by Cavendish Square Mall, Stadium on Main and many schools are within walking distance of the PTI.

4.2.5 Claremont PTI Layout

Figure 4-3 below shows an aerial view of the Claremont PTI. The pins show the intersections that form part of the investigation area. Six intersections have been chosen, four surrounding the PTI and an additional 2 located at Newry Road to cover the pedestrian accessing the PTI from the Mall. The three different sections have also been colour coded: Red-Taxi, Blue-Bus and Purple-Train.

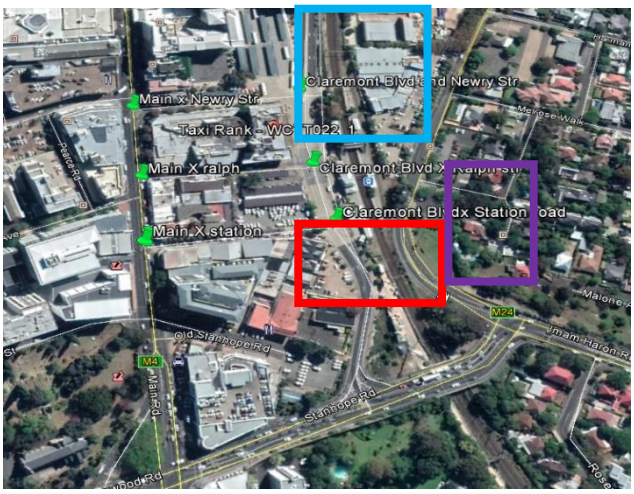


Figure 4-3: Layout of Claremont PTI

Table 4-2 below lists the roads adjacent to the PTI that will form part of the investigation. The table gives the intersections names and indicates how the intersection is currently being controlled.

Table 4-2: Intersection road names and intersection types surrounding the Bellville PTI

ROAD NAME	INTERSECTION
Claremont Blvd and station road	One-way access toward Main Road
Main Road and Station road	Stop control
Claremont Blvd and Ralph Street	Signalized
Main Road and Ralph Street	One-way access towards Claremont Blvd
Claremont Blvd and Newry Street	One-way access towards Main Road
Main Road and Newry Street	Signalized

The distinguishing features of Claremont PTI included:

The entrance and exit on opposite sides of the facility and a continuous flow of vehicles limited the congestion. Each transport mode is separated with adequate pedestrian facilities located between the various areas.

4.2.6 Pedestrian movement

Figure 4-4 shows the observed route most commonly used by pedestrians at the Claremont PTI. Many commuters travel from the along these routes since it is the most

direct route to access the PTI from the Main Road as well as from the train station. Since their area around the PTI is developed, the pedestrian routes are pre-set along with the road geometry.

Figure 4-4: Main pedestrian movement around Claremont PTI

4.2.7 Mitchells Plain PTI

Mitchells Plain was established in the 1970s when people of colour were forced to move out of the “white” areas under the Group Areas Act. With this, the taxi rank was established to move people from Mitchells Plain to the designated area of employment (Graham, et al., n.d.). The Mitchells Plain Town Centre (MPTC) project was launched in 2001 to upgrade the PTI as it was then the busiest taxi rank in the Western Cape. The MP PTI forms part of the Eastern Corridor in terms of the MBT routing system and has had the MyCiti operational from 5 July 2014 (MyCiti, 2014). MPTC PTI is used by approximately 75 000 commuters during the morning peak and the evening peak. The initial contract to upgrade the facility was signed and commenced in 2003.

The problems experienced at the MP PTI included:

- Busses and taxi sharing a sheltered area.
- Uncontrolled informal trading which congested the pedestrian walkways.
- Level of criminal activity such as gangsters, robberies and drug dealing.
- Decline informal business because of the uncontrolled informal settlements
- Functional conflicts between the movement of public transport, private vehicles and pedestrians(Graham, et al., n.d.).

The MP PTI will not form part of the statistical analysis as the criminal data could not be obtained. In addition, the crash data was found to be unreliable. MP PTI will, however, form part of the PEATS assessment and questionnaires will be distributed.

4.2.8 Mitchells Plain PTI Layout

MPTC PTI is a multimodal PTI that consists of a taxi rank, a bus stops, and MyCiti bus stop and a train station. The area is spacious and allows vehicles to move around freely. The facility has an entrance which is in the First Avenue and an exit located on 5th. This provides constant flow for the MBT with minimal traffic flow issues. The PTI is constructed in a way that each modal area is divided and operated independently from the others.

Figure 4-5 below has been colour coded to indicate the intersections that will form part of the investigation area as well as the road links being considered. The four different sections have also been colouring coded: Red-Taxi, Blue-Golden Arrow Bus, Purple-train and Yellow - MyCiti.

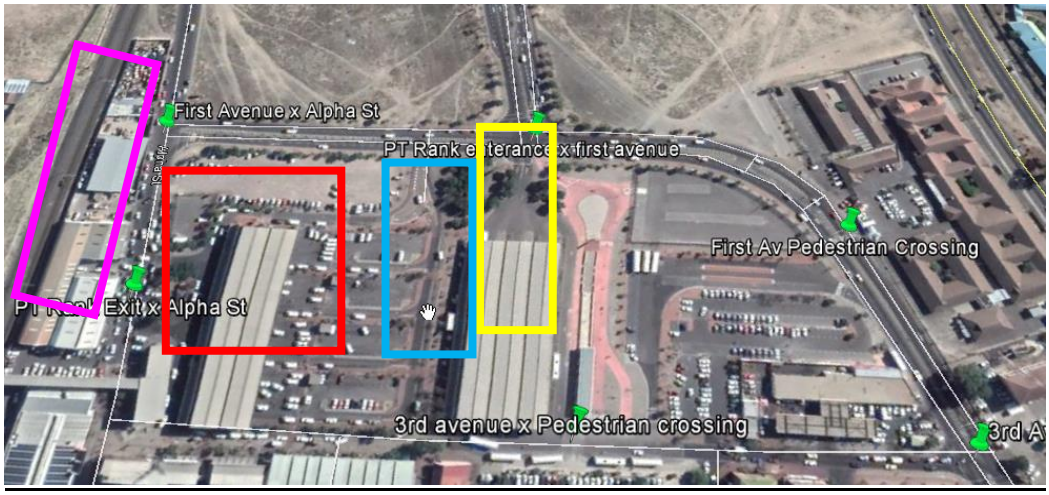


Figure 4-5: Layout of Mitchells Plain PTI

Table 4-3 below shows the list of roads that form part of the investigation and the number of pedestrian crossings used by commuters to travel from the community to the MBT.

Table 4-3: Intersections road names and intersection types surrounding the MP PTI

ROAD NAME	INTERSECTION TYPE
First Ave and Alpha Street	Stop control
First Ave and PTI entrance	One- way access into PTI
PTI Exit and Alpha Street	Uncontrolled
First Avenue and Third Ave	Signalized
Pedestrian Crossing and Third Ave	One-way access towards Main Road
Pedestrian Crossing and First Ave	Signalized

4.2.9 Pedestrian movement

Figure 4-6 depicts the dominant pedestrian routes leading towards the PTI. When comparing MP to the other PTI's, one can see that the area around the PTI is not as developed. The PTI has open spaces surrounding it which is used as part of the commuters desire lines. The routes do not follow the roadway as in the other examples.

Figure 4-6: Dominant pedestrian movement around MP PTI

5. CHAPTER 5: DATA ANALYSIS AND INTERPRETATION

5.1 Introduction

Chapter 5 discussed the various data sets collected over the duration of the research. Criminal and crash data was collected from various state parastatals, surveys were conducted using questionnaires at various PTI's, site visits and pedestrian facility evaluations were completed. The data has been presented in various forms to ascertain the level of safety and security of NMT users.

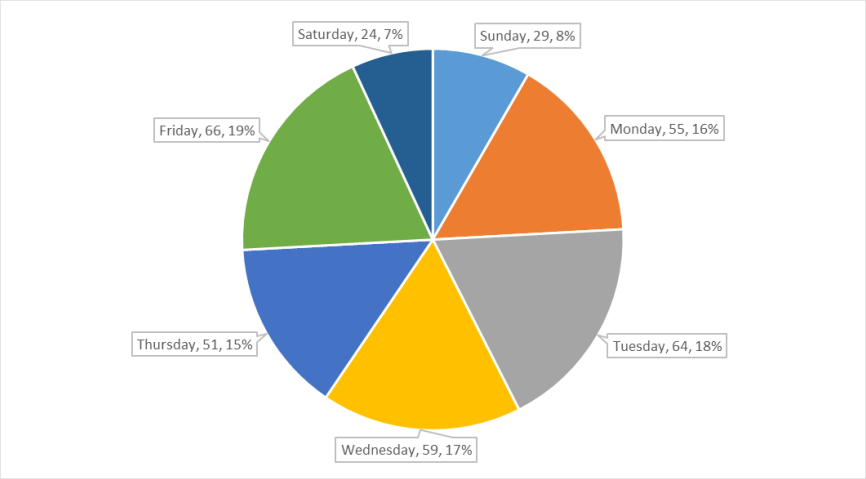
5.2 Crash data

The crash data was collected from the CoCT to identify the number of vehicle crashes and crashes involving pedestrians recorded around the PTI to identify key features that may result in these crashes. The overall crash data results are summarized below.

5.2.1 Crashes per weekday over a 5-year period

Graph 5-1 shows the total number of incidents that occurred at the Bellville PTI over a period of 5 years. A total of 348 incidents were recorded with the highest crashes seen Friday, Wednesday and Monday, although all weekdays resemble similar values these three days, were the worst. The highest number of crashes was recorded on a Friday with 66 incidents accounting for 19% of the total incidents and the lowest, 24 incidents accounting for 7% of the total incidents was recorded on a Saturday at the Bellville PTI.

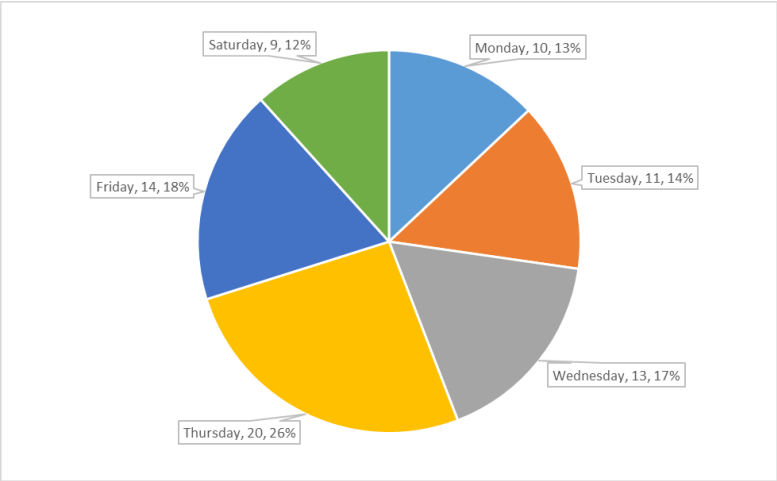
Graph 5-1: Total number of crashes per weekday over a 5-year period



Graph 5-2 below shows the incidents recorded at the Claremont PTI per week with a total of 67 incidents recorded. The most common day for incidents to occur was on a Thursday and Friday recording 20 incidents and 14 incidents respectively. 26% of the

incidents have been recorded on a Thursday with the lowest incident numbers recorded on a Saturday at 13% which followed the same trend as Bellville.

Graph 5-2: Number of incidents recorded, daily over a period of 5 years

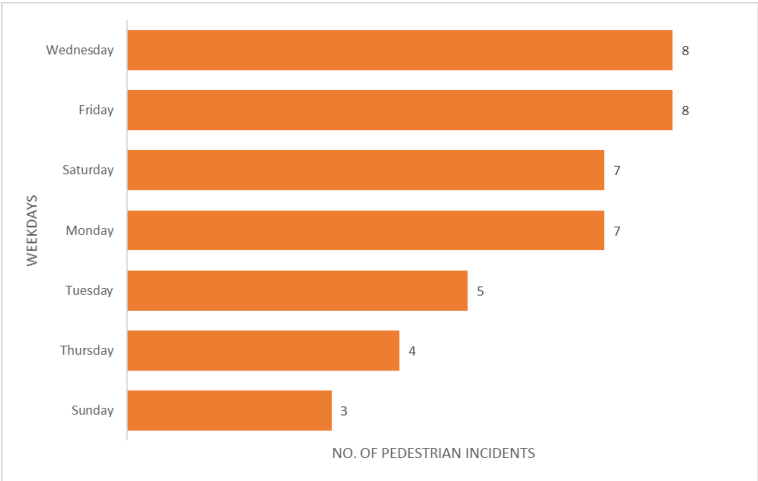


Bellville and Claremont both recorded Friday as a common day with high crash incidents, however, the highest number of crashes were recorded on a Thursday in Claremont and Friday in Bellville.

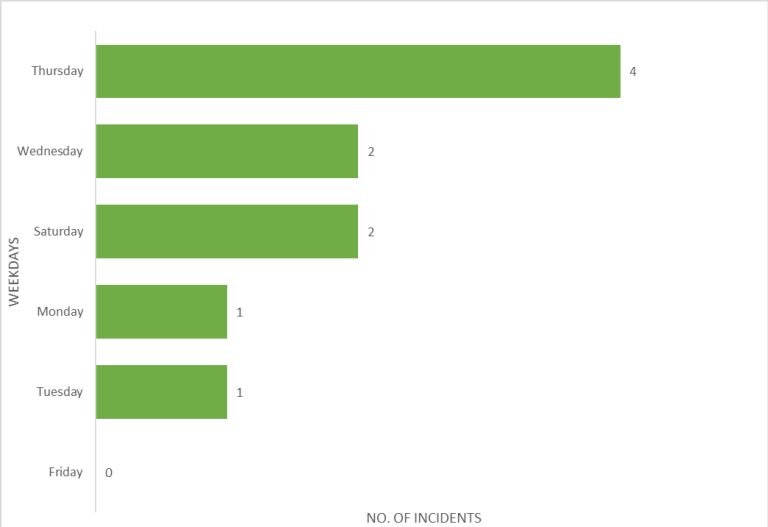
In terms of the weekend volume, Saturdays are generally labelled as the busiest days to complete activities that could not be completed during the week, specifically shopping. In this regard, most commuters are travelling with children and this could result in the commuter being on high alert resulting in the crash rate is lower on the weekend. Both PTI resemble similar trends which show low crash volumes on weekends.

5.2.2 Total Pedestrian crashes

Graph 5-3: Number of pedestrian incidents recorded over a 5-year period at Bellville PTI



Graph 5-4: Pedestrian incidents recorded over a 5-year period at Claremont PTI



A comparison was made in Graph 5-3 and Graph 5-4 between the pedestrian incidents at the Bellville and Claremont PTIs'. In the 5-year period, Bellville recorded 42 pedestrian incidents which equate to 12% of total crashes within this period. When converting the figure to a total number of pedestrian's incidents per year the record shows 8 pedestrian crashes per annum.

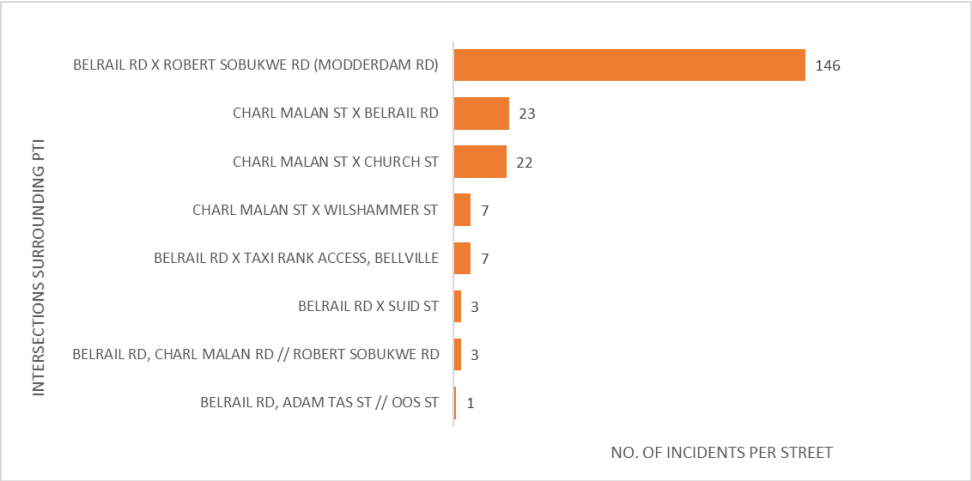
Bellville recorded the highest number of incidents on Friday, Wednesday, Monday and Saturday. The statistic corresponds to the crash data however the results at Bellville show a high pedestrian crash figure on a Saturday whereas the overall crashes show that Saturdays account for the lowest total crashes.

