

DEATH OR ALIVE: CAN ROAD ACCIDENT VICTIMS IN THE WESTERN CAPE GET ACCESS TO TRAUMA CARE?

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ABSTRACT

The World Health Organization (2009) indicates that the African region has some of the world's highest road traffic fatalities globally making it the 9th leading cause of death in the region. Data shows that the risk of dying, as a result of a road traffic collision, is highest in the African region at 24.1/100 000 population (the global rate is 18/100 000). Nigeria and South Africa have the highest road traffic fatality rates (33.7 and 31.9/100 000, respectively) and, together with the Democratic Republic of Congo, Ethiopia, Kenya, Tanzania and Uganda, account for 64% of all road traffic deaths in the region (Peden et al., 2013).

There is consensus in the literature that the provision of appropriate medical care following a road accident is a critical determinant of both the chance of survival and, on survival, the quality of life (ETSC, 1999; OECD, 1999). The potential to reduce fatalities by means of early and appropriate medical treatment is associated with the so called "golden hour" (the time to access a trauma care facility). This paper identifies the accessibility of trauma care facilities in the Western Cape.

1 INTRODUCTION

In March 2013 the WHO published the *Global Status Report on Road Safety 2013: Supporting a Decade of Action* (WHO, 2013). The report presents 2010 data for 182 participating countries and provides a baseline for monitoring the Decade of Action for Road Safety (2011 - 2020). About 1.24 million road traffic deaths occurred throughout the world in 2010, indicating a plateau (stabilisation of fatalities) since the publication of the first status report in 2009. In South Africa, fatality rates also seem to have plateaued.

The World Health Organization (WHO, 2009) indicates that the African region has some of the world's highest road traffic fatalities globally making it the 9th leading cause of death in the region. Of the 1.24 million fatalities each year, 90% are in low and middle-income countries, such as those in Sub-Saharan Africa. Death and injury on the roads in these countries exacerbates poverty by depriving households of the main income earner (as many fatalities are male breadwinners) and imposing a heavy burden on health services. Some 50% of all fatalities are amongst vulnerable groups (e.g. pedestrians, cyclists and public transport users). Death and injury burdens are heavily skewed towards lower income groups. It is estimated that by 2030 road accidents could be the fifth leading cause of death (it is currently the ninth leading cause of death) unless serious attention is given to addressing the root causes.

Data shows (see Figure 1) that the risk of dying as a result of a road traffic collision is highest in the African region at 24.1/100 000 population (the global rate is 18/100 000). Nigeria and South Africa have the highest road traffic fatality rates (33.7 and 31.9/100 000, respectively) and, together with the Democratic Republic of Congo, Ethiopia, Kenya, Tanzania and Uganda, account for 64% of all road traffic deaths in the region (Peden et al., 2013). Overall, the African region has less than 2% of the world's registered vehicles, but almost 20% of the global traffic deaths. An 80% increase in traffic deaths between 2000 and 2020 has been predicted in developing countries, by Kopits and Cropper (2005).

