Project report

Traffic Injury Study

Literature Review – Traffic Injury Study

Road Traffic Management Corporation (RTMC)

March 2021

Prepared for:
Road Traffic Management Corporation
Research, Innovation and Engineering
Contact: Deon Roux
Email: Deon.Roux@rtmc.co.za

Prepared by:
Zutari
Melissa Groenewald
Email: Melissa.Groenewald@zutari.com

List of Acronyms and Abbreviations

Acronym/Abbreviation	Description
AAAM	Association for the Advancement of Automotive Medicine
AIS	Abbreviated Injury Scale
AVPU	A = alert, V = responding to voice, P = responding to pain, U = unconscious
BRICS	Brazil, Russia, India, China and South Africa
CARE	International humanitarian agency delivering emergency relief and long-term international development projects
CT	Computed Tomography
DVLA	Driver and Vehicle Licensing Authority
E	Eye Opening
EC	European Commission
ECMT	European Conference of Ministers of Transport
EU	European Union
IFSTTAR	French Institute of Science and Technology for Transport, Development and Networks
GCS	Glasgow Coma Scale
GDP	Gross Domestic Product
GIDAS	German In-Depth Accident Study
HES	Hospital Episodes Statistics
HPCSA	Health Professionals Council of South Africa
HT	Head Trauma
ICD	International Classification of Diseases
IRTAD	International Traffic Safety Data and Analysis
ICDMAP	Johns Hopkins University
ICDPIC	Boston College Department of Economics
ISS	Injury Severity Score
KTS	Kampala Trauma Score
LHS	Length of Hospital Stay
LMIC	Low-and Middle-Income Countries
M	Motor responsiveness
MAAP	Micro-computer Accident Analysis Package
MAIS	Maximum Abbreviated Injury Scale
MAIS3+	Clinically defined serious injuries
MEWS	Modified Early Warning Score

Acronym/Abbreviation	Description
min^{-1}	Beats per minute or breaths per minute
mmHg	Millimetres of mercury
MOI	Mechanism of Injury
MRC	Medical Research Council
NISS	New Injury Severity Score
NH	Not hospitalised (injured but)
NLTA	National Land Transport Act
NRSS	National Road Safety Strategy
NRSSC	National Road Safety Strategy Council
OECD	Organisation for Economic Co-operation and Development
PMI	Permanent Medical Impairment
RR	Respiratory Responsiveness
RTC	Road Traffic Crashes
RTI	Road Traffic Injuries
RTMC	Road Traffic Management Corporation
RTS	Revised Trauma Score
SANRAL	South African Roads Agency Limited
SAPS	South African Police Services
SARTSM	South African Road Traffic Sign Manual
SATS	South African Triage Score/Scale
SBP	Systolic Blood Pressure
SSA	Sub-Saharan Africa
SPI	Safety Performance Indicator
STATA	General-Purpose Statistical Software package
SPSS	Statistics Software Package
TEWS	Triage and Early Warning Score
TRISS	Trauma and Injury Severity Score
TRB	Transport Research Board
TRL	Transport Research Laboratory
TSM	Transportation System Management
UK	United Kingdom
UND(o)A	United Nations Decade of Action (for Road Safety)
V	Verbal Performance
WHO	World Health Organisation

Contents

Appendices

Figures

Tables

1 Introduction

1.1 Background to the project

The Road Traffic Management Corporation (RTMC) published a Request for Proposals and invited competent service providers (Panel of Researchers) to assist the RTMC in undertaking a Traffic Injury Study for South Africa.

The severity of injuries sustained as a result of a motor vehicle crash has an effect on our public health system and economy. A refined classification of the severity of injuries can increase the understanding of the risk factors that resulted in those injuries and to address and develop and implement interventions (engineering, education, enforcement, encourage and evaluation). The impact on the economy in terms of the cost of crashes will be improved by adding levels to serious injuries. Post-crash care (the fifth pillar of the WHO Decade of Action) can be improved by the increased level of detail by being able to detect crash and transport to hospital, appropriate pre-hospital care and care in the hospital emergency room and improving on long term medical and rehabilitation care required (post- crash outcomes).

The current death toll on our roads is not just traumatic for families but places a huge burden on our health system and is detrimental to the economy in lives lost and medical expenses and loss of income. We have not yet made significant improvements in reducing the death toll nor on the amount of crashes annually. Amongst our challenges to address road safety concerns are improving on our reporting and on the quality of reporting and improving the systems of how we report. The other is understanding the reasons why crashes occur and understanding human error and how it differs in different provinces to enable the more effective targeting of road safety interventions to address the causes of crashes.

There is a need to make better distinction between slight and serious injury classifications as reported by SAPS. There is also an annual difference in law enforcement reporting on the death toll and the statistics provided by the Medical Research Council due to recording of deaths by emergency services and those captured in hospitals (within 30 days of a crash).

The number of serious injuries recorded annually play a role in determining the total annual cost of crashes. Internationally it has been determined that there is in fact a huge discrepancy between the real serious injuries and perceived serious injuries. Merely stating that a person was taken to hospital and had an overnight stay might still not be classified as a serious injury with loss of income and ongoing medical attention needed in future.

The RTMC as the custodian of road crash information and reporting and road safety research objective with the study is the benchmarking of serious injurie scoring systems and to . benchmark South African scoring systems to be able to compare with other countries. In addition to this, maybe include a background on safety and recording of road traffic injuries, that way we can introduce the Injury severity scoring and the rest of the report.

Safe System approach to road safety places a huge emphasis on reducing the severity of crashes. The reduction of fatal crashes is one way of tracking the progress countries are making, but when countries are also able to understand trends in the severity of crashes and how and if road safety interventions are making a difference.

For this reason, the Maximum Abbreviated Injury Scale (MAIS) has been developed. South Africa needs to adopt a MAIS of 3 or greater as the basis for a road safety target, similar to the MAIS3+ scale used in the European Union. The aim of the scale is to have a common definition of serious injury across South Africa.

MAIS 3+, MAIS 2+ and injuries leading to permanent medical impairment (PMI) will be identified and used to identify problem scenarios. A national data set of injuries reported to hospitals will be used from historic data. Police-reported injuries will be considered.

The proportion of deaths after 30 days of a crash need to be determined.

The National Road Safety Strategy 2016-2030 (NRSS) set specific interventions to be concluded towards reducing road related fatalities with 50% by 2030, underpinned by the United Nations Decade of Action (UNDA) to which South Africa is a signatory.

These interventions include various road safety related research and inter alia research on traffic injuries in South African road safety programmes towards safer roads in South Africa.

The project is linked to the following NRSS interventions that need to be implemented:

- Develop a new crash reporting framework for improving the collection and accuracy of data, and development of new forms;
- Commission research into situational conditions of crashes (time of day, weather, other vehicles present/involved), which should feed into road safety guidelines;
- Strengthen programme to share data across the private and public sector; including short-term insurance industry to discuss the effective use of this data to introduce new services and products jointly between the private and public sector;
- Identify availability and potential integration of other crash data sources;
- Strengthen interaction with Department of Health and private medical sector in post-crash response (also Health Professionals Council of South Africa (HPCSA), medical schools, Medical Research Council (MRC), etc.).

The TOR requires that the Traffic Injury Study include inter alia the following:

- Conduct a literature review of International Published Maximum Abbreviated Injury Scale (MAIS) research;
- Conduct a comparative analysis of:
    - Injury severity caused by traffic accidents and classified as serious injury in the recorded SAPS data vs. Maximum Abbreviated Injury Scale (MAIS) 3+ injury in hospital databases and determine correction factors;
    - Proportion of deaths due to a crash after 30 days of the occurrence of a crash.
- Formulation of recommendations regarding the way forward in using MAIS data;
- Formulation of recommendations for related further research;
- Relating road crash injury to the objectives and interventions of the NRSSC;
- Considering the necessity for the potential improvement of crash reporting.

1.2 Background to reporting crashes

Every year, nearly 1.35 million people die in car accidents worldwide. This works out to an average of 3,287 deaths per day. An additional 20 to 25 million are left injured or disabled. Road traffic accidents rank as the ninth leading cause of death and account for 2.2 per cent of all deaths globally. The accidents cost US$518 billion globally, costing individual countries from 3% of their annual Gross Domestic Product (GDP). **(**https://www.budgetdirect.com.sg/car-insurance/research/road-accident- statistics-in-singapore**)**

In most countries both developed and developing, fatal crashes are reported by the police. The police are responsible for collecting information on the number of casualties, assessing the severity of injuries, and the overall severity of the crash. They record three levels of severity namely: fatality; serious injury; and slight injury.

The information on crash severity, reported by the police, is rarely checked with medical records, except when the injured person dies in hospital. It has been revealed in many countries that many road traffic casualties admitted to hospital are not known to the police. It has been recommended by research that police data be used in conjunction with hospital data to classify road crash injuries. The use of both data sets (police and hospital) will result in:

- Securing of basic information on casualties not reported to the police, such as age, and gender and vehicle type;
- Better understanding of the total number of casualties;
- Better understanding of injury severity; and
- In-depth understanding of the medical consequences of a particular type of crash, if police and hospital records were linked.

Injury severity should be defined based on medical diagnosis (and not solely on police reports). The International Traffic Safety Data and Analysis (IRTAD) report on Serious Road Casualties (ITF,2011), outlines options for combined analysis of police and hospital data and recommends that the assessment of injury severity be made on the basis of the Abbreviated Injury Scale (AIS) and a serious injury be defined with a maximum AIS score of 3 or more (MAIS 3+).

1.2.1 Limitation of this study

This study will be limited to limited information already captured on previous crashes and available information. Most of the solutions were taken from processes done in European Union (EU), bearing in mind that systems are not the same, the way data is captured is not the same, the International Codes for Diseases (ICD codes) are also not the same. South Africa is a unique country and were however compared to the work of the EU and their traffic and injury reporting systems that more developed than ours, which is not always applicable to a developing country like South Africa.

This study is also performed during a worldwide pandemic with both public and private hospitals under pressure to save lives.

1.3 Structure of this report

The literature review consists of four main chapters. Each section deals with a specific theme, and each theme provides a review of available local and international literature applicable to traffic injury studies, the Abbreviated Injury Scale development to MAIS3+, then Injury Severity Scoring, followed by how road traffic injuries are addressed in developing countries and finally a chapter on the South African context. The remainder of this report is therefore structured as follows:

- Chapter 2: Road Traffic Injuries in Developing Countries
- Chapter 3: Injury Severity Scoring
- Chapter 4: Abbreviated Injury Scale
- Chapter 5: South African context
- Chapter 6: Conclusions
- Chapter 7: Recommendations

2 Road Traffic Injuries in Developing Countries

Road traffic injuries (RTIs) have been identified by the World Health Organization (WHO) as one of leading causes of deaths in developing nations. 93% of the world's fatalities on the roads occur in low- and middle-income countries, even though these countries have approximately 60% of the world's vehicles (World Health Organisation (WHO) Africa, 2020). The increase in urbanisation and motorization resulted in an increased rate of traffic injuries in developing countries.

Traffic injuries cause a huge economic burden on countries, through loss of productivity from individuals either killed or disabled by injuries sustained from accidents. Worldwide, approximately 1.2 million people are killed in road crashes annually, and as many as 50 million are injured. Projections indicate that these figures will increase by about 65% over the next 20 years, unless there is new commitment to prevention (Peden, 2004). A disproportionate burden of RTIs rests on low and middle-income countries (LMIC), which have seen a precipitous increase, while high-income countries have observed a decrease (Vissoci, et al., 2017). Comparative to advanced countries, the rate of people killed in road accidents in developing countries is very high (Aden, 2019).

The pervasive problem of RTIs inexplicably affects the socioeconomically disadvantaged in sub-Saharan Africa (SSA) which is aggravated by the limited access to healthcare and limited resources and infrastructure. Developing Countries are marred by challenges of trauma care that include insufficient manpower, limited physical and financial resources and uncoordinated healthcare system (Laytin, et al., 2015). Several injury severity scoring systems are used in developing countries to determine the impact of RTIs on the economy and the quality of life of the population. The following section describes the current conditions and effect of road crashes in developing countries in order to adequately address the effects of RTIs and severity scoring of injuries sustained in road crashes.

2.1 BRICS

BRICS is a community comprising of five key emerging economies – Brazil, Russia, India, China and South Africa. The member states have been vital in engaging and influencing regional affairs in their respective regions. Road traffic crashes contribute substantially to the economic burden of countries and for the BRICS countries that are currently experiencing accelerated economic growth – leading to higher volumes of traffic –institutional capacity is still needed to cope with such growth or to invest adequately in the systems needed to maintain or increase road safety.

BRICS already account for approximately 20% of the world's deaths from road traffic injuries and the associated economic losses –estimated at 1 to 3% of gross domestic products – are likely to increase unless investments to improve road safety are made (Hyder & Vecino-Ortiz, 2014). The effects of from fatalities, injuries and disabilities from road traffic accidents billow into the community and the economy, having adverse effects especially on emerging economies. Road traffic accidents are very prominent in low- and middle-income countries (Bhalla, et al., 2011) and these countries require a comprehensive and cost-effective approach to road safety that addresses the recent changes in the risks of such injuries, at least in the short to medium term (Hyder & Vecino-Ortiz, 2014).

This section investigates the state of road traffic injuries in BRICS countries (excluding South Africa) and different approaches and solutions that BRICS countries are incorporating to assess the extent of traffic injuries on the economy and on the road infrastructure.

2.1.1 Brazil

Injuries and deaths from accidents on roads have become a global epidemic, especially in developing countries, such as Brazil. Traffic injuries are showing a growing trend in the countries of average and low income: more than half of the deaths worldwide take place in 10 countries. In numbers, Brazil is in the fifth position in this ranking, after India, China, the United States and Russia (Malta, et al., 2016). The annual socioeconomic cost of road traffic accidents in Brazil has an impact of about $6.8 billion on the economy. The country has a road fatality rate of 24.80 per 100,000 (Grous, 2019). At 24.8, Brazil's fatality rate is significantly higher than that of its neighbours.

Literature on Brazil underlines the continued and systematic implementation of actions of communication and education, coordinated, and integrated between the various governmental and non-governmental sectors that have responsibility to arrange for safe and sustainable traffic for the population, investing in the promotion of safe environments for human mobility and quality of life. These coordinated actions could avoid collisions, prevent injuries, and reduce adverse consequences and deaths in traffic (Malta, et al., 2016).

2.1.2 Russia

Road accidents in Russia reached the scale of a national disaster accompanied by a rapid increase in the motorisation together with an accident risk rate that is 3–4 times higher in Russia than in other countries with a high level of motorization (Pugachev, Kulikov, Markelov, & Sheshera, 2017). The Russian Federation has a costly road safety problem which, on a year-by-year basis, and against the background of rapidly rising motorisation is, increasingly, running out of control (The European Conference of Ministers of Transport (ECMT), 2006).

In urban Russia, there has been an increase in road crash deaths and severe injuries as a result of crashes. These crashes primarily involve pedestrians and car occupants as the two largest key casualty groups with their safety being gravely challenged by inappropriate mixes of traffic in urban and rural areas, a poor road environment, high motor vehicle speeds, and poor vehicle crash protection (The European Conference of Ministers of Transport (ECMT), 2006).

In order to overcome the road injury challenges in Russia, the problems require commitment and a combined effort from policy makers in all responsible departments and at central, regional and local levels. The emphasis has been put on hospital injury surveillance by incorporating set standards and disseminate clinical protocols specifying procedures on the management of patients during emergency medical services on the roads, while in transport and in hospitals to reduce pre-admission deaths rates and disability from road crashes (The European Conference of Ministers of Transport (ECMT), 2006).

2.1.3 India

The GDP growth in India has resulted in an increase in vehicles on the road of the country. India is an LMIC with more than 1 million annual trauma deaths, and by 2020, trauma is predicted to become the country's third leading cause of death (Attergrim, et al., 2018) . Trauma injuries also include road traffic injuries. The death rates for road injuries among motorcyclists and cyclists were higher in India than the global average in 2017, and the proportion of deaths due to road injuries among all deaths has increased over time in India (India State-Level Disease Burden Initiative Road Injury Collaborators, 2019).

The methods adopted by India in determining the extend of traffic injury severity in India stem from a tool designed by Dr William Haddon. The analytical tool incorporates a comprehensive systematic approach defining a traffic crash in three phases: pre-crash, crash, and post-crash – as well as the epidemiological triad of human, vehicle, and environment that can interact during each phase of a crash. The resulting nine-cell Haddon matrix models a dynamic system, with each cell of the matrix allowing opportunities for intervention to reduce road crash injury (Mitra, et al., 2018).

The Haddon Matrix for road traffic accidents is shown in Table 1 below:

Table 1: The Haddon Matrix for Road Traffic Accidents

Phase	Nature of Intervention	Factors		
		Human	Vehicles and Equipment	Environment
Pre-cash	Crash Prevention	Information Attitude Impairment Police Enforcement	Road Worthiness Lighting Braking Handling Speed Management	Road Design Road Layout Speed Limit Pedestrian Facility
Crash	Injury Prevention during crash	Use of Restraint Impairment	Occupant Restraints Other Safety Devices	Forgiving Roadsides (i.e. Crash Barriers)
Post -crash	Life Sustaining	First Aid Skills Access to	Ease of Access Fire Risk	Rescue Facilities

Source: (Keshr, 2015)

The steps in using the Haddon Matrix are as follows:

- Step 1: Use community data to determine injury problem that requires an intervention.
- Step 2: Brainstorm potential ideas for interventions and fill them into the cells of Haddon's Matrix.
- Step 3: Make decisions about best intervention options based upon effective strategies and practical to implement in your local situation.

The Haddon matrix enables planning for injury interventions and prevention strategies by phases in time of the event. It is a holistic approach that allows for preventing crashes before they reach the stage of severity scoring in India. The use of the Haddon injury analysis framework matrix India demonstrates the essential areas that need to be developed to reduce the road traffic crashes burden experienced in the country (Rustagi, Kumar, Norbu, & Vyas, 2017).

2.1.4 China

The rapid urbanisation, industrialisation and motorisation in China have eventuated a growing demand in road traffic. Unfortunately, the increase in road traffic in China has resulted in road accidents frequently occurring in China, characterising a great threat to public safety and health, and creating a serious problem for road traffic development (Wang & Wu, 2019). Motorisation in China has also led to the arrival of a motorised society and environmental pollution that has dramatically increased the possibility of road injuries and has been reported as a risk factor for trip and fall-related injury (Leilei & Pengpeng, 2019). The fatal and injury crashes in the urban setting account for 35.12% and 47% of the total crashes, respectively. Therefore, resulting in considerable losses in life and property.

In many countries, especially developing countries and major countries producing and using vehicles, such as China, road safety risks have raised major social concerns today (Wang & Wu, 2019). Currently, many BRICS countries such as China urgently need to find better strategies to improve their road safety. China's road safety still confronts considerable challenges with substantial road accidents and casualties, together with a high mortality rate. According to (WHO, 2013), the mortality in road accidents approximately accounted for 1 to 3% of the Gross Domestic Product (GDP) of China.

In China, traffic crashes are divided into extremely serious crashes, serious crashes, ordinary crashes, and light crashes. The crash classification only considers the number of injuries and deaths. The current crash chart for China as depicted by (Cao, Li, & Yu, 2020) is shown in the table below:

Table 2: The classification of traffic crashes in China

Class Classification	Casualty Situation
Slight Crash	1 to 2 minor injuries
Ordinary crash	1 to 2 serious injuries or more than 3 minor injuries
Serious crash	1 to 2 deaths or 3 to 10 serious injuries
Extremely serious crash	More than 3 deaths or more than 11 serious injuries or 1 death with more than 8 serious injuries or 2 deaths with more than 5 serious injuries

Source: (Cao, Li, & Yu, 2020).