From Graph 5-4 above, representing the Claremont data set, pedestrian incidents are most likely to occur on a Thursday. This finding coincides with the graph that recorded the total number of incidents. Both results indicated that Thursday was the day with the highest number of crashes. Overall, for a 5-year period, 10 pedestrian incidents were recorded with 4 pedestrian incidents reported on Thursdays.

Both data sets correspond with the highest crash rates and highest pedestrian crashes being recorded on the same day of the week namely Bellville on Fridays and Claremont on Thursdays.

5.2.3 Crash locations

Graph 5-5: Top location for crashes o occur at Bellville PTI



A graphical representation of the top crash locations which account for the most incident locations surrounding the Bellville PTI can be seen in Graph 5-5 above. According to the graph above Robert Sobukwe Road recorded a total of 146 crashes. The CoCT provided the various location of crashes, from the 11 critical points 2 intersections recorded the highest crashes namely: Robert Sobukwe and Belrail Road and Robert Sobukwe and Tienie Meyer. Images of the intersections have been provided below to give context with regards to the intersectional cross-section.

Figure 5-1and Figure 5-2 shows the cross-section of Robert Sobukwe and Belrail Road where all possible vehicle movements can be identified.

Figure 5-1: Street view of Bellville at the intersection of Belrail road and Robert Sobukwe

Figure 5-2:Aerial view of the cross-section of Belrail road and Robert Sobukwe drive

The intersection of Robert Sobukwe and Belrail Road is the busiest intersection surrounding the PTI. Both intersections recorded the highest crash rates, also have the highest traffic volume and traffic movement towards the PTI even though the intersections are signalized. This intersection is the main access for vehicles travelling from North to South into Bellville. This signalized intersection has a significant number of traffic movements including right filter arrows, left filter arrows, slip movement and straight movements. The road cross-section is quite extensive with 4 lanes in the North-South direction and three lanes in the East-West direction. The intersection configuration favours vehicle movements but is less than ideal for pedestrian movement and the environment would be prone to pedestrian conflicts.

Figure 5-3 and Figure 5-4 below shows the intersection of Tiene Meyer and Robert Sobukwe Road showing the T-junction intersection layout with its various movements.

Figure 5-3: Street view of Tiene Mayer Bypass and Robert Sobukwe Drive

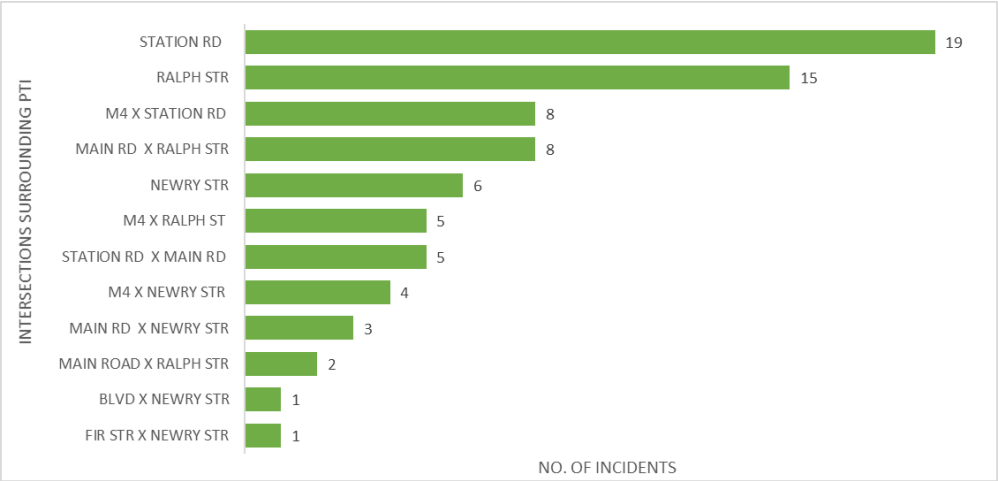
Figure 5-4: Aerial view of the cross-section of Tiene Meyer Bypass and Robert

Tienie Meyer Bypass is a three-way intersection with a cross-section of 4-lanes in each direction, recorded 104 incidents, which is the second-highest number of crashes surrounding Bellville PTI. South of Tienie Meyer Bypass is an industrial area and South East is the Bellville South residential area. Tienie Meyer would be the safest route for commuters to travel as a 2m sidewalk is provided on both sides of the carriageway with sufficient lighting and a refuge island dividing an 8-lane carriageway. Pedestrians travelling from Bellville South follow the same route to access the PTI and the provided pedestrian facilities are ideal to accommodate pedestrian behaviour.

While reviewing the intersection spacing it was found that the distance between Tienie Meyer Bypass and the Belrail intersection was measured at 178m, according to the standards as specified by the WCG and CoCT specification. The minimum distance between two intersections on a Class 2 road with a speed limit of 60 is 350m (WCG, 2016; CSIR, 1986). According to the design specification, this link falls outside the specification and may contribute to limited decision-making time, stopping distance and not enough room for vehicles to execute various movements. The substandard design could also explain the traffic build-up during the peak periods and driver's frustration influencing reckless driving behaviour such as driving through a red robot to avoid further delays. Since the two intersections are interdependent it can be expected that the two busiest intersections have a knock-on effect on one another. Another repercussion is the pedestrian vehicle-conflict, which is created when drivers behave

recklessly, and pedestrians are required to anticipate much more vehicle movement than is needed.

Graph 5-6: Top locations for crashes to likely occur surrounding the Claremont PTI



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Graph 5-6 above shows the most common locations for the incident to occur near Claremont PTI. Two signalized intersections, approximately 65 meters apart, recorded the most incidents at Station Street (20) and Ralph Street (14). The road most commonly used by the pedestrian is Ralph Street, where the PT exits the PTI. Figure 5-5 and Figure 5-6 and Station Road, Figure 5-7 and Figure 5-8 below show Ralph Road and Station Road. The characteristics of the two roads are as follows: Station Road is adjacent to the PTI and is a 2 lane, dual carriageway whereas Ralph is parallel to the PTI and is a one-way side street. Both roadways have sidewalks on each side, but Station Road has sufficient sightlines in every direction whereas Ralph Street is located between two buildings and this creates limited vision.

An observation made during the site visit was that commuters are unaware of the paved area let alone the meaning of different colour paving bricks that are found throughout the PTI. No signs have been erected to explain the variation nor has information been indicated on the ground in the form of painted instructions.

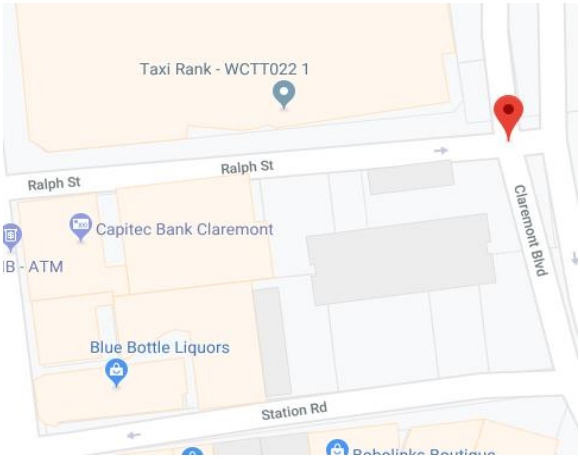


Figure 5-5: Arial view of Ralph Road

Figure 5-6: Street view of Ralph Road

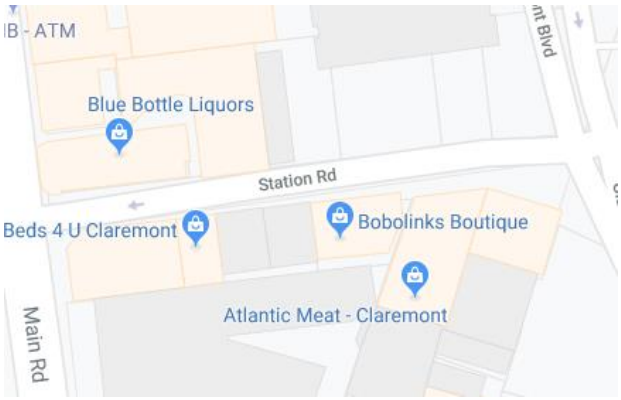
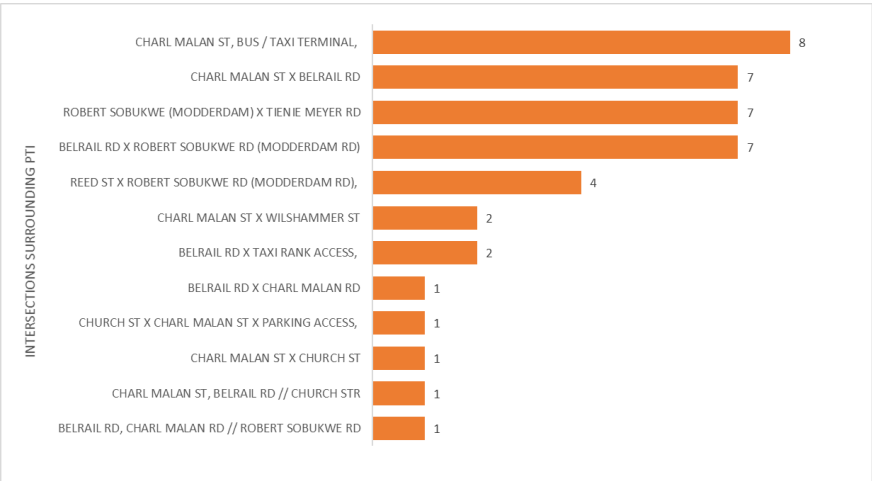


Figure 5-7: Aerial view of Station Road

Figure 5-8: street view of Station Road

5.2.4 Pedestrian crash locations

Graph 5-7: Total pedestrian incidents recorded in roads surrounding the PTI

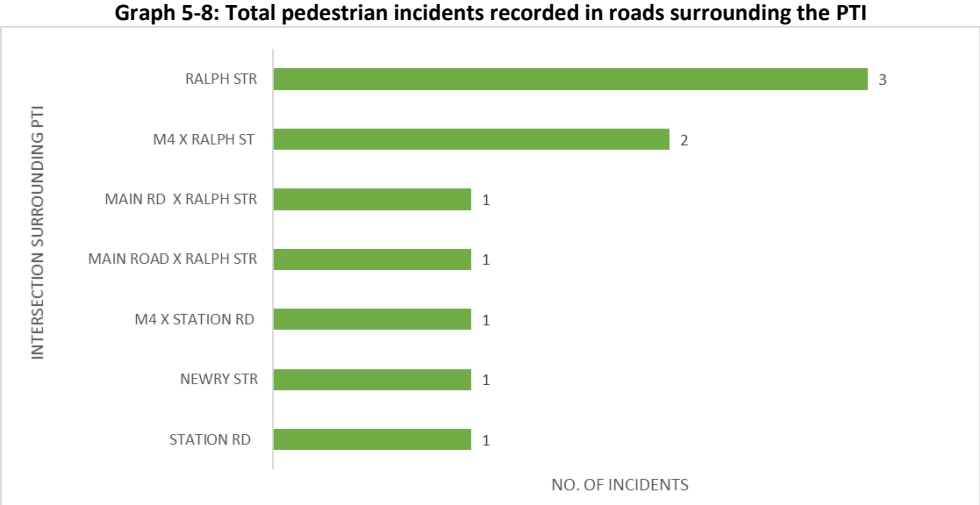


Graph 5-7 above shows the pedestrian incidents recorded in various locations around the PTI. Apart from the busiest intersections, the intersection of Charl Malan and Belrail

Road as well as the intersection of the PTI and Charl Malan Road record high numbers of pedestrian crashes.

The site investigation revealed that a pedestrian crossing is located approximately 60m from the Charl Malan and Belrail Road intersection and even though the facility is available a high number of crashes was still recorded.

Graph 5-8: Total pedestrian incidents recorded in roads surrounding the PTI



The data recorded in Graph 5-8 above shows that 8 incidents were reported at Ralph Street although, Ralph Street has features that are beneficial to commuters like a sidewalk on both sides of the road and lighting and shop fronts, the road is extremely narrow and has on-street parking which can obstruct the sight distance and many blind corners which can encourage criminal activity. During the site visit, the researcher found the area to be dark and this was immediately identified as a possible conflict zone.

As stated, the trends in terms of days of the weeks and location of crashes involving pedestrians are in line with the crash data of each PTI. No outliers have been recorded and the connection between crashes and pedestrians are graphically shown. Though no correlation in terms of similarities in days can be seen between the 2 PTI's.

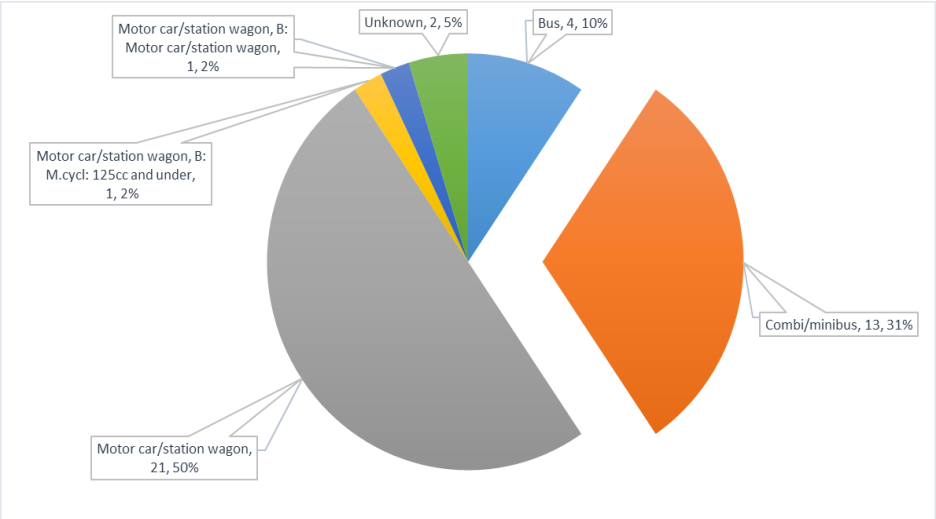
5.2.5 Vehicle types

Section 2.13.5 in the literature review elaborated the role of minibus taxi in crashes. According to the literature MBT was ranked as the second-highest vehicle involved in pedestrian crashes while the highest was recorded as motor vehicles.

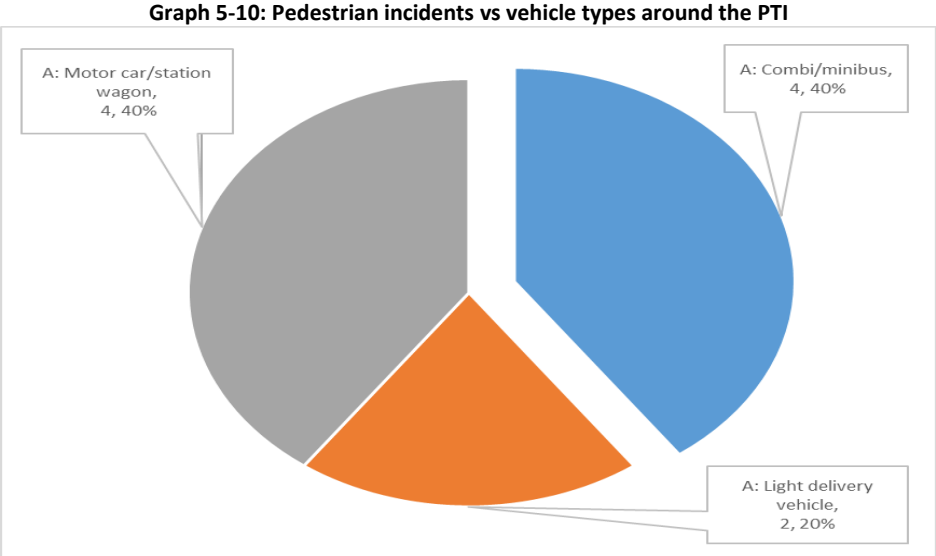
Both Claremont and Bellville recorded the same results with PT not being the main cause crashes, in addition to the mix modes at the PTI Claremont experienced light

delivery vehicles as part of the traffic. This is because of the business surrounding the PTI and it is important to identify the different land use which can show to expect in certain areas. The modal split found at the PTI can be seen in Graph 5-9 below for Bellville and in Graph 5-10 for the Claremont PTI. The land use surrounding both PTI's cater to a wide variation of business and vendors. The position of the PTI also allows vehicles to rat run through the street to access adjoining area's or facilities generating a range of different trips that are not necessarily expected at the PTI.

