**DURBAN UNIVERSITY OF TECHNOLOGY**

# GEOSPATIAL ANALYSIS OF FATAL ROAD TRAFFIC ACCIDENTS FOLLOWING AMBULANCE RESPONSES IN CAPE TOWN

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**GEOSPATIAL ANALYSIS OF FATAL ROAD TRAFFIC ACCIDENTS FOLLOWING AMBULANCE RESPONSES IN CAPE TOWN**

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**Abstract**

Road traffic accidents (RTAs) are a leading global health concern and are projected to rank as the seventh leading cause of death by 2030, with low- and middle-income countries, particularly in Africa, facing the greatest burden. In Cape Town, South Africa, pedestrians are disproportionately vulnerable to RTA fatalities. This study aimed to examine demographic, temporal and geographic patterns of fatal RTAs to guide safety and emergency response interventions. Using data from the Western Cape Government Health and Wellness Emergency Medical Services (WCGHW EMS) from January 2021 to May 2024, descriptive statistics and geospatial analyses were conducted on 784 RTA cases, including 167 fatalities. Males accounted for 70.7% of deaths, and pedestrian accidents represented 65.3% of fatalities, with night-time RTAs posing nearly twice the mortality risk of daytime incidents. Fatalities clustered in poorly lit eastern suburbs, including Gugulethu, Nyanga, Mitchells Plain and Khayelitsha, which had a two-fold higher mortality risk compared to other areas. These findings highlight the critical need for improved infrastructure, including better lighting and pedestrian facilities, alongside enhanced emergency response systems. Targeted interventions addressing these vulnerabilities are essential to reducing RTA fatalities in Cape Town and similar settings.

**Keywords**: Emergency medical services; geospatial analysis; night-time fatalities; pedestrian safety; road traffic accidents

## Declaration by student

I hereby declare that this work is my own intellectual property and has not been previously submitted for assessment or any other purpose at Durban University of Technology or any other institution. Unless explicitly acknowledged, the content does not include the work or contributions of any other person. I understand the importance of academic integrity and affirm that this submission is a true reflection of my own original efforts.

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Date: 15/08/2025

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## Table of contents

## List of tables

## List of figures

## List of acronyms

| | |
|---|---|
| ADS | Augmented Dickey-Fuller test |
| CAD | Computer-Aided Dispatch |
| CI | Confidence Interval |
| COCT | City of Cape Town |
| EMS | Emergency Medical Services |
| ePCR | Electronic Patient Care Report |
| GDP | Gross Domestic Product |
| GIS | Geospatial Information System |
| KDE | Kernel Density Estimation |
| KPSS | Kwiatkowski-Phillips-Schmidt-Shin test |
| MVA | Motor Vehicle Accident |
| PVA | Pedestrian-Vehicle Accident |
| QGIS | Quantum Geographic Information System |
| RR | Relative Risk |
| RTA | Road Traffic Accident |
| WCGHW | Western Cape Government Health and Wellness Emergency Medical Services |
| WHO | World Health Organisation |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction and background of the study

Road traffic accidents (RTAs) are a global concern, and they are expected to become the seventh biggest cause of death by 2030 (Berhanu et al. 2023a). There were 50 million injuries and 1.35 million fatalities reported worldwide in 2018, with patients between the ages of 5 and 29 being the most at risk (Odusola et al. 2023). Modernising transport networks has led to increased RTAs, causing injuries and fatalities (Haseeb et al. 2018). Although accounting for less than 60% of the global motor vehicle population, low- and middle-income countries account for over 90% of road traffic deaths (Haseeb et al. 2018; Berhanu et al. 2023b). Despite having the fewest vehicles per person and the smallest road network of any continent, Africa has the highest rate of road transport fatalities (Statistics South Africa 2024). However, a prevalent issue in most African countries is the inadequate documentation of RTAs, where police records serve as the principal means of ascertaining the extent of road accidents and injuries (Statistics South Africa 2024).

According to the South African Medical Research Council, RTAs ranked as the ninth most common cause of death among children under the age of five in South Africa in 2000 (Carreira et al. 2022). Additionally, RTAs were the primary cause of death for children aged between 5 and 14 years, with a rate twice as high as the global average (Carreira et al. 2022). The increased road fatalities in South Africa may be due to the number of motorised vehicles, which have experienced a twofold growth over the past two decades, while the rate of road deaths has risen by 25% between 1990 and 2011 (Mabila and John 2022). In 2015, the estimated overall cost of RTAs was ZAR 142.95 billion (about US$ 79 12 billion)[1], which is comparable to 3.4% of South Africa's gross domestic product (GDP) (Verster and Fourie 2018).

[1] The exchange rate was calculated on 14 August 2025 at 1 USD = 18.08 Rands

Recent research has highlighted the complexity and breadth of emergency medical operations (Abdullah et al. 2025). During their three-year study period (2021-2023), the Western Cape EMS responded to 2,587,979 activations, of which 23,899 (0.9%) required specialised medical rescue, and 11,699 (0.5%) were for transport-related emergencies. Notably, 719 (6.1%) cases involved vehicle extrication, a technically demanding aspect of prehospital care. Light motor vehicles accounted for most of these extrications (78.2%, n =562), although heavy motor vehicles had higher proportional extrication rates (127.5 vs. 75.8 extrications per 1,000 RTCs). Rescue activations peaked between 08h00 and 20h00 (11.9%, n =1,388), with predominant extrication techniques including vehicle stabilisation (24.9%, n =501), third-door conversion (23.9%, n =482), and dashboard lift (13.9%, n =282). Counterintuitively, most patients (83.1%, n =24,588) presented with routine or non-urgent acuity; however, rural areas exhibited a higher proportion of high-acuity cases relative to metropolitan settings.

Factors that often lead to a high incidence of accidents include speeding, irresponsible driving, impaired driving (due to alcohol or drugs), fatigue and failure to comply with traffic laws (Chand et al. 2024; Dela Cruz et al. 2021; Modipa 2023; Pires and Sipos 2022). Equally, inadequate road infrastructure, which is characterised by insufficient road signage, badly maintained roads, absence of pedestrian crossings, and inadequate lighting also heightens the likelihood of accidents (Hossain et al. 2023). Road accidents are also caused by inadequate vehicle maintenance and the utilisation of unroadworthy vehicles (Hussain et al. 2021; Mesic et al. 2024). Factors such as malfunctioning brakes, deteriorated tyres, and vehicle defects might increase the probability of road accidents (Casado-Sanz et al. 2020). A significant issue on South African roads is the lack of comprehension and interpretation of road regulations by drivers and pedestrians. The use of mobile phones while driving is recognised as a growing concern for road safety in South Africa (Modipa 2022).

The impact of road safety on the economy, public health, and the general welfare of South African citizens is substantial and diverse. RTAs lead to a decrease in productivity, as people may be unable to work owing to injuries from accidents (Modipa 2023). The decrease in productivity has a negative impact on the affected individuals, businesses, and the overall economy. Road accidents resulting in fatalities and injuries might result in a depletion of skills within the workforce. The demise or debilitation of proficient employees can have enduring repercussions on businesses and sectors that depend on their competence, subsequently affecting economic expansion (Statistics South Africa 2024). Equally, the fatalities resulting from these incidents frequently deprive households of their primary income earners, intensifying the economic repercussions.

Emergency medical services (EMS) are crucial in reducing the severity of injuries and fatalities in RTAs (Odusola et al. 2023). Ambulances are equipped with skilled medical staff and essential medical equipment to deliver prompt medical aid to individuals involved in accidents. Timely medical intervention can effectively stabilise individuals and mitigate further deterioration. Additionally, they expedite transportation to the closest suitable medical facility, where individuals can access specialised medical care. The study concentrates on the Western Cape, a province bearing the highest number of pedestrian deaths between 2007 and 2019 (Statistics South Africa 2024). The WCGHW EMS offers emergency assistance to all residents within the province. However, there is limited knowledge of their call patterns, particularly regarding RTAs.

## 1.2 Problem statement

While significant progress has been made in “Arrive Alive” campaigns, road traffic accidents remain a cause for concern in South Africa. The country continues to experience a high frequency of road transport accidents, substantially impacting society and the economy. In 2018, there were 12 921 road fatalities in South Africa, with an 18% increase in transport-related deaths per 100 000 people from 2000 to 2018 (Statistics South Africa 2024). This emphasises the dire need for comprehensive efforts to tackle road safety and reduce the number of RTA-related injuries and fatalities in South Africa.

The Western Cape province had the third-highest RTA pre-hospital deaths between 2007 and 2019 in South Africa (Statistics South Africa 2024). The province also had the highest number of pedestrian accidents between 2007 and 2019 in South Africa (Statistics South Africa 2024). Furthermore, recent data indicates that Cape Town had more pedestrian accidents than any other city in the country between 2021 and 2023 (Staff Writer 2024).

These accidents come with significant economic consequences. These include increased healthcare costs from prolonged hospital admissions following RTAs, property damage and reduced quality of life for the affected patients. This financial burden exerts pressure on an already burdened healthcare system, individuals and families. There is also the unmeasurable emotional turmoil following the loss of a productive member of society, which can have adverse effects on mental health.

## 1.3 Aim and objectives of the study

This study aimed to identify the areas with high incidences of road traffic mortality at the scene following public emergency medical services response in the city of Cape Town to inform targeted EMS deployment and road safety and road safety policy interventions. This aim was achieved through the fulfilment of three objectives, namely:

i. To establish the demographic characteristics of patients involved in fatal road traffic accidents following public emergency medical service responses in Cape Town,

ii. To identify fatal road traffic accident hotspots in Cape Town, and

iii. To inform policy on emergency services' resource allocation towards road traffic accident hotspots.

## 1.4 Significance of the study

Analysing road accident data is crucial for identifying high-risk regions for serious injuries and fatalities (Berhanu et al. 2023b). Publishing hotspot information can alert road users to exercise extra caution in high-risk areas. This could reduce road RTA fatalities and serious injuries. By identifying places with a high prevalence of fatal accidents, the study can enable authorities to execute targeted measures. This could involve infrastructure upgrades such as enhanced lighting, pedestrian crossings and traffic calming measures. Furthermore, the findings may inform new traffic laws, speed restrictions, or enforcement strategies. Understanding the spatial distribution of fatal accidents can also lead to more strategic deployment of emergency services, reducing response times and saving lives. The study can help ensure that suitable resources are accessible where they are most needed. The study can also enhance public awareness about road safety issues by emphasising gravity and specific areas of fatal incidents. This can encourage individuals to embrace safer behaviours and endorse programmes targeted at mitigating road traffic deaths.

## 1.5 Organisation of the study

The rest of the study is organised into four chapters. Chapter 2 reviews existing literature, discussing geospatial analysis and road traffic accidents. Chapter 3 provides the methodology employed in the study. Chapter 4 presents and discusses the findings of the study. Chapter 5 concludes the study, providing recommendations and possibilities for future research.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

This chapter provides a comprehensive review of the theoretical and empirical literature on RTAs. It starts by exploring theoretical frameworks, including the Koper curve and deterrence theories, which examine the potential impact of law enforcement visibility on reducing RTAs. The review transitions to empirical literature, emphasising the role of geospatial analysis in identifying and characterising accident hotspots, with examples from previous studies demonstrating the effectiveness of this methodology in understanding RTA trends. A global perspective is presented, highlighting the disproportionate burden of RTAs on low- and middle-income countries, such as South Africa. The chapter concludes by examining key factors contributing to RTAs, including mobile phone use, vehicle speed, alcohol consumption, car characteristics, environmental factors, gender and age.

## 2.2 Theoretical literature

This section discusses some theories underpinning road traffic accidents. These include the Koper curve and deterrence theories. Theories provide a lens through which researchers can view their research question. They help to place the study within a larger body of knowledge by emphasising pertinent concepts, links and potential explanations.