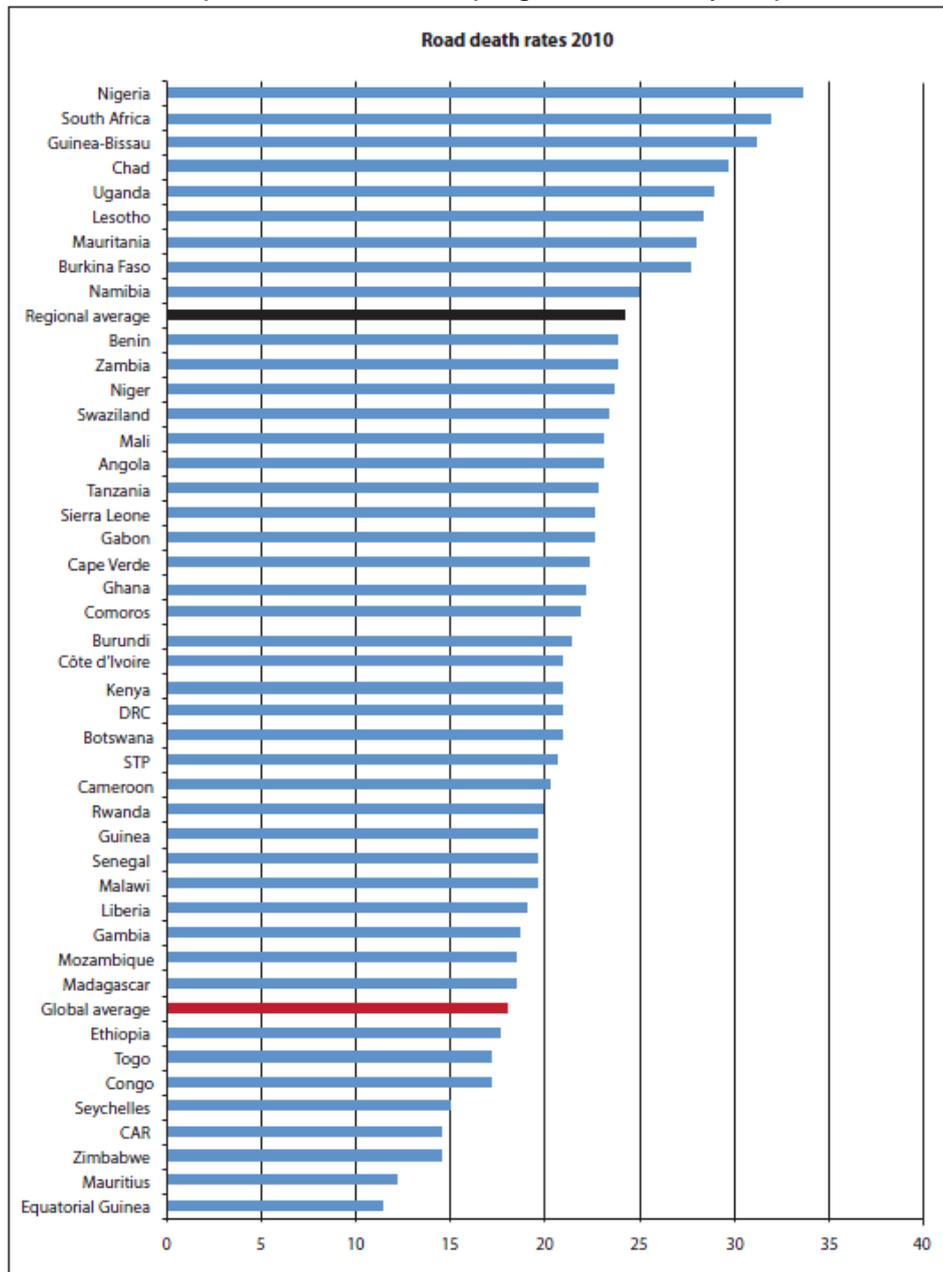


Figure 1: Road Fatality Rates in Africa (per 100 000 inhabitants) in 2010¹
Source: Peden et al., 2013

¹ CAR = Central African Republic; DRC = Democratic Republic of Congo; STP = Sao Tome & Principe

There is consensus in the literature that the provision of appropriate medical care following a road accident is a critical determinant of both the chance of survival and, on survival, the quality of life (ETSC, 1999; OECD, 1999). The importance of a rapid response by emergency services was proven by OECD (1999) by indicating differences between the survival rates in accidents that occur in rural versus urban areas. Furthermore, the ETSC (1999) highlighted that evidence-based actions for the organization of optimal trauma care in the European Union (EU); through the European action programme of the Commission of the European Communities (CEC, 2003), could save several thousands of lives in the EU, by merely improving the response times of the emergency services and other elements of post impact care.

The potential to reduce fatalities by means of early and appropriate medical treatment is associated with “survivable” injuries, i.e. during the “golden hour” and later period of hospital treatment (OECD, 1999; Sasser et al., 2005). Dr R Adams Cowley (University of Maryland Medical Centre, 2011) coined the phrase ‘Golden Hour’ in 1963. The trauma doctor stated that: *“There is a golden hour between life and death. If you are critically injured, you have less than 60 minutes to survive. You might not die right then; it may be three days or two weeks later – but something has happened in your body that is irreparable”*.