Graph 5-9: Pedestrian incident VS the vehicle type involved in the incident



Graph 5-10: Pedestrian incidents vs vehicle types around the PTI



5.3 Criminal analysis

The data for the six-year period, 2012 to 2018, was collected from the CIMAC departments at the Bellville and Claremont Police stations. The criminal data included

all the crimes experienced at PTI's as well as crime experienced by commuters when walking towards the PTI. Each PTI presented a range of crimes unique to the area, however, the most common criminal activities were common robbery, robbery with a weapon other than a firearm and robbery with a firearm. In addition, the Claremont PTI also experienced a high rate of general theft. Although common robbery and general theft are similar in nature, there is a distinct difference in terms of the intention of the criminal. The crimes can be differentiated as follows:

Common robbery: It consists of theft of property by intentionally using violence or threat of violence to induce submission to the taking from another.

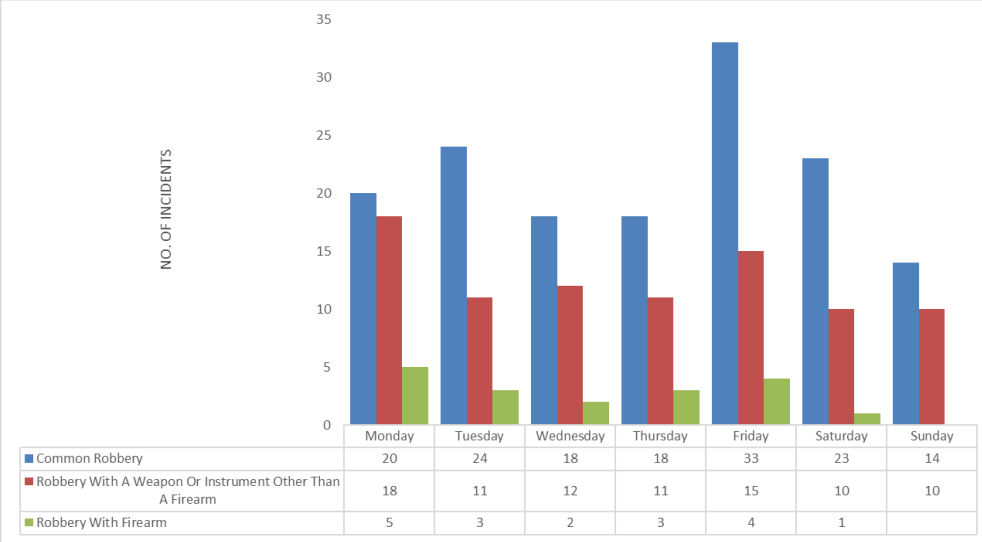
General theft: Consisting of unlawful appropriation of moveable corporeal property belonging to another with intent to deprive the owner permanently of the property".

Total crimes recorded over the six-year period in Bellville was 255 and in Claremont was 250.

5.3.1 Total record of criminal activity

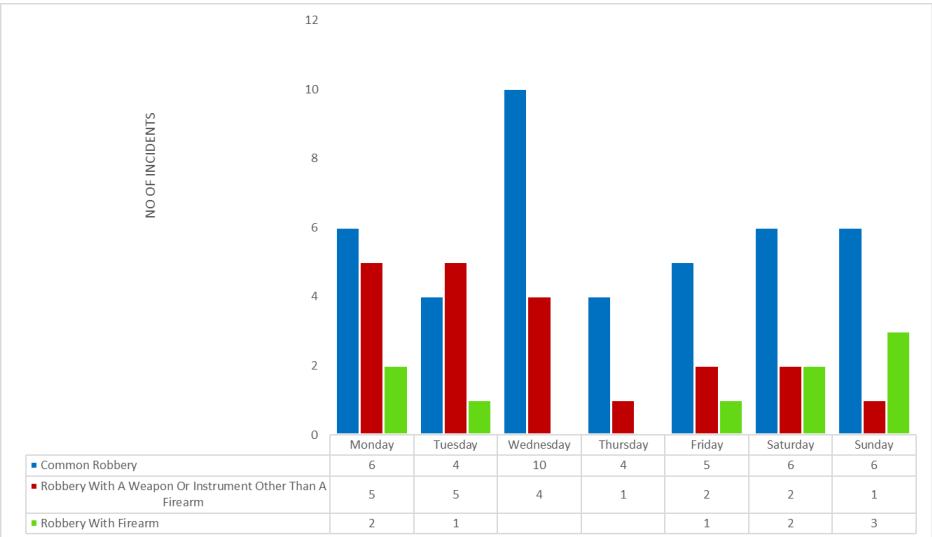
Graph 5-11 below illustrates the different crimes per weekday, recorded at the Bellville PTI. The graph shows a consistent trend in criminal activity throughout the week, however, the criminal activity accounting for the highest statistics are common robbery, most popular on a Friday and robbery with a weapon other than a firearm on a Monday. On a Sunday, no robbery with a firearm occurs even though it varies throughout the week with Monday recording the highest number of incidents with a firearm.

Graph 5-11: Criminal activity recorded at the Bellville PTI per weekday



Graph 5-12 below illustrates the breakdown of the crimes committed in and around the Claremont PTI. Within a six-year period, 70 incidents were reported with 41 reported as common robberies, 20 incidents with a weapon other than a firearm and 9 incidents of robbery with a firearm. The weekday that recorded the highest number of crimes was Wednesday (14) and Monday (13). An interesting finding was that in theft with a firearm was common at Claremont, yet the Claremont PTI was not prone to taxi violence outbreaks. Throughout the six-year period, no robbery with firearms was recorded on Wednesday and Thursday.

Graph 5-12: Total number of criminal activities recorded per weekday



When comparing the two PTI in terms of criminal activity per weekday it was found that the PTI does not have any correlation in terms of when criminal activities occurred. In

both sets of results, the data did not have any similarities across PTI's but remained consistent with the specific PTI crash data.

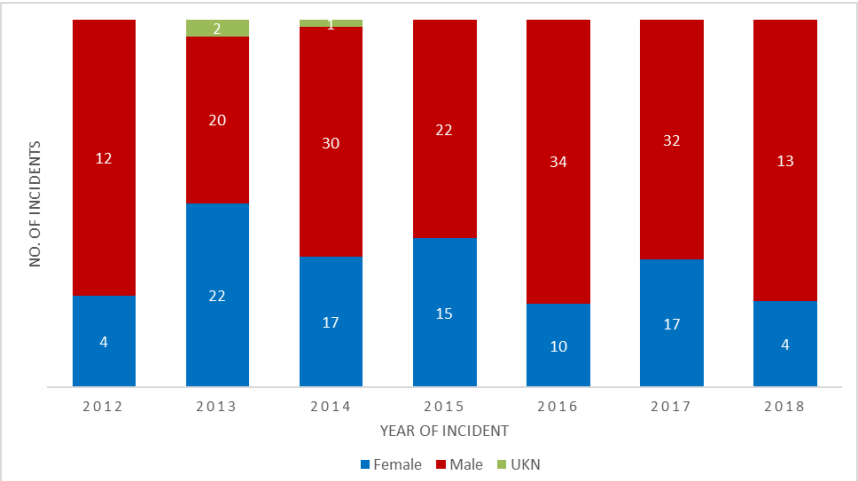
5.3.2 Gender-Based Statistics

Section 2.16 in the literature explained the characteristics of the road users which highlights the vulnerability of women and children using public transport. This group of road users are highly regarded in the design process.

A comparison was made between the number of males and females who reported criminal activities. Graph 5-13 below compares the difference between the various PTI and the male and female commuters in terms of incidents recorded over a five-year period.

Graph 5-14 below indicates that most of the annually reported incidents, for criminal activity, were from males. This is evident in 2016, where males reported 66% of the overall incidents. Consecutively, 2017 also recorded one of the highest male-female splits with 65% of incidents being reported by males that year. The only year females were found to report more incidents than males were in 2013, where females accounted for 50% of the incidents recorded.

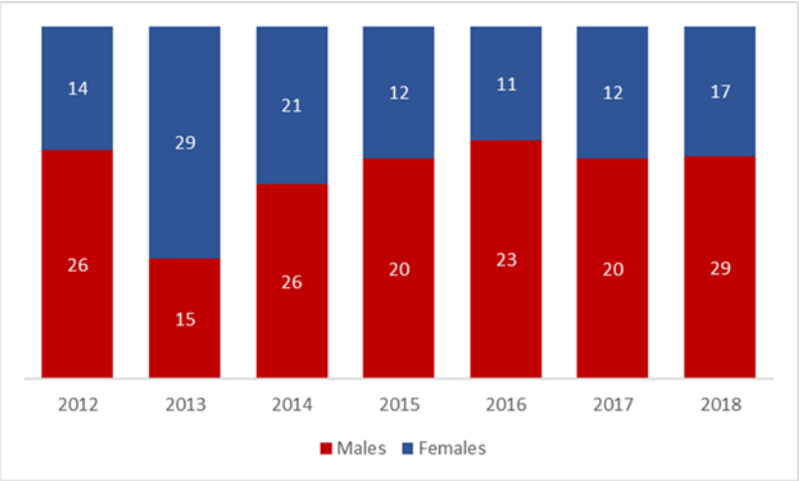
Graph 5-13: Total number of victims of criminal activity by gender at the Bellville PTI



A similar trend can be seen at the Claremont PTI where more males are found reporting criminal activity than females. In 2012, 2018 and 2014 males reported 63%, 65% and 55% respectively. The period of 2013 was the only year that recorded higher female statistics of 65%. The statistics referring to the female records in 2013, was like Bellville. This is the first trend that corresponds between the PTI's.

The reason for this trend could stem from the females wanting intervention measures to be out in place to address the criminal activity. As a result, more females found reporting incidents to pressure SAPS to provide safer conditions.

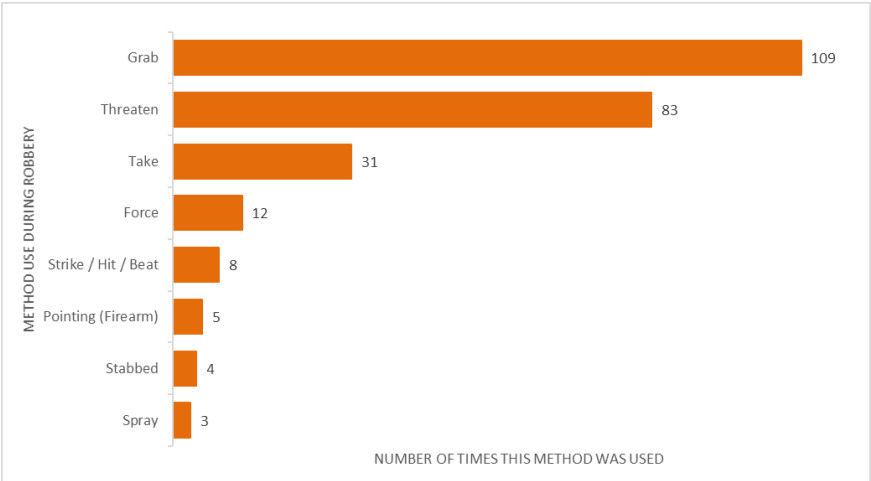
Graph 5-14: Total number of victims of criminal activity by gender at the Claremont PTI



5.3.3 Methods used for criminal activity

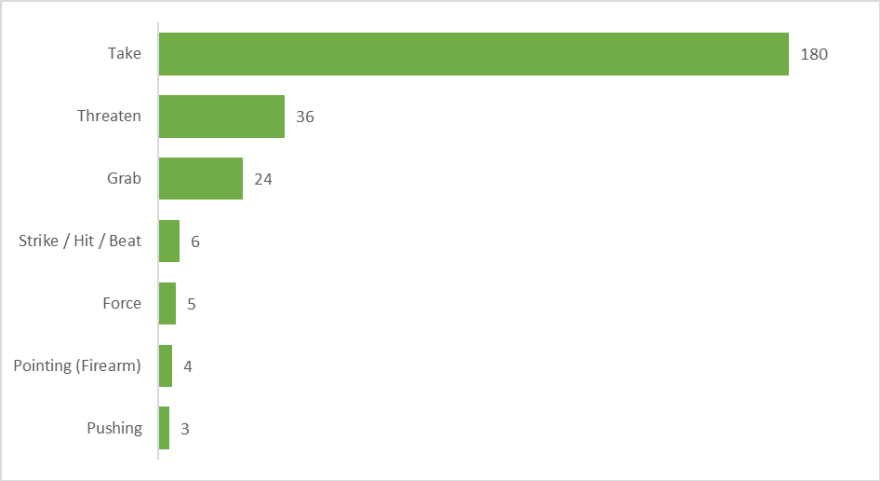
Graph 5-15**Error! Reference source not found.** and Graph 5-16 below shows the methods used to commit various criminal activities. The most common method at Bellville PTI and Claremont PTI are grabbing, threatening and taking. Grabbing and taking would be the easiest as the PTI's are generally full of commuters and the criminal could escape into the crowd with ease. However, threatening, which is also one of the top three methods of depriving someone of their belongings would require close contact.

Graph 5-15: Variants of methods use to execute robberies at the PTI



An observation showed more methods are used at the bigger PTI, namely Bellville

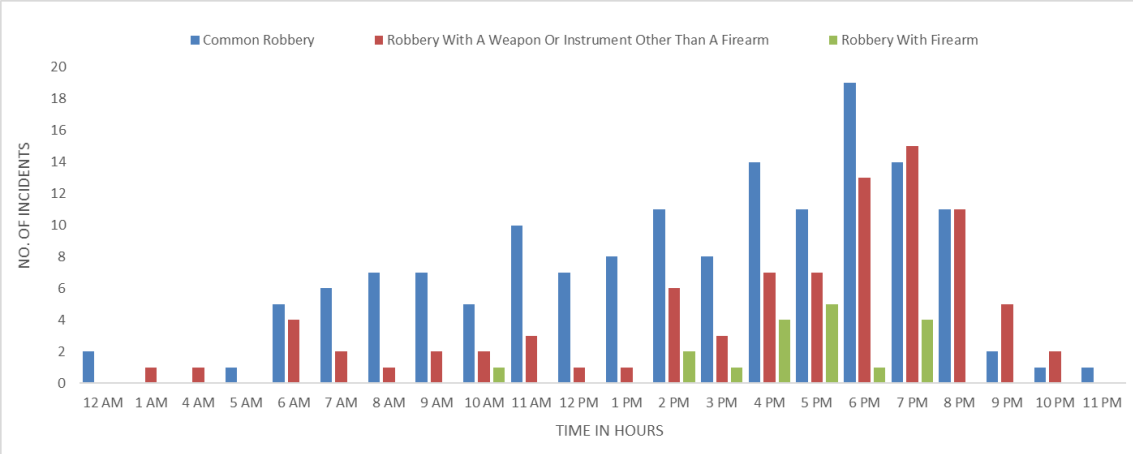
Graph 5-16: Variants of criminal activity recorded at the PTI displayed in days



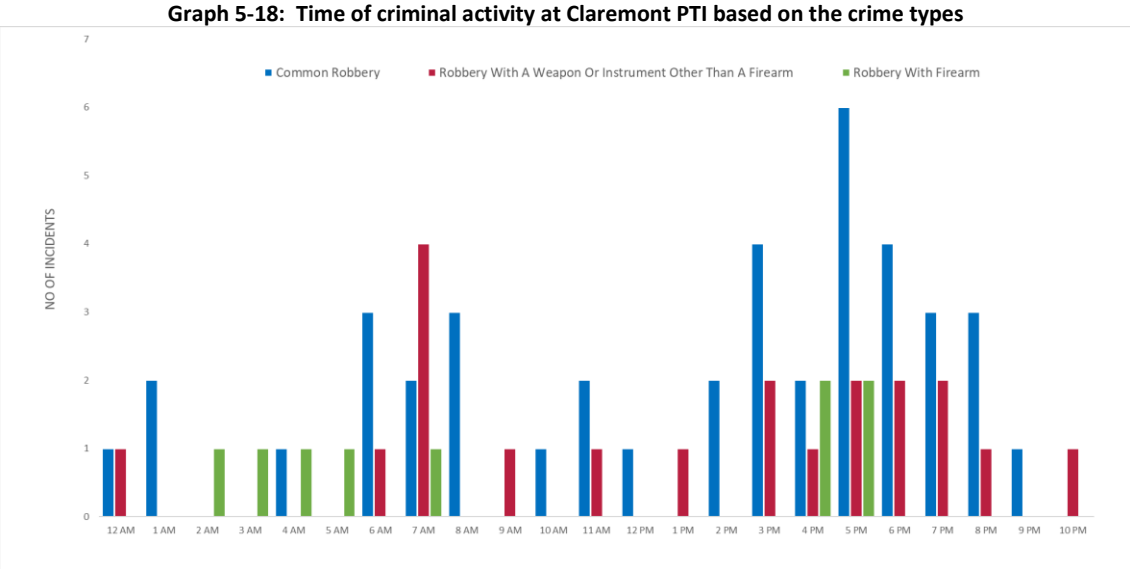
when compared to the smaller PTI, Claremont, but the most common methods remain uniform throughout.