### *2.2.1 The Koper curve theory*

Introduced by Koper in 1995, the theory posits that an ideal length of time exists for police patrols in high-crime areas that maximises the effectiveness of deterring criminal activity (Williams and Coupe 2017). Crime often concentrates in specific localised areas known as hot spots. Concentrating police patrols in areas of high criminal activity can effectively decrease crime rates (Sherman et al. 2014). The argument posits that officers do not require prolonged stays in high-crime areas. Brief, sporadic visits are equally, if not more, helpful. According to Koper's research, the optimal strategy for deterrence is to conduct random patrols in high-crime areas, lasting between 10 and 16 minutes, and repeat them at least every two hours. This practice keeps criminals vigilant and diminishes the probability of criminal activity compared to extended or foreseeable patrols (Sherman et al. 2014). Research has provided evidence for the effectiveness of the Koper Curve, establishing it as a viable instrument for law enforcement agencies seeking to effectively allocate their resources (Williams and Coupe 2017). Numerous studies have supported Koper's finding that approximately 10 minutes of patrol time is a turning point for increased deterrence, while patrol durations beyond this threshold demonstrate diminishing gains in crime reduction (Williams and Coupe 2017; Braga et al. 2019).

There are several causes of RTAs described in the literature, including drunken driving, reckless and negligent driving, and unroadworthy vehicles (Statistics South Africa 2024). The Koper curve theory suggests that law enforcement efforts can be strategically placed in fatal accident hotspots. These patrols should be short (approximately 10-16 minutes), frequent and unpredictable. This theory suggests that these measures deter unwanted behaviour more than longer, predictable patrols. The theory also suggests that these patrols should be repeated at least every two hours to maintain unpredictability and vigilance among potential offenders. These principles can be applied by law enforcement in hotspot areas to reduce fatal accidents (Williams and Coupe 2017).

### *2.2.2 The deterrence theory*

The deterrence theory was formulated by three influential philosophers: Thomas Hobbes (1651), Jeremy Bentham (1789), and Cesare Beccaria (1872) (Abramovaite et al. 2023). They argued that when punishment is severe, certain and swift, rational individuals will consider the potential benefits against the risks before committing illegal acts, which ultimately discourages them from violating the law (Abramovaite et al. 2023). It encompasses three principles: severity, certainty and celerity. Severity refers to the notion that the punishment for a crime should be commensurate with the seriousness of the offence. This idea posits that more severe penalties will dissuade individuals from participating in unlawful activities. The concept of certainty suggests the probability of being apprehended and penalised for wrongdoing acts as a deterrent. Greater perceived certainty of punishment leads to increased effectiveness in deterrence. Celerity refers to the notion that the promptness of punishment plays a vital role in discouraging illegal conduct. Immediate consequences are more effective in deterring individuals than delayed or ambiguous punishments (Lee 2017).

The deterrence theory has expanded to include new aspects influencing people's decision-making processes. Novel ideas like penalty avoidance, deterrability, disobedience, and the influence of informal social influences on an individual's decision-making have been proposed (Tomlinson 2016; Lee 2017). This progression demonstrates a transition towards a more sophisticated comprehension of how deterrence functions in practical situations. Furthermore, recent studies on deterrence have emphasised the significance of non-legal elements, including social connections, employment situations, peer pressure and moral convictions, in influencing individuals' behaviour (Tomlinson 2016; Lee 2017). These elements have been determined to exert a greater influence on obedience than conventional threats of punishment (Lee 2017).

The theory suggests that increasing the perceived certainty of being caught and punished for traffic offences such as speeding and reckless, negligent driving can deter drivers from engaging in such behaviours (Lee 2017). This could be achieved through law enforcement visibility and the use of speed cameras in hotspot areas. The theory also proposes that punishment severity should be proportionate to the seriousness of the offence. This could involve stricter penalties for traffic offences that contribute to fatal accidents, such as reckless and negligent driving or impairment due to substance abuse (Tomlinson 2016).

The theory also emphasises the importance of swift or certain punishment in deterring risky driving behaviours (Abramovaite et al. 2023). This includes faster processing of traffic violations, quicker court proceedings and timely penalty impositions. Deterrence theory can also be applied to public awareness campaigns and educational programmes aimed at promoting road safety. Highlighting the potential consequences of risky driving behaviour and emphasising the increased enforcement efforts in hotspot areas can influence drivers' perceptions of the certainty and severity of punishment, potentially leading to safer driving practices.

## 2.3 Empirical literature

This section addresses some of the empirical literature on road accidents. First, the section presents literature on geospatial analysis in the context of identifying road accident hotspots. It then offers a global overview of RTAs before discussing RTA deaths in South Africa. Thirdly, a discussion on the factors that contribute to RTAs is presented. This section contextualises the current RTA literature, ensuring the study is well-informed and rigorous.

### *2.3.1 Literature on geospatial analysis*

Geospatial analysis is a method for analysing and interpreting data that has a geographic or spatial component (Smedley et al. 2019). Accordingly, this study entails collecting, displaying and analysing data about a specific geographic region (Cape Town) on the Earth's surface. The geospatial analysis thus integrates geographical information with other forms of data to reveal patterns, trends and relationships that would not be visible in standard data analysis (Berhanu et al. 2023). Geospatial analysis can assist in identifying hotspots or locations with a high rate of accidents, allowing authorities to initiate targeted strategies. Geospatial analysis maps out RTA sites and analyses spatial patterns. It provides significant insights into the causes that contribute to accidents and aids in formulating initiatives to improve road safety and reduce the occurrence of accidents (Wee et al. 2021).

Spatial analysis was used in an Ethiopian study to identify hotspots for RTAs in Addis Ababa between 2014 and 2019 (Berhanu et al. 2023b). The study identified 46 hotspot locations within the Addis Ababa road network by applying spatial analysis techniques, such as Getis-Ord spatial statistics and crash rate analysis. These hotspots were distributed across 33 road segments, three intersections, and ten roundabouts/squares throughout the city. Among the identified hotspots, Djibouti Street emerged as the most critical accident hotspot. This segment recorded 212 accidents, with an average of 37.5 crashes per kilometre per year, underscoring the concentration of accidents in this specific segment of the road network (Berhanu et al. 2023b).

Another geospatial analysis study successfully identified distinct hot zones in Tunisia's North-West, Centre-East and Centre-West regions across three time periods (2002–2013), revealing that crash patterns vary regionally and temporally (Ouni and Belloumi 2019). Significant spatial clusters of crashes were found along major highways like NH1 and NH2, indicating higher accident susceptibility due to factors such as traffic volume and road conditions. The study also introduced the concept of "probable hot zones", identifying 23 areas in the Centre-West region that may experience future crashes, highlighting the need for targeted interventions. The study also noted variability in the lengths of hot zones, providing insights into the risks associated with different road segments. Each region's unique characteristics, including population density and built environment, necessitate region-specific safety policies (Ouni and Belloumi 2019).

A geospatial analysis of RTAs in Singapore from January 2013 to December 2014 revealed several key findings (Wee et al. 2021). A total of 35 673 individuals were injured, with 920 classified as Tier 1 victims (injury severity score > 15). A total of 745 individuals (81.0%) of the Tier 1 victims were discharged alive, while 175 individuals (19.0%) did not survive. The median ISS for those who died was significantly higher (38.00) than for survivors (22.00). The majority of Tier 1 victims were motorcycle riders (50.1%), followed by pedestrians (21.8%) and cyclists (9.9%). Most victims were male and aged between 20 and 40 years, with a peak in accidents occurring between 06:00 and 07:59 hours. The study identified nine significant hotspots ($p < 0.01$) for severe RTAs, identifying locations with a higher prevalence of severe injuries (Wee et al. 2021).

Spatial and temporal analysis of RTAs in Lagos revealed several key findings (Odusola et al. 2023). Accidents were predominantly located in five urban local government areas LGAs-Eti-Osa, Ikeja, Kosofe, Ikorodu and Alimosho-accounting for over half of all incidents. The RTA distribution exhibited distinct spatial patterns, with certain areas being more accident-prone, influenced by factors like population density and traffic congestion. Traffic congestion significantly delayed ambulance responses, especially in densely populated LGAs such as Agege and Apapa, highlighting a link between high traffic volumes and increased RTAs. There was variability in emergency response times across different LGAs, with some areas experiencing longer delays in ambulance dispatch and transit, potentially affecting patient outcomes. The analysis also indicated that RTAs peaked at specific times of the day and during certain seasons, providing insights for better resource allocation and emergency response planning (Odusola et al. 2023).

A study in Lahore used spatial analysis to identify high-risk locations for pedestrian accidents (Haseeb et al. 2018). The spatial analysis identified high-risk areas in Lahore with a significant concentration of pedestrian accidents, totalling 702 recorded incidents from 2012 to 2017. Most accidents occurred during peak traffic hours, particularly between 12:00 p.m. and midnight, coinciding with increased commercial and educational activities. The analysis revealed that males were more frequently involved in pedestrian fatalities than females, with cars being the most commonly involved vehicle type in these accidents (Haseeb et al. 2018).

### *2.3.2 Literature on road accidents*

The first mass-produced automobile was introduced in 1908 (Stevenson and Bhalla, 2020). Over the next nineteen years, 15 million automobiles were sold. The exponential growth of automobile sales marked the rise of private motorisation in many high- and middle-income countries. The growth of private motor cars in the first half of the 20$^{th}$ century resulted in increased road accidents, a negative consequence of investing in a road transport system geared primarily for private motor vehicle use (Stevenson and Bhalla, 2020). Approximately 1.35 million people currently die from road traffic accidents each year globally (Odusola et al. 2023). The literature projects that road traffic injury will rank as the seventh most common cause of death by 2030 (Berhanu et al. 2023a). These RTAs are not without consequences to the economy. A study of 17 high-income countries found that the social cost of RTAs ranged from 0.5% to 6% of a country’s GDP (Wee et al. 2021). On the other hand, low- and middle-income countries account for 90% of the global road traffic deaths (Berhanu et al. 2023b). In South Africa, the cost of RTAs to its GDP is 3.4% (Verster and Fourie 2018), highlighting the increased burden compared to high-income nations. Thus, effective road safety measures to mitigate RTA costs are warranted. South Africa has one of the world's highest road traffic mortality rates, with a mortality rate of 24.64 per 100 000 people (Mabila and John 2022). RTAs cost the country an estimated R307 billion annually (Mabila and John 2022). Statistics South Africa (2024) reported that deaths due to RTAs increased from 6 190 in 2007 to 6 423 in 2019 in South Africa. These statistics are very high when compared to deaths due to RTAs recorded in developed countries. For example, Great Britain reported 1 711 road collision fatalities in 2022 (Department of Transport, United Kingdom 2023). Thus, South Africa's road accident mortality is almost four times higher than the fatalities reported in Great Britain.

Generally, the highest annual number of fatalities in South Africa's RTAs are recorded during the month of December (Statistics South Africa 2024). In the Western Cape province, the number of pedestrian fatalities increased from 640 in 2007 to 771 in 2019 (Statistics South Africa 2024). The province registers a greater incidence of pedestrian deaths than other South African provinces. The number of fatalities among car occupants rose from 363 in 2007 to 548 in 2019, with the Western Cape and Free State provinces reporting higher fatality rates (Statistics South Africa 2024).

### *2.3.3 Factors contributing to road traffic accidents*

Studies have shown that mobile phone usage contributes to a significant percentage of incidents due to driver distraction (Hossain et al. 2022; Chand et al. 2024). When pedestrians use their phones while walking, they become less aware of their surroundings and are more likely to get into accidents with cars or other objects (Dangisso 2023). Texting while walking has been found to decrease situational awareness and increase the risk of accidents (Hossain et al. 2022). Similarly, engaging in hands-free mobile phone conversations while driving can negatively impact driving performance and safety. Inexperienced teenage drivers are particularly at risk when using mobile phones while driving, especially during weekends or in poor weather conditions (Yan et al. 2018). However, more experienced drivers tend to have better risk management skills and are less likely to engage in such dangerous behaviours, which results in lower crash severity rates (Yan et al. 2018).