One of the main limitations of measuring injury burden in China is a lack of reliable injury incidence data. with all vital registration and surveillance systems, issues such as misclassification and under-reporting of incidents and injury severities. However, strict internal data quality auditing methods such as the underreporting survey and other reviewing procedures at different levels (county, precinct, provincial, and national), including crosschecking using multiple sources based on the electronic surveillance system management platforms, have been implemented to continuously improve the quality of the data. Therefore, there is a need for perfecting the existing training, implementation, and assessment of data quality control measures and should be reinforced for all staff at all levels of institutions involved in the data collection processes of these two systems. Second, data sharing among researchers, both domestic and international, should be encouraged.

2.2 Africa

In the last decades, the African continent has experienced rapid urbanisation, resulting in an increase in motorization on the continent. Road crashes have been one of the leading causes of death and disabilities amongst African countries. The Road Safety research is limited in low-and middle-income countries particularly in Africa. Road traffic injuries constitute a major health and development problem the world over but especially in the African Region (World Health Organisation (WHO) Africa, 2020). Africa is still developing and has a number of challenges when it comes to road safety and accident rates.

In Cameroon, the management of injury is especially challenging, owing to limited resources and complex cultural contexts (Mefire, Mballa, Kenfack, Juillard, & Stevens, 2013).To put it into context, police inquiries are not systematically performed in Cameroon as post-mortem analysis is regarded a cultural taboo and is usually rejected by relatives of victims of injuries. In addition, there is no pre-hospital transport and management system in the region. Given this scarcity of data sources, the best currently available resource is hospital-based information. (Mefire, Mballa, Kenfack, Juillard, & Stevens, 2013) notes that the establishment of a formal trauma registry, has potential to improve the quality and comprehensiveness of injury surveillance data, in Cameroon. There is a gap in the information regarding traffic injuries because the police attend to road traffic crashes or have information reported to them. There are some road crashes that are not reported to the police; specifically crashes involving "vulnerable road users" like cyclists, motorcyclists and pedestrians, including victims who have mild injuries (Eric, Zipporah, Joseph, Jared, & Elizabeth, 2011). Additionally, a small number of police officers have received medical training hence, injury severity is classified into one of only three broad categories: slight, serious or fatal stresses (Eric, Zipporah, Joseph, Jared, & Elizabeth, 2011). There is room for more formal training of police officers on determining traffic injury severity at the site of crashes.

In Nigeria, RTIs have been identified as a major public health problem, but there are no pragmatic approaches to combat this problem (Onyemaech, 2020). Despite Nigeria being the most populous country in Africa, there is insufficient data on road traffic injuries in the region. Injuries from motorcycle crash and pedestrian injuries (open vehicle injuries) being more severe in road crashes. This is a trend in developing countries where pedestrians and motorcyclists sustain severe traffic injuries (Onyemaech, 2020).

In the Gambia, injuries to pedestrians, bicyclists, and motorcyclists have become inevitable without an appropriate safety infrastructure. Furthermore, the recovery from injury is further challenged for individuals who are injured in countries with underdeveloped trauma system. The Gambia does not have a national emergency ambulance service or an emergency number to call when an injury event occurs (Sanyang, et al., 2017). A number of key services that assist in traffic injury response are still lacking.

Road traffic crashes information in Ghana is recorded using a standard crash form. The form contains information about the nature of the crash, the location, the vehicle(s) and casualties involved in the crashes. (National Road Safety Commission (NRSC), 2016) of Ghana also emphasises how each police crash report should include details from some surviving crash victims, witnesses, and a report by vehicle examiners from the Driver and Vehicle Licensing Authority (DVLA), a sketch of the crash, post-mortem report(s) from the hospital in the case of fatal crashes and a general report by the investigator summarizing the facts surrounding the crash. The information collected by the police is coded and recorded in computers Micro-computer Accident Analysis Package (MAAP, windows version) software developed by the Transport Research Laboratory (TRL), UK, for storage and further analysis.

Botswana also uses the MAAP system to capture road crash data from accident report forms. Since 2010, the MAAP system in Botswana incorporates georeferencing which assist in determining crash rates and fatality rates in order to determine crash hot spots on the road and to determine the trends of crashes on road. On the other hand, the (National Road Safety Commission (NRSC), 2016) notes shortfalls in recovery, which are that the crash database is subject to some measure of under-reporting which includes both non-reporting and under-recording. There is an opportunity for technology to assist in improving data collection and collecting accurate information.

3 Injury Severity Scoring

3.1 Traffic Injury Severity

There is an upwards trend of 50% of trauma deaths in LMIC occur in the prehospital setting (Chandran, Hyder, & Peek-Asa, 2010). The survival of trauma patients has been linked to the quality of the care, the severity of the injury and the time from injury to ultimate care. (Singh, Gupta, Garg, & Gupta, 2011) explains that trauma score systems aim to translate the severity of injury into a number. These scores facilitate physicians to translate different severity of injuries into a "common language". The ideal scenario would be to reduce these deaths before they reach the hospital, by precisely identify injury severity to prepare physicians for receiving trauma patients. (Manoochehry, Vafabin, Bitaraf, & Amiri, 2019) references how trauma deaths are classified into different groups groups. The groups are classified in Table 3 below:

Table 3: Classification of trauma deaths

Group Number	Description
Group one (50%)	Consists of patients who die at the scene (often because of severe vascular injury or major head trauma.
Group two (30%)	Includes patients with hospital admission who die within the first hours of admission called "golden hour". The deaths of this group are usually because of major head, thorax or abdominal trauma.
Group three (20%)	Includes those who die at a later time (usually due to multi-organ failure or sepsis).

The deaths of the last groups can be reduced by accurately determining the injury severity before patients reach the hospital and the use of speedy and efficient treatment methods. There is a limitation of comprehensive and quality data sources for injury in low and middle-income countries. Provided the available resources and economic climates of countries, numerous methods of determining injury severity have been developed around the world to assist medical professionals and emergency care workers, to ascertain injuries sustained from traumatic events such as road traffic injuries. The primary treatment failures for trauma patients lean towards errors and delays during the first phases of hospital assessment and care. Determining the severity of an injury has become paramount in treating trauma patients.

Injury severity assessments are essential, as seriously injured patients have the greatest chance of survival at a trauma centre. The Global Status Report on Road Safety 2018 compiled by the WHO, states that in order to minimise the consequences and severity of road traffic injuries, there is need to improve the crash response. Inadequate patient evaluation can result in underestimation of injury severity, which is a common threat in low- and middle-income countries due to lack of radiographic, intra-operative or autopsy data. The burden of RTIs has been concerningly high in developing countries. However, the registry-based data sets available from SSA and other low-income countries do not accurately reflect the true incidence and proportion of RTIs due to systematic under-reporting, which is estimated to be as high as 50% in some LMIC (Vissoci, et al., 2017).

Specialists have developed a wide range of scoring systems for the purpose of triage in prehospital care and to evaluate care outside and inside hospitals. Triage is the process of quickly examining patients who are taken to a hospital in order to decide which ones are the most seriously ill and must be treated first (Cambridge Dictionary, 2020). Severity scoring systems are generally based on physiological parameters (such as respiratory rate, blood pressure and consciousness level), anatomical injuries or a combination of these two (Lichtveld, Spijkers, Hoogendoorn, Panhuizen, & van der Werken, 2008).

There are over 50 injury severity scoring systems published for the classification of trauma patients (Singh, Gupta, Garg, & Gupta, 2011). The significant number of scoring systems suggest not only the demand for such scoring systems but also their shortcomings to meet all conditions. The methods discussed in this section are the scores generally used in low-and middle-income countries.

3.2 Trauma Scores and Triage systems in South Africa

Trauma scoring systems have been used to aid clinicians' decision making and to allow for a more objective approach. The prehospital triage systems in South Africa are generally simple and different from region to region, however, they are categorised in four groups usually colour coded. The systems in use at selected South African ambulance training colleges are presented in Table 4 below.

Table 4: EMS triage criteria as instructed at colleges throughout South Africa

College	Red (P1)	Yellow (P2)	Green (P3)	Blue (Dead)
Cape Technikon, Cape Town	Primary Survey compromised	Maintaining own Primary Survey. Injury/illness requires treatment within 60 minutes	Injury/illness that should not compromise the Primary Survey within 60 minutes	The obviously dead
Wits Technikon, Gauteng	Primary Survey compromised	Maintaining own Primary Survey. Injury/illness requires treatment within 60 minutes.	Injury/illness that should not compromise the Primary Survey within 60 minutes	The obviously dead
DTI, Natal	Life-threatening emergencies	Non-life-threatening emergencies requiring hospital treatment.	Minor injury/illness. Walking wounded	The obviously dead
Lebone Ambulance College (Pretoria)	Treatable life-threatening injuries/ illness	Serious non-life-threatening injuries.	Minor, easily managed injury/ illness that may not require Ambulance transportation	The obviously dead
Natal Ambulance College	Life-threatening Emergencies	Seriously injured patients	Moderate injuries	The obviously dead
EMS College, Cape Town	Primary Survey is compromised or an injury that will lead to permanent disability	Maintaining own Primary Survey. Injury/illness requires treatment within 60 minutes.	Injury/illness that will not compromise Primary Survey within 60 minutes	Mortal injury

Source: (B Gottschalk, et al., 2006).

Discrepancies in triage appear when personnel of differing levels of medical experience and qualifications classify patients, as there are no clear definitions of 'unstable' physiology. Without objective clinical parameters, such variations in patient assessment are inevitable. (B Gottschalk, et al., 2006) mentions that, triage must be rapid to undertake whilst being easy to use.

The current system of triage fulfils both these criteria but lacks sensitivity and specificity (as well as consistency).

The discussion below is aimed at understanding and exploring the current scoring systems in South African hospitals and how we can apply that to road accidents to predict mortality in patients.

Triage in South Africa for RTIs

The ideal triage tool would comprise of the following characteristics:

- Primarily identifies patients with life-threatening conditions;
- Requires minimal training;
- Easy to use;
- Able to process many patients quickly;
- Provides information regarding services and waiting times;
- Determines appropriate treatment area in the emergency department;
- Decreases waiting area congestion;
- Provides continuity between the roadside (ambulance) and emergency units and
- Encompasses trauma and medical cases (GOTTSCHALK, 2004).

The need for a standardised system of triaging emergency medical and trauma presentations in South Africa is apparent. The complex nature of triage tools currently used in the developed world makes them unsuitable for South African purposes. Many of the physiologically based systems are too complex for triage use (essentially designed for research purposes or ICU settings) or focus on one particular area of emergency (e.g. trauma).

3.2.1 Kampala Trauma Score (KTS)

The computation and performance of severity scoring systems require diagnostic tools which are difficult to assess provided the resource limitation in developing countries. To achieve better accuracy in determining injury severity in developing countries, in 1996, the Kampala Trauma Score was developed in Uganda. The KTS uses a combination of physiological and anatomical scores. The Kampala Trauma Score has been used in a number of countries in Africa to determine the severity of traffic injuries in the country. This severity scoring instrument was initially developed as alternative to other scoring tools to simplify injury severity and accurately establish the trauma severity in low- and middle-income countries. The KTS was developed as a method to cater for developing countries with limited resources (Weeks, et al., 2014).

The KTS is a simplified score for resource-limited countries, and it reflects age, systolic blood pressure (SBP), respiratory rate (RR), patient age, number of serious injuries and neurologic status. Table 5 shows the Kampala Trauma Score system

Table 5: Kampala Trauma Score

	Description	Score
A	**Age (in years)**	
	5-55	1
	<5 or >55	0
B	**Systolic Blood Pressure on admission (mm Hg)**	
	More than 89 mm Hg	2
	Between 89-50 mm Hg	1
	Equal or below 49 mm Hg	0
C	**Respiratory rate on admission (breaths/minute)**	
	0-29/minute	2
	30+	1
	< or = 9/minutes	0
D	**Neurological Status**	
	Alert	3
	Responds to verbal stimuli	2
	Responds to painful stimuli	1
	Unresponsive	0
E	**Score for serious injuries**	
	None	2
	One injury	1
	More than one	0
Kampala Trauma Score total = A+B+C+D+E		
Possible range is 5-16		
5- Most Severe		
16 – Least severe is a perfect score on all variables		

Source: (Weeks, et al., 2014).

There is utility in using the KTS to predict mortality in trauma patients, however, there are peculiarities of the injury scoring system in which it necessitates the collection of data elements that are not routinely included in many trauma registries (Laytin, et al., 2015).

In South African context, the KTS could be used as a triage tool for emergency health care personnel to determine decision-making regarding individual injured patient's needs. This could be easier to implement in South Africa as it is used in resource-limited countries. The KTS is simple to apply in road crashes' emergency situations because it does not require a lot of information.

3.2.2 Glasgow Coma Scale (GCS)

The Glasgow Coma Scale was presented in 1974 aiming at standardizing assessment of degree of consciousness in head injured patients (Matis & Birbilis, 2008). It is as a method for determining objectively the severity of brain dysfunction and coma six hours after the occurrence of head trauma

(HT) (Teasdale & Jenette, 1974). The three characteristics of behaviour are individually measured—motor responsiveness (M), verbal performance (V), and eye opening (E). The Glasgow Coma Scale scores are shown in Table 6.

Table 6: Glasgow Coma Scale with scores

Verbal Responses		
Score	**Parameter**	**Response**
5	Oriented	Knows who, where, when; year, season, month
4	Confused Conversation	Attends & responds but answers muddled/wrong
3	Inappropriate words	Intelligible words but mostly expletives or random
2	Incomprehensible speech	Moans and groans only – no words
1	None	
Motor Response		
6	Obeys commands	Exclude grasp reflex or postural adjustments
5	Localises	Other limb moves to site of nailbed pressure
4	Withdraws	Normal flexion of elbow or knee to local painful stimulus
3	Abnormal flexion	Slow withdrawal with pronation of wrist, adduction of shoulder
2	Extensor response	Extension of elbow with pronation and adduction
1	No movement	
Eye Opening		
4	Spontaneous	Indicates arousal, not necessarily awareness
3	To speech	When spoken to – not necessarily the command to open eyes
2	To pain	Applied to limbs, not face where grimacing can cause closure
1	None	

Source: (Jennett, 2005).

A GCS score of 13-15 is considered a mild head injury, a 9-12 is moderately severe head injury and a score of 3-8 is severe head injury. It is important to note that patients should be communicated by the three individual scores (E, V, M) and never by total sum. If eye or verbal response cannot be evaluated, this should be indicated by recording as “c” (Eye closed) or “T” (Intubated) respectively (Agrawal, 2018). A person who is alert, oriented and fully conscious the GCS will be E4 M6 V5 (15/15) and the decrease in the score is suggestive of deterioration in the state of consciousness. The GCS shortcomings include disregarding the other predictive factors like patient’s age, history of lucid interval, papillary reactions, eye movements, pulse rate, blood pressure, respiration and initial CT findings etc (Agrawal, 2018). In addition, the GSC does not apply to children and a patient can record the best motor response (M6), but the patient could be monoplegic, hemiplegic or tetraplegic. More drawbacks of the GCS include verbal response being triggered by other factors such as hypoxia, shock, intoxication, language problem and alcohol intoxication. Furthermore, the verbal response cannot be prompted in intubated or tracheostomised patients. Intubation to put a tube into a hollow organ or tube-shaped structure in the body in order to keep it open, remove liquid for testing, or give a drug (Cambridge Dictionary, 2020) and a tracheostomy is an operation to open the trachea (= the tube that carries air from the throat to the lungs) through the front of the neck if it becomes blocked for any reason (Cambridge Dictionary, 2020).

The GCS is mostly effective in determining the severity of head injuries – was originally developed as an easy scoring method for cerebral functions in patients with head trauma; however, it falls short when compared to other scoring systems that are effective for injuries of the entire body. In regard to South Africa, the GCS is too specified and complex for determining mortality from road accidents. The GCS alone is note effective alone that is why it used as an element of the revised trauma score.

3.2.3 Modified Early Warning Score (MEWS)

The Modified Early Warning Score (MEWS) is a validated scoring system based on physiological parameters that can be calculated at the patient's bedside, parameters that are routinely measured (pulse, blood pressure, heart rate, level of consciousness and temperature), which has been successfully used to assess medical inpatients at risk of clinical deterioration. The MEWS scores are shown in Table 7 below.

Table 7: Modified Early Warning Score (MEWS)

Score	3	2	1	0	1	2	3
Respiratory rate (min^{-1})		≤8		9–14	15–20	21–29	> 29
Heart rate (min^{-1})		≤ 40	41–50	51–100	101–110	111–129	> 129
Systolic BP (mmHg)	≤ 70	71–80	81–100	101–199		≥ 200	
Urine output (ml/kg/h)	Nil						
Temperature (°C)		≤ 35	35.1–36	36.1–38	38.1–38.5	≥ 38.6	
Neurological				Alert	Reacting to voice	Reacting to pain	Unresponsive
The scores for each parameter are recorded at the time that observations are taken. If the total is 4 or more then the ward doctor is informed.							

Source: (GARDNER-THORPE, et al., 2006).

MEWS does not necessitate complex, costly equipment to assess any of the parameters and is reproducible. The scoring system can be used to promptly identify patients who are clinically deteriorating and who need urgent intervention (Naidoo, et al., 2014). However, the MEWS score is flawed with respect to triage in that it has a medical bias. Trauma patients (who are generally previously healthy and therefore have more physiological reserve) may have severe injuries and yet have a low MEWS score if they have stable physiology (B Gottschalk, et al., 2006).

This scoring system forms the basis of the South African Triage System, which is currently being used by a number of hospitals in South Africa.

3.2.4 Triage and Early Warning Score (TEWS)

The South African Cape Triage Group adapted the MEWS to include mobility and trauma parameters in response to local emergency department needs. This resulted in the development of the Triage Early Warning Score (TEWS) (Naidoo, et al., 2014). The addition of both a mobility parameter and trauma factor were felt necessary to increase the severity score for trauma cases. This modified MEWS score was renamed the Triage Early Warning Score (TEWS) (B Gottschalk, et al., 2006).

The Triage and Early Warning Score (TEWS) is a component in the South African Triage Scale (SATS); it includes documentation of mobility, respiratory rate, heart rate, systolic blood pressure, temperature, level of consciousness, and presence of injury. The adult TEWS scores are presented in Table 8. However, the presence of injury is not further defined and there's no clarity on the extend of the injury in SATS. The two other components of the SATS include a list of clinical discriminators and the final opinion of a senior health professional. Accordingly, the SATS is based on physiological measures and symptoms, in combination with the presence of injury and level of mobility. The triage scale has been implemented outside of South Africa, for example, in Ghana as well as other sites by Medecins Sans Frontieres (MSF) (Aspelunda, et al., 2019).

Advantages of TEWS:

- It requires a comprehensive assessment of the ill patient early on.
- It translates parameters that can be easily measured in both the prehospital and emergency unit setting, by even the basic trained levels of staff, to an equally easy and interpretable triage score.
- It encompasses both trauma and medical patients, in both the prehospital and emergency unit setting.
- By using this system, health care providers will be able to classify patients, similarly, allowing for transparency of communication between medical staff and with more appropriate transfer of patients.

Table 8: The adult Triage Early Warning Score

Physiological characteristics	Adult triage score (> 12 years, > 150 cm)						
	3	2	1	0	1	2	3
Mobility				Walking	With help	Stretcher or immobile	
Resting Rate (min^{-1})		< 9		9–14	15–20	21–29	≥ 29
Heart Rate (min^{-1})		< 40	41–50	51–100	101–110	111–129	≥ 129
Systolic Blood Pressure (mmHg)	< 70	71–80	81–100	101–199		≥ 200	
Temperature (degrees C)		Feels cold or under 35		35–38.4		Feels hot or over 38.4	
AVPU		Confusion		**A**lert	Reacts to **V**oice	Reacts to **P**ain	**U**nresponsive
Trauma				No	Yes		

AVPU: A = alert, V = responding to voice, P = responding to pain, U = unconscious

(Source: (Naidoo, et al., 2014)

In a study by (Naidoo, et al., 2014) in Durban, increased TEWS was considerably associated with increased admission to hospital and in-hospital death. Therefore, calculation of the TEWS early on in the patient's presentation in the emergency room can serve as a baseline and help to categorise patients at risk of clinical deterioration. In another study conducted in Khayelitsa by (Aspelunda, et al., 2019), in comparison of trauma cases from gunshot wounds, the KTS was specifically developed for low-resource countries and proved to be useful in predicting mortality in trauma patients; however, KTS was not superior to TEWS.