5.3.4 24-hour criminal period

Graph 5-17: Time of criminal activity at Bellville PTI based on the crime types



Graph 5-18: Time of criminal activity at Claremont PTI based on the crime types



Graph 5-17 and Graph 5-18 depicts criminal activity over a 24 hours period. This is done to, determine the most common hour in terms of criminal activity at the PTI. Both graphs show consistent criminal activity throughout the day**.**

Very little activity was recorded during the early hours of the morning. As the morning peak approaches the crime rate starts to rise. One would expect a decrease in criminal activity between the AM peak [7]and PM peak[8], specifically between 9 am and 2 pm, as the morning rush settles and the PTI becomes less busy. However, commuters are more prone to criminal activity during off-peak times as the commuters tend to walk in smaller groups or even alone.

[7] AM Peak: 06:00 – 09:00
[8] PM Peak: 15:00 – 18:00

When analysing the graph generated by the Bellville data, it showed that the PTI consistently recorded criminal activity irrespective of the chosen travel time. One can see the slightly higher values during peak hours, but the time average seems to be approximately 8 victims per hour per 24-hour period. Specifically, when focusing on the peak hours, the graph shows a heightened level of criminal activity for an additional 2 hours thereafter.

In Graph 5-18 above, representing the Claremont criminal activities, show that most of the criminal activities occur during the peak periods namely, between 6 am and 8 am and between 4 pm and 6 pm. The graph, however, illustrates a pattern with slight flares of activity throughout the day but shows definite peaks in the morning and afternoon when most commuters are using public transport. A higher number of robberies with weapons are recorded in the morning and evening. Contrary to what the Bellville graph indicates, the Claremont graph shows that the criminal activities are heightened during the peak periods and lower during the off-peak periods which is expected.

During the data collection, it was noted by SAPS, that most of the criminal activities occur on streets leading towards the PTI. This can be due to security personal being placed at the PTI and as a result, a pedestrian is targeted on-route to the PTI.

5.4 Analysis Questionnaires

300 survey questionnaires were distributed at the PTI's forming part of the investigation. The survey was made up of multiple-choice questions. The multiple-choice questions were chosen to ensure that none of the participants was disadvantaged due to writing limitations. This section presents the data collected from the completed questionnaires.

Of 300 questionnaires the data received was as follows: 220 questionnaires were completed, 48 were distributed but never returned by the respondent and 32 were impermissible as all the questions where not completed.

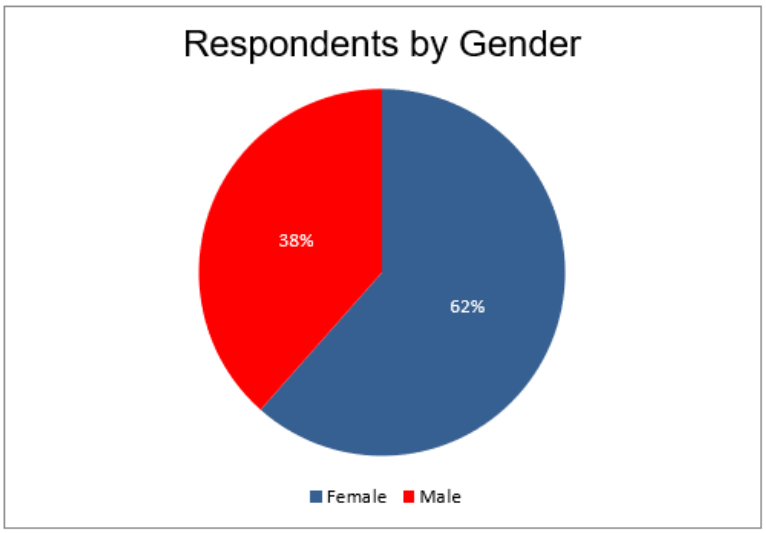
The investigation sample size is 220.

5.4.1 Questionnaire General Responses

Each respondent was asked to complete 6 general questions to indicate gender, the PTI from which they travelled, whether they possessed a driver's license, age and time of AM and PM travel. The results are displayed below.

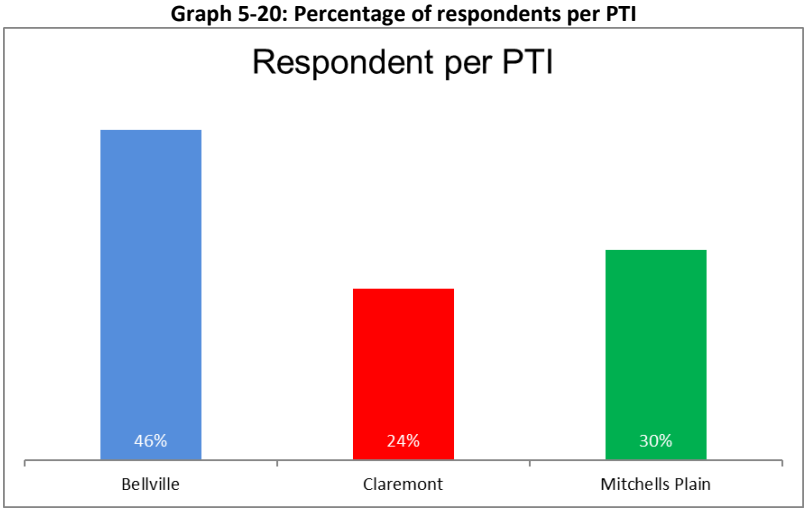
Graph 5-19 below, compares the percentage of females and male respondents. Of the 220 participants, 62% were women and 38% were men.

Graph 5-19: Variation of respondents by gender



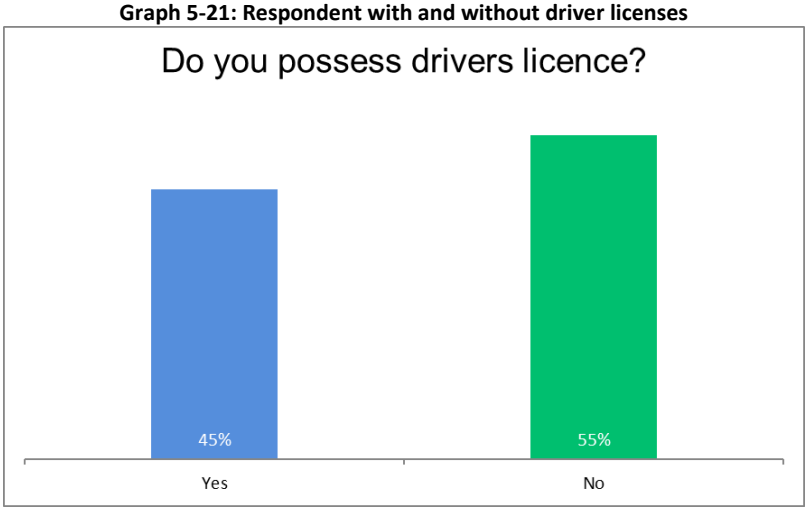
Graph 5-20 below shows the breakdown of respondents from the various PTI's. Since Bellville is the biggest PTI in the research, most questionnaire respondents originate from the Bellville PTI. The result shows a 46% response from Bellville, 30% of the questionnaires were completed at Mitchells Plain and 24% at Claremont.

Graph 5-20: Percentage of respondents per PTI



Graph 5-21 shows the split between respondents with valid driver's license and those without. A 10% different can be seen between the respondents that answered yes and no. The assumption is that commuters without driver's licenses are classified as captive uses since public transport is their only option. The data showed many licensed drivers using public transport. The reason for this was not established as we did not investigate economic status or why public transport was chosen over a different transportation mode.

Graph 5-21: Respondent with and without driver licenses

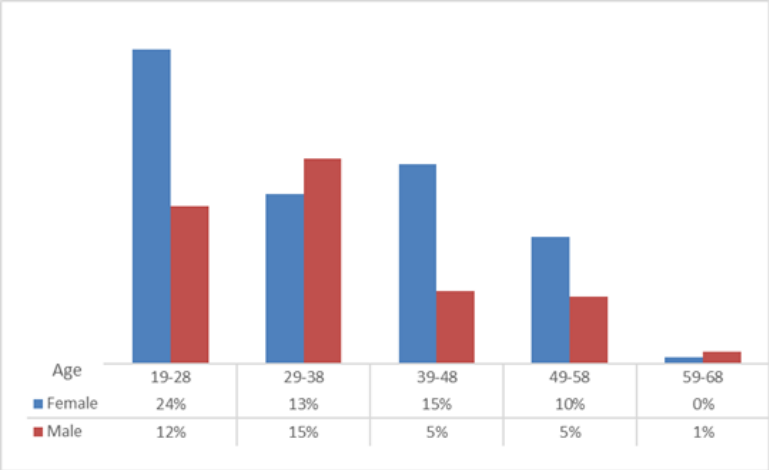


Graph 5-22 below, compares the age range of the respondents that participated in the survey. Each age range has been divided by gender. As stated in section 2.4 that elaborated on The vulnerable road user, age group 19-30 is classified as the youth and is the most active age group of commuters. From the data, age group, 19-28 accounts for the highest number of respondents, making up 36% of the sample.

In all the age categories the female makes up a higher respondent percentage than males, however, age category 29-38, the males surpass the females making up 15% of this age category.

Age category 59-68 would be form part of the vulnerable road users. This group only makes up 1% of the total sample. Since the age group, 59-68 are commuters coming towards the end of their working careers the low number is justified, these commuters may also be using public transport to access health care facilities or completing recreational activities.

Graph 5-22: Respondent's by age and gender



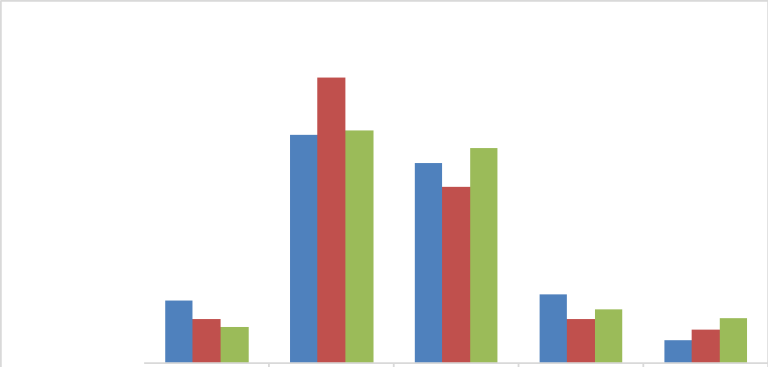
The respondents were asked to indicate their morning (AM) and afternoon (PM) travel time. For this research the peak periods were set at: AM peak between 06:00 - 08:00 and PM peak between 16:00 - 18:00.

Graph 5-23 shows a high number of commuters travelling before the AM peak officially begins. Although a high number of commuters travel during the peak hour, the data shows a trend where most commuters are now travelling between 5 am and 6 am.

High volumes of commuters are travelling before the designated peak period. The Claremont PTI experience 49%, the highest of the three PTI's. Bellville and Mitchells Plain recorded 39.22% and 40% respectively.

The AM peak reduces substantially in the last hour of the peak period. A 50/50 commuter volume split can be seen between 5 am-6 am and 6 am-7 am. The traffic and congestion study review in the literature reported that Cape Town has quite a long travel time. With this said, the data indicate that commuters are forced to travel earlier to avoid delays or peak hour traffic which resulted in a longer peak period. As a result of spatial planning, commuters experience longer travel distances and longer travel times.

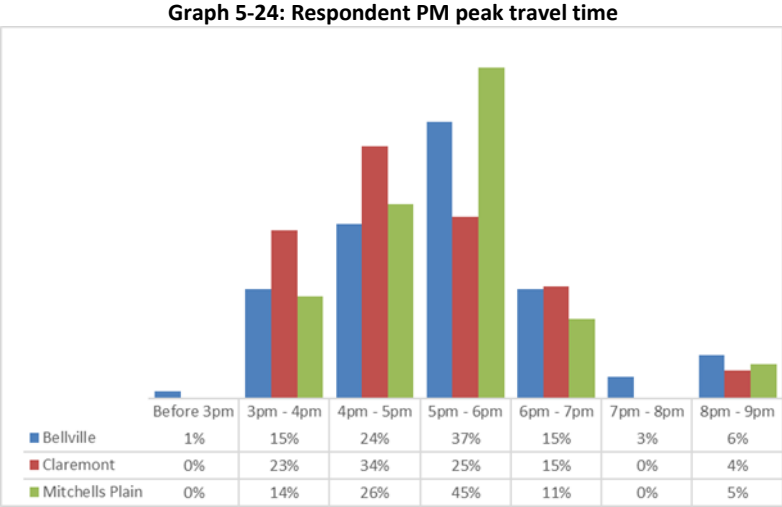
Graph 5-23: Respondent's AM peak travel time at the various PTI's



	Before 5am	5am-6am	6am - 7am	7am - 8am	8am - 9am
Bellville	11%	39%	34%	12%	4%
Claremont	8%	49%	30%	8%	6%
Mitchells Plain	6%	40%	37%	9%	8%

When comparing the AM and PM peaks, Graph 5-24 below shows that the PM peak experience the highest commuter volumes between 16:00 – 18:00 continuing the 50/50 split between the first and second hours of the peak period. The data shows a steady increase in users from 3 pm, peaking between 5 pm and 6 pm and then a sudden decline in volume between 7 pm and 8 pm. During the PM peak Mitchells Plain shows that 45% of the total respondents commuting home between 5 pm-6 pm.

Graph 5-24: Respondent PM peak travel time



	Before 3pm	3pm - 4pm	4pm - 5pm	5pm - 6pm	6pm - 7pm	7pm - 8pm	8pm - 9pm
Bellville	1%	15%	24%	37%	15%	3%	6%
Claremont	0%	23%	34%	25%	15%	0%	4%
Mitchells Plain	0%	14%	26%	45%	11%	0%	5%

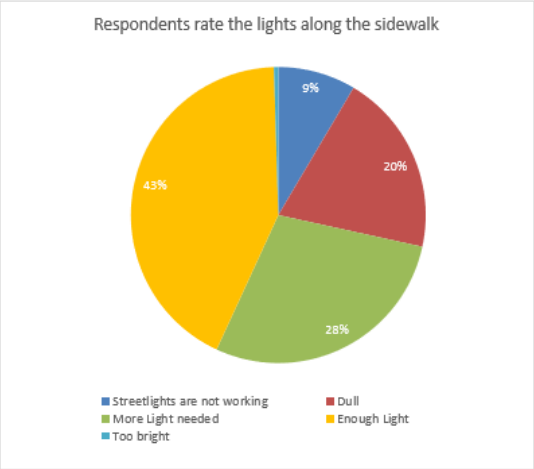
5.4.2 State of NMT facilities

The respondents were asked a host of questions about the NMT infrastructure leading to and at the PTI. The questions in this section were based on the respondent's opinion and perception.

Graph 5-25 compares the quality of street lighting at the various investigation areas. Street lighting is one of the key characteristics of a good NMT facility and can be directly linked to both the safety and security of NMT road users'. Commuters were asked to rate the level of lighting along their route.

3% of respondents said the sidewalks had enough light, 28% answered more light needed, 20% answered that the lights were too dull and 9% did not have working streetlights. Overall, 57% of the respondents perceived that the lighting along their rate was insufficient.

Graph 5-25: Respondents perception of lighting along the route



Graph 5-26 shows the level of comfort, that the commuter's experience when using the sidewalk. According to 46% of respondents, the sidewalk had enough space. 30% experienced overcrowded sidewalks, 16% had to squeeze past other NMT users and 8% took turns using the sidewalk. A total of 54% of commuters experienced sidewalks that were not designed for the volume of commuters.

