ROAD SAFETY IMPROVEMENTS IN THE CITY OF CAPE TOWN: AN ECONOMY BASED APPROACH

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ABSTRACT

Road safety is an undisputed problem in South Africa (SA). Zutobi, an innovative online driver education platform, rates SA as the world's most dangerous country to drive in, largely based on low rates of seat belt use and extremely high prevalence of alcohol abuse. The road fatality rate stands at 26.9 fatalities per 100 000 population (RTMC, 2023). As the global average is 17 fatalities per 100 000 population (WHO, 2018), rates in this country are significantly higher. The City of Cape Town's fatal crash rate is 15.5 per 100 000 residents (City of Cape Town, 2023). More than 50 000 crashes occurred in the city in 2021, which is estimated to have cost Cape Town's economy more than R5.4 billion. The purpose of this paper is to propose and analyse interventions that can be implemented in the City of Cape Town to improve its road safety situation. Historical accident data is used to identify high accident areas in the metropolitan area. Site surveys are combined with data analysis to determine the possible causes of accidents at each site, and to identify the most appropriate road safety improvement interventions. An economic analysis is conducted for each location, indicating break-even values and potential cost savings over a 20-year horizon.

1. INTRODUCTION

Global road crash fatalities and injuries have only seen a small decrease (5%) between 2010 and 2021 (WHO, 2023), despite the significant efforts made in many parts of the world during the first 'decade of action for road safety'. The target was to halve road fatalities over the indicated decade, although this was only realised in ten countries globally. The European and the Western Pacific Regions are the only regions that have seen a significant decrease in road traffic fatalities, while the African Region (17%) is the only region that has witnessed an increase (WHO, 2023). Road traffic fatalities in the African Region constitutes 19% of global fatalities (WHO, 2023).

The Road Traffic Management Corporation (RTMC) is responsible for road traffic crash statistics in South Africa. Based on data available in various reports and databases, it can be concluded that South Africa is one of the few countries in the African Region that has seen a decrease of fatalities between 2010 and 2021. Figure 1 provides the South African absolute road traffic fatalities, as well as the fatalities per 100 000 population. According to the statistics available from the RTMC, South Africa has seen a 10.2% decrease in absolute fatalities between 2010 and 2021. Furthermore, the road traffic fatality rate per 100 000 population reduced from 26.9 to 21.1.

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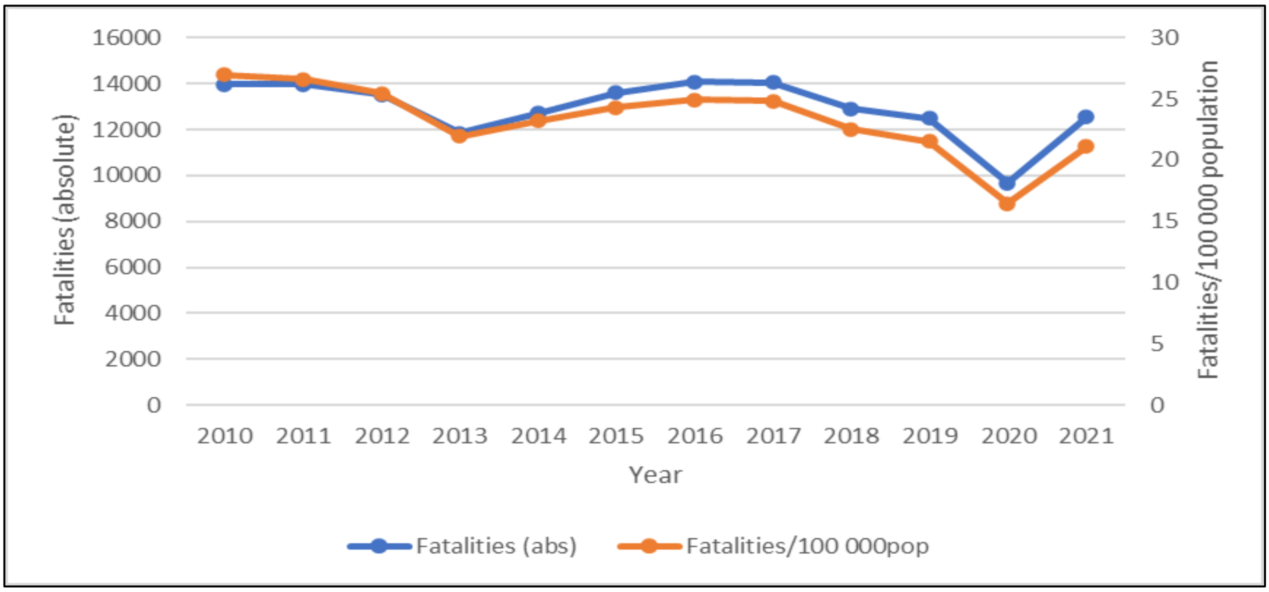

Figure 1: Road Traffic Fatalities in South Africa, Absolute and per 100 000 Population
Source: RTMC Annual Databases

While the reduction in road traffic fatalities and fatality rates is commendable, the reduction is not in line with the 'decade of action for road safety' that stated the aim of a 50% reduction. It would also appear that this value is still well above the global average of 17 per 100 000 people (WHO, 2018), but the authors need to warn the reader that the road traffic fatality rates, based on RTMC information, cannot be compared directly with any rates quoted by the WHO, as the definition of the two sources are currently not 100% aligned.