3.2.5 South African Triage Scale (SATS)

The South African Triage Scale (SATS) was introduced in 2006 and was adopted in hospitals in Africa and some low- and middle-income Asian countries (Soogun, et al., 2017). SATS derives from the Cape Triage Score (CTS) which was developed by the Cape Triage Group (CTG), a Joint Division of Emergency Medicine of the University of Cape Town (UCT) and University of Stellenbosch, as a triage system suitable for local use. The SATS consists of three elements involving the documentation of the Triage Early Warning Score (TEWS), the discriminator list, and the final opinion of a senor healthcare professional.

The CTS is a 5-colour coding system comprising the following:

- TEWS score
- Discriminators
    - Mechanism of injury
    - Presentation
    - Pain
    - Senior health care professional's discretion.

There are three versions: adult, child, and infant. The adult version is intended for patients aged over 12 years, or taller than 150 cm. The infant version is for children under three years, or less than 95 cm, and the child version is for other children (three to 12 years, 95 to 150 cm). The SATS adult version is presented in Table 9.

Table 9: SATS (Adult Version)

	RED	ORANGE	YELLOW	GREEN	BLUE
TEWS	>7	6 to 7	3 to 5	0 to 2	Dead
MOI	Entrapment	Impact – high	Impact – low		
SYMPTOM ***Respiratory*** ***Cardiac*** ***Vascular*** ***AVPU*** ***Neuro*** ***Psych*** ***Ortho*** ***Burn*** ***Medical*** ***GIT*** ***Obs and gynae***	Asthma – status Unresponsive Seizure – current Burn – face/ inhalation Hypoglycaemia < 2.2	Asthma Chest pain Haemorrhage – arterial Responds to Pain Seizure – post-ictal Psychosis/Aggression Limb – threatened Dislocation – major joint Fracture – open Burn > 20% Overdose/Poisoning Haemetemesis – fresh blood Pregnancy – trauma	Responds to Voice Dislocation – minor joint Fracture – closed Burn – minor Abdominal pain Pregnancy – PV bleed	Alert	
ANATOMY	Trauma – airway	Trauma – head/neck torso Evisceration	Trauma – limb		
PAIN		Severe	Moderate	Mild	
	~~~~~~~~Senior health-care professional's discretion~~~~~~~~				
"trauma" = penetrating/blunt "torso" – chest/abdo/back					

There is a five-step approach used for SATS:

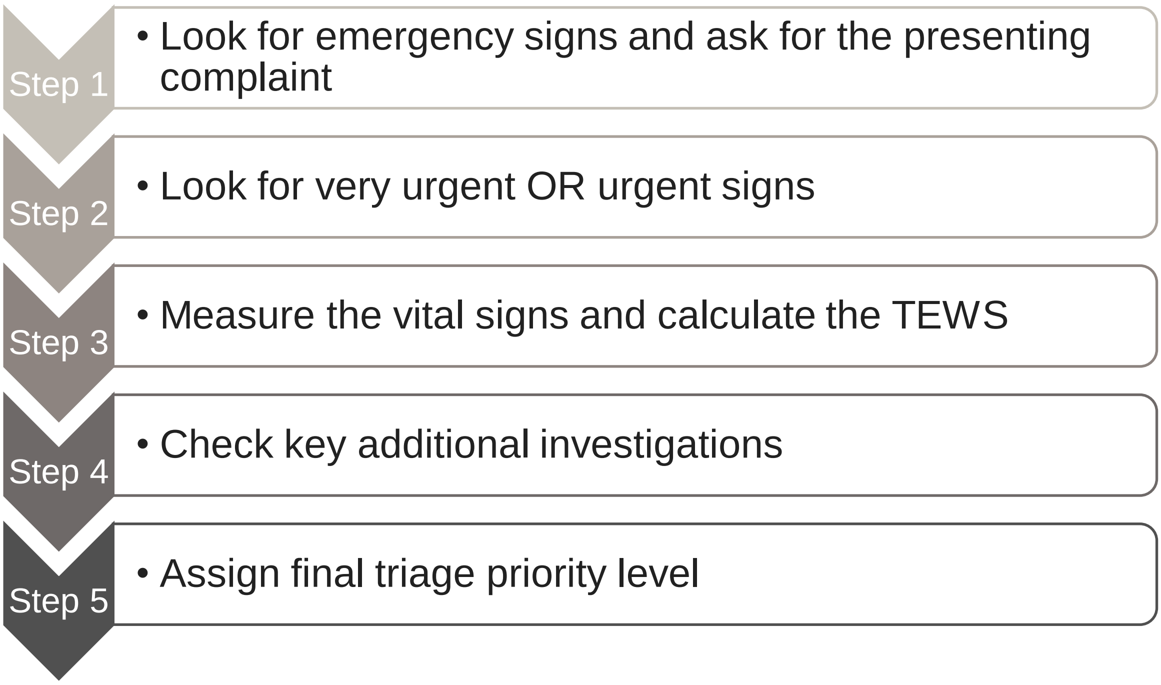


Figure 1: SATS five step approach

Source: (Western Cape Government, 2012)

The SATS process of prioritising patients is highlighted in Appendix B. The priority colours and management of patients is highlighted in the Figure 2 below:

Priority COLOUR	Target time	Management
RED	IMMEDIATE	Take to the resuscitation room for **emergency** management
ORANGE	< 10 mins	Refer to majors for **very urgent** management
YELLOW	< 1 hour	Refer to majors for **urgent** management
GREEN	< 4 hours	Refer to designated area for non-urgent cases
BLUE	< 2 hours	Refer to doctor for certification

Figure 2: SATS priority levels and target times to be seen with-in

(Source: (Western Cape Government, 2012).

SATS is fully supported by the Western Cape provincial Department of Health. In addition, even inexperienced staff can learn the triage system following only a brief teaching period. SATS is simple yet robust triage instrument for use in the South African medical field. The SATS has been found useful specifically in trauma settings. The TEWS alone and the TEWS as part of the SATS is not traditionally seen as an injury severity score as it encompasses all Emergency Centre presentations, which have also not been validated to be used as such. However, TEWS has been shown as a good predictor of 29-day trauma-related mortality (Aspelunda, et al., 2019).

3.2.6 Revised Trauma Score (RTS)

The Revised Trauma Score (RTS) is a standard physiological scoring tool used in trauma settings and research in both high income countries and low-and middle-income countries. The RTS was developed as a triage tool and the use has evolved into being a predictor of the outcome of traumatic injuries (Gabbe, Cameron, & Finch, 2003). The RTS is used by ambulance crews to classify patients in terms of the severity of their injuries. The scoring system is also used by emergency services to determine the severity of an injury, and to make rational decisions about the choice of hospital (Lichtveld, Spijkers, Hoogendoorn, Panhuizen, & van der Werken, 2008).

This scoring method is based on physiologic parameters of systolic blood pressure (SBP), respiratory rate (RR) and the level of consciousness according to the Glasgow Coma Scale (GCS). The coded value is multiplied by a weighting factor derived from regression analysis of the database (Yates, 1990). Higher score highlights a lower severity of injury. The RTS ranges from 0 (no signs of life) to 12 (normal vital functions). The three parameters which are circulation, respiratory rate and consciousness each provide a maximum of four points to the overall score, to total 12. The RTS is an independent predictor of mortality in hospitals. The rule presently applied in ambulance care stresses that ambulance crews should immediately establish patients' RTS at first examination at the scene of the accident, including upon arrival at the hospital's emergency room (Lichtveld, Spijkers, Hoogendoorn, Panhuizen, & van der Werken, 2008). The Revised Trauma Score codes are presented in Table 10.

Table 10: Revised Trauma Score

Revised Trauma Score	Coded Value	x Weight = Score
Respiratory rate (breaths/min):		
10-29	4	
>29	3	
6-9	2	x 0.2908 =_________
1-5	1	
0	0	
Systolic blood pressure (mm Hg):	**Coded Value**	**x Weight = Score**
>89	4	
76-89	3	
50-75	2	x 0.7326 = _________
1-49	1	
0	0	
Glasgow coma scale:	**Coded Value**	**x Weight = Score**
13-15	4	
9-12	3	
6-8	2	x 0.9368= _________
4-5	1	
3	0	

Source: (Yates, 1990).

Each physiologic parameter is measured and then coded. The code is multiplied by a weight and the total of the different coded parameters give the Revised Trauma Score.

The RTS emphasises on the Glasgow Coma Scale having more significance to compensate for major head injury without multisystem injury or major physiological changes. In addition, the RTS has been validated in many studies and is able to combine with other scoring systems to precisely determine injury severity. According to a study by (Heydari-Khayat, Sharifipoor, Ali Rezaei, Mohammadinia, & Darban, 2012), the revised trauma score is helpful in classification of traumatic patients and prediction of their mortality. It can act as a tool to facilitate the prioritization of the care of traumatic patients with different intensities especially when dealing with lack of resources, however, application of other tools may enhance the value of mortality prediction in traumatic patients and decrease the likelihood of error in prioritizing and care of patient.

The RTS is a well-established predictor of mortality in trauma populations, however, there is a lack of definitive evidence supporting its use as a primary triage tool and as a predictor of outcomes other than mortality (Gabbe, Cameron, & Finch, 2003). In high income countries, the RTS is also limited, considering a number of severely injured patients are intubated or sedated prior to hospital arrival, resulting in inaccurate measurements of GCS and respiratory rate (Laytin, et al., 2015). These apprehensions are irrelevant in developing countries with inadequate pre-hospital care.

RTS is combined with the HTI-ISS to obtain the Trauma Score and Injury Severity Score (TRISS), which is used to assess patients' chances of survival in the hospital. The RTS seems to be an effective predictor of mortality in traumatic brain injuries, but performed poorly in the setting of penetrating injuries (Aspelunda, et al., 2019).

In the process of developing the Cape Triage Score, the RTS was assessed as an effective triage tool and has been successfully used to identify seriously injured trauma cases presenting to an emergency unit (systolic hypotension was found to be a particularly useful sign of serious injury). However, this score may not include sufficient clinical parameters to differentiate between medical cases. Which makes it unsuitable for the South African road crashes patients. The RTS will have to be used in conjunction with other severity scoring methods to accurately predict patient mortality.

3.2.7 Injury Severity Score (ISS)

The Injury Severity Score (ISS) relies on the six-point ordinal scale Abbreviated Injury Scale (AIS) on six body regions. Abbreviated Injury Scale (AIS) is an anatomical-based coding system created by the Association for the Advancement of Automotive Medicine (AAAM), first published in 1969. The AIS is based on several dimensions of severity, including energy dissipation, extent of tissue damage, threat to life, permanent impairment, and treatment period, to assess the severity of the anatomical injury on a six-point ordinal scale ranging from minor (1), moderate (2), serious (3), severe (4), critical (5), to un-survivable injury (6).

The Injury Severity Score is described as the sum of squares of the highest AIS score in the 3 most severely injured body regions. The intention is to identify the highest AIS in each body region. The nine anatomic regions assessed are head, face neck, thorax, abdominal and pelvic contents, spine, upper extremity, lower extremity and external. The score only allows one injury per body region. The scoring system only considers the most severe injury in a body region with multiple injuries. The ISS ranges from 1 to 75 and the maximum ISS score of 75 ($5^2 + 5^2 + 5^2$) is allocated to a patient with AIS of 6. It shows a relationship with morbidity, length of hospital stays and mortality.

The limitations of the ISS include the inability to account for multiple injuries to the same body region. The ISS typically excludes some injuries from the measurement process, because it only accounts for a one injury per body region. The limited total number of contributing injuries is three body regions. The ISS assigns the same weighting of injuries to each body region equally and disregards head injuries. The ISS has significant drawbacks in the assessment of multiple musculoskeletal injuries. For a patient who has sustained multiple fractures, the ISS will only factor in the most severe axial skeleton injury, and may underestimate the overall severity by ignoring other significant skeletal injuries indicated (Sutherland, Johnston, & Hutchison, 2006).

The ISS a heterogeneous score and reduces its ability to predict mortality. (Laytin, et al., 2015), indicates that there are considerable logistical demands accompanying implementing the ISS, including detailed medical records, extensive radiographic studies and autopsy results, which are often unavailable in resource-poor setting such as developing countries.

For the South African context, a study by (Aspelunda, et al., 2019) states that the ISS is an anatomical scoring system that requires an intricate knowledge of anatomical and radiological findings to determine the severity of the injury. These findings are often too detailed to incorporate during emergency situations.

3.2.8 New Injury Severity Score (NISS)

The New Injury Severity Score (NISS) was developed intending to overcome the shortcomings of the Injury Severity Score. This scoring system was a response to the limitations that the ISS exhibited such as excluding certain injuries from measurement process, because considers only a single injury per body region.

(NISS) results from the sum of the squares of the three most severe injuries (highest AIS scores) irrespective of the body region. This scoring methodology allows for a more suitable rating of the severity of a patient sustaining multiple injuries. The NISS takes full account of multiple injuries in the same body region, particularly musculoskeletal injuries (Sutherland, Johnston, & Hutchison, 2006). This scoring system has been shown to increase the seeming injury severity in multiple trauma, and to accurately predict more short-term mortality. Primary studies suggest NISS more accurate predictor of trauma mortality than the ISS, particularly in penetrating trauma.

Other researchers demonstrated NISS superior to the ISS as a measure of tissue injury in predictive models of post-injury multi-organ failure. The NISS was superior to the ISS at predicting mortality outcome. It also further supports the finding that NISS is a more robust purely anatomical injury severity scoring system as it identifies the three most severe injuries, regardless of body zone injured (BAIRAGI, 2016). For South Africa, the NISS would still require personnel with medical background to assess the severity on an injury.

3.2.9 Trauma and Injury Severity Score (TRISS)

The Trauma and Injury Severity Score (TRISS) was developed in 1981 and is based on a combination of other injury severity scoring systems, namely the RTS, ISS and age of the patient. The TRISS includes both anatomical and physiological components. It is a method used to quantify probability of survival in relation to severity of injury (Singh, Gupta, Garg, & Gupta, 2011). The score estimates the probability of a patient surviving based on a regression equation which encompasses:

- Age of Patient;
- Type of injury – penetrating vs blunt;
- Anatomical Injury – ISS; and
- Physiological Status – RTS.

The case study in Figure 3Figure 3: Case Study on calculation of TRISS. shows how the TRISS is calculated after a pedestrian is hit by a vehicle. The Case study highlights how they initially measured the patient’s sustained injury severity using the Revised Trauma Score that incorporates blood pressure, respiratory rate and the Glasgow coma score. The injuries are assessed using AIS and the probability of survival is calculated.

Case Study

A 65 year old pedestrian is knocked down, sustaining head abdominal , and leg injuries. On arrival in the accident and emergency department he has a Glasgow coma score of 9, respiratory rate of 35 beats/min, and systolic blood pressure of 80 mm Hg. Computed tomography shows a small subdural haematoma with swelling of the left parietal lobe. This is a major laceration of the liver but no other intra-abdominal injury. Radiographs of the lower limbs shown displaced fracture through both upper tibias.

Revised trauma score:

Glasgow coma score = 9; coded value 3 x weighting 0.9368	= 2.8104
Respiratory rate = 35, coded value 3 x wieghting 0.2908	= 0.8724
Blood pressure = 80, coded value 3 x wieghting 0.7326	= 2.1987
RTS	**= 5.8806**

Injury severity score:

	Abbreviated injury score
Subdural haematoma (small)	4
(Parietal lobe swelling)	(3)
Liver laceration (major)	4
Upper tibial fracture (displaced)	3

ISS = $\mathbf{4^2+4^2+3^2=41}$

Probability of survival

Coefficients from major trauma outcome study database for blunt injury b_0 = 1.2470
b_1 = 0.9544
b_2 = 0.0768
b_3 = 1.9052

b = - 1.2470 + (0.9544)(5.8806) – (0.0768((41) + (-1.9052((1)))))

$$P_s = \frac{1}{1+e^{abs(b)}} = 0.3343$$

Probability of survival = 33%

Figure 3: Case Study on calculation of TRISS.

Source: Scoring Systems for Trauma (Yates, 1990).

The shortcomings of this score stem from pre-existing precursor problems already observed with the ISS and the RTS. Analogous to the RTS, the TRISS intubated patients have respiratory responses (RR) and verbal responses are not available. The TRISS does not account for pre-existing conditions of the patient such as cardiac diseases, amongst others. Moreover, TRISS is obviously not available to ambulance personnel in the pre-hospital phase (Lichtveld, Spijkers, Hoogendoorn, Panhuizen, & van der Werken, 2008).

The study conducted by (Aspelunda, et al., 2019) in a public hospital in Cape Town, on the comparison on triage scores, TRISS has been previously documented as a having limitations and underperformance and the score favours poor prognostic outcome in head and neck injuries and fails to distinguish between different types of penetrating injuries.

3.2.10 International Classification of Diseases Injury Severity Score (ICISS)

The International Classification of Disease, Ninth Edition (ICD-9) codes are the basis of the International Classification of Disease Injury Severity Score (ICISS) score. ICISS is a widely used method of determining injury severity around the world. It is purely an anatomical score. The ICISS employs survival risk ratios (SRRs) which are calculated by dividing the number of survivors in each ICD-9 code by the total number of patients with the same ICD-9 code. It includes all injuries. The ICD-9 codes are easily available and do not necessitate training or expertise.

The ICISS scoring method has been noted to be better at mortality predictability compared to the ISS. ICISS outperforms the ISS in predicting other outcomes of interest (e.g. hospital length of stay, hospital charges).

The method has not replaced other methods when it comes to outcome analysis and it is used worldwide regardless of income of the country.

4 Abbreviated Injury Scale

The Abbreviated Injury Scale (AIS) classifies each injury in every region of the body according to its relative importance on a six-point ordinal scale from 1 (minimum) to 6 (maximum) provided in Table 11.

Table 11: Abbreviated Injury Scale

AIS Code / Scale	Description
AIS 1	Minor injury
AIS 2	Moderate injury
AIS 3	Serious injury
AIS 4	Severe injury
AIS 5	Critical injury
AIS 6	Maximum injury /un-survivable

Source: Transport Research Laboratory, 1997

AIS scores are based on the ‘threat to life’ associated with an injury. For injuries with an AIS score of 6 the probability of death is 100% which makes them virtually un-survivable. An AIS-Code of 9 is used to describe injuries for which not enough information is available for assessing its severity. The AIS scale is a measurement tool for single injuries.

The Maximum Abbreviated Injury Scale (MAIS) refers to the single highest AIS score assigned to a casualty and is used to assess the overall severity of various injuries. For instance, if a patient has one injury with an AIS score of 2 (moderate) and another with an AIS of 4 (severe) then their MAIS score is 4. A casualty that sustains an injury with a score of 3 or higher on the AIS is classified as clinically seriously injured (MAIS3+) (UK Department of Transport,2015).

Due to some shortcomings of the MAIS, the Injury Severity Score (ISS) is used together with MAIS to score the crash serious injury severity. MAIS and ISS are directly calculated from the AIS.

Injury Severity Score (ISS)

Injury Severity Score refers to an anatomical scoring system that provides an overall score for patients with multiple injuries. The Injury Severity Score was developed to predict mortality. Each injury is assigned an AIS allocated to one of six body regions (Head, Face, Chest, Abdomen, Extremities including Pelvis, External). Only the highest AIS score in each region is used. The three most severely injured regions have their Abbreviated Injury Scale score squared and summed to produce the Injury Severity Score.

