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WAYS OF REDUCING ACCIDENTS ON SOUTH AFRICAN ROADS



UNIVERSITY OF CAPE TOWN

Masters Dissertation

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DECLARATION

I, Isaac Ojungu-Omara, declare that the work presented in this dissertation document is my original work but where ideas and work of other people has been used, the due credit has been given and referenced.

ISAAC OJUNGU-OMARA

Signed by candidate

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TERMS OF REFERENCE

The aim of this research is to primarily determine ways of reducing fatalities on South African roads.

A hierarchy of human, vehicle and road factors will be used to determine the top tier of contributory factors. Identify measures that mitigate the main contributory factors by:

- changing the mindset of motorists and pedestrians
- using measures that ensure road users adhere to traffic regulations
- adopting the appropriate available technology that controls some of the contributory factors

Statistical estimates would be used to guesstimate the percentage reduction in fatality rates due to these measures. These estimates will highlight the effectiveness of these measures in lowering the occurrence of the contributory factors.

Methods of investigating this research involve:

- Identifying literature available on the internet and library regarding the causes of road accidents and remedies that reduce road accidents in different parts of the world.
- Identify relevant metropolitan councils that will supply raw data for accident statistics needed to determine frequent causes of road accidents in order to formulate a national model to reduce road accidents. Determine how statistical valid these provincial causes of road accidents and the corresponding solutions are in terms of a national model.
- Attend symposia and seminars available on road safety; develop linkages with for example Arrive Alive, in order to get insight into the problem and practical solutions available. Where possible, look at models used in Europe and North America that are used to reduce road accidents; and determine how feasible these models are in a South African context.

SUMMARY

In order to reduce the number of road accidents, the causes must be identified and measures adopted to minimise these causes. Causes of road accidents can be categorised into human factors, vehicle factors and road factors. In South Africa, road accidents are primarily caused by human factors and to a lesser degree vehicle and road factors.

December is the month of the year with the highest number of road fatalities in South Africa. Measures adopted to reduce the road carnage in December, need to be applied throughout the year.

Jaywalking and speeding are the main contributory factors of road accidents in South Africa. Jaywalking would be reduced by re-settling residents of informal settlements adjacent to freeways away from these high mobility routes. South African road users are aggressive with a lot of road rage compounded by alcohol abuse. Education of pedestrians and motorists is vital in changing driver and pedestrian behaviour. Enforcement is required to ensure that traffic rules and regulations are adhered to. Engineering will mitigate human, vehicle and road factors that education and enforcement could not.

Secondary contributory factors include: tyre bursts, faulty brakes, poor visibility, sharp bends and slippery roads. Public education highlights the accident risks associated with unroadworthy vehicles and the appropriate travel speed along road sections with poor visibility, sharp bends or slippery roads. Enforcement would ensure vehicles with worn-out tyres and faulty brakes are kept off the roads, appropriate travel speeds are adhered to along these road sections. Engineering would improve visibility, reduce travel speeds round sharp bends and increase skid resistance along slippery road sections. These measures would reduce the road carnage.

Authorities need to work with traffic police to improve collection of accident statistics and accurately quantify reductions in fatalities due to various human, vehicle and road factors being mitigated.

ABBREVIATIONS AND ACRONYMS

Abbreviation	Definition
C.O.L.T.O.	Committee of Land Transport Authorities
C.R.O.W.	Centre for Research and Contract Standardisation in Civil Engineering
C.S.I.R.	Council for Scientific and Industrial Research
E.A.N.	Equivalent Accident Number
Gautrans	Gauteng's Department of Public Transport, Roads and Works
M.I.T.	Massachusetts Institute of Technology
M.R.C.	Medical Research Council
N.D.O.T.	Department of Transport
O.A.R.	Officer's Accident Report
O.P.E.C.	Oil and Petroleum Exporting Countries
S.A.P.S.	South African Police Services
S.W.O.V.	Institute for road safety research
TTT Africa	Transportation and Traffic Technology Africa (Pty) Ltd
U.N.I.A.R.C.	University of KwaZulu-Natal Interdisciplinary Accident Research Centre

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1. INTRODUCTION

As part of fulfilling the requirements for a masters degree at the University of Cape Town, a dissertation topic needs to be identified, researched and findings documented. In this case, road safety in South Africa is the subject under investigation.

1.1. Background

One negative aspect in moving people, goods and services between origins and destinations, is that fatalities, serious or slight or damage to vehicles-only accidents could occur. In South Africa, numerous road accidents occur annually, especially over the festive season. In 2000, there were 5.2 fatal road accidents per million vehicle-kilometres travelled in South Africa, 7.74 in 2001 and 8.71 in 2002 [1]. Accident statistics indicate that there is a road safety problem in South Africa because the fatality rate is increasing with a rise in vehicle ownership and kilometres travelled.

A large concern was raised as to how this road carnage could be reduced, bearing in mind that the annual vehicle ownership increases annually. A large amount of data relating to accident statistics is collected and analysed annually by Department of Transport (NDOT), Statistics South Africa, Arrive Alive, Council of Scientific and Industrial Research (CSIR), various South African universities and Metropolitan Councils of the major South African cities. These institutes have quantified the annual number of road accidents and identified the causes of accidents over the festive seasons. The question is: What needs to be done to reduce the annual road carnage in South Africa?

1.2. Objectives

This thesis will determine ways of reducing accidents on South African roads by:

- identifying the main contributory factors,
- categorising these factors in terms of magnitude in order to identify the top tier, and
- determining ways of reducing the top tier of contributory factors.

1.3. Scope and Limitations

Accident statistics for the various provinces are not easily accessible unless contact is made personally. At the time of collecting data for this thesis (i.e. 2003), the Western Cape had a web site with their accident statistics and KwaZulu Natal was able to submit their data. Numerous phone calls have been made to the officials concerned in Gauteng in order to determine where their accident statistics could be obtained from, but in vain. No contact details of officials of the other provinces were available when putting together this thesis. Provinces, with the exception of the Western Cape, do not have a web site, where accident statistics are readily available to the public.

Accident statistics for KwaZulu Natal and the Western Cape reflect only processed data and access to raw data is not possible. In processing raw data, certain assumptions are made in order to determine contributory factors; which have not been made known. Without access to raw data, it is difficult to determine how the quality of processed data can be improved. It is possible for the database to be set up so that the public has access to the input and output of raw data.

Different sources of South African accident statistics (e.g. Arrive Alive, Statistics South Africa, NDOT, etc.) reveal great variation in the data. Countrywide the O.A.R. is used and data is captured through the TRAFMAN system, however most often data on the O.A.R. is incomplete.

Literature reviews were conducted on South African and international case studies. Request for information from the local traffic police departments in Cape Town did not bear meaningful results.

Accident statistics for the Western Cape and KwaZulu Natal need to show common denominators of contributory factors, for example:

- driver fatigue and time of the day,
- age or gender and alcohol abuse,
- age or gender and jaywalking,
- age or gender and speeding,
- age or gender and traffic violations,
- alcohol or drug abuse and time of day or day of the week or month of the year,
- slippery road sections and weather conditions (e.g. sunny or rainy day),
- sharp bends and available road signage,

- poor visibility and available road signage,
- road surface type (e.g. tar, gravel or concrete) and weather conditions, and
- worst known intersections and road sections (i.e. black spots) and available road signage.

These common denominators could be reflected in the raw data but probably get lost during the processing of accident statistics. Data is more meaningful if a holistic picture of what the driver encountered at the time of the accident is made available.

Limitations in terms of time and finance include not being able to analyse specific contributory factors (e.g. alcohol abuse and jaywalking) in more detail by conducting real-life experiments or studies to determine the precise decrease in fatality rates due to the measures proposed.

1.4. Methodology

National and international contributory factors of accidents and possible trends thereof need to be determined. In addition, ways of reducing accidents, nationally and internationally, which are currently in practice and their effectiveness, had to be identified. Therefore, a literature review was done using the internet, libraries at the Universities of Cape Town and KwaZulu-Natal, research papers issued by the CSIR and NDOT and various textbooks that discuss road safety.

Available accident statistics were collected to identify contributory factors in South Africa and also which month of the year is road safety most at risk. National and provincial accident statistics were collected from the internet (e.g. Arrive Alive and Western Cape websites) and from various personal contacts KwaZulu-Natal and DOT.

The magnitude of contributory factors was categorised in a hierarchy to identify the top tier of causes of accidents. The literature review was used to identify national and international measures that are in practice in order to reduce fatality rates. The percentage reductions of fatalities due to these measures are factored to represent a local situation in South Africa.

Estimated reduction of fatalities were determined to see to what extent the top tier of contributory factors would still be potential risks of road safety in South Africa. Where no research or data is available to determine ways of reducing contributory factors and effectiveness of the corresponding measures, the author estimates possible percentage reductions in fatality rates and states why these assumptions are made.

The top tier of contributory factors is tabulated against decrease in number of fatalities due to the various measures stated earlier. This gives a holistic view of what the bulk of contributory factors are and what measures would substantially lower the national and provincial fatality rate.

Ways of reducing accidents on South African roads are identified and recommended.

1.5. Contents of the Report

In chapter one, the research topic is introduced, who commissioned it and why it was considered relevant. This chapter also entails the objectives of the dissertation, problems encountered in trying to gather and analyse data and limitations in terms of time and finance. Lastly, it describes how the subject was investigated, data collected and analysed; findings documents and the way forward determined.

Chapter two documents national and international causes of road accidents. These causes are categorised into human, vehicle and road factors. A literature review was carried out to give insight into how these factors cause accidents.

Chapter three identifies international and national ways of reducing the number and severity of road accidents. A literature review was done to determine how these human, vehicle and road factors can be reduced in practice and the effectiveness of these measures.

Chapter four develops a statistical model to estimate reductions in accidents. South African provincial and national accident statistics are analysed in this chapter. The data is grouped into human, vehicle and road factors. The various factors are arranged in a hierarchy in terms of magnitude in order to determine the top tier of contributory factors. Measures identified in chapter 3 are adopted to estimate the decrease in number of fatalities where information is available. The author also makes assumptions of the percentage decrease rates in fatalities for contributory factors

where no information is available. The decrease in number of fatalities is quantified to determine the most effective measures.

Chapter five concludes the findings and states various ways of reducing accidents on South African roads. This chapter documents the findings in terms of what the top tier of contributory factors is, ways of reducing these factors and the effectiveness thereof.

Chapter six recommends the way forward in terms of what priority measures are needed to improve road safety. This chapter recommends which measures should be implemented based on their effectiveness in decreasing the national and provincial fatality rate.

University of Cape Town

2. FACTORS CAUSING ROAD ACCIDENTS

Are speeding and alcohol abuse the primary causes of accidents on South African roads?

There were 9918 fatal road accidents in South Africa during 2002 [1]. The main contributory factors to fatal accidents in December 2002 were grouped as follows: human factors 77%, road factors 13% and vehicle factors 10% [11].

Road accidents occur when a driver collides with another road user or fails to keep a vehicle on the road. This chapter will provide an overview of the causes of road accidents influenced by human, vehicle and road factors in order to provide possible solutions.

2.1. Human Factors

In December 2002, 77% of fatal accidents on South African roads were caused by human factors. An individual's ability to hear, see, evaluate and react to information influences traffic safety [4]. Information that a driver is subjected to includes: on-coming traffic, adjacent vehicles and pedestrians or bystanders, and vehicles behind or in front of the driver. Human factors that reduce a driver's ability to safely interact with this information resulting in accidents are discussed in this section.

2.1.1. Speeding

Every driver knows the stipulated speed limit for a particular road, yet many fail to adhere to it. Peer pressure among teenagers or adults trying to keep time or ignoring rules could explain this tendency. Speed is a contributory factor in 75% of accidents on South African roads and the higher the speed, the greater the impact [1]. Speed is considered an underlying contributory factor in most road fatalities by Arrive alive.

The severity of accidents increases with higher speeds. If accidents occur at 30km/h, there is a high probability of bone fractures and concussions, at 30-50km/h serious injuries, and at speeds greater than 50km/h a high probability of death or disability exists [7]. If a vehicle travelling at 80km/h hits a pedestrian, there is almost 100% probability that the pedestrian will die [1].

Therefore, a variation of speed limits according to the class of road (the degree of accessibility by pedestrians) can be witnessed. Classes of roads that stipulate speed limits of 80km/h or more are designed for 100% mobility and 0% accessibility. Pedestrian accessibility should be avoided. Unfortunately, this is not the case in practice.

The speed limit for a public road within an urban area is 60km/h, 100km/h on rural roads that are not freeways and 120km/h on every freeway [1]. With higher speeds on non-urban roads, the likelihood of pedestrian fatalities increases.

At higher speeds, one's vision focus narrows [8]. At high speeds, vision is reduced to seeing what is immediately in front of the driver, increasing the likelihood of hitting moving objects that suddenly pop up in front of the vehicle. Visual acuity is the ability to see fine details of an object and there are two types of acuity: static and dynamic visual acuity [7]. At high speeds, visual acuity is greatly reduced. This explains why signboards on freeways have very large lettering. Dynamic acuity vision is a driver's ability to clearly detect moving objects not necessarily in one's direct line of vision [7]. At high speeds, motorists cannot detect moving objects outside the driver's direct line of vision. This explains why the risk of having an accident rises as speed increases. Most people have clear vision within conical angle of 3° to 5° , fairly clear vision within a conical angle of 10° to 12° , and vision beyond this range is usually blurred [7]. At high speeds, a driver's vision is blurred outside a conical angle of 3° to 5° increasing the risk of pedestrian accidents outside the 5° conical angle. Peripheral vision is a driver's ability to see objects beyond the cone of clearest vision; objects can be seen within this zone but detail and colour are not clear [7]. At high speeds, drivers concentrate on what is directly in front of them eliminating their peripheral vision. This increases the risk of accidents involving pedestrians or animals that suddenly pop up in front of the driver. Cone of peripheral vision could be subtended up to 160° and is affected by speed and age [7]. The worst-case scenario is when motorists on freeways and national roads do not adhere to speed limits. This implies that pedestrians or animals in the cone of peripheral vision will be killed if directly in front of motorists. This stresses the importance of drivers maintaining stipulated speed limits and the need for drivers to have their eyes tested as they grow older as part of the process of renewing their driver's licence.

Perception-reaction time is time elapsed from the start of perception to the end of reaction and is the total time required for perception, identification, emotion and reaction [7]. At higher speeds, perception-reaction time may not be adequate to avoid an accident. Perception-reaction time is an

important factor in determining braking distances, which dictate minimum sight distances required on highways and the duration of amber traffic lights in signal design [7]. Traffic lights on downgrades should have a longer duration of the amber phase to allow drivers ample time to reduce speed. The time needed to react to unexpected information is clearly longer than the time needed to react to expected information [9]. On roads with higher speed limits, pedestrians or animals that unexpectedly appear on the road outside their designated crossing points can be killed as motorists take longer to apply their brakes. The larger the quantity and more complex the information, the longer it takes drivers to comprehend and react accordingly [9]. Overhead information signboards and traffic signs should therefore present information in the simplest form possible and be spaced reasonably apart to be understood by motorists.

For a given reaction time, distance is proportional to speed and the faster you go the longer the stopping distance [8]. Longer following distances are required at higher speeds to avoid instantaneous or emergency deceleration.

Three particular values of deceleration are relevant to the operation's safety level namely: normal or comfortable deceleration, emergency deceleration and instantaneous or stonewall stop [9].

Normal or comfortable deceleration is the safest level of operation occurring when the spacing between vehicles is such that the following vehicle can safely stop by applying normal deceleration even when the leading vehicle comes to an instantaneous stop [9]. Normal deceleration is possible on uncongested roads or at speeds lower than the stipulated speed limit. Legally, if a driver collides with a leading vehicle that driver is held liable for not maintaining a safe following distance in order to allow for normal deceleration.

At high speeds, longer braking distances are required, as motorists will emergently decelerate to avoid collisions. Emergency deceleration occurs when the spacing between vehicles is not enough for a comfortable deceleration [9]. When a road or highway is operating at full capacity, drivers not maintaining a safe following distance, given their current speed, may have to apply emergency deceleration to prevent rear end collisions.

The instantaneous stop condition may arise when a stalled vehicle or other obstruction suddenly comes within the perception field of the subject vehicle [9]. This stresses the importance of fencing off the road reserve preventing livestock, game and other wild animals from crossing rural roads.

A dilemma zone is when a driver approaches a signalised intersection as the traffic signal turns amber (amber). The driver is faced with the decision of whether to apply the brakes in order to stop before the red signal or to attempt to clear the intersection on amber [9]. This is a situation all drivers are familiar with but depends on whether the driver is a risk taker or risk averse at high speeds.

This may warrant that the duration of the amber phase of traffic signals at night or at black spots be extended to allow drivers sufficient time to react, therefore avoiding accidents. A properly selected amber duration that incorporates the motion of the vehicle during the driver's perception-reaction time can eliminate this problem [9]. In the interests of safety, the duration of the amber phase at black spots must include the perception-reaction time and time for the driver to comfortably cross the intersection at the approach speed assuming motorists are over the stipulated legal speed limit.

2.1.2. Alcohol or drug abuse

Alcohol or drug abuse is a habit or lifestyle problem occurring most frequently over the weekends or at night. The report entitled, "Alcohol use in South Africa: Findings from the First Demographic and Health Survey" by M.R.C., 1998 indicates that the highest levels of alcohol consumption were among white men (71%), white women (51%) and coloured men (45%) while the lowest levels among African and Asian women (12% and 9% respectively). This report found that higher rates of alcohol consumption among both men and women were:

- in urban areas,
- people with low or high levels of education than moderate education (Grades 6-12),
- age groups 35-44 and 45-54,
- 4-5 times greater on weekends than weekdays.

Under the influence of alcohol or drugs visual acuity, peripheral visual, depth and hearing perception are greatly reduced, as one's mind is sleepy and no longer alert. At the same time, the perception-reaction time increases greatly (See also Section 1.1.1.).

Static visual acuity is a driver or pedestrian's ability to identify an object when both the object and driver or pedestrian are stationary [7]. A drunk driver may not be able to judge the distance between vehicles before pulling out of a parking lot, increasing the risk of an accident. Drunken pedestrians may not be able to judge the distance between themselves and vehicles while attempting to cross

roads. Factors affecting static acuity include background brightness, contrast and time [7]. Drunk drivers or pedestrians will not notice contrast and background brightness, as the mind at that moment in time is mildly alert. Static acuity increases with an increase in illumination up to a background brightness of ± 3 candles (cd) per ft^2 and then remains constant with an increase in illumination [7]. Increasing the minimum illumination in all parking facilities or streets has no effect on motorists or jaywalkers under the influence of alcohol or drugs. The mind is in 'auto-pilot' mood and is barely sensitive to its surroundings.

Peripheral vision is the ability to see objects beyond the cone of clearest vision. Objects can be seen within this zone but detail and colour are not clear [7]. Motorists or pedestrians under the influence of alcohol or drugs have no peripheral vision as they can barely see and recognise what is directly in front of them. This increases the risk of accidents if pedestrians or animals suddenly appear directly in front of the vehicle. Drunk drivers tend to damage road furniture located in the zone of peripheral vision, as their eyes are barely open while driving. Drunken pedestrians are not aware of adjacent vehicular traffic and often stagger into on-coming traffic.

Depth perception affects the ability to estimate speed and distance (e.g. head-on collisions on a two lane highway are due to poor judgement of speed and distance) [7]. Drunk drivers and pedestrians are prone to head-on collisions as they are not aware of their speed or distance between their vehicle and immediate surroundings. It has been noted that the human eye is not very good at estimating absolute values of speed, distance, size and acceleration [7]. This inherent human weakness is further enhanced by the influence of drugs or alcohol as the mind can no longer estimate any absolute value and thus increases the risk of accident with anything in the immediate surroundings.

Hearing perception is the ability to detect warning sounds given out by emergency vehicles [7]. Drunk drivers and pedestrians may not hear warning sounds from other vehicles, as their senses are partly inactive. Loss of hearing ability can be corrected by hearing aids [7] and it is the drivers or pedestrians' responsibility to correct their hearing disabilities accordingly to ensure their own and others' safety.

Perception-reaction depends on existing environmental, emotional and medical conditions, as well as age, fatigue, and sleep deprivation or whether the driver is under the influence of drugs or alcohol [7]. Motorists or pedestrians under the influence of alcohol or who are fatigued or emotionally stressed pose a bigger risk to fellow motorists as their perception-reaction time is

greatly increased. Drunk drivers or pedestrians take longer to perceive, identify and react to any situation making them more prone to accidents. The ability to interact with information is influenced by alcohol, fatigue and the time of the day and affects an individual's reaction time [7]. The worst-case scenario is at night when most consumption of alcohol occurs, making drunk drivers or pedestrians very susceptible to accidents. Driver or pedestrian behaviour results from their evaluation of and reaction to information they obtain from certain stimuli that they see or hear [7]. Drunken pedestrians or drivers are not fully aware of what they see or hear, and take much longer to evaluate and react to this information increasing the likelihood of having an accident. Visual reception is an important source of information for both drivers and pedestrians [7]. Drunken pedestrians or drivers see things in pairs or things appear to be spinning round in circles, therefore making them prone to accidents.