1.1 Road Safety in the City of Cape Town

The Urban Mobility Directorate of the City of Cape Town (CoCT) have indicated that more than 55 000 crashes occurred on the city's roads in 2021, with an average of more than 7 000 people injured and approximately 700 fatalities per annum (CoCT, 2023). A devastating total of between 400 and 500 of these deaths are pedestrians and it is worrisome that 54.5% of road deaths are among people younger than 35 (CoCT, 2023). In total, 71% of crashes occur on either national, regional, or main roads, resulting in 74% of deaths and 71% of all non-fatal injuries. The remainder of crashes, deaths and injuries occur on collector and residential streets (CoCT, 2023). The city has a crash related fatality rate of 15.48 per 100 000 population (CoCT, 2023). This is despite the Traffic Services Department issuing numerous fines and averaging more than 200 arrests per month for driving under the influence of alcohol in 2022 (CoCT, 2023).

1.2 Development of the Safe System Approach to Road Safety Management

Academics and practitioners have aimed to reduce road fatalities, through the development of new theories and approaches, for decades. Between 1920 and 1960, engineering colleagues predominantly used the three E's approach, identifying 'Engineering, Education, and Enforcement' as the drivers for addressing road safety issues (Collaborative Sciences Centre for Road Safety, UD). In the late 1960s and early 1970s, it was concluded that this was not enough. Haddon (1968) developed a road safety theory based on an epidemiological model, displaying multiple factors and stages (pre-crash, crash, and post-crash) involved in a crash event. For each stage, the human-, vehicle- and roadway factors would be analysed. In the 1980s, the responsibility of road infrastructure suppliers started to become more prominent in various parts of the world (Collaborative Sciences Centre for Road Safety, UD). In Europe, this resulted in the Dutch Sustainable Safety (forgiving road designs) approach (Wegman & Aarts, 2006) and the Swedish Vision Zero aim (Wegman et al., 2015) in the 1990s. In parallel, the three E's notion has been expanded to five E's, first with 'Evaluation' (good data collection and analysis enabling evidence-based practices), and 'Equity' of late (see: Martens et al., 2012; Vanderschuren & Newlands, 2024).

Theories, such as Sustainable Safety, Vision Zero and the equity approach have ultimately informed the Safe Systems Approach (SSA) that is currently adopted in many parts of the world. The SSA aims to eliminate fatal and serious injuries for all road users through a holistic view of the road system (FHWA, 2017). The SSA recognises that humans make mistakes and that humans are vulnerable. System designs, therefore, require redundancies to protect everyone. The first version of the SSA (Wegman et al., 2012) was based on five pillars: safer people, safer roads, safer vehicles, safer speeds, and post-crash care. More recently, the Global Plan for the Decade of Action for Road Safety 2021-2030 (UN & WHO, 2016) includes safer road infrastructure, safer road users, multi-modal transport and land-use planning, safe vehicles, and post-crash responses (WHO and UN, 2020). Figure 2 provides a visual summary of the SSA and all its facets.

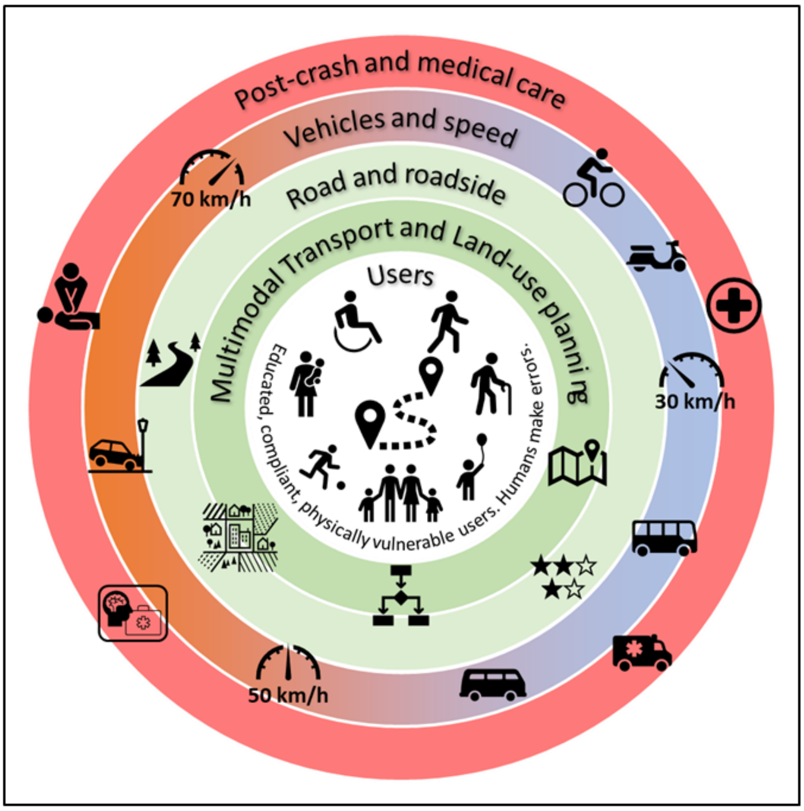

Figure 2: Safe Systems Approach Visualisation.
Source: Vanderschuren and Mwaura, 2023

While traditional road safety strived to prevent all crashes, the Safe System approach refocuses transportation system design and operation on lessening impact forces to reduce crash severity and save lives (FHWA, 2017). "While no crashes are desirable, the Safe System approach prioritises crashes that result in death and serious injuries, since no one should experience either when using the transportation system." (FHWA, 2017).

1.3 Aim of Paper

The work presented in this paper forms part of the international Trans-Safe consortium work. The Trans-Safe consortium involves national, regional, and city-level demonstrations to test different types of innovative and integrated SSA based solutions in four African municipalities, including Cape Town. This paper is focused on the ‘Road and roadside’ component of the SSA. The SSA postulates that designing to accommodate human mistakes and injury tolerances can greatly reduce the severity of crashes that do occur (FHWA, 2017). Examples of such a design include physically separating people traveling at different speeds, providing dedicated times for different users to move through a space, and alerting users to hazards and other road users. The purpose of this paper is to propose and analyse road and roadside interventions that can be implemented in the City of Cape Town to further improve its road safety situation. The intention is to concentrate on relatively low-cost interventions that can be implemented on collector and minor roads in the city.