ISS score = $A^2 + B^2 + C^2$

- Where A, B and C are the AIS scores of the three most severely injured ISS body regions;
- ISS scores range from 1-75;
- If an injury is assigned an AIS of 6 (maximum injury) automatically has the ISS score of 75.

Example:

Region	Injury description	AIS	Square top three
Head & Neck	Cerebral Contusion	3	9
Face	No injury	0	
Chest	Flail Chest	4	16
Abdomen	Minor Contusion of Liver	2	
	Complex Rupture Spleen	5	25
Extremity	Fractured femur	3	
External	No injury	0	
		Injury Severity Score (ISS)	**50**

Source: Trauma Scoring Systems, 2016

4.1 Determination of AIS

AIS may be directly coded by trained medical staff, based on the available medical files regarding the injuries of the patient. It can also be derived from the International Classification of Diseases 9th or 10th revision (ICD-9 or 10 classification) (IRTAD Group, 2011). This coding allows inpatients whose injuries have been caused by a road traffic accident to be identified. The patient's ICD-9 or 10 codes are converted to AIS scores using a lookup file. The AIS scores associated with the patient's injuries are then used to determine whether the patient has sustained a MAIS3+ injury (UK Department of Transport,2015).

IRTAD Group, 2011 highlights methods to determine the AIS in IRTAD countries provided in Table 12.

Table 12: Methods used to determine AIS in IRTAD countries

IRTAD country	Method used to determine the AIS
Czech Republic	▶ Derived from the diagnosis expressed in ICD-10 classification
Denmark	▶ Determined by medical doctors.
France	▶ The medical diagnosis is directly coded into the Abbreviated Injury Scale (which includes the AIS severity score). This is done by a trained physician; the diagnosis is the result of all text injury descriptions from all hospital departments the person has attended.
Japan	▶ Determined by medical doctors. The Japan Association for the Surgery of Trauma periodically trained medical doctors and other relevant staff on AIS coding.
Netherlands	▶ AIS is derived from the ICD-9 by use of ICDmap90 (Johns Hopkins 2002).
Spain	▶ Software is used to convert ICD9-CM codes to AIS using the following software: • ICDMAP (Johns Hopkins University). • ICDPIC: (Boston College Department of Economics). This is a STATA module to provide methods for translating ICD9-CM diagnosis codes into standard injury categories and/or scores.

United Kingdom	► Mapping from ICD-10 codes using coding developed by University of Navarra (European Centre for Injury Prevention, University of Navarra, Algorithm to transform ICD-10 codes AIS and ISS, version 1 for SPSS. Pamplona, Spain 2006).
United States	► AIS derived either from ICD-9 codes provided by hospitals, or, in the case of NASS-CDS, by forensic analysts reading the case file.

4.1.1 The International Classification of Diseases and related Health Problems (ICD)

The International Classification of Diseases and related Health Problems is published by the World Health Organisation (WHO) and provides codes to classify diseases as well as signs, symptoms and external causes of injury or disease. Every health condition can be assigned to a unique category and given a code, of up to six characters. The International Classification of Disease (ICD) system was created for the accurate tracking of diseases within a population.

History of ICD

According to Hirsh et.al (2016), the ICD was developed in the year, 1703 where a categorization of 10 distinct classes of diseases was developed. These classes were further divided into 2400 unique diseases. In 1853 a system of classifying causes of mortality that could be used across borders and languages was developed. This was the origin of what became known as the "International List of Causes of Death. Across time, this "International List of Causes of Death" was updated and published about once per decade in 1900, 1910, 1920, 1929, and 1938.

In 1948, the World Health Organization (WHO) took charge of the classification system, which was expanded the following year to include coding for causes of morbidity in addition to mortality. The system was renamed as the International Classification of Disease system. Under the support of the WHO, ICD development continued in a more predictable manner.

The ICD has been revised and published in a series of editions to reflect advances in health and medical science over time.

The International Classification of Diseases is currently in its tenth edition (ICD10), although the ninth edition is still widely used (ICD9). The causes of accidents are classified, and traffic injuries have a specific code in the section "external cause" as well as codes to describe the injury (Department of Infrastructure and Regional Development, 2016).

ICD10 and its application in South Africa

The South African ICD-10 Coding Standards defines an ICD-10 as a diagnostic coding standard that was adopted by the National Department of Health in 1996 as the national standard for South Africa. ICD-10 was implemented in July 2005 under the auspice of the National ICD-10 Implementation Task Team which is a joint task team between the National Department of Health and the Council for Medical Schemes. ICD-10 remains the responsibility of the National Department of Health. It is a diagnostic coding standard that is accepted by all the parties as the coding standard of choice.

There are different versions of ICD10. In South Africa, the WHO 'vanilla' version of ICD-10 is used, with a few local code additions. The SA ICD-10 Master Industry Table (MIT), Jan 2014 (containing all WHO Corrigenda updates until January 2014), is the only official reference list for ICD-10 codes appropriate for use in South Africa (PHISC, 2019).

The American ICD-10-CM (Clinical Modification), the new diagnostic coding system replacing ICD-9-CM in America is also referred to as ICD-10. This is a very different set of codes, although based on ICD-10, a clinical modification has been done and some of the codes now have up to 7 characters (Format: XXX.XXXX). These are not appropriate for use in South Africa. The WHO also have a version of ICD-10 (2016) available in electronic look-up format on their website, but this does not contain the South African local codes or specific rules for use of the code set in South Africa. An updated 2016 set of ICD-10 books is available from DENOSA – please note that there are some new codes in this edition which are not in the SA ICD-10 MIT January 2014 (PHISC, 2019).

The ICD-10 codes are mainly used by health practitioners, hospitals (private and public) and insurances.

Table 13 below show of the ICD-10 code options for trauma injuries of multiple body regions.

Table 13: ICD-10 code options for trauma injuries of multiple body regions

Trauma Code	Description
T07-T07	Injuries involving multiple body regions
T14-T14	Injury of unspecified body region
T15-T19	Effects of foreign body entering through natural orifice
T20-T25	Burns and corrosions of external body surface, specified by site
T26-T28	Burns and corrosions confined to eye and internal organs
T30-T32	Burns and corrosions of multiple and unspecified body regions
T33-T34	Frostbite
T36-T50	Poisoning by, adverse effect of and underdosing of drugs, medicaments and biological substances
T51-T65	Toxic effects of substances chiefly nonmedicinal as to source
T66-T78	Other and unspecified effects of external causes
T79-T79	Certain early complications of trauma
T80-T88	Complications of surgical and medical care, not elsewhere classified

Source: ***https://www.icd10data.com/ICD10CM/Index/I/Injury***

In Figure 4 below the ICD-10 code options for trauma injuries of multiple body regions are indicated and how the level of detail can be indicated with the numbering system that was developed.

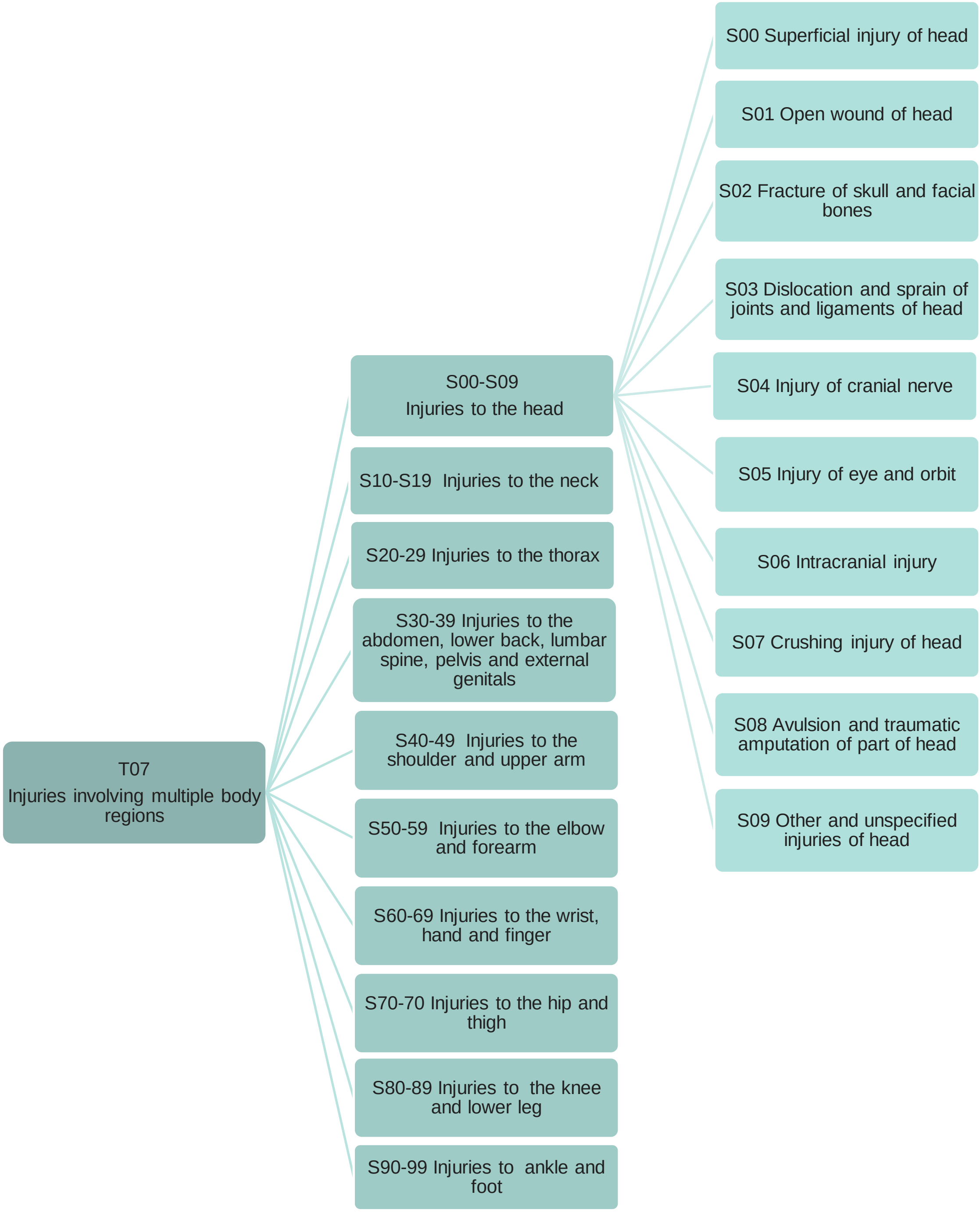


Figure 4: Depiction of ICD-10 code options for trauma injuries of multiple body regions

Source: ***https://www.icd10data.com/ICD10CM/Index/I/Injury***

4.1.2 Adopted AIS /MAIS Formula

The adopted MAIS formula adopted in United Kingdom is provided below:

$MAS3+_{y, g,a,u}^{UK} = (MAS3+_{y,g,a,u}^{Eng} / C_{y,g,a,u}^{Eng}) * C_{y,g,a,u}^{UK}$

where:

- $MAS3+_{y, g,a,u}^{UK}$ is the number of MAIS3+ casualties in the UK for a given year, gender, age group and road user type to be estimated;
- $MAS3+_{y, g,a,u}^{Eng}$ is the number of MAIS3+ casualties in the UK for a given year, gender, age group and road user type;
- $C_{y,g,a,u}^{Eng}$ is the number of police reported seriously and slightly injured casualties in the UK for a given year, gender, age group and road user type;
- $C_{y,g,a,u}^{UK}$ is the number of police reported seriously and slightly injured casualties in the UK for a given year, gender, age group and road user type.

Source: (UK Department of Transport,2015)

This MAIS 3+ formula can be tailored for South Africa as well depending on the availability of data**.**

4.2 Application of AIS/ MAIS

In 2013, the EC (European Commission) adopted a new common definition of seriously injured road victims. All road victims with a MAIS score of 3 or more (MAIS3+) are considered as severely injured. In 2014, the European High-Level Group on Road Safety issued a directive that all European Union member states are requested to estimate their number of critically injured persons, defined as those with injuries rated as Maximum Abbreviated Injury Scale of 3 or more (MAIS3+) Table 14 presents the EU countries using AIS/MAIS/ISS scoring and Figure 1 graphically illustrate OECD countries (including EU countries) using the same scoring.

Table 14: EU and other developed countries that have adopted the MAIS/ISS/ICD-9 or 10

Country	MAIS	ISS	ICD 9/10	Comment
Austria	Yes			Since 2015, the number of people seriously injured with a Maximum Abbreviated Injury Scale of three or more (MAIS3+) injuries is being reported. The MAIS estimate was derived from the International Classification of Diseases-10 (ICD-10) hospital data on road traffic victims.
Belgium	Yes	Yes		Belgium is able to express the severity of injuries in terms of MAIS, but also in terms of other severity scales such as ISS (Injury Severity Scale) , NISS (New Injury Severity Scale) and ICISS (ICD-9- Based Injury Severity Score)
Czech Republic	In Progress			The severity value based on the Maximum Abbreviated Injury Scale (MAIS3+) or more is not in general use and its future utilisation is still to be decided.
Denmark	In Progress			Denmark is working on a process to convert diagnosis codes into AIS and Maximum Abbreviated Injury Scale (MAIS) scores.

Country	MAIS	ISS	ICD 9/10	Comment
Finland	Yes			Since 2014, police and hospital data have been linked to facilitate correct estimation of the number of serious injuries (defined as MAIS3+).
France	Yes			The French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR) estimates the number of people in road traffic crashes with a MAIS3+ injury.
Germany	Yes			In Germany, the number of MAIS3+ is extrapolated from data from the German In-Depth Accident Study (GIDAS)
Greece	No			Data on the severity of injuries are not systematically collected by hospitals; only road fatalities are properly reported. Consequently, it is not currently possible to have data on serious injuries according based on the Maximum Abbreviated Injury Scale (MAIS)
Hungary	Yes			Hungary is expected to fulfil requirements of the data reporting method on MAIS3+ serious injuries from 2018. The preparation process related to the implementation of MAIS3+ method as well as related legal steps have started recently.
Iceland	In Progress			Iceland is working towards using the Maximum Abbreviated Injury Scale of three or more (MAIS3+) to define a serious injury.
Ireland	In Progress			The Road Safety Authority (RSA) is working with the Health Intelligence Unit (HIU) of the Health Services Executive to develop an appropriate methodology for reporting on serious injuries with a Maximum Abbreviated Injury Scale of 3 or more (MAIS3+)
Italy	Yes			The first estimate of the number of serious injuries, based on hospital discharge data, has been calculated for the years 2013 and 2014 using a conversion table to translate data from the International Classification of Diseases (ICD-9CM).
Lithuania	In progress			The concept of using the Maximum Abbreviated Injury Scale of three or more (MAIS3+) for a serious injury is under discussion.
Luxembourg	Yes			Luxembourg is currently not using the Maximum Abbreviated Injury Scale of three or more (MAIS+3) to define serious injuries
Netherlands	Yes		Yes	Serious injuries are based on the data from both police and hospital databases, and the definition of a serious injury is based on the MAIS score, not the police report. Based on this method, the Netherlands is also able to report on MAIS2 or MAIS3+ injuries.
Norway	No			Currently in Norway the Maximum Abbreviated Injury Scale of three or more (MAIS3+) is not used to classify serious injuries, but this will hopefully be the case in the future when such injury data is provided by hospitals.

Country	MAIS	ISS	ICD 9/10	Comment
Poland	No			Poland does not yet rate serious injuries as having a score of three or more on the Maximum Abbreviated Injury Scale (MAIS3+).
Portugal	Yes		Yes	Since 2010, Portugal has started estimating serious injury data according to the new European Union definition (MAIS3+). The method used is based only on hospital data
Serbia	Yes			Preparation for use of MAIS 3+ scale for injuries has been planned for 2017
Slovenia	Yes		Yes	With support from the Institute of Public Health, the Traffic Safety Agency has started work on estimating the number of persons injured with a Maximum Abbreviated Injury Scale of 3 or more (MAIS3+) using ICD 10
Spain	Yes		Yes	Since 2011 Spain has reported the number of MAIS injured based on hospital data. The methodology has recently been revised, in the framework of the work that European Member States are conducting with the aim of having harmonised data in the CARE database.
Sweden	Yes			Sweden is therefore not using the score of three or more on the Maximum Abbreviated Injury Scale (MAIS3+) as a formal measure of a seriously injured person. MAIS3+ is, however, used to calculate the number of persons seriously injured and is therefore an important part of the Swedish efforts to increase the level of road safety.
United Kingdom	Yes			Linking HES data from hospitals and police data for England gives a better understanding of injury severity and outcomes. Around 47% of the police-reported seriously injured casualties for England alone are matched to the hospital records. As part of this linkage, the Department for Transport has been working with the Maximum Abbreviated Injury Scale (MAIS) to rate the severity of injury crashes.

Source: IRTDA, 2017

Systems regarding the estimation of the number of MAIS3+ casualties differ between countries, and differences in methodology affect the estimate. In a survey conducted on 26 countries in June 2016, by Safety Cube, the 17 responses from countries highlighted that: two countries applied correction factors to police data, nine countries used only hospital data, four countries used linked police and hospital data, and two countries applied a combination of methods. In the UK, they conducted a study on an overview and commentary of reported road casualties in 2019. The section on the evaluation of the accuracy of severity and injury based MAIS3+ serious injuries revealed that out of the MAIS3+ clinically serious casualties linked with STATS19 (software which enables access to and processing of Great Britain's official road traffic casualty database), 82% were successfully identified as serious in the injury-based approach. However, this not the same for some of the other countries because they are still in the process adopting the MAIS3+ and use difference methods to determine MAIS3+. It is important to note that to ensure that police reporting rates are stable, and one should have access to at least a sample of good-quality hospital data to estimate reliable correction factors, which is a process for the other countries using MAIS3+. In addition, it is not known to what extent differences in methodology influence the estimated number of MAIS3+ casualties this makes benchmarking MAIS3+ amongst countries very challenging.

Figure 5: OECD countries using MAIS

4.3 Assessment of MAIS3+

The European Commission developed three main guidelines for the determination and assessment of serious injuries (MAIS 3+) namely:

- Using matched / paired police and hospital data;
- Using only hospital data; and
- Applying the correction factor to police data.

4.3.1 Matched / linked police and hospital data

The matched/linked police and hospital data is the predominantly used MAIS3+ assessment method. Linking police and hospital data identifies the greatest number of MAIS3+ casualties. This method (police and hospital data linkage) is used to identify records within different data sources that refer to the same person using data such as name, address, sex, date of birth and/or age; and event dates (such as the dates of a crash and of a hospital admission). However, this method has its short comings. The general short comings of the matched / paired police and hospital data, identified in EU countries are as follows:

- Linking hospital and crash databases require necessary approvals from ethics committees and permissions from data custodians which is a hurdle;
- Privacy provisions limit access to data identifying individuals in health and transport sectors at both the jurisdiction and at the national level;
- This process is time consuming and costly, and in some jurisdictions, there may be additional requirements (for example, specific legislation can prohibit sharing of identifying data);
- Jurisdictions would need to use consistent matching criteria so injury data could be aggregated into national totals. It may also be difficult for all jurisdictions to fund the on-going process to provide routine injury data needed for NRSS reporting.

4.3.2 Hospital only data

The availability of hospital data is essential for the determination of the number of serious traffic injuries. The availability of this data countrywide can assist to determine the number of MAIS ≥ 3 traffic injuries. The main source for hospital data is the Hospital Discharge Register (HDR). This register includes all hospitalisations for diseases and injuries from all or some public and/or private hospitals of the country. Hospital data is not always available for institutions that are responsible for the determination of the number of serious traffic injuries. Such data is often extremely protected by legislation because it includes very sensitive information such as individual health (Perez et.al (2017).