Alcohol or drugs make an individual less alert and less conscious of their immediate surroundings. It also makes individuals less in touch with their senses and lowers body and mind control. This slows down reflex actions thereby increasing the likelihood of an accident.

2.1.3. Violation of traffic rules and regulations

Roads are public spaces with rules and regulations that must be adhered to. This ensures the safety of fellow road users. Reasons why motorists do not follow traffic rules and regulations include aggressive driver behaviour, road rage, speeding, and alcohol or drug abuse.

Traffic violations include:

- driving above stipulated speed limits,
- driving under the influence of alcohol or drugs,
- driving without a safety belt,
- failing to adhere to traffic signals i.e. driving during the red phase,
- overtaking on a barrier line
- driving without a valid driver's licence,
- driving without a valid road licence,
- driving with smooth or damaged tyres or unroadworthy vehicles, and
- dysfunctional headlights, brake lights or indicators.

Violation of traffic rules and regulations could result in collisions with adjacent vehicles, pedestrians, bystanders or road furniture. Fining motorists or revoking their drivers licence can ensure rules and regulations are adhered to.

2.1.4. Fatigue

Fatigue sets in at the body's natural resting hours (i.e. night time), after a heavy meal and after a long period of uninterrupted driving. Fatigue causes a lapse in concentration and the tendency to sleep behind the steering wheel while driving increases the likelihood of accidents occurring.

Driving during the body's natural resting time forces the mind to try to stay alert and concentrate when it wants to shut down and rest. This causes nodding off behind the steering wheel and sleepy drivers crossing into adjacent lanes.

'Morning people' feel most alert in the early part of the day, while 'night people' enjoy staying up late [1]. Circumstances arise when 'morning people' have to drive for long hours at night or vice versa causing driver fatigue. Most people are programmed to sleep when it's dark, and sleep becomes irresistible late at night [1]. An overriding fact of nature is that everyone will want to sleep at night regardless of the use of stimulants (e.g. coffee) and the number of hours slept during the day prior to night driving. This also increases the risk of accidents especially for workers at the end of nightshift.

Circadian rhythm, the body's natural rhythm associated with the earth's rotation, causes nearly everyone to be less alert or even drowsy between 1 and 5 pm [1]. After a heavy lunch we feel drowsy and driving can prove to be fatal as mentally an afternoon nap is required. In today's capitalistic world where time is money, this is not viable. Therefore, a balance needs to be sought to avoid accidents.

Sleep disorders such as chronic insomnia, sleep apnoea and narcolepsy, all of which lead to excessive daytime sleepiness, afflict potential motorists [1]. Long distance drivers should be clinically tested for these sleep disorders in order to avoid accidents outside the body's natural resting hours.

2.1.5. Jaywalking

Some pedestrians feel the need to walk along freeways, do not apply the necessary precautions prior to crossing roads and do not cross the road at designated pedestrian crossings. This is commonly referred to as jaywalking. Jaywalking increases the conflicts between motorists and themselves (i.e. the likelihood of pedestrian accidents), as motorists do not expect the presence of pedestrians.

Jaywalkers are pedestrians with little regard for traffic rules and regulations or people that rarely use cars and cannot perceive what situations may pose safety threats to motorists. Jaywalking also occurs when there is lack of pedestrian facilities or incorrectly placed pedestrian infrastructure or merely to avoid large and very complicated intersections. Jaywalking also occurs when pedestrians are under the influence of alcohol or drugs adjacent to roads. Jaywalking occurs when individuals naturally have reduced peripheral vision, depth and hearing perception and longer perception-reaction time [7]. These features reduce their ability to see vehicles beyond the cone of clearest vision, estimate speed and distance, detect warning sounds from vehicles and increase the total time required for perception, identification, emotion and reaction [7] increasing the likelihood of accidents.

2.1.6. Age

Naturally younger people are risk takers and less cautious as their perception-reaction time [7] is lower. This probably explains why people of a certain age are more prone to accidents. Children are naive and less experienced making them more vulnerable to jaywalking. The author feels that younger people are also naturally more aggressive and energetic, which extends to their driving and they take more risks. This all increases the risk of accidents occurring from traffic violations.

Naturally the human senses are less sensitive and reflexes slow down as the body gets older. This increases perception-reaction time and affects sensitivity to glare [7].

Direct glare occurs when relatively bright light appears in the individual's field of vision [7]. Road courtesy is when on coming traffic dim their lights when using single or dual carriageway to prevent glare. Direct glare in older people may cause them to veer off the road due to reduced glare recovery.

Glare recovery is the time required to recover from the effects of glare after passing a light source [7]. While a driver is recovering from the glare, the vehicle is still in motion posing a risk to oncoming traffic, road furniture and the immediate surroundings. Studies show glare recovery is three seconds when moving from dark to light, six seconds from light to dark [7]. Older people exposed to direct glare take longer than six seconds when moving past bright on-coming vehicle lights on an unlit road. Glare vision is important for night driving especially for older people [7]. This stresses the importance of design and location of street lighting in order to minimise the effects of glare, especially among the elderly. Glare effects are minimised by brightness and increased background brightness in the driver's field of view. These include higher mounting heights, positioning lighting supports farther away from the highway, and restricting light from the source in order to obtain minimum interference with visibility of the driver [7]. These are aspects that should be incorporated into the design and location of street lighting, especially outside old age homes, rural areas and residential areas with high numbers of elderly people.

Specular glare occurs when the image reflected by the relatively bright light appears in the field of vision [7]. Road courtesy is when the following vehicle dims its lights to prevent glare.

Both types of glare result in a decrease in visibility and cause discomfort to the eyes [7]. Lack of road courtesy may lead to a driver not being able to focus on the road ahead causing accidents involving road furniture, oncoming traffic or vehicles, pedestrians and animals. Age affects sensitivity to glare [7]. The older the driver, the greater the effects of glare and older drivers are therefore more prone to accidents when exposed to glare.

2.1.7. Gender

Males are naturally more aggressive than females. This is particularly evident among animals, and to lesser degree among human beings. The author strongly believes that road rage and aggressive driver behaviour are more prevalent among male motorists and this increases the accident risk among male motorists.

Naturally men and women do not have the same degree of visual acuity, peripheral vision, glare recovery, depth and hearing perception, perception-reaction time [7], drug or alcohol consumption levels, jaywalking tendencies and speeding trends. This could explain the varying accident rates

between men and women. 75% of pedestrian casualties are male [1]. This indicates that this variation but also could be due to higher levels of alcohol consumption among men than women.

2.1.8. Wearing of seat belts

Inertia keeps the body travelling at the same speed prior to collision, when the vehicle has come to a standstill. Wearing of seat belts ensures that occupants of vehicles are not propelled through the windscreen during head-on collisions, because seat belts reduce the effects of inertia.

2.2. Vehicle Factors

10% of fatal accidents on South African roads during December 2002 were caused by vehicle factors.

2.2.1. Un roadworthy vehicles

Because vehicles drive on roads that are public spaces it is stipulated that vehicles need to be in proper working order to guarantee the safety of fellow road users. Vehicle roadworthiness refers to the quality of the vehicle that ensures it is safe on the road both for the driver and other road users. The quality of the engine, brakes, hand brakes, park brakes, seat belts, hooters, indicators, headlights, brake lights, reverse lights, head lights and tyres must all be in working order. Kinematical characteristics include the acceleration capabilities of vehicles [7] dictating that the brakes, headlights, brake lights, indicators, seat belts and hooters must be in acceptable working conditions.

Grade resistance is the force acting opposite a moving vehicle up an incline or grade [7] and this dictates that all vehicle engines especially heavy duty trucks, should be in adequate working conditions in order to climb steep grades.

Rolling resistance is the frictional effect on moving parts of vehicles [7]. This means that engine oil leaks will not be tolerated at roadworthy testing stations and traffic law enforcers should randomly check vehicles.

Vehicle roadworthiness tests are done when a vehicle changes owners and not when renewing annual road licences. During the annual renewal of road licences, traffic law enforcers must ensure that vehicle tyres are not smooth or worn out, proper functioning of hand brakes, brakes and lights and that there are no oil leakages.

Corrupt roadworthiness testing stations grant unroadworthy vehicles licences and thus increases the accident risk. Road safety in South Africa will continually be threatened as long as traffic law enforcement has loopholes due to corruption.

2.2.2. *Vehicle tyres and air pressure*

Vehicle tyres should have adequate threads to enable the vehicle to brake when required and prevent skidding when on slippery road sections. Tyre threads should have grooves deep enough to bury a matchstick (i.e. 1mm minimum depth) as a rule of thumb.

Vehicle tyres must also have adequate wall thickness to prevent bursting at high speeds; stipulating changing of smooth or worn out tyres immediately. Each tyre has a load rating (i.e. maximum load under a certain air pressure) it can bear before bursting (See Appendix A). After long durations of travel on hot days, tyres heat up with internal air pressure building. Given the vehicle load, a tyre will burst if the air pressure rises above its load rating, hence the need to stop at regular intervals on long journeys. When brakes are applied when a tyre bursts at high speeds, the entire vehicle mass is transferred to the burst tyre as it is lower than the other tyres and this causes the vehicle to overturn. The use of wrong tyres is affected by load rating e.g. use of passenger tyres on taxis instead of commercial ply.

The Geometric design of roads is influenced by static characteristics of vehicles that include the weight and size of vehicles [7]. The weight and size of a vehicle determine the rate of wear and tear on the tyres given the quality of the road. Smooth tyres allow skidding or sliding into adjacent vehicles, road furniture or pedestrians under wet or slippery road conditions. Rolling resistance is the force that resists motion or the frictional slip between the pavement surface and tyres [7]. Smooth tyres on wet or slippery roads do not offer much rolling resistance and this increases accident risks during the rainy season.

Smooth tyres increase braking stopping distances. Friction is a force that opposes motion; in this case the force that acts against the motion of the vehicle occurring between the tyres and the road surface [7]. The rougher the road surface the greater the friction, and smoother tyres have less friction thus reducing a vehicle's braking capability.

2.2.3. *Overloading of vehicles*

All vehicles are designed to carry a maximum load, with the centre of gravity acting through its base, preventing toppling as it goes round horizontal curves. Overloading raises the centre of gravity and the weight acts outside its base causing toppling round horizontal curves as shown in Figure 1.

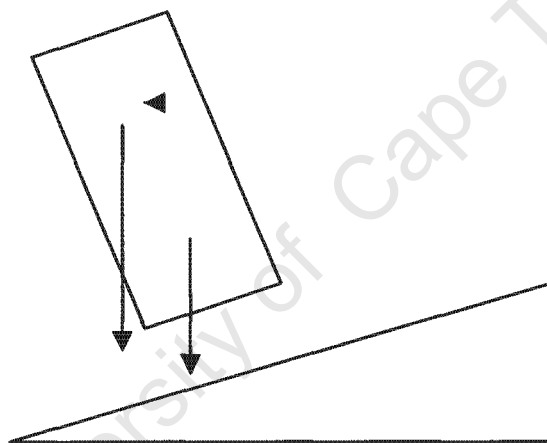


Figure 1: Shift in centre of gravity due to overloading

Also slight increases in speed round horizontal curves for overloaded vehicles makes overturning or toppling easier. The base to height ratio of vehicles plays a major role in toppling; with overloaded buses and trucks more prone to toppling due to higher bodies. This poses a threat to public transport that involves minibus taxis and buses. Overloaded vehicles reach their tyre load rating easier resulting in burst tyres. Education of motorists coupled with stringent traffic law enforcement can reduce the number of overloaded vehicles on South African roads.

2.2.4. *Vehicle brakes*

Depending on the weight of the vehicle, the braking system must produce a force large enough to bring the vehicle to a standstill over shorter distances given the effects of inertia.

Curve resistance is the external force acting on the front wheels of a vehicle as it goes round a corner [7]. It dictates that the front brakes must be adequate enough in the event that the vehicle needs to reduce speed under centrifugal forces.

Geometric road design considers static characteristics of vehicles i.e. weight and size [7] and dictates that all vehicles brakes, hand brakes and park brakes must be in acceptable working condition. The geometric design of freeways is influenced by dynamic characteristics of vehicles and this includes forces that cause or affect the motion of the vehicle [7]. This stresses the importance of adequate brakes as freeways are made for free-flowing high speed traffic volumes; and all vehicles are expected to reduce speed appropriately without any collisions.

2.2.5. Vehicle lights

At night, during misty weather, sunset or sunrise, vehicles must be inter-visible. This implies the daily working condition of vehicle headlights and in particular the correct power rating of bulbs to minimise glare. The author believes that inappropriate power ratings for the bulbs used increases the effects of glare causing motorists to veer off the road and collide with road furniture, animals or pedestrians.

The author observed that vehicles with only one working head light make it hard for on-coming traffic to know where the edges of the vehicle lie and this increases the chance of sideswipes and accidents.

2.3. Road Factors

Road factors make up 13% of fatal accidents on South African roads during December 2002 [1].

2.3.1. Road surface type

The road surface type refers to whether the road is tarred, gravel/ dirt, concrete or other. The coefficient of friction between tyres and various road surface types is different resulting in varying safe travelling speeds given minimum braking distances [7].

Concrete and asphalt roads should have almost similar safe travel speeds compared to gravel or dirt roads that are lower, given any drivers' experience. The author noted that gravel or dirt roads have lower safe travelling speeds due to the presence of stones that may cause tyre bursts. The author observed that the nature of gravel also fills up tyre threads at high speeds creating skidding and subsequent failure to keep vehicles on the road. At higher speeds, the risk of having an accident is higher on gravel or dirt roads than concrete or asphalt roads.

Concrete and asphalt roads have shorter braking distances compared to gravel or dirt roads as the road surface is rougher and without fine moveable particulates that increase the coefficient of friction. If a driver needs to suddenly stop to avoid a collision, concrete or asphalt is safer than gravel or dirt roads.

2.3.2. *Slippery roads*

Skid resistance of roads varies according to whether the road is wet or dry. The author observed that wet roads offer less skid resistance than dry roads as water between the road and tyres reduces friction needed to increase skid resistance necessary to avoid accidents.

Concrete will not let water flow through it due to low porosity, so the roughness of the riding surface depends on the concrete finish. The author noted that rough concrete finishes are achieved using wooden floats and smooth finishes with steel floats (e.g. smooth housing floors). Rougher concrete finishes reduce the surface run-off rate but increase friction between tyres and the concrete surface. This ensures reduced contact of water between tyres and the concrete surface.

Depending on the nature of soil present on the dirt or gravel road, porosity varies and is indicated by the amount of stagnant water on the road. Gravel roads are compacted under vehicle weight thus reducing their natural porosity. The author observed that gravel roads retain water on the driving surface and is not like sandy or clay soils that easily form deep layers of mud and cause tyres to dig deep and get stuck.

Asphalt takes on different forms of drainage i.e. open, closed or semi-open [7]. The difference lies in the varying void ratios present that allow different amounts of water to penetrate down the pavement thickness. Open asphalt reduces aquaplaning as it drains more rainwater and improves visibility as less water is splashed onto the windscreens of following vehicles. Closed asphalt will

retain more water at the riding surface than the open asphalt. So depending on the rainfall pattern in the area, different types of asphalt are used. "Bleeding" of asphalt makes the road very slippery during wet weather. "Rutting" causes water to accumulate in ruts causing vehicles to "hydroplane" and loose grip.

2.3.3. *Poor visibility or inadequate street lighting*

Motorists need to see what is in front of them at all times when driving in order to avoid collisions. The author observed that poor visibility on eastbound roads during sunrise or westbound roads during sunset prevents drivers from seeing ahead, making them susceptible to accidents. Rainy or misty weather poses an additional threat to traffic safety. Trees within the road reserve or inadequate street lighting reduces visibility and thus increases the risk of accidents.

Veldt fires in the road reserve produce smoke clouds that reduce visibility, stipulating the need for regular maintenance of road reserves by cutting of grass.

Poor visibility also arises when rural roads do not have the necessary road furniture (e.g. reflectors, road studs) that inform drivers at night that they are crossing a bridge or the road is curving left or right. Accidents arise as motorists drive through guardrails or straight round a bend in the road resulting in collisions or overturning.

The author observed that gravel roads produce dust from vehicles ahead in that particular direction or oncoming traffic. This greatly reduces sight distance during the day and even more so at night. If objects are present in this dusty zone, the likelihood of an accident is inevitable, as bright vehicle lights will not enable a driver to see through a cloud of dust.

The author noted that rural roads have inadequate street lighting, inappropriate control of pedestrians and a large presence of animals suddenly crossing the roads increase the risk of accidents due to poor visibility.

2.3.4. Sharp curves

Motorists tend to drive faster on straight sections but when they are suddenly faced with sharp curves, they do not have enough time to reduce speed while going round the curve. Accidents subsequently arise as they drive off the road.

Sharp curves have small radii of curvature requiring drivers to reduce speed substantially as centrifugal forces tend to make vehicles drive straight round horizontal curves. Centrifugal forces increase with speed forcing motorists to drive straight off the road.

2.3.5. Inadequate road fencing

The author observed that livestock tend to lie down on surfaced roads in winter in order to capture heat retained during the day. Moreover, some game and livestock run towards a vehicle's lights at night, colliding with vehicles and creating the need for deceleration at high speeds. Both scenarios involving livestock and wild animals increase the likelihood of accidents if the road reserve is not fenced off.

This highlights the fact that all rural road reserves should be fenced off with gates to allow animals to cross at specified points that are clearly marked with road signs. This will inform drivers of their presence and will avoid possible accidents.

2.3.6. Sight distance

Road characteristics are related to stopping and passing because these have a direct relationship with the characteristics of drivers and vehicles. [7]. Roads should give drivers ample time to react to any situation by ensuring they can see a certain distance ahead.

Sight distance is the length of the roadway a driver can see ahead at any particular time [7]. Road safety is primarily influenced by the driver's ability to see objects ahead at any time in order to avoid a collision. The sight distance available at each point on the road must give drivers travelling at the design speed, adequate time to make necessary evasive manoeuvres to avoid colliding with objects observed in the vehicle's path [7]. Drivers have a right to see a certain distance ahead on every road section, placing responsibility on road engineers to ensure all road sections have an

adequate minimum sight distance. The two types of sight distance are: stopping sight distance and passing sight distance [7].

a. Stopping sight distance

The stopping sight distance is the minimum sight distance required for a driver to stop a vehicle after seeing an object in the vehicle's path without hitting that object [7]. Drivers have a right to ample time required to stop early enough, which road engineers must ensure. This distance is the sum of the distance travelled during perception-reaction time and braking [7]. At design speeds, this distance should also be long enough to react and stop round horizontal and vertical curves.

Stopping sight distance requirements dictate the minimum length of vertical curves and minimum radius of horizontal curves that should be designed for any given road [7]. Road markings indicate road sections where overtaking is prohibited (e.g. sections of vertical and horizontal curves) as there is not enough time or distance available for drivers to react and stop given the presence of obstacles.

b. Decision sight distances

Stopping sight distances are usually adequate for ordinary conditions or when the driver expects the stimulus [7]. Minimum radii for vertical and horizontal curves create stopping sight distances that ensure accident free zones. When the stimulus is unexpected or when the driver must make unusual manoeuvres, longer stopping sight distances are required as the perception-reaction time is much longer; and this longer sight distance is the decision sight distance [7]. Road reserves should be as flat as possible with minimal vegetation allowed to grow thus exposing drivers to fewer unexpected features. Decision sight distances depend on the type of manoeuvre required in order to avoid the hazard on the road and also on whether the road is located in a rural or urban area [7]. This stresses the importance of road signs, other appropriate road furniture and fencing off of rural roads.

c. Passing sight distances

Passing sight distance is the minimum sight distance required on a two-lane, two-way road that will permit a driver to complete a passing manoeuvre without colliding with an opposing vehicle and without cutting off the passed vehicle [7]. Road markings highlight passing sight distances but road engineers must ensure that passing sight distances are adequate enough for the stipulated design speed to avoid head-on collisions and sideswipes.

2.3.7. Lack of pedestrian infrastructure

Pedestrian fatalities occur where there is lack of pedestrian infrastructure that ensures safe crossing at intersections or walking along side roads. Studies should be carried out to determine whether pedestrian infrastructure is available at pedestrian “black spots” and what appropriate measures should be adopted.

Provision of inappropriate pedestrian infrastructure puts pedestrians in situations where crossing points are perceived too far or too cumbersome to use. In incidences where, transport authorities realise that pedestrian infrastructure is not be used, measures should be adopted that make these facilities the only way of crossing the adjacent streets e.g. use of fencing along the medians. In incidences when pedestrians perceive intersections as too wide and pedestrian infrastructure is not used, studies should be carried out to determine whether grade separated pedestrian infrastructure is suitable or reference should be made to the report entitled, “Pedestrian and Bicycle Facility Manual” August 2003.

3. REDUCING THE NUMBER AND SEVERITY OF NATIONAL ROAD ACCIDENTS

A rise in the number of vehicle-kilometres travelled due to annual growth of vehicle ownership and use increases the probability of accidents. Moreover, annual population growths also increase the probability of accidents. With the steady growth of vehicle-kilometres driven and urban inhabitants in South Africa, how can the number of road accidents be reduced or avoided?