Many papers have been published in which the ‘Golden Hour’ concept has been challenged. Berger (2010) states that scientists have gathered an increasing amount of evidence that shows that time to care does not matter. However, in the past five years, further research has been conducted surrounding post-accident care for road-traffic accidents, supporting the Golden Hour theory. Evidence from evaluation studies demonstrates that a lower Emergency Medical Services (EMS) response time is associated with reduced fatality rates (Brodsky, 1993; Feero et al., 1995; Henriksson et al., 2001).

Elvik et al. (2009) has stated that: “In the case of serious injuries, a major factor that determines the outcome, i.e. the chances of survival, is the time to definitive care”. Sánchez-Mangas et al. (2010) analysed the significance of quick medical responses to the scenes of road-traffic accidents in Spain. In this study, it was found that a ten minute reduction in the medical response time can be associated with a one third reduction in the probability of death from road-traffic accidents.

Gitelman et al. (2013) recently developed a set of Trauma Management Safety Performance Indicators (TM SPIs) characterising the extent, scope and quality of the post-accident care in 19 European countries. The TM SPIs were developed in terms of the EMS treatment potential, EMS response time and the treatment potential of permanent medical facilities. The study identified, through cluster analysis, groups of European countries with similar levels of the TM system’s performance. It was concluded that the TM SPIs have a significant impact on survival rates of road accident trauma patients.

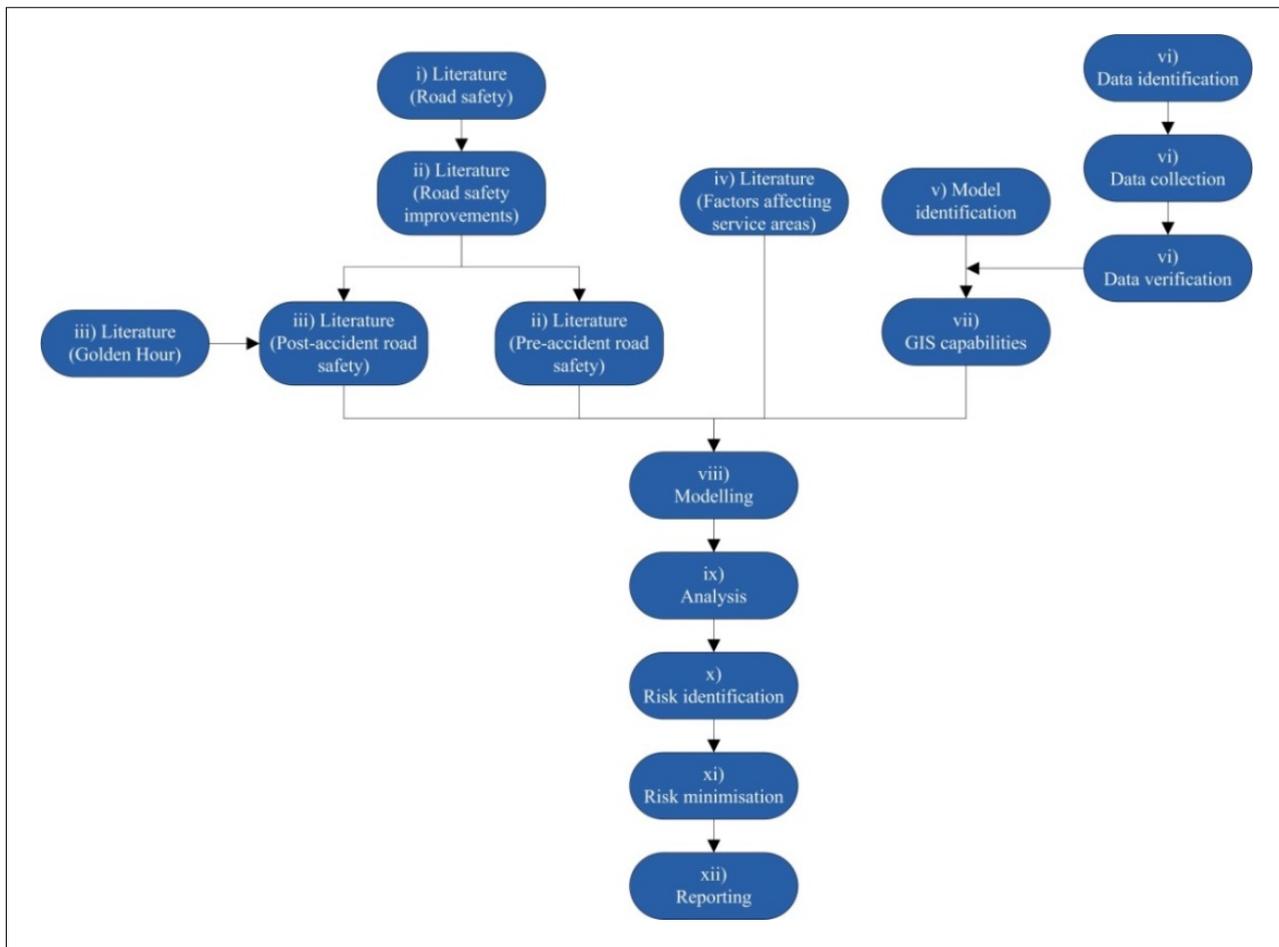
This paper analyses the likelihood that rural road accident victims are able to receive appropriate medical care within the, so called, Golden Hour.

