ALCOHOL AND ITS IMPLICATIONS FOR ROAD TRAFFIC CRASHES IN SOUTH AFRICA

PHASE A - REVIEW

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND ABBREVIATIONS

BAC	Blood Alcohol Concentration
BoD	Burden of Disease
CDC	Centers for Disease Control and Prevention
CSIR	Council for Scientific and Industrial Research
GDP	Gross Domestic Product
HIC	High-Income Countries
HSRC	Health Sciences Research Council
IMS	Injury Mortality Survey
ISS	Injury Severity Score
ITF	International Traffic Forum
LIC	Low-income countries
LMIC	Low- and middle-income countries
NIMSS	National Injury Mortality Surveillance System
RTMC	Road Traffic Management Corporation
RTC	Road Traffic Crashes
RTI	Road Traffic Injury
SA	South Africa
SAMRC	South African Medical Research Council
SAPS	South African Police Services
Stats SA	Statistics South Africa
WHO	World Health Organization

EXECUTIVE SUMMARY

Road traffic deaths remain unacceptably high, accounting for 1.35 million deaths worldwide, with 20 to 50 million people annually sustaining serious non-fatal injuries. RTCs was globally estimated to be the 8th leading cause of death in 2016, with the leading cause of death among children and young adults aged 5 to 29 years old. In South Africa, road traffic injuries are estimated at 27 mortalities per 100 000 population, accounting for 17 597 road traffic mortalities in 2012. South Africa's relatively high incidence of RTCs may partly be due to the countries rapid economic and social development, which has led to the increase of vehicles on the road. This may be compounded by a range of structural factors including poor and deteriorating road infrastructure, increasing congested road conditions, driver behaviour and driver attitudes towards road safety. Furthermore, international and South African research has indicated alcohol use as a leading risk factor in RTCs as it impairs driving ability, influences the drivers' attitude, decision-making, alertness, judgment, response and controlling of the motor vehicle. Additionally, alcohol use is also a significant contributing factor for pedestrians who are involved in a motor vehicle crash.

In recognition of the current limited scope of alcohol-related RTC research in SA, the Road Traffic Management Cooperation commissioned the SAMRC-UNISA Violence, Injury and Peace Research Unit to conduct a scientific review on the impact of alcohol on RTCs in SA. This study i.e. 'Review' is Phase A of the impact of alcohol on RTCs in SA. Phase B, i.e. Collaboration Research: Study on Alcohol Use by Road Users will be published in March 2020 by the RTMC and VIPRU. The present study aimed to explore the relationship between alcohol use and RTCs in SA through three research questions, 1) what is the extent and epidemiology of alcohol-related road traffic crashes in South Africa? 2) What are the risk factors that contribute to the magnitude of alcohol-related road traffic crashes in South Africa? and 3) What is the severity, health and economic outcomes of alcohol-related road traffic crashes in South Africa?

A title search across selected databases yielded a search result of 4433 titles of which only 53 titles were relevant and included. Once duplicates were removed, a total of 40 titles underwent abstract screening and 33 moved onto full-text reading resulting in 16 included articles. Included literature revealed that drivers are the largest proportion of victims with positive BAC, with an overrepresentation of males, and that most alcohol-related RTCs occurred during the early evening and during spring. Furthermore, human factors are reported to play a significant role in the likelihood of driving under the influence with young adults most likely to engage in drink driving. Moreover, only one South African study found that the lack of enforcement of laws, regulations and policies may result in the increased burden to alcohol-related RTCs. With regards to the consequences of alcohol-related RTCs, the results indicated that more severe crashes result in greater costs and that medical costs related to RTCs increases with the number of injuries sustained. South Africa's cost estimate is estimated to be 2 to 4 times higher than comparable low- to middle-income countries, although the cost of alcohol-related RTCs are largely unknown in South Africa.

This phenomenon remains neglected, with a relatively limited research platform on alcohol and RTCs circumstances. it is recommended that:

1. The local research platform be strengthened in order to develop interventions and strategies to prevent alcohol use while driving. Future research should focus on the analysis of existing alcohol data, especially that related to RTCs in South Africa.

2. More research be conducted to assess the severity of injury and crash outcomes between BAC positive and BAC negative RTCs. Additionally, it is recommended that further research be conducted on causes of death, type of injuries, and number of injuries sustained as a result of alcohol-related RTCs.

3. Future research should focus on economic costs attributable to BAC positive RTCs and how and why these costs differ compared to BAC negative RTCs.

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INTRODUCTION

Globally, road traffic deaths remain unacceptably high, accounting for 1.35 million deaths worldwide in 2016, with 20 to 50 million people sustaining serious non-fatal injuries (Global Status Report on Road Safety, 2018). The Global Status Report on Road Safety (2018) reported road traffic injuries to be the 8th leading cause of death across all age groups, rising from the 9th leading cause of death in 2016, and now the leading cause of death of children and young adults aged 5 to 29 years. Despite the global attention on road traffic crashes (RTCs)[1] through the United Nations Decade of Action, the global rate of road traffic deaths has not declined, and instead has remained constant at 18 per 100 000 population over the past 15 years (Global Status Report on Road Safety, 2018).

The burden of road traffic deaths is disproportionately concentrated in low- and middle-income countries (LMICs). Mortality rates are more than three times higher in low-income countries (LIC) than in high-income countries (HIC), where the average rate is 8.3 deaths per 100 000 population (Global Status Report on Road Safety, 2018). In 2016, the World Health Organization (WHO) Africa region reported the highest rate of road fatalities at 26.6 deaths per 100 000, significantly higher than the global rate of 18.2 deaths per 100 000 (Global Status Report on Road Safety, 2018). In South Africa, road traffic injuries are estimated to be higher than the WHO African region and nearly twice the global average, accounting for 27 mortalities per 100 000 (Wesson, Boikhutso, Hyder, Bertram, & Hofman, 2016).