Vehicle speed is another significant factor in road accidents, with studies showing a correlation between speeding and collision risk (Dela Cruz et al. 2021; Pires and Sipos 2022). Exceeding the speed limit has been found to increase the likelihood of being involved in a road accident, and higher speeds are associated with a greater risk of pedestrian fatalities (Yue et al. 2020). One study found that speeding accounted for 13% of all crashes, with a higher incidence in non-commercial vehicles (16%) than in commercial vehicles (11%) (Hussain et al. 2021). Speeding affects driver reaction time and braking distance, making it harder to avoid incidents with pedestrians who are more vulnerable to the impact of speeding cars (Yue et al. 2020). However, it is worth noting that some collisions occur at speeds below 55 km/h, and low-speed cars can contribute to traffic congestion and waste traffic resources (Xu et al. 2023).

Alcohol-impaired driving is a major threat to road safety and a leading cause of accidents (Modipa et al. 2022). Studies have shown that alcohol is a significant predictor of mortality in RTAs (Culhane et al. 2019; Statistics South Africa 2024). Many countries have implemented campaigns to address drunk driving and enforce regulations. In India, alcohol-impaired driving accounted for nearly a quarter of the accidents (Chand et al. 2024). Similarly, in South Africa, the number of cases of driving under the influence of alcohol or drugs has been on the rise (Modipa 2022). Impaired drivers are likelier to commit speeding offences, such as exceeding the speed limit, and exhibit unsafe driving behaviours. Alcohol affects a person's judgement, alertness, decision-making, and control of the vehicle, leading to impaired driving performance and increased risk of accidents (Valen et al. 2019). It is thus unsurprising that the odds ratio for mortality for drivers who test positive for alcohol is 2.57, showing a significantly increased risk of death compared to drivers who test negative for alcohol (Culhane et al. 2019).

Wearing seatbelts is crucial in reducing the likelihood of fatalities in road accidents, as unrestrained individuals face a higher risk of sustaining fatal injuries (AlKheder et al. 2022a). Furthermore, inadequate vehicle maintenance, lack of safety measures, and overloading contribute to accidents and fatalities (Mesic et al. 2024). Poorly maintained vehicles are more prone to mechanical malfunctions, while vehicles without essential safety equipment are more susceptible to accidents and severe injuries (Casado-Sanz et al. 2020). Mechanical faults, such as engine failures and brake malfunctions, contribute significantly to road crashes, particularly in commercial vehicles. Tyre bursts are also critical, with deteriorated tyre conditions increasing the risk of losing vehicle control (Hussain et al. 2021). The prevalence of older vehicles on the roads, influenced by economic conditions, contributes to insufficient maintenance. Different vehicle types have varying impacts on crash severity, with auto-rickshaws, motorcycles, and buses more often involved in severe crashes (Bhuiyan et al. 2022). Vehicle age and condition play a crucial role in safety, as poorly maintained vehicles are at a higher risk of accidents, and larger and heavier vehicles tend to result in more severe outcomes in crashes (Bhuiyan et al. 2022).

Poor visibility, caused by factors such as lack of streetlights and adverse weather conditions, significantly contributes to RTAs (Hossain et al. 2023). Studies have shown that winter weather conditions, including snow and cold, substantially impact increasing RTAs, particularly in regions with prominent winter weather (Henderson et al. 2021). Human factors, such as drivers trying to maintain velocity on slick roads and diminished vehicle reactivity in winter, play a role in these accidents. Contrary to previous beliefs, darkness is not the main reason for increased accidents, as most winter crashes occur during daylight (Henderson et al. 2021). In Pakistan, hot weather conditions have increased crash severity, potentially due to decreased traffic flow and increased speeding (Alshehri et al. 2024). Moderate temperatures also increase traffic flow and a higher likelihood of road crashes (Li et al. 2023). Additionally, lighting conditions play a crucial role, with daytime conditions leading to more severe crashes due to greater traffic volume and potentially more hazardous driving behaviours (Bhuiyan et al. 2022).

Male drivers have a higher likelihood of being injured in accidents compared to female drivers due to their aggressive driving behaviours (Lee et al. 2023). Younger male drivers are especially prone to risky driving behaviours, while older drivers tend to be more cautious.

The age and gender of the at-fault driver significantly impact crash severity, with younger drivers being more likely to experience bodily injury or fatal crashes (Lee et al. 2023). In particular, younger drivers are associated with a higher likelihood of experiencing bodily injury or fatal crashes. For example, at age 15, the probability is 0.703 for female drivers and 0.718 for male drivers (Lee et al. 2023). However, the impact of gender on crash severity varies across different age groups, with males in the younger age group facing greater risks (Ayuso et al. 2020). In the 65- to 75-year-old group, males have a higher probability of fatal crashes. However, in the 75 and older age group, gender does not significantly explain variations in crash severity (Ayuso et al. 2020). Historically, males have had higher mortality rates from road accidents. Still, recent trends suggest that this gap is closing as societal gender roles change, a phenomenon known as the convergence hypothesis. This convergence hypothesis suggests that as traditional gender roles decline, the disparities in accident fatality rates between males and females may also decrease (Karaye et al. 2023).

A study by McCarty and Kim (2024) found that drivers aged between 15 and 24 years were more likely to engage in risky driving behaviours, increasing their chances of being involved in accidents. However, this age group has a lower overall accident rate. On the other hand, the study also revealed that places with a higher percentage of individuals aged 65 and up have lower accident rates per capita, suggesting that elderly populations may drive more cautiously.

Additionally, the study found a positive correlation between the proportion of individuals aged between 35 and 49 years in the population and the average projected accidents per capita. Another study showed that age plays a crucial role in crashes involving adolescents on two-wheeled vehicles, with the highest proportion of fatalities occurring among 15-year-olds (Unkuri et al. 2024). Furthermore, Karaye et al. (2023) found that younger individuals have higher risks of injury from road traffic accidents, while older adults have increased mortality rates. A Korean study highlighted that older groups, especially those over 55 years, face a greater risk of severe thoracic injuries compared to younger individuals (Choi et al. 2023). They noted that occupants aged 60 years and above had a 2.43 times higher risk of mortality than those under 60, reflecting a similar pattern in the severity of injuries (Choi et al. 2023).

While demographic patterns explain variations in crash risk and injury severity, EMS capacity ultimately determines patient outcomes. Large-scale studies underscore the link between rapid EMS deployment and survival after RTAs (Byrne et al. 2019; Mahdinia et al. 2022; Huang et al. 2024). A US analysis of over 2.2 million ambulance responses found that each additional minute in response time increased fatality odds by 2.6% (Byrne et al. 2019). Counties with prolonged response times (≥12 vs <7 minutes) had a 46% higher MVC mortality rate, independent of rurality, scene/transport times, trauma access, and traffic laws. Similar findings from a spatial-temporal analysis of pedestrian fatalities showed that shorter response times extended survival, allowing greater scope for intervention (Mahdinia et al. 2022). The impact of EMS timing, pedestrian behaviour, and roadway features varied by location and time, highlighting the need for targeted strategies. Overall, minimising EMS response times is a critical determinant of survival in both vehicular and pedestrian RTAs (Huang et al. 2024).

## 2.4 Conclusion

In conclusion, the literature review provides insights into the global prevalence of RTAs and their economic costs. South Africa has one of the highest road traffic mortality rates, with factors such as mobile phone use, vehicle speed, alcohol use, vehicle characteristics, environmental factors, gender, and age contributing to RTAs. Geospatial analysis has been used to identify hotspots and spatial patterns of RTAs, providing insights for targeted interventions and road safety measures. Overall, the literature review underscores the need for effective law enforcement strategies, behaviour change interventions, and geospatial analysis to mitigate the occurrence and severity of traffic accidents. The next chapter presents the research method used in the study.

# CHAPTER 3

# METHODOLOGY

## 3.1 Introduction

This chapter outlines the research methodology employed to investigate fatal RTAs following emergency medical service (EMS) responses in Cape Town. The study adopted a retrospective descriptive approach, utilising data from the WCGHW EMS for the period between January 2021 and May 2024. The methodological framework is designed to analyse demographic, temporal and spatial patterns of RTAs to identify high-risk locations and inform strategic road safety interventions.

The chapter details the research design, study site, data sources and analytical techniques, including geospatial mapping and statistical analyses. Ethical considerations and limitations of the study are also addressed. By systematically assessing the frequency, distribution and characteristics of fatal RTAs, the methodology ensures a comprehensive understanding of road safety challenges in Cape Town, providing insights for targeted policy recommendations.

## 3.2 Research design

An appropriate research design must be chosen to conduct a successful research study (Asenahabi 2019). A research design is defined as a plan devised by a researcher to meet the study objective in a legitimate and reliable way. The term "research design" refers to the entire plan employed to conduct a study. It is the framework that researchers utilise to address a given research issue (Asenahabi, 2019; Bloomfield and Fisher 2019). A study design consists of three unique components: a plan, a structure and a strategy (Bloomfield and Fisher 2019). A research design is thus chosen based on its ability to convert a research problem into data for analysis while providing appropriate answers to research questions at a low cost. Additionally, it must align with the study's goals and objectives while considering practical constraints such as time, funding and researcher availability (Asenahabi 2019).

This study employed a retrospective descriptive analysis of EMS dispatch data collected for RTAs victims in Cape Town to identify geographic hotspots and temporal peaks associated with the highest incidences of RTA mortality. By pinpointing these hotspots, the study aimed to generate evidence for targeted EMS policy interventions and resource deployment strategies in the areas of greatest need. A descriptive design was chosen to allow for systematic characterisation of spatial and temporal patterns without altering the study environment (Bloomfield and Fisher 2019). Retrospective data were well suited to this purpose, offering comprehensive coverage of attended incidents and enabling hotspot mapping. Similar hotspot-focused analyses have been in South African and international contexts to guide location-specific EMS planning and improve outcomes in high-risk zones (Ouni and Belloumi 2019; Stassen et al. 2020; Wee et al. 2021; Stassen et al. 2022; Gage et al. 2025).

### 3.3 Empirical setting

The study was conducted in the city of Cape Town, which had an estimated population of 4.7 million inhabitants in 2022 (City of Cape Town 2022). Cape Town covers an area of approximately 2 455 km² and has a coastline of 294 km (City of Cape Town: 2022). Cape Town's population density rose from 1 529.3/km² in 2011 to 1 951.7/km² in 2022, representing a 27.6% increase (City of Cape Town 2022). The decline of the rail service in Cape Town has led to a steep increase in road usage (City of Cape Town 2020). This has resulted in serious gridlock during peak periods, with a shift of passengers to the road network (City of Cape Town 2020).

The Western Cape Emergency Medical Services has approximately 253 ambulances and 1633 operational personnel (Abdullah et al. 2024). They do between 400 000 and 620 000 cases a year, with assaults being the most common cause of trauma emergencies, accounting for 50% of the EMS caseload (Abdullah et al. 2021; Binks et al. 2023). Figure 3.1 provides a detailed view of Cape Town and its surrounding areas, highlighting the city's road networks, geographical features and urban layout.