Traffic law enforcers can address the human and vehicle factors that cause accidents. Traffic and road engineers can improve road design and ensure adequate road furniture. Educators can inform the public about the way in which motorists are both part of the problem and the solution as accidents can be avoided by improving driver and pedestrian behaviour. Awareness campaigns can stress the dangers of speeding and alcohol abuse, while traffic law enforcers can fine violators. Traffic law enforcers can also reduce the number of unroadworthy vehicles on South African roads.

Accident statistics should give an indication of what human, vehicle or road factors are the main causes of accidents. And although provincial authorities in South Africa collect raw data on accident statistics, unfortunately, these statistics often leave out essential information that is needed to make the data meaningful.

Accident statistics do not include black spots, making it difficult to analyse road factors. Officer's Accident Reports (O.A.R.) completed at accident scenes do not state whether the driver was drunk or sober, due to legal complications of for example having to appear in court.

They also do not measure the length of skid marks (if any) to determine the vehicle speed prior to the accident or check the condition of tyres. This makes it difficult to assign rising number of accidents to particular causes. The O.A.R. should give an indication of the causes of an accident in order to develop a proactive approach to solving the problem. However, it is sometimes impossible to determine at accident scenes whether the brakes were not working or if pedestrians involved were jaywalking or the vehicle's speed prior to the accident in the absence of skid marks. This makes it hard to identify causes of fatalities.

Speed information for black spots would help investigate problem areas better. Although speed cameras are available in Cape Town, and in particular at some black spots, data was not made available.

Other means have therefore been used to determine the effect of reducing various human, vehicle and road factors. Reductions in the number and severity of accidents due to improvements in traffic law enforcement, vehicle roadworthiness and better public education are also determined.

3.1 Human Factors

A change in mindset can alter driver behaviour. Ways of altering driver behaviour involve public education, communication and stringent traffic law enforcement. How effective are these techniques in reducing human factors?

3.1.1 Speeding

Higher vehicle speeds yield a greater momentum at the moment of collision increasing the severity of accidents. Momentum is directly proportional to speed and mass (Momentum = mass x speed). The most severe accidents will therefore include heavy trucks (i.e. large mass) colliding with a vehicle at high speeds or head-on collisions at high speeds. In head-on collisions two vehicles come to a standstill, with the momentum between two moving vehicles being absorbed by the vehicles and its occupants.

A unit rise in vehicle speed increases the number of fatal accidents in multiples of 2.5% [10]. This shows how a slight rise in speed increases the number and severity of accidents, as the human body is not built to withstand high impact collisions as shown in Table 1.

Table 1: Percentage increase in fatal accidents due to speed

Speed (km/hr)	Number of fatal accidents	% Increase in fatalities per km/h
32	5	2.5
48	45	2.5
64	85	

Source: SWOV website www.swov.nl, 2004

Table 1 indicates that the higher the speed, the greater the percentage of fatal accidents.

The fatality rate is strongly correlated to speed limits, particularly the speed limit in urban areas [5]. Human reflexes are better at lower speeds, so it can be expected that higher speeds increase the number and severity of accidents. Urban as opposed to rural areas have higher traffic volumes and

pedestrian activity. So any accident in an urban area will involve more vehicles or people. In rural areas, vehicles are more likely to collide with animals due to lower traffic volumes. This results in a lower fatality rate as animals are sometimes kept off roads by adequate road furniture.

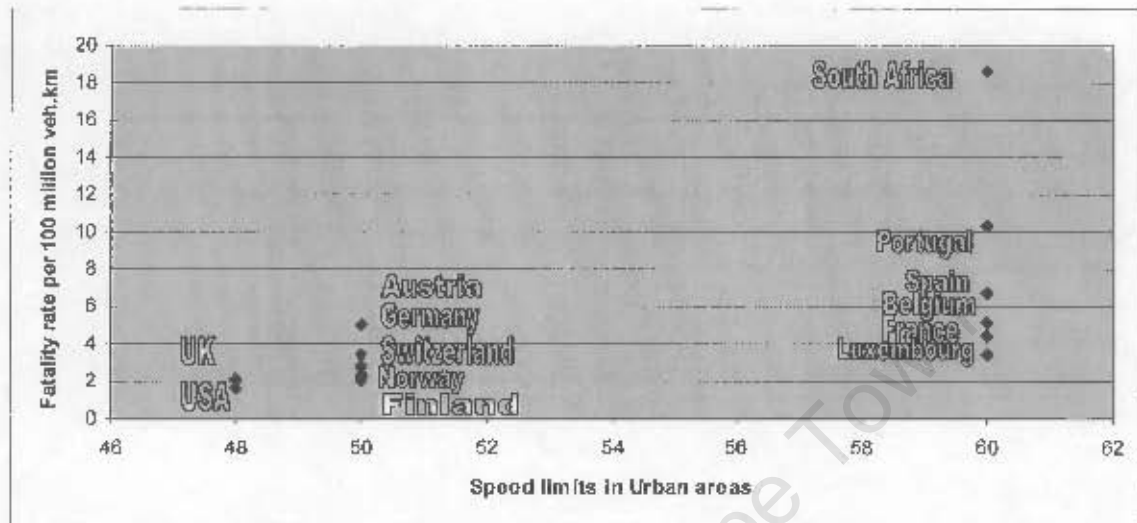


Figure 2: Relationship between fatality rate and speed limits

Source: The rural speed limit and traffic accidents, Fieldwick R, de Beer B, 1987

Figure 2 shows an increase in fatality rates with an increase in urban speed limits. Conversely, reducing urban and rural speed limits should reduce the number of fatalities per vehicle-kilometres travelled. The outliers at the 60 km/h speed limit indicate there is a relationship between speed and fatality rates but also that other factors influence the fatality rate.

Appendix C shows that South Africa (18.6) has the highest fatality rate that is about twice that of other countries. This indicates the need to equate fatality rates to speed limits considering the fact that Germany (3.4) with no speed limits on the Autobahns has a much lower fatality rate. This notion highlights that the fatality rate is influenced by other factors in addition to speed.

The OPEC oil crisis in 1973 caused the South African government to introduce fuel conservation measures. Hence on November 14th, 1973 the speed limit on rural roads was reduced from 120 km/hr to 80 km/hr and the urban limit was reduced from 60 km/hr to 50 km/hr (a year later restored to 60 km/hr) [5]. The impact of lowering speed limits on the number and severity of road accidents in South Africa will be determined for this period. However, it must be remembered that driver behaviour could have changed over the years.

Table 2: Relationship between number of accidents and speed limits in South Africa

Month	Urban			Rural		
	Speed limit	% Change in accidents	% Change in accidents per unit speed limit	Speed limit	% Change in accidents	% Change in accidents per unit speed limit
All accidents						
Nov-73	60			120		
Dec-73	50	-21.0	-2.1	80	-17.1	-0.43
Jan-74	50	-21.8	-2.2	80	-23.9	-0.60
Feb-74	60	14.5	1.5	80	-27.9	-0.70
Mar-74	60	19.4	1.9	80	-8.2	-0.20
Apr-74	60	14.1	1.4	80	-1.5	-0.04
Casualties						
Nov-73	60			120		
Dec-73	50	-25.7	-2.6	80	-14.1	-0.35
Jan-74	50	-34.1	-3.4	80	-22.1	-0.55
Feb-74	60	34.9	3.5	80	-26.4	-0.66
Mar-74	60	11.8	1.2	80	-5.3	-0.13
Apr-74	60	7.5	0.7	80	2.7	0.07
Fatalities						
Nov-73	60			120		
Dec-73	50	-40.1	-4.0	80	-22.7	-0.57
Jan-74	50	-36.8	-3.7	80	-38.5	-0.96
Feb-74	60	19.3	1.9	80	-33.6	-0.84
Mar-74	60	6.1	0.6	80	-12.6	-0.31
Apr-74	60	22.3	2.2	80	-12.2	-0.31

Source: The rural speed limit and traffic accidents, Fieldwick R, de Beer E, 1987

A unit change in urban speed limits resulted in a change in all accidents by a range of 1.4% to 2.1% as seen in table 2. Reducing speed limits by 10km/hr does not ensure all motorists reduce speed by the same amount explaining the range of results; as shown below:

- Unit change in urban speed limits resulted in a change of casualties by 0.7%-3.5%.
- Unit change in urban speed limits resulted in a change of fatalities by 0.6%-4.0%.
- Unit change in rural speed limits resulted in a change of all accidents by 0.04%-0.7%.

- Unit change in rural speed limits resulted in a change of casualties by 0.1%-0.7%.
- Unit change in rural speed limits resulted in a change of fatalities by 0.3%-1.0%.

A unit change in speed limits causes the largest percentage change in fatalities compared to injuries and all accidents. The range of results also shows varying driver behaviour across the provinces in South Africa, given the same nationwide speed regulations and quality of roads.

Table 2 shows that lowering speed limits on rural and urban roads reduces the number and severity of accidents. The number and severity of accidents are directly proportional to speed limits, as a unit change in speed limits alters the actual speed at which motorists drive. This pattern is observed in South Africa but does it hold internationally?

Table 3: Changes in number and severity of accidents per unit change in speed

Country	% Change in all accidents	% Change in fatalities	% Change in injuries	% Change in all accidents	% Change in fatalities	% Change in injuries
	Per unit change in speed limits			Per unit change in mean speed		
Belgium	0.6%	1.5%	1.5%			
Finland	0.1-0.5%	0.9-2.4%	0.2-1.0%	2.3-3%	5-8%	3.3-4%
Denmark						4.3-7%
South Africa	0.1-2.2%	0.3-4.0%	0.1-3.5%			

Source: The rural speed limit and traffic accidents, Fieldwick R, de Beer E, 1987

Table 3 illustrates that fatalities change the most when considering per unit change in speed limits and mean speed. This is followed by injuries and all accidents. Speed is a primary factor in fatalities given its large differential responsiveness.

Injuries, compared to fatalities, are greatly influenced by speed. Injuries occur at lower speeds as higher speeds generate more momentum that is required to increase the severity of accidents. It can be expected that various countries have different numbers of injuries per unit vehicle-kilometres due to varying levels of speed enforcement and driver behaviour, as seen in Table 4.

Table 4 indicates that the number of injuries on freeways is higher than non-freeways in Great Britain, Germany and Sweden. Speed limits and mean speeds travelled are higher on freeways than non-freeways with corresponding higher number of injuries. This denotes that the higher the speed the larger the number of people involved in accidents.

Table 4: Relationship between speed limits and injury rates for various countries

Country	Speed limit change in km/hr		Injury accidents per million veh.km		% change in accident rate	% change in accident rate /speed limit
	From	to	From	to		
Non-Freeways						
South Africa	120	80	0.59	0.44	-25	-0.37
South Africa	70	90	0.37	0.48	30.1	-0.56
Belgium	US (130)	70	0.51	0.47	-8.1	-0.07
Finland	US (130)	90	0.59	0.48	-17.9	-0.26
Finland	US (130)	90	0.51	0.48	-6.1	-0.08
Finland	US (130)	80	0.53	0.47	-11	-0.12
France	US (130)	100	1.03	0.62	-40	-1.37
France	US (130)	110	0.67	0.57	-14.1	-0.47
France	US (130)	90	0.59	0.48	-19.1	-0.28
France	US (130)	110	0.69	0.58	-14.9	-0.51
France	US (130)	90	0.62	0.48	-23	-0.36
Great Britain	US (130)	113	0.52	0.51	-3.4	-0.11
Germany	US (130)	100	0.56	0.50	-11	-0.21
New Zealand	89	80	0.47	0.38	-18.9	-0.99
Sweden	US (130)	90	0.57	0.48	-15.9	-0.23
Sweden	US (130)	110	0.52	0.50	-4	-0.11
Sweden	90	110	0.48	0.62	30	-0.72
Sweden	110	90	0.71	0.48	-32	-1.13
Sweden	90	70	0.48	0.37	-22.1	-0.53
Sweden	90	110	0.48	0.53	11	-0.27
Sweden	90	110	0.48	0.75	56	-1.35

Country	Speed limit change in km/hr		Injury accidents per million veh.km		% change in accident rate	% change in accident rate /speed limit
	From	to	From	to		
Freeways						
Great Britain	US (130)	113	0.39	0.35	-9.9	-0.23
Germany	US (130)	100	0.46	0.34	-25.9	-0.4
Sweden	130	110	0.79	0.55	-30.9	-1.22

US (130km/hr) = unrestricted speed (numerically equivalent to 130 km/hr)

Source: The rural speed limit and traffic accidents, Fieldwick R, de Beer E, 1987

The percentage change in injuries per unit change in speed limits varies across the different countries due to the varying levels of traffic speed enforcement and driver behaviour. Belgium at 0.07%, Finland ranging from 0.08-0.26%, Great Britain at 0.11% and Germany at 0.21%; must all have very stringent traffic speed enforcement which is responsible for the low levels of injuries. France ranges from 0.28-1.37% with Sweden ranging from 0.11-1.35% and the numerous investigations carried out in these two countries, denotes a wide range of driver behaviour. While change in accident rates in New Zealand are at 0.99%, the South African range from 0.37-0.56% is probably due to fewer traffic speed enforcement measures and techniques. South Africa also faces the problem of pedestrians from informal settlements travelling along freeways which is not the case internationally. This introduces another factor in determining the relationship between speed and fatality rates.

3.1.2. Alcohol or drug abuse

Extensive research showed that a blood-alcohol level of 0.08g per 100ml or higher was the point at which most drivers became accident-prone [1]. Every one driving home after a few drinks knows their limits to ensure safety but do some people take more risks than others? And considering the fact that a person accustomed to heavy drinking may have a high alcohol tolerance [1], provinces with numerous incidents of alcohol abuse offences with low fatality rates could have the majority of motorists who are accustomed to heavy drinking.

It is known that alcohol or drug abuse contribute to accidents, but it has not been documented by how much the number and severity of accidents are reduced due to fewer cases of alcohol or drug abuse.

3.1.3. Fatigue

Fatigue can also be caused by alcohol or drug abuse or due to inadequate resting periods in between long distance trips. This stresses the need for highway patrol officers to randomly stop and check the mental state of long distance truck and bus drivers. Studies suggest that bus and/ or truck-driver fatigue may be a contributing factor in at least 30 to 40 percent of all heavy truck and/ or bus accidents [1]. If traffic law enforcers stop three out of ten long distance trucks and buses on national routes, accidents due to bus/ truck-driver fatigue can be eliminated or minimised.

3.1.4. Age

The earliest age at which motorists are permitted to obtain drivers' licences varies across different countries and is mainly related to levels of economic development. The author feels young drivers are more prone to drunk driving and speeding, but this problem can be controlled by traffic law enforcement or raising the age limit at which motorists can obtain driver's licences. Alternatively, a graduated licensing system would issue a temporary licence for 5 years after which a permanent driver's licence could be considered if the driver had a low risk profile.

Certain age groups are more prone to accidents than others and therefore reducing age limits at which people can obtain licences may affect the accident rate. Exactly by how much, has not been researched and determined. Alternatively, a point demerit system could be implemented to identify high risk age groups.

3.1.5. Violation of traffic rules & regulations

While adhering to traffic rules and regulations can reduce damage to fixed objects (e.g. traffic lights, sign posts), no overtaking on barrier lines can minimise head-on collisions and sideswipes in the same or opposite direction. Stringent traffic law enforcement can make motorists adhere to traffic signals, rules and regulations eliminating these accident types and educating the public about

the dangers involved due to not adhering to traffic regulations is valuable. But to combine this education with stringent traffic law enforcement is a more effective solution.

3.1.6. Use of seatbelts

Not wearing a seatbelt is a traffic violation that could save lives when a vehicle collides with another vehicle, a pedestrian or an animal. Inertia ensures that the driver and passengers remain travelling at the speed of the vehicle prior to impact. Yet at the moment of collision, the vehicle comes to a standstill, resulting in people being thrown out (e.g. via the windscreen).

Table 5: Reduction in severity of accidents by wearing seat belts

Severity of Accidents	Front seat (%)	Back seat (%)
Injured	25	20
Killed	40	30

Source: SWOV website www.swov.nl, 2004

Table 5 shows that accident statistics for the back seat are lower than the front seat mainly due to inertia. Inertia throws vehicle occupants in front through the windscreen, while the front seats physically restrain passengers in the back seat.

Traffic law enforcers should educate the public about the percentage reduction in the number and severity of accidents due to wearing seat belts. Fines issued to motorists for not wearing seat belts creates incentive but is not a long-term solution as many people do not pay these fines. Like HIV/Aids awareness campaigns, the public should be made aware of the importance of seat belts to guarantee long-term change in driver and passenger behaviour.

Minibus taxis and buses used in public transport do not have seat belts for all passengers except front-seated passengers. This stipulates the need for long-distance vehicles to be fitted with seat belts for all passengers.

3.2. Vehicle Factors

Motorists are responsible the safe driving condition of vehicles. Public education and stringent traffic law enforcement ensure that only roadworthy vehicles are driven on South African roads.

How effective are these techniques in reducing vehicle factors?

3.2.1. Roadworthy vehicles

Smooth or damaged tyres increase the risk of having an accident due to inadequate braking capabilities. Educating the public coupled with stringent traffic law enforcement can eliminate vehicles with smooth or damaged tyres and this prevents these accident types.

It is hard for traffic law enforcers to apprehend motorists with dysfunctional headlights, indicators and brakes. Public education can be a self-enforcing technique. Nevertheless, the shortage of disposal income limits roadworthiness of vehicles on South African roads. Dysfunctional headlights can be noted at night but the limited amount of traffic law enforcers assigned to night shift makes it hard to identify these vehicles. At the time of renewal of annual road licences, all vehicles should be tested for roadworthiness and corruption in testing stations should be rooted out in the interests of traffic safety. South African National Standards (SANS 10399:2003) Quality management systems-Requirements for bus operators is currently in place to govern bus operations. A similar standard can be set up and enforced for mini-bus taxis.

Apart from vehicles being roadworthy, the range of cars fitted with air bags should increase in order to reduce the severity of accidents. Inertia propels front seat passengers forward into the steering wheel, dashboard or through the windscreen if not wearing a seat belt. Air bags soften the blow or act as cushions reducing the impact of momentum and in turn prevent or minimise bodily damage or severity of accidents.

Table 6: Reduction in serious injuries due to presence of air bags and wearing seat belts

	% Reduction in serious injuries
From not wearing to wearing a seat belt	41
Not a wearing seat belt with only an air bag	17
Wearing a seat belt with an air bag	8

Source: SWOV website www.swov.nl, 2004

The restraining action of seat belts and the cushioning of air bags during collision absorb momentum. However, seat belts are also essential in preventing injuries as seen by 41% as opposed to 17% in Table 6.

Air bags are not available in minibus taxis and buses. This means that all public transport drivers must wear seatbelts at all times in order to reduce the severity of accidents.

3.3. Road Factors

Roads are sometimes built with safety hazards. Traffic engineers can be alerted of known hazardous road sections. The South African road safety manual Volume 1-7 by C.O.L.T.O. May 1999 prescribes ways of rectifying these black spots e.g. Road safety audits. How effective are these techniques in reducing road factors?

3.3.1. Slippery roads

Black spots with drainage problems should have their skid resistance tested to determine if this is a main contributory factor. A layer of chip and seal surfacing can be added to the existing asphalt layer to increase the skid resistance.

Increasing skid resistance for identified slippery black spots will reduce the number of accidents, as braking distances are reduced.

3.3.2. Poor visibility or inadequate street lighting

If the level of light is raised from 1 to 2cd/m², the incidence of nighttime accidents can be reduced by up to 65% [4]. In order to reduce accidents at night, especially on urban roads, the light intensity can be increased by 1 cd/m². This is also cost effective in terms of lives saved.

3.3.3. Poor road network design: Access points

Access control involves connecting parallel or adjacent streams of traffic flow; marking points of likely accidents. The reason why access control improves safety is because there are fewer unexpected events caused by vehicles entering and leaving the traffic stream at slower speeds, resulting in less interference with through traffic [7]. The time of day should be noted when most accidents occur at intersections considered black spots. Traffic signals are generally not adhered to at night, but if most accidents occur during the day at intersections, then road safety audits are essential.

Table 7 shows that full access control has lower accident rates in both rural and urban areas. Pedestrian fatality rates can also be reduced on freeways with full access control.

Table 7: Effect of access control on accident rates

	Accident rates per million vehicle-miles			
	Urban		Rural	
Access Control	Total	Fatal	Total	Fatal
Full	1.86	0.02	1.51	0.03
Partial	4.96	0.05	2.11	0.06
None	5.26	0.04	3.32	0.09

Source: Traffic and Highway Engineering, Garber N.J, Hoel L.A, 1997

The increase in roadside development, which creates an increased number of at-grade intersections and businesses with direct access to the highway, will also increase accidents significantly [7]. Freeways should have restricted access to reduce unexpected crossing by pedestrians, animals and vehicles. Ample grade-separated pedestrian crossings should provide for development with high pedestrian activity adjacent to high mobility routes.

Table 8: Effect of access points on accident rates on two-lane rural highway

Intersection per mile	Businesses per mile	Accident rate
0.2	1.0	126
2.0	10.0	270
20.0	100.0	1 718

Source: Traffic and Highway Engineering, Garber N.J, Hoel L.A, 1997

Table 8 shows that increasing the number of businesses and intersections per mile increase the accident rate. Businesses increase pedestrian activity and intersections improve access to high mobility routes, thus increasing the likelihood of accidents. Highways are built to carry large traffic volumes at high speeds so by reducing businesses that have access will reduce the number of accidents. Intersections and businesses must have access to highways that is grade separated to limit the number of conflict points.