Matzopoulos and colleagues (2013) analysed South African injury mortality data for 2009 and reported that transport-related injuries accounted for 36.1 deaths per 100 000. Msemburi and colleagues (2016) conducted the 2nd Burden of Disease (BoD) Study in 2012 which analysed secondary data obtained from Statistics South Africa (Stats SA) for the period of 1997 to 2012, the Injury Mortality Survey 2009 (IMS), and the National Injury Surveillance System (NIMSS) 2000 (Msemburi et al., 2016). The BoD (2012) reported road traffic injuries to be the 9th leading cause of death in South Africa, with 17 597 road traffic mortalities reported. More recently, the Road Traffic Management Corporation (RTMC) analysed fatal crashes reported to the South African Police Services (SAPS) between January and December 2017 and reported a total of 14 050 road traffic related fatalities, with pedestrians contributing 38%, followed by

[1] The term ‘crash’ imparts the same meaning as “accident” noted in the National Road Traffic Act, 93 of 1996.

passengers with 33%, drivers with 26%, and cyclists 2.6% of the total number of fatalities (State of Road Safety Report, 2017).

ROAD TRAFFIC CRASHES AND ALCOHOL

The increased burden of road traffic fatalities and injuries in South Africa is partly due to the country's rapid economic and social development, which has led to a significant increase in vehicles on the road (Setlalentoa, Pisa, Thekisho, Ryke, & Loots Du, 2010; State of Road Safety Report, 2017). This is compounded by a range of structural factors, including poor and deteriorating road infrastructure, increasingly congested road conditions, driver behaviour and driver attitudes towards road safety (Matzopolous, Lasarow, & Bowman, 2013; Sukhai, Seedat, Jordaan, & Jackson, 2005). Notwithstanding these, international and South African research has indicated alcohol use as a leading risk factor in RTCs, especially in low-income countries, where alcohol has been detected in 33% to 69% of fatally injured drivers (Matzopoulos, et al., 2013; Wesson et al., 2016). The NIMSS in 2003, for example, indicated that more than 58% of driver fatalities tested positive for alcohol with a mean level of 0.18g/100ml (Matzopoulos, Myers, & Jobanputra, 2008), significantly above the legal blood alcohol concentration (BAC) limit for vehicle drivers of 0.05g/100ml.

Alcohol impairs driving ability by either depressing or stimulating the central nervous system. Zhao, Zhang and Rong (2014) measured the effects of alcohol on drivers and driving performance and found that alcohol consumption influenced drivers' attitude, decision-making, alertness, judgement, response, and control of the motor vehicle. With regards to driving performance, researchers found that average speed, speed standard deviation, average lane position and lane position standard deviation were significantly affected by alcohol intoxication, indicating changes in driving attitudes and behaviours (Zhao et al., 2014). In addition to the direct impact of alcohol consumption on road traffic crashes, alcohol is also believed to influence other aspects of driver safety, for example seat belt wearing, helmet use and speed choice (Global Status Report on Alcohol and Health, 2014).

Alcohol use is also a significant contributing factor for pedestrians who are involved in a motor vehicle crash. In the United States, Dultz et al. (2011) conducted a study that investigated the influence of alcohol on pedestrians by assessing how alcohol affects pedestrian crossing patterns, medical management and outcomes. The results revealed that alcohol impaired pedestrians engaged in risky street-crossing behaviours as pedestrian who were intoxicated were less likely than non-impaired pedestrians to cross the street in the crosswalk with the pedestrian signal (22.6%; 64.7%) and more likely to cross either in the crosswalk against the pedestrian signal (22.6%; 12.4%) or midblock (54.8%; 22.8%). Alcohol use was related to a higher Injury Severity Score (8.82; 4.85; $p<0.001$) and longer hospital stay (3.89 days; 1.82 days; $p<0.001$) compared to those who were not intoxicated. Patients who used alcohol had a lower average Glasgow Coma Scale score (13.80 vs. 14.76; $p<0.001$) and a higher incidence of head and neck, face, chest, abdomen, and pelvic related injuries compared to those who were not intoxicated (Dultz et al., 2011).

INDIVIDUAL CONSEQUENCES OF ROAD TRAFFIC CRASHES

Drunk driving influences both the risk of RTCs and the severity and outcomes of consequent injuries (Drinking and Driving: A road safety manual for decision-makers and practitioners, 2007; Global Status report on Road Safety, 2018; Global Status Report on Alcohol and Health, 2014; Zhao et al., 2014). Alcohol-related crashes are reported to result in a high burden of death and disability globally and may have long-lasting effects on surviving individuals, families, communities and entire societies (Global Status report on Road Safety, 2018; Global Status Report on Alcohol and Health, 2014). The most common injuries sustained during RTCs include traumatic brain injuries, spinal cord injuries, burns, amputations, and blindness (Craig et al., 2016). In addition to the immediate health-related consequences, road traffic crash-related disabilities and impairments can impede the quality of life after the crash, as it influences the productivity, career development, the career choices of the victim, career progress, income potential, and socio-economic status (Diedericks, 2014). Furthermore, Juillard, Labinjo, Kobusingye and Hyder (2010) explored the cost and disability consequences of road traffic crashes in Nigeria and found that of the 29.1% of participants had sustained a disability, 67.6% were unable to perform activities of daily living, 16.7% consequently lost their jobs, and 88.6% had a reduction in earnings.