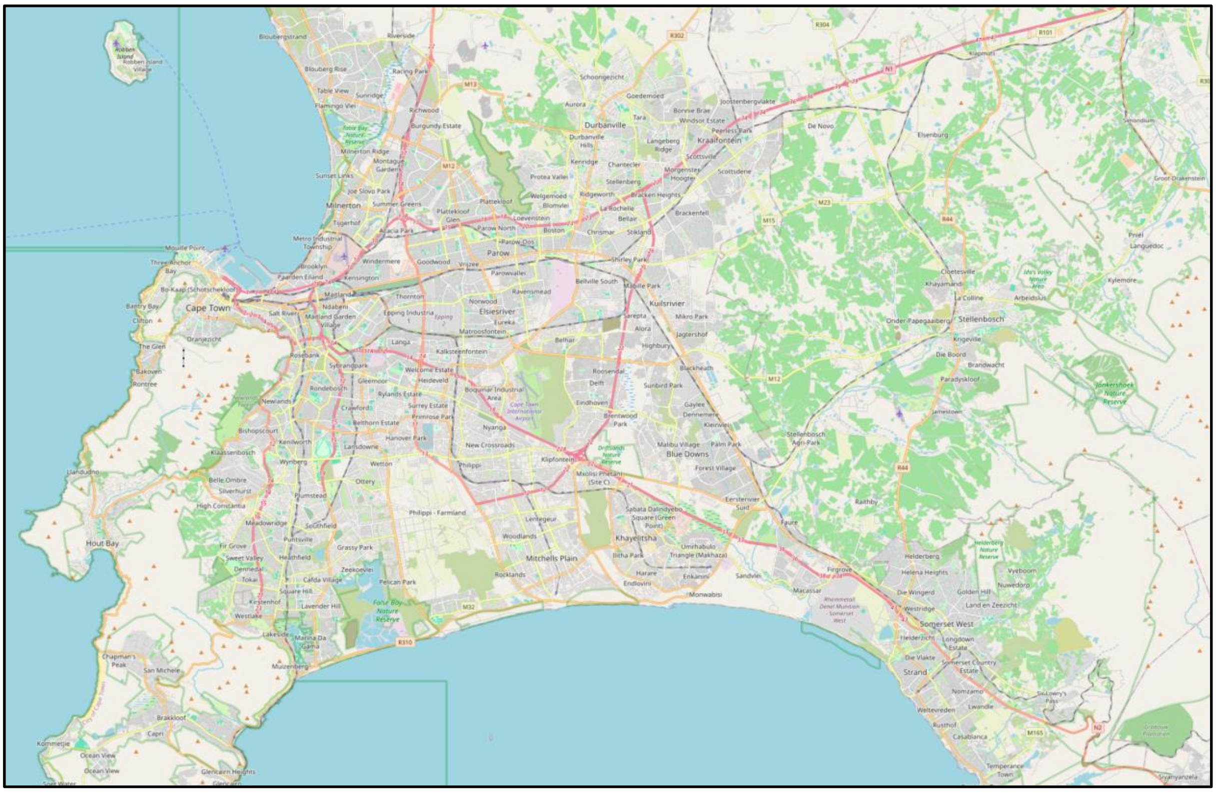



**Figure 3.1:** Map of the City of Cape Town

Source: Own diagram using qGIS

### 3.4 Data and data sources

The study used monthly time-series data for all patients involved in RTAs between 01 January 2021 and 31 May 2024. The WCGHW EMS uses a Computer-Aided Dispatch (CAD) system to send pre-hospital teams to emergencies during regular operations. An electronic Patient Care Report (ePCR) system dispatches the case to each emergency resource. This allows the pre-hospital teams to document the pertinent information on each patient they manage. After completion, this data is synced with the WCGHW EMS database. For medico-legal, quality assurance and health planning purposes, only the WCGHW EMS Information Management Department has access to this extensive database, which is constantly updated and monitored. However, each practitioner has access to their own completed patient care documentation.

The CAD system collects all non-clinical information related to the physical resources that EMS assigns to each call it manages. The pre-hospital assessment and diagnosis, medical interventions given, comorbidities, patient acuity, patient demographics, type of emergencies requiring intervention, and receiving medical facility are all collected by the ePCRs from information entered by the attending practitioner. Practitioners are still required to complete the ePCR for medico-legal purposes, even if the patient is deceased on arrival. The EMS data variables included call reference number, shift, time of the accident, type of vehicle involved, incident suburb, incident suburb longitude and latitude, incident longitude and latitude, patient sex, patient age and triage colour. All ePCRs for patients involved in RTAs in the Cape Town Metropole between 01 January 2021 and 31 May 2024 were included in this study. Cases where patients were deceased on arrival are highlighted as code blue in the ePCRs following emergency response. Any patients not involved in RTAs and not managed by the WCGHW EMS within the specified period were omitted from the study.

### 3.5 Validity and reliability

To obtain meaningful findings, data collection procedures must be valid and dependable. The research should measure what it intends to measure to ensure that conclusions formed from its findings are valid. Validity and reliability are used to assess research quality. They describe the effectiveness of planning the methodology, data collection technique and data analysis to measure the given study characteristics (Heale and Twycross 2015). Validity refers to how effectively data represents real findings among study participants and similarly situated individuals who did not participate in the investigation. This applies to all sorts of clinical research, including prevalence, diagnosis, treatments and disease-association studies (Mellinger and Hanson 2020). Reliability is defined as the method's consistency in measuring something. The measurement is considered reliable if the same result can be obtained repeatedly using the same approach under similar conditions. As a result, validity is concerned with what an instrument measures and how well it does so, whereas reliability is concerned with the accuracy of the data obtained and the extent to which any measuring tool accounts for random error (Ahmed and Ishtiaq 2021).

Before the data analysis was performed, the data was analysed for completeness. Although no forecasting analysis was planned as part of this study, the possible impact of trends and/or seasonality on data was also considered. It was deemed plausible that time-related trends in RTA frequency may impact the internal validity of the analysis and had the possibility to introduce a selection bias, as the data collection period only spanned three years and five months. Stationarity in the time series data for the frequency of RTA- and RTA-related mortality (deaths and non-deaths) was analysed using the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests, as well as time series plots.

The results indicated that for RTA-related deaths, the ADS test indicated non-stationarity ($p = 0.53$), while the KPSS indicated stationarity ($p = 0.099$). For RTA-related non-deaths (survivors), the ADS and KPSS tests indicated non-stationarity (ADS $p = 0.53$, KPSS $p = 0.036$). For the overall frequency of RTA cases (all included cases), both the ADS and KPSS tests again indicated non-stationarity (ADS $p = 0.50$, KPSS $p = 0.034$). Based on these results, it can be concluded that, in general, the time series is non-stationary and appears to exhibit a seasonal trend with increases in RTA frequency during certain months. For RTA-related deaths, the results indicate trend stationarity. When these results are considered with the same data graphically plotted, there appeared to be a small but consistent increase in RTA deaths over this study's data collection period. Considering these results, the possible implication for this study could be that some degree of selection bias may be present in relation to natural seasonal trends in RTA frequency and longer-term trends in RTA-related deaths, considering the relatively short data collection period. These factors were considered in the interpretation of the data analysis results.

This was expected, given that the data was obtained from a period where natural seasonal trends in RTA frequency and longer-term trends in RTA-related deaths may have influenced the results. The relatively short data collection period (January 2021–May 2024) may not have fully captured the seasonal fluctuations in accident rates, potentially leading to selection bias. The time-series analysis indicated non-stationarity, suggesting that RTA cases tend to peak during specific months, which could have skewed the findings. Additionally, the observed increase in RTA-related deaths over time may reflect a longer-term trend that was not fully accounted for within the study period. As a result, the risk assessments for pedestrian vulnerability, night-time fatalities, and accident hotspots might be influenced by the specific timeframe analysed rather than representing year-round patterns.

### 3.6 Data analysis

The data was analysed to establish patterns and trends of fatal incidents in Cape Town, focusing on accident location, whether the incident involved a car or pedestrian, and the time of the accident. A descriptive analysis and exploratory post hoc analysis were conducted to present descriptive statistics and analyse observed relationships in the data. The Quantum Geographic Information System (QGIS) 3.34.9, was used to map the RTA and RTA-related death frequency distributions over time. The QGIS heatmap function was then used to make heatmaps. This process involved applying a Kernel Density Estimation (KDE) algorithm to create a density raster from the GPS locations of individual RTA cases. The resulting raster indicated the relative density of frequency and geospatial proximity of these cases, with higher frequencies and closer proximities appearing as 'hotspots' on the heatmap. This technique helped the researchers assess the accident risk spread area, defined as the area surrounding a cluster with the highest accident risk, acknowledging that the risk associated with an accident is dispersed throughout the site, not confined to a single point.

To evaluate the relationship of RTA location to road infrastructure, a geospatial information system (GIS) road map layer of Cape Town was imported into QGIS to construct the density maps of fatal accidents in relation to road infrastructure. To bring both the imported digital map and the GIS data frame to the same scale, they were assigned the same "projected coordinate" system. WGS1980 UCS was used as the coordinate system for this study. All data used for the GIS mapping (with the exception of the RTA GPS location vector layer) was obtained from the City of Cape Town Open Data Portal. This portal is freely open online to the public (https://odp-cctegis.opendata.arcgis.com) GIS data repository, including GIS vector and raster layers created, managed and maintained by the City of Cape Town.

### 3.7 Ethical considerations

Access to patient data is governed by strict protocols to protect confidentiality and uphold patient privacy, in line with the Protection of Personal Information Act (POPIA) in South Africa. The centralised ePCR and CAD databases are restricted to authorised personnel only. The researcher obtained full research ethics approval (IREC 228/24) from the Durban University of Technology (Appendix 1), after which the WCGHW EMS provided gatekeepers' permission (Appendix 2) to extract the necessary data. There was no direct patient interaction throughout this evaluation of secondary data. Thus, there was no need to enlist or recruit any participants. The research process did not obtain any patient-identifying information, ensuring anonymity. Online resources include the WCGHW EMS database, which contains CAD and ePCR records for each corresponding case. The information was then uploaded into a Microsoft Excel file for analysis. The data was used strictly for the purposes of this study and in accordance with the conditions outlined in the ethics approval.

Due to the retrospective and secondary nature of the data and the impracticality of obtaining individual informed consent from all patients managed over the study period, a waiver of informed consent was sought and granted by the ethics committee. This waiver was justified on the basis that the research posed minimal risk to participants, did not infringe upon their rights or welfare, and the public health benefits of understanding and improving emergency response to road traffic accidents outweighed the need for individual consent.

## 3.8 Conclusion

This chapter outlined the study's methodology, employing a retrospective descriptive design using WCGHW EMS data (Jan 2021–May 2024) to analyse fatal RTAs in Cape Town. Geospatial mapping with KDE and statistical analyses identified accident hotspots and temporal patterns. Time-series tests indicated non-stationarity, suggesting seasonal trends that may impact findings. Ethical approvals and gatekeeper permissions ensured compliance. The relatively short data period may introduce selection bias due to seasonal variations and long-term mortality trends. These considerations were accounted for in the analysis. The next chapter presents the study's results, highlighting key accident patterns and high-risk areas.

# CHAPTER 4

# RESULTS

## 4.1 Introduction

The study set out to achieve the following three objectives. The first was to establish the demographic characteristics of patients involved in fatal road traffic accidents following public emergency medical service responses in Cape Town. The second was to identify fatal road traffic accident hotspots in Cape Town. The third was to inform policy on emergency services' resource allocation towards road traffic accident hotspots. This chapter presents and discusses the results in an integrated and structured manner. The findings are organised thematically, beginning with descriptive statistics to establish demographic patterns, incident types, and temporal distributions of RTA-related mortality. This is followed by inferential analysis, including relative risk comparisons, to identify significant predictors and contextual factors associated with fatal outcomes. The chapter then transitions into a spatial analysis section, using geospatial heatmaps to visualise the geographical distribution of both accident frequency and fatality density, and to assess potential associations with infrastructure indicators such as lighting coverage.

Throughout the chapter, the presentation of results is accompanied by interpretive commentary, drawing on relevant literature to contextualise findings within both national and international road safety trends. This approach ensures that the results are not only reported but also critically analysed to provide insights relevant to emergency medical services planning and road safety policy development. Where applicable, patterns are interpreted with a focus on their implications for targeted interventions, resource optimisation, and infrastructure improvements.