2 METHODOLOGY

Given the high level of fatalities in South Africa and anecdotal information that rural hospitals can, sometimes, not handle the number of injured road accident victims needing trauma care, the need for a more detailed study was identified. Figure 2 shows the sequence that was followed during the study.

The status quo of road safety was first established, looking into the situation on a global, national and provincial level. Current views on both pre-crash road safety measures and post road-accident trauma care measures have been investigated. The concept of the 'Golden Hour' was researched, looking into the link between the time to receive care and the chances of survival. The 'Golden Hour' was then linked to post road-crash trauma care.

Figure 2: Study Sequence/Methodology



A mathematical analysis model was then established to simulate the travel times, travel patterns etc. of ambulances. ArcGIS, an internationally used and recognised tool, was chosen as the geographical information analysis tool to develop the model, as it is capable of the required analysis and available at the University of Cape Town. The data required for the model were then identified and gathered from various sources. Once collected, the data was validated by choosing samples and checking the validity of the samples.

Numerous analyses were run, incrementally improving assumptions and findings, particularly those relating to ambulance travel patterns (route choice etc.).

Once the analysis phase had been completed, critical zones were identified. In addition, the effect of various factors on the service areas was investigated. On identification of the risks, possible mitigation measures were recommended based on current pre-accident road safety systems and post road-accident trauma care systems.

3 CASE STUDY SELECTION: THE WESTERN CAPE

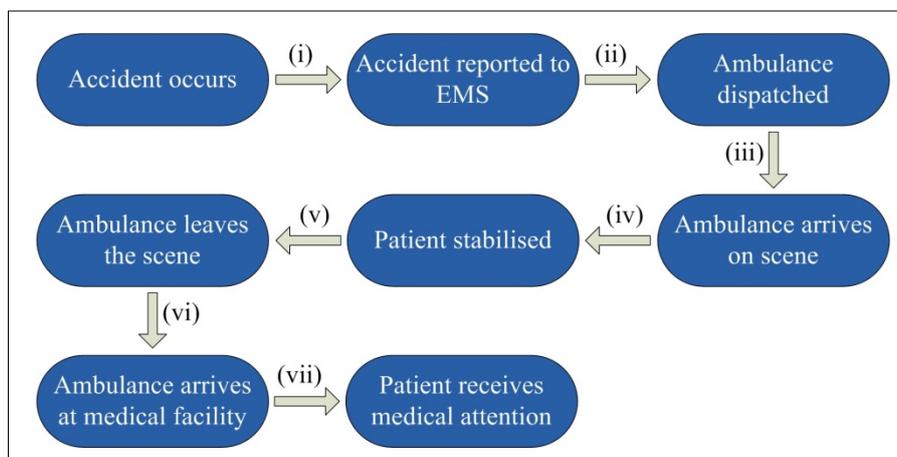
In the 2010/11 period, the Road Traffic Management Corporation (RTMC) reported that there were 1 026 fatal accidents, resulting in 1 258 fatalities in the Western Cape (RTMC, 2011). This is 9% of the 13 802 fatalities that occurred throughout South Africa in the 2010/11 period. About 80% of all accidents in the Western Cape happen in the City of Cape Town, which is home to about 80% of the provinces population. Fatalities in the province provide a different view though. Around 50% of all fatalities occur in the rural parts of the province (Vanderschuren and Jobanputra, 2010). Besides the higher average speeds, which increase the accident impact, the hypotheses is that rural victims often do not receive 'definitive care' within the Golden Hour. Definitive care refers to the completion of recommended treatments.