With regards to the severity of road traffic injuries, Stübig et al. (2012) compared the accident kinematics, severity of injury and mortality of alcohol intoxicated and sober car motor vehicle crash patients at a primary admitting hospital in Germany. Of the 37,635 road traffic crashes evaluated there were 20,741 recorded patient injuries and 2.3% fatalities. Among the injured group, there were more fatal injuries recorded for patients with a positive BAC (4.6%) compared to negative BAC (2.2%; $p < 0.0001$). The BAC positive (8%) patients also sustained more severe injuries compared to BAC negative patients (3.6%; $p < 0.0001$). The relative speed of the motor vehicle at impact was significantly higher for BAC positive patients compared to the BAC negative patients ($p < 0.0001$).

RTCs have a reportedly vast societal impact in South Africa (Labuschagne, De Beer, Roux & Venter, 2016). Those directly involved in the crash may suffer a disability, loose income or employment. Those indirectly involved may lose a source of income, a home, or they may lose a child, partner or close others which may lead to psychological distress and disruption of their life (Labuschagne et al., 2016). Internationally, a number of mental health conditions have been observed in individuals following a road traffic crash. These include high levels of anxiety, driving phobia, depressed mood, as well as the presence of more severe mental disorders such as Post Traumatic Stress Disorder or Major Depressive Disorder (Guest et al., 2016). If left unmanaged, psychological distress can contribute to, or exacerbate negative outcomes such as social disengagement (e.g., loss of employment) and poor health-related quality of life, as well as contribute to higher costs to insurers (Guest et al., 2016).

ECONOMIC CONSEQUENCES OF ROAD TRAFFIC CRASHES

The high number of road traffic crashes and its associated consequences not only results in the loss of human life, with the associated pain, grief and suffering, but has negative effects on the well-being of South Africans and on the country's socio-economic development (Labuschagne et al., 2016; Verster & Fourie, 2018). Economic costs of RTCs and RTIs place an immense burden on the victims, their families, employers, insurance companies, countries and globally, particularly to the LMICs that endure the major burden due to RTA (Centers for Disease Control and Prevention [CDC], 2016; Gorea, 2016). The CDC (2016) estimates that RTI cost roughly US $518 billion globally and US $65 billion in low- and middle-income countries.

RTCs are however considered highly preventable, especially those affected by alcohol (Anderson et al., 2009; Goodwin et al., 2015; Global Status Report on Alcohol and Health, 2014; Morrison & Cameron, 2015). Prevention refers to those activities that are undertaken to prevent injury from occurring by eliminating the risk factors that promote the occurrence of injury incidents, such as alcohol-related road traffic crashes (WHO, 2019). Internationally, several strategies that have been shown to be effective in preventing alcohol-related road traffic crashes. Effective interventions included good legislation that clearly defines illegal levels of BAC and penalties for drinking and driving offences (Goodwin et al., 2015; Global Status Report on Alcohol and Health, 2014); raising the minimum drinking age (Anderson et al., 2009); random roadside breath tests (Anderson et al., 2009); large scale media campaigns (Goodwin et al., 2015; Global Status Report on Alcohol and Health, 2014); school-based instructional programs (Goodwin et al., 2015); reducing the physical availability of alcohol in public spaces (Morrison & Cameron, 2016); ignition interlocks installed in cars to measure alcohol on the driver's breath (Goodwin et al., 2015); and public education to change attitudes to drinking and driving (Global Status Report on Alcohol and Health, 2014).

RATIONALE

South Africa has one of the highest road traffic death tolls globally, with alcohol use reported as a leading risk factor to road traffic crashes (Global Status Report on Road Safety, 2018; Matzopoulos et al., 2013; Wesson et al., 2016) and fatalities (Global Status Report on Road Safety, 2018; Matzopoulos et al., 2013; Wesson et al., 2016). The strengthening of understandings of the extent and epidemiology of alcohol-related crashes, the psycho-social contributors to such incidents, and the factors that impact upon the related health outcomes, is required to enhance road safety approaches and interventions in South Africa. Several international and national studies have demonstrated that alcohol exacerbates the risk of road traffic crashes (Dultz et al., 2011; Zhao et al., 2014), however, there seems to be a paucity of such research in South Africa. There is a requirement for the development of clear recommendations for further prevention research in this field. This would necessitate a clear description of the magnitude of the problem and an identification of the risk factors that contribute to the use of alcohol and its relationship with road traffic crashes. Overall, this study aims to explore the relationship between alcohol use and road traffic crashes in South Africa. The research questions are as follows:

1. What is the extent and epidemiology of alcohol-related road traffic crashes in South Africa?
2. What are the risk factors that contribute to the magnitude of alcohol-related road traffic crashes in South Africa?
3. What is the severity, health and economic outcomes of alcohol-related road traffic crashes in South Africa?

THE PUBLIC HEALTH APPROACH

The public health approach to road traffic injury is scientific in nature and draws on knowledge from several disciplines including, epidemiology, medicine, psychology, sociology, criminology, education and economics (Peden et al., 2004). Additionally, this approach is multi-sectoral as it draws from diverse sectors such as health, education, social services, justice, policy and the private sector (Krug, Dahlberg, Mercy, Zwi, & Lozano, 2002; WHO, 2019a). The public health approach places importance on the prevention of road traffic injury in emphasising that certain behaviours and its consequences can be prevented. This approach consists of four steps that is rooted in the scientific method. Figure 1 displays the four-step approach.

STEP 1: IDENTIFY THE PROBLEM

The first step in preventing alcohol-related RTCs is to identify the 'who', 'what', 'when', 'where', and 'how' associated with it. Through injury surveillance and surveys, and systematically collecting data on the magnitude, scope, characteristics and consequences of RTCs, one can identify how frequently alcohol-related RTCs occur, where it occurs, trends and who the victims are (Peden et al., 2004). This kind of data can be obtained from reports, vital records, registries, literature and other sources.