## 4.2 Descriptive statistics

This section presents the descriptive statistics of RTA cases recorded between January 2021 and May 2024, focusing on demographic characteristics, accident types, time of occurrence and geographical distribution. Understanding these patterns is essential for identifying high-risk groups and locations and informing targeted road safety interventions. The data was analysed to establish key trends in fatalities, highlighting factors such as sex, age, accident type and time of occurrence. Table 4.1 summarises the distribution of RTA mortality, categorising cases by gender, age, accident type, time of day, and whether they occurred in identified hotspot areas.

**Table 4.1:** Road accident mortality stratified by sex, age incident, shift and geo hotspots (Jan 2021–May 2024)

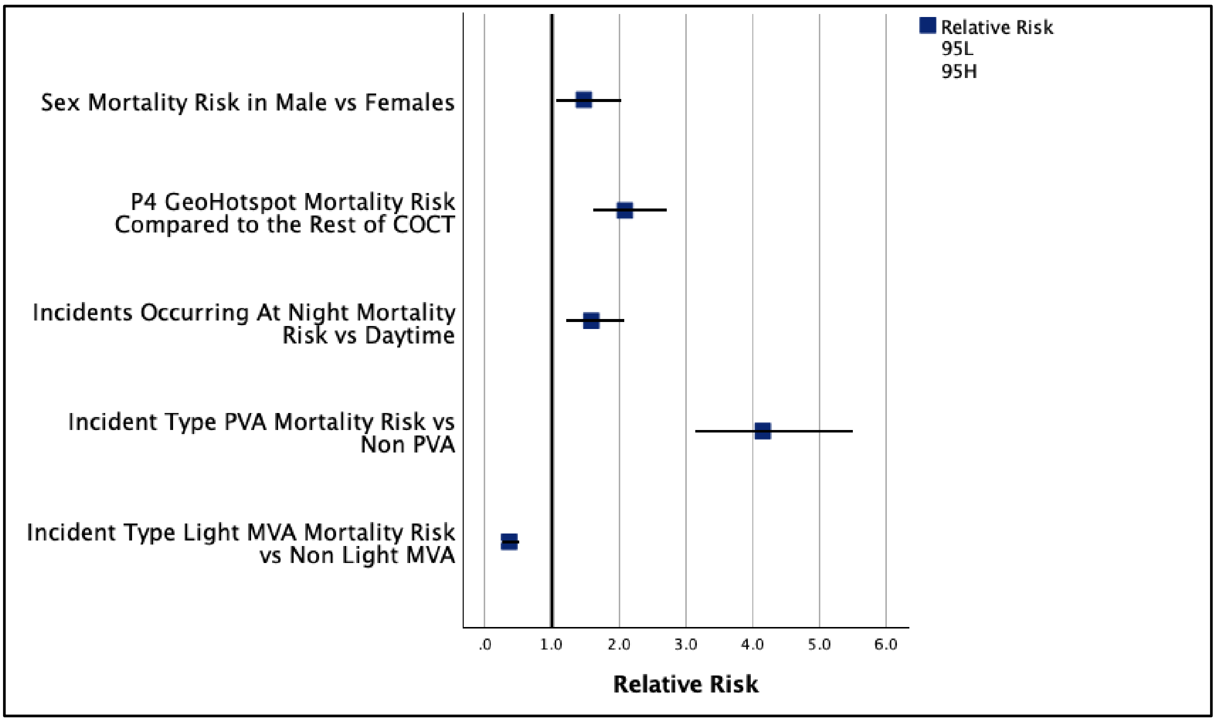
| | | Mortality | | | |
|---|---|---|---|---|---|
| | | Died on scene or in the ambulance | | Survived to hospital admission | |
| | | N (%) | Min - Max | N (%) | Min - Max |
| **Sex** | *Male* | 118 (70.7) | | 388 (65.1) | |
| | *Female* | 39 (23.4) | | 208 (34.9) | |
| | *Unknown* | 8 (4.8) | | | |
| | *Missing* | 2 | | | |
| **Age** | *Mean* | 34.5 ±13.9 | 1 - 71 | 34.1 ± 14.9 | 1 - 83 |
| **Incident Type** | *Bus / Taxi* | 0 (0) | | 14 (2.3) | |
| | *Cyclist* | 2 (1.2) | | 6 (0.9) | |
| | *Light Motor Vehicle* | 38 (22.8) | | 313 (50.7) | |
| | *Motorcyclist* | 6 (3.6) | | 47 (7.6) | |
| | *Pedestrian* | 109 (65.3) | | 135 (21.9) | |
| | *Transport (Other)* | 10 (6.0) | | 93 (15.1) | |
| | *Truck / Heavy Vehicles* | 2 (1.2) | | 9 (1.5) | |
| **Shift** | *Day (07h00 – 18h59)* | 81 (48.5) | | 389 (63.0) | |
| | *Night (19h00 – 06h59)* | 86 (51.5) | | 228 (37.0) | |
| **Geo Hotspot** | *Geo hotspot* | 65 (38.9) | | 118 (19.1) | |
| | *Non-geo hotspot* | 102 (61.1) | | 499 (80.9) | |
| | Total | 167 (100) | | 617 (100) | |

*Note: N represents the number of cases; % is the percentage (shown as a column %); ± is the standard deviation; Min is the minimum; Max is the maximum*

Table 4.1 shows that there were 784 patients who were involved in RTAs between 2021 and May 2024, with 167 fatalities (i.e., patients who died on the scene or in the ambulance before reaching the hospital). The mean age of the accident victims was 34 years. Male patients had a higher mortality rate (70.7%) compared to females (22.8%). This finding aligns with global trends, as reported by the World Health Organization (WHO 2018), which consistently shows higher road traffic fatality rates among males. According to the South African road transport accident death data from 2007 to 2019, the total number of male deaths from RTAs was three times the total number of female deaths during this period (Statistics South Africa 2024). The reasons for this disparity may include higher risk-taking behaviour, more frequent travel, and potentially different vehicle use patterns between genders. Both fatal and non-fatal accident victims were predominantly young adults. This finding is particularly concerning as it highlights the significant impact of RTAs on the most economically productive age group, potentially leading to substantial socioeconomic consequences for families and communities. This supports earlier findings that accident victims are mostly young individuals (Karaye et al. 2023; McCarty and Kim 2024; Statistics South Africa 2024; Unkuri et al. 2024).

Pedestrian accidents had the highest mortality rate (65.3%) compared to all other accident types. This pattern is consistent with findings across the African continent (WHO African Region 2024). This vulnerability shows distinct temporal and spatial patterns in Cape Town. Despite lower overall incident volumes at night, pedestrian mortality rates increase significantly during these hours (51.5%), possibly due to poor lighting conditions in accident-prone areas (Jackett & Frith 2013; Law and Petric 2024; Sari and Yudhistira 2021). While this broader pattern aligns with regional trends, this study provides unique insights into Cape Town's specific challenges, accounting for local infrastructure, traffic patterns, and socioeconomic conditions. These findings emphasise the urgent need for targeted pedestrian safety interventions, particularly focusing on improving lighting and infrastructure in high-risk locations.

A comparative analysis examining several key variables was conducted to better understand the various risk factors associated with mortality in this context. These included demographic factors like sex differences, geographical considerations regarding geo hotspot zones, temporal patterns comparing day versus night incidents, and incident type classifications focusing on PVA (pedestrian vehicle accidents) and MVA (motor vehicle accidents) categories. Figure 4.1 presents a forest plot displaying the relative risks across these different parameters, with confidence intervals indicating the statistical significance of these relationships. The standardised presentation allows for direct comparison between these diverse risk factors, with a relative risk of 1.0 representing no difference between compared groups.




*Note: PVA = pedestrian-vehicle accident; COCT = City of Cape Town; P4 = Dead; MVA = motor vehicle accident; diagram from SPSS*

**Figure 4.1:** Relative risk of mortality by sex, incident location, time and incident type

The findings presented in Figure 4.1 highlight key risk factors influencing road traffic accident (RTA) fatalities, with male patients facing a 48% higher risk of death compared to females, possibly due to differences in risk-taking behaviours, responses to injuries, or other underlying factors. Geographical location also played a significant role, as individuals in accident hotspot areas had more than double the risk of death compared to those in other parts of Cape Town, likely due to higher traffic volumes, poor road infrastructure, or inadequate emergency response times. The timing of accidents was another critical factor, with night-time accidents being 59% more likely to result in fatalities than daytime incidents. This trend could be attributed to reduced visibility, driver fatigue, and a higher likelihood of impaired driving. Pedestrians were found to be the most vulnerable, with a four-fold increase in mortality compared to other accident types, underscoring their vulnerability in urban traffic settings due to inadequate pedestrian infrastructure, high vehicle speeds, or a lack of enforcement of road safety regulations. Interestingly, accidents involving light motor vehicles (LMVs) were associated with a lower risk of death than other RTAs, potentially due to improved vehicle safety features, better occupant protection, or lower impact forces in such accidents.

Table 4.2 presents the relative risk (RR) of mortality across different geographical locations. Although the risk of death was slightly higher in hotspot areas (RR = 1.235) than non-hotspot areas (RR = 1.066), the overlapping confidence intervals indicate that this difference may not be statistically significant. The overall risk for all cases combined was 1.167. These findings suggest that while accident hotspots may have a higher incidence of fatal crashes, other factors—such as emergency response times, road infrastructure, and traffic volume—could influence mortality outcomes.

**Table 4.2:** Relative risk for ambulance shift change periods

| **Group** | **Relative Risk** | **Confidence Interval (95%)** |
|---|---|---|
| All cases | 1.167 | 0.868 - 1.569 |
| Hotspot areas | 1.235 | 0.822 - 1.856 |
| Non-Hotspot areas | 1.066 | 0.712 - 1.598 |

Table 4.2 shows the relative risk of mortality in different accident locations, but none of the results are statistically significant, as all confidence intervals include 1.0. While hotspot areas had a slightly higher risk (RR = 1.235), this does not conclusively indicate location as a major factor in fatalities. Similarly, non-hotspot areas showed no significant difference (RR = 1.066). This suggests that factors like accident severity, response times, and infrastructure may have a greater impact on mortality. When considering possible hypotheses for the increased risk of mortality associated with

specific geographical hotspot areas, it was deemed that ambulance shift changes in periods may play a role. As noted in Figure 4.2 below, many RTA incidents and fatalities appear to occur within these periods (06:00 to 08:00 and 18:00 to 20:00). During these periods, ambulances return to their bases, which are typically located outside hotspot areas. At the same time, the number of ambulances available to respond to RTA incidents varies.

The analysis of shift-change periods and mortality outcomes in road traffic accident (RTA) cases revealed no significant increase in the risk of death during these periods compared to other times. The overall relative risk (RR) of mortality was 1.167, with a confidence interval (CI) of 0.868 to 1.569 and a p-value of 0.31, indicating no statistically significant difference. This trend was consistent in both accident hotspots and non-hotspot areas. In hotspot areas, the RR was 1.235 (CI: 0.822 – 1.856, p = 0.32), while in non-hotspot areas, the RR was 1.066 (CI: 0.712 – 1.598, p = 0.76). Since all confidence intervals include 1.0 and the p-values are greater than 0.05, no strong evidence exists that shift change periods contribute to higher mortality risk. Figure 4.2 illustrates the distribution of RTA mortality outcomes across different hours of the day. The number of cases is categorised into survivors (blue) and fatalities (red), providing insight into the periods associated with higher accident severity. The data reveals noticeable peaks in accident occurrences during certain hours, particularly in the late afternoon and early evening.