1.4 Methodology

The methodology applied in this research is based on a research approach created and applied by the authors during the development of a Road Safety Implementation Framework for the Western Cape in 2017 (Vanderschuren et al, 2017). Historical accident data was used to identify four high accident areas in the metro that are not on national, regional, or main roads. Site surveys were combined with data analysis and expert consultation to determine the possible causes of accidents at each site, and to identify the most appropriate road safety improvement interventions. An economic analysis was conducted for each location, indicating break-even values and potential cost savings over a 20-year horizon. Sensitivity analysis was used to address uncertainty in terms of the costing of interventions. Keeping in line with the SSA, the focus of the analysis was predominantly on fatal crashes, although the total cost of non-fatal incidents was also calculated. It should be noted that the paper described an economic evaluation of road safety costs and benefits and does not provide a traditional cost-benefit analysis. Furthermore, no other (positive or negative) benefits, such as congestion, travel times, pollution etc. are included in the analysis.

2. ROAD TRAFFIC ASSESSMENT FOR CAPE TOWN

2.1 Identification of the Four High Accident Hot Spots

The availability of South African road safety data that includes geo-coded location information is sparse. However, historic geo-coded data up to 2014 was received and ‘cleaned’ for the Road Safety Implementation Framework for the Western Cape study (Vanderschuren et al, 2017). Currently, this is the most recent geo-coded data available to the researchers.

Analysis of this database identified four accident hot spots on lower order roads in the CoCT for further analysis:

1. The intersection of Stafford Street and 1st Avenue in Claremont,
2. Hannes Louw Drive,
3. A 180º bend on the R101, and
4. Govan Mbeki Road.

2.1.1 The Intersection of Stafford Street and 1st Avenue

The pictures included in Figure 3, obtained from Google Maps, provide information on the intersection of Stafford Street and 1st Avenue in Claremont. Whilst the overhead view shows a standard intersection, the street level views show that a building on the corner obstructs the line of sight into and from Stafford Street. It should be noted that, although a speed hump is shown on the images, this speed hump was not present when the accident data was collected (prior to 2015). There were, on average, no fatalities, 0.33 serious injuries, 0.67 slight injuries and 11 accidents with vehicular damage only, per year at this site.

a) Overhead

b) Eye-level

Figure 3: Stafford Street and 1st Avenue. Source: Google Maps

The suggested intervention for this intersection is to install a speed hump (as can be seen in the pictures) and to complement that with a mirror that drivers can view to determine the state of the road in the areas obscured by the building on the corner. As 1st Avenue has multiple speed humps already, the impact on rerouting of traffic, due to this intervention, is assumed minor. It is also assumed that the speed hump will be correctly implemented, avoiding negative impacts on vehicle.

2.1.2 Hannes Louw Drive

Although Hannes Louw Drive runs through a residential area, there is a small shopping centre and fuel station along the road (Figure 4a). It is postulated that the need for drivers to turn right, crossing left bound traffic, could be a reason why many accidents occur on this road (Figure 4b - top). The existence of parallel street parking and pedestrian crossings from the parking to the shops further adds to the unaccommodating design of this road (Figure 4b - bottom). An annual average of 0.25 fatalities, 0.25 serious injuries, 1.25 slight injuries and 12.25 damage only accidents are reported at this location. The intervention proposed, during a discussion by road traffic engineers, is to install a kerb in the centre of the road to prevent right turn movements, as well as incoming vehicles from turning right to access the facilities. If fencing is installed along the kerb, jaywalking and illegal U-turns can also be eliminated. Given the short road-segments in the neighbourhood and, therefore, sufficient alternative routes to businesses, no opposition from residents is assumed.

a) Overhead b) Eye-level

Figure 4: Hannes Louw Drive. Source: Google Maps

2.1.3 The 180º Bend on the R101

This location, shown in Figure 5a, is technically not within the boundaries of the CoCT but was included in the analysis to represent a rural example of a low-cost road safety intervention. As visible in Figure 5b, the current design does little to warn the driver of the sudden sharp turn ahead. The road boundaries are also not clearly marked, which is problematic as there is no street lighting in this rural setting. Accommodative design, accepting that humans make mistakes, would assist, and alert the driver to the sharp turn as much as possible.

a) Overhead b) Eye-level

Figure 5: The 180º Turn on the R101. Source: Google Maps

To this end, the addition of rumble strips, cats' eyes and additional signage are proposed. These interventions will be effective both during the day and at night-time. The average annual number of fatalities recorded is 0.67, along with 3 serious injuries, 8.44 slight injuries and 31.56 damage only accidents.

2.1.4 Govan Mbeki Road

Govan Mbeki Road runs along two schools, Thembelihle Secondary School, and Chuma Primary School, which are situated across an informal settlement (Figure 6a). The current road design (Figure 6b) does little to prevent unauthorised pedestrian crossings and the long, straight, and mostly flat roadway does not deter drivers from speeding. Pedestrian safety enhancements along the public transport routes at schools on Govan Mbeki Road are proposed, including, but not limited to, improved signage, raised crosswalks, the continuous connection of sidewalks and proper road markings. This aims to address the 0.3 fatalities, 4.7 serious injuries, 22.5 slight injuries and 102 damage only accidents reported on average per year.