Other countries use the length of hospital stay (LHS) classification to officially report injury severity e.g. Portugal. Hospital data is another method for assessing the MAIS 3+. This method is essential for determining the number of serious road injuries. In order to identify road traffic injuries in hospital data it is necessary to know the police definition. Even when applying correction factors to police data, at some point one needs hospital data.

The selection of MAIS 3+ road traffic casualties from hospital data can be done in several ways namely:

- Applying different in and exclusion criteria to select road casualties from hospital data;
- Direct AIS coding and the use of various recoding tools for the determination of MAIS.

All methods that are used to determine the number of serious traffic injuries (MAIS ≥ 3) are in one way or another based on a selection of hospital records therefore it is very imperative to have clear criteria for inclusion or exclusion of hospital data in order to establish the population of people injured in traffic accidents.

Figure 6 presents the determination of inclusion and exclusion criteria for hospital data.

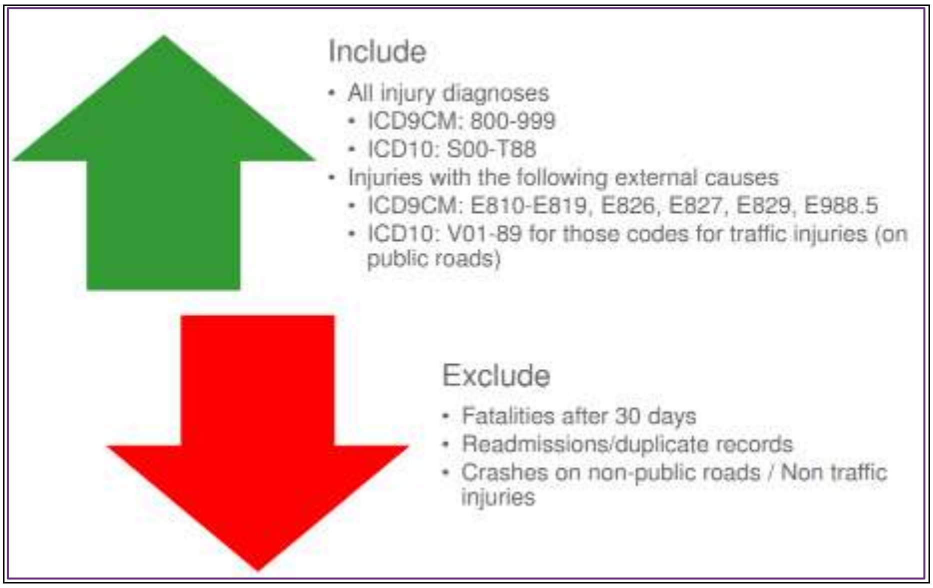


Figure 6: Inclusion and exclusion criteria for hospital data records

Source: (Van den Berghe, 2016)

4.3.2.1 Hospital data and the use of ICD codes

Hospital Discharge Register (HDR) use the International Statistical Classification of Diseases published by the World Health Organization (WHO) to codify the main diagnosis, or reason for the hospital admission. Hospital data are coded with ICD-9 or ICD-10, and, based on those codes, road traffic injuries have to be identified.

- According to the ICD9-CM (clinical definition) the definition of road traffic injuries includes any traumatic injury including codes from **800 to 959**. These include fracture, dislocation, sprain, internal injury, open wound, injury to blood vessel, superficial injury, contusion, crushing, foreign body entering through body orifice, burns, and injury to nerves and spinal cord. Although it also includes late effects of injury and complications of physical trauma (**905 to 909, 958 and 959**) they automatically are excluded when obtaining severity.
- Countries using ICD10 codes for traumatic injury include codes S00-T88. According to ICD10, “A transport accident is any accident involving a device designed primarily for or being used at the time primarily for, conveying persons or goods from one place to another”.
- ICD10 distinguishes between “Traffic accident” (any vehicle accident on a public road) and “Non-traffic accident” (any vehicle accident occurring entirely somewhere other than on a public road), so it is possible to consider traffic injuries occurring on public roads, as has been proposed by international organizations, and to exclude non-traffic casualties. That information is explained in the external codes. General recommendations are to include codes **V01-89** and/or weighting -correcting for non-public road- for non-traffic injury codes.

4.3.2.2 Direct coding and conversion of ICD codes to AIS

The AIS level of injuries can be determined in several ways. AIS coding can be direct, i.e. when traffic victims are registered, an AIS code is given for each of the injuries (or diseases) of the casualty. AIS coding can also be derived from other injury coding systems, like the International Classification of Diseases in its several versions (ICD, ICD9-CM, ICD10, etc). In cases of large hospital databases, AIS cannot be coded directly but derived using a convertor algorithm. There are several conversion tools available for recoding ACD codes into AIS codes namely: ICDmap90, ICDpic, DGT, European Centre for Injury Prevention Algorithm (ECIP), AGU and Association for the Advancement of Automotive

Medicine (AAAM). The use of any of these conversions tools results to ICD-derived AIS values (Perez et.al 2019).

4.3.2.2.1 Limitation of recoding

Recoding as opposed to direct coding has its shortcomings. This may result in some information getting lost or not available so that a best match is selected in the recoding tool.

Perez et.al 2019 highlighted the main factors that might affect the final estimates when deriving MAIS3+from ICD codes using conversion tools:

- AIS versions and ICD-derived AIS compared to direct AIS coding;
  Countries use different versions of AIS. To make data from different countries more comparable to each other, the number of MAIS3+ casualties should be multiplied by a factor 0.89 when injuries are coded in AIS1990 or AIS1998 instead of AIS2005 or AIS2008;
- Conversion tools for converting ICD codes into AIS codes (this is a mixed effect of the ICD-version, the tool and the AIS version that it converts to) – in relation to the gold standard of direct AIS coding;
- Using a limited number of injuries per casualty for the MAIS score;

  In some countries, only a limited number of diagnoses is recorded per casualty. This results in an underestimation of the number of MAIS3+ casualties, as the second or third recorded injury can be more severe than the first diagnosis. The following weighting factors should be applied:
  - 1.28 in case of 1 diagnosis recorded;
  - 1.11 in case of 2 diagnoses; and
  - 1.05 in case of 3 diagnoses.

- Using 4 digits instead of the full ICD injury code when deriving AIS

  ICD codes are truncated in some countries. The use of truncated codes leads to a less reliable selection of MAIS3+ casualties. In cases where truncated ICD codes are used, it is recommended that ICDpic and AAAM10 tools are not used. The following weighting factors should be used to correct for truncated ICD codes in combination with other ICD to AIS recoding tools:
  - 1.06 in case of ICDmap90
  - 1.03 in case of ECIP/Navarra
  - 1.11 in case of AAAM9

A study undertaken by Safety Cube in 2019, investigated the use of the various conversion tools from ICD to AIS based on hospital data (2011, 1993-2013) for Spain and Netherlands. The study recommended that conversion tables for AAAM10 tool be adapted to better-fit European needs. Other tools – ICDmap90, DGT, and AAAM9- result in an underestimation of MAIS3+casualties between 3% and 10%.

The AAAM10 tool can be adopted to convert South African ICD10 codes to MAIS 3+ as well provided the ICD 10 codes used in South Africa are available in the AAAM10 mapping tool.

4.3.3 Applying the correction factor to police data

Police data is the main source of information for road safety statistics. There is growing awareness on the need to also collect and analyse other sources of collision data for road safety analysis. Short comings of using police data only include:

- Under reporting that is, when collisions are not reported to the police or when some collisions are reported but not recorded;
- The degree of injury recorded in police records, may include incorrect information.

The above-mentioned short comings require that a correction factor be included to the police data.

There are other cases where the police correction factor can also be utilized, when:

- Hospital data for the entire country and/or every year is not available;

- ► Hospital data become available too late.

The police correction factor can be applied when using hospital data as follows:

- ► Since police and hospital registration differs between different groups of casualties, multiple correction factors should be derived. First step would require that the effects of various variables (such as year, type of road user, age, gender) on the ratios of police/hospital registrations be modelled. This will determine the variables that significantly affect these ratios and subsequently the correction factors.
- ► Use a sample of hospital data (previous years and/or part of the country) to derive correction factors that can subsequently be applied to recent police data from the entire country.
- ► Update correction factors on a regular basis. Correction factors are likely to vary over time and place.

4.4 Pros & cons of using AIS/ MAIS & ISS systems

A brief review in scoring systems published by Mashhad University of Medical Sciences in 2014, highlights the pros and cons of the widely used scoring systems AIS/MAIS and ISS.

Pros and Cons of the AIS/MAIS system

- ► Pros:
  - Viewed as an independent system of the injury scoring;
  - Relatively simple to calculate;
  - Achievable for many countries and hence potential of comparability across countries;
  - Limited under registration (almost all MAIS3+ victims are hospitalized).
- ► Cons:
  - Non-linear correlation with the risk of mortality in multiple traumas;
  - Access to hospital data is problematic for some countries, due to privacy regulations;
  - Specific legislation can prohibit sharing of identifying data in some countries;

Pros and Cons of the ISS system

- ► Pros:
  - It integrates anatomic areas of injury in formulating a prediction of outcomes.
  - It is a reliable tool for the mortality prediction, and it has been tested in various trauma databases;
  - It has acceptable results in prediction of the final outcomes in combination with other scoring systems;
  - The results from this system are independent of race and sex and it can be applied to all ages
- ► Cons:
  - It is difficult to calculate during initial evaluation and resuscitation in emergency room;
  - It is difficult to predict outcomes for patients with severe single body area injury;
  - A decrease in discrimination power of the ISS in scores greater than 15 (ISS>15) and older ages

5 South African context

5.1 Data collection in South Africa

All road traffic crashes need to be reported to the nearest SAPS station by the persons involved and an Accident Report (AR) form completed within 24 hours. In the case where law enforcement attends to the scene of the collision, the AR form will be completed by them. A representative from the Traffic Department collects the AR forms from all SAPS stations on a weekly basis. This information is then entered into an excel spreadsheet and monthly report to the province on all crashes. Quarterly reports are compiled by the Traffic departments and sent to the RTMC, mandated to collate all traffic crash data and report annually.

Unfortunately, not all data is accurate, and the location of the crash scene is poorly noted. In terms of traffic injury, even though the names and contact details of the drivers and passengers and pedestrians are captured, only 4 categories for traffic injury status exists, namely no injuries, slight injuries, serious injuries and fatal injuries. The classification is too broad. Broadly speaking a no injury will be a person that did not receive any medical assistance on the scene. Slight injury will be a person that received medical attention but was not admitted to hospital. Serious injury is usually classified as somebody who overnights in hospital. Fatal injuries are those who were dead on arrival, died on the scene or arrived deceased at the hospital. There is a discrepancy between the SAPS fatal data and those from the Medical Research Council (MRC) who collates data from all hospitals. The discrepancy is relatively small.

The SAPS AR form is shown in Appendix A.

There is no description on what is classified as serious, slight or no injury but only a note stating when a seriously injured person is killed within 6 days that the AR form needs to be updated.

Emergency services also have a four-code system for classifying injured persons, namely the Ambulance triage coding as presented in Table 15 below.

Table 15: Ambulance triage coding

Colour coding	Urgency	Mobility	Physiology	Priority
Red	Immediate	Stretcher	Unstable	P1
Yellow	Urgent	Stretcher	Stable	P2
Green	Stable	Walking	Stable	P3
Blue	Dead	n/a	n/a	P4

5.1.1 Proposed new code structure to align AR and Triages Codes

Colour Code	Urgency	Mobility	Physiology	Priority Code	NCDMS Categories
Red	Immediate	Stretcher	Unstable	P1	Serious Injuries
Yellow	Urgent	Stretcher	Stable	P2	Serious Injuries
Green	Stable	Walking	Stable	P3	Slight Injuries
Blue	Dead	n/a	n/a	P4	Killed
Pink	n/a	Walking	n/a	P5	No Injuries

5.1.2 Gaps of adopting MAIS3+ and ISS for South Africa

The following gaps have been identified:

- ► Only fatal injuries are captured by RTMC and not the full spectrum of crashes
- ► SAPS AR form and ambulances only use 4 scales of injury
- ► Key to implementing an advanced method of traffic injury data is to link SAPS information (ultimately compiled by RTMC) with hospital data
- ► South Africa have two major types of hospitals, namely private hospitals with electronic patient records and government hospitals with varying levels of accuracy and electronic patient data.
- ► The MRC ultimately compiles records of road traffic crash fatalities.
- ► The discrepancy between the RTMC and MRC annual statistics exists due to SAPS only capturing fatalities on their AR forms up to 6 days and the MRC up to 30 days. Yet the discrepancy is less than 10% and much better when compared to the rest of the continent.
- ► The following challenges exist with the AR form as Data Source for injuries
    - SAPS supply incomplete of AR forms
    - Illegibility of AR forms due to poor handwriting and Language skills
    - Form collection from SAPS stations by Provinces and Local Authorities
    - Multiple 3rd Party System used by some province and Local Authorities
    - AR form storage
    - Major Backlogs in capturing of Data by provincial Authorities
    - Provincial Infrastructure and insufficient number of capturing staff
    - Traffic Law Enforcement and SAPS incorrect injury assessments on scene
- ► The alignement of triage codes to MAIS3+ and EMS Triages codes will be a major challenge
- ► A post crash data collection process needs to be implemented to align captured crash data with MAIS3+ for analysis and assesment.
- ► The implementation of a traffic injury system is dependent on the assistance of other stakeholders.
- ► There is no other country in Africa that has already implemented either a MAIS3+ or ISS.

6 Conclusions

In this Literature Review we have investigated the Abbreviated Injury Scale (AIS) and in particular MAIS3+ and its development, and also looked at other methods of collecting traffic injury data collection, like the Injury Severity Scale (ISS). MAIS is an injury-based approach in an attempt to move away from subjective based approach to an objective injury-based approach. Police officers make a subjective assessment of whether an injury is serious or slight and the objective of injury-based approaches, like MAIS, will allow police officers to select a category.

We have found that many countries have been expanding on the basic classification of no injury, slight injury, serious injury and fatal injury (as is still used in South Africa). AIS, how it expanded to MAIS and MAIS3+ (classification for serious injuries) and the countries that use these methods as well as the pros and cons were discussed.

Some countries use a combination of traffic injury classification/reporting methods.

6.1 Road Traffic Injuries in Developing Countries

One of the problems faced by developing economies is there is limited institutional capacity to generate smart and effective traffic regulations and the resources needed to provide a safe infrastructure for the incoming flow of new vehicles and to adjust both urban and suburban space to match the higher demand for motorisation. India and China, the most populous countries, do not have reliable vital registrations systems (Bhalla, Sharaz, Abraham, Bartels, & Yeh, 2011). Pedestrians and motorcyclists suffer severe injuries in road traffic accidents compared to other road transport users. In Russia, India, Nigeria and in Kenya, the crashes involving motorcyclists, cyclist and pedestrians are not even recorded. There is gap in the information collected regarding pedestrians and smaller vehicles in developing countries.

One of the vital propositions in developing countries is to improve the availability of reliable and comprehensive data on the road injury burden to target and monitor progress towards reducing deaths due to road injuries (India State-Level Disease Burden Initiative Road Injury Collaborators, 2019).

Most attempts by developing countries to address the increasing incidence of road traffic injury is likely to be hampered by budget and institutional constraints and by a scarcity of accurate data on and continuous monitoring of the factors that influence road safety. However, there is emphasis on coordination of organisations such as police, policy makers at every level to help reduce the effects of RTIs. The improvement in technology such as traffic surveillance, data quality control and assessment to assist in improving the information available on road traffic crashes and injuries.

One of the vital propositions in developing countries is to improve the availability of reliable and comprehensive data on the road injury burden to target and monitor progress towards reducing deaths due to road injuries (India State-Level Disease Burden Initiative Road Injury Collaborators, 2019). Most countries have noted the inaccurate or missing data from police especially pertaining road traffic injuries.

6.2 Injury Severity Scoring in South Africa

In terms of injury severity scoring, concerns have been raised that purely physiologic injury scoring systems like RTS are inferior to those that also include anatomic or injury mechanism information (Laytin, et al., 2015). Physiologic scoring systems are not reliant on comprehensive anatomic evaluation and possibly provide a more feasible means of estimating injury severity in low- and middle-income countries using readily available clinic or administrative data.

RTS, KTS and ISS used in low-and middle-income countries are predominant compared to other injury scoring systems. However, in a study of lessons learned from Mumbai by (Laytin, et al., 2015) the ISS performed poorly compared to the KTS and the RTS. Missing and incomplete data limit the utility of RTS and KTS, nonetheless both injury scoring systems predict hospital mortality well when values were available. In the South African context, taking elements of the RTS and KTS such as when used to develop SATS, can assist in determining serious injuries pre-hospital. Table 16 highlights the score for a "serious injury" per severity score.

Table 16: Serious injuries per severity score

Scoring System	Serious injuries/Immediate attention	Comment
Glasgow Coma Scale (GCS)	3-8	Severe head injury
Modified Early Warning Score (MEWS)	>4	If the total is 4 or more then the ward doctor is informed.
Triage and Early Warning Score (TEWS)	>4	
Kampala Trauma Score	5	Most severe injury
South African Triage Scale (SATS)	>6	Orange and Red priority colours.
Revised Trauma Score (RTS)	3-10	A threshold of RTS < 4 has been proposed to identify those patients who should be treated in a trauma centre, although this value may be somewhat low.
Injury Severity Score (ISS)	48	AIS = 4 (severe, life threatening, survival probable) (4^2)* 3 =48