STEP 2: IDENTIFYING THE CAUSES AND RISK FACTORS

Identifying the magnitude of the problem is not merely enough, the second step in the public health approach identifies where prevention efforts need to be focused. In this step, causes of RTCs and injuries are researched and in doing so, one tries to determine the causes and risks of RTCs, the factors that may increase or decrease this risk, and factors that may be modifiable through interventions (Peden et al., 2004).

STEP 3: DEVELOP, IMPLEMENT AND EVALUATE

Through identifying the magnitude and the risk factors, prevention programs can now be designed. Through evidence-based research, prevention programmes can be developed, implemented and evaluated.

STEP 4: IMPLEMENT AND TEST EFFECTIVENESS

The final step in the approach involves the implementation of intervention programmes and measuring the effectiveness thereof. This step may include the monitoring and evaluation of prevention programmes. As this study aims to investigate the magnitude, risk factors and consequences of alcohol-related RTCs, only steps one and two will be applied.

Figure 1. Four steps of the public health approach

When RTCs occur, the traditional view is to assume that a RTC is the sole responsibility of the driver, despite considering that several other factors such as the environmental and social factors may have come into play. Therefore, for this study, the public health approach was applied in conjunction with an ecological or systems perspective to understand the multiple contributing factors to road traffic injuries. The ecological model is a holistic approach that explores the relationship between individuals and contextual factors and considers injury to be the product of four levels of influence as seen in Figure 2 (Krug et al., 2002). The first level encompasses individual risk factors, such as, behaviour, knowledge, and past experiences; level two includes the persons immediate relational or social networks; level three includes the community contexts that the individual functions in; and level four encompasses the broader societal factors such as culture, norms, attitudes and political boundaries (CDC, 2019; WHO, 2019). The ecological model provides a useful basis for considering the multitude of risk factors that may contribute to alcohol-related road traffic crashes.

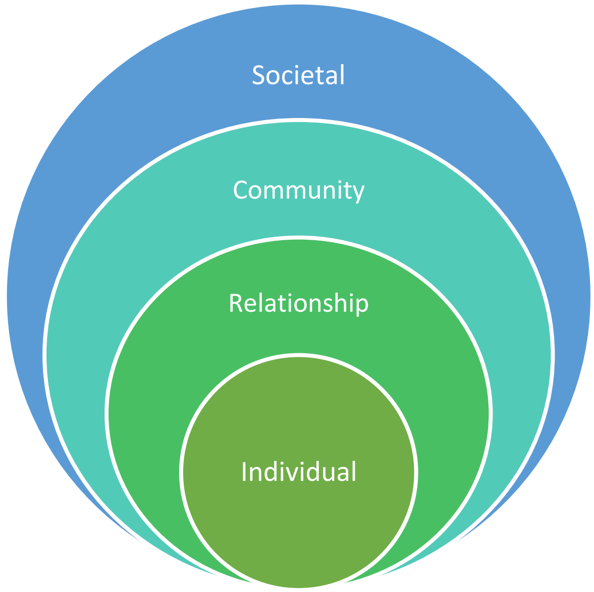

Figure 2. Ecological model

METHOD

The current research will seek to establish the extent of alcohol related RTCS, the factors contributing to alcohol consumption and RTCs, and the severity, health and economic impact of this public health burden. The study will therefore comprise of a desktop review of South African published and unpublished literature summarising the factors related to alcohol consumption and RTCs.

STUDY DESIGN

This study comprises a desktop review to identify existing evidence related to the extent and epidemiology of alcohol-related RTCs in South Africa, the risk factors that contributes to the magnitude of alcohol-related RTCs, and the RTC consequences of alcohol use in terms of the severity, health and economic outcomes. A review of peer reviewed published literature was performed concurrent to a review of grey, unpublished literature including but not limited to newspaper articles, pamphlets, and institutional reports. The review included English and Afrikaans published and unpublished literature, dated between 2008 and 2019.

SEARCH STRATEGY

Several databases were searched to collect relevant published and unpublished literature, these included Ebscohost; Pubmed; Sabinet; ScienceDirect; Scopus and Tailor and Francis. Theses and dissertations were sought from 'Open access theses and dissertations' database. Additionally, several South African institutions such as the Council of Scientific and Industrial Research (CSIR), Human Sciences Research Council (HSRC), Road Traffic Management Cooperation (RTMC), the South African Medical Research Council (SAMRC) and Arrive Alive were reviewed for institutional reports.

Database searches started with the identification of appropriate keywords. The following keywords were identified from literature: 'road traffic accidents', 'road traffic crashes', 'motor vehicle accidents', 'alcohol', 'alcohol-impaired driving', 'drunk driving', 'drink driving', 'Intoxication', 'alcohol-related' and 'South Africa'. The review was conducted along three levels, firstly, the identification of potential titles through database searches. Secondly, a pair of reviewers worked together to screen the abstracts which were retrieved based on the titles included, and thirdly, the abstracts that were successfully screened moved on to full-text reading. The review considered South African studies only that included road traffic crashes and alcohol impaired driving. All literature was stored electronically. A descriptive analysis was conducted considering the aim and the research questions of this study.

RESULTS AND DISCUSSION

Figure 3 summarises the results of each step of the review process. The title search across all databases yielded a search result of 4433 titles of which only 53 titles were relevant and included. Once duplicates were removed, a total of 40 titles underwent abstract screening and 33 moved onto full-text reading resulting in 16 included articles.