a) Overhead b) Eye-level

Figure 6: Govan Mbeki Road. Source: Google Maps

2.2 Calculating the Costs of the Interventions

Costs for the implementation of the various interventions were obtained from civil engineering practitioners in South Africa, based on recent projects that they have done with similar road design elements. Capital and operational expenditures over the 20-year project horizon are included. Inflation and the time value of money are, however, excluded from the analysis, as this would impact both costs and benefits, over time, in a similar fashion and will not provide greater insight to the analysis. The assumed costs per intervention used in this analysis are summarised in Table 2. It needs to be noted that, if any of these interventions are implemented as a standalone project (i.e., not forming part of a larger road upgrade project), the costs might be substantially higher than what is listed. The cost for the interventions on Hannes Louw Drive and Govan Mbeki Road are dependent on the scale of implementation. To account for uncertainty relating to cost estimates, a conservative and optimistic scenario was modelled for each location. The conservative cost for Stafford Street is the high end of the range and the optimistic the low cost specified in Table 2. For Hannes Louw Drive, the optimistic scenario assumes a cost of R1 000/m, whilst the conservative scenario assumes a 20% higher cost for the interventions on the R101, if implemented in isolation. The cost provided for Govan Mbeki is a total cost estimate for a project of this scale and encompasses multiple interventions.

For the optimistic scenario, it is assumed that the interventions will only be applied right next to the schools (over approximately 400m) and that this reduction from the 550m conservative estimate reduces the total cost stated in Table 1 by 27.2%. Maintenance costs refer to damage repairs and paint touch ups, in most cases, and are averaged approximations of the extent of work required.

Table 1: Assumed Costs per Intervention

Main Intervention	Capital Cost and Replacement Frequency in 20 Years	Operational (maintenance) Cost and Frequency in 20 Years
Speed Hump & Mirror	R25 000 – R45 000, once off	R2 000 per annum
Kerb	R2 000 per metre, once off	R1 000 per annum
Rumble Strips, Cats' Eyes and Signage	R20 000, every 7 years	R500 per annum
Raised Crosswalks and Pedestrian Infrastructure	R5 000 000, once off	R2 000 per annum

2.3 Estimating the Benefits of the Interventions

To estimate the benefit accrued from intervention implementation, a projection of the total number of fatalities, expected over the 20-year period, is needed. The average annual number of accidents per severity at each location is assumed to increase by an accident growth rate which is the combination of Cape Town's population growth rate of 1.8% per year (Labuschagne, 2022) and the city's assumed annual motorisation growth rate of 2.8% per year (Palmer & Graham, 2013). An intervention impact profile is then applied to this forecast to determine the number of fatalities and injuries avoided, due to the intervention, over time. Measure profiles published in Vanderschuren et al (2020; 2017) were adapted for use in this analysis. Figure 7 indicates the profiles applied to each intervention.

Speed humps and raised crosswalks are assumed to be 100% effective from the moment of completion. It is not possible to avoid or ignore these interventions. Rumble strips, on the other hand, will increase in effectiveness as people become more accustomed to them and familiar with the roadway where the strips are located. When driving on a strange road for the first time, drivers might be surprised by the rumble strips and not fully understand what the strip is alerting them to, and not modify their behaviour appropriately, but frequent drivers of the route will get to know the strips and to be mindful of a hazard ahead. The effectiveness thus increases over time as behaviour is modified, due to the rumble strips' presence (https://dot.alaska.gov/stwddes/dcstraffic/rumble/rumble_faqs-temp.shtml). A similar logic is applied to the kerb installation. In South Africa, drivers with a high resistance to change will initially ignore the kerb and still drive where and how they used to or want to, but over time the new traffic routing becomes normal, and behaviour is modified to follow the new design, increasing the effectiveness of intervention implementation.