It is paramount to help raise the matter of what the optimal injury scoring system in South Africa, especially in cases where resources and accurate hospital records are a challenge. There are constraints which highlight the prevalent challenge of complete data collection for trauma registries in developing countries. Therefore, there is emphasis placed on the importance of simplified, context-appropriate measurements. The aim is to develop a scoring instrument that had to fulfil the requirements of being easy to use by all levels of prehospital providers, nursing staff and doctors - from the roadside through to the emergency unit.

All role players, from prehospital to the emergency units, must use a standardised system. Furthermore, trauma scoring systems are frequently validated within the setting they are developed in and perhaps, therefore, more context appropriate. It is important to note, some scores are validated only for trauma triage, whilst others are too detailed to be of roadside use. To find the perfect score to use in South Africa, there needs to be a score that is informative enough to properly determine the extent of injury and the medical needs of the patient and also the ease of use on the roadside.

Possibly the answer is in the merging of a simplified numerical scoring system into a standard (e.g. colour-coded) triage system; the basic ambulance coding would still be in place while definite physiological parameters would be incorporated to avoid misunderstanding and ensure continuity. There is lack of uniformity and continuity in triage processes in South Africa. A uniform national ambulance and hospital-based system would facilitate triage and treatment (B Gottschalk, et al., 2006). A tool that can best suit this would be using components of SATS and KTS, both require very few details and, KTS has been noted to properly predict mortality and death in a study by (Macleod, et al., 2007). SATS is used by several hospitals in South Africa in accordance with South African Triage Scale Manual, which shows how to determine injury severity. It is a response to a context appropriate system; however, it might require adaptation to suit road accident specific injuries.

Appropriate training in measuring essential physiological parameters and use of these measurements in determining correct scores would add value to patient care in emergency units. More work needs to be done through a formal process to train and certify pre-hospital care providers, ensuring access to quality emergency care and have speciality training pathways in emergency medicine and trauma surgery including national or subnational trauma registries in place (World Health Organization (WHO), 2018).

More work needs to be done through a formal process to train and certify prehospital care providers, ensuring access to quality emergency care and have speciality training pathways in emergency medicine and trauma surgery including national or subnational trauma registries in place (World Health Organization (WHO), 2018).

Systems regarding the estimation of the number of MAIS3+ casualties differ between countries, and differences in methodology affect the estimate. It is important to note that to ensure that police reporting rates are stable, and one should have access to at least a sample of good-quality hospital data in order to estimate reliable correction factors, which is a process for the other countries using MAIS3+. In addition, it is not known to what extent differences in methodology influence the estimated number of MAIS3+ casualties this makes benchmarking MAIS3+ amongst countries very challenging.

There is not yet a MAIS3+ nor an ISS system in Africa. South Africa will be the first country in Africa to implement, but the success will be dependent on the buy in of all stakeholders.

Table 17 below indicate a summary of the Injury Severity Scores discussed in the Literature review.

Table 17: Summary table of Injury Scoring Systems

Injury Scoring System	Description	Advantages	Disadvantages	Application
Trauma scores and triage systems	▶ Is a description of level of consciousness ▶ Primarily identifies patients with life-threatening conditions; ▶ Requires minimal training; ▶ Easy to use; ▶ Able to process many patients quickly; ▶ Provides information regarding services and waiting times; ▶ Determines appropriate treatment area in the emergency department; ▶ Decreases waiting area congestion; ▶ Provides continuity between the roadside (ambulance) and emergency units and ▶ Encompasses trauma and medical cases Examples: ▶ Kampala Trauma Score (KTS) ▶ Glasgow Coma Scale (GCS) ▶ Modified Early Warning Score (MEWS) ▶ Triage Early Warning Score (TEWS) ▶ South African Triage Scale (SATS) ▶ Revised Trauma Score (RTS)	▶ Primarily identifies patients with life-threatening conditions; ▶ Requires minimal training; ▶ Easy to use; ▶ Able to process many patients quickly; ▶ Provides information regarding services and waiting times; ▶ Determines appropriate treatment area in the emergency department; ▶ Decreases waiting area congestion; ▶ Provides continuity between the roadside (ambulance) and emergency units and ▶ Encompasses trauma and medical cases	▶ Description of level of consciousness but not detailed description of injuries	▶ EMS ▶ Emergency rooms ▶ Level of consciousness
Kampala Trauma Score	▶ Uses combination of physiological and anatomical scores. ▶ It reflects age, systolic blood pressure (SBP), respiratory rate (RR), patient age, number of serious injuries and neurologic status ▶ Predicts mortality in trauma patients	▶ A simplified score for resource-limited countries ▶ Used in a number of countries in Africa to determine the severity of traffic injuries in the country	▶ It necessitates the collection of data elements that are not routinely included in many trauma registries	▶ EMS ▶ Emergency rooms ▶ Level of consciousness
Glasgow Coma Scale (GCS)	▶ Method for determining objectively the severity of brain dysfunction and coma six hours after the occurrence of head trauma. ▶ Three characteristics of behaviour are individually measured—motor	▶ Accurately determines the severity of head injuries.	▶ Disregards the other predictive factors like patient's age, history of lucid interval, papillary reactions, eye movements, pulse rate,	▶ Emergency rooms ▶ Level of consciousness

Injury Scoring System	Description	Advantages	Disadvantages	Application
	responsiveness (M), verbal performance (V), and eye opening (E)		blood pressure, respiration and initial CT findings ▶ Does not apply to children and a patient can record the best motor response (M6), but the patient could be monoplegic, hemiplegic or tetraplegic. ▶ The verbal response cannot be prompted in intubated or tracheostomised patients ▶ Too specified and complex for determining mortality from road acciden	
Modified Early Warning Score (MEWS and Triage Early Warning Score (TEWS)	▶ Validated scoring system based on physiological parameters that can be calculated at the patient's bedside ▶ Parameters that are routinely measured (pulse, blood pressure, heart rate, level of consciousness and temperature) ▶ Forms the basis of the South African Triage System,	▶ Does not necessitate complex, costly equipment to assess any of the parameters and is reproducible ▶ It translates parameters that can be easily measured in both the prehospital and emergency unit setting, by even the basic trained levels of staff, to an equally easy and interpretable triage score ▶ It encompasses both trauma and medical patients, in both the prehospital and emergency unit setting ▶ By using this system, health care providers will be able to classify	▶ MEWS score is flawed with respect to triage in that it has a medical bias - Trauma patients (who are generally previously healthy and therefore have more physiological reserve) may have severe injuries and yet have a low MEWS score if they have stable physiology ▶ TEWS as part of the SATS is not traditionally seen as an injury severity score as it encompasses all Emergency Centre presentations, which have also not been validated to be used as such	▶ EMS ▶ Emergency rooms ▶ Level of consciousness

Injury Scoring System	Description	Advantages	Disadvantages	Application
		patients, similarly, allowing for transparency of communication between medical staff and with more appropriate transfer of patients ▶ TEWS has been shown as a good predictor of 29-day trauma-related mortality		
South African Triage Scale (SATS)	▶ Consists of three elements involving the documentation of the Triage Early Warning Score (TEWS), the discriminator list, and the final opinion of a senor healthcare professional ▶ TEWS score ▶ Discriminators • Mechanism of injury • Presentation • Pain ▶ Senior health care professional's discretion.	▶ SATS is fully supported by the Western Cape provincial Department of Health. ▶ It was developed for the South African context. ▶ Wildey used by a number of hospitals and emergency centres.		▶ EMS ▶ Emergency rooms ▶ Level of consciousness
Revised Trauma Score	▶ A standard physiological scoring tool used in trauma settings ▶ Scoring method is based on physiologic parameters of systolic blood pressure (SBP), respiratory rate (RR) and the level of consciousness according to the Glasgow Coma Scale (GCS) ▶ Emphasises on the Glasgow Coma Scale having more significance to compensate for major head injury without multisystem injury or major physiological changes	▶ Used by ambulance crews to classify patients in terms of the severity of their injuries. ▶ It can act as a tool to facilitate the prioritization of the care of traumatic patients with different intensities especially when dealing with lack of resources ▶ In the process of developing the Cape	▶ Application of other tools may enhance the value of mortality prediction in traumatic patients and decrease the likelihood of error in prioritizing and care of patient. ▶ There is a lack of definitive evidence supporting its use as a primary triage tool and as a predictor of outcomes other than mortality.	▶ EMS ▶ Emergency rooms ▶ Level of consciousness

Injury Scoring System	Description	Advantages	Disadvantages	Application
		Triage Score, the RTS was assessed as an effective triage tool and has been successfully used to identify seriously injured trauma cases presenting to an emergency unit (systolic hypotension was found to be a particularly useful sign of serious injury	▶ In high income countries, the RTS is also limited, considering a number of severely injured patients are intubated or sedated prior to hospital arrival, resulting in inaccurate measurements of GCS and respiratory rate	
ISS - Injury Severity Score (ISS)	▶ Injury Severity scores relies on the six-point ordinal scale Abbreviated Injury Scale (AIS) on six body regions. sum of squares of the highest AIS score in the 3 most severely injured body regions. ▶ requires an intricate knowledge of anatomical and radiological findings to determine the severity of the injury. These findings are often too detailed to incorporate during emergency situations. ▶ NISS was developed intending to overcome the shortcomings of the Injury Severity Score Examples ▶ Injury Severity Score (ISS) ▶ New Injury Severity Score (NISS) ▶ Trauma and Injury Severity Score (TRISS)	▶ It integrates anatomic areas of injury in formulating a prediction of outcomes. ▶ It is a reliable tool for the mortality prediction, and it has been tested in various trauma databases; ▶ It has acceptable results in prediction of the final outcomes in combination with other scoring systems; ▶ The results from this system are independent of race and sex and it can be applied to all ages	▶ It is difficult to calculate during initial evaluation and resuscitation in emergency room; ▶ It is difficult to predict outcomes for patients with severe single body area injury; ▶ A decrease in discrimination power of the ISS in scores greater than 15 (ISS>15) and older ages	▶ RAF ▶ Doctors and hospitals ▶ Research (road safety and Medical)
International Classification of Disease Injury Severity Score (ICISS)	▶ The international classification of disease (ICD) injury severity score (ICISS) is a tool used to determine injury severity . This score uses survival risk ratios (SRRs), empirically derived for each	▶ Detailed description of injuries and treatment ▶ System that is already used by doctors and hospitals	▶	▶ RAF ▶ Doctors and hospitals ▶ Research (road safety and Medical) ▶ Medical aid

Injury Scoring System	Description	Advantages	Disadvantages	Application
	unique ICD code, to estimate the mortality predictability. ▶ ICISS is a widely used method of determining injury severity around the world. It is purely an anatomical score. The ICISS employs survival risk ratios (SRRs) which are calculated by dividing the number of survivors in each ICD-9 code by the total number of patients with the same ICD-9 code. It includes all injuries. The ICD-9 codes are easily available and do not necessitate training or expertise. ▶ The ICISS scoring method has been noted to be better at mortality predictability compared to the ISS. ICISS outperforms the ISS in predicting other outcomes of interest (e.g. hospital length of stay, hospital charges). ▶ The method has not replaced other methods when it comes to outcome analysis and it is used worldwide regardless of income of the country. te a patient's probability of survival. ▶ Detailed description of injuries and treatment ▶ System that is already used by doctors and hospitals ▶ Used in many countries around the world	▶ No additional training needed ▶ South Africa diverted by adding a few codes that might not be part of the conversion tool, because you can add your own codes for your own country ▶ Used in many countries around the world and in the medical industry		▶ Insurance
AIS	▶ Abbreviated Injury Scale (AIS) is an anatomical-based coding system created by the AAAM. ▶ Abbreviated Injury Scale (AIS) classifies each injury in every region of the body according to its relative importance on a six-point ordinal scale from 1 (minimum) to 6 (maximum). ▶ AIS scores are based on the 'threat to life' associated with an injury. For injuries with an AIS score of 6 the probability of death is	▶ Viewed as an independent system of the injury scoring; ▶ Relatively simple to calculate; ▶ Achievable for many countries and hence potential of comparability across countries;	▶ Non-linear correlation with the risk of mortality in multiple traumas; ▶ Access to hospital data is problematic for some countries, due to privacy regulations; ▶ Specific legislation can prohibit sharing of identifying data in some countries;	▶ RAF ▶ Doctors and hospitals ▶ Research (road safety and Medical)

Injury Scoring System	Description	Advantages	Disadvantages	Application
	100% which makes them virtually un-survivable. An AIS-Code of 9 is used to describe injuries for which not enough information is available for assessing its severity. The AIS scale is a measurement tool for single injuries. ▶ Coded by trained medical staff, based on the available medical files regarding the injuries of the patient. It can also be derived from the International Classification of Diseases 9th or 10th revision (ICD-9 or 10 classification) (IRTAD Group, 2011). This coding allows inpatients whose injuries have been caused by a road traffic accident to be identified. The patient's ICD-9 or 10 codes are converted to AIS scores using a lookup file. The AIS scores associated with the patient's injuries are then used to determine whether the patient has sustained a MAIS3+ injury	▶ Limited under registration (almost all MAIS3+ victims are hospitalised).		
MAIS/MAIS 3+	MAIS is the Maximum Abbreviated Injury Severity Scale Difference between MAIS and MAIS 3+ is that MAIS 3+ refers to serious injuries . Guidelines for determining and assessing MAIS3+ injries: ▶ Using matched / paired police and hospital data; ▶ Using only hospital data; and ▶ Applying the correction factor to police data.	▶ MAIS 3+ formula can be tailored for South Africa as well depending on the availability of data ▶ Viewed as an independent system of the injury scoring; ▶ Relatively simple to calculate; ▶ Achievable for many countries and hence potential of comparability across countries; ▶ Limited under registration (almost all MAIS3+ victims are hospitalised).	▶ Non-linear correlation with the risk of mortality in multiple traumas; ▶ Access to hospital data is problematic for some countries, due to privacy regulations; ▶ Specific legislation can prohibit sharing of identifying data in some countries;	▶ Research (road safety and Medical) ▶ Doctors and hospitals

7 Recommendations

From the Literature Review, having investigated the Abbreviated Injury Scale (AIS) and its development as well as other methods of collecting traffic injury data, we propose that a case study be undertaken to compare SAPS AR forms initial classification of crash severity, to detailed investigations (like the RTMC Major crash investigations) and then with detailed hospital records in order to determine how accurate the initial subjective assessment indeed was and if it is worth adding a AIS or ISS to the system of collecting crash data that is already under pressure and not reporting the full spectrum of crash data.

As in other countries where MAIS3+ have been implemented, a case study was undertaken to test the traffic injury scale. Due to lessons learned the systems have been developed over time and in some countries even a combination of methods is used.

Is it also proposed that three main guidelines for determining and assessing MAIS 3+ casualties be applied when undertaking the case study in order to make a more informed recommendation for future application in South Africa:

- Using matched / paired police and hospital data;
- Using only hospital data; and
- Applying the correction factor to police data.

Literature review revealed that most developed countries use AIS/MAIS 3+ scale together with ISS to score the injury severity from road crashes. It is thus recommended that South Africa follow suit and utilize both scoring systems to score road crash injury severity. This will assist to compare South Africa's road crash injury score with the rest of the world.

The literature review highlighted the use of the International Classification of Diseases, ninth edition (ICD-9) and tenth edition (ICD-10) as a widely used method of determining injury severity around the world, the ICD-10 being widely used as it is latest version and various tools used for converting ICD codes to AIS/MAIS3+. Literature study explored the use of different conversion tools from ICD-10 codes to AIS/MAIS 3+. The AAAM 10 mapping tool was recommended to be a best fit for the European Union. The same conversion tool will be adopted for the South African case provided the ICD10 codes used in South Africa can be mapped to the AAAM10 mapping tool.