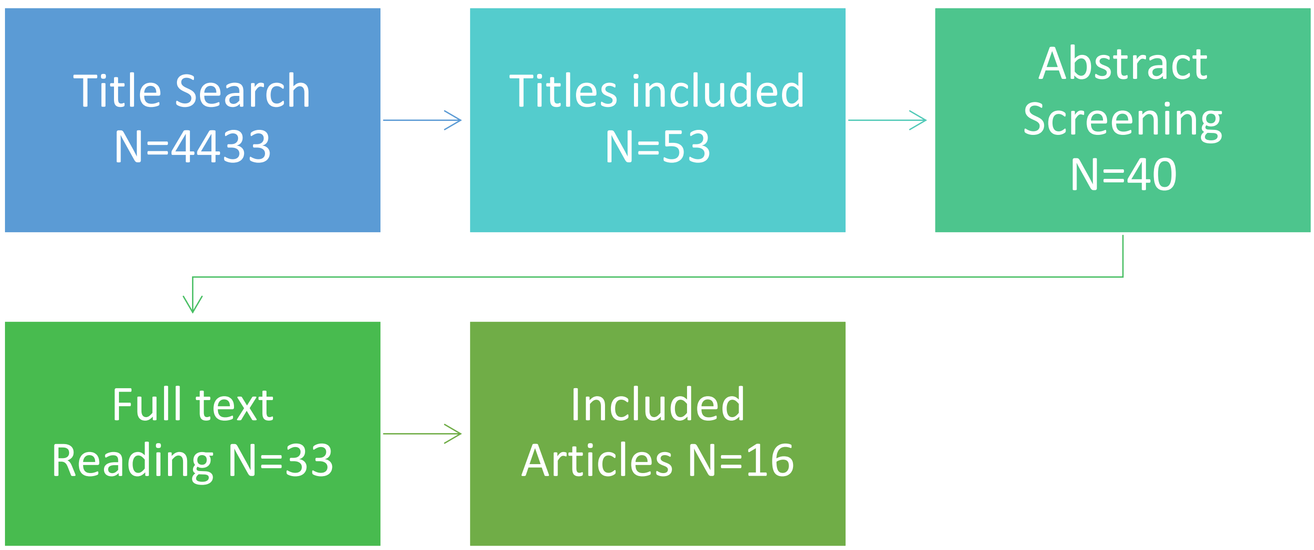

Figure 3. Search Strategy flowchart

Studies were grouped into three categories and analysed based on the research questions of this study: i) the extent and magnitude of alcohol-related RTCs (n = 4), ii) the risk factors contributing to alcohol-related RTCs (n = 4), and iii) the severity, health, and economic outcomes of alcohol-related RTCs in South Africa (n = 9). Table 1 displays the characteristic of the included articles.

Table 1: Characteristics of included articles

AUTHORS	TITLE	YEAR	AIM	COUNTRY	METHOD	EXTENT AND EPIDEMIOLOGY	RISK FACTORS	CONSEQUENCES
Casswell et al.	The alcohol environment protocol: A new tool for alcohol policy	2018	To report data on the implementation of alcohol policies regarding availability and marketing, and drink driving, along with ratings of enforcement from two small high-income to three high-middle income countries and one low-middle income country.	Scotland, New Zealand, St. Kitts and Nevis, Thailand, **South Africa** and Vietnam.	The study used the Alcohol Environment Protocol (AEP), an International Alcohol Control study research tool, which documents the alcohol policy environment by standardised collection of qualitative and quantitative data from administrative sources, observational studies, and interviews with key informants to allow for cross-country comparison and changeover time. Purposive sampling was used. The time period covered by AEP was 2013 to 2015. Participants interviewed varied from 12 in Scotland to 48 in SA.	Not stated	In South Africa, alcohol policies and regulations have been implemented. However, these legislations and policies are often not complied with and not well enforced.	Not stated
Du Plessis et al.	Ethanol-related death in Ga-Rankuwa road-users, South Africa: A five-year analysis	2016	To examine the relation of blood ethanol in road traffic fatalities among different road-user groups in the jurisdiction of Ga-Rankuwa medico-legal mortuary, South Africa from 1 April 2007 to 31 March 2012.	Ga-Rankuwa, North of Pretoria, South Africa	A retrospective descriptive study was conducted over a 5-year period (1 April 2007 to 31 March 2012) on all cases of road traffic fatalities admitted to mortuary. Mortuary records were reviewed and only cases that died at the scene were included in the study. Blood ethanol was tested during autopsy in all cases. Post-mortem blood ethanol analysis was conducted. A Chi-square test was used to test for difference between expected and observed frequencies in different categories with an alpha value of 0.01. The total study population that was identified for inclusion consisted of 672 cases.	60.4% of drivers tested positive for BAC, followed by pedestrians (55.6%) and motorcyclists (55.0%). Male victims with positive BAC were more prevalent whereas most females had a negative BAC. The highest incidence of all road traffic fatalities occurred during 19h01 and 22h00.	Not stated	Not stated
Ehmke et al.	A retrospective	2014	To review the alcohol levels in medico-legal	Pretoria, South Africa	A retrospective descriptive study was conducted on all case files of	63% of drivers tested positive for alcohol	Not stated	Not stated