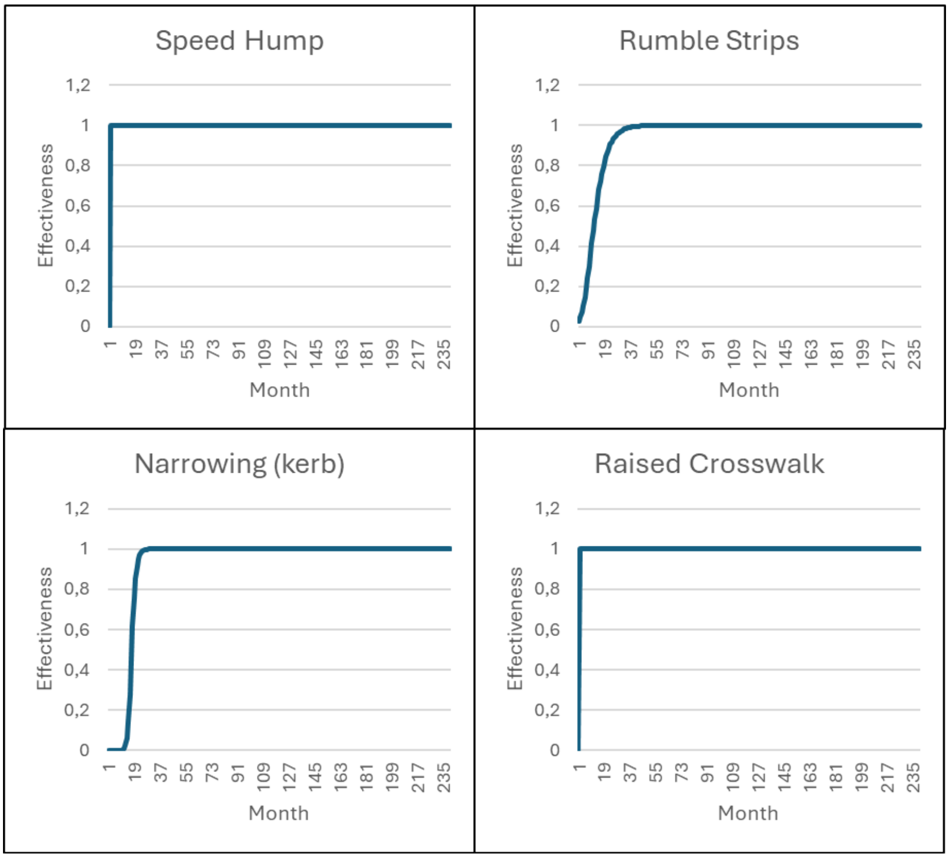

Figure 7: Measure Impact Profiles. Adapted from Vanderschuren et al., 2020

The literature is not conclusive on the exact impact that an intervention can have on the total number of collisions avoided. Table 2 shows the impact ranges found in the literature for the four key interventions included in this analysis. To address this uncertainty, the conservative scenarios use the lowest impact ratings, and the optimistic scenarios the highest impact scores, shown in Table 2. Please note that the list of sources is not exhaustive, as many other literature publications were consulted in the formulation of this table.

Table 2: Intervention Impact Ranges

Main Intervention	Impact Range	Source
Speed Hump	38% - 95%	ROSPA, 2017; Vanderschuren & Jobanputra, 2009
Mirror	95% - 100%	Mori et al., 2008
Kerb+	27% - 62%	Vanderschuren & Jobanputra, 2009; Gallager, 2006
Rumble Strips	14% - 76%	Afukaar et al., 2003; Obeng et al., 2022
Cats' Eyes*	3% - 63%	Faheem, 2011
Signage*	0% - 22%	Charlton et al, 2018; Fiolic et al., 2023; Jongen et al, 2011
Raised Crosswalks & Pedestrian Infrastructure	42% - 68%	CCMTA, 2013; Kockelman et al., 2022

+ Combination of the impacts of diagonal diverters, volume control and narrowing interventions
* Estimates based on speed reduction, not collision reduction

The South African Road Traffic Management Corporation (RTMC) published a document on the costs of crashes in South Africa in 2016 (RTMC, 2016), shown in Figure 8. Costs are provided for dealing with the injuries only (Road Traffic Injury (RTI) and for the total cost associate with a crash, including damage to the vehicle or road, as well as injury costs (Road Traffic Crash (RTC)). An average growth rate in the cost of crashes (5% per annum) was developed based on the average of the cost of fatalities and fatal crashes between 2016 and 2022 (RTMC, 2023) and applied to project the cost of crashes over the 20-year horizon.

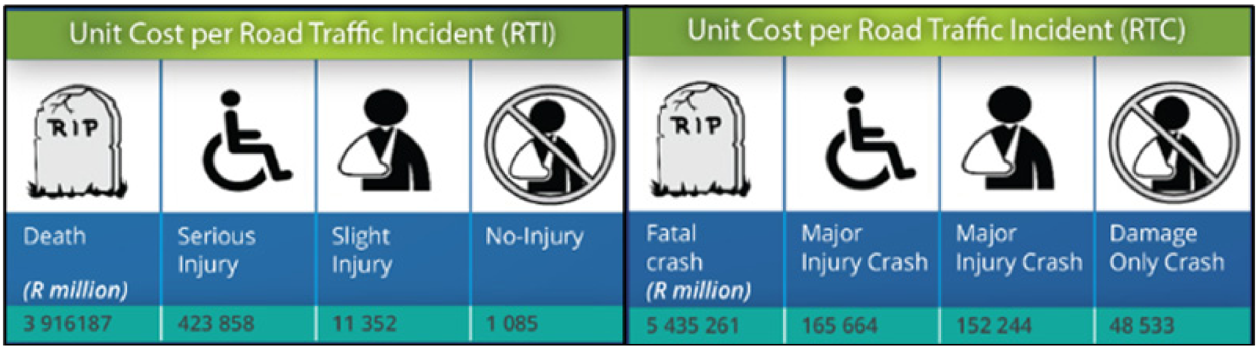

Figure 8: Cost of Crashes in South Africa. Source: RTMC, 2016

The economic benefit of each intervention is calculated by estimating the total cost of fatalities and crashes avoided through the intervention. This is done both for injury only costs, as well as the total cost of crashes, and for both the conservative and optimistic scenarios.

2.4 Results of the Economic Analysis

The economic analysis divides the economic benefits of intervention implementation (value of crashes avoided) by the cost to implement and maintain the intervention, monthly, over the 20-year study period, as mentioned. This enables the determination of a break-even point for each scenario, which is the point where economic benefits start to exceed the costs.

2.4.1 Stafford Street and 1st Avenue

Table 3 shows the break-even analysis for installing a mirror and speed hump at the intersection of Stafford Street and 1st Avenue.

A composite maximum impact of 96% effectiveness is assumed to account for the combination of a speed hump and mirror. The accidents at this junction typically occur at low speeds and have not proved fatal in the dataset. Despite there being no fatalities, the intervention proves to be very viable. If crash related costs alone are considered, the project will break-even within a few months of operation, whilst the benefits continue to accrue over all 240 months. Costs to the economy will be recouped between 81 and 2 102 times over the 20-year horizon. There is no additional justification required to render this intervention viable. Sensitivity analysis on the cost assumption in the most stringent scenario (conservative), assuming that the costs are underestimated by 10%, 20%, 50% and 100%, respectively, all finds the intervention to break-even within the first year of implementation. There is, thus, little doubt that the intervention will accrue benefits, surpassing the cost of implementation by a substantial margin, over its lifespan.