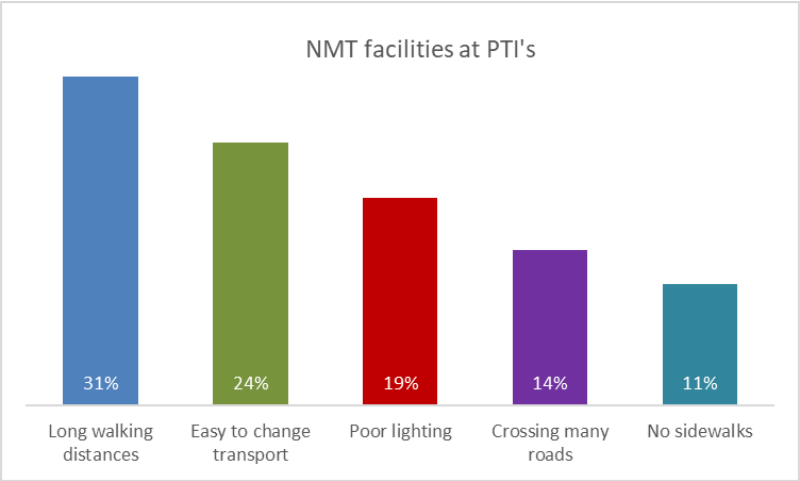
The example in section 2.12.1 elaborates on a reduction in NMT facilities resulting in NMT users spilling over into the roadway. Similarly, from the data collected around the PTI, 54% of users are likely to walk in the roadway because of inadequate facilities or an unexpected increase in NMT user volumes.

Graph 5-26: Level of comfort experienced when using the sidewalk

To encourage the use of public transport the facility must be attractive to the user. The survey found that collectively, 31% of the respondents experienced long walking distances, poor lighting and poorly integrated sidewalk.

Graph 5-27 shows that 14% of respondents crossed many roads, directly linked to longer vehicle exposure times and higher safety risks. 11% indicated that no sidewalks were provided. This increase the pedestrian-vehicle exposure creating a direct safety risk.

Graph 5-27: NMT facilities for ease of mode transfer

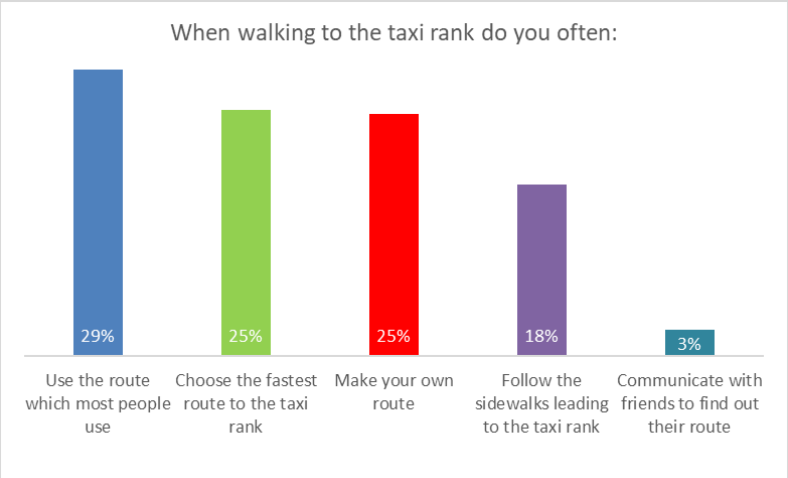


To determine the variation in route choice, commuters were asked if alternative NMT routes were available. Commuters being able to choose a route indicates characteristics of an integrated NMT network. When the commuters do not have this choice, it shows that the network is isolated, and commuters may need to create their own paths to fill in the gaps. In terms of safety, Graph 5-28 below shows that 29% of

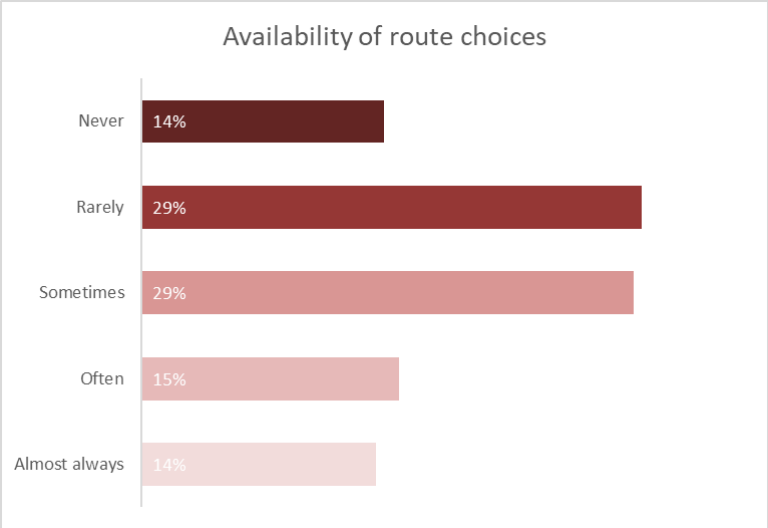
respondents indicated that they use the route that most people use - the most common routes. 25% of the respondents indicated that they used the fastest route or made their own route which may include a combination of the route most people use, the fastest route and route made up as they travel. Only 18% indicated that they follow the sidewalk towards the PTI. A connection was identified when comparing Graph 5-28 and

Graph 5-29. Inadequate facilities result in pedestrians having to decide what to do without specified guidelines. Only 3% indicated that they communicated with other commuters to determine their route choice. Communicating with other commuters would reduce the safety risk when walking in bigger groups rather than walking alone.

Graph 5-28: Daily route choice travelling towards the PTI



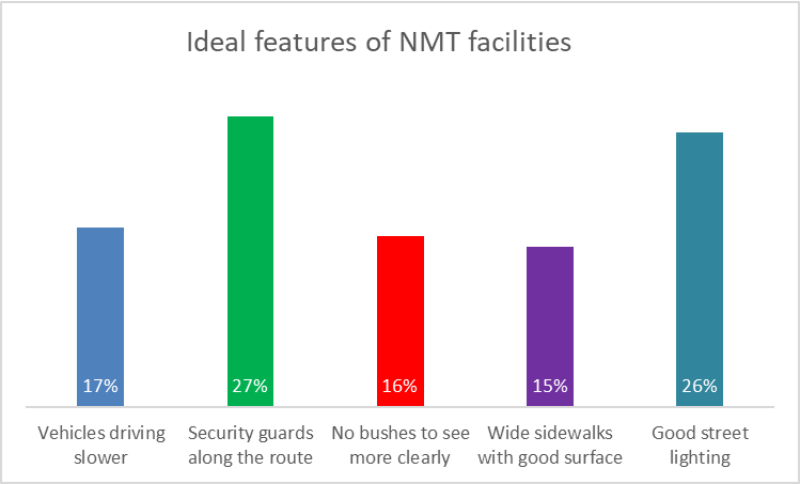
Graph 5-29: Alternative route choices available



Graph 5-30 provides an overview of the availability of alternative routes. Unfortunately, according to the data collect, 14% never have an alternative route to choose from. Rarely and sometimes having a route to choose from accounted for 29% of the sample. In total, 71% of commuters do not have an alternative route to the one they currently travel along.

Respondents were given the opportunity to select NMT features that would form part of their ideal route. 26% indicated that good lighting would improve their route and 27% indicated that security along the route would enhance the NMT facility. Commuters also understood the importance of having clear sight distance and wider NMT facilities. The results are displayed in Graph 5-30 below.

Graph 5-30: Commuters perception of ideal NMT features



17% of the respondents answered that vehicles driving slower would improve the NMT facilities. All these features are key characteristics to an improved NMT facility yet more respondents answered focused on the inadequate infrastructure instead of human behaviour.

5.4.3 Level of Safety

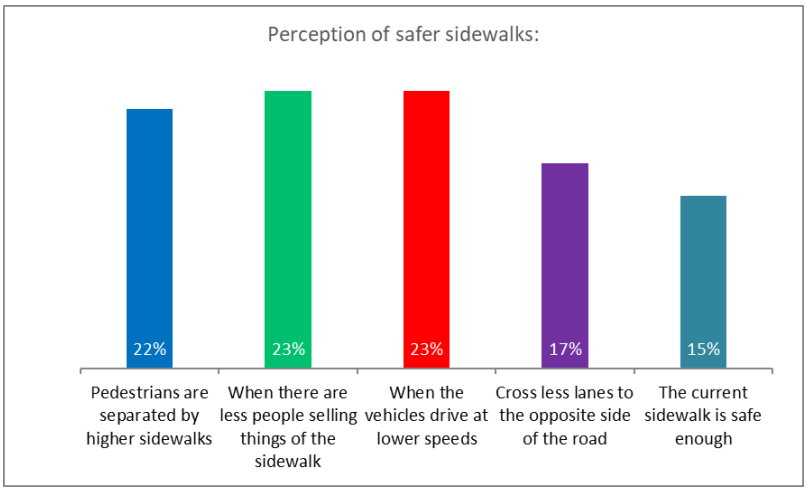
The following questions aimed to determine the pedestrian perception of safety. Commuters have different risk appetites, some more conservative than others. The questions aimed to evaluate the safety of their route based on certain criteria.

In the literature, 2.10.3 Bangladesh reported that 40% of their sidewalks obstructed by illegal vendors. From the survey, 23% of the respondents answered the sidewalk would be safer with fewer vendors operating within the NMT space.

Graph 5-31 show well-distributed data. 15% of the respondents answered that the sidewalks were safe enough. 23% of the respondents would feel safer if the vehicle operated at lower speeds and 22% believed that if commuters were separated from vehicles the NMT facility would be safer.

Throughout the literature, the challenges faced by NMT users are reported. After the various NMT improvements are completed the buy-in from the end-user was quite important. Similarly, asking commuters what their ideal route would consist of would improve community buy-in and use of the facility.

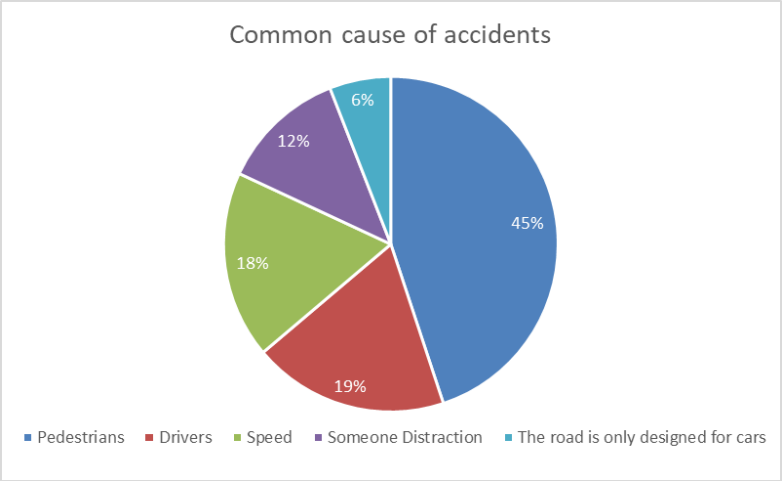
Graph 5-31: Attributes of a safer sidewalk according to respondents



The statistics showed that the main cause of accidents are pedestrians. In section 2.5, Pedestrian factors, one of the contributing factors to crashes was road user distraction. According to the respondents, 45% believe that pedestrians are the most common cause of accidents and 6% believe that the road is only designed for vehicles. 12% respondents that distraction causes a crash while 18% believe it was speed.

All the answers from the selection are related to human behaviour and in no order, contribute to the cause of crashes. These results can be seen in Graph 5-32 below.

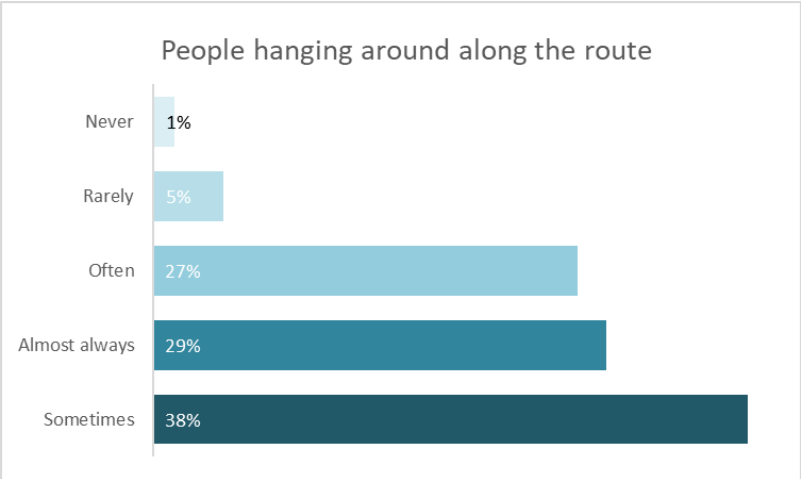
Graph 5-32: Perceived common causes of accidents



The security risk is directly linked to the external factors likely to harm commuters. Commuters are vulnerable to external forces including criminal activity. A 5-point Likert scale was used to determine the severity of people encounters along their route.

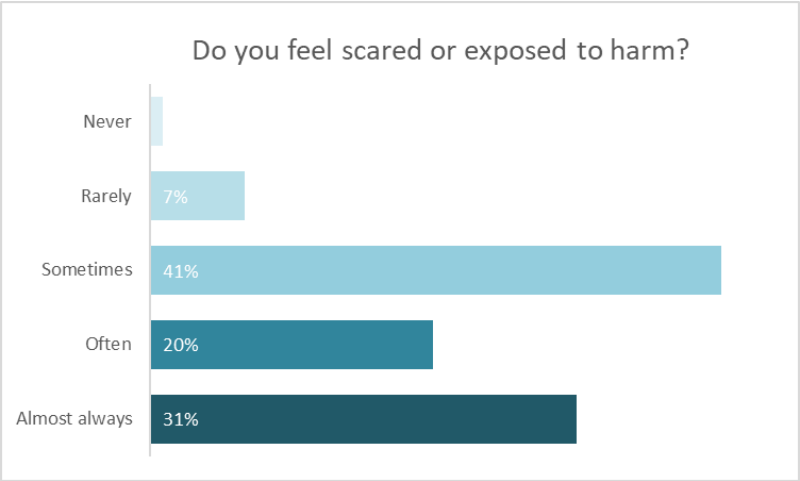
Graph 5-33 provides the results of the data which skewed to the negative end of the scale. Collectively, 94% of respondents had unwanted encounters with strange people along their route. Only 6% answered that they rarely or never experience unwanted encounters.

Graph 5-33: Security risk along the route



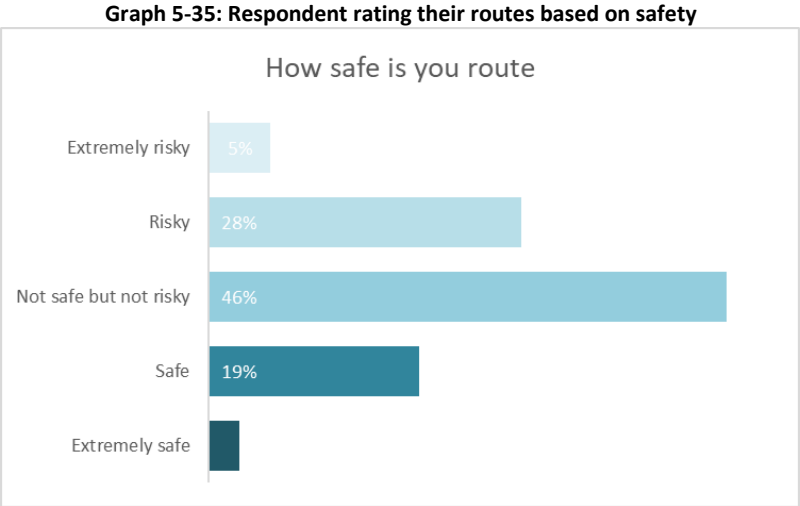
Graph 5-34 shows the results from feelings of fear or being exposed to harm. Once again, the scale is skewed to the negative side. More than 90% of the respondents feel that exposed to harm.

Graph 5-34: The Respondent feeling when travelling to the PTI



Graph 5-35 displays the data where respondents were asked to rate their routes. 46% indicated that the route travelled is not safe but not risky. The result of being exposed to a high-risk environment enhances their risk appetite and because the system has neglected NMT for this long it could be a feeling of hopelessness and making the best of the situation. Irrespective of whether the route, respondents are obligated to travel.