The fatalities that were included in the analysis were obtained from the Provincial Government of the Western Capes (PGWC's) iPAS fatalities database. For this study, the fatalities that occurred in the 2000-2007 period were utilised (a total of 7 210 fatalities).

4 ACCESSING TRAUMA CARE

Traditionally, engineers (and others) analyse pre-accident conditions categorised into six E's, which include Engineering, Education, Enforcement, Evaluation, Environment and Encouragement. More often than not, post-accident conditions are not taken into account when analysing fatalities and looking for measures to implement in order to reduce the casualty rate. The analysis in this study focuses on the post-accident phase of road-traffic accidents. Figure 3 gives the events in chronological order. Information needed for assessing the serviceability of a medical facility, is the time it takes between each of the post-accident events shown (i.e. the arrows). The summation of the time it takes between each post-accident event must not exceed the 'Golden Hour'. The events were adapted from a study performed by Gitelman into Safety Performance Indicators for trauma management in Europe (Gitelman et al., 2013).

Figure 3: Sequence of post-crash events



The arrows in Figure 3 represent the time taken between each of the post-accident events.

The seven arrows represent the following times:

- **Notification time:** the time it takes from when an accident occurs until it is reported to EMS. This time can vary drastically depending on the consciousness of those involved in an accident, the presence of any witnesses, and the availability of a landline or mobile phone,
- **Dispatch time:** the time taken between the EMS call centre receiving the emergency call and the ambulance being dispatched,
- **Travel time (a):** the time it takes for the ambulance to travel to the scene of the accident,
- **Stabilisation time:** the time taken by the paramedics to stabilise the patient,
- **Loading time:** the time taken to load both the patient and any equipment used,
- **Travel time (b):** the time it takes for the ambulance to travel to a medical facility, and
- **Admission time:** the time taken between arrival at the hospital and the patient receiving the required medical attention.

In order to do an analysis for the whole of the Western Cape, the summation of the times between each post-accident event needs to be calculated for each medical facility. Of the seven time sequences discussed, three were obtained directly from the PGWC. These three time sequences include the dispatch time, the stabilisation time and the loading time. Table 1 shows the dispatch time and on-scene time (loading time plus stabilisation time) per region, as well as an overall average. The times were obtained from the 2012 transport related incidents to which ambulances made call-outs – these records are kept by the PGWC.

Table 1: Time sequences per region

Region	Dispatch time *	On-scene time *
	Minutes	Minutes
Cape Winelands	0.10	24.46
Central Karoo	0.05	32.25
Eden	0.16	20.25
Overberg	0.22	28.26
West Coast	0.79	33.62
Overall	0.26	27.55

*Values were obtained directly from the PGWC records.

Assuming the best case scenario, i.e. that the notification time and the admission time are zero, the remaining time can be split into travel times a and b. Overall, there are 32.19 minutes of the Golden Hour unaccounted for, which leaves an average of 16.09 minutes for each component of travel time. The analysis also included variations of travel times, with a maximum of 32.19 minutes in total for both directions.

5 ANALYSIS AND FINDINGS

5.1 Medical facilities

The medical facilities that were used in the analysis were obtained from the PGWC. The total number of medical facilities within the study area is 392 (excluding EMS stations). However, not all of these facilities provide 'definitive care'. In the final analysis, 44 EMS stations and 29 definitive care facilities were included.

5.2 Golden Hour Service Areas

Having obtained all the required information, the areas that fall outside of the Golden Hour service areas could be identified. The following data were included in the analysis:

- 'Definitive care' medical facilities (29 in total),
- All EMS stations (44 in total),
- Overall average dispatch time of 0.26 minutes, which was used for all five regions,
- Overall average on-scene time of 27.55 minutes, which was used for all five regions, and
- A maximum total travel time in both directions of 32.19 minutes.