Mechanisms of reducing accidents require the elimination of access points from through traffic by [7]:

- The removal of the access point by closing median openings and frontage road accesses for business driveways.

- Special turning lanes to separate through vehicles from those vehicles using the access point.
- Proper signage and pavement markings to warn motorists of changing conditions along the roadway.

Road design can incorporate land-use planning to cater for new businesses by creating frontage roads, slip lanes and improved road furniture that gives drivers ample time to react to changing road dimensions. Intersections with high accident rates can also be improved, as stated above, in order to minimise accident rates.

3.3.4. Poor road design: Cross-sections

In general, wider lanes and/or shoulders will result in fewer accidents [7]. Wider lanes and shoulders give drivers more room to manoeuvre when avoiding collisions with adjacent vehicles (i.e. side swipes).

Table 9: Effect of lane widening for related accident types on two-lane rural road

Amount of lane widening (ft)	Reduction in accident types (%)
1	12
2	23
3	32
4	40

Source: Traffic and Highway Engineering, Garber N.J., Hoel L.A., 1997

Table 9 shows that there is an average reduction of accidents by 9.33% per ft of lane widened. Widening of lanes has an effect of increasing travel speed as motorists feel safer but this also increases the risk of more severe accidents. Sideswipes will reduce with wider lanes but could increase the possibility of head-to-rear accidents with increased travel speeds.

Table 10: Effect of shoulder widening for related accident types on two-lane rural road

Shoulder widening per side (ft)	Reduction in related accident types (%)	
	Paved	Unpaved
2	16	13
4	29	25
6	40	35
8	49	43

Source: Traffic and Highway Engineering, Garber N.J, Hoel L.A. 1997

Table 10 shows that widening paved shoulders reduces accidents on average by 5.5% and unpaved shoulders on average by 5% per ft, which can be applied to black spots involving head on collisions and off-road accidents. Paved shoulders have higher reductions in accident rates than unpaved shoulders due to reduced braking distances. If both pavement and shoulder width improvements are made simultaneously, the percentage reductions are not additive [7]. Black spots with high occurrence of head-on collisions, sideswipes and off-road accidents should have pavement and shoulder width improvements.

Roads are perceived to serve vehicular travel only, which creates conflicts if pedestrians and/ or cyclists are part of the traffic stream. Road design should incorporate appropriately designed pedestrian and bicycle facilities where the traffic stream includes substantial volumes of pedestrians and cyclists.

4. STATISTICAL MODEL TO ESTIMATE ACCIDENT REDUCTION

It was observed that using accident data at a local level, more detail would be required to achieve better estimates. Thus two provinces with the most detailed information were selected (Western Cape and KwaZulu-Natal) to develop a statistical model. These provinces are compared statistically to the national average, to establish if the developed model can be used at a national level.

Data for the Western Cape falls within the standard deviation margin from 1998 to 2002 as shown in Table 11. KwaZulu-Natal's statistics for 1998 and 1999 are within the national standard deviation but 2000 to 2002 are not. Table 11, therefore, indicates that KwaZulu-Natal's data cannot be used to develop a national model. KwaZulu-Natal's statistics have been documented in Appendix C but are not used anymore in this thesis. Analysis of fatal accidents per 10 000 registered vehicles and 100 000 human inhabitants showed similar trends (See Appendix D).

Table 11: Annual number of fatal accidents per million vehicle-km travelled

Province	1998	1999	2000	2001	2002
Gauteng	4.5	5.4	3.8	5.7	6.0
KwaZulu-Natal	6.2	6.2	7.3	10.7	11.7
Western Cape	5.8	6.1	3.9	6.7	6.9
Eastern Cape	8.2	6.5	6.1	7.4	9.0
Free State	8.2	8.2	6.8	11.6	11.5
Mpumalanga	8.9	7.1	5.5	10.1	11.2
North West	7.9	8.1	6.7	8.2	11.9
Limpopo	6.5	6.0	5.4	7.0	11.0
Northern Cape	8.6	9.2	7.8	7.9	10.6
Standard deviation	1.5	1.2	1.4	2.0	2.2
Provincial average	7.2	7.0	5.9	8.4	10.0
KwaZulu-Natal deviation	0.0	0.1	2.1	3.0	3.0
Western Cape deviation	0.4	0.2	1.3	1.0	1.8
RSA	6.2	6.3	5.2	7.7	8.7

Source: Arrive Alive website www.arrivealive.co.za, 2004

4.1. Severity of Road Accidents Analysed

Fatal accidents result in deaths while serious accidents involve fractures, crushing, concussions, internal injuries and severe cuts. While slight accidents involve cuts, bruises, sprains and light shock not requiring hospitalisation, damage-only accidents involve vehicle or property damage but no injury of any kind to persons [2]. This thesis will only analyse ways to reduce fatal and serious accidents because slight and damage-only accidents do not involve long-term bodily harm, health implications or loss of walking capabilities. This denotes minimal or no cost implications in terms of loss of human life. Equivalent Accident Number (E.A.N.) is used to compare or rate locations by applying factors to different accident types based on accident costs for all accidents i.e. for fatal accidents multiply by 25.2, serious injury accidents by 5.8, slight injury accidents by 1.5 and damage-only accidents by 1 [2]. Slight accidents have a 50% additional cost rating, while damage-only accidents have a 0% additional cost rating, validating their omission from this thesis.

4.2. Statistical Analysis of National Road Accident Data

National road accident statistics highlight dominant trends, giving an indication of driver behaviour, which can be used to reduce the number and severity of accidents.

Table 12 shows that December 2001 and 2003 and July 2002 had the highest number of vehicle kilometres travelled. The question is: Does this influence the number and severity of accidents?

The absolute number of fatal accidents is highest in December for all three years (see Table 12). The risk was calculated as fatal accidents per 10 000 vehicle-km travelled. The risk indicates that there is a relationship between fatal accidents and vehicle-kilometres travelled in 2001 but not in 2002 or 2003. This notion indicates that other factors (e.g. jaywalking, speeding, alcohol abuse, etc) are contributory causes to fatal accidents.

From 2001 to 2003, December was the month with the highest number of fatal accidents. Identifying the causes of fatalities in December will determine ways of substantially reducing accidents.

Table 13 indicates that unknown and other factors under human factors comprise 25%, vehicle factors 90% and road factors 85%. This is extremely high, reflecting bad data collection.

Moreover, the fact that the number of causes reported is much higher (almost three times) than the number of accidents, indicates that every accident has several factors contributing to it.

Table 12: Risk in terms of fatal accidents per 100 million vehicle.kilometre travelled

Year	2001			2002			2003		
Month	No. of fatal accidents	Est. 10 ⁶ veh. km	Risk	No. of fatal accidents	Est. 10 ⁶ veh. km	Risk	No. of fatal accidents	Est. 10 ⁶ veh. km	Risk
January	627	9 186	6.8	613	9 132	6.7	655	9 756	6.7
February	677	8 822	7.7	620	8 667	7.2	675	9 078	7.4
March	630	9 661	6.5	831	9 946	8.4	949	9 859	9.6
April	750	9 293	8.1	769	9 906	7.8	839	9 020	9.3
May	756	9 371	8.1	839	8 802	9.5	843	9 714	8.7
June	785	8 927	8.8	951	8 756	10.9	864	9 942	8.7
July	613	9 131	6.7	837	9 982	8.4	921	10 063	9.2
August	693	9 824	7.1	963	9 929	9.7	936	9 917	9.4
September	744	9 170	8.1	899	9 626	9.3	822	9 401	8.7
October	737	9 874	7.5	830	9 844	8.4	845	10 676	7.9
November	855	9 610	8.9	845	9 522	8.9	891	9 977	8.9
December	935	10 199	9.2	976	9 872	9.9	968	10 924	8.9

Source: Arrive Alive website www.arrivealive.co.za, 2004

As mentioned, total number of contributory factors for fatalities in Table 13 (2736) and Table 12 (976) are not equal. The high number of unknown and other factors in Table 13 is most probably due to there being more than one factor per accident. To identify the most important factor per accident, it was decided to omit unknown and other factors from Table 13. This adjustment to Table 13 is shown in Table 14.

Table 13: Recorded contributory factors of fatal accidents for December 2002

Human Factors	Urban	Rural	Total	Group %	Group %
Unknown	26	153	179	18.3	
Pedestrian: Jaywalking	76	272	348	35.5	
Speed	30	191	221	22.6	
Overtaking	1	34	35	3.6	
Turn in front	9	25	34	3.5	
Disregard robot/ stop sign	7	10	17	1.7	
Following too close	2	6	8	0.8	
Driver-alcohol suspected	3	24	27	2.8	
Pedestrian: alcohol suspected	4	16	20	2.0	
Fatigue	1	27	28	2.9	
Other	11	52	63	6.4	
Subtotal	170	810	980	100	35.8
Vehicle Factors	Urban	Rural	Total	Group %	Group %
Unknown	126	607	733	75.4	
Overload	0	9	9	0.9	
Brakes	1	17	18	1.9	
Tyre burst	1	51	52	5.4	
Tyres smooth	1	2	3	0.3	
Lights	0	11	11	1.1	
Other	41	105	146	15.0	
Subtotal	170	802	972	100	35.5
Road Factors	Urban	Rural	Total	Group %	Group %
Unknown	561	105	666	84.9	
Poor visibility	34	6	40	5.1	
Poor street lighting	9	1	10	1.3	
Sharp bend	18	2	20	2.6	
Blind rise/corner	6	0	6	0.8	
Poor road surface	12	3	15	1.9	
Road wet/slippery	18	2	20	2.6	
Poor/defective road signs	1	0	1	0.1	
Narrow road	2	0	2	0.3	
Road works	3	1	4	0.5	
Subtotal	664	120	784	100	28.7
Total	1 004	1 732	2 736		100
Percentage of total	37%	63%	100%		100%

Source: Festive-season report on road accidents, NDOT, 2003

Table 14: Adjusted contributory factors to fatal accidents for December 2002

Human Factors	Urban	Rural	Total	Group %	Group %
Unknown			0	0	
Pedestrian: Jaywalking	76	272	348	47	
Speed	30	191	221	30	
Overtaking	1	34	35	5	
Turn in front	9	25	34	5	
Disregard robot/ stop sign	7	10	17	2	
Following too close	2	6	8	1	
Driver-alcohol suspected	3	24	27	4	
Pedestrian: alcohol suspected	4	16	20	3	
Fatigue	1	27	28	4	
Subtotal	133	605	738	100	78
Vehicle Factors	Urban	Rural	Total	Group %	Group %
Unknown			0	0	
Overload	0	9	9	10	
Brakes	1	17	18	19	
Tyre burst	1	51	52	56	
Tyres smooth	1	2	3	3	
Lights	0	11	11	12	
Subtotal	3	90	93	100	10
Road Factors	Urban	Rural	Total	Group %	Group %
Unknown			0	0	
Poor visibility	34	6	40	34	
Poor street lighting	9	1	10	8	
Sharp bend	18	2	20	17	
Blind rise/corner	6	0	6	5	
Poor road surface	12	3	15	13	
Road wet/slippery	18	2	20	17	
Poor/defective road signs	1	0	1	1	
Narrow road	2	0	2	2	
Road works	3	1	4	3	
Subtotal	103	15	118	100	12
Total	239	710	949		100

Source: Festive season report on road accidents, NDOT, 2003

The main contributory factors to fatal accidents in December 2002 were grouped as follows: human factors 77%, road factors 13% and vehicle factors 10% [11]. Table 14 shows that human factors comprise 78% of fatal accidents, vehicle factors 10% and road factors 12%. As the difference between Tables 13 and 14 is minimal, Table 14 will be used to determine the main contributory factors of fatal accidents in December 2002.

4.2.1. National human factors

Under human factors, jaywalking (47%) and speed (30%) were the main contributory factors.

Jaywalking in South African cities is associated with informal settlements closest to high mobility routes. Informal settlements very often settle next to high mobility roads because of the accessibility to transport. Taxis and employers stop on the freeway at interchanges, resulting in people having to cross one or both sides of the freeway. Barrier walls will not prevent people from crossing freeways; instead provide footbridges at strategic places. In addition, public transport should be made available at the entrances to informal settlements. The author assumes that this approach would reduce pedestrian fatalities by 95%. This assumption is made to allow for the odd jaywalker crossing high mobility routes at undesignated points or walking alongside i.e. one out of twenty pedestrians. This translates to pedestrian fatalities reducing from 348 to 17.

Informal settlements are also characterised by low-income residents and high pedestrian travel. These settlements should not allow residents to have direct access to adjacent freeways, as pedestrians are exposed to large traffic volumes at high speeds. This increases the likelihood of pedestrian fatalities. The first option would be to erect a high impassable concrete wall to prevent pedestrians from having direct access to these high mobility routes. Residents of these informal settlements would then merely circumvent the barrier in order meet their daily needs across the roads. Government should, therefore, not permit informal settlements next to these routes. The initial informal dwellings should prompt government to quickly identify resettlement zones away from high mobility routes. On an annual basis, government should designate areas for settlement of rural-urban migrates. Globally, cities are perceived as big employment centres and the attraction to cities is inevitable. The author assumes that if government adopts this mindset and implements re-settlement measures, pedestrian fatalities would reduce by 95%. This assumption is made to allow for the odd jaywalker crossing high mobility routes at undesignated points or

walking alongside i.e. one out of twenty pedestrians. This translates to pedestrian fatalities reducing from 348 to 17.

However, government may be considered to have other key priorities (e.g. AIDS) and this measure not foreseen as applicable immediately. Given the fact that pedestrian fatalities on high mobility routes in South Africa are the main contributory factors, more research is required to:

- Determine how and where pedestrians are getting killed (e.g. crossing the road or walking along side it, etc.)
- Determine why pedestrians are crossing the road or what trips attractions are on the other side of the road (e.g. shops or mini-bus taxi pick up spots)
- Determine what measures can be used to eliminate the need to cross the road

A report BL01/04 entitled, "Diepsloot land use and transportation assessment" by Gautrans (2001) used the approach mentioned above to determine ways of reducing pedestrian fatalities in Diepsloot, Gauteng. Finding of this report are documented in Appendix E. Cities with high pedestrian fatalities need to adopt this approach to tackle the root cause of the problem, as a second option. The author assumes that this technique would reduce pedestrian fatality rates by 90%. This assumption is made as the average pedestrian, sober or not, would have no reason to cross the road or walk alongside it and allows for a one in ten chance for the odd jaywalker. The number of pedestrian fatalities would reduce from 348 to 35. Provincial authorities need to either adopt the approach to provide special facilities in order to lower the national pedestrian fatality rate substantially, or relocate settlements along high mobility routes.

Jaywalking is a large portion of fatalities, caused by alcohol abuse and lack of pedestrian infrastructure. Educating the public together with stringent traffic-law enforcement can reduce the number of jaywalkers, as a third option or secondary remedial measure.

Educating the public should include signs or campaigns indicating the risk of alcohol abuse among pedestrians. Unfortunately, no national or international data was found with regards to the effect of campaigns, therefore the author assumed that these signs will deter one out of five jaywalkers i.e. a 20% reduction in fatal accidents.

K FM radio indicated in December 2004 that 50% of jaywalkers are under the influence of alcohol or drugs. The 20% reduction rate in fatalities is quite low because most jaywalkers are under the influence of alcohol or drugs and only one out of five would notice these signs and use designated road crossings.

Traffic police should position themselves in places where pedestrians do not use pedestrian infrastructure or road sections with high pedestrian fatalities such as informal settlements adjacent to high mobility routes. The traffic police cannot be placed at these spots all the time, creating situations where jaywalkers transgress in their absence. Sadly no national or international data was found, but the author assumed that stringent traffic law enforcement will prevent three out of ten pedestrian fatalities i.e. a 30% reduction in fatal accidents. This reduction rate in fatalities is assumed because the presence of traffic police along pedestrian black spots would occur during pedestrian peak travel times i.e. 6h00-8h00, 12h00-14h00 and 16h00-18h00 on weekdays and weekends. This constitutes six out of 24 hours but pedestrian travel during peak periods is greater than 25%.

Educating the public and stringent traffic-law enforcement can reduce pedestrian fatalities by 50%. Table 14 shows that there were 348 pedestrian fatalities. Stringent traffic-law enforcement and educating the public could reduce these fatalities by 174 i.e. from 348 to 174. The report entitled, "Pedestrian and Bicycle Facility Manual" August 2003 indicates pedestrian volumes required to warrant the use of grade-separated pedestrian infrastructure. If pedestrian volumes at black spots do not meet the warrants, the DOT report allows for costs in terms of pedestrian fatalities to warrant the use of grade-separated pedestrian infrastructure.

Stringent traffic-law enforcement and traffic engineers implementing speed reduction techniques at these road sections can lower actual travel speeds that are above the speed limit. Severe penalties and a demerit system should form the core of speed enforcement.

As mentioned before, a unit rise in vehicle speed increases the number of fatal accidents in multiples of 2.5% [10] (see Table 1). Conversely, the fatality rate decreases by 2.5% per unit change in vehicle speed. This value was taken in the Netherlands. It can be assumed that fatality rates in the developing world would be slightly higher. Unit change in urban speed limits resulted in a change in fatalities by 0.6% - 4.0% in 1981 [6] (see Table 3). These South African fatality

rates reflect a varying range. It was decided to use a slightly higher percentage than the current Dutch 2.5%, i.e. 3.5%.

By law, the speed limit is exceeded by travelling 10% over the stipulated limit i.e. 66km/h in urban areas and 132km/h on roads in rural areas. Speed enforcement by traffic police is assumed to keep motorists within the speed limit i.e. 6km/h speed reduction in urban areas and 12km/h in rural areas.

Table 15: Estimated reduction in fatalities due to speed enforcement

	Urban roads	Rural roads
Reduction in average travel speeds	6 km/h	12 km/h
% Change in fatality per unit change in speed	3.5%	3.5%
Percentage decrease in fatal accidents	21%	42%
Number of fatal accidents reduced	6	80

Currently 40% of South African drivers exceed the 120km/h speed limit, 80% the 100km/h limit and 90% the 60km/h limit [1]. It can be stated that 40% of motorists on rural roads exceed the speed limit and 80-90% of motorists on urban roads. Table 14 shows that 30 speed-related fatalities occurred on urban roads and 191 on rural roads. Speed is a contributory factor in 75% of accidents on South African roads and the higher the speed, the greater the impact [1]. Higher travel speeds increase the number and severity of accidents. This explains why although fewer drivers exceed the speed limit on rural roads, there are more fatal accidents on rural roads. This highlights the need for more traffic police to be assigned to urban roads and for very high fines to be given to speed-limit violators on rural roads. Since speed is a contributory factor in 75% of all accidents, speed violators should pay spot fines or have their vehicles impounded until the fine is settled. This approach should be adopted throughout the year, and not merely over the festive season. The shortage of traffic police warrants the use of speed cameras.

4.2.2. National vehicle factors

Under the vehicle category, tyre bursts (56%) and faulty brakes (19%) were the main contributory factors (Table 14).

Tyre bursts result in vehicles overturning, head-on collisions, sideswipes and head-rear accidents. The public should be educated about how load rating of tyres causes tyre bursts. Motorists should also be educated about the importance of regular stops on long-distance trips. Drivers should be aware that regular stops prevent overheating of tyres, thus minimising the chance of tyre bursts. The author assumes that public education reduces one out of five possible tyre bursts i.e. a 20% reduction of fatal accidents. This reduction rate in fatalities is assumed because four out of every five drivers simply want to get to their destination as soon as possible. A study by CSIR in the 1990s on the route between Pretoria and Polokwane (Pietersburg) showed that 19% of all minibus accidents could be related to tyre bursts. During festive seasons (e.g. Easter and the December holidays), the relevant transport authorities could measure the tyre heat of public transport vehicles at toll gates in order to minimise the likelihood of tyre bursts.

Traffic police should also ensure that overloaded vehicles are not permitted to undertake long-distance trips. The author assumes that stringent traffic-law enforcement reduces one out of every four possible tyre bursts i.e. a 25% reduction of fatal accidents. This reduction rate in fatalities is assumed because the shortage of traffic police only stops one out of four overloaded vehicles along high mobility routes during the peak hours only.

Collectively, a 45% reduction of fatal accidents translates into 23 tyre bursts out of 52 being prevented due to public education and stringent traffic-law enforcement.

Every driver is aware of the importance of vehicle brakes but not all vehicles have brakes in proper working condition. It is hard for traffic police to check whether brakes are in proper working condition because it requires heavy, specialised equipment that is fixed into roadworthy testing stations. Corruption in roadworthy testing stations put vehicles with faulty brakes on South African roads. Given the various problems associated with trying to curb faulty brakes, the author assumes that public education, traffic-law enforcement and testing of vehicle roadworthiness will reduce one out of 10 accidents due to faulty brakes i.e. a 10% reduction of fatal accidents. This translates into two accidents being avoided due to faulty brakes. This reduction rate in fatalities is assumed because traffic police never check for faulty brakes and probably one out of ten motorists would immediately fix their faulty brakes once detected.