Graph 5-35: Respondent rating their routes based on safety

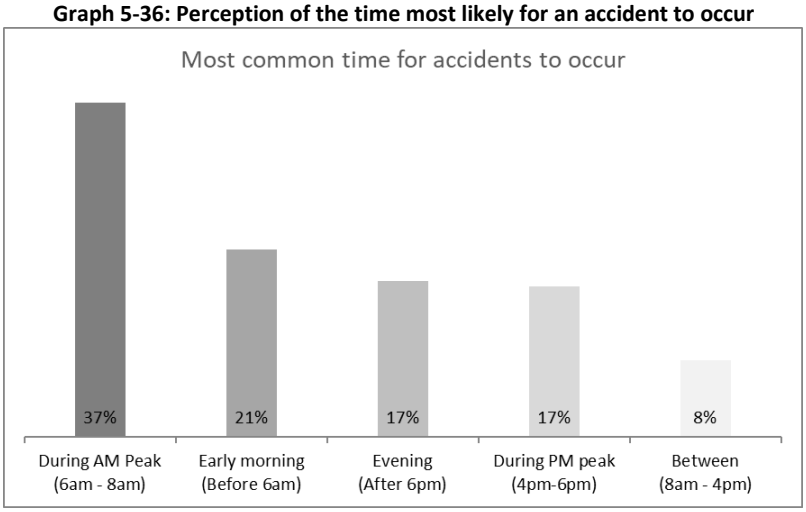


Based on Graph 5-33, Graph 5-34 and Graph 5-35, the trend is that there is almost always, sometimes and often, a safety or security threat while travelling from home to the PTI.

Graph 5-36 shows the time people believe it is the most unsafe and most likely for a crash to occur. 37% of respondents answered between 6 am and 8 am. The literature shows that these are the most likely hours to be in a crash. The crash data displayed in Graph 5-23: Respondent's AM peak travel time at the various PTI's showed that the peak had been extended to between 5 am and 6 am.

From the results, 21% answered that crashes occur before 6 am which can be correlated to the shift in peak hour travelling.

Graph 5-36: Perception of the time most likely for an accident to occur

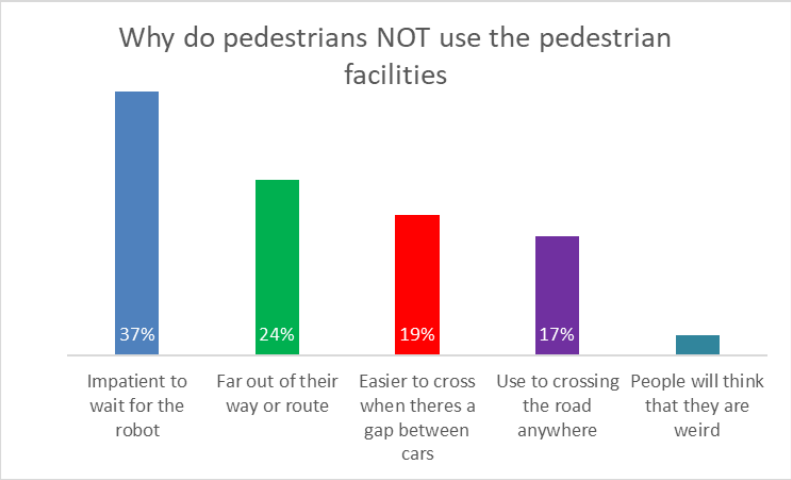


5.4.4 Security Risk faced by pedestrian

Different influences affect pedestrian behaviour and in some cases, dictates their norms. Most times someone continues executing a certain action as a matter of routine. The respondents were asked, in their opinion, why do people neglect to use the NMT facilities provided, specifically pedestrian crossings.

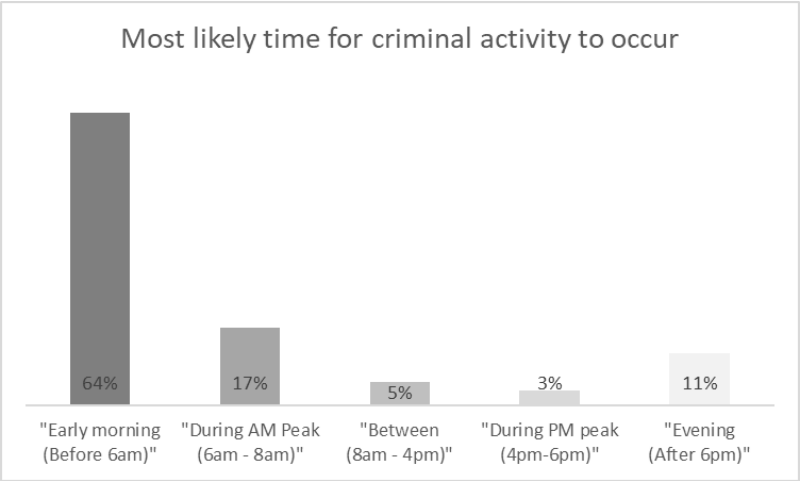
Graph 5-37 displays the results of the collected data. 37% answered that commuters are impatient to wait for the signal. 24% and 19% believe that the facility was out of their desired route and that it was easier, although not safer, to cross between the gaps. 17% crossed anywhere as a habit and 3% answered that people would think that they were weird to cross at the pedestrian crossing. The behavioural trends seen in the graph below concur the findings of 2.18 Pedestrian behaviour which states that pedestrian is unpredictable which makes NMT difficult to anticipate. Social norms accept this behaviour, therefore, the behaviour pattern will continue to thrive.

Graph 5-37: Reason why NMT provided NMT facilities are not utilised



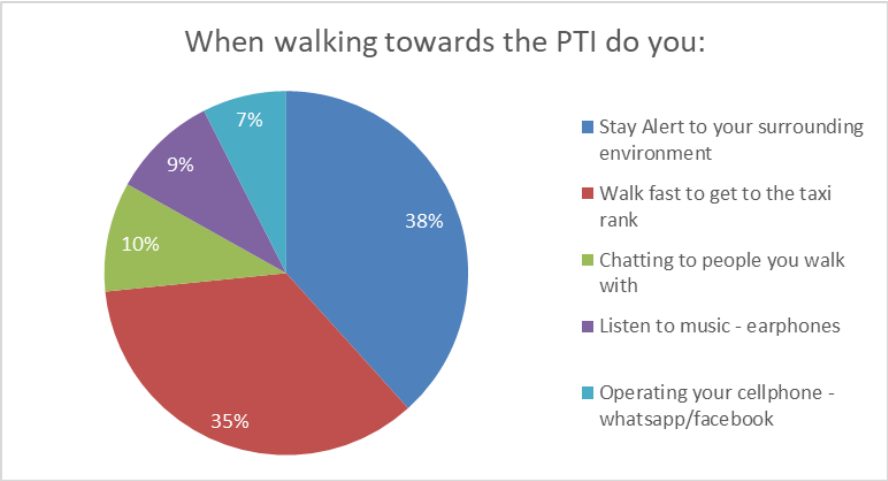
The criminal data coincides with Graph 5-38 in the earlier hours of the morning. Again, this can be compared to more commuters leaving earlier than the normal peak hours

Graph 5-38: Most likely time for criminal activity to occur



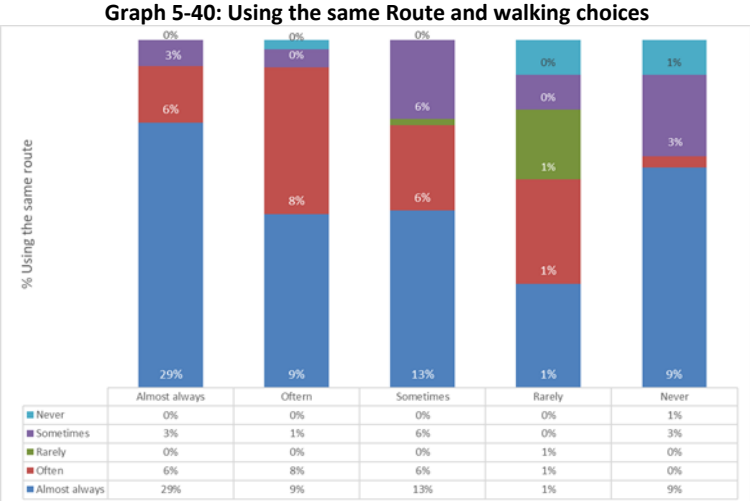
Graph 5-39 below, shows that 38% of commuters consciously stay alert of their surroundings. 35% of respondents answered that they walk to the PTI fast, to get to their destination. It could be assumed that respondents using electronic devices while walking show a sense of fearlessness. These respondents may be comfortable walking along their route, or the chosen route is safe enough to operate an electronic device without the fear of being attacked.

Graph 5-39: Respondents walking to the PTI are pre-occupied



Graph 5-40 compares the choice of the same route versus walking alone or in a crowd. 29% of the respondents answered that the same route is taken, and commuters walk alone. The second highest response was 13%, where the respondents answered that sometimes the same route was taken, and they almost always walked alone.

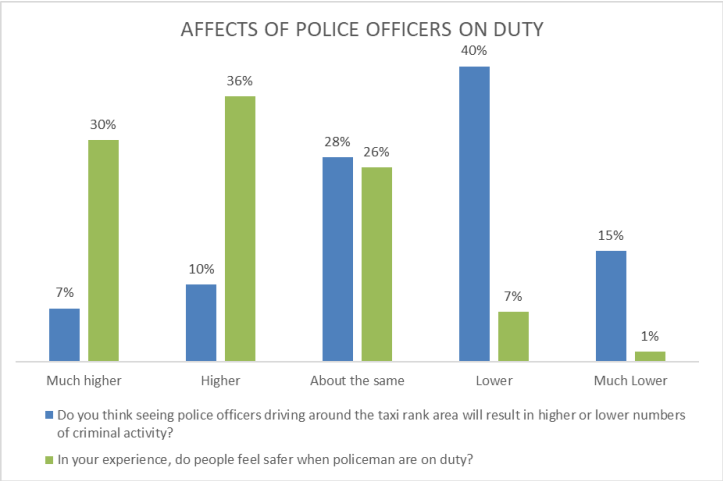
Graph 5-40: Using the same Route and walking choices



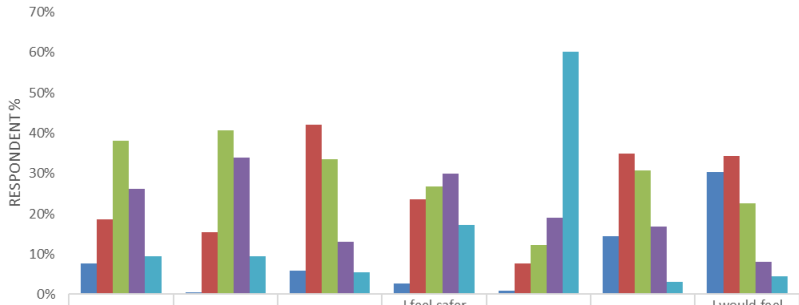
Respondents were asked to provide their opinion about law enforcement visibility and the effects their presents have at the PTI. The data was displayed in Graph 5-41. 28% and 26% of respondents believe that the condition will remain unchanged whether SAPS are present or not. 36% of respondents feel safer when police are visible at the PTI while 40% believes that criminal activity will be much lower.

The graph is skewed to the right as more commuters believe that law enforcement is required for safety, however, the level of criminal activity will remain unchanged.

Graph 5-41: The role of Law enforcement within the PTI and NMT context



Graph 5-42: Respondents using the same route versus walking alone



	I feel safe when waiting at the taxi rank	I feel safe when crossing the road in the gap between cars	I would feel safe to share a road with cars that driver slower	I feel safer walking in the road rather than on the sidewalk or the provided facilities	I feel safe to walk through a dark alley to get to the taxi rank faster	I would feel safer if I knew how to protect myself better	I would feel safer knowing I can leave my home without fear of being robbed
Extremely Safe	8%	0%	6%	3%	1%	14%	30%
Safe	19%	15%	42%	24%	8%	35%	34%
Not risky but Not Safe	38%	41%	33%	27%	12%	31%	23%
Risky	26%	34%	13%	30%	19%	17%	8%
Extremely Risky	10%	10%	5%	17%	60%	3%	5%

The last section of the questionnaire requested that respondent's rate certain statements related to their journeys with a scale from extremely safe to extremely risky. All the statements begin with, "I would feel". Graph 5-42 displays a combination of the questions and the rating. A trend can be seen from the data as commuters fear for their safety.

From the graph above, the respondents provided a range of answer across the spectrum. In most cases, not safe but not risky was the dominant answer. The following can be said for each question overall:

- 38% feel not safe but not risky waiting at the PTI
- 41% feel not safe but not risky when passing through the gaps between cars
- 42% feel safe to share the road with cars in a shared space environment
- 30% felt that it was risky to walk in the road rather than the sidewalk.
- 60% found it extremely risky to walk through dark alleys ways as a faster route to the PTI
- 34% answered that they would feel safer if they knew how to protect themselves.

Overall, the respondents had mixed perceptions and expectation for safety requirements of NMT facilities. When looking at the graph a heavier weighing of responses can be seen on the risky portion of the answers.

5.5 Pedestrian Environment Assessment Tool

"The roadside environment is considered an important factor influencing the nature and frequency of pedestrian activities"

(Albers, et al., 2010)

The Pedestrian Environment Assessment Tool (PEATS) was created to evaluate South African Roadways given its unique characteristics, therefore PEATS was used to evaluate the non-motorized facilities at the 3 selected PTI's forming part of the investigation.

The site visits where conduct on separate days to ensure that the facility was thoroughly investigated. The investigation included features such as intersection safety, traffic, street design, road condition and perceived safety.

5.5.1 Intersection safety

Intersection safety considers both vehicles and pedestrians since both play a vital role in the safety and security of one another.

The intersection safety evaluation considered the crossing requirements and pedestrian movement. The intersection provides a safe crossing zone for pedestrians since vehicles are forced to stop. The PTI's presented a combined of pedestrian crossings.

5.5.1.1 Crossing requirements

Claremont and Mitchells Plain had well maintained pedestrian facilities, Claremont had a combination of paved and painted pedestrian crossing which can be seen in Figure 5-9 below and MP had raised painted pedestrian crossings shown in Figure 5-10 below. These features were easily identifiable and visible to the pedestrians which made them easier to use. The pedestrian crossing throughout the PTI's was raised, wide and linked the various modes of transport to one another allowing for continuous pedestrian flow. During the site visit, pedestrians were observed using the facilities on site, vehicles allowed pedestrians to ROW before proceeding.

Figure 5-9: Pedestrian crossing at Claremont

Figure 5-10: Pedestrian crossing, at the MP PTI

5.5.1.2 Pedestrian movement

Claremont PTI had an underpass which leads from the taxi rank to the train station. This area was filled with graffiti and was used as a shelter for the homeless. This underpass, unfortunately, has been the scene of many criminal activities and is prone to safety and security risks.

A pedestrian footbridge was provided at MP which provided access from the taxi rank to the railway station. The footbridge was in a good condition, clean, well maintained and two guards were stationed on each end of the facility to enhance the pedestrian safety when using the facility. Figure 5-11 below shows the pedestrian footbridge.

Figure 5-11: Pedestrian footbridge at the MP PTI

Bellville had more pedestrian crossings than any of the other PTI's. These crossings were located on the streets surrounding. The crossings leading from the mall to the public transport area, although poorly maintained, the crossings were easily identifiable. It was observed that the pedestrian facilities surrounding the PTI where better maintain specifically the signalized intersections. However, it was found that the MBT's did not stop to allow pedestrians to cross.

Figure 5-12: Condition of the pedestrian crossing at Bellville PTI

5.5.2 Traffic calming

Combinations of different traffic calming measures were used at the various PTI's such as raised pedestrian crossings (RPC), smaller speed humps, narrowed lanes widths, many curves and unidirectional vehicle flow. The most common form of traffic calming used at the PTI's was raised pedestrian crossings. Raised pedestrian crossings serve a dual purpose of calming traffic and improving pedestrian flow and safety.

Claremont provided ample facilities at the bus station, taxi rank and the in-between the facilities including the shared pedestrian area which acts like traffic calmer illustrated below in Figure 5-13. Although Claremont has a 5-lane cross-section, these measures have effectively assisted in keeping the crash statistics low.

Figure 5-13: Raised pedestrian crossings at the Claremont PTI

Figure 5-14 shows the conditions of the pedestrian facilities at Mitchells Plain. The features ensure reduced speed, clear pedestrian ROW and effective pedestrian flow to allow for interchangeable movements at the PTI. These facilities were easily identified and located in an area that eliminated long walks distances reach the facilities. Figure 5-15 shows the conditions of the facility at the Mitchells Plain PTI and on evaluation, the facility was well maintained.

Figure 5-14: Examples of a raised pedestrian crossing at the MP PTI

Figure 5-15: Condition of the pedestrian facilities at the MP PTI

At Bellville PTI the raised pedestrian crossings however, the crossings were not being used by pedestrian but rather by MBT as seen in Figure 5-16. Parking on the pedestrian crossing forced pedestrian to weave in between vehicles creating conflict points especially when MBT reverse or are executing a turning movement.