Of the 20 981.5 km of road analysed, it was found that 14 682.4 km (70.0%) of the road network is outside of the Golden Hour.

5.3 Definitive Care Accidents

When investigating previous accidents in the Western Cape, there are multiple theoretical possibilities to access definitive care. Various analyses were carried out. The final analysis is based on the 'Closest Facility' function available in the Geographical Information System (GIS) tool. It was found that, of the 7 210 fatalities that occurred in the 2000-2007 period, 3 825 (53.1%) of the fatalities were outside of the Golden Hour (see Figure 4).

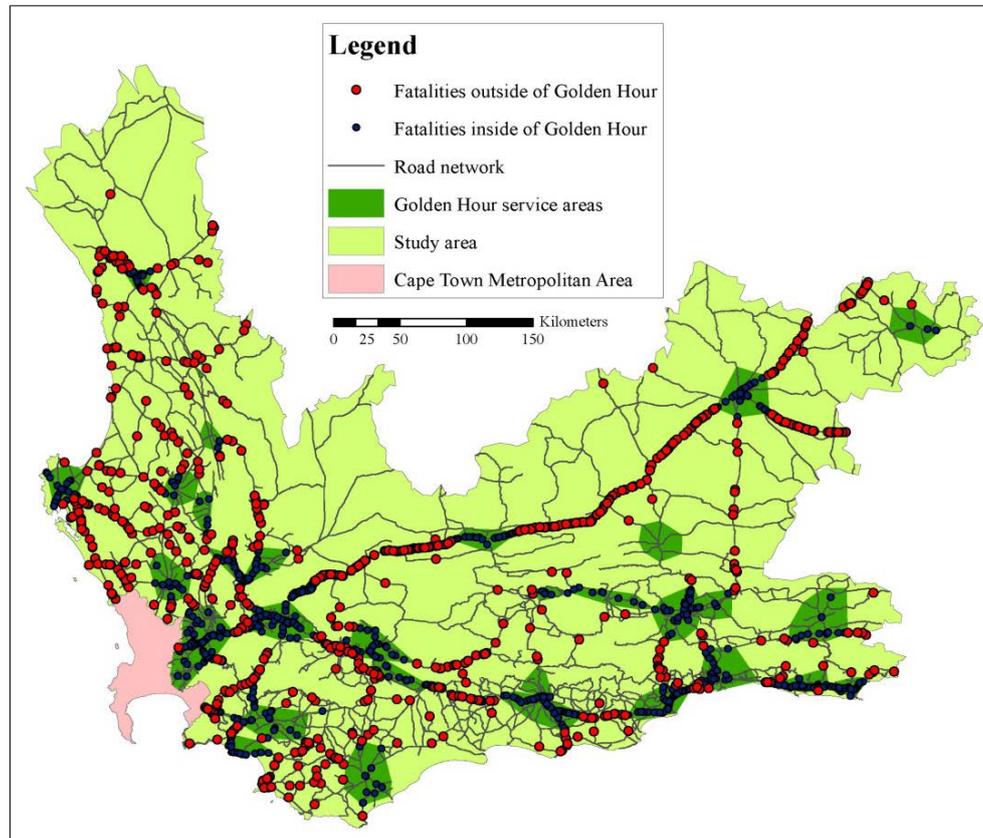


Figure 4: Inside vs. Outside Golden Hour Results (Western Cape)

5.4 Hazardous Location identification

Hazardous zones (i.e. areas with significantly higher fatality rates than the average rate) in the Western Cape were identified in a study called 'Safely Home – Baseline' (Vanderschuren and Jobanputra, 2010). The study revealed nine hazardous zones. A total of 4 022 fatalities or 55.8% of all rural fatalities in the Western Cape (including some rural towns), were situated within these hazardous zones.

The next step was to overlay hazardous zones and service gaps (areas outside the Golden Hour service areas), to enable the identification of critical zones. Four of the nine hazardous zones were not identified as critical zones, as the majority of the fatalities in the four zones were within the 'Golden Hour'. For the other five critical zones (see Figure 5), a total of 1 934, or 26.8%, of the fatalities from the 2000-2007 period were found within the areas. The total length of road that is found in critical zones is 671.3 km, which is 3.2% of the road network.