	analysis of alcohol in medico-legal autopsied deaths in Pretoria over a 1-year period		investigations of unnatural deaths in Pretoria from 01/01/2009 to 31/12/2009.		non-natural deaths, in which sample were taken for alcohol analysis between 01 January 2009 and 31 December 2009. Blood samples were collected during autopsies and analysed. 1455 cases were analysed. Emphasis were placed on the alcohol level obtained in blood/fluid samples harvested at autopsy and the relevance thereof t the cause of death. Concurrently, comparisons were drawn to the parameters at hand (demographics, cause of death, and laboratory analysis) and to find trends in alcohol consumption and other drug or poison usage	with a mean BAC 0.17 ± 0.09g per 100ml, and 89% of these had a BAC over 0.05 g/100ml.		
Labuschagne et al.	The cost of crashes in South Africa 2016	2016	The RTCM commissioned the evaluation and review of the methodology of the 2004 DoT report (Cost of crashes 2004) with the overall aim to adopt a more user-friendly methodology to account appropriately for the local realities of the social and indirect cost of RTCs in the South African context.	South Africa	The first phase of the project updated the RTC unit cost tables of CoC 2004 using the RTMC's 2015 validated fatal RTC dataset and other relevant data for the three cost categories namely, human casualty, vehicle repair, and incident related costs. The methodology followed included a review of local and international literature; stakeholder interactions; data collection and processing; and the calculation of unit and total crash costs for use in applications. The outputs from these actions include the Crash Cost Data Source Traceability Matrix (CCDSTM), a Data Dictionary, and User Requirement Specifications (URS). The cost analyses calculations made use of the validated RTMC's 2015 fatal RTC dataset.	Not stated	Not stated	**Severity**: A total of 832 431 RTCs were recorded for 2015 of which, 11 144 cases were fatal crashes, 40 117 major, 132 609 minor and 648 560 cases resulted in damages alone. A total of 1 708 414 road traffic injuries were recorded for 2015 of which there were 13 591 fatalities, 62 520 serious injuries, 202 509 slight injuries and 142 9794 involved in RTCs sustained no injuries

Mabunda, Swart, & Seedat.	Magnitude and categories of pedestrian fatalities in South Africa	2008	Aims to provide a better understanding of the profiles associated with pedestrian fatalities to inform the development of pedestrian safety measures that are sensitive to the needs of various pedestrian groups at risk.	Pretoria, Johannesburg, Durban and Cape Town, South Africa.	Data was obtained from the NIMSS for the 2001-2004 period. All deaths classified as pedestrian traffic fatalities were identified and data for four major cities were selected namely, Pretoria, Johannesburg, Durban and Cape Town where the NIMSS has full coverage of non-natural fatalities. Descriptive analysis, including frequency distributions were conducted. A multiple correspondence analysis was used, and a two-step cluster analysis was performed.	A total of 7433 pedestrian deaths for the four cities of which only 2326 cases tested positive for alcohol. The majority of pedestrian fatalities in the 20-44-year age group and in the 45 year and older age group tested positive for alcohol. More males were found to be alcohol positive than females.	Not stated	Not stated
Matiwane & Mahomed	Cost analysis of road traffic crashes in a tertiary hospital in Mpumalanga Province, South Africa	2018	To estimate the cost of inpatient management of RTC injured patients in a tertiary hospital in Mpumalanga province between 1 April 2015 and 31 March 2016.	Mpumalanga, South Africa	Cost analysis of patient care following a RTC was conducted using a mixed-costing approach. A retrospective review of hospital records (208 patients) was conducted to extract services consumed by patients during hospital admission between 1 April 2015 and 31 March 2016. Patient and financial records were used to obtain expenditure information. The bottom-up approach and top-down approach were used to calculate direct costs and indirect costs respectively. A sensitive analysis was conducted to analyse how changes in resource use change the average costs. An average exchange rate of R13.50 is equivalent to US$1 was used.	Not stated	Not stated	**Economic:** The total cost of inpatient management of RTC injured patients equated to R11,014,187 with direct and indirect costs amounting to R5,995,872 and R5,018,315. **Health:** The most common body region injured in RTCs was the head and neck (32%), lower limbs (28%), upper limbs injuries (20%), pelvis and lumber injuries (8%), abdominal (7%), and chest and thorac (5%).
Matzopoulos, Lasarow, & Bowman.	A field test of substance use screening devices as part of routine drunk-driving spot detection operation	2013	To test four substance use screening devices developed in Germany under local South African conditions and assess their utility for detecting driving under the influence of drugs as part of the standard roadblock operations of local law enforcement agencies.	Gauteng and Western Cape Provinces, South Africa	Motorists were diverted for screening at roadblocks at the discretion of the law enforcement agencies involved, as per their SOPs for the routine spot detection of DUI. Fieldworkers administered a questionnaire that described the screening procedure as well as information about vehicles, demographic information about the motorists and their	A total of 269 drivers were tested for DUID at 22 roadblocks between 22 February and 5 September 2008, at which 261 breath alcohol tests were also administered.	Not stated	Not stated

	procedures in South Africa				attitudes to the screening process during testing. Blood samples were collected from those participants testing positive. A confirmatory blood analysis on the full blood samples within 6 h of roadside collection. Frequency counts were used to demonstrate the demographic distribution of the data. Proportions were compared using the chi-squared test and Fisher's exact estimates for small samples with fewer than 5 observed cases. The significance level for all statistical tests was set at 5%.	73 drivers (28%) of the 261 included cases tested positive for breath alcohol. alcohol impaired driving was prevalent from early evening (17h00) and peaked towards midnight and during the early hours of the morning.		
Matzopoulos, Truen, Bowman, & Corrigall.	The cost of harmful alcohol use in South Africa	2014	To provide a more comprehensive cost estimate to inform evidence-based alcohol policy and legislation.	South Africa	Reviewed existing international best-practice costing frameworks to provide the costing definitions and dimensions. Data was sourced from South African costing literature, or, if unavailable, estimated costs using socio-economic and health data from secondary sources were sourced.	Not stated	Not stated	**Economic:** In 2009, R7,9 billion in damages attributed to alcohol-related RTC in SA.
Nkwana	Risks associated with road safety in South Africa	2018	Editorial	South Africa	N/A	Not stated	Alcohol can make it difficult for a driver to concentrate on their driving, as well as impair vision and hearing. Alcohol use may result in taking unnecessary risks on the road.	Not stated
Parkinson, Kent, Aldous, Oosthuizen, & Clarke	Patterns of injury seen in road crash victims in a South African trauma centre	2013a	Reviewed all trauma admissions subsequent to an RTC at a single busy regional hospital and attempted to determine the common mechanisms of injury and associated patterns of injury.	Pietermaritzburg, KwaZulu-Natal, South Africa.	A prospective study of all patients presenting to Edendale Hospital following a RTC over a 10-week period from late 2011 to early 2012 was conducted. Fatalities recorded at a state mortuary for the same period were included. A total of 305 patients were seen at the hospital following a RTC. 100 of the sample were admitted. 45 deaths from RTCs were	Not stated	Not stated	**Health:** Common injuries included lower limb, head, upper limb, soft-tissues injuries, thoracic, facial, neck, and intra-abdominal injuries. There were differences in injury region between injured pedestrian and injured motorists.