Pedestrians are forced to weave in between taxi's and create various routes since the MBT are imposing on the designated pedestrian facilities shown in Figure 5-17 and Figure 5-18.

Figure 5-16: Pedestrian facility being obstructed by MBT

Figure 5-17: MBT driving through pedestrian shared space

Figure 5-18: MBT parked on the walkway

A traffic calming feature unique to the Bellville PTI is the traffic circle located at the entrance of the facility. Initially, the circle was intended to allow vehicle quick access to allow passengers to alight and secondly to control the inflow and outflow of the PTI.

Like the sidewalks the circle has been taken over by vendors and MBT's are using the roadway around the circle as additional parking and as an illegal wash bay. The intention of the circle was to create a pedestrian-friendly space with shaded areas and benches.

5.5.3 Street design

When investigating the pavement, the following was considered: Is the pavement under construction, does it require repair and is the pavement operational?

Mitchells Plain and Claremont were being maintained and the areas were in good conditions. The defects found were localized but overall the roadway was in good

condition. No prominent pedestrian tripping hazards were identified and one could walk with ease. The drain covers had been stolen and the paving was collapsing, drainage facilities and on the paved sidewalk needed maintenance.

Figure 5-19: Deformation of the Sidewalk at Claremont PTI

Figure 5-20: Deformation from poor drainage at the MP PTI

During the evaluation at Bellville, similar defects were identified. Paving bricks had been removed which left holes in the sidewalk, potholes formed due to poor drainage that caused flooding and many drains without lids were identified. See **Figure 5-21** and **Figure 5-22** below.

Figure 5-21: Deformation and condition of the pedestrian facilities at the Bellville PTI

Figure 5-22: Pedestrian tripping hazards

Makeshift ramps were constructed to allow MBT to cross the sidewalks without having to access the taxi rank through designated routes. Even when MBT was driving over the pedestrian facilities illegally, the MBT's were hooting at the pedestrians to move out of the way. **Figure 5-23** shows the MBT parked on the sidewalk.

The slope of the pedestrian environment is important for ease of pedestrian movement. Sudden change in grades, material or direction is not recommended when designing for pedestrians. All the PTI's had reasonable slopes across the facility, although Bellville had a few areas that were uneven but maintained a good standard overall. Claremont and Mitchells plain were completely flat which made it easy for a pedestrian to move around.

The Belville PTI uses a combination of different construction materials like paving, colour paving bricks, indicating ROW, and continuous concrete slabs to construct the pedestrian space.

Figure 5-23: Different materials used in shared space

Claremont PTI used paving bricks throughout the area including the roads used by private vehicles. Figure 5-24 shows how the PTI used different colour paving bricks to differentiate between pedestrian area (red-brown), motorized vehicle (dark grey) area and then common area (brown). Certain areas within the PTI vicinity had trees and concrete benches for commuters to sit, relax and wait for public transport. This provided shared space within the PTI to allow the pedestrians to feel safe while using the PTI.

Figure 5-24: Colour paving blocks showing ROW at the Claremont PTI

Mitchells Plain adopted a similar design style as Claremont where most of the facilities are paved. What sets Mitchells Plain apart is the MyCiti bus service. All the areas are paved with grey paving bricks and the pedestrian crossing are painted with white paint. Furthermore, the pedestrian walkways are paved with red paving bricks and this can be seen throughout the PTI as shown in Figure 5-25. The facilities at Mitchells Plain were well utilized by commuters.

Figure 5-25: Colour paving bricks indicating ROW at the MP PTI

Pavement obstruction is classified as any object that hinders the pedestrian flow on the pedestrian walkway. The most common walkway obstruction was the empty planter boxes and dirt bins. Figure 5-26 shows the sideway obstruction found that at the Bellville PTI. Irrespective of whether it was in the main walkway or along the MBT loading lanes, the researcher observed new jersey barriers, the private vehicle parked, MBT, many hawkers and beggars moving along the pedestrian area.

Figure 5-26: Obstructed pedestrian facility around the Bellville PTI

5.5.4 Road conditions

5.5.4.1 Potholes and Debris

The road conditions that were considered during the investigation were the presence of potholes, debris and road markings. When visiting the Claremont and Mitchells Plain PTI's few potholes were identified. In the Mitchells Plain PTI, the potholes had started forming because of poor drainage and ponding whereas in Claremont no visible potholes could be seen of the pedestrian surface or in the vehicle driving path.

Bellville, however, had many potholes that one could see had been forming over a long period.

5.5.4.2 Road marking

In Section 2.5, the literature elaborated on the importance of signage and road markings of the roadway. The road markings are features that assist both motorists and pedestrians to navigate and forms an unknown communication between motorists and pedestrians.

The road markings within the Bellville PTI had not been maintained although the marking in the roadways surrounding the PTI had been maintained. The road markings at both Claremont and Mitchells Plain were also well maintained but starting to fade.

Figure 5-27: Road marking at the Bellville, Claremont and Mitchells Plain PTI's

5.5.4.3 Perception of security

A critical factor considered throughout this research investigation is the pedestrian perception of security. Certain physical attributes of PTI's can make commuters feel safer like surveillance. Surveillance includes features like residential houses, business fronts facing the PTI, restaurants and garages and then the more obvious forms, like a security camera and police presence. During the site visit, the researcher experienced a strong police presence at Mitchells Plain PTI. Figure 5-28 shows a mobile police office located at the PTI as well as the footbridge security guards patrolling the sections. Three sides of the MP PTI have shop faces and this creates constant movement at the PTI.

Figure 5-28: Law enforcement and security presences at MP PTI

Claremont is situated between two streets filled with small shops. As illustrated in Figure 5-29. Security cameras were placed around the PTI. During the site visit, police activity was observed.

Figure 5-29: Shopfronts facing towards the PTI in Claremont

Bellville is surrounded by residential housing, open lots and small businesses along the road where Middestad mall is located. Figure 5-30 shows the CCTV cameras located at the Bellville PTI in each of the lanes and one of the many security guards stationed around the PTI but no law enforcement activity. Based on where the camera is situated, the camera does not overlap one another and seems to be solely focused on the activity within each taxi lane.

Figure 5-30: CCTV and PTI Security present in Bellville

Claremont and Mitchells Plain shared similar positive features like little to no graffiti, litter, abandoned buildings, open spaces, very few hawkers and beggars in the area. However, at Bellville PTI, once again had graffiti, litter lying all around and stockpiled on certain places despite the bins provided. The area had open spaces that were filled

with informal dwellings and the area was flooded with hawkers so much so that you could not use the walkways and beggars that walked around the PTI.

The layout, depicted below in Graph 5-31 of the PTI's has a significant impact on the number of crashes and this can be seen in the large variation above. The layout of the PTI contributes to the vehicle flow of the vehicle, making the design easy to understand and protects pedestrians from multiple vehicle movements.

Bellville Claremont Mitchells Plain

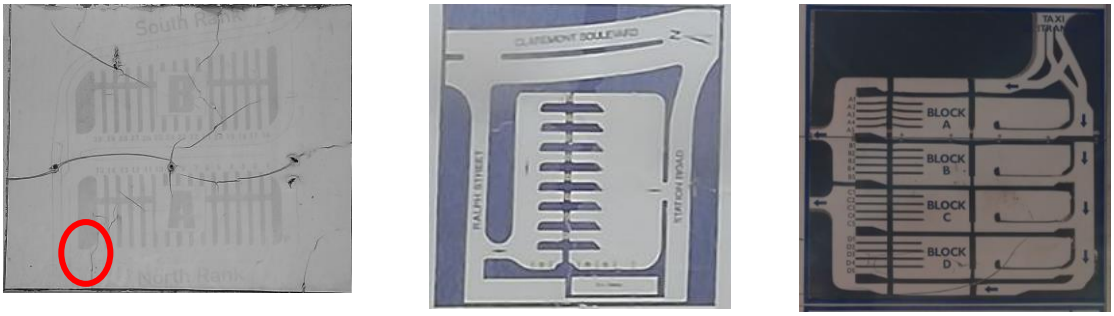


Figure 5-31:Schematic presentation of the three PTI's being investigated

The PTI design layout significantly influences the pedestrian. From the figures above, Claremont and Mitchells Plain have a similar layout with the entrance and exit on the opposite side of the PTI. Bellville PTI has a single entrance and exit at the same point indicated on the image with a red circle.

5.5.5 PEATS matrix

From the PEATS model, a rating system was developed. The rating system colour coded certain features in terms of their safety and security contributions to the PTI.

After the full PEATS evaluation was completed a matrix was compiled to rate the features at the different PTI's. The matrix is made up of 71 features that were assessed during the site visit. A colour-coded system, using green, yellow and red ratings shows the quality of all the features at the PTI.

When a feature falls within the green category, it indicates that more than 80% of the features evaluated at the PTI was in good condition. When the feature has a red rating, it indicates that the feature requires attention and either has no effect or a negative effect on the pedestrian environment. Annexure B shows the completed matrix.

Although the matrix was extensive, all the features were not found at all the PTI's. Bellville had 52 features, Claremont 21 and Mitchells Plain 33.

The Bellville PTI had 52 features of which 23 features were rated red. 19 was orange and only 10 were in good condition positive influencing the pedestrian environment. The conditions at the Bellville PTI that did not have any negative ratings were the pavement conditions, slope and pavement material used within the pedestrian environment.

Claremont and Mitchells Plain provided no red rated items however, these PTI's is much smaller than Bellville. Claremont and Mitchells Plain had 18 and 24 green ratings respectively bit also presented fewer evaluation features.

5.6 ANOVA

A one-way analysis of variance (ANOVA) was used to determine the statistical significance between the data groups for selected variables. The data collected from the questionnaire were analysed using this statistical method to analyse the respondents' feedback on the various levels of safety and the NMT facilities along their route.

ANOVA was used to determine whether there were significant differences amongst the respondents travelling from different regions to different PTIs. The aim was to identify the different levels of safety and security experience and the perception of safety and security amongst respondents. The respondents that participated in the survey were all randomly selected and all used public transport as their primary mode.

Theoretically, the Null Hypothesis assumed that there are no differences between the means of the groups being compared. The assumption is that there is no difference in the level of safety experienced when travelling to and from the three PTIs'.

The level of significance was determined in Chapter 3 Section 3.8. A confidence interval of 95% was chosen and the level of significance was recorded as 0.05 (α = 0.05).

The Hypothesis for this research are as follows:

$$H_0 = No\ difference\ in\ the\ means\ of\ the\ groups\ being\ compared$$

$$H_1 = At\ least\ one\ difference\ is\ found\ when\ travelling\ to\ the\ various\ PTI's$$

Table 5-1 below summarises the results from the various iterations of the ANOVA analysis.

Table 5-1:Summary of ANOVA results

	SOURCE OF VARIATION		SS	df	MS	F	P-value	F-crit
PERCEPTION OF SAFETY	I feel safe when:	Between Groups	0.00	1.00	0.00	0.00	0.95	3.88
		Within Groups	169.34	218.00	0.78			
	Ability to protecing yourself	Between Groups	0.15	1.00	0.15	0.14	0.71	3.88
		Within Groups	233.03	218.00	1.07			
	Leave home without fear	Between Groups	2.97	1.00	2.97	2.45	0.12	3.88
		Within Groups	264.55	218.00	1.21			
	Feeling scared when travelling	Between Groups	1.80	2.00	0.90	0.90	0.41	3.04
		Within Groups	217.83	217.00	1.00			
	Feeling safe when police is on duty	Between Groups	1.00	2.00	0.50	0.53	0.59	3.04
		Within Groups	205.64	217.00	0.95			
	Police visibility reduce crime	Between Groups	1.43	2.00	0.72	0.60	0.55	3.04
		Within Groups	260.91	217.00	1.20			
LEVEL OF SAFETY	Walking in Dark alley	Between Groups	0.46	1.00	0.46	0.44	0.51	3.88
		Within Groups	225.34	218.00	1.03			
	Waiting for public transport at the PTI	Between Groups	1.67	1.00	1.67	1.48	0.23	3.88
		Within Groups	246.49	218.00	1.13			
	Crossing between gaps instead at pedestrian facilities	Between Groups	0.18	1.00	0.18	0.24	0.63	3.88
		Within Groups	166.73	218.00	0.76			
	Sharing the road with vehicle travelling at reduced speed	Between Groups	0.07	1.00	0.07	0.07	0.79	3.88
		Within Groups	200.53	218.00	0.92			
	Walk in road vs sidewalk	Between Groups	1.19	1.00	1.19	0.97	0.32	3.88
		Within Groups	265.16	218.00	1.22			
	Using the same same route daily	Between Groups	4.05	2.00	2.03	2.15	0.12	3.04
		Within Groups	204.39	217.00	0.94			
	Walking alone when travelling to the PTI	Between Groups	11.24	2.00	5.62	2.94	0.05	3.04
		Within Groups	414.45	217.00	1.91			
	Suspicious characters encountered towards PTI	Between Groups	0.70	2.00	0.35	0.38	0.69	3.04
		Within Groups	201.94	217.00	0.93			
	Availability of route choices	Between Groups	4.67	2.00	2.34	1.55	0.21	3.04
		Within Groups	326.76	217.00	1.51			

The summary has been divided into two sections namely factors affecting the perception of safety and factors affecting the level of safety. The results show that all the p-values are greater than α = 0.05. Since all the p-values are greater than α = 0.05 the null hypothesis will not be rejected.

A p-value greater than the level of significance indicates that the null hypothesis is true. Furthermore, the F-value and the F-critical values are evaluated in conjunction with the p-value. In this regard, the F-value is smaller than the F-critical, indicating that none of the results falls into the region of rejection. Therefore, the following is true: there is no difference in the mean, for groups travelling to the various PTI in terms of the level of safety experienced.

In terms of perception of safety, female and male perceptions were compared with one another. The comparison was made to determine whether a variation would be found between the perception of safety in terms of gender. The p-values in all tested cases are greater than α = 0.05. This shows that there is no difference in perception of safety when comparing the genders to one another. When comparing the F-values, the F-values is smaller than the F-critical, indicating that the results do not fall within the

region of rejection. Therefore, both males and females have a similar perception of safety and there is no difference in their perception of safety. In both cases, there is not a significant difference in the level of safety experienced and the perception of safety at the various PTI's.

One of the results that stood out was in the perception of safety category. The "I feel safe" questions had a p-value of 0.95. The p-value moves towards 1, showing that it is highly significant, the results are probably true and that the results did not happen by chance. Therefore, commuters are most likely feeling unsafe often when travelling towards the PTI's. Additional questions about seeing police on duty and having police patrol areas did not change the perception respondents had or the level safety they felt.

The p-values of the police question where 0.55 and 0.59, respectively. These results indicate that we fail to reject the null hypothesis and that there is no difference in the means from all respondents at the different PTI's. Meaning that regardless of which PTI the respondent was at, the perception of the safety of the respondent did not change whether or not the police were visible and on duty. Therefore, the null hypothesis will not be rejected. The result illustrates that there is no difference in the mean in terms of the level of safety and the perception of safety. Irrespective of which PTI commuters travel towards, there is no difference in the level of safety and the perception of safety.

The lowest p-value was computed in the level of safety category was walking alone (0.07). Although the value is greater than $\alpha = 0.05$ a low p-value leans towards rejecting the hypothesis. However, the value is above the alpha level of 0.05, therefore, we fail to reject the null hypothesis.

5.7 Summary of findings

The following key points were found from the data:

5.7.1 Crash data

The research showed that the day that recorded the most crashes was Friday and most of these crashes occurred in the street adjacent to the entrance of the PTI where most pedestrian movements occurs. The data revealed that the most common vehicle type involved in the crashes were private motor vehicles.

5.7.2 Criminal data

The data showed that most criminal activities occur on Friday and Monday and the most common time for crimes to occur is between 5 pm and 6 pm. The data also indicated that a higher number of males reported incidents than females. The most common forms of crime being grab, threaten and take.

5.7.3 Questionnaire

The questionnaire revealed that more females participated in the questionnaire and Bellville provided the highest number of respondents. The age group of most commuters ranged between 19 and 28 years old and most of the respondents did not have drivers licenses. The peak period was identified between 5 am and 7 am while the afternoon peak period was from 3 pm to 6 pm.

It was deduced from the questionnaire that the facility included lighting however most commuters found difficulty interchanging between different transport modes. The study indicated that respondents wanted improved safety and security measures implemented such as security guards and improved NMT facilities, in particular, lighting. According to the results, the respondents assumed pedestrians were the main causes of accidents even though they were a representation of the pedestrian sample group. The respondents further expressed that they felt as if their safety was compromised due to loitering along their route. The majority of respondents believed that most criminal activities occured in the morning peak period.