The South African Triage Score could serve a good scoring system for injury severity because it is already used in South Africa and fairly simple for emergency personnel to get training in.

There are not other countries in Africa that have implemented either MAIS3+ or ISS. South Africa will be the country to do so but will remain dependent on the buy in and assistance with data from stakeholders.

8 References

Aden, W. A. (2019). A Comparative Study on the Characteristics of Road. American Scientific Research Journal for Engineering, Technology, and Sciences, 55(1), 204-225.

Agrawal, S. N. (2018). The Glasgow Coma Scale: A Breakthrough in the Assessment of the Level of . Journal of Traditional Medicine & Clinical Naturopathy Consciousness, 7(2).

Aspelunda, A. L. et al., 2019. Evaluating trauma scoring systems for patients presenting with gunshot injuries to a district-level urban public hospital in Cape Town, South Africa. African Journal of Emergency Medicine, 08 August, p. 193–196.

Attergrim, J., Sterner, M., Claeson, A., Dharap, S., Gupta, A., Khajanchi, M., . . . Warnberg, M. G. (2018). Predicting mortality with the international classification of disease injury severity score using survival risk ratios derived from an Indian trauma population: A cohort study. Plos One.

Baru, A., Azazh, A., & Beza, L. (2019). Injury severity levels and associated factors among road traffic collision victims referred to emergency departments of selected public hospitals in Addis Ababa, Ethiopia: the study based on the Haddon matrix. BMC Emergency Medicine, 19(2).

Bastien, C., Neal-Sturgess, C., Christensen, J., & Wen, L. (2019). A Deterministic Method to Calculate the AIS Trauma Score from a Finite Element Organ Trauma Model (OTM). Institute for Transport and Cities, Coventry University.

Bhalla, K., Sharaz, S., Abraham, J., Bartels, D., & Yeh, P.-H. (2011). ROAD INJURIES IN 18 COUNTRIES: Methods, data sources and estimates of the national incidence of road injuries. Boston: Harvard University.

B Gottschalk, et al., 2006. The cape triage score: a new triage system South Africa. Proposal from the cape triage group. Emergency Medical Journal, Volume 23, p. 149–153.

Brown, T. (2003). Prehospital Care of Road Traffic Injuries in Chiang Mai, Thailand. Berkeley: Safe Transportation Research & Education Center, Institute of Transportation Studies, UC Berkeley.

Cambridge Dictionary. (2020, October 29). https://dictionary.cambridge.org/dictionary/english/triage.

Cao, Y., Li, S., & Yu, C. (2020). An Assessment Method of Urban Traffic Crash Severity Considering Traveling Delay and Non-Essential Fuel Consumption of Third Parties. Sustainability, 12(17).

Chandran, A., Hyder, A. A., & Peek-Asa, C. (2010). The Global Burden of Unintentional Injuries and an Agenda for Progress. Epidemiologic Reviews, 32(1), 110-120.

Cherry, C., Hezaveh, A. M., Noltenius, M., Khattak, A., Merlin, L., Dumbaugh, E., . . . Sandt, L. (2018). Completing the Picture of Traffic Injuries: Understanding Data Needs and Opportunities for Road Safety. Chapel Hill: Collaborative Sciences Center for Road Safety.

Department of Health, (2009). The South African ICD-10 Coding Standards, Version 3.

Eric, O. M., Zipporah, N., Joseph, O., Jared, O., & Elizabeth, L. (2011). Factors associated with severity of road traffic injuries, Thika, Kenya. PanAfrican Medical Journal, 8(20).

Ferreira, S., Amorim, M., & Couto, A. (2016). Risk factors affecting injury severity determined by the MAIS score. Traffic Injury Prevention, 18(5), 515-520.

Gabbe, B. J., Cameron, P. A., & Finch, C. F. (2003). IS THE REVISED TRAUMA SCORE STILL USEFUL? ANZ Journal of Surgery, 73(11), 944-948.

GARDNER-THORPE, J. et al., 2006. The value of Modified Early Warning Score (MEWS) in surgical in-patients: a prospective observational study. The Royal College of Surgeons of England, Volume 18, p. 571–575.

Grous, D. A. (2019). The Impact of Road Traffic Accidents with Child Victims. London: Foundation Abertis in association with the United Nations and The London School of Economics and Political Science .

GOTTSCHALK, S., 2004. TRIAGE — A SOUTH AFRICAN PERSPECTIVE. Continuing Medical Education, 22(6), pp. 325-327.

International Traffic Safety Data and Analysis Group (IRTAD), 2011. Reporting on Serious Road Traffic Casualties: Combining and using different data sources to improve understanding of non-fatal road traffic crashes, s.l.: International Transport Forum.

Heydari-Khayat, N., Sharifipoor, H., Ali Rezaei, M., Mohammadinia, N., & Darban, F. (2012). Correlation of Revised Trauma Score with Mortality Rate of Traumatic Patients within the First 24 hours of Hospitalization. Zahedan Journal of Research in Medical Sciences, 16(11), 33-36.

Hirsch,J.A. et.al (2016). ICD-10: History and Context, Practice Perspectives.

Hyder, A. A., & Vecino-Ortiz, A. I. (2014). BRICS: opportunities to improve road safety. Bulletin of the World Health Organisation, 92(6), 423-428.

India State-Level Disease Burden Initiative Road Injury Collaborators. (2019). Mortality due to road injuries in the states of India: the Global Burden of Disease Study 1990–2017. Lancet Public Health, 5(2), 86-98.

Jennett, B. (2005). Development of Glasgow Coma and Outcome Scales. Nepal Journal of Neuroscience, 2, 24-28.
Keshr, D. V. (2015). Epidemiology of Road Traffic Accidents.
Laytin, A. D., Kumar, V., Juillard, C. J., Sarang, B., Lashoher, A., Roy, N., & Dicker, R. A. (2015). Choice of injury scoring system in low- and middle-income countries: Lessons from Mumbai. International Journal of the Care of the Injured, 46(12), 2491-2497.
Leilei, D., & Pengpeng, Y. (2019, September). The burden of injury in China, 1990–2017: findings from the Global Burden of Disease Study 2017. Lancet Public Health, pp. 449–461.
Lichtveld, R. A., Spijkers, A. T., Hoogendoorn, J. M., Panhuizen, I. F., & van der Werken, C. (2008). International Journal of Emergency Medicine, 21-26.
Loftis, K. L., Price, J., & Gillich, P. J. (2018). Evolution of the Abbreviated Injury Scale: 1990–2015. Peer-Reviewed Journal for the 62nd Annual Conference of Association for the Advancement of Automotive Medicine (AAAM), 19(sup2), S109-S113.
Malta, D. C., Caribé de Araújo Andrad, S. S., Gomes, N., Alves da Silva, M. M., Libânio de Morais Neto, O., Chioro dos Rei, A. A., & Figueiredo Nardi, A. C. (2016). Injuries from traffic accidents and use of protection equipment in the Brazilian population, according to a population-based study. ScieLO Analytics, 21(2).
Manoochehry, S., Vafabin, M., Bitaraf, S., & Amiri, A. (2019). A Comparison between the Ability of Revised Trauma Score and Kampala Trauma Score in Predicting Mortality; a Meta-Analysis. Archives of Academic Emergency Medicine, 7(1).
Matis, G., & Birbilis, T. (2008). The Glasgow Coma Scale – a brief review. Past, present, future. Acta neurologica Belgica, 108, 75-89.
Macleod, J., Kobusingye, O., Frost, C. & Lett, R., 2007. Kampala Trauma Score (KTS): Is it a New Triage Tool?. East and Central African Journal of Surgery, 12(1).
Mefire, A. C., Mballa, G. A., Kenfack, M. A., Juillard, C., & Stevens, K. (2013). Hospital-based injury data from level III institution in Cameroon: Retrospective analysis of the present registration system. International Journal of Care of the Injured, 44(1), 139-143.
Mitra, S., Sarkar, A. P., Saren, A. B., Haldar, D., Saha, I., & Sarkar, G. N. (2018). Road Traffic Injuries: A Study on Severity and Outcome among Inpatients of a Tertiary Care Level Hospital of West Bengal, India. Journal of Emergencies, Trauma and Shock, 11(4), 247-252.
Naidoo, D. K., Rangiah, S. & Naidoo, S. S., 2014. An evaluation of the Triage Early Warning Score in an urban accident and emergency department in KwaZulu-Natal. South African Family Practice, 56(1), pp. 69-73.
National Road Safety Commission (NRSC). (2016). Road Traffic Crashes in Ghana. Kumasi: Ministry of Ghana.
Onyemaech, N. O. (2020). Road traffic injuries in a Nigerian referral trauma center: Characteristics, correlates, and outcomes. International Journal of Critical Illness and Injury Science, 10(2), 64-69.
Owor, G., & Kobusingye, O. C. (2001). Trauma registries as a tool for improved clinical assessment of trauma patients in an urban African hospital. Kampala: Makerere Clinical Epidemiology Unit.
Peden, M. M. (2004). World Report on Road Traffic Injury Prevention. Geneva: World Health Organization (WHO).
Perez, K., Weijermans, W., Bos, N., Filtness, A. J., Bauer, R., Johannsen, H., . . . Olabarria, M. (2019). Implications of estimating road traffic serious injuries from hospital data. Accident Analysis & Prevention, 130, 125-135.
Perez, K. et.al (2019). Implications of estimating road traffic serious injuries from hospital data, Accident Analysis and Prevention Journal.
Perez, K. et.al (2017). Practical guidelines for the registration and monitoring of serious traffic injuries, French Institute of Science and Technology for Transport, Development and Networks, Research Report.
Private Healthcare Information Standards Committee (PHISC) (2019). Addendum to the South African ICD-10 Morbidity Coding Standards and Guidelines document.
Pugachev, I., Kulikov, Y., Markelov, G., & Sheshera, N. (2017). Factor Analysis of Traffic Organization and Safety Systems. Transportation Research Procedia, 20, 529 – 535.
Rustagi, N., Kumar, A., Norbu, L., & Vyas, D. (2017). Applying Haddon Matrix for Evaluation of Road Crash Victims in Delhi, India. Indian Journal of Surgery.
Safety Cube (Safety Causation, Benefits and Efficiency), (2016). Practical guidelines for determining the number of serious road injuries (MAIS3+), European Commission.
Sanyang, E., Peek-Asa, C., Bass, P., Young, T. L., Daffeh, B., & Fuortes, L. J. (2017). Risk Factors for Road Traffic Injuries among Different Road Users in the Gambia. Journal of Environmental and Public Health.
Singh, J., Gupta, G., Garg, R., & Gupta, A. (2011). Evaluation of trauma and prediction of outcome using TRISS method. Journal of Emergencie, Trauma, and Shock, 4(4), 446–449.

Soogun, S., Naidoo, M. & Naidoo, K., 2017. An evaluation of the use of the South African Triage Scale in an urban district hospital in Durban, South Africa. South African Family Practice, 1(1), pp. 1-5.

Sutherland, A. G., Johnston, A. T., & Hutchison, J. D. (2006). The New Injury Severity Score: Better Prediction of Functional Recovery after Musculoskeletal Injury. International Society for Pharmacoeconomics and Outcomes Research (ISPOR), 9(1), 24-27.

Teasdale, G., & Jenette, B. (1974). ASSESSMENT OF COMA AND IMPAIRED CONSCIOUSNESS: A practical scale. The Lancet, 304(7872), 81-84.

The European Conference of Ministers of Transport (ECMT). (2006). Road Safety Performance National Peer Review: Russian Federation. Paris: OECD Publications Service.

Vissoci, J. R., Shogilev, D. J., Krebs, E., de Andrade, L., Vieira, I. F., Toomey, N., . . . Staton, C. A. (2017). Road Traffic Injury in Sub-Saharan African Countries: A Systematic Review and Summary of Observational Studies. Traffic Injury Prevention, 18(7), 767-773.

Wang, B., & Wu, C. (2019). Using an evidence-based safety approach to develop China's road safety strategies. Journal of Global Health, 9(2).

Weeks, S. R., Juillard, C. J., Monono, M. E., Etoundi, G. A., Ngamby, M. K., Hyder, A. A., & Stevens, K. A. (2014). Is the Kampala trauma score an effective predictor of mortality in low-resource settings? A comparison of multiple trauma severity scores. World Journal of Surgery, 38(8).

Weeks, S. R. et al., 2014. Is the Kampala Trauma Score an Effective Predictor of Mortality in Low-Resource Settings? A Comparison of Multiple Trauma Severity Scores. World Journal of Surgery.

Western Cape Government, 2012. The South African Triage Scale (SATS) Training Manual , Cape Town: Western Cape Government Health.

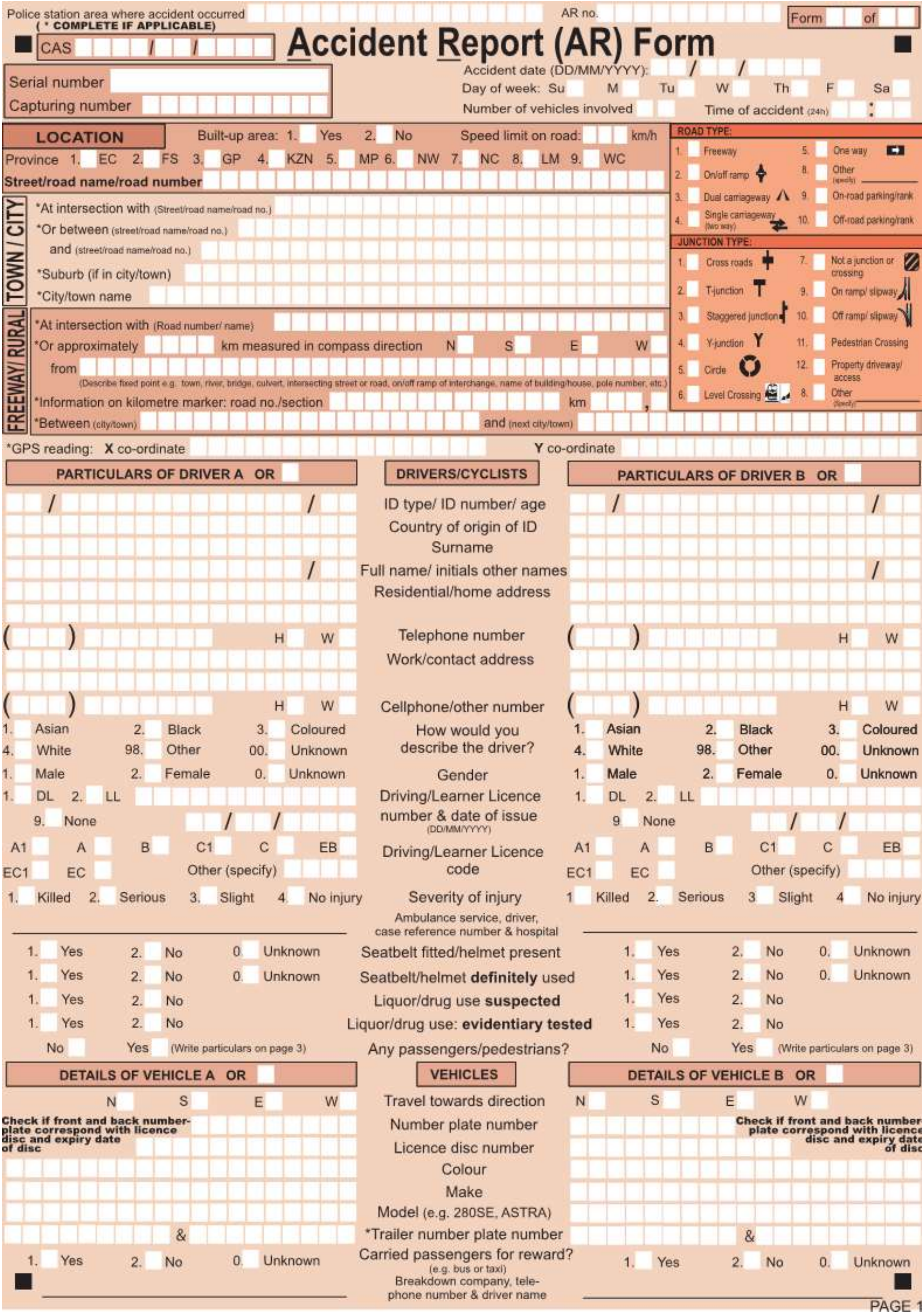
WHO. (2013). Global Status Report On Road Safety: Time for Action. World Health Organization.

World Health Organisation (WHO) Africa. (2020). Road Safety. Retrieved October 22, 2020, from https://www.afro.who.int/health-topics/road-safety

World Health Organization (WHO). (2018). Global Status Report on Road Safety 2018. WHO.

Yates, D. W. (1990). SCORING SYSTEMS FOR TRAUMA. ABC of Major Trauma, 301.

Appendix A: RTMC Accident Report Form



Police station area where accident occurred
(* COMPLETE IF APPLICABLE)
AR no.
Form of
CAS / /

Accident Report (AR) Form

Serial number
Capturing number
Accident date (DD/MM/YYYY): / /
Day of week: Su M Tu W Th F Sa
Number of vehicles involved
Time of accident (24h) :

LOCATION
Built-up area: 1. Yes 2. No
Speed limit on road: km/h
Province 1. EC 2. FS 3. GP 4. KZN 5. MP 6. NW 7. NC 8. LM 9. WC
Street/road name/road number

TOWN / CITY
*At intersection with (Street/road name/road no.)
*Or between (street/road name/road no.)
and (street/road name/road no.)
*Suburb (if in city/town)
*City/town name

FREEWAY/ RURAL
*At intersection with (Road number/ name)
*Or approximately km measured in compass direction N S E W
from
(Describe fixed point e.g. town, river, bridge, culvert, intersecting street or road, on/off ramp of interchange, name of building/house, pole number, etc.)
*Information on kilometre marker: road no./section km ,
*Between (city/town) and (next city/town)

ROAD TYPE:
1. Freeway
2. On/off ramp
3. Dual carriageway
4. Single carriageway (two way)
5. One way
8. Other (specify)
9. On-road parking/rank
10. Off-road parking/rank

JUNCTION TYPE:
1. Cross roads
2. T-junction
3. Staggered junction
4. Y-junction
5. Circle
6. Level Crossing
7. Not a junction or crossing
9. On ramp/ slipway
10. Off ramp/ slipway
11. Pedestrian Crossing
12. Property driveway/ access
8. Other (Specify)

*GPS reading: X co-ordinate Y co-ordinate

PARTICULARS OF DRIVER A OR	DRIVERS/CYCLISTS	PARTICULARS OF DRIVER B OR
/ /	ID type/ ID number/ age	/ /
	Country of origin of ID	
	Surname	
/	Full name/ initials other names	/
	Residential/home address	
( ) H W	Telephone number	( ) H W
	Work/contact address	
( ) H W	Cellphone/other number	( ) H W
1. Asian 2. Black 3. Coloured 4. White 98. Other 00. Unknown	How would you describe the driver?	1. Asian 2. Black 3. Coloured 4. White 98. Other 00. Unknown
1. Male 2. Female 0. Unknown	Gender	1. Male 2. Female 0. Unknown
1. DL 2. LL / 9. None / /	Driving/Learner Licence number & date of issue (DD/MM/YYYY)	1. DL 2. LL / 9. None / /
A1 A B C1 C EB EC1 EC Other (specify)	Driving/Learner Licence code	A1 A B C1 C EB EC1 EC Other (specify)
1. Killed 2. Serious 3. Slight 4. No injury	Severity of injury	1 Killed 2. Serious 3 Slight 4 No injury
	Ambulance service, driver, case reference number & hospital	
1. Yes 2. No 0. Unknown	Seatbelt fitted/helmet present	1. Yes 2. No 0. Unknown
1. Yes 2. No 0. Unknown	Seatbelt/helmet **definitely** used	1. Yes 2. No 0. Unknown
1. Yes 2. No	Liquor/drug use **suspected**	1. Yes 2. No
1. Yes 2. No	Liquor/drug use: **evidentiary tested**	1. Yes 2. No
No Yes (Write particulars on page 3)	Any passengers/pedestrians?	No Yes (Write particulars on page 3)

DETAILS OF VEHICLE A OR	VEHICLES	DETAILS OF VEHICLE B OR
N S E W	Travel towards direction	N S E W
Check if front and back number-plate correspond with licence disc and expiry date of disc	Number plate number	**Check if front and back number plate correspond with licence disc and expiry date of disc**
	Licence disc number	
	Colour	
	Make	
	Model (e.g. 280SE, ASTRA)	
&	*Trailer number plate number	&
1. Yes 2. No 0. Unknown	Carried passengers for reward? (e.g. bus or taxi)	1. Yes 2. No 0. Unknown
	Breakdown company, telephone number & driver name	

PAGE 1

VEHICLE TYPE

Passenger vehicles: Write the vehicle reference letter (A, B, C, etc.) in the blocks.

01. Motor car or station wagon
02. Combi/minibus
03. Midibus
04. Bus
05. Bus-train

Goods vehicles: Write the vehicle reference letter (A, B, C, etc.) in the blocks.

06. Light delivery vehicle
07. Panel van
08. GVM>3500kg (greater than)
09. Truck: articulated
10. Truck: articulated multiple

Motor cycles: Write the vehicle reference letter (A, B, C, etc.) in the blocks.

11. 125cc and under
12. Above 125cc
13. Tri-cycle
14. Quadru-cycle

Other vehicles: Write the vehicle reference letter (A, B, C, etc.) in the blocks.

15. Bicycle
16. Mobile equipment: (driven)
17. Caravan/trailer
18. Tractor
19. Animal-drawn vehicle
98. Other (specify) ____

LIGHT CONDITION: (Mark ONE only)

1. Daylight 3. Night: unlit 8. Other (specify)
2. Night: lit by street lights 4. Dawn/dusk

WEATHER CONDITIONS AND VISIBILITY: (May mark more than one)

1. Clear 4. Mist/fog 7. Fire/smoke
2. Overcast 5. Hail/Snow 9. Severe wind
3. Rain 6. Dust 0. Unknown

ROAD SURFACE TYPE: (Mark ONE only)

1. Concrete 3. Gravel 8. Other (specify)
2. Tarmac 4. Dirt ____

QUALITY OF ROAD SURFACE: (Mark ONE only)

1. Good 4. Cracks
2. Bumpy 5. Corrugated
3. Pothole 8. Other (specify) ____

ROAD SURFACE: (Mark ONE only)

1. Dry 5. Snow 9. Water: standing or moving
2. Wet 6. Loose gravel or sand
3. Wet in areas 7. Slippery
4. Ice 8. Other (specify) ____

ROAD MARKING VISIBILITY: (Mark ONE only)

0. Unknown 2. Not good (specify)
1. Good 7. N/A

OBSTRUCTIONS:

1. Accident site 3. Roadblock 9. None
2. Roadworks 8. Other (specify) ____

OVERTAKING CONTROL: (Mark ONE only)

1. Barrier line 2. Road sign 7. N/A
9. None

TRAFFIC CONTROL TYPE: (Mark ONE only)

1. Robot
2. Stop sign
3. Yield sign
4. Officer
5. Officer+robot
6. Uncontrolled junction
7. Not at junction, crossing or barrier line
8. All robots out of order
9. Some robots out of order (specify) ____
10. Flashing robots (red/ yellow)
11. Boom
12. Pedestrian crossing
13. Barrier line

ROAD SIGNS CLEARLY VISIBLE:

1. Yes 2. No 7. N/A

CONDITION OF ROAD SIGNS:

1. Good 2. Not good 3. Damaged or missing
7. N/A (specify) ____

DIRECTION OF ROAD: (Mark ONE only)

1. Straight 2. Curving 3. Sharp curve 90 degree bend

FLAT OR SLOPED: (Write vehicle reference letter (A, B, C, etc.) in the blocks)

1. Flat 2. Uphill 3. Downhill 4. Steep uphill 5. Steep downhill

POSITION OF VEHICLE BEFORE ACCIDENT:

Write the vehicle reference letter (A, B, C, etc.) in the blocks.

1. Correct road lane
2. Wrong road lane (but right side of road)
3. Wrong side of road
4. Road shoulder
5. On-road parking bay
6. Off-road parking bay

VEHICLE MANOEUVRE/ WHAT DRIVER WAS DOING:

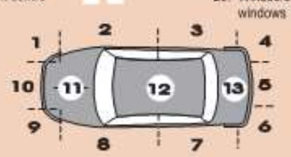
Write the vehicle reference letter (A, B, C, etc.) in the blocks.

01. Turning right
02. Turning left
03. U-turn
04. Enter traffic flow
05. Merging
06. Diverging
07. Overtaking: pass to right
08. Overtaking: pass to left
09. Travelling straight
10. Reversing
11. Sudden start
12. Sudden stop
13. Busy parking
15. Changing lane
16. Swerving
17. Slowing down
18. Avoiding object
19. Stationary (e.g. waiting in traffic)
20. Parked (e.g. in parking bay)
98. Other ____

VEHICLE DAMAGE: (More than ONE of the options below may be selected for each vehicle, if applicable.)

Write the vehicle reference letter (A, B, C, etc.) in the blocks.