					recorded at the police mortuary. 13 fatalities were excluded from the study. This makes a total of 320 RTC victims. Medical records were reviewed, and the admitted patients were interviewed. Injury severity scores (ISS) were calculated for all the admitted patients			
Parkinson, Kent, Aldous, Oosthuizen, & Clarke	Road traffic crashes in South Africa: the burden of injury to a regional trauma centre	2013b	To record the mortality and morbidity associated with RTCs at a regional hospital in South Africa and investigate preventable factors associated with RTCs.	Pietermaritzburg, KwaZulu-Natal, South Africa.	Prospective study of all patients presenting to Edendale Hospital following a RTC over a 10-week period, from late 2011 to early 2012. Fatalities recorded at a state mortuary for the same period were included. Medical records were reviewed, and the admitted patients were interviewed. Injury severity scores (ISS) were calculated for all the admitted patients. An injury pyramid was calculated.	Not stated	Not stated	**Health**: A total of 197 injuries were sustained and 26 of the sample suffered 3 or more injuries. 32 patients sustained fatal injuries, 33 severe injuries, 63 moderate injuries, and 192 minor injuries. 62 of the 100 patients required surgery. Health outcomes were reported.
Parkinson, Kent, Aldous, Oosthuizen, & Clarke.	The hospital cost of road traffic accidents at a South African regional trauma centre: A micro-costing study	2013c	Study attempts to cost RTC related injury using a bottom up micro-costing approach.	Pietermaritzburg, South Africa	A prospective micro-costing study was conducted over a ten-week period during late 2011 and early 2012. A total of 100 patients who were admitted after RTC were included. Injury details, demographics, investigations and interventions were recorded. A bottom up costing analysis were performed. To calculate costs patients were reviewed every 48h and all interventions were recorded for each individual patient. Prices of interventions were obtained from hospital pricelists. A total cost was calculated on an individual basis. Student t-test was used to determine significance.	Not stated	Not stated	**Economic:** The total cost of in-patient hospital care for victims of RTCs over the ten-week period was US $698850. The average cost of care for a pedestrian victim of an RTC was US $6789 and for an occupant of a vehicle involved in an RTC was US $7127 ($p > 0.5$).

					Significance was inferred at $p < 0.05$.			
Phaswana-Mafuya & Davids	Drinking and driving and other risk-taking behaviours among university students in South Africa	2011	To Assess the relationship between drinking and driving and other risk-taking behaviours among university students in Limpopo South Africa, aged 17 to 24 years old.	Limpopo, South Africa	A cross-sectional study was conducted, and purposive sampling method was used. A total of 111 undergraduate university student drivers aged 17-24 years participated in the study. A structured questionnaire was completed by respondents. Mean scores were calculated and an independent-samples test and logistic regression analysis were performed	Not stated	Young people who had engaged in risky behaviour previously were more likely to engage in drink driving.	Not stated
Pienaar & Nel	Road traffic accidents: The risk of alcohol abuse	2009	Editorial	South Africa	N/A	Not stated	As drivers' abilities are impaired by higher blood-alcohol concentrations, their judgment worsens progressively, and drivers believe that they are performing normally or may even feel more confident which in turn may result in taking unnecessary risks.	Driver who are under the influence of alcohol cause more severe RTCs. A driver who tests positive for alcohol use is 33.3 times more at risk of dying in an RTC compared to a driver who tests negative
Verster & Fourie	The good, the bad and the ugly of South African fatal road accidents	2018	To raise awareness of the effects of accidents, more specifically fatal accidents.	South Africa	An exploratory investigation was conducted. The data used in this paper refer specifically to fatal accidents that occurred on South African roads during 2015 and were retrieved from a report published by South Africa's RTMC. A total of 10 613 fatal accidents occurred from 1 January to 31 December 2015 and resulted in 12 944 fatalities.	Not stated	Not stated	**Economic:** The cost of RTC in South Africa in 2015, amounted to approximately ZAR 142,95 billion, which equates to 3.4% of the Gross Domestic Product.
Wesson, Boikhutso, Hyder, Bertram, & Hofman	Informing road traffic intervention choices in South Africa: the role of	2016	Aim is three-fold: 1. Describe sources of information and the full extent to which RTI-related costing data are available in SA.	South Africa	A review of published economic evaluations of RTI-related prevention in LMICs. Descriptive analysis of the data was performed. Searches were not limited by year. A total 13 articles were included.	Not stated	Not stated	**Health:** Four studies reported the average road traffic injury costs per injured person in terms of total, medical, and loss of productivity costs. The total road

	economic evaluations		2. Describe the extent to which RTI-related costing data are available in other LMICs through a review of the literature. 3. Use these findings to suggest potential cost-effective RTI prevention interventions for SA.					traffic injury costs ranged between US$2,980 and US$8,770. South Africa's cost estimates were found to be two to four times higher than costs reported from other LMICs.