5.5 Fatality Rates

When looking at the fatality rate, the average for the whole study area is 0.34 fatalities/km. However, when analysing the hazardous zones, the fatality rate is 2.48 fatalities/km, which is 7 times higher than the average. Within critical zones, the fatality rate is higher, i.e. 2.88 fatalities/km, which is 8.5 times higher than the average. Reviewing the National Route 1 (N1), which has a length of 562.5 km, and is host to 1 776 fatalities, there is a fatality rate of 3.16 fatalities/km. This is higher than the average critical zone, and is 9 times higher than the average. It was expected that the service gaps on the N1 would have a higher fatality rate than the service areas on the N1. However, it was found that they both had the same fatality rate (3.16 fatalities/km).

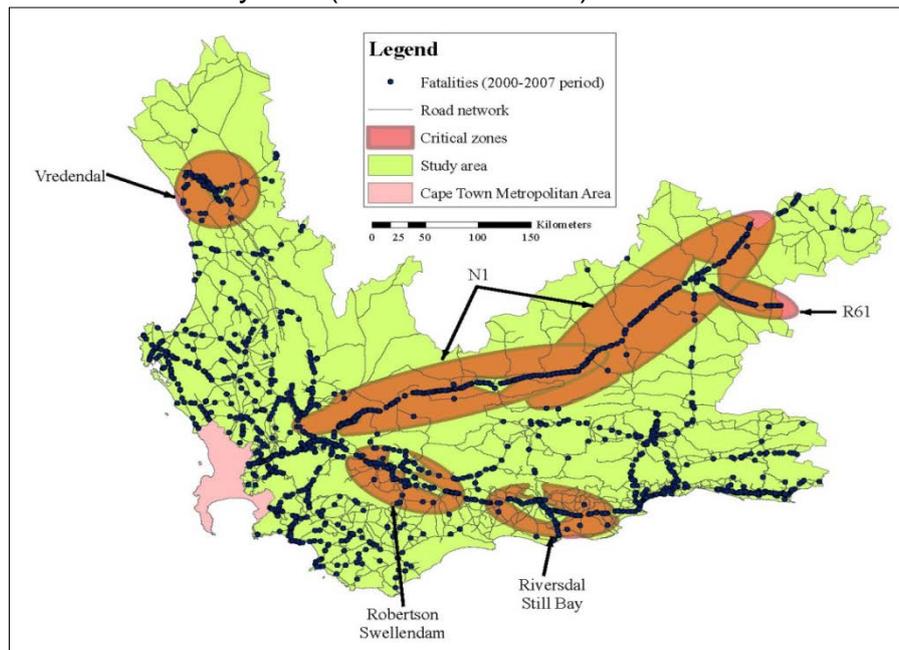


Figure 5: Combined Critical Zone Results (Western Cape)

The authors were surprised by the last finding and attempted to identify the reason for the lack of difference between the service and non-service areas. The population densities along the N1 route between Beaufort West and Paarl vary significantly, from 1 700 people/km² in Paarl, to 7.8 people/km² in Laingsburg. A higher population density suggests that there are more causes for accidents. These causes include increased pedestrian activity in addition to speed differentials. Therefore, a higher number of accidents should imply a higher number of fatalities. The pedestrian fatalities are concentrated in the densely populated areas (in particular De Doorns and Paarl). When excluding the pedestrian fatalities from the total fatalities, there is a significant change in the fatality rates. The fatality rate within the service areas is 2.25 fatalities/km, and within the service gaps the fatality rate is 2.91 fatalities/km. This finding supports the notion that the pedestrian accidents have an impact on the fatality rates in densely populated areas. Furthermore, non-pedestrian fatality rates are significantly different between service and non-service areas (see Figure 6).

5.6 Positioning of EMS stations

The effectiveness of an EMS station is dependent on its position relative to a medical facility that provides 'definitive care'. The analysis revealed that 10 EMS stations do not fall within service areas. This is because there are no 'definitive care' medical facilities within the 'Golden Hour' reach of an EMS station.