5.7.4 Pedestrian Environmental Assessment Tool

The pedestrian assessment tool identified various features that would improve the pedestrian experience. The results showed each facility has multi-coloured paving to indicate pedestrian ROW. Although maintenance was required, all the investigated PTI

had traffic calming features such as raised intersections, speed humps, narrow lanes and clear road markings. Localised deteriorating pavement layers were observed at some PTIs. Most of PTIs had vendors which dominated the shared space byobstructing the sidewalk. In addition to this, other obstructions included light poles and new jersey barriers. In addition, the PEATS investigation revealed that there was a police presence at only one of the three PTIs.

5.7.5 ANOVA

The ANOVA analysis showed the following: The Null hypothesis was not rejected as all the P-values were greater than the significance level of 0.05 ($\alpha = 0.05$). It found that no significant difference was identified between the means. The level of safety was determined as low irrespective of which PTI. In addition, the perception of safety does not vary amongst the PTIs.

6. CHAPTER 6: LOCAL ROAD SAFETY PLAN

6.1 Introduction

Research has been completed on the effectiveness of specific treatments which will reduce pedestrian-vehicle crashes and provided a safer pedestrian environment around the PTI's. The literature reviewed from an international and national context provides countermeasures that have been tried and tested to provide recommendations in a South African context.

In terms of improving the PTI, a Local Road Safety Plan (LRSP) is the most suited action plan. The LRSP focuses on a list of priority issues, the risk surrounding the area and countermeasures that will be implemented to improve the environment (FHWA, 2018). The LRSP's follows a four-step framework to address the problem: identity, evaluate, analyse and prioritise the safety of the road environment. This LRSP developed solutions best suited for the PTI from the evaluation and analysis done above. Below, the list of priority issues that have been identified from the investigation.

Countermeasures provided aim to improve the safety and security of pedestrians by addressing:

- Movement of pedestrians
- Pedestrian accessibility and mobility to PTI, safely crossing the road network
- Pedestrian crashes hot spots
- Reducing exposure to criminal activity

Crash Reduction Factors (CRF's) will be provided with the countermeasure. The CRF will provide percentages of the improvements, using the current system as a base and how much improvement can be expected after implementation.

6.2 Safety plan

Facility improvement	Implementation	CRF
Application of multiple low-cost countermeasures	• Enhancing signage • Improve pavement marking • High visibility crossings and traffic calming • Various strategic stop control • Assistance with identification of potential conflict	10% reduction in Injury and Fatality
Leading Pedestrian Interval	• Provides pedestrians with 3-7s to enter the intersection before vehicles • Allows pedestrian to establish a presence before the vehicle can enter the intersection • Increases visibility • Increase awareness and likeliness vehicles yielding for pedestrians • Enhance pedestrian safety	60% reduction in ped-veh crashes
Marked Pedestrian Locations	• Provides designated areas where the vehicle must stop for pedestrians to cross • Significant in areas that experience high volumes of pedestrians	Research on the CRF incomplete
Corridor access management	• Control exit and entrance access • Ideally located in PTI or urban roads	25 – 31% reduction in fatal crashes

	• Access management enhances safety for all modes • Reduces delay and congestion and improves traffic flow with circulation roads • Limit turning movement • Balancing overall safety and mobility of road users	along urban roads
Walkways	• Fully integrated PTI and walkways improve safety conditions from the community for at least 1 km • Providing accessible walkways on both sides of the roads, specifically in transit locations • Provides ROW within the public space that deliberately separates vehicles from pedestrians • Reduces significant reduction in pedestrian exposure to vehicles, in turn, reducing the pedestrian-vehicle conflict.	88% reduction according to the San Antonio Pedsafe, 54th street corridor improvement
Kerb Ramps	• Improves integration of transportation modes • Promotes pedestrian use of designated crossings and pedestrian facilities leading off from the ramps • Significant improvement in mobility near transport stops or shopping facilities.	On-going research to determine the CRF

Kerb extensions	• Minimizes pedestrian exposure in the street by reducing the crossing distance • Forces vehicles to reduce speed in these area's • Prevent sightlines from being obstructed by vehicles • Provide additional on-street parking or parking space for MBT's not obstructing pedestrian facilities	CRF being researched
Sidewalk Buffers	• Creates a buffer between vehicle and pedestrians creating a level of safety, comfort and security • Bicycle lanes and environmental strips can be used within the buffer. • Allows space for ramps and landing and to ensure full accessibility to all NMT users	88% reduction
Transit Stop Location	• Should be safe, convenient and well lit. • Transit stops should allow for easy transition between transportation modes thus ideally placed close to intersections • The configuration of the transit stop location should support traffic flow	PedSafe

	• Transit stop positions should include a reduction in bus delay, encourage pedestrian participation • Connected to the sidewalk for easy accessibility and mobility • Increased transit stop space to improve capacity especially at high volumes stops	
PTI Access Control	• One-way in, one-way out • Reduces crash locations • Ideal where movement needs to be limited to a certain transport mode • Improve traffic flow and control	72% reduction in pedestrian-vehicle crashes
Parking restriction and road diet	• Removal of the parking spaces within the main MBT movement. • Implementation of the road diet to enforce the parking restrictions • Reduction in movements creating conflict points for pedestrian	39% elimination of obstructing the main roadway
Community watch	• Community watch interlinked between the PTI's • Daily schedules of crime watch rotations • Walk-with-me service when the PTI is quite or early in the morning or late at night • NPO SA community crime watch	Further research to be done

7. CHAPTER 7: RESPONSE TO RESEARCH QUESTIONS

The aim of the research was to review the current state of NMT and to determine the level of safety and security of pedestrians travelling towards the Bellville, Claremont and Mitchells Plain Public Transport Interchanges. The research provided insight into the state of international and national infrastructure and the improvements made to prioritise pedestrians. Chapter one provided a list of research questions that the research has answered.

1. **What is the level of security experienced by pedestrians when travelling from home to the PTI and at the PTI's?**

The research showed that the level of security is low. Commuters are travelling, between 5 am and 7 am, outside the normal peak period of 6 am to 8 am. Travelling earlier creates a security risk, with 54% of respondents indicating that the lighting along their route and at the PTI is insufficient. Travelling towards the PTI, 94% of respondents indicated that they encountered random people occupying the NMT space.

Security is directly linked to criminal activity. Although crime is consistent throughout the day, spikes have been experienced in the morning and afternoon. The domino effect occurs when criminal activity extends to the daily route of the commuters especially when they are restricted by limited alternative routes. According to the respondents, 52 % did not have the choice of an alternate route increasing the level of a security risk as patterns are formed over a long period of time that can be monitored and targeted.

During the pedestrian environment evaluation, the researcher identified that none of the PTI's had accessed controlled. Parameter gates are available but not operated. As a result, informal settlements have developed within the PTI area. Although one would expect crimes to occur during peak period, with the constant activity within the informal settlement commuters become easy targets.

The ANOVA results revealed that there is no difference in the level of safety and security when considering the various PTI. The results also revealed that it is highly probable that the low level of safety is not by chance but is a true reflection of what is experienced at the PTI's around the Western Cape.

2. **What is the state of NMT facilities at the various PTI's chosen as part of the investigation and how do the facilities differ?**

The NMT facilities were evaluated using the PEATS Analysis Tool and sourcing the commuter's perception through means of a survey. During the evaluation, NMT facilities were identified at the PTI. However, the questionnaire revealed that inadequate facilities were available especially lighting. In two questions, the lack of lighting was emphasised by the respondents.

The investigation revealed that commuters experience a low level of comfort when using the facilities especially the sidewalk. The research revealed that the sidewalks were overcrowded, and commuters struggled to share the over capacitated facility. Commuters were forced to walk in the roadway or take turns passing certain areas. The lack of accessibility and continuation was emphasized when respondents indicated that when travelling, they are required to walk long distance to move between public transport facilities, many roads were to be crossed and that in some regards no sidewalks were available.

During the PEATS evaluation, it was also found that the NMT facilities were not maintained. More specifically, the pedestrian crossing and road markings were faded making it difficult to identify. Furthermore, the walkways were filled with vendors and the MBT obstructed the NMT facilities throughout the PTI. The MBT used the NMT facilities as a makeshift ramp to cross from one section of the PTI to another, forcing the pedestrian's manoeuvre around them.

The planter boxes that formed part of the design for environmental improvement caused tripping hazards when the plants were stolen. Certain facilities were obstructed with California barriers, heaps of rubbish and light poles.

One of the positive features that were identified where pedestrian shared areas. These spaces were designated for commuters for recreational activities. The shared space included benches, tables and shaded area that were well utilised. The area was well located in proximity to the PTI and well maintained.

Each PTI has a set of traffic calming features that controlled traffic flow, speed and pedestrian flow. The Mitchells Plain PTI provided a well-integrated facility that accommodated the correct modes in separated areas, prioritized pedestrian

movements and utilised traffic calming measure to ensure the PTI operation was smoothly executed.

3. Which is the biggest risk faced by pedestrians when using PTI?

The biggest risk faced by pedestrians is unsafe routes and the fact that, due to an unintegrated network, no alternative routes are available. The research revealed that throughout the investigation, commuters are more concerned about their safety than the available facilities. This was evident when respondents were asked what their ideal facility was and 27% indicated that security guards along the road would take priority over vehicle driving slower, clear sightlines, wider sidewalks and better lighting. Although the NMT facility is important, respondents would substitute the facility for a safer route.

62% of respondents answered that they feel scared and exposed to harm while travelling to the PTI. 77% of respondents rated their routes as extremely risky, risky or not safe but not risky. Further to that, commuters travelling to the PTI are always alerted to their surroundings and walking fast to the PTI facility. This response emphasizes the fear experience daily when travelling to the PTI. It was determined that commuters are in a constant state of fear when travelling.

The survey gave commuters an opportunity to voice their opinions with regards to enforcement. 40% of the respondents answered that increased visibility from SAPS would lower the criminal activity. Similarly, the respondents answered, if police were stationed at the PTI, they would feel safer. Regulating the SAPS presence at the PTI would improve the usability and the level of safety. The data revealed that commuters do not hold law enforcement in high regard. Whether law enforcement is available or not, it is believed that the commuter would still travel in fear.

4. What are the major threats influencing pedestrian security when using public transport and when travelling to and from the PTI on foot?

The most common crimes recorded at the PTI was general robbery, robbery with weapons other than a firearm and robbery with a firearm. Commuters are aware of the threat. In section four of the survey, various scenarios were given, and each statement started with “do you feel safe when”. The finding showed that people were constantly aware of their surroundings. When waiting at the taxi rank, they felt that it was risky. Respondents also answered that they would feel safer if they could protect themselves.

Another threat that was identified was the MBT using pedestrian facilities as part of the roadway. Pedestrians were manoeuvring around the vehicle to complete their trips and stepping into the line of conflict even when the facilities were available. Allowing the NMT facilities to deteriorate without maintaining the infrastructure results in the NMT users being negatively affected. The poor state of the facilities affects the vulnerable road users, exposing them to unnecessary conflicts.

The ANOVA results revealed that the features with the highest P-value were computed from the results of the questions that commuters answered based on how they felt when executing a certain activity. This shows that commuters are constantly in fear or alert when travelling.

5. **What different methods can be used to improve the level of conflict around the PTI?**

Implementation and maintenance of the correct NMT facilities. Providing facilities that the end-user believe is beneficial would positively contribute to the commuter using the facilities. Many of the respondents believe that more than one route would improve safety and security risk. Commuters answered that the most important infrastructure feature is good lighting along the path travelled and at the PTI.

23% of the respondents indicated that vehicle driving at slower speeds would improve their experience and if there were fewer vendors on the sidewalks the facility will be usable. 22% answered that separating modes would increase the safety of the NMT user and that they are willing to share the roadway with vehicles if they travel at slower speeds.

Throughout the literature, examples of shared spaces and NMT improvements are emphasized. Developing countries with similar problems to South Africa implemented various NMT facilities that were accepted and have had great success in fatality rate reduction, travel time and environmental impact. The research showed that the most important aspect of the facility's success is the buy-in of the end-user.

6. **How significant is the presence of NMT facilities in risk mitigation?**

NMT is extremely vital to the safety and security of the pedestrian. Sometimes it is taken for granted that road users use the facilities more often than expected. Respondents answered that some facilities fall outside their desired path and currently it is easier to cross the way they have always cross particularly between the gaps in

the traffic stream. However, 37% of people referred to the signal being out of sync and the time wasted waiting for the signal to change.

Research reveals that people are aware of the facilities and are willing to use them. However, the correct education and training to gain an understanding of how to use the facility are vitally important, to its success and risk mitigation.

The perception of safety contributed to the commuter experience in its entirety. The safety and security of commuters should have a higher priority than implementing the correct NMT facilities as identified by the PEATS evaluation.

8. CHAPTER 8: CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

The investigation aimed to determine the level of safety and security faced by commuters travelling towards various PTIs' in the Cape Town municipal area. Combining the crash data, criminal data, questionnaire, PEATS and ANOVA the following was concluded.

The crash data showed that the most popular days for crashes are Fridays and this correlated with the criminal data because the highest number of crimes were recorded on Friday as well. Both the criminal and crash data show trends of being the highest on the main pedestrian movement routes surrounding the PTI.

It was also found that the cross-sectional layout of the roads surrounding all the PTI's played a role in the crash locations. Although public transport is expected to be the main mode, more crashes occur between pedestrians and private vehicles than public transport.

The criminal data revealed that the most common criminal activities experienced at the PTI's are common robbery, robbery with a weapon that is not a firearm and robbery with a firearm. These crimes all required the victim and the perpetrator to be close to one another. In addition, it was found that the most common methods used during these robberies are grabbing, threating and taking. Furthermore, the data revealed that males report crimes more readily than females.

From the questionnaire, it was observed that more females participated in the survey than males with the biggest sample was taken at the Bellville PTI. The common age groups for commuters was 19 – 28 years old. Most commuters travelled during the peak periods: 5 am – 7 am and 4 pm – 6 pm. The survey revealed that NMT facilities were available however the state of the NMT facilities was poor.

The level of security and perception of security was poor as concluded in the questionnaire. Suspicious characters, lack of policing and constant fear where key factors contributors to rating ones commute as risky and extremely risky.

The PEATS analysis concurred the infrastructure is available, although it is not well maintained and can increase the risk of pedestrian incidents, however, features like traffic calming and good street design were recorded at all PTI's. Many challenges at

NMT facilities were incurred and emphasizing the importance of the facility would increase awareness and encourage the use thereof.

Furthermore, it was concluded that from the ANOVA statistical analysis, theory, crash and criminal data collected substantiates the experience of the commuters within the Western Cape. The ANOVA provides statistical results showing that irrespective of where you are travelling in the Western Cape commuters experience low safety levels and similarly a poor perception of safety.

8.2 Recommendations

The recommendations of the study are as follows:

Bellville is the only PTI with the entrance and the exit at a common point and Claremont and Mitchells Plain are designed with a one way in, one way out layout configuration. It is recommended that the Bellville PTI be upgraded to follow a similar design as the other PTI's. The upgrade will ensure that a constant flow of traffic is maintained, improve pedestrian flow and reduce the concentration of pedestrians in one space. This design would improve the pedestrian's experience as it would not require pedestrians to interpret too many vehicle movements at the same time.

Secondly, maintenance of the NMT infrastructure should be prioritized. Instead of waiting for the city to repair the infrastructure local communities can be involved in the PTI improvements to ensure that less of the NMT facilities deteriorate to an unusable condition.

As indicated in the literature, shared spaces can be implemented around the PTI which would control the vehicle movement and raise awareness with regards to NMT. Converting unused space at the PTI to commuter-friendly spaces and allocating space to vendors would improve the mobility and accessibility of the pedestrian space.

The final recommendation is improving the safety and security of pedestrians. The infrastructure is available, however, more law enforcement is required. The PTI experiences high volumes of commuters daily. Providing programmes that incorporate police and community volunteers to protect the community would provide communities with a sense of pride. As recommended in the action plan, a neighbourhood walk initiative can be implemented to improve safety in certain areas.

8.3 Future Research

- The economic impact of dilapidated NMT facility on the safety and security of pedestrians.
- Network evaluation of the NMT facilities in the City of Cape Town Municipal area as this research was limited to the scope of the research.
- The economic output to improve the NMT facilities.

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10. ANNEXURES

ANNEXURES A: ETHICS COMMITTEE LETTER OF APPROVAL

ANNEXURES B: PEATS EVALUATION

ANNEXURES C: QUESTIONNAIRE

ANNEXURES D: PLAGERISM DECLARATION