4.2.3. National road factors

Under road factors category, poor visibility (34%), sharp bends (17%) and slippery roads (17%) were the main contributory factors nationally in December 2002.

Visibility enables motorists to make the necessary manoeuvres preventing road accidents. Accidents due to misty weather or inadequate street lighting can be avoided by improving visibility i.e. increasing light intensity. If the level of light is raised from 1 to 2cd/m^2 , the incidence of night-time accidents can be reduced by up to 65% [4]. This assumes that all fatal accidents after dark are due to motorists not having adequate lighting. It does not take into account other factors that cause accidents at night (e.g. driver fatigue, alcohol or drug abuse, speed, etc). The author believes that fatal accidents that occur after dark purely because of inadequate lighting are due to objects suddenly appearing in front of a moving vehicle. This usually occurs where roads with wild animals in the vicinity are not fenced off or when pedestrians jaywalk at night. Fencing off the roads will eliminate wild animals being hit by vehicles. The author assumes that one out of 20 fatal accidents after dark are due to wild animals suddenly appearing in front of vehicles and jaywalking. In December 2002, 40 accidents were caused by poor visibility. Increasing light intensity from 1 to 2cd/m^2 would thus prevent two fatal accidents due to poor visibility.

Traffic engineers can identify sharp bends but these road sections cannot be re-aligned as it is not cost effective. Travel speeds on sharp bends should be reduced to safe speeds in relation to available stopping sight distance. Traffic engineers can apply various speed reduction measures to ensure motorists reduce their travel speeds. The author assumed that the right speed reduction measures can lead to three out of five motorists lowering their speeds. This would ensure a 60% reduction of fatal accidents i.e. 12 fatal accidents would be avoided. This reduction rate in fatalities is assumed because two out of every five drivers could be under the influence of alcohol or drugs, extremely tired or simply risk takers.

Traffic engineers can also identify slippery road sections. These road sections can have a layer of single or double seal applied to increase skid resistance. The author assumes that increased skid resistance would reduce fatal accidents due to slippery roads by 80% i.e. 16 fatal accidents would be avoided. This reduction rate in fatalities is assumed as there is a one out of five chance that accidents at these road sections are due other human or vehicle factor.

4.3. Statistical Analysis of Western Cape Road Accident Data

Statistical analysis of Western Cape data will be used to develop a national model. A hierarchy of human, vehicle and road factors will be created. The top tier of these factors will be used to develop a national model.

Road safety audits should be carried out at the worst-known road sections and intersections in the Western Cape in accordance with the South African Road Safety Manual Volume 1-7 by C.O.L.T.O. May 1999.

4.3.1. Human factors in the Western Cape

Western Cape statistics (derived from www.capetown.gov.za) do not indicate which human factors cause accidents. Table 14 (national accident causes) were used in conjunction with chapter 3 to estimate accident reductions.

In 2001, 569 pedestrian fatalities and 774 serious pedestrian accidents occurred (Table 16). This constitutes 64% of fatal accidents and 48% of serious accidents in the Western Cape. Pedestrian accidents constitute the bulk of Western Cape accidents. Reducing the number of fatal and serious pedestrian accidents will substantially reduce the accident rate in the Western Cape.

Jaywalking occurs mostly along highways and is often associated with alcohol or drug abuse. The severity of accidents depends on the vehicle's speed. If a vehicle travelling at 80 km/h hits a pedestrian, there is almost a 100% probability that the pedestrian will die [2]. The minimum highway speed is 80km/h denoting that all highway jaywalkers will be killed instantly if hit. This means that highways should be completely inaccessible to pedestrians.

The report entitled, "The development of a road traffic safety strategy for the Western Cape Province" by Mr. Patrick Oliver, Road safety in Goodwood, March 2005 recommends using education, enforcement and engineering to lower the pedestrian fatality rate as follows:

- The Department of Community Safety should continue to develop customised educational material and communication messages aimed at improving pedestrian safety.
- The Department of Education should become more involved in the implementation of pedestrian safety projects in schools.

- The Department of Transport and Public Works, the City of Cape Town and local municipalities should identify and improve pedestrian hazardous locations on a continuous basis.
- The Department of Transport and Public Works, the City of Cape Town and local municipalities should implement the guidelines for the provision of safe pedestrian and bicycle facilities developed by DOT.
- Law enforcement to improve pedestrian safety should be done in conjunction with engineering and education measures. Offences that should be targeted include speeding, alcohol use, failure to stop at pedestrian crossings, failure to observe traffic signals and stop signs, jaywalking, etc.
- Street lighting should be provided in pedestrian-sensitive areas.
- Programmes should be implemented to encourage pedestrians to wear reflective clothing.
- Traffic calming and other speed-management programmes should be implemented in pedestrian-sensitive areas.

The author believes that these measures would reduce pedestrian fatalities by 80%. This would translate to 455 pedestrian fatalities being avoided. This assumption is made as pedestrians would realise the need for the use of designated crossings, enforcement and engineering would minimise jaywalking but there is a one in five chance of the odd jaywalker ignoring all measures in place.

The initial response to pedestrian fatalities in the Western Cape is for the provincial government to re-prioritise its annual budget to allow for settlement zones for rural-urban migrants away from high mobility routes. As mentioned earlier, the author strongly believes that this approach would reduce 95% of the pedestrian fatalities. In the Western Cape, the number of pedestrian fatalities would decrease as shown in Table 16 under rural-urban settlements.

If the provincial government cannot implement this approach in the immediate future, studies should be conducted at pedestrian black spots in the Western Cape, in a similar manner as the report entitled, "Diepsloot land use and transportation assessment" by Gautrans in December 2001, as shown in Appendix E. As stated previously, the author stoutly feels that this approach would reduce the pedestrian fatality rate by 90%. The number of pedestrian fatalities avoided is shown in Table 16 under Appendix E.

Pedestrian accidents are very high in South Africa because of inappropriate land use closest to high mobility routes (e.g. informal settlements near highways) and/or high levels of alcohol or drug abuse among pedestrians. Separating pedestrian and vehicular travel ensures that jaywalking will not occur, thus reducing the accident rate. As mentioned earlier improved pedestrian crossing facilities, traffic calming at black spots and public education as to the dangers of jaywalking under the influence of alcohol or drugs, reduces pedestrian fatalities by 20%. As stated previously, positioning traffic police along freeways where there is a high occurrence of jaywalking will kerb pedestrian fatalities by 30%. Both measures could reduce pedestrian fatalities by 50%. This approach is shown in Table 16 as secondary measure.

Table 16: Estimated pedestrian accident reduction in Cape Town in 2001

	Fatal pedestrian accidents					Serious pedestrian accidents				
	1997	1998	1999	2000	2001	1997	1998	1999	2000	2001
Pedestrian accidents	404	379	420	321	569	625	549	653	896	774
Rural-urban settlements	384	360	399	305	541	594	522	620	851	735
Appendix E	364	341	378	289	512	563	494	588	806	697
Secondary measure	202	190	210	161	285	313	275	327	448	387

Source: Cape Town metropolitan council website: www.capetown.gov.za 2003

The measure shown in Appendix E involves identifying why pedestrians cross high mobility routes at undesignated crossing and determines ways of preventing jaywalking.

Table 16 is shaded to highlight the fact that these figures are derived from an assumption which requires more research to determine the precise reduction in pedestrian fatality rates.

Table 17 shows that in 2002, 168 fatal accidents and 707 serious accidents related to age occurred. These constitute 19% of fatal accidents and 44% of serious accidents. The 36-45 age group has the highest number of fatal accidents, while the 26-35 age group has the highest number of serious accidents [2] (see Table 17). Generally, fatal accidents occur at higher speeds implying that the 36-45 age group constitutes more aggressive drivers prone to speeding or jaywalkers hit along freeways. There are also probably higher levels of alcohol abuse among the 26-35 age group. Changing driver behaviour and jaywalking tendencies among certain age groups requires stringent

traffic law enforcement. Traffic police need to determine risky driver and pedestrian behaviour (e.g. drunken driving from certain night clubs over the weekends or drunken jaywalkers) and imprison offenders for at least one night. The author assumes that the locking up of drunken drivers and jaywalkers serves as a deterrent, preventing two out of five accidents i.e. 40%. This translates into 67 fatal accidents and 283 serious accidents being avoided. This reduction rate in fatalities is assumed because three out of every five drunken drivers and jaywalkers will not get apprehended due to the varying travel times and routes used at night.

Table 17: Accidents categorised according to age in Cape Town in 2001

Age group	Fatal accidents		Serious accidents	
	No.	% of total	No.	% of total
0-15	0	0	18	2.6
16-17	2	1.2	9	1.3
18-21	4	2.4	42	5.9
22-25	14	8.3	52	7.4
26-35	29	17.3	148	20.9
36-45	30	17.9	97	13.7
46-55	19	11.3	46	6.5
56-65	9	5.4	22	3.1
66-75	3	1.8	11	1.6
>75	2	1.2	1	0.1
Unknown	56	33.3	261	36.9
Total	168	100	707	100

Source: Cape Town metropolitan council website- www.capetown.gov.za, 2003

Other human factors associated with many fatal accidents include drunken driving and driver fatigue. Table 18 shows that in 2001, 13 203 accidents occurred on Friday, constituting 18% of accidents in Cape Town. Table 19 shows that between 16h00-16h59 on Fridays is when the highest number of accidents (i.e. fatal, serious, slight injury and damage-only) occurs [2]. It is assumed that alcohol and/or drug abuse is one of the major causes as this is when the weekend drinking spree starts and mental exhaustion is highest. This could explain the high accident rates. The author assumes that if traffic police set up roadblocks on Fridays from 12h00 until 18h00, two out of five accidents could be prevented. This denotes that 5 281 accidents would be avoided. This reduction rate in fatalities is assumed because three out of every five drunken or extremely tired drivers will not get apprehended due to the various travel routes used.

Table 18: All accidents categorised by day of the week in Cape Town in 2001

Day	Cape Town Admin	Tygerberg	South Peninsula	Oostenberg	Blauwberg	Helderberg	Total	%
Monday	4 725	2 379	1 284	647	739	523	10 312	14
Tuesday	4 608	2 399	1 185	655	732	531	10 124	14
Wednesday	4 591	2 475	1 201	624	690	570	10 165	15
Thursday	4 531	2 530	1 266	663	734	542	10 280	14
Friday	5 843	3 259	1 524	927	903	747	13 221	18
Saturday	4 735	3 014	1 448	993	819	647	11 671	16
Sunday	3 393	2 072	995	609	543	493	8 115	11
	32 426	18 128	8 903	5 118	5 160	4 053	73 888	100

Source: Cape Town metropolitan council website- www.capetown.gov.za, 2003**Table 19:** All accidents categorised by day and hour of the week in Cape Town in 2001

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	%
0h-1h	143	131	133	198	204	369	326	2
1h-2h	84	61	61	109	138	293	262	1
2h-3h	80	50	61	94	102	255	223	1
3h-4h	45	42	34	53	67	214	181	1
4h-5h	36	37	40	61	57	168	134	1
5h-6h	72	42	77	68	81	153	112	1
6h-7h	231	243	224	198	240	185	123	2
7h-8h	866	884	865	753	823	264	160	6
8h-9h	689	748	754	636	788	398	232	6
9h-10h	539	547	475	475	548	473	300	5
10h-11h	593	557	523	537	650	677	395	5
11h-12h	656	620	558	611	731	800	477	6
12h-13h	696	666	654	682	838	803	501	7
13h-14h	609	653	655	642	793	644	384	6
14h-15h	691	673	725	647	794	657	434	6
15h-16h	714	722	659	711	1 008	658	439	7
16h-17h	874	777	827	849	1 102	611	472	7
17h-18h	892	911	915	941	1 040	667	553	8
18h-19h	534	562	523	570	733	630	585	6

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	%
19h-20h	423	362	437	421	689	751	538	5
20h-21h	308	270	311	349	576	625	496	4
21h-22h	235	229	250	281	433	494	349	3
22h-23h	148	171	226	195	407	429	246	2
23h-24h	139	152	164	185	361	438	183	2
Total	10 297	10 110	10 151	10 266	13 203	11 656	8 105	100
%	14	14	14	14	18	16	11	100

Source: Cape Town metropolitan council website- www.capetown.gov.za, 2003

Studies suggest that truck-driver fatigue may be a contributing factor in at least 30 to 40% of all heavy-truck accidents [1]. Conversely, educating the public (especially heavy-duty truck drivers) about the importance of resting periodically during long-distance trips and the provision of shower facilities in filling stations along national routes can reduce heavy-truck accidents by 30-40%. Freight operators (employers) want loads delivered as fast as possible over long distances, and replace drivers that do not perform. This creates a "catch 22" situation where drivers are aware of the risks involved due to not resting periodically during long distance travel, yet at the same time need to retain their jobs. Measures should be put in place to control freight operators.

5 274 vehicles with Gross Vehicle Mass (GVM) > 3 500kg were involved in accidents during 2001 [2]. This constitutes 7% of all accidents in Cape Town. Public education in terms of driver fatigue could prevent 1 582-2 110 accidents.

Intelligent Speed Adaptation (ISA) is technology placed in vehicles to warn or force motorists to keep within the speed limit. ISA is divided into open, half-open and closed categories. Open ISA alerts the driver that the vehicle has exceeded the speed limit by producing various warning sounds. Half-open ISA stiffens the accelerator pedal when the speed limit is exceeded. Closed ISA cuts off fuel supply to the engine until the vehicle is within the stipulated speed limit. It can be noted that open ISA will not directly reduce speeding as this technique depends on the driver's awareness of the importance of maintaining the speed limit. Half-open ISA can reduce speeding as the driver has no choice but to gradually reduce speed until within the speed limit. However, closed ISA keeps all vehicles within the stipulated speed limit. Therefore, closed ISA should be installed in all public transport vehicles and speed limit violators. The author assumes that this would reduce the average travel speed by 10% of the speed limit. This assumption considers that speed limit is exceeded by 10% and ISA reduces travel speed by the same amount.

On national or provincial roads, on-coming traffic is warned of the presence of traffic law enforcers making it hard to apprehend speed-limit violators. Limited human resources increase the spacing between the positions traffic police take up along national and provincial roads, thus reducing their effectiveness. Speed cameras along urban roads will make drivers reduce their speeds to avoid traffic fines. Trucks, long-distance buses and mini-bus taxis could be fitted with half-open ISA as it is impractical for traffic police to monitor their speed over the full length of the trip; making speed cameras along black spots a practical alternative. It can be assumed that stringent traffic law enforcement and speed cameras would reduce the average travel speed by 10% of the speed limit.

Intelligent speed adaptation, the use of speed cameras and stringent traffic law enforcement is assumed to reduce average travel speeds by 6km/h in urban areas and 12km/h in rural areas. These measures are assumed to result in a 21% reduction in fatality rates in urban areas and 42% in rural areas (see Table 15), as illustrated in Table 20. As stated earlier, 75% of accidents are due to speeding and 90% of motorists exceed the 60km/h speed limit. The author assumed most speed related accidents in the Western Cape occur in urban areas with speed limits of 60km/h.

Table 20 is shaded to highlight the fact that these figures are derived from an assumption, which requires more research to determine the precise accident reductions.

As mentioned previously, if a vehicle travelling at 80 km/h hits a pedestrian, there is almost a 100% probability that the pedestrian will die [2]. Speeds greater than 80km/h result in pedestrian fatalities and the same can be assumed for occupants of the vehicle, depending on whether or not seat belts are worn as depicted in Table 21.

Table 20: Estimated reduction of fatalities due to speeding in the Western Cape

Year	Fatal accidents	75% of fatal accidents	Accident reduction: 21% of fatal accidents
1997	622	467	98
1998	574	431	91
1999	672	504	106
2000	551	413	87
2001	896	672	141

Source: Cape Town metropolitan council website- www.capetown.gov.za, 2003

Table 21: Accident reduction by wearing seat belts

Reduction in accident severity by wearing seat belts	Front seat	Back seat
Would have been injured (serious accidents)	25%	20%
Would have been killed (fatal accidents)	40%	30%

Source: SWOV website- www.swov.nl/en/links/index.htm, 2004

Stringent traffic law enforcement and public education about the importance of wearing seat belts can further prevent 56 fatal accidents in the Western Cape during 2001 according to Table 20.

4.3.2. *Vehicle factors in the Western Cape*

Western Cape statistics (derived from www.capetown.gov.za/reports) do not indicate which vehicle factors cause accidents unlike Table 14 on a national scale. Table 14 will be used in conjunction with chapter 3 to estimate accident reductions.

The type of vehicle involved in the majority of accidents gives an indication of probable vehicle factors or simply reflects that the likelihood of a particular vehicle type having an accident increases, as it comprises a larger percentage of vehicle types.

According to Table 22, mini-bus taxis have more accidents than heavy trucks (GVM>3500kg) due to more frequent public transport trips made, even if heavy trucks make up a larger percentage of vehicle types. Motorcars make up the largest percentage of vehicle types. The probability of this vehicle type being involved in accidents would therefore be very high as shown in the accident statistics in Table 22. Generally, lighter vehicle types are involved in more accidents due to higher travel speeds and more vehicle-kilometres travelled. Motorcycles have the same accident risk as motorcars although they constitute a lower percentage (see Table 22). This could be due to higher acceleration capabilities of motorcycles and lack of dedicated lanes for this vehicle type.

Table 22: Types and number of registered vehicles involved in all accidents in 2001

Vehicle type	No. of vehicles involved in accidents	%	No. of registered vehicles	Risk per registered vehicle type
Motor car/ station wagon	85 825	66.0	551 892	0.16
Light delivery vehicle	18 227	14.0	147 306	0.12
Combi/ Mini bus	8 428	6.5	10 254	0.82
GVM >3500 kg	5 274	4.1	18 090	0.29
Unknown	5 254	4.0	3 240	1.62
Motor cycle	3 073	2.4	19 717	0.16
Bus	1 394	1.1	5 202	0.27
Other	1 361	1.0	14 515	0.09
Articulated trucks	1 212	0.9	2 601	0.47
Total	130 048	100.0	772 817	

Source: Cape Town metropolitan council website- www.capetown.gov.za, 2003

All vehicles are required to be registered, which does not necessarily mean that all are roadworthy at the time of the accident. This is because vehicle roadworthiness is only tested when vehicles change owners. The risk per registered vehicle type is a reflection of driver behaviour among vehicle types. Generally, drivers of mini-bus taxis have very little regard for traffic rules and regulations. This is reflected in Table 22, with combi/ mini-bus taxis having the highest accident rate or risk per vehicle type. The unknown vehicle types have not been considered, as this is an indication of bad data collection. Articulated trucks, vehicles with a gross mass over 3 500kg and buses are the next set of vehicle types prone to accidents. These drivers should be educated and go for advanced driving courses.

Western Cape accident statistics do not indicate how accidents are caused i.e. by tyre bursts, inadequate brakes, inappropriate headlights, overloading of vehicles, unroadworthy vehicles. Accidents due to these vehicle factors have not been quantified, making it difficult to estimate accident reductions due to eliminating these vehicle factors. Traffic police that arrive at the scene of an accident should be trained to identify what vehicle factors could have caused the accident.

4.3.3 Road factors in the Western Cape

Western Cape statistics indicate which road factors cause accidents and these will be used in conjunction with chapter 3 to estimate accident reductions.

Poor visibility results in collisions with fixed objects, pedestrians and animals due to fog or misty weather, inadequate street lighting and lack of road furniture (i.e. road studs, reflectors). All road authorities should ensure that the provision of road signage and markings on roads under their jurisdiction, complies with all the requirements as prescribed by the South African and SADC Road Traffic Signs Manual. Accidents on dusty roads where vehicles hit animals or people hidden in dust clouds can be avoided by people and animals keeping clear of the road when dust clouds approach due to oncoming vehicles. When motorists are blinded by the sun, leading vehicles should use their hazard signs to communicate their position to fellow road users. Road engineers must also ensure these roads are curvilinear in order to minimise the glare from the setting or rising sun.

Table 23: Accident rate per 10 million vehicle-km travelled

Light condition	Fatal		Serious		All accidents	
		Risk		Risk		Risk
Daylight	150	0.8	896	5.0	51 791	291
Dark	181	1.0	556	3.1	16 060	90
Unknown	553	3.1	109	0.6	3 667	21
Dawn/ Dusk	12	0.1	66	0.4	2 270	13
Total	896	5	1 627	9.1	73 788	414

Source: Cape Town metropolitan council website- www.capetown.gov.za, 2003

Accidents during unknown light conditions reflect bad data collection. Table 23 shows that the fatality rate is highest after dark. If the level of light is raised from 1 to 2cd/m^2 , the incidence of night accidents can be reduced by up to 65% [4]. As mentioned earlier, other factors contribute to accidents after dark. The author assumes that one out of 20 fatal accidents after dark are due to wild animals suddenly appearing in front of vehicles and jaywalking. This is because most wild animals are deep in the bush, far away from the nearest road. Therefore, increasing the light intensity by 1cd/m^2 would prevent nine fatal accidents, 28 serious accidents and 803 of all accidents after dark.