Table 3: Break-Even Analysis for Stafford Street & 1st Avenue

Name of Scenario:	Short	Medium	Long
Speed hump and mirror at Stafford Street & 1st Avenue	(1 year)	(3 year)	(20 year)
Conservative Scenario			
Total Capital Investment	R45 000,00		
Operational costs/annum	R2 000,00		
Road fatalities avoided	0	0	0
Direct fatality related injury only costs avoided	0	0	0
Injury only costs avoided	R109 370	R383 727	R6 760 468
Overall road safety costs avoided	R485 102	R1 701 986	R29 985 408
Economic Ratio - Injuries Only	2,43	7,83	81,45
Economic Ratio - Overall	10,78	34,73	361,27
Break-Even Year - Injuries Only	Year 1 (Month 6)		
Break-Even Year - Overall	Year 1 (Month 3)		
Optimistic Scenario			
Total Capital Investment	R25 000,00		
Operational costs/annum	R2 000,00		
Road fatalities avoided	0	0	0
Direct fatality related injury only costs avoided	0	0	0
Injury only costs avoided	R276 304	R969 417	R17 079 078
Overall road safety costs avoided	R1 225 521	R4 299 755	R75 752 610
Economic Ratio - Injuries Only	11,05	33,43	271,10
Economic Ratio - Overall	49,02	148,27	1202,42
Break-Even Year - Injuries Only	Year 1 (Month 3)		
Break-Even Year - Overall	Year 1 (Month 2)		

2.4.2 Hannes Louw Drive

A 40m long kerb is assumed to be installed in this location, including all other related infrastructure requirements, for example, signage. The useful life of a kerb is expected to be between 40 and 100 years (North Sydney Council, 2018; City of Salisbury, 2019), hence, only a once-off installation cost and minimal annual maintenance to repair damage is assumed. The break-even analysis for Hannes Louw Drive is summarised in Table 4. Both scenarios and cost comparisons find the intervention to break-even during its second year of installation. Based on the measure profile, benefits accrue slowly, at first, but once the intervention is fully embraced, the benefits are substantial and accrue quickly. Sensitivity analysis, varying the cost by +10%, +20%, +50% and +100%, respectively, or by assuming the measure effectiveness in the conservative scenario, is overstated by 5%, 10% and 15%, respectively, still finds the break-even point within the second year of operation. This implies high confidence in the conclusion that the intervention is feasible.

Table 4: Break-Even Analysis for Hannes Louw Drive

Name of Scenario:	Short	Medium	Long
Restrict right turn movements through kerb installation	(1 year)	(3 year)	(20 year)
Conservative Scenario			
Total Capital Investment	R80 000,00		
Operational costs/annum	R1 000,00		
Road fatalities avoided	0	0	2
Direct fatality related injury only costs avoided	R432	R765 698	R22 858 074
Injury only costs avoided	R524	R928 720	R27 724 715
Overall road safety costs avoided	R1 031	R1 826 219	R54 517 418
Economic Ratio - Injuries Only	0,01	11,33	280,05
Economic Ratio - Overall	0,01	22,27	550,68
Break-Even Year - Injuries Only	Year 2 (Month 7)		
Break-Even Year - Overall	Year 2 (Month 5)		
Optimistic Scenario			
Total Capital Investment	R40 000,00		
Operational costs/annum	R1 000,00		
Road fatalities avoided	0	0	5
Direct fatality related injury only costs avoided	R992	R1 758 269	R52 488 911
Injury only costs avoided	R1 204	R2 132 616	R63 664 160
Overall road safety costs avoided	R2 367	R4 193 541	R125 188 144
Economic Ratio - Injuries Only	0,03	50,78	1079,05
Economic Ratio - Overall	0,06	99,85	2121,83
Break-Even Year - Injuries Only	Year 2 (Month 4)		
Break-Even Year - Overall	Year 2 (Month 3)		

2.4.3 The Sharp Curve on the R101

Although there are three interventions combined at this location, the rumble strips profile is applied, as this is regarded the intervention drivers are least likely to miss or ignore. The conservative effectiveness estimate for rumble strips is higher than for cats' eyes and signage, but because all three are combined it can be expected that the other two interventions will be more effective than if implemented in isolation. Results from the break-even analysis are shown in Table 5. Again, the proposed interventions appear to be feasible, with all scenarios and cost variates breaking even in the first year of operation. Lowering the effectiveness expectation for the conservative scenario by 5% and 10%, respectively, does not change the break-even year. Neither does increasing the cost estimates by 10%, 20%, 50% or 100%.

Table 5: Break-Even Analysis for the R101

Name of Scenario:	Short	Medium	Long
Rumble strips, cats' eyes and signage at the R101 curve	(1 year)	(3 year)	(20 year)
Conservative Scenario			
Total Capital Investment	R72 000,00		
Operational costs/annum	R500,00		
Road fatalities avoided	0	0	3
Direct fatality related injury only costs avoided	R140 813	R1 301 052	R31 844 806
Injury only costs avoided	R243 740	R2 252 047	R55 121 546
Overall road safety costs avoided	R471 263	R4 354 264	R106 575 815
Economic Ratio - Injuries Only	10,16	90,08	676,34
Economic Ratio - Overall	19,64	174,17	1307,68
Break-Even Year - Injuries Only	Year 1 (Month 5)		
Break-Even Year - Overall	Year 1 (Month 4)		
Optimistic Scenario			
Total Capital Investment	R60 000,00		
Operational costs/annum	R500,00		
Road fatalities avoided	0	1	16
Direct fatality related injury only costs avoided	R764 415	R7 062 855	R172 871 805
Injury only costs avoided	R1 323 159	R12 225 400	R299 231 249
Overall road safety costs avoided	R2 558 287	R23 637 435	R578 554 422
Economic Ratio - Injuries Only	66,16	582,16	4305,49
Economic Ratio - Overall	127,91	1125,59	8324,52
Break-Even Year - Injuries Only	Year 1 (Month 2)		
Break-Even Year - Overall	Year 1 (Month 1)		