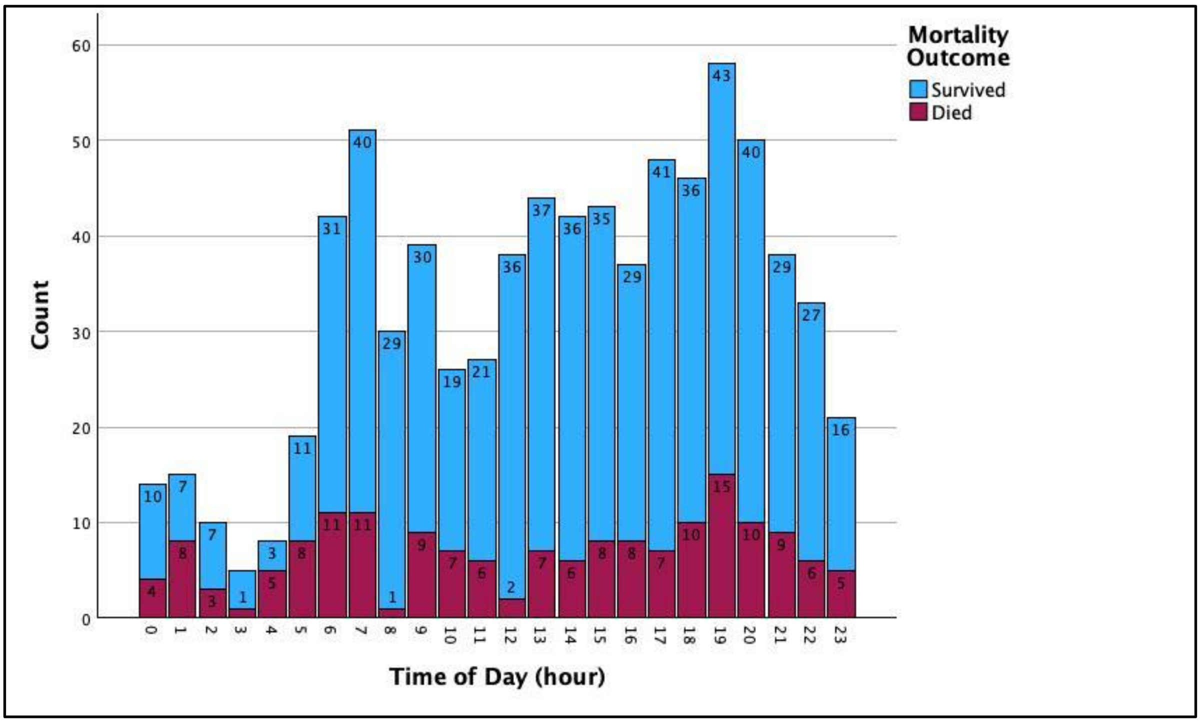



**Figure 4.2:** Distribution of traffic accident mortality outcomes over 24 hours

Figure 4.2 illustrates that accident volumes peak during the early evening hours, particularly around 19:00, shortly after the evening rush hour. Although this period is marked by high incident counts, the proportion of fatalities is lower than in late-night or early-morning hours. This may reflect multiple protective factors at this time, including moderate traffic speeds due to lingering congestion and greater public presence on roads. While streetlighting may contribute to visibility in early evening hours, the higher fatality rates later at night suggest that lighting alone is insufficient to offset the increased risks associated with higher speeds and alcohol-related impairment (Culhane et al. 2019; Valen et al. 2019; Doecke et al. 2020).

However, a concerning trend emerges during the early morning hours (between 02:00 and 05:00), when overall accident volumes decrease, but the proportion of fatalities rises significantly. This suggests that accidents occurring at these hours are more severe, likely due to a combination of factors such as reduced visibility, driver fatigue, and a higher incidence of impaired driving due to alcohol or drug consumption. The empty roads during these hours may also encourage reckless behaviour, such as speeding, which increases the likelihood of high-impact collisions. Research has shown that excessive speed correlates with more severe injuries and higher fatality rates, particularly in single-vehicle crashes or pedestrian-involved incidents (Gargoum and El-Basyouny 2016; Hussain et al. 2019; Doecke et al. 2020; AlKheder et al. 2022b).

### 4.3 Accident hotspot identification

Understanding the spatial distribution of RTAs is crucial for identifying high-risk areas and implementing effective road safety measures. This section uses geospatial analysis to examine the geographical patterns of motor vehicle accidents and fatalities in Cape Town from 2021 to 2024. Heatmaps visualise accident density by highlighting key hotspots across the city. A heatmap is a geospatial visualisation tool that represents data density using colour gradients, making it easier to identify areas with high concentrations of incidents. Kernel Density Estimation (KDE), a spatial analysis technique that smooths data points to create a continuous surface, was used to make the heatmap for this study, highlighting regions with a higher frequency of RTAs. Each accident location is plotted as a point, and KDE assigns a higher intensity to areas where points are clustered. Warmer colours, such as red and orange, indicate high-density accident zones or hotspots, while cooler colours, like blue and green, represent areas with fewer accidents. This approach allows for a clearer understanding of accident-prone areas by considering individual crash sites and their spatial relationships.

This analysis provides insights into the relationship between road network characteristics and accident occurrences by overlaying accident data with transport infrastructure, including major roads, highways and informal settlements. Additionally, the influence of night-time visibility on accident severity is explored by incorporating street lighting data. The findings in this section offer a data-driven approach to understanding accident risks and guiding targeted safety interventions to reduce fatalities and improve overall road safety. Figure 4.3 illustrates the spatial distribution of all motor vehicle accidents in Cape Town from 2021 to 2024. Using a heatmap representation, Figure 4.3 highlights areas with high accident densities, particularly along major roadways and densely populated urban centres. The overlay of highways, major roads, and informal settlements provides context for understanding accident hotspots in relation to infrastructure and settlement patterns.

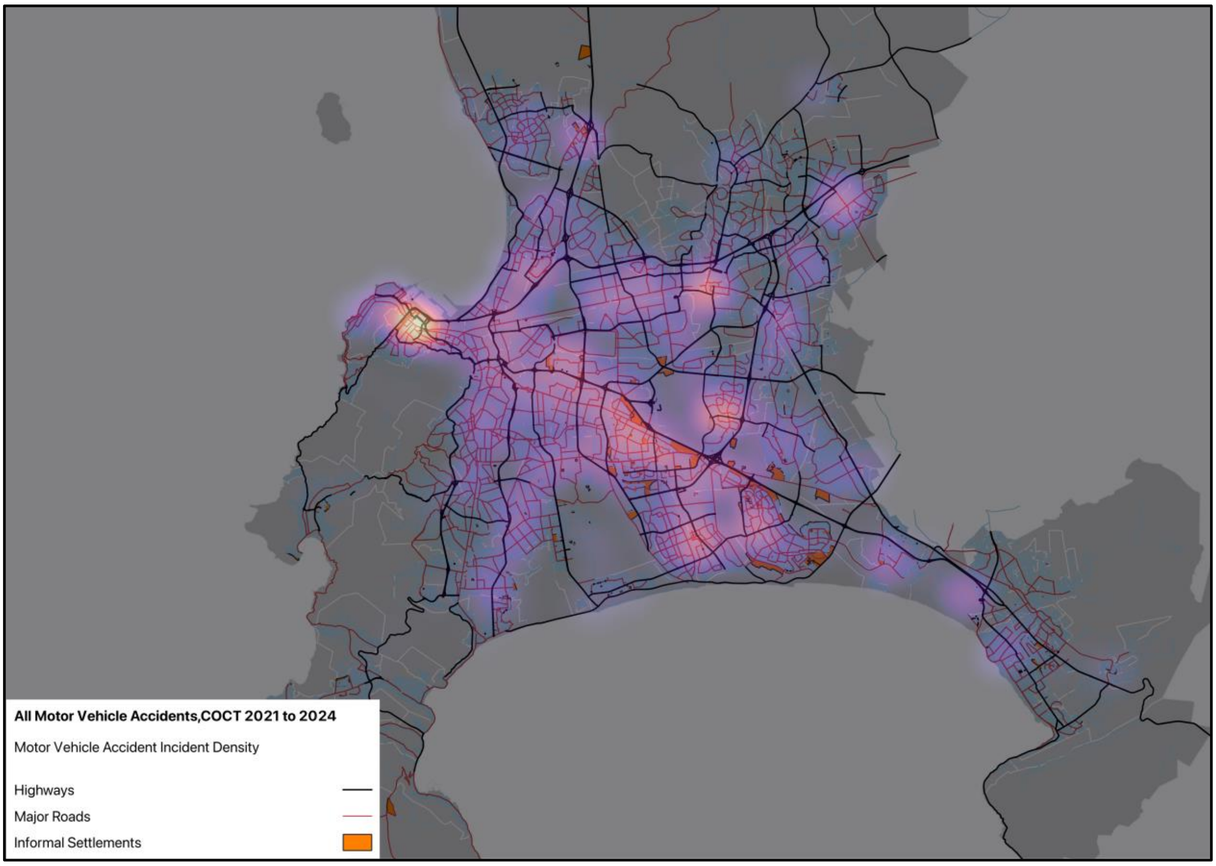



**Figure 4.3:** Spatial distribution of motor vehicle accidents in Cape Town (2021–2024)

Figure 4.3 shows that when considering all RTA cases, the data shows that most RTAs were in the Cape Town central business district, with a wide and relatively consistent distribution mainly following the major roads (highways, arterial roads) throughout the city. This pattern aligns with expected traffic density patterns, as the CBD represents a major employment hub with high daily vehicle volumes. The concentration of accidents along major arterial routes, particularly the N1, N2, and M3 highways, reflects the high traffic volumes these corridors experience during peak commuting hours. The relatively lower accident densities in affluent southern suburbs compared to other areas might reflect differences in road infrastructure quality, traffic management systems, or reporting patterns that warrant further investigation.

Figure 4.4 visualises the spatial distribution of motor vehicle accident deaths in Cape Town from 2021 to 2024. Using a heatmap representation, it highlights high-density fatal accident zones, particularly in the eastern and central suburbs. The map overlays key transport infrastructure, including highways and major roads, to illustrate accident hotspots in relation to road networks. Informal settlements are also marked, providing context for areas where traffic fatalities may be more prevalent due to infrastructure challenges.