Table 23 shows that the most serious accidents occur during daylight. This could be due to the fact that most vehicle-kilometres driven are during the day. Table 23 does not give an indication of what percentage of these accidents are due to misty weather or fog or wiper blades being worn out. The author assumes one out of 20 of these accidents are due to misty weather. It is assumed that there is a one in 20 chance of hitting another vehicle, jaywalker or animal in misty weather because other vehicles would have their headlights on; jaywalkers avoid rainy and misty weather as much as possible and animals are less active during cold weather.

Road sections with known occurrences of misty weather should have adequate signage put up to alert motorists to this hazard. Public education and road signage can prevent 45 serious accidents.

Table 23 indicates that accidents are lowest during dawn or dusk. A sunrise on east-bound roads or a sunset on west-bound roads blind motorists and increase the possibilities of accidents. The author assumes that appropriate road signage and public education would prevent two out of five accidents on east-bound and west-bound roads. It is assumed that three out of five accidents on these roads are due to other human, vehicle or road factors.

However, accidents at dusk or dawn on roads that are not east-bound or west-bound are due to various human, vehicle or other road factors, not indicated in Table 23.

Table 24 shows that more accidents occur on dry rather than wet roads. It can be said that most of the time it is not raining (i.e. roads are dry), explaining the high frequency of accidents on dry roads. Reducing the risk of accidents on any road surface type involves addressing various human, vehicle and road factors.

Table 24: Accident rate per million vehicle-km travelled

Road surface condition	All accidents	Risk
Dry	56 104	3.1
Wet	13 561	0.8
Loose gravel / sand	3 997	0.2
Unknown	126	0.0
	73 788	4.1

Source: Cape Town metropolitan council website- www.capetown.gov.za, 2003

4.4. Number of Fatalities Reduced Annually Due to the Various Measures

Table 14 is used to estimate the human, vehicle and road factors that contribute to annual fatalities, as shown in Table 25.

Table 25: Annual contributory factors to road fatalities in South Africa

Year	Fatalities nationally	Human factors (78%)	Vehicle factors (10%)	Road factors (12%)
1998	7 260	5 663	726	871
1999	7 342	5 727	734	881
2000	5 848	4 561	585	702
2001	8 754	6 828	875	1 050
2002	9 918	7 736	992	1 190

Source: Arrive Alive website www.arrivealive.co.za, 2004

Table 14 is used to estimate the specific human, vehicle and road factors that contribute to annual fatalities, as shown in Table 26.

Table 26: Detailed annual contributory factors to road fatalities in South Africa

Year	Human factors		Vehicle factors		Road factors		
	Jaywalking (47%)	Speed (30%)	Tyre bursts (56%)	Faulty brakes (19%)	Poor visibility (34%)	Sharp bends (17%)	Wet/Slippery roads (17%)
1998	2 662	1 699	407	138	296	148	148
1999	2 692	1 718	411	139	300	150	150
2000	2 144	1 368	327	111	239	119	119
2001	3 209	2 048	490	166	357	179	179
2002	3 636	2 321	555	188	405	202	202

Various measures were considered to reduce pedestrian fatalities but a few are applicable in practice i.e. Appendix E and the education, enforcement and engineering outlined by Mr. Patrick Oliver. The author believes that the measure documented in Appendix E that identifies and minimises trip attractions that cause jaywalking can not be implemented nationally as effectively as the education, enforcement and engineering (“EEE”) outlined by Mr. Patrick Oliver. This is because the Appendix E measure involves identifying pedestrian black spots in each of the various provinces unlike the “EEE” approach can be stipulated nationally and trickled down to individual municipalities. It was therefore decided to only consider the “EEE” approach outlined by Mr. Patrick Oliver (see Table 27).

Various measures outlined sections 4.2 and 4.3 were used to determine the number of road fatalities that can be prevented, as shown in Table 27.

Table 27: Reduction in number of fatal accidents nationally

Year	Human factors		Vehicle factors		Road factors		
	Jaywalking (80%)	Speed (21%)	Tyre bursts (45%)	Faulty brakes (10%)	Poor visibility (5%)	Sharp bends (60%)	Wet/ Slippery roads (80%)
1998	2 129	357	183	14	15	89	118
1999	2 153	361	185	14	15	90	120
2000	1 715	287	147	11	12	72	95
2001	2 567	430	221	17	18	107	143
2002	2 297	487	250	19	20	121	162

Sections of the table are shaded to highlight the fact that these figures are derived from an assumption which requires more research to determine the precise accident reduction rate.

Table 27 shows that in order to reduce the road carnage substantially at a national level, education, enforcement and engineering should be implemented to reduce jaywalking, measures adopted to decrease occurrences of speeding, tyre bursts and road sections that are slippery or have sharp bends.

4.5. Annual National Model and Cost Estimates

The author strongly believes that the likelihood of the relevant transport or government authorities to implement the various measures to reduce pedestrian fatalities is 35%, speeding 25%, faulty brakes 5%, tyre bursts 10%, poor visibility 5%, sharp bends 10% and wet/ slippery roads. These percentages were chosen because of the current enforcement of speed, disuse of worn-out tyres and engineering measures continually adopted to address sharp bends, poor visibility and wet/ slippery roads. It is envisaged that likelihood of the relevant government or transport authorities to continual implement education, enforcement and engineering to lower pedestrian fatalities is 35%.

Table 28 indicates the viability in implementing the various measures.

Table 28: Likelihood of possible reductions in the number of fatal accidents nationally

Year	Human factors		Vehicle factors		Road factors		
	Jaywalking (35%)	Speed (25%)	Tyre bursts (10%)	Faulty brakes (5%)	Poor visibility (5%)	Sharp bends (10%)	Wet/Slippery roads (10%)
1998	745	89	18	1	1	9	12
1999	754	90	19	1	1	9	12
2000	600	72	15	1	1	7	10
2001	899	108	22	1	1	11	14
2002	1018	122	25	1	1	12	16

Table 29 shows the unit cost of fatal and serious accidents in the Western Cape. It is assumed that the unit cost of accidents in the Western Cape does not vary substantially with national unit costs.

Table 29: Unit costs of accidents in South Africa (2001 Rands) [2]

Severity	Drivers/ Passenger	Pedestrian	All
Fatal	694 584	225 457	471 424
Serious	148 549	57 387	108 098

Source: Arrive Alive website www.arrivealive.co.za, 2004

The costs shown in Table 29 were used to estimate the cost savings annually in South Africa due to the various measures, as shown in Table 30.

Table 30: Estimated cost savings due to accident reductions in South Africa (2001 million Rands) [2]

Year	Human factors		Vehicle factors		Road factors		
	Jaywalking	Speed	Tyre bursts	Faulty brakes	Poor visibility	Sharp bends	Wet/Slippery roads
1998	168	62	13	0	1	6	8
1999	170	63	13	0	1	6	8
2000	135	50	10	0	0	5	7
2001	203	75	15	1	1	7	10
2002	230	85	17	1	1	8	11

Table 30 shows that the “EEE” measure documented by Mr. Patrick Oliver should be implemented to substantially lower the pedestrian fatalities, given the forecasted cost savings. The other measures would fine-tune the reduction in the national road fatality rate.

5. CONCLUSIONS

In South Africa, pedestrians are more prone to road fatalities than motorists. In order to lower the fatality rate on South African roads substantially, measures need to be implemented to reduce pedestrian fatalities, speeding and alcohol abuse among pedestrians and motorists.

December was one of the months with the highest number of fatal accidents from 2001 to 2003. Applying measures that reduce pedestrian fatalities, speeding and alcohol abuse in December, should also be practiced throughout the year to lower the national fatality rate.

Fine-tuning the reduction of fatalities in South Africa involves adopting measures to reduce the occurrence of:

- vehicles prone to tyre bursts or have faulty brakes
- road sections with poor visibility, sharp bends or are slippery
- road authorities not ensuring that road markings and signage compile with all the requirements prescribed by the South African and SADC Road Traffic Signs manual

In South Africa, jaywalking is the main contributory factor causing fatal accidents. Reducing the incidences of jaywalking will substantially lower the national fatality rate. Government and transport authorities need to educate the public starting from primary school, continual enforcement and engineering to improve pedestrian safety. The author believes this would reduce the pedestrian fatalities by 80%.

However, if government has other key priorities, the cost savings shown in Table 30 should serve as incentive in making lowering of pedestrian fatalities a national priority.

Before authorities attempt to deal with motorists, the approach in Appendix E should be implemented i.e. identify and minimise trip attractions that cause jaywalking. Authorities should accurately quantify the number of pedestrian fatalities reduced due to this approach in order to develop a data base of ways of reducing accidents on South African roads.

In December 2002, speed is the second main human factor causing fatal accidents nationally. Speed is a contributory factor in 75% of accidents on South African roads [1]. Higher travel speeds increase the number and severity of accidents. Drivers need to be educated to realise the importance

of speed limits. Traffic police should then ensure motorists adhere to the stipulated speed limit by introducing a demerit system or severe penalties. Finally, engineering should be applied to reduce the occurrence of speeding in the absence of traffic police.

It is important that drivers are informed that speed limits are set to ensure safe travel speeds. Enforcement of speed limits will reduce fatality rates in multiples of 0.5–4% per 1km/h decrease in travel speed achieved [6]. Traffic police should be made aware of this notion as part of the drive to lower the national fatality rate due to speed.

Currently 40% of motorists on roads in rural areas exceed the speed limit and 80-90% on roads in urban areas. Therefore, more traffic police should be deployed on roads in urban areas than rural areas. The use of speed cameras abundantly will cover the shortfall in traffic police numbers.

Education of the public about the importance of wearing seat belts would further prevent speed-related fatalities. It was found that speed enforcement reduces the number of fatal accidents on urban roads by 21% and rural roads by 42%.

Traffic police in conjunction with various authorities responsible should accurately quantify the actual reduction in average travel speeds due to speed enforcement. This approach should be carried out at black spots initially, then accident statistics will identify where and when it is required throughout the year.

Intelligent Speed Adaptation (ISA) warns a driver that the speed limit was exceeded or reduces travel speeds till the vehicle is within the speed limit. Half-open ISA can reduce speeding, as the driver has no choice but to gradually reduce speed till within the speed limit but closed ISA keeps all vehicles within the stipulated speed limit. Closed ISA should be installed in all public transport vehicles and speed limit violators' vehicles; and be legislated in obtaining and renewing their road licences.

Enforcement of alcohol or drug abuse among pedestrians and motorists should involve apprehended offenders spending a night in holding cells, serving as a deterrent. Authorities should quantify the effectiveness of this measure.

Table 28 takes into account the viability of various measures being implemented in practice to lower the national fatality rate.

Table 28: Likelihood of possible reductions in the number of fatal accidents nationally

Year	Human factors		Vehicle factors		Road factors		
	Jaywalking (35%)	Speed (25%)	Tyre bursts (10%)	Faulty brakes (5%)	Poor visibility (5%)	Sharp bends (10%)	Wet/Slippery roads (10%)
1998	745	89	18	1	1	9	12
1999	754	90	19	1	1	9	12
2000	600	72	15	1	1	7	10
2001	899	108	22	1	1	11	14
2002	1018	122	25	1	1	12	16

Table 28 shows that measures that reduce jaywalking and speeding would substantially lower the national fatality rate. After these measures have been implemented and the actual reduction in fatalities quantified, then fine-tuning of other contributory factors should occur.

Vehicle and road factors are secondary causes of fatal and serious accidents on South African roads. As stated earlier, fine-tuning of fatality rate reductions involves these factors.

Nationally tyre bursts contribute to 56% of vehicle factors in December 2002 and brakes 19%. Drivers need to be educated how fatalities arise due to tyre bursts and brakes.

Tyre bursts result in vehicles overturning, head-on collisions, sideswipes and head-rear accidents. Motorists should be educated about the importance of not overloading vehicles and disuse of worn-out tyres. Drivers should be aware that regular stops during travel prevent overheating of tyres minimising the chances of tyre bursts.

Traffic police should also ensure that overloaded vehicles are not permitted to travel long distances, tyres checked to ensure that the threads are not worn out. The author assumed that education of the public reduces 20% of fatal accidents due to tyre bursts and stringent traffic law enforcement 25%. Collectively, 45% decrease in the fatality rate due to tyre bursts was assumed. Further research is required to determine the actual reduction in fatality rates due to these measures.

Legislation should be put in place to ensure that motor insurance companies do not compensate motorists involved in accidents due to inadequate brakes.

Corruption in roadworthiness testing stations put vehicles with faulty brakes on South African roads. Given the various problems associated with trying to curb faulty brakes, the author assumed that public education; traffic law enforcement and testing of vehicle roadworthiness will reduce the fatality rate due to faulty brakes by 10%. Research is required to determine the actual reduction in fatality rates due to these measures.

Under road factors, poor visibility (34%), sharp bends (17%) and slippery roads (17%) were the secondary contributory factors nationally in December 2002. Motorists need to be educated how to drive under poor visibility, round sharp bends and on slippery roads. Road signage informs motorists how to adjust accordingly when traversing these road sections. All road authorities should ensure that the provision of road signage and markings on roads under their jurisdiction, complies with all the requirements as prescribed by the South African and SADC Road Traffic Signs Manual.

Traffic engineers should identify sharp bends but the road sections cannot be re-aligned, as it is not cost effective. Road signage should be erected at these road section indicating safe travel speeds in relation to available stopping sight distance. Traffic engineers should apply various speed reduction measures to induce motorists to reduce travel speeds round sharp bends. The author believes that the right speed reduction measures result in a 60% reduction of fatalities. Further research is required to determine the actual reduction in fatality rates due to these measures.

Traffic engineers can identify slippery road sections. These road sections should have a layer of single or double seal applied to increase skid resistance. The author strongly believes that increased skid resistance would reduce fatal accidents due to slippery roads by 80%. Research is required to determine the actual reduction in fatality rates due to these measures.

Road safety audits should be carried out at the worst known road sections and intersections in accordance with the South African Road Safety Manual, the South African & SADC Road Traffic Signs Manual and Pedestrian & Bicycle Facility Manual.

More research is required to validate some of the assumptions used in fatality reduction rates due to human, vehicle and road factors. Improved data collection among traffic police can be a source of

valid accident statistics needed to quantify fatality rate reductions due to various measures and techniques proposed.

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6. RECOMMENDATIONS

Authorities primarily need to focus on lowering the pedestrian fatalities and speeding. Apply measures that reduce pedestrian fatalities and speeding in December, throughout the year.

The government and transport authorities should educate the public from an early age, continual enforcement and engineering to improve pedestrian safety in order to lower the pedestrian fatality rate.

Furthermore, at pedestrian black spots studies should identify trip attractions causing jaywalking and determine measures to reduce these incidences.

Inform drivers that speed limits are set to ensure safe travel speeds, higher travel speeds increase the number and severity of accidents and the importance of wearing seat belts. Notify traffic police that enforcement of speed limits will reduce fatality rates in multiples of 3.5% per 1km/h decrease in travel speed achieved. Deploy more traffic police on roads in urban than rural areas. Use speed cameras abundantly to cover the shortfall in traffic police numbers. Fit half-open ISA in all public transport vehicles, articulated trucks and vehicles with a gross mass of 3500kg. Install closed ISA among gross speed limit violators. Pass legislation for these measures to be part of the legalities in obtaining road licences.

Traffic police need to determine risky behaviour (e.g. drunken driving from certain night clubs over the weekends or drunken jaywalkers) and imprison offenders for at least one night. Traffic police should set up roadblocks from Friday 12h00 to 18h00 and fine apprehended offenders very stiffly. Implement very stringent traffic-law enforcement among drivers of mini-bus taxis.

Educate the public (especially heavy-duty truck drivers) about the importance of resting periodically during long-distance trips and how it prevents overheating of tyres minimising the chances of tyre bursts. Provide shower facilities in filling stations along national routes for heavy truck drivers. Construct arrestor beds at black spots on steep grades that usually involve heavy trucks.

Educate the public about how load rating of tyres causes tyre bursts, the importance of not overloading vehicles and disuse of worn-out tyres. Traffic police need to ensure that overloaded vehicles are not permitted to travel, check tyres to ensure that the threads are not worn out.

Put legislation in place to ensure that motorists involved in accidents due to inadequate brakes do not get compensated by motor insurance companies. Carry out random spot checks on roadworthy testing stations to minimise corruption.

For road sections with poor visibility, sharp bends or slippery; use road signage to alert drivers of hazards ahead and the appropriate travel speeds. Apply various speed reduction measures at round sharp bends. Identify slippery road sections and apply a layer of single or double seal to increase skid resistance.

Carry out road safety audits at the worst known road sections and intersections in accordance with the South African Road Safety Manual, the South African & SADC Road Traffic Signs Manual and Pedestrian & Bicycle Facility Manual.

Authorities need to improve data collection, train traffic police how to identify causes of accidents in terms of human, vehicle or road factors; carry out more research on causes of accidents and reduction in fatality rates due to various measures.

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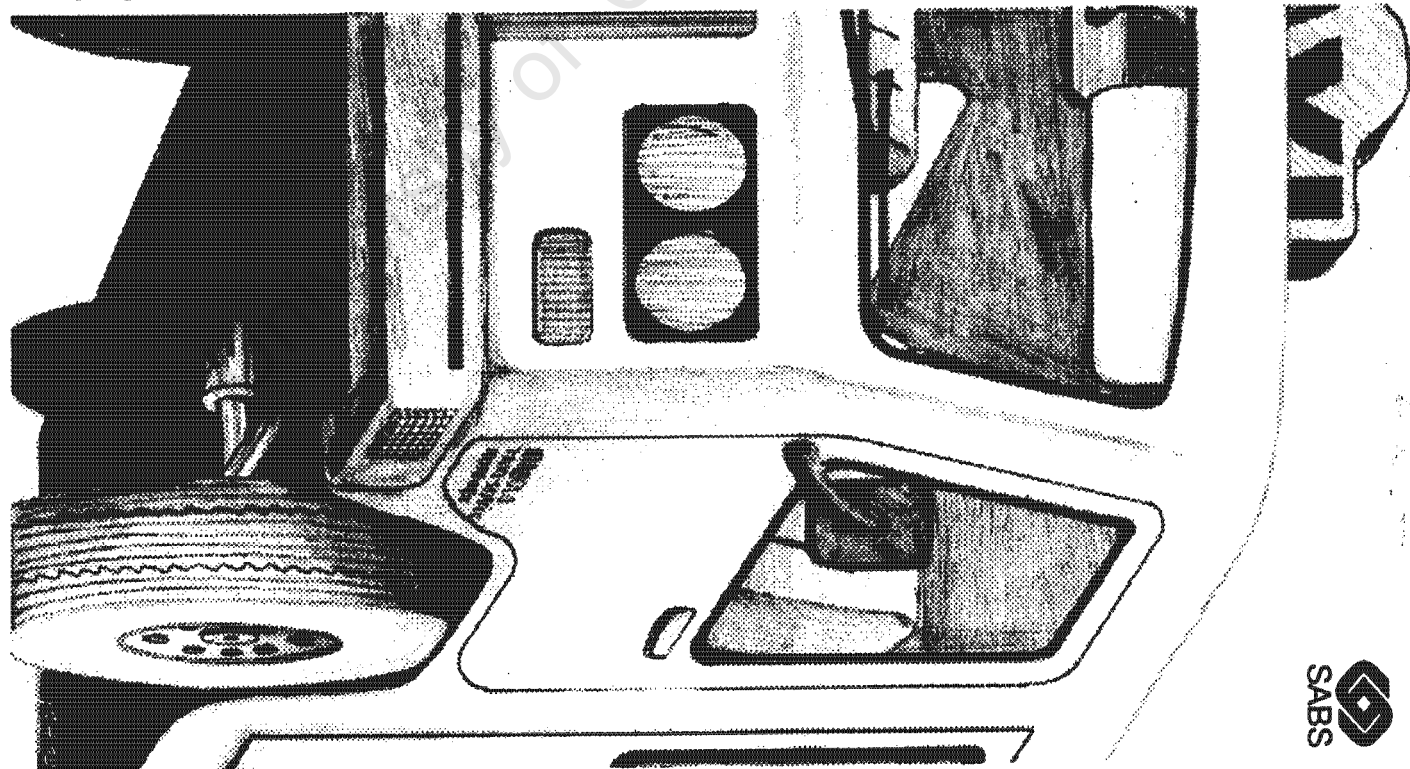
APPENDIX A

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TAXI TYRES

FOR 10 TO 16 SEATERS

WHY 16 SEATERS NEED COMMERCIAL RADIAL PLY TYRES



Published by the SABS as a service to the Taxi Industry
March 1993



Chapter 5 — Summary of advice to help you and the Taxi Trade

- Check the loads that the tyres on your taxi can carry according to the type and using column 5 of table 2.
- Replace them if they cannot carry the loads given in table 1.
- Fit the tyres that the vehicle manufacturer recommends for his latest models. For maximum safety, maximum tyre strength and lowest long term operating costs, fit "Commercial Radial Ply" tyres marked with a "C".
- Talk to retailers and show them this brochure when you buy tyres. If they sold you the wrong tyres and you now need to replace them, ask them why they gave you incorrect advice.
- Get to know the correct pressure for the correct tyres fitted to your minibus, then help to educate the petrol station attendants to tell others the correct pressure. Ask the tyre company to provide tyre pressure stickers.
- If you want "Whitewalls", go for the "Commercial Radial Ply" or in some cases the "Reinforced Radial Ply" but avoid imported whitewall passenger car tyres — they are not made for high loads and they are certainly not made for continuously high load operation with occasional overloads.
- Do all you can to make other people aware of the correct sizes and pressures. The other people are other operators, tyre retailers and petrol attendants.
- Ask filling stations to show you their tyre pressure charts. Create a demand for correct inflation facilities.
- Report the sale of regrooved tyres to the SAP. These tyres are lethal and are prohibited by the Price Control Act, Notice No. 256 of 15 February 1991, and by the Road Traffic Regulation 347(i).
- Check on wheel rim size if you are deviating from the vehicle manufacturer's tyre recommendations, because the wrong size on a rim is dangerous.
- Do not buy wider rims or wider tyres without first checking that they will not foul or touch the bodywork at full steering lock or at full suspension travel or both. Be especially careful with alloy wheels for quality, load capacity and clearance.
- If wear on a tyre is uneven, have the vehicle checked at a competent repair shop as soon as possible. The costs of adjustment are much less than the cost of rapid tyre wear.
- Be careful not to overtighten wheel studs. This can lead to stud failure and wheel loss, especially on the rear axle.
- Tell others and promote awareness of correct sizes and pressures and you will save lives and cut costs.