2.4.4 Govan Mbeki Road

Govan Mbeki is the location with the most accidents on average per annum (129.6) of all four sites. Even though this is by far the most expensive intervention proposed, the volume of accidents renders all scenarios breaking even within a maximum of 2 years (Table 6). A sensitivity analysis on the cost estimate used shows a break-even for the conservative, injury only scenario, from 2 years and 8 months to 3 years and 11 months if the costs are doubled. Similarly, reducing the assumed effectiveness of the proposed interventions by 5%, 10% and 15%, respectively, delays the break-even point to 3 years and 5 months at most. Applying the accident prevalence profiles of the three other locations does significantly affect the break-even point of the intervention. If the same number and type of accidents were to occur as at the Stafford Rd and 1st Avenue intersection, break-even would only happen in year 17, month 7, whilst the crash volumes for the R101 would have a break-even point like that of Govan Mbeki's actual averages (2 years and 9 months). This is despite the R101 having 86 fewer accidents on average per year but double the fatalities. Fatalities are much more costly than other accident types, hence, sites with high fatalities are more amenable to costly safety interventions than those without.

Table 6: Break-Even Analysis for Govan Mbeki Road

Name of Scenario:	Short	Medium	Long
Restrict right turn movements through kerb installation	(1 year)	(3 year)	(20 year)
Conservative Scenario			
Total Capital Investment	R5 000 000,00		
Operational costs/annum	R1 000,00		
Road fatalities avoided	0	0	4
Direct fatality related injury only costs avoided	R707 311	R2 481 609	R43 720 713
Injury only costs avoided	R2 939 876	R10 314 591	R181 721 341
Overall road safety costs avoided	R8 193 716	R28 747 748	R506 474 706
Economic Ratio - Injuries Only	0,59	2,06	36,07
Economic Ratio - Overall	1,64	5,74	100,53
Break-Even Year - Injuries Only	Year 2 (Month 8)		
Break-Even Year - Overall	Year 1 (Month 3)		
Optimistic Scenario			
Total Capital Investment	R3 640 000,00		
Operational costs/annum	R1 000,00		
Road fatalities avoided	0	1	7
Direct fatality related injury only costs avoided	R1 145 170	R4 017 843	R70 785 916
Injury only costs avoided	R4 759 800	R16 699 814	R294 215 504
Overall road safety costs avoided	R13 266 016	R46 543 973	R820 006 667
Economic Ratio - Injuries Only	1,31	4,58	79,99
Economic Ratio - Overall	3,64	12,77	222,95
Break-Even Year - Injuries Only	Year 1 (Month 4)		
Break-Even Year - Overall	Year 1 (Month 2)		

3. FINDINGS AND CONCLUSIONS

Road fatalities bear a significant cost to society. This study establishes that, when financially calculating these costs, a relatively small investment generates significant benefits. The interventions included in this study show an economic ratio of between 4.5 and 8 325 points in the medium to long term. It can, therefore, be concluded that investing in road safety measures is socially and economically attractive. Put differently, it will be public money well spent.

All three low-cost interventions proposed are found to be viable in terms of the economic analysis. Even the more expensive project planned for Govan Mbeki Road is feasible, due to the higher volumes of accidents typically occurring at this site per year. The total amount of direct fatality only related costs, that can be avoided if these interventions are all implemented, amounts to R848 556 in the first year alone. Looking at the injury only costs for all types of injuries, the total increases to R3.29 million, and to R9.15 million if the total cost of crashes is considered. This, when compared to the initial capital investment cost of R5.24 million, will result in a net positive economic impact for the City of Cape Town. The long lifespans of transport infrastructure, compared to the relatively short break-even periods found, are very favourable, indicating benefits to accrue for extended periods of time.

It is worth mentioning that this break-even is calculated considering the benefits obtained from a reduction in crashes only, and that other benefits in terms of congestion, travel times and traffic flow management, for example, are excluded from the analysis, demonstrating that the implementation of such road and roadside transport safety improvement measures are worth doing based on their own merit. Even if interventions lead to negative benefits, for example, additional travel times, the road safety based break-even periods are so short that no significant changes in the findings are expected.

This study highlights the importance of resuming geocoded data collection activities, which are vital in supporting evidence-based decision making and planning, as demonstrated in this project. The authors recognise that while the study approach is not perfect, being a simplification of the true complexity of transport engineering and highly assumption driven, the sensitivity analysis and scenario exploration employed provides confidence and value in the findings. It is proposed that the outputs of this analysis can be used as an initial sifting tool for decision makers, to be used to identify most promising interventions before spending time and other resources on the detailed design and engineering of transport safety interventions.

As mentioned in Section 2.2, inflation and the time value of money are excluded from the analysis as costs and benefits are both effected and results would not significantly change. The assumption that is made by doing this is that current and future fatalities and injuries are equally bad. While discounting of economic effects may be warranted as the value of money changes over time, discounting environmental and social effects warrants further discussion.

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5. REFERENCES

Afukaar FK, Antwi P & Ofosu-Amaah S. 2003. Pattern of road traffic injuries in Ghana: implications for control. *Injury control and safety promotion,* 10 (1-2):69-76.

CCMTA. 2023. Countermeasures to Improve Pedestrian Safety in Canda, Canadian Council of Motor Transport Administrators. Available at:
https://www.ccmta.ca/web/default/files/PDF/CCMTA_Pedestrian_Report_Eng_FINAL.pdf

Charlton, SG, Starkey, NJ, & Malhotra, N. 2018. Using road markings as a continuous cue for speed choice. *Accident Analysis and Prevention,* 117:288-297.

City of Cape Town. 2023. Urban Mobility Directorate Stats on Traffic Fatalities, Urban Mobility Directorate, City of Cape Town.