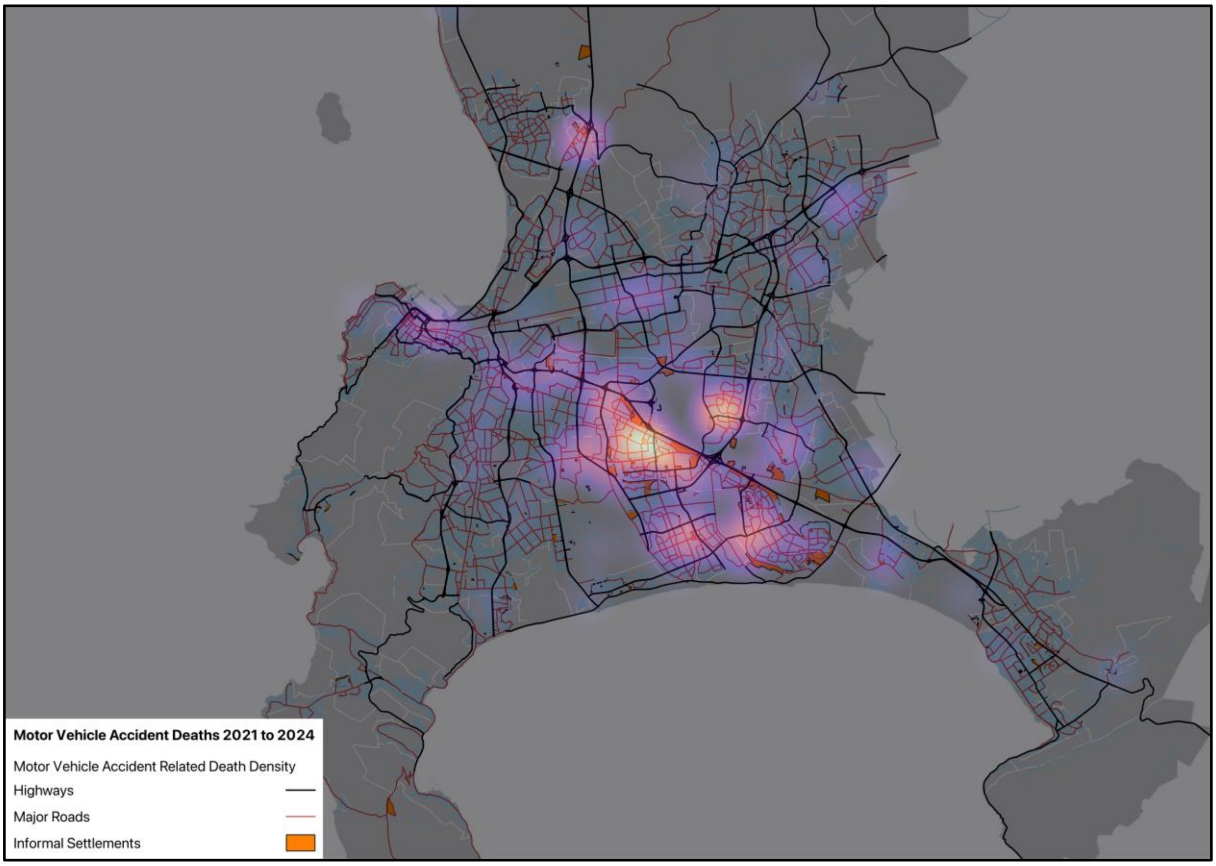



**Figure 4.4:** Spatial distribution of motor vehicle accident deaths in Cape Town (2021-2024)

Figure 4.4 illustrates that most deaths occurred in the geo hotspot areas, mostly located in the eastern part of the city, which includes the suburbs of Gugulethu, Nyanga, Mitchells Plain and Khayelitsha. It was also noteworthy that many of these fatal cases occurred on smaller suburb-level roads or major roads within suburbs as opposed to highways. This distribution reveals a striking contrast with the overall accident pattern shown in Figure 4.3, suggesting that accident frequency does not necessarily correlate with fatality risk. The concentration of fatalities in these eastern suburbs highlights significant socio-spatial disparities in road safety outcomes. These areas are characterised by higher population densities, lower-income households, and historically underserved infrastructure. The prevalence of fatal accidents on smaller suburban roads rather than highways is particularly concerning, as these roads are typically designed for lower speeds and greater pedestrian activity.

The spatial pattern of fatalities suggests that road safety interventions should prioritise suburban arterial routes and local streets rather than focusing solely on high-speed highways. This challenges traditional assumptions about where road safety resources should be concentrated and highlights the need for context-specific interventions that consider local community needs and movement patterns. When considering the higher risk of mortality associated with night-time cases, a GIS vector layer of all streetlights was superimposed on the geo hotspot map (Figure 4.5). Figure 4.5 illustrates the relationship between motor vehicle accident deaths and street lighting distribution in Cape Town from 2021 to 2024. The heatmap highlights areas with high fatal accident densities, while the overlay of public streetlights provides insight into the possible correlation between lighting infrastructure and road safety. Major roads and informal settlements are also depicted to contextualise accident hotspots within the broader urban landscape. This visualisation aims to identify areas where inadequate street lighting may contribute to road fatalities, resulting in targeted interventions to enhance night-time visibility and improve traffic safety.

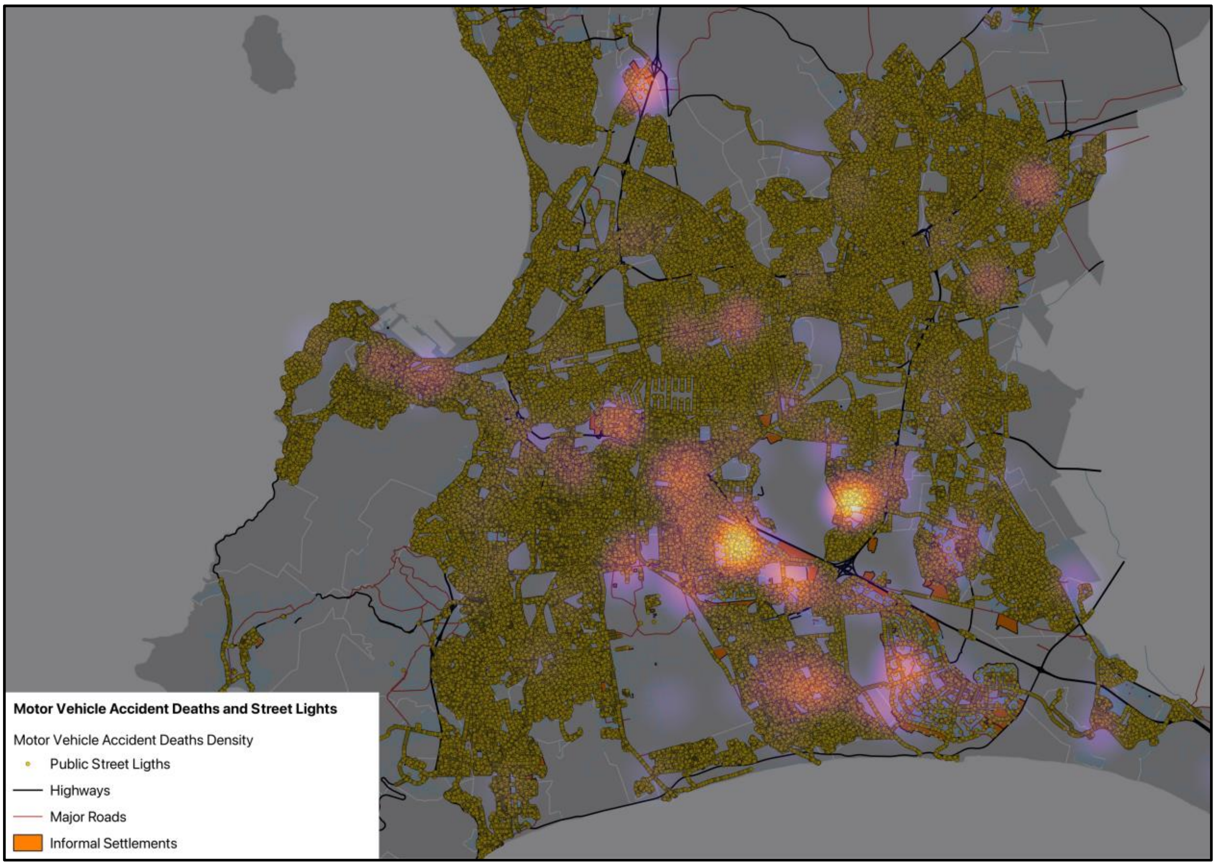



**Figure 4.5:** Motor vehicle accident deaths and street lighting in Cape Town (2021-2024)

Figure 4.5 shows that the fatal case hotspot areas appear to occur in locations with lower streetlight density, suggesting that the accident death hotspots may be related to poorly lit areas. This correlation between limited street lighting and fatal accidents is particularly evident in the eastern suburbs identified as high-risk zones in Figure 4.4. The spatial analysis reveals several critical insights about the relationship between infrastructure and road safety outcomes. The overlay of street lighting infrastructure demonstrates significant disparities in lighting coverage across Cape Town. Areas with comprehensive street lighting networks, typically found in the central and western suburbs, show notably lower concentrations of fatal accidents. In contrast, the eastern suburbs, including Gugulethu, Nyanga, and Khayelitsha, exhibit both sparse street lighting and higher fatality rates. This pattern is especially concerning given the higher pedestrian activity in these areas. The data suggests that strategic investment in lighting infrastructure could be a cost-effective intervention for reducing night-time road fatalities in identified hotspot areas.

## 4.4 Conclusion

This chapter provided an overview of fatal road traffic accidents in Cape Town, highlighting the particular vulnerability of pedestrians, the increased risk during night-time hours, and the presence of geographical hotspots for fatal RTA incidents. These findings have important implications for policy and practice, particularly regarding targeted interventions for pedestrian safety and strategic allocation of emergency medical resources. By addressing these critical areas, there is potential to significantly reduce the burden of road traffic fatalities in Cape Town.

# CHAPTER 5

# CONCLUSION

## 5.1 Introduction

This chapter summarises the key findings of the study by highlighting the demographic, temporal, and spatial patterns of fatal RTAs in Cape Town. The study's contributions to road safety research and policy are discussed, emphasising the implications for EMS deployments, infrastructure improvements, and law enforcement strategies. Additionally, recommendations are provided to address the identified risk factors, including pedestrian safety measures, improved lighting, and traffic-calming interventions. The chapter concludes by outlining the study’s limitations and proposing areas for future research to further enhance road safety and reduce RTA fatalities in Cape Town and similar urban settings.

## 5.2 Summary of the study

This study aimed to identify areas with high road traffic mortality following public emergency medical service (EMS) responses in Cape Town. It addressed three key objectives: (1) analysing the demographic characteristics of fatal road traffic accident (RTA) victims; (2) identifying accident hotspots; and (3) informing policy on emergency services' resource allocation. A retrospective descriptive analysis was conducted using data from the WCGHW EMS between January 2021 and May 2024. The study utilised geospatial analysis, KDE and statistical modelling to map accident hotspots and assess mortality risks. The key findings highlighted pedestrian fatalities account for 65.3% of RTA deaths, with males comprising 70.7% of fatalities. Night-time accidents had a 59% higher mortality risk than daytime incidents, with the highest concentration of fatalities occurring in the eastern suburbs of Cape Town, particularly in Gugulethu, Nyanga, Mitchells Plain, and Khayelitsha. Poorly lit areas emerged as critical hotspots for fatal RTAs.

## 5.3 Recommendations and policy implications

The findings of this study revealed significant factors contributing to fatal RTAs in Cape Town, particularly the high risk to pedestrians, the increased likelihood of fatalities at night, and the concentration of fatal accidents in specific geographic hotspots. To mitigate these risks and improve road safety, the study proposes five key recommendations.

First, the study proposes the enhancement of pedestrian safety infrastructure, as pedestrians accounted for the majority (65.3%) of RTA fatalities in Cape Town, highlighting an urgent need for targeted interventions. Infrastructure upgrades on identified suburban and major inner-city roads, such as well-lit crosswalks, pedestrian bridges, traffic calming measures, and designated pedestrian zones in the identified suburban and major inner-city roads, can significantly reduce pedestrian deaths by providing safer crossing points and improving visibility. Designating pedestrian zones in these same areas can further minimise vehicle-pedestrian interactions and enhance overall safety. Studies have shown that well-designed pedestrian crossings and bridges help separate pedestrian traffic from high-speed vehicle zones, reducing conflicts and lowering the risk of severe injuries. In cities where such measures have been implemented, pedestrian fatalities have decreased by up to 86% (Namatovu et al. 2022). Therefore, the City of Cape Town, in collaboration with the Western Cape Government and the Department of Transport, should conduct a detailed pedestrian movement study in high-risk areas to identify locations for safety improvements. Priority should be given to areas near public transport hubs, schools, and commercial districts, with funding allocated for constructing pedestrian bridges over high-speed roads and installing clearly marked crosswalks with pedestrian signals. Additionally, traffic calming measures, such as speed humps, raised intersections, and extended kerbs, should be introduced in accident-prone areas to further enhance pedestrian safety and reduce fatalities.

Second, the study recommends the improvement of street lighting in high-risk areas, as night-time accidents were found to be 59% more likely to result in fatalities than daytime incidents, with many occurring in poorly lit locations. Enhancing street lighting in these areas can significantly improve visibility for both drivers and pedestrians, reduce accident risks and enhance overall road safety. Research has consistently shown that improved street lighting decreases night-time accidents by allowing drivers to react more quickly to potential hazards (Sari and Yudhistira 2021). Additionally, better lighting serves as a deterrent to crime, further contributing to urban safety. To address this issue, the City of Cape Town should conduct a lighting audit in accident hotspot areas, particularly in Gugulethu, Nyanga, Mitchells Plain, and Khayelitsha, where pedestrian activity is high. LED streetlights should be installed along major roads and pedestrian walkways, with a focus on improving visibility in high-risk zones. Regular maintenance and monitoring programmes should also be implemented to ensure the streetlights remain functional. Furthermore, smart lighting systems, which adjust brightness based on pedestrian and vehicle movement, should be explored to improve efficiency and reduce energy consumption while maintaining optimal visibility in critical areas.