APPENDIX B

University of Cape Town

Table 2: Relationship between fatality rate and speed limits

Country	Urban limit	Fatality rate per 100 million veh.km
Austria	50	5
Belgium	60	5.1
Finland	50	2
France	60	4.4
Germany (West)	50	3.4
Italy	50	2.8
Luxembourg	60	3.4
Netherlands	50	2.3
Norway	50	2.2
Portugal	60	10.3
Spain	60	6.7
Switzerland	50	2.7
UK	48	2.1
USA	48	1.6
South Africa	60	18.6

Source: The rural speed limit and traffic accidents, Fieldwick R, de Beer E, 1987

4.6.2 Recent trends

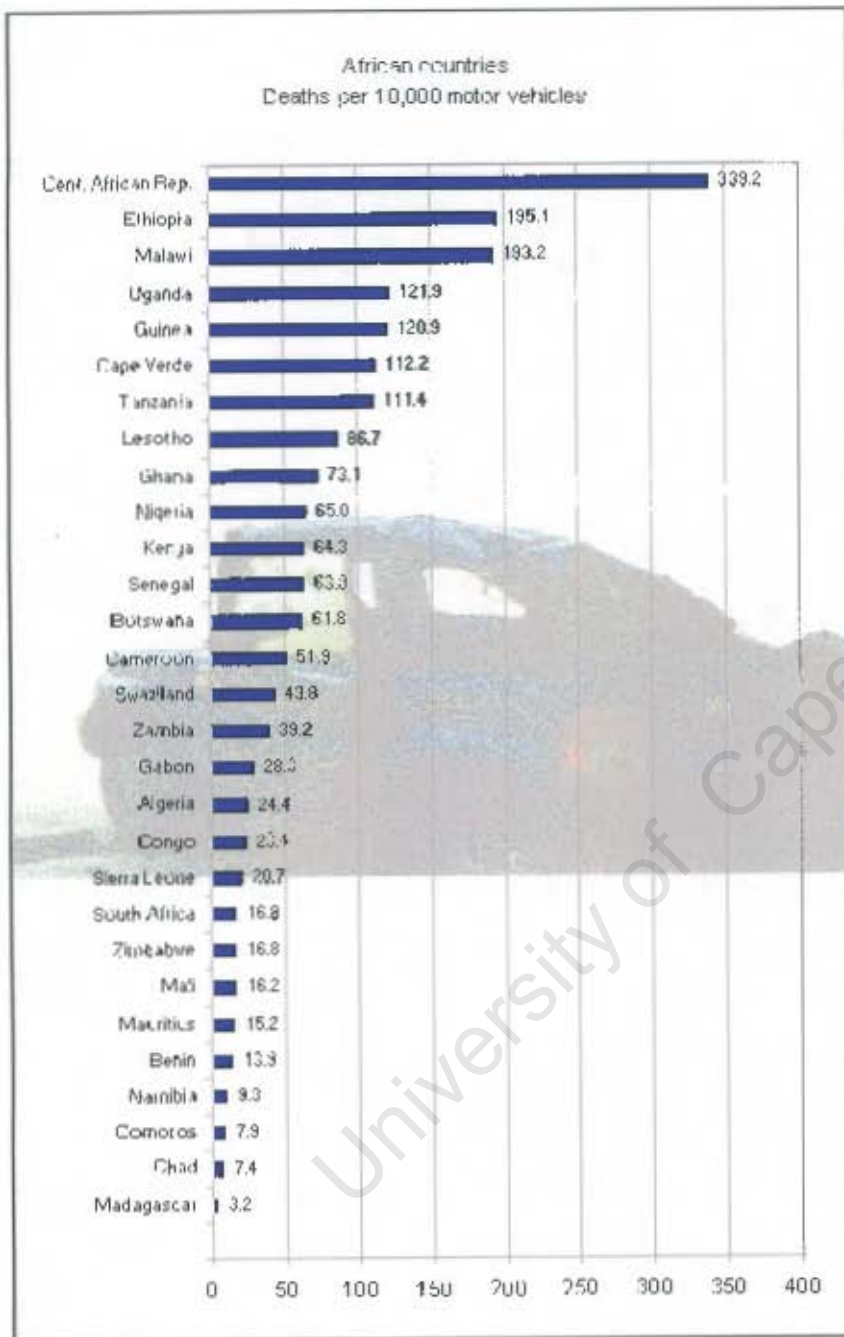
As shown in Figure 17, South Africa's experience has been quite different from other countries. The road fatality toll has grown by over a quarter in the other large African countries (Nigeria, Kenya, Ethiopia, Tanzania, Malawi and Zambia) over the past several years. South Africa, on the other hand, experienced a boom in both motorisation and population while road fatalities, since peaking in 1991, appear to have stabilised at approximately 10,000 fatalities per year. The relative personal safety risk doubled for many African countries while it decreased for South Africa (although by comparison it is still very high).

Figure 15 - Africa fatality risk (1996)

African countries
Deaths per 100,000 pop.



Figure 16 - Africa fatality rates (1996)



APPENDIX C

University of Cape Town

3.4. Statistical analysis of KwaZulu-Natal road accident data

KwaZulu-Natal's statistics is categorised according to the month when accidents occurred, most frequent accident types, time of the day, age sets and type of vehicles. Chapter 2 indicates how controlling human, vehicle and road factors reduces the number and severity of accidents which will be applied to KwaZulu-Natal statistics to develop a model that can be used nationally by identifying the main contributory factors.

The month of the year when accidents occurred in KwaZulu-Natal can be compared with national statistics. December is the month with the highest number of fatal accidents countrywide in 2002 and this will give an indication which accident types or factors follow the national accident trend.

Accidents categorised into age sets reflect human factors, type of vehicles vehicle factors and time of the day could be road or human factors or a combination of both.

3.4.1. Pedestrian accidents categorised according to month of the year

Table 21 shows that December had the highest number of fatal accidents nationally with pedestrian fatalities as the main human factors constituting 36%. Table 32 indicates that June had the highest number of pedestrian fatalities, followed by December in KwaZulu-Natal. March had the highest number of serious pedestrian accidents, followed by October as shown in table 32.

Table 32: Pedestrian accidents in KwaZulu-Natal during 2002

Month	Fatal		Serious	
	Number	% of total	Number	% of total
January	22	5.5	126	7.9
February	32	7.9	131	8.2
March	36	8.9	148	9.3
April	40	9.9	134	8.4
May	40	9.9	129	8.1
June	43	10.7	139	8.7
July	37	9.2	143	9.0
August	36	8.9	131	8.2
September	30	7.4	133	8.3
October	23	5.7	144	9.0
November	23	5.7	112	7.0
December	41	10.2	126	7.9

Total	403	100	1 596	100
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Source: eThekweni Transport Authority

It is known that there is a lot of alcohol abuse over the festive season, especially December in South Africa. However, there is no underlying explanation as to why most fatal pedestrian accidents occur in June or serious accidents in March. Pedestrian alcohol abuse leads to jaywalking resulting in pedestrian fatalities but this is peculiar for the months of June or March.

Table 33: Daily occurrence of pedestrian fatalities in KwaZulu-Natal

	Saturday	Sunday	Week
January	87	58	413
February	92	76	490
March	127	80	479
April	95	71	414
May	94	46	457
June	125	63	451
July	98	52	464
August	109	43	443
September	115	77	366
October	82	52	421
November	96	52	374
December	69	74	395
	1 189	744	5167

Source: eThekweni Transport Authority

Table 33 indicates that most accidents on Saturday and Sunday occurred in March, during the week February. In a South African context, there is no distinct behaviour pattern associated with February or March. Road safety audits could be carried out at pedestrian black spots to identify possible causes of accidents or blood alcohol levels of victims can be captured and recorded to determine possible behavioural trends.

Table 34: Time of the day when all pedestrian accidents occur in KwaZulu-Natal

	Day		Night		Twilight	
		% of total		% of total		% of total
January	3 423	8.9	543	4.7	233	4.7
February	3 437	8.9	679	5.9	236	4.8

APPENDIX C: KwaZulu KwaZulu-Natal accident statistics

March	3 576	9.3	978	8.4	296	6.0
April	3 059	8.0	1 034	8.9	491	10.0
May	2 880	7.5	1 149	9.9	579	11.8
June	2 711	7.1	1 224	10.6	620	12.6
July	2 903	7.6	1 339	11.6	714	14.5
August	3 005	7.8	1 160	10.0	596	12.1
September	3 127	8.1	948	8.2	359	7.3
October	3 406	8.9	880	7.6	321	6.5
November	3 441	9.0	767	6.6	223	4.5
December	3 437	8.9	892	7.7	256	5.2
	38 405	100	11 593	100	4 924	100

Source: eThekweni Transport Authority

Most pedestrian travel occurs during the day but the risk of fatality is greatest at night. This explains why most pedestrian accidents occur during the day, less at night and the least at twilight. There is no particular reason why most pedestrian accidents during the day occur in March, night and twilight in July, as shown in table 34. In addition, to capturing the time of the day when pedestrian accidents occurred; levels of pedestrian infrastructure and degree of alcohol intoxication should be included in the data collection. The month and time of day do not highlight causes of pedestrian accidents.

Table 35 expresses the relationship between traffic volume peaks and pedestrian accidents. Pedestrian travel is greatest during the morning peak and evening peak for commuters going to and from work during the week, and off peak on weekends. The month of the year can be compared to vehicle-kilometres travelled to correlate frequency of vehicular and pedestrian travel to accident rates.

Table 35: Pedestrian accidents in relation to peak traffic volumes in KwaZulu-Natal

	Peak					
	Am(6-8)	% of total	Pm(6-8)	% of total	Off	% of total
January	86	6.5	95	7.8	377	8.3
February	139	10.5	108	8.8	411	9.0
March	143	10.8	110	9.0	433	9.5
April	100	7.6	108	8.8	372	8.2
May	129	9.8	93	7.6	375	8.2
June	134	10.2	124	10.2	381	8.4
July	116	8.8	121	9.9	377	8.3
August	109	8.3	107	8.8	379	8.3
September	105	8.0	81	6.6	372	8.2
October	111	8.4	98	8.0	346	7.6

November	90	6.8	67	5.5	365	8.0
December	57	4.3	109	8.9	372	8.2
	1 319	100	1 221	100	4 560	100

Source: eThekweni Transport Authority

The most vehicle-kilometres travelled in KwaZulu-Natal in 2002 were during December, June the second least while March the fifth highest. This indicates that there is no correlation between pedestrian accidents and vehicle-kilometres travelled. There is no known reason why pedestrian accidents are highest in March or June for morning, afternoon or off-peak travel.

Table 36: Pedestrian accidents in KwaZulu-Natal categorised according to road condition

	Road condition			
	Wet	% of total	Dry	% of total
January	39	13.0	498	7.4
February	31	10.4	614	9.1
March	16	5.4	657	9.8
April	19	6.4	558	8.3
May	6	2.0	588	8.7
June	11	3.7	622	9.3
July	25	8.4	586	8.7
August	33	11.0	562	8.4
September	30	10.0	527	7.8
October	27	9.0	524	7.8
November	24	8.0	492	7.3
December	38	12.7	494	7.3
	299	100.0	6 722	100.0

Source: eThekweni Transport Authority

Table 36 indicates that most pedestrian accidents on wet roads occur in January and March for dry roads. Roads are designed to ensure water runs off and tyre threads maintain traction under wet conditions. Pedestrian accidents in relation to road conditions could be interpreted as a road or vehicle factor or simply lack of pedestrian infrastructure that would keep pedestrians safe. The month of the year when the pedestrian accidents occurred on wet or dry roads does not give an indication of the cause of these accidents.

Pedestrian accidents frequently occur in March and June under most of the above mentioned scenarios. Research into levels of visibility, pedestrian alcohol abuse and jaywalking tendencies in March and June should be investigated further to reduce pedestrian fatalities.

3.4.2. All accidents categorised according to month of the year

Table 37 indicates that most fatal accidents in KwaZulu-Natal occurred in April and serious accidents in March. Easter is in April and alcohol consumption associated with this festive season could explain why fatal accidents are highest in April; but not serious accidents in March. Causes of fatal and serious accidents cannot be determined by stating the month of occurrence but requires additional information e.g. levels of alcohol intake.

Table 37: Fatal and serious accidents in KwaZulu-Natal in 2002

Months	Highest level of			
	Fatal		Serious	
		% of total		% of total
January	40	6.5	198	7.7
February	46	7.5	205	7.9
March	64	10.4	247	9.5
April	65	10.6	228	8.8
May	52	8.5	200	7.7
June	64	10.4	206	8.0
July	49	8.0	240	9.3
August	55	9.0	225	8.7
September	49	8.0	218	8.4
October	34	5.5	223	8.6
November	37	6.0	180	7.0
December	58	9.5	218	8.4
	613	100	2 588	100

Source: eThekweni Transport Authority

Table 38 indicates there were 691 deaths in KwaZulu-Natal while table 37 shows that 613 fatal accidents occurred in the same province. 3765 serious accidents occurred in KwaZulu-Natal according to table 38 while 2588 as stated in table 37. Data collection in KwaZulu-Natal has some errors but more emphasis should be put in recording at least the blood alcohol level of each driver involved in fatal accidents.

Table 38: Number of deaths and serious accidents in KwaZulu-Natal in 2002

	Casualties			
	Death		Serious	
		% of total		% of total
January	45	6.5	298	7.9
February	51	7.4	259	6.9
March	85	12.3	370	9.8
April	73	10.6	355	9.4
May	54	7.8	326	8.7
June	73	10.6	277	7.4
July	57	8.2	328	8.7
August	59	8.5	344	9.1
September	50	7.2	326	8.7
October	43	6.2	337	9.0
November	37	5.4	253	6.7
December	64	9.3	292	7.8
	691	100	3 765	100

Source: eThekweni Transport Authority

Table 39 shows that most accidents on Saturdays occurred in March and August in KwaZulu-Natal. If it can be assumed that most alcohol abuse occurs on Saturday, then traffic law enforcement should be extremely strict on Saturday, especially in March and August. Most accidents on Sunday occur in September in KwaZulu-Natal as shown in table 39. Assuming that driver fatigue is highest on Sundays, the public should be educated about the importance of regular stops after every 2 hours of driving. Most accidents during the week occurred in July in KwaZulu-Natal according to table 39. There is no distinct behavioural pattern associated with July, so it is not known why most accidents during the week occurred in this month.

Table 39: All accidents according to days of the week in KwaZulu-Natal in 2002

	Day of the week					
	Saturday		Sunday		Week	
		% of total		% of total		% of total
January	512	6.3	353	6.3	3 341	8.1
February	636	7.8	400	7.1	3 320	8.1
March	792	9.7	514	9.1	3 557	8.6
April	624	7.7	446	7.9	3 516	8.5

May	636	7.8	448	7.9	3 528	8.6
June	773	9.5	539	9.6	3 245	7.9
July	773	9.5	466	8.3	3 718	9.0
August	792	9.7	531	9.4	3 438	8.4
September	603	7.4	607	10.8	3 224	7.8
October	637	7.8	414	7.3	3 556	8.6
November	786	9.6	404	7.2	3 241	7.9
December	587	7.2	519	9.2	3 479	8.5
	8 151	100	5 641	100	41 163	100

Source: eThekwin Transport Authority

Table 40: All accidents according to visibility in KwaZulu-Natal in 2002

	Visibility					
	Day		Night		Twilight	
		% of total		% of total		% of total
January	3 423	8.9	543	4.7	233	4.7
February	3 437	8.9	679	5.9	236	4.8
March	3 576	9.3	978	8.4	296	6.0
April	3 059	8.0	1 034	8.9	491	10.0
May	2 880	7.5	1 149	9.9	579	11.8
June	2 711	7.1	1 224	10.6	620	12.6
July	2 903	7.6	1 339	11.6	714	14.5
August	3 005	7.8	1 160	10.0	596	12.1
September	3 127	8.1	948	8.2	359	7.3
October	3 406	8.9	880	7.6	321	6.5
November	3 441	9.0	767	6.6	223	4.5
December	3 437	8.9	892	7.7	256	5.2
	38 405	100	11 593	100	4 924	100

Source: eThekwin Transport Authority

Most vehicle-kilometres travelled is during the day explaining why more accidents occur then than at night or twilight, as shown in table 40. July has the highest number of night and twilight accidents while March the most daytime accidents. There is no known reason why these accidents frequently occur in July or March, except that most pedestrian accidents coincide with the same months for the same time of day illustrated in table 34.

Table 41: All accidents according to traffic volumes in KwaZulu-Natal in 2002

	Peak					
	Am (6-8)		Pm (4-5)		Off	
		% of total		% of total		% of total
January	638	6.6	777	8.8	2 791	7.7
February	925	9.5	706	8.0	2 725	7.5
March	939	9.7	734	8.3	3 190	8.8
April	832	8.6	735	8.3	3 019	8.3
May	899	9.3	751	8.5	2 962	8.1
June	861	8.9	702	7.9	2 994	8.2
July	758	7.8	864	9.7	3 335	9.2
August	887	9.2	722	8.1	3 152	8.7
September	800	8.3	734	8.3	2 900	8.0
October	841	8.7	753	8.5	3 013	8.3
November	770	7.9	708	8.0	2 953	8.1
December	541	5.6	694	7.8	3 350	9.2
	9 691	100	8 880	100	36 384	100

Source: eThekweni Transport Authority

Table 41 shows that most accidents during the morning peak occur in March while afternoon peak in July and off-peak in December. Most daytime accidents occur in March but could this correlate with the morning peak and pedestrian accidents? Road safety audits should be carried out in March at the various black spots in KwaZulu-Natal to establish why most daytime, pedestrian and morning peak accidents occur during this month. There is no apparent reason why most afternoon peak accidents occur in July. Nationally, December is associated with alcohol abuse and this can explain why most off-peak accidents occur in this month. Off-peak accidents are more frequent than morning and afternoon peak accidents because of a larger time span; which does not give an indication of the underlying causes.

Table 42: All accidents categorised by road conditions in KwaZulu-Natal during 2002.

	Road Condition			
	Wet		Dry	
		% of total		% of total
January	700	11.7	3 460	7.1
February	566	9.5	3 757	7.7

March	315	5.3	4 515	9.3
April	358	6.0	4 218	8.6
May	127	2.1	4 472	9.2
June	181	3.0	4 356	8.9
July	657	11.0	4 290	8.8
August	658	11.0	4 102	8.4
September	707	11.8	3 723	7.6
October	544	9.1	4 057	8.3
November	399	6.7	4 021	8.2
December	765	12.8	3 812	7.8
	5 977	100	48 783	100

Source: eThekweni Transport Authority

Table 42 shows that most accidents under wet road conditions occur in December while dry road conditions in March in KwaZulu-Natal. It is not known whether these accidents in December are due to the associated alcohol abuse or high rainfall received during that month. There is more dry than wet weather explaining why there are more accidents under dry than wet road conditions; but as to why March has more accidents under dry road conditions is not known. Accidents under wet road conditions can be reduced by traffic police ensuring that vehicles have adequate tyre thread depth and road engineers reduce aquaplaning.

3.4.3. Types of accidents

Table 43 shows that pedestrian accidents make up the majority of fatal and serious accidents in KwaZulu-Natal. Previously, it was noted that most fatal pedestrian accidents occur in June and serious pedestrian accidents in March (See table 32). This holistic approach is the first step in identifying the bulk of the problem; but causes will identify ways of reducing accidents. Accident statistics in KwaZulu-Natal should focus on identifying primary causes of accidents e.g. speeding or alcohol abuse. Stringent traffic law enforcement can reduce accidents due to these two human factors.

Table 43: Accident types according to severity in KwaZulu-Natal in 2002

Accident type	Highest level of			
	Fatal		Serious	
		% of total		% of total
Fixed Object/ Overturning	92	15.0	252	9.7
Opposite direction	48	7.8	185	7.1

Other	11	1.8	82	3.2
Reversing/ Parking	3	0.5	24	0.9
Right Angle	21	3.4	168	6.5
Same direction	35	5.7	281	10.9
Vehicle/ Pedestrian	403	65.7	1 596	61.7
	613	100.0	2 588	100

Source: eThekweni Transport Authority

Table 44 indicates that 691 deaths and 3765 serious accidents occurred while table 43 shows that there were 613 fatal accidents and 2588 serious accidents. The data collection has some errors but more attention should focus on identifying possible causes of accidents, in order to reduce the number and severity of accidents.