01. Right front
02. Right mid-front
03. Right mid-back
04. Back right
05. Back centre
06. Back left
07. Left mid-back
08. Left mid-front
09. Left front
10. Front centre
11. Bonnet
12. Roof
13. Boot
14. **Multiple**
15. Caught fire
16. **Rolled**
17. Damage undercarriage
18. Damage no detail
19. No damage
20. Windscreen/ windows



ACCIDENT TYPE:

1. Head/rear end
2. Head on
3. Sideswipe: opposite directions
4. Sideswipe: same direction
8. Approach at angle - both travelling straight
16. Single vehicle: left the road
11. Single vehicle: overturned
12. Accident with pedestrian
13. Accident with animal (specify) ____
14. Accident with train
15. Accident with fixed/ other object (specify) ____

Was this a Hit & Run accident? 1. Yes 2. No

ACCIDENT SKETCH:

Show Direction North with arrow. Show direction, position and reference number of each vehicle, pedestrian, alleged point of impact, tyre marks, fixed point(s), and other object(s) involved. Measurements are optional.

BRIEF DESCRIPTION OF THE ACCIDENT:

PAGE 2

SUMMARY OF PERSONS INVOLVED (including driver/cyclist)

1. Number of persons dead (killed):
2. Number of persons seriously injured:
3. Number of persons slightly injured:
4. Number of persons not injured:

PARTICULARS OF PASSENGERS WHO ARE NOT INJURED

Surname and initials | Passenger number | in vehicle (A, B, etc)
ID number / | Telephone/Cellphone number ( ) | H | W

Surname and initials | Passenger number | in vehicle (A, B, etc)
ID number / | Telephone/Cellphone number ( ) | H | W

Surname and initials | Passenger number | in vehicle (A, B, etc)
ID number / | Telephone/Cellphone number ( ) | H | W

PARTICULARS OF KILLED OR INJURED PASSENGERS AND PEDESTRIANS

Passenger number (1, 2, etc.) in vehicle (A, B, etc.) — Pedestrian (P, Q, etc.)		Passenger number (1, 2, etc.) in vehicle (A, B, etc.) — Pedestrian (P, Q, etc.)
/	ID type/ ID number	/
	Country of origin of ID	
	Surname	
Initials — Age		Initials — Age
	Home/contact address	
( ) H W	Telephone number	( ) H W
( ) H W	Cellphone/other number	( ) H W
1. Asian 2. Black 3. Coloured 4. White 98. Other 00. Unknown	How would you describe the person?	1. Asian 2. Black 3. Coloured 4. White 98. Other 00. Unknown
1. Male 2. Female 0. Unknown	Gender	1. Male 2. Female 0. Unknown
1. Killed 2. Serious 3. Slight 4. No injury	Severity of injury	1. Killed 2. Serious 3. Slight 4. No injury
	Ambulance service, driver, case reference number & hospital	
1. Yes 2. No 0. Unknown	Seatbelt fitted/helmet present	1. Yes 2. No 0. Unknown
1. Yes 2. No 0. Unknown	Seatbelt/helmet **definitely** used	1. Yes 2. No 0. Unknown
1. Yes 2. No	Liquor/drug use **suspected**	1. Yes 2. No
1. Yes 2. No	*Liquor/drug use: **evidentiary tested**	1. Yes 2. No

Passenger number (1, 2, etc.) in vehicle (A, B, etc.) — Pedestrian (P, Q, etc.)		Passenger number (1, 2, etc.) in vehicle (A, B, etc.) — Pedestrian (P, Q, etc.)
/	ID type/ ID number	/
	Country of origin of ID	
	Surname	
Initials — Age		Initials — Age
	Home/contact address	
( ) H W	Telephone/contact number	( ) H W
( ) H W	Cellphone/other number	( ) H W
1. Asian 2. Black 3. Coloured 4. White 98. Other 00. Unknown	How would you describe the person?	1. Asian 2. Black 3. Coloured 4. White 98. Other 00. Unknown
1. Male 2. Female 0. Unknown	Gender	1. Male 2. Female 0. Unknown
1. Killed 2. Serious 3. Slight 4. No injury	Severity of injury	1. Killed 2. Serious 3. Slight 4. No injury
	Ambulance service, driver, case reference number & hospital	
1. Yes 2. No 0. Unknown	Seatbelt fitted/helmet present	1. Yes 2. No 0. Unknown
1. Yes 2. No 0. Unknown	Seatbelt/helmet **definitely** used	1. Yes 2. No 0. Unknown
1. Yes 2. No	Liquor/drug use **suspected**	1. Yes 2. No
1. Yes 2. No	*Liquor/drug use: **evidentiary tested**	1. Yes 2. No

PAGE 3

Form of

WITNESSES

A police/traffic officer/other authorised person must make an attempt to obtain witnesses to an accident. This is particularly important in respect of independent eyewitnesses.

Bystanders at a scene of an accident must not be chased away before a good attempt is made by an officer to find out whether anyone witnessed (saw) the accident, and/or can give valuable information about circumstances relating to the accident, and/or can assist with the identification of deceased or seriously injured persons involved in the accident.

In the event of a reliable witness (passenger or independent eyewitness) residing or working in another city/town, an affidavit must, as soon as possible, be taken from him/her either at the scene or at the police station/traffic department. (This is in the event of a CR/CAS police case docket being registered.)

Independent eyewitness | Passenger of vehicle

Surname & initials

Work/contact address

Code

Cellphone number/ Telephone number ( )

Independent eyewitness | Passenger of vehicle

Code

( )

PEDESTRIANS AND CYCLISTS ONLY: Person Reference

Position
1. Roadway 2. Sidewalk /verge 3. Shoulder of road 4. Median

Location
1. Within marked crossing 2. Within 50m of crossing 3. Not at crossing

Manoeuvre
1. Facing traffic 2. Back to traffic 3. Crossing road

Pedestrian Action (for pedestrians only)
1. Walking 2. Running 3. Standing 4. Playing
5. Sitting 6. Lying down 7. Working 8. Other

Colour of clothing
1. Light 2. Dark 3. Light&Dark 4. Reflective
8. Other (Specify)

SPECIAL OBSERVATIONS: Vehicle reference

Tyre appears to have burst 1. No 2. Yes 0. Unknown

Length of skidmarks: Tape measure ______ metres

Lights 1. Good 2. Faulty/not visible 0. Unknown

Reflector quality (or reflective tape) 1. Good 2. Faulty/not visible 0. Unknown

Chevron quality 1. Good 2. Faulty/not visible 0. Unknown

Other/Comment

SPECIAL OBSERVATIONS: Vehicle reference

Tyre appears to have burst 1. No 2. Yes 0. Unknown

Length of skidmarks: Tape measure ______ metres

Lights 1. Good 2. Faulty/not visible 0. Unknown

Reflector quality (or reflective tape) 1. Good 2. Faulty/not visible 0. Unknown

Other/Comment

DANGEROUS GOODS ONLY: Vehicle Reference

Dangerous goods carried in/on vehicle

1. Dangerous goods carried Yes No
2. Spillage occurred Yes No
3. Vapour/gas emission occurred Yes No

If dangerous goods were carried

UN No

Dangerous goods placard displayed on vehicle: Yes No

Draw placard and write UN No of goods involved on the diagram

Company name

Type of load 1. Bulk 2. Packaged goods 3. Tanker 4. Freight Container 5. Tank container

Approximate quantity of goods spilled or released

Brief details of release of vapour (direction of travel and area affected)

If goods were on fire, brief details of damage to goods

Brief details of damage to property caused by dangerous goods

	Y	N
Dangerous Goods Declaration completed correctly?		
Correct transport emergency card in vehicle?		
Correct information obtained from specialist advice number?		

Brief details of clean-up operation, if applicable

Which emergency services were activated?

Office in which area the accident occurred

Occurrence Book no.

Accident Register no.

SAPS CAS no.

Name of Department (Met/Mun Pol/ Traffic/ SAPS)

Date Stamp

Signature

INSPECTED BY: Initials Rank

Surname

Service number

Capturing Number (Copied from Page 1)

Office where accident was reported/ form is completed

Name of Department (Met/Mun Pol/ Traffic/ SAPS)

Occurrence Book no.

COMPLETED BY: Driver, official, etc.

Initials Rank

Surname

Service number

Date / / Time :

Signature

PAGE 4

GPS:05\05 V3

81/149020
Z1523

Accident Report (AR) Form

GENERAL INFORMATION

1. In terms of the National Road Traffic Act, Act No 93 of 1996, a driver must report her/his involvement in an accident ***in person*** within 24 hours of its occurrence to the nearest Municipal/Metro Police, Traffic Department (MMT) office or South African Police Service (SAPS) station. This is only applicable if a police/traffic officer did not attend the accident due to the apparent minor nature thereof. However, the hours of operation of these offices must be taken into consideration. ***A driver must present her/his driving licence when the accident is reported***. It is advisable for a road accident to be reported at the MMT office or SAPS station in whose area of jurisdiction the accident occurred, since officials are familiar with the roads and important reference numbers can be obtained with minimum delay.

2. *This form must be completed for all accidents which occur on a public road and where a vehicle was involved, i.e. all roads where the public or part of the public has right of access. This could include private property.*

3. This form can/may be completed personally by a driver of a vehicle involved in an accident where no criminal case docket has been opened/registered (such as 'damage only' accidents), ***only*** if s/he is in a condition to do so. ***A police official, traffic officer or other authorised person must be prepared to help the driver complete the form***.

4. *At the prescribed fee, a photocopy of this form (certified as a true copy of the original form on every page), may be furnished to an involved party (namely, the driver, passenger, pedestrian, cyclist or owner of damaged property) if an official request form is completed, and they can prove that they are the involved party. If a person who is not an involved party requests a photocopy of this form, they must have the written permission/authority of the involved party if they are acting on their behalf or the request must be referred to the relevant* **Deputy Information Officer** *(MMT or SAPS) for the necessary attention. The Road Accident Fund (RAF) or an agent acting on their behalf (with the necessary documentary proof from the RAF), may be furnished with a certified photocopy of this form without the consent of a party involved in the accident, and free of charge. If a case docket has been opened/ registered for a crime investigation by the SAPS and the matter is still under investigation, any request for a photocopy of this form must be attended to in the same manner as described above.*

5. The name of the SAPS station in which area the accident occurred must be supplied on Page 1 of the form, even if the accident is reported and/or the form completed at/by an MMT office/officer.

6. ***NB:*** *Every effort must be made to specify the exact* ***'LOCATION'*** *of the accident on Page 1 of the form. Always specify the* ***Province*** *and* ***Street*** *or* ***Road*** *(by name and/or number, e.g. N4) before proceeding to complete the appropriate section for accidents in town or on rural roads/freeways. Be sure to complete the* ***Speed Limit*** *and box with* ***Road Type*** *and* ***Junction Type*** *in* ***all cases***.

INSTRUCTIONS FOR COMPLETION OF THE FORM

7. It is essential that the information recorded on this form is an ***accurate*** reflection of the circumstances of the accident.

8. *When completing this form, please use* ***BLOCK/CAPITAL LETTERS*** *only.*

9. Mark the relevant ***blocks*** with a cross (***X***), and ***not*** the picture/illustration. However, to identify a particular vehicle (e.g. on Page 2), write the **reference letter** allocated to each vehicle (**A**, **B**, **C**, etc.) in the relevant blocks. Refer to pedestrians as **P**, **Q**, **R**, etc. and passengers as **1**, **2**, **3**, etc.

10. *When correcting a mistake, the person completing the form must initial and date against the correction, without interfering with any of the white blocks.* ***No correction fluid/tape may be used***.

11. Pages 1 and 2 must be completed in all instances. If there were any passengers in any vehicle (even if they were not injured), their particulars must be entered on Page 3. The particulars of witnesses must be entered at the top of Page 4 and those of the person completing the form ***must*** be entered in the 'Completed By' section in the bottom right-hand corner of Page 4.

12. *All four pages of this form must be completed in full if a driver/cyclist or passenger was killed or injured in the accident, or pedestrians were involved.*

13. All four pages of this form must also be completed in full if a vehicle carrying dangerous goods or hazardous materials is involved in an accident.

14. *Once a driver has reported an accident at an MMT office or SAPS station, and this form has been completed, an entry must be made in the Occurrence Book (OB), Accident Register, etc. The driver must then be furnished with an OB or Accident Register reference number as proof that the accident has been reported.*

PAGE 1a

OPERATIONAL PROCEDURES FOR MMT AND SAPS OFFICERS

15. This Accident Report (AR) form replaces the Officer's Accident Report (OAR) form.

16. *An AR form must be completed for each driver/pedestrian reporting an accident at an MMT office or SAPS station.*

17. A pedestrian may also report an accident within 24 hours of its occurrence to his/her nearest MMT office or SAPS station. S/he ***must*** present proof of identification.

18. *A person wanting to report his/her involvement in an accident must not be referred unnecessarily from one department to another, one office to another, or from one SAPS station to another.*

19. The Capturing Number on the top left section on Page 1 of the form must be supplied by the data capturing authority, from the accident number generated by the computer system on which the form is captured.

20. *If there is not sufficient space on the form for further particulars of witnesses, passengers, casualties or the description of the accident, etc., relevant sections of additional forms must be completed and attached to the original.*

21. If there are more than two parties (e.g. more than two vehicles) involved in the accident, additional forms must be completed. Each form must be numbered in sequence on the spaces provided (at 'Form-of-') e.g., Form 1 of 2, or Form 2 of 2.

22. *When a person, who reports an accident, prefers to write the description, and/or draw an accident sketch, s/he should sign next to the relevant item.*

23. A police/traffic officer who attends an accident must complete this form immediately. Thereafter, an entry in the Occurrence Book (OB) or Accident Register must be made. This must be done before going off duty. **Accident victims must not be told to report an accident at an MMT office or SAPS station unless they are mentally composed and their vehicle is in a driveable and roadworthy condition**.

24. *A police/traffic officer who attends an accident must ensure that the particulars of all cyclists, passengers and pedestrians (even if they are not injured) are recorded, since names cannot be added to a completed AR form once it has been processed.*

25. When a member of the SAPS attends an accident of a serious nature (where a criminal case docket has to be opened/registered), s/he must conduct an on-site crime scene investigation and open/register a case docket immediately after the accident has been attended, or before s/he goes off duty. This must be done at the SAPS station in whose area the accident occurred.

26. *When this form is completed for an accident in which a case docket is opened/registered, 2 photocopies of the completed form must be made. Both copies must be certified as true copies of the original form. One copy must be filed in the "A" clip of the case docket. The second copy must be collected by the relevant MMT or other authorised person under cover of the SAPS 506 Delivery Note.* ***The original completed form must be filed in the SAPS station monthly accident file****. The CAS/CR reference number must be entered on all documents (original and photocopies).*

27. When this form is completed at an SAPS station, the SAPS 176 Accident Register process must be followed. If **no** case docket has to be opened/registered for a crime investigation of an accident, the **original completed form** must be collected by the relevant MMT or other authorised person, under cover of the SAPS 506 Delivery Note, within the prescribed period. It is not necessary for a photocopy to be made and kept in the SAPS station monthly accident file.

28. *When this form is completed at an MMT office, it must not be registered at the SAPS station (SAPS 176 Accident Register process),* ***unless*** *a case docket has to be opened/registered for the accident to be criminally investigated. (In this instance it must be presumed that an MMT officer attended the accident and conducted the on-site crime scene investigation. S/he must open/register a case docket at the SAPS station in which area the accident occurred before s/he reports off duty. For such an on-site crime scene investigation function to be performed by an MMT officer, a Memorandum of Understanding must exist between the SAPS and relevant MMT to ensure professional service delivery, responsibility and accountability.)*

29. 'Signatures' and 'Initials' of persons who complete and inspect/check the correct completion of the form, **and the official date stamp**, must be entered in the relevant spaces.

30. *If the form is completed at an SAPS station, but the accident occurred in another SAPS station area, an Occurrence Book (OB) number must be allocated. A photocopy must then be made, and each page certified as a true copy of the original form. The original completed form, together with a covering letter, must be posted by registered mail or transferred by police vehicle to the SAPS station in which area the accident occurred. For record purposes the photocopy must be filed in the accident file of the SAPS station where the form was completed.*

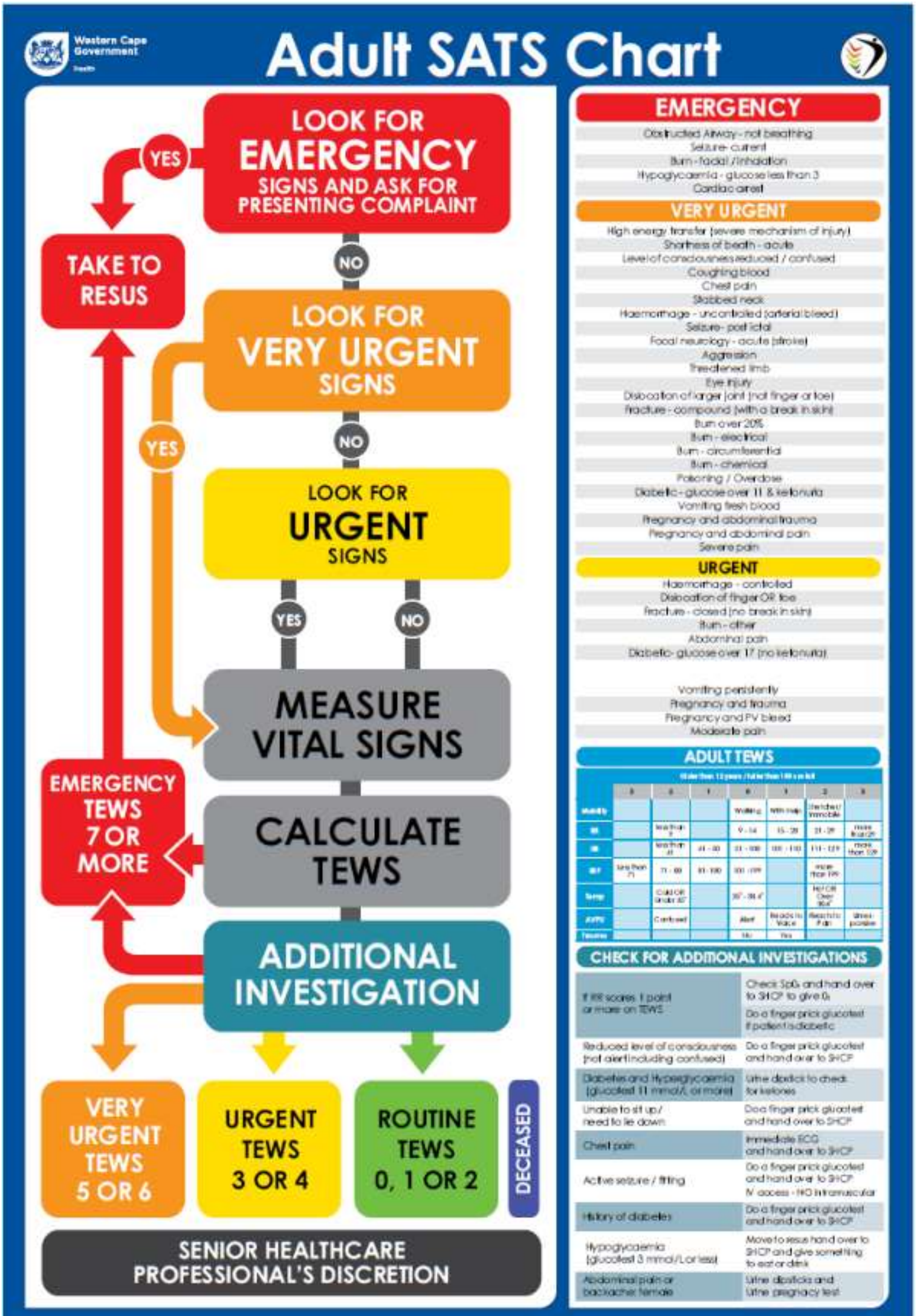
31. **If any of the injured persons dies within six (6) days of the accident**, the particulars on Page 1 and 3 of the form must be changed accordingly by the office at which the form was completed before the form is collected by the relevant MMT officer or any other authorised person.

32. ***All culpable homicide motor vehicle accidents*** *(in which a person is killed),* ***must*** *be reported to the National Arrive Alive Fatal Accident Information Centre immediately after such an accident, or before the police/traffic officer goes off duty.*
Tel: 0800 005 619 (toll free) or (012) 665 6089. Fax 0800 111 301 (toll free) or (012) 665 6085.
The 'Arrive Alive Quick Response Form' must be used for this purpose.

33. All spoilt AR forms must be officially cancelled by double lines (10cm apart) and the word CANCELLED across the face of Page 1, date stamped and signed by the officer completing the form. Such cancelled forms must be submitted together with the other completed AR forms to the data capturing office for recording.

PAGE 1b

Appendix B: SATS Flowchart for decision making



In diversity there is beauty and there is strength.

MAYA ANGELOU

Document prepared by:
Zutari (Pty) Ltd
Reg No 1977/003711/07
Riverwalk Office Park, 41 Matroosberg Road,
Ashlea Gardens, Extension 6, Pretoria

South Africa
PO Box 74381, Lynnwood Ridge 0040

T +27 12 427 2000
F +27 86 556 0521
E tshwane@zutari.com