Third, the study recommends strengthening law enforcement and road safety campaigns, as fatal RTAs are often linked to risky behaviours such as speeding, reckless driving, or driving under the influence of alcohol or drugs. Increasing traffic patrols, enforcing stricter penalties, and implementing public awareness campaigns can help deter dangerous driving behaviours (Lee 2017). The deterrence theory supports this approach, suggesting that the certainty, severity, and swiftness of punishment influence behaviour (Tomlinson 2016). Studies have shown that countries implementing strict drunk-driving laws and increasing enforcement efforts have experienced a 14-20% decline in alcohol-related accidents (Eun 2021). To address these issues, the Western Cape Traffic Department should intensify random sobriety checkpoints, particularly during night-time and weekends when the risk of fatal accidents is highest. Additionally, speed cameras and automated enforcement systems should be expanded in high-risk areas to effectively monitor and penalise offenders. Public awareness campaigns should be tailored to high-risk groups, including young male drivers and pedestrians by using targeted messaging through social media, schools, and community outreach programmes. Collaboration with taxi associations and ride-sharing companies can further promote responsible driving behaviour among public transport operators, ensuring a safer road environment for all.

Fourth, the study emphasises the critical importance of optimising EMS deployment based on the observed concentration of fatalities in specific areas, suggesting that EMS response times significantly influence survival outcomes. Research has indicated that shortened response times are associated with improved mortality following RTAs (Byrne et al. 2019; Mahdinia et al. 2022; Huang et al. 2024). Based on the study's findings, specifically the concentration of fatalities in identified hotspot areas, the higher mortality risk during night-time hours, and the disproportionate vulnerability of pedestrians, the Western Cape Government Health and Wellness EMS should implement a comprehensive optimisation strategy. This should include establishing strategically located EMS stations in identified accident hotspots, utilising real-time data analysis to predict peak accident periods, enhancing paramedic training in advanced trauma care techniques, and fostering collaboration with private EMS providers. This multi-faceted approach would ensure more efficient service delivery, reduced response times in high-risk areas, and ultimately improved patient outcomes through timely medical intervention in critical cases.

The study advocates for the implementation of traffic-calming measures in high-risk areas, particularly in response to the concentration of fatal accidents in specific geographic hotspots, predominantly on suburban roads rather than highways. Speed reduction interventions in urban areas can decrease pedestrian fatalities by up to 30% (Yannis and Michelaraki, 2024), as traffic calming features such as speed bumps, roundabouts, and narrowed lanes compel drivers to reduce speed and provide additional reaction time to potential hazards. Based on these findings, the City of Cape Town should undertake comprehensive traffic flow assessments in accident hotspots to implement targeted interventions, including the installation of speed bumps and raised pedestrian crossings near schools, public transport hubs, and commercial centres, alongside road design modifications such as lane narrowing and kerb extensions. These infrastructure improvements should be complemented by community engagement programmes to educate residents about the benefits of these safety measures and promote compliance, ultimately creating a safer road environment for all users.

## 5.6 Limitations

While this study provides valuable insights, it has several limitations. The study did not have access to traffic volume or exposure data, which could provide context for the observed patterns. The study did not investigate the role of factors such as alcohol use, speeding, or road conditions, nor did it objectively measure lighting conditions associated with RTAs. The study accounted only for pre-hospital deaths and not in-hospital. Although the WC EMS service is the largest EMS service provider, there are several private EMS services for which this study did not obtain data. The lack of this data could act as a possible confounder in that private EMS services operated in more affluent areas of the city (which tended to be non-hotspot areas). It is plausible that some fatal RTA incidents may have been attended to by these services and not included in this study. As discussed earlier, we also noted some seasonality and trend stationarity in the data. This may imply that a longer timeframe should be used in future research to reduce the influence of seasonality and other trends in future analysis. This study did not include an analysis of EMS response time metrics, which may influence patient outcomes in RTAs. Such data were not available within the approved extraction protocol, and their omission limits the ability to assess the impact of prehospital time to care on mortality patterns. Future research should address these limitations by conducting longitudinal studies to identify trends over time and investigate the role of behavioural, environmental factors and EMS response times in RTAs.

## 5.7 Possibilities for future research

Conducting longitudinal studies can provide valuable insights into how RTAs evolve over time and whether implemented safety measures are effective. By tracking accident patterns over an extended period, researchers and policymakers can identify trends, assess the long-term impact of interventions, and refine strategies to enhance road safety. This continuous monitoring is crucial for adapting policies to emerging risks and ensuring that resources are allocated to the most pressing issues.

Another critical area of research involves incorporating traffic volume and road usage data to develop a more comprehensive understanding of accident risk. By analysing the relationship between traffic density and RTAs, authorities can pinpoint high-risk locations and times, allowing for more targeted interventions. This approach enables the implementation of congestion management strategies, such as adjusting traffic flow, optimising signal timing, and enhancing road infrastructure in heavily trafficked areas to effectively mitigate accident risks. In addition to analysing traffic patterns, investigating driver behaviours such as speeding, alcohol consumption, and adherence to road regulations can uncover additional causes of accidents. Environmental factors, including road conditions, weather patterns, and lighting, also play a crucial role in accident severity and frequency. Understanding these variables enables authorities to implement specific countermeasures, such as stricter law enforcement, enhanced driver education programmes, and road design modifications that reduce accident risks under varying conditions.

Expanding the scope of RTA studies to include in-hospital mortality data is essential for obtaining a more complete picture of accident outcomes. While pre-hospital fatality data provide critical insights, in-hospital mortality rates reveal how effectively medical interventions contribute to survival. Examining factors such as the severity of injuries, hospital response times, and the availability of trauma care services can help improve emergency medical systems and post-accident treatment protocols. To ensure that interventions yield tangible results, evaluating the effectiveness of safety measures such as improved street lighting, pedestrian bridges, and traffic calming strategies is vital. By assessing which interventions lead to measurable reductions in fatalities and serious injuries, authorities can prioritise investments in the most impactful solutions. Conducting pilot projects in high-risk areas and systematically measuring their outcomes can inform broader policy decisions and enhance road safety across the city.

Comparative studies between Cape Town and other cities or regions can provide valuable insights into shared challenges and unique risks. By analysing RTA trends in different contexts, policymakers can adopt best practices from other urban areas that have successfully reduced accident rates. Learning from international experiences and adapting proven safety strategies to local conditions can accelerate progress in mitigating traffic-related fatalities. Finally, assessing the impact of public health campaigns on driver and pedestrian behaviour is key to refining road safety initiatives. Understanding how awareness programmes influence compliance with traffic laws, pedestrian caution, and responsible driving behaviour allows for the development of more effective communication strategies. Tailoring campaigns to specific risk groups, leveraging social media outreach, and incorporating behavioural science principles can enhance the effectiveness of public safety messaging, ultimately contributing to a reduction in RTAs.

### 5.8 Conclusion

The study provided a detailed discussion of fatal road traffic accidents in the city of Cape Town, shedding light on key high-risk areas and the heightened dangers during night-time. Findings from the study emphasised the importance of targeted actions. Such actions include better street lighting, safer pedestrian infrastructure, and smarter emergency service planning. Taking these steps could make a real difference in reducing road traffic deaths.

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# Appendices

## **Appendix 1:** Ethics approval letter

**Institutional Research Ethics Committee**
Research and Postgraduate Support Directorate
2nd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

**www.dut.ac.za**

15 November 2024

Dr S Sobuwa
DUT Business School
Faculty of Management Sciences
Durban University of Technology

Dear Dr Sobuwa

**Geospatial analysis of fatal road traffic accidents following ambulance responses in Cape Town**

I am pleased to inform you that Full Approval has been granted to your proposal.

The Proposal has been allocated the following Ethical Clearance number **IREC 228/24**. Please use this number in all communication with this office.

Approval has been granted for a period of **ONE YEAR**, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures [SOP's] of the DUT-IREC. This form must be submitted to the DUT-IREC at least 3 months before the ethics approval for the study expires.

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the DUT-IREC according to the DUT-IREC SOP's.

Please note that any deviations from the approved proposal require the approval of the DUT-IREC as outlined in the DUT-IREC SOP's.

**It is compulsory for a student or researcher to apply for recertification on an annual basis. The failure to do so will result in withdrawal of ethics clearance. It is the responsibility of the researcher and the supervisor to apply for recertification.**

**Please note that you are required to submit a Notification of Completion of Study form together with an abstract to the DUT-IREC office on completion of your study.**

Yours Sincerely

________________
Professor P Mashau
Chairperson: DUT-IREC

## **Appendix 2:** Gatekeeper approval letter

**Western Cape Government**

**Directorate: Health Intelligence**
Health.Research@westerncape.gov.za
24th Floor, 4 Dorp Street
Cape Town, 8001

REFERENCE: WC_202410_044
ENQUIRIES: Dr Glynis Denicker

For attention: Dr Simpiwe Sobuwa

**Re: Approval of research at Emergency Services (EMS)**
Study Reference: **WC_202410_044**
Study Title: **Geospatial analysis of fatal road traffic accidents following ambulance responses in Cape Town**

Thank you for submitting your proposal to undertake the above-mentioned study. We are pleased to inform you that the department has granted you approval for your research.
Please contact the following people to assist you with any further enquiries:

**Emergency Services (EMS)**
Facility contact person: **Craig Wylie**
Contact Details: **Email: Craig.Wylie@westerncape.gov.za   Telephone:**

Kindly ensure that the following are adhered to:

1. Arrangements can be made with managers, provided that normal activities at requested facilities are not interrupted and staff are not put under pressure to comply with the research activities.
2. Researchers must provide the department with an electronic copy of a Final Report using the Annexure 9 template within six months of completion of research. This can be submitted to Health.Research@westerncape.gov.za. Future research will not be allowed on the health platform if a Final Report is not submitted.
3. In the event where the research project goes beyond the *estimated completion* date which was submitted, or the final date of the ethics clearance letter, researchers are expected to complete and submit a progress report (Annexure 8) and an updated ethics clearance letter to Health.Research@westerncape.gov.za. Failure to do so will render this approval letter void.
4. Please note that if you are conducting a folder audit, and you do not have consent from individual study participants/subjects, you may not capture identifiable patient information in your database, as per the Protection of Personal Information Act 4 of 2013 (POPIA).
5. If you do have consent from individual participants in this study, and you are collecting identifiable patient data through your chosen research methodology, you should not keep the data for any longer than is required to complete this research, as per POPIA.
6. The reference number above should be quoted in all future correspondence.

Yours sincerely

Lesley Shand
Acting Director: Health Intelligence
Health
Western Cape Government

DATE: **03 December 2024**

https://www.westerncape.gov.za/general-publication/health-research-approval-process

## **Appendix 3:** Proof of language editing

**Sury Bisetty Academic Editing Services**

CIPC No. 2021/360666/07

*My editing adds tremendous value to your document, but I am only human. Although I rigorously check and recheck my work, it is impossible to guarantee 100% perfection.*

To whom it may concern

I edited the thesis titled: “Geospatial analysis of fatal road traffic accidents following ambulance responses in Cape Town” by Dr Simpiwe Sobuwa, submitted in partial fulfilment of the requirements of the degree of Master of Business Administration (MBA) in the Faculty of Management Sciences at the Durban University of Technology

Signed: Date: 15 February 2025

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Editing Mastery: How to Edit to Perfection
Complete writing, editing master class.
PEGSA: Critical Reading [etc.]

Disclaimer: I provided language and technical editing as per discussion with the client. The **content and structure of the thesis were not amended in any way**. The edited work described here may not be identical to that submitted. The author, at his/her sole discretion, has the prerogative to accept, delete, or change amendments/suggestions made by the editor before submission.