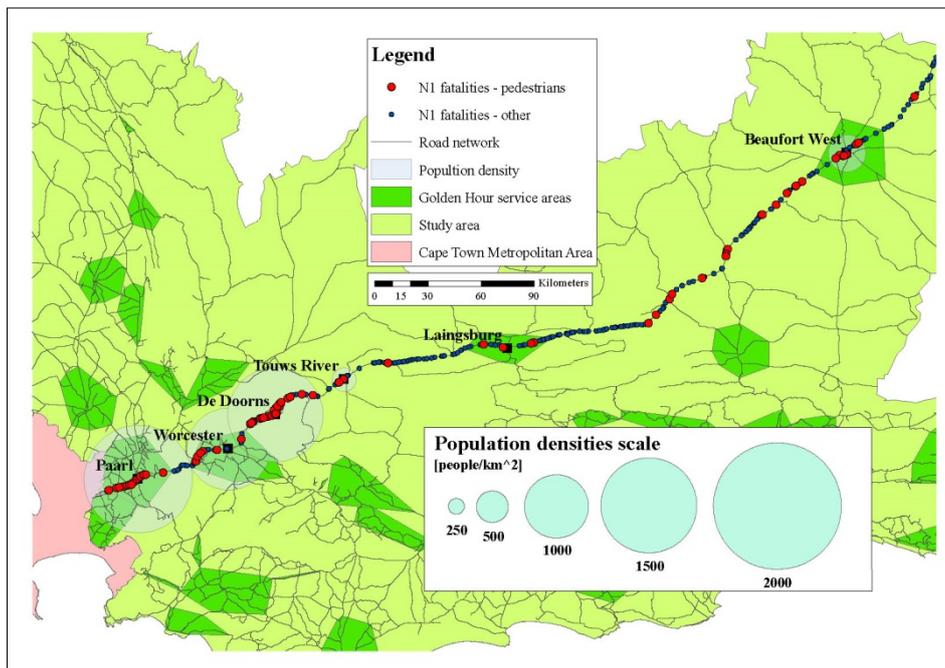


Figure 6: Population densities and fatalities along the N1

6 CONCLUSIONS AND RECOMMENDATIONS

South Africa has an extremely high fatality rate. Although measures are taken to reduce these high fatality rates, this rate seems to stay among the highest in the region (31.9/100 000 inhabitants). In the rural parts of the Western Cape, nine hazardous zones were identified (host to 55.8% of all fatalities in the rural parts of the Western Cape) that need further, detailed investigation, especially regarding the need of more and/or better located EMS services.

It was established that people in need of trauma care after a road accident are most likely to survive if they receive definitive care within the first hour after the accident (i.e. the Golden Hour). The Western Cape has 44 Emergency Medical Services (EMS) services and only 29 Medical facilities that can assist to provide definitive care.

The procedure followed by EMS, within the Western Cape, to get trauma patients to definitive care facilities was established. It was found that only 32.19 minutes are available for travel (in total for both directions). Through the use of a GIS tool, including the EMS and definitive care facilities, an analysis was carried out, identifying geographical areas where trauma patients can receive the required care within the so called Golden Hour (i.e. service areas). A total of 53.1% of all accidents, happen in the service gaps (i.e. areas outside the Golden Hour).

When overlapping the hazardous zones with the service gaps, four critical zones were identified. The National Road 1 (N1) is the largest and most critical area. In this study, the chances of survival were, therefore, ranked according to fatality rates (fatalities/km) including the service areas and the N1 corridor. Table 2 summarises the fatality rates for the areas that were investigated. It is clear that the fatality rates in the hazardous zones and service gaps are a multitude of the average for the study area. For the N1, population densities and the presence of pedestrians appear to influence the results.

Table 2: Fatality rates

Location	Fatality rate (fatalities/km)	Ratio to the average
Study area (average)	0.34	1
Hazardous zones	2.48	7
Critical zones	2.88	8.5
N1 service areas	3.16	9
N1 service gaps	3.16	9
N1 service areas (excluding pedestrians)	2.25	7
N1 service gaps (excluding pedestrians)	2.91	8.5

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