City of Salisbury. 2019. *City of Salisbury Infrastructure Guidelines-2019*; City of Salisbury: Adelaide, Australia. Available at: https://www.salisbury.sa.gov.au/assets/files/sharedassets/public/website_digitalpublications/development_-_development_engineering/city_of_salisbury_infrastructure_guidelines_march_2019.pdf.

Collaborative Sciences Centre for Road Safety (Undated). History of Traffic Safety Paradigms in the United States. Available at: https://www.roadsafety.unc.edu/.

Faheem, H. 2011. Effectiveness of using cat-eye reflectors as warning and traffic calming devices in local roads and highways, 3rd International Conference on Road Safety and Simulation, September 14-16, 2011, Indianapolis, USA.

Federal Highway Administration (FHWA). 2017. The Safe System, US Department of Transportation. Available at: https://safety.fhwa.dot.gov/zerodeaths/docs/FHWA_SafeSystem_Brochure_V9_508_200717.pdf.

Fiolic, M, Darko Babic, D, Babic, D & Tomasovic, S. 2023. Effect of road markings and road signs quality on driving behaviour, driver's gaze patterns and driver's cognitive load at night-time. *Transportation Research Part F: Psychology and Behaviour,* 99:306-318.

Gallager, M. 2006. *City of La Crosse Traffic Calming Policy*, City of La Crosse, WI.

Haddon W, Jr. 1968. The changing approach to the epidemiology, prevention and amelioration of trauma: the transition to approaches etiologically rather than descriptive. *Am. Journal of Public Health Nations Health*, 58:1431-1438. Doi: 10.2105/ajph.58.8.1431.

Jongen, EM, Brijs, K, Mollu, K, Brijs, T & Wets, G. 2011. 70 km/h speed limits on former 90 km/h roads: effects of sign repetition and distraction on speed. *Hum. Factors*, 53:771-785.

Kockelman, K, Perrine, KA, Zuniga-Garcia, N, Pleason, M, Bernhardt, M, Rahman, M, Lee, J & Karner, A. 2022. *Developing Countermeasures to Decrease Pedestrian Deaths*, University of Texas at Austin Centre for Transportation Research, USA. Available at: https://library.ctr.utexas.edu/ctr-publications/0-7048-1.pdf.

Labuschagne, FJJ. 2022. #KnowYourMunicipality: The 2022 Socio Economic Profile, City of Cape Town, Western Cape Government, Cape Town.

Martens, K, Golub, A & Robinson G. 2012. A justice-theoretic approach to the distribution of transportation benefits: implications for transportation planning practice in the United States. *Transportation Research Part A,* 46:684-695. 2012.

Mori, M, Horino, S, Kitajima, S, Masaru Ueyama, M, Ebara, T & Itanie, T. 2008. Ergonomics solution for crossing collisions based on field assessment of visual environment at urban intersections in Japan. *Applied Ergonomics,* 39:697-709.

North Sydney Council. 2018. *Kerb and Gutter-Asset Management Plan*; North Sydney Council: Sydney, Australia. Available at: https://www.northsydney.nsw.gov.au/files/assets/public/docs/1_council_meetings/policies_plans/plans_of_management/nsc_amp_kerbs_gutters.pdf.

Obeng, DA, Tuffour, YA, Poku-Boansi, M. 2022. The effectiveness of rumble strips installations in speed reduction along major highways in Ghana – The case of N1 highway, *Scientific African,* 16, e01215.

Palmer, I & Graham, N. 2013. *Western Cape Infrastructure Framework*, Western Cape Government, Cape Town.

RTMC. 2023. State of Road Safety in South Africa, January 2022 to December 2022, Road Traffic Management Corporation, South Africa.

RTMC. 2016. Costs of crashes in South Africa, Research and Development Report, Road Traffic Management Corporation, South Africa.

Vanderschuren, M & Mwaura, O. 2023. Transforming Road Safety in Africa, HORIZON-CL5-2021-D6-01-11: Radical improvement of road safety in low- and medium-income countries in Africa, D4.2 - Demonstration Project Updates, Trans-Safe UCT Task Lead.

Vanderschuren, MJWA & Newlands, AG. 2024. A comparison of traditional road safety assessment methods and the newly developed 'road safety deserts' approach. *Journal of the South African Institution of Civil Engineering*, 66(1):20-29. Available at: http://dx.doi.org/10.17159/2309-8775/2024/v66n1a3.

Vanderschuren, M, Arendse, M, Lane-Visser, T & Janmohammed, A. 2020. Combatting the Road Safety Burden in the Developing World: The Case of South Africa, *Transportation Research Procedia*, 48:1174-1184. Doi: 10.1016/j.trpro.2020.08.141.

Vanderschuren, M, Phayane, S, Sinclair, M & Janmohammed, A. 2017. Safety Implementation Framework: Cape Town, Report 029, Western Cape Government, Cape Town (SA).

Wegman, F & Aarts, L. 2006. Advancing Sustainable Safety, SWOV Institute for Road Safety Research, Leidschendam (NL), ISBN-10: 90-807958-7-9.

Wegman, F, Berg, H-Y, Cameron, I, Thompson, C, Siegrist, S & Weijermars, W. 2015. Evidence-based and data-driven road safety management, IATSS Research, 39(1):19-25. Available at: https://doi.org/10.1016/j.iatssr.2015.04.001.

World Health Organisation (WHO). 2018. Global Status Report on Road Safety – 2018. World Health Organisation. Geneva (CH). ISBN 978-92-4-156568-4.

World Health Organisation (WHO). 2023. Global Status Report on Road Safety – 2023. World Health Organisation. Geneva (CH). ISBN 978-92-4-008651-7

World Health Organisation (WHO) and the United Nations (UN), 2020. Global Plan: Decade of Action for Road Safety 2021-2030, Geneva (CH) and Washington DC (USA).