Table 44: Accident types according to casualties in KwaZulu-Natal in 2002

Accident type	Casualties				
		Death:		Serious	
		% of total		% of total	
Fixed Object/ Overtuning	123	17.8	677	18.0	
Opposite direction	69	10.0	406	10.8	
Other	11	1.6	95	2.5	
Reversing/ Parking	3	0.4	36	1.0	
Right Angle	28	4.1	343	9.1	
Same direction	47	6.8	515	13.7	
Vehicle/ Pedestrian	410	59.3	1 693	45.0	
	691	100.0	3 765	100.0	

Source: eThekweni Transport Authority

Regardless of the day of the week in KwaZulu-Natal in 2002, most accidents occur in the same direction as shown in table 45. These accident types can represent side swipes which arise due to a number of human, vehicle and road factors. This holistic view towards data collection initially helps determine the bulk of the problem; but the actual causes of accidents will determine ways of reducing the number and severity of accidents.

Table 45: Accident types according to day of the week in KwaZulu-Natal in 2002

Accident type	Day of					
	Saturday		Sunday		Week	
		% of total		% of total		% of total
Fixed Object/ Overtaking	806	9.9	853	15.1	3 125	7.6
Opposite direction	658	8.1	467	8.3	2 687	6.5
Other	175	2.1	143	2.5	931	2.3
Reversing/ Parking	1 095	13.4	786	13.9	5 415	13.2
Right Angle	874	10.7	598	10.6	4 152	10.1
Same direction	3 354	41.1	2 050	36.3	19 686	47.8
Vehicle/ Pedestrian	1 189	14.6	744	13.2	5 167	12.6
	8 151	100	5 641	100.0	41 163	100.0

Source: eThekweni Transport Authority

Table 46: Accident types according to levels of visibility in KwaZulu-Natal in 2002

Accident type	Visibility					
	Day		Night		Twilight	
		% of total		% of total		% of total
Fixed Object/ Overtaking	2 239	5.8	2 196	18.9	347	7.0
Opposite direction	2 387	6.2	1 073	9.3	348	7.1
Other	724	1.9	418	3.6	106	2.2
Reversing/ Parking	5 305	13.8	1 523	13.1	462	9.4
Right Angle	3 947	10.3	1 108	9.6	567	11.5
Same direction	19 027	49.5	3 754	32.4	2 303	46.8
Vehicle/ Pedestrian	4 776	12.4	1 521	13.1	791	16.1
	38 405	100.0	11 593	100.0	4 924	100.0

Source: eThekweni Transport Authority

Accidents in the same direction in 2002 are the majority of accident types regardless of levels of visibility in KwaZulu-Natal, as shown in table 46. Are inadequate road widths or worn out tyre threads and aquaplaning resulting in side swipes as vehicles cannot keep to their lanes? It is difficult to assume what the underlying causes of accidents in the same direction are, stipulating the need for road safety audits at black spots.

Table 47 indicates that accidents in the same direction in KwaZulu-Natal are the main causes of accidents, regardless of traffic volumes. Data collection should identify causes of accidents in the

same direction in KwaZulu-Natal in order to substantially reduce the number and severity of accidents.

Table 47: Accident types according to traffic volumes in KwaZulu-Natal in 2002

Accident type	Peak					
	Am. (6-8)		Pm. (4-5)		Off.	
		% of total		% of total		% of total
Fixed Object/ Overtuning	569	5.9	487	5.5	3 728	10.2
Opposite direction	576	5.9	581	6.5	2 655	7.3
Other	189	2.0	152	1.7	908	2.5
Reversing/ Parking	795	8.2	977	11.0	5 524	15.2
Right Angle	998	10.3	952	10.7	3 674	10.1
Same direction	5 245	54.1	4 510	50.8	15 335	42.1
Vehicle/ Pedestrian	1 319	13.6	1 221	13.8	4 560	12.5
	9 691	100.0	8 880	100.0	36 384	100.0

Source: eThekweni Transport Authority

Accidents in the same direction are a definite cause of the majority of accidents in KwaZulu-Natal as confirmed in table 48; regardless of the road condition. The underlying factors contributing to accidents in the same direction must be determined in order to reduce the number and severity of accidents.

Table 48: Accident types according to road conditions in KwaZulu-Natal in 2002

Accident type	Road condition			
	Wet		Dry	
		% of total		% of total
Fixed Object/ Overtuning	1 284	21.5	3 489	7.2
Opposite direction	443	7.4	3 361	6.9
Other	129	2.2	1 110	2.3
Reversing/ Parking	435	7.3	6 836	14.0
Right Angle	541	9.1	5 072	10.4
Same direction	2846	47.6	22 193	45.5
Vehicle/ Pedestrian	299	5.0	6 722	13.8
	5 977	100.0	48 783	100.0

Source: eThekweni Transport Authority

3.4.4. Human factors in KwaZulu-Natal

Table 49 shows that most deaths and serious accidents occur among the 25-29 age set in KwaZulu-Natal in 2002. This age group is categorised by high levels of alcohol abuse, road rage, and aggressive driver behaviour as inexperienced peers try impressing their friends. Random alcohol tests, especially over the weekends at night outside the various night clubs that the 25-29 age-set frequent will reduce the number of accidents. Stiff penalties among drunken drivers or imprisonment till sober will act as a deterrent. Education of the public in conjunction with stiff penalties and imprisonment will force this age group to have sober drivers among their peers.

Table 49: Accidents in 2002 categorised according to age sets in KwaZulu-Natal

Age range	Total Casualties		Death		Serious	
		% of total		% of total		% of total
Under 5	230	1.1	11	1.6	52	1.4
5-9	571	2.8	42	6.1	152	4.0
10-14	569	2.7	19	2.7	129	3.4
15-19	912	4.4	41	5.9	180	4.8
20-24	1 944	9.4	60	8.7	295	7.8
25-29	2 303	11.1	78	11.3	356	9.5
30-34	1 816	8.8	69	10.0	266	7.1
35-39	1 536	7.4	60	8.7	228	6.1
40-44	1 245	6.0	50	7.2	195	5.2
45-49	881	4.2	20	2.9	137	3.6
50-54	672	3.2	29	4.2	106	2.8
55-59	401	1.9	17	2.5	75	2.0
60-64	273	1.3	16	2.3	51	1.4
65-69	122	0.6	8	1.2	22	0.6
70+	160	0.8	9	1.3	33	0.9
Child	137	0.7	1	0.1	29	0.8
Adult	6 795	32.8	157	22.7	1 419	37.7
Unknown	169	0.8	4	0.6	42	1.1
	20 736	100	691	100	3 767	100

Source: eThekweni Transport Authority

Table 50 shows that most accidents on Monday, Tuesday, Wednesday and Friday occur at 7h00, Sunday at 18h00, Thursday at 16h00 and Saturday at 11h00. Accidents are more frequent during the morning traffic peak on Monday, Tuesday, Wednesday and Friday; afternoon peak on Thursday and midday peak on Saturday. An increase in vehicle-kilometres travelled will increase the likelihood of

accidents occurring; but this does not explain why the morning peak on some days or afternoon peak on others have the most accidents. Further research is required and data collection should try identifying possible causes of accidents in conjunction with time of the day and hour of the week.

Table 50: Accidents according to hour and day of the week in KwaZulu-Natal in 2002

Hour	Total		Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
		% of total							
0	443	0.81	122	25	41	38	34	47	136
1	479	0.87	125	21	39	38	41	71	144
2	425	0.77	153	31	37	19	27	43	115
3	348	0.63	96	25	28	28	36	37	98
4	394	0.72	93	39	38	42	35	41	106
5	660	1.20	89	101	90	88	87	105	100
6	2 097	3.82	121	404	371	322	325	349	205
7	4 690	8.53	141	883	874	830	753	916	293
8	2 904	5.28	205	494	496	460	453	482	314
9	2 536	4.61	234	379	388	363	360	378	434
10	2 912	5.30	285	425	432	388	372	495	515
11	3 237	5.89	333	444	438	447	480	523	572
12	3 426	6.23	328	488	462	499	452	649	548
13	3 317	6.04	295	453	515	479	488	574	513
14	3 760	6.84	372	567	525	539	545	737	475
15	3 730	6.79	357	576	586	514	596	676	425
16	4 643	8.45	347	685	783	758	759	872	439
17	4 237	7.71	416	618	668	655	657	740	483
18	3 121	5.68	451	379	450	383	384	534	540
19	2 484	4.52	392	277	313	315	261	453	473
20	1 874	3.41	316	191	200	201	245	311	410
21	1 271	2.31	166	122	119	152	153	258	301
22	1 004	1.83	114	89	89	104	119	241	248
23	761	1.38	66	48	59	76	89	196	227
24	202	0.37	24	24	24	25	30	38	37
	54 955	100	5 641	7 788	8 065	7 763	7 781	9 766	8 151

Source: eThekweni Transport Authority

3.4.5. Vehicle factors in KwaZulu-Natal

Table 51 indicates that motor cars are involved in most fatal and serious accidents; probably due to their high composition of vehicle types which increases the likelihood of accidents occurring. The

percentage make up of accidents according to vehicle types reflects the distribution of vehicles in KwaZulu-Natal. All motor cars should be fitted with minimum safety features given their high frequency in accidents.

Table 51: Accidents according to vehicle types

Vehicle type	Accidents	%	Fatal	Serious
Motor car	58 003	58.5	332	1 574
Combi/ Minibus/ Taxi	10 479	10.6	143	616
Light delivery van	17 399	17.6	130	530
Heavy commercial vehicle	2 795	2.8	33	72
Articulated vehicle	2 819	2.8	29	66
Bus	2 820	2.8	33	111
Motor cycle	849	0.9	16	87
Bicycle	375	0.4	5	40
Tractor/ Trailer	123	0.1	3	4
Other	84	0.1	1	5
Unknown	3 390	3.4	69	296
	99 136	100.0	794	3 401

Source: eThekweni Transport Authority

APPENDIX D

University of Cape Town

Annual number of fatal accidents per 100 000 human population

Province	1998	1999	2000	2001	2002
Gauteng	22.65	26.57	18.15	27.39	28.79
KwaZulu Natal	13.43	13.33	14.8	21.61	23.33
Western Cape	25.94	27.98	16.92	28.5	28.7
Eastern Cape	10.61	8.06	7.17	8.54	10.22
Free State	22.64	21.34	16.59	27.51	26.37
Mpumalanga	27.2	20.23	14.89	27.27	30.04
North West	15.47	15.43	12.31	15.29	22.16
Limpopo	7.72	6.95	5.95	7.53	11.5
Northern Cape	27.47	28.99	23.55	23.76	31.86
standard deviation	7.54	8.32	5.45	8.33	7.89
Natal deviation	3.72	3.63	-1.41	-1.86	-1.37
RSA	17.15	16.96	13.39	19.75	21.96

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APPENDIX E

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Department of Public Transport, Roads and Works



Diepsloot land use and transportation assessment



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File No 1/1/2/27

- 32 (11%) proposed a taxi service to the other side;
 - 19 (7%) proposed traffic lights;
 - 17 (6%) had no response;
 - 28 (9%) reported various other options such as more shops to be built in Diepsloot (6 people), a fence should be erected for safety purposes (7 people) etc.
- Given solutions ranked in order of importance
 - 204 (78%) ranked a pedestrian bridge as first priority.
 - 25 (9%) of the respondents chose a traffic light and pedestrian crossing as their first choice.
 - 21 (8%) chose a taxi service to the other side as first priority.
 - 13 (5%) wanted a fence to be erected as first priority.

10. CONCLUSIVE SUMMARY

The Diepsloot residents represent a low-income community. They are immobile, and highly dependant on public transport for making long distance (inter-regional) journeys. Movement within Diepsloot generally takes place on foot.

A reasonable distance to walk to public transport, business, shopping or community facilities is commonly agreed to be ± 500 meters. Currently large numbers of Diepsloot residents have to travel much further to reach such facilities as many of the facilities in Diepsloot are located at the entrances to Diepsloot along road K46 (R511 - William Nicol). These entrances on the eastern side of the village are at least 2 kilometres away from the people living in the western portions of Diepsloot.

The Laezonia Agricultural Holdings provide employment and shopping services in closer proximity to a number of Diepsloot residents, but the residents have to cross the P158-2 (R28) freeway to get there. The respondents interviewed indicated that the services provided in the Laezonia area are better than the services provided in Diepsloot. The shortest distance from the Diepsloot settlement to the Laezonia area is by crossing over the P158-2 (R28) freeway.

The P158-2 (R28) freeway (used as pick-up point for public transportation purposes), the small shopping centres of the Laezonia Agricultural Holdings, and the employment opportunities that exist on the Laezonia Agricultural Holdings (and at the Gomes and Sand Cats quarries) have been identified as destinations by the survey.

From the survey conducted, 38% of the respondents indicated that they used the P158-2 (R28) freeway to get to and from work. The respondents use the P158-2 (R28) freeway to catch lifts to both Pretoria and Johannesburg. The survey also showed that 30% of the respondents shop in the Laezonia area. A number of respondents (5%) indicated they use the bushes between the P158-2 (R28) freeway and road P39-1 (M34) as toilet facilities.

The survey also identified that people crossing in the opposite direction from the Laezonia area to Diepsloot did so mainly to attend the school and visit the clinic in Diepsloot.

From the survey it is clear that 77% of the respondents indicated they experienced problems crossing the freeway. On enquiring why they did not make use of road K46 (R511) that runs under the P158-2 (R28) freeway, they reported that it was indirect (\pm 4 kilometres detour), unsafe and time consuming.

The community (78% of respondents) proposed that pedestrian bridges be built over the P158-2 (R28) freeway that are well lit and safe.

SECTION 3: PROPOSALS AND GENERIC GUIDELINES

The purpose of this section is to provide proposals and generic guidelines to help resolve the land use and transportation conflict that exists.

11. PROPOSALS

From the survey and land use analysis completed the following proposals seem most appropriate for solving the land use / transportation conflict that exists as a result of pedestrians crossing the P158-2 (R28) freeway:

- A **pedestrian bridge** (which also makes provision for cyclists) to be provided across the P158-2 (R28) freeway at the most accessible point from the settlement. This effectively means that up to three pedestrian bridges may be required as there are three main lines of movement (± 800 meters apart) across the P158-2 (R28) freeway. The pedestrian bridges will have to be accompanied by some type of fencing between the settlement and the freeway. The fencing will ensure that pedestrians have no other alternative than to cross the P158-2 (R28) freeway at the bridges provided.

One of the pedestrian bridges could be combined with a well-planned taxi-facility to accommodate the needs of the pedestrians. Such a facility could be positioned along road P39-1 (M34), adjacent north of P158-2 (R28).

- The community and local authority should promote the **even distribution** (not only at the main entrances) of **community and retail facilities** within the Diepsloot settlement. Shopping and activity nodes should be developed in the western and southern parts of Diepsloot, where few facilities currently exist. The walking distances of Diepsloot residents to retail and community facilities should as far as possible be reduced to ± 500 meters.
- Better **ablution facilities** to be provided in Diepsloot. Although sanitation infrastructure exists in the Diepsloot settlement, residents indicated that they are using the land between the P158-2 (R28) freeway and road P39-1 (M34) as toilets facilities. The lack of public toilet facilities should be brought to the attention of the local authority. A study may be needed to ascertain the exact nature and extent of the problem.
- The **fencing off of Diepsloot** could be a solution, but should be discussed with the community first as it could be socially unacceptable. By fencing the Diepsloot settlement off from the Laezonia Agricultural Holdings the travelling distances of

the pedestrians working on the agricultural holdings will be increased significantly. It is therefore proposed that any fencing exercise be accompanied by pedestrian bridges (and vice - versa) to maintain the linkages between Diepsloot and Laezonia.

- **Provide more telecommunication facilities** in Diepsloot. The fact that Diepsloot residents cross the P158-2 (R28) freeway to use public telephones on the Laezonia side of the freeway indicates that either there are too few public telephones in Diepsloot and / or that the walking distances to the public phones in Diepsloot are further than the distance to the public phones at Laezonia.
- **Community facilities** should be offered in rural areas so that people do not flock to the Diepsloot settlement to access such facilities. Rural areas are dependent on mobile clinics for their medical needs. The services provided by the mobile clinics are very limited and infrequent. Until the rural health services are upgraded to acceptable standards, rural inhabitants will continue to flock to the closest permanent (fully fledged) clinics, in this case the Diepsloot settlement.
- **Sizeable shopping centres** should be provided within the Diepsloot settlement so that the need to cross the freeway is minimised.
- **Collector/distributor taxi services** should be provided to bring commuters to strategically located pick-up points in the village from where longer distance transport can be provided to places of work. (This option could, however, be unpractical as it would be unaffordable to most residents). Alternatively these pick-up points should be centrally situated in the area (within walking distance) and good access roads be provided.
- The **taxi organisations** should be brought together to sort out matters regarding regional and local taxi routes in order to integrate taxi facilities and services. Regional and local taxis are in conflict about routes travelled i.e. who operates where, which results in residents having to walk long distances to get to the taxi services and facilities.
- **Additional signage** can be implemented along the P158-2 (R28) freeway. Existing signage indicating that *pedestrians may not cross* the P158-2 (R28) freeway is directed at the motorists travelling along and not at pedestrians intending to cross the freeway. More appropriate signage would be to *caution motorists about pedestrians crossing* the freeway thereby heightening their vigilance for possible accidents.

12. GENERIC GUIDELINES

This section identifies the generic guidelines that should be implemented along all major arterials/freeways that passes by a low-income community (low mobility) and also when planning low-income (low mobility) settlements adjacent major arterials/freeways.

12.1 Empowerment and Affordability

In most poor communities (as we have seen in Diepsloot) mobility is achieved either by foot or via some sort of public transport service, be it by train, bus or taxi. If people are to be empowered in an affordable way, then access by foot or bicycle should form part of any planning strategy.

The real measure of empowerment is pedestrian/cyclist proximity (to retail, services, public transport etc.).

If people cannot access the abovementioned facilities by foot/cycle, the people are relatively disempowered.

12.2 Layout and design

12.2.1 Facility Provision

The location of the business, social, and public transport facilities should be done in such a manner that most people are served within a 400m (5-minute) walking distance. In other words the street layout must be designed to cater for the shortest walking distance to facilities. Cul-de-sac and loop street patterns are therefore not appropriate in this case.

12.2.2 Crossing Points

The layout should also be designed with certain access points (on K-routes or freeways) in mind, where people could be directed to use predetermined crossing points (e.g. crossing at traffic lights, pedestrian bridge etc.). The street layout as such should restrict the number of alternative crossing points.

12.2.3 Public Transport Plan

As part of the layout plan of the proposed town, a proper public transportation plan should be compiled for the settlement indicating how and where each of the modes of transport will be accommodated in the settlement.

12.3 Adequate facilities

Adequate facilities in the form of retail and other social services such as schools, clinics, municipal pay points etc. must be provided within the community (walking distance). Although interaction with other areas will not be eliminated totally, the daily needs of the people should be satisfied as far as possible within walking distance inside the settlement. Access to facilities, particularly for people residing outside the settlement, should be accommodated. This is particularly true where facilities provided in a settlement serve regional needs.

12.4 Pedestrian facilities

Safe pedestrian facilities in the form of a pedestrian bridge should form part of the layout design if the need exists for people to cross a busy road. These facilities could include lights in the vicinity of the bridge, an "open" bridge structure, guards from the community and fencing to enhance the use of the pedestrian bridge facility etc.

12.5 Taxi facilities

Taxi facilities for both the local and regional taxi operators should be provided. Where it is not possible to reconcile these groups at one rank, alternative arrangements could be made i.e. regional taxi ranks along major arterials and freeways and local taxi ranks within the settlement.

12.6 Employment opportunities

The provision of employment opportunities should be provided on the same side of the freeway as the residential area(s) are provided, particularly where low-income communities are involved. This will decrease the need for pedestrians to cross over a freeway.

13. RECOMMENDATION

Low income communities (pedestrian communities) adjacent to freeways in Gauteng Province will occur more and more in future. In some cases new settlements will develop adjacent existing freeways in which case the land use/community facility proposals listed above can be implemented; and in other cases new freeways will be built through existing settlements e.g. PWV5 through the Winnie Mandela settlement.

Gautrans will need to be pro-active in its approach regarding the planning and design of its facilities through such pedestrian communities, and provide for the necessary structures, standards and control measures from the outset i.e. during the preliminary and detail design phases.

In order to achieve this objective it is recommended that Gautrans make an assessment of what would typically be required, draw up guidelines on the associated typical facilities, formulate control measures, and include these in a design guideline. This would then serve as terms of reference to be used whenever preliminary or detail design of any portion of road through such an area is undertaken in Gauteng Province or where any low income settlements adjacent to freeways are contemplated.

The control measures would then also guide Gautrans in terms of its requirements whenever a layout plan/design for a new township needs to be commented on/approved.

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