The included articles were methodologically appraised. Studies ranged in methods used. Four of the included studies were reviews, three studies adopted a retrospective descriptive approach, three studies adopted a prospective approach, two were cross-sectional studies, one study employed an exploratory investigation, and one used a mixed method approach. Two of the included articles were editorials and the methods were not explicitly stated. Furthermore, the sampling methods included purposive sampling (n=2), simple random sampling (n=1), and the remaining studies used secondary data (n=13). Interviews (n=2), questionnaires (n=3), mortuary records (n=3), and hospital records (n=4) were used to collect data.

THE EXTENT AND DEMOGRAPHICS OF ALCOHOL-RELATED ROAD TRAFFIC CRASHES IN SOUTH AFRICA

Two institutional reports (Global Status Report on Road Safety 2018, 2018; International Transport Forum [ITF], 2017) and four peer reviewed published literature (du Plessis, Hlaise, & Blumenthal, 2016; Ehmke, du Toit-Prinsloo, & Saayman, 2014; Mabunda, Swart, & Seedat, 2008; Matzopoulos, Lasarow, & Bowman, 2013) reported on the extent and demographics of alcohol-related RTCs in South Africa. Drivers were identified as the largest proportion of victims with positive BAC, with an overrepresentation of males. Studies reported that alcohol related RTCs most likely occurred during the early evening and during spring.

The extent of alcohol-related RTCs

The two institutional reports reported on the extent of alcohol-related RTCs in SA. The Global Status Report on Road Safety (2018) analysed NIMSS 2010 data and estimated that 58% of road traffic deaths in South Africa involved alcohol. Whereas, the International Transportation Forum (ITF) (2017) analysed 2015 RTMC crash reports and concluded that 7.8% of all road traffic crashes involved alcohol, with 5.5% involving a driver and 1.8% involving a pedestrian with BAC levels above 0.05g/100ml. The variation in the findings (58% and 7.8%) may reflect limitations in both studies. The limitation to NIMSS data may be as a result of the limited geographical coverage, as NIMSS in 2010 only had coverage over two provinces. Thus the 58% as reflected in the results, may be an overestimation of road traffic deaths that involved alcohol. RTMC results may also have some limitations in terms of data capturing and the quality of data.

Du Plessis, Hlaise and Blumenthal (2016) reported that drivers represented the largest proportion of victims (60.4%) with positive BAC, followed by pedestrians (55.6%) and motorcyclists (55.0%). The mean BAC for all road fatalities was 0.20 ± 0.13 g/100ml and the mean BAC in all road-user groups was ≥0.05

g/100ml (Du Plessis et al., 2016). Similarly, Ehmke, du Toit-Prinsloo and Saayman (2014), and Matzopoulos et al. (2013) both reported higher frequencies of drivers under the influence of alcohol. In Ehmke, du Toit-Prinsloo and Saayman's (2014) article, 63% of drivers, in Pretoria, tested positive for alcohol with a mean BAC 0.17 ± 0.09g per 100ml, and 89% of these had a BAC over 0.05 g/100ml. Matzopoulos et al (2013) reported 73 drivers (28%) of the 261 included cases tested positive for breath alcohol in Gauteng and the Western Cape.

Demographic and temporal factors

Du Plessis et al. (2016) reported that 78.1% of fatalities involved males while only 21.9% involved females. Male victims with positive BAC were more prevalent with a mean BAC of 0.20 ± 0.13 g/100ml, whereas most females had a negative BAC. Furthermore, du Plessis et al. (2016) reported that those with positive BAC ranged from 35 to 44 years and most victims that had a negative BAC were younger than 18, which is expected as the drinking age limit in SA is 18 years and older. Du Plessis et al. (2016) further reported that the highest incidence of all road traffic fatalities among those with positive BAC occurred during 19h01 and 22h00. Similarly, Matzopoulos et al. (2013) concluded that alcohol impaired driving was prevalent from early evening (17h00) and peaked towards midnight and during the early hours of the morning. Du Plessis et al. (2016) reported that fatalities with negative BAC occurred mostly during 05h01 and 08h00 and that most fatalities irrespective of BAC occurred during weekends and road traffic fatalities with positive BAC occurred mostly in spring.

Pedestrian alcohol-related RTCs

Only one study reported on pedestrian fatalities involving alcohol use. Mabunda, Swart and Seedat (2008) reported the magnitude, demographic and temporal factors associated with pedestrian fatalities in Pretoria, Johannesburg, Durban and Cape Town. Blood alcohol analysis was conducted in 4004 pedestrian fatalities, with 2326 (58%) cases tested positive for alcohol with a mean concentration of 0.22g/100ml. Mabunda et al. (2008) reported that of the 2326 cases which tested positive for alcohol, 147 had a BAC level between 0.01 and 0.04g/100ml, 368 were between 0.05 and 0.14g/100ml, 827 were between 0.15 and 0.24g/100ml, and 984 had a BAC level over 0.24g/100ml. The majority of pedestrian fatalities in the 20-44-year age group and in the 45 year and older age group tested positive for alcohol. Furthermore, more males (62,3%) were found to be alcohol positive than females (42%) with a mean BAC of 0.22g/100ml and .21g/100ml respectively (Mabunda et al., 2008).

THE RISK FACTORS THAT CONTRIBUTE TO THE MAGNITUDE OF ALCOHOL-RELATED ROAD TRAFFIC CRASHES IN SOUTH AFRICA

Four of the included studies provided information regarding the risk factors that contribute to the magnitude of alcohol-related RTCs in South Africa (Casswell et al., 2018; Nkwana, 2018; Pienaar & Nel, 2009; Phaswana-Mafuya & Davids, 2011). It is reported that human factors play a role in the likelihood of driving under the influence as studies found that young adults who engaged in previous risky behaviours were most likely to engage in drink driving (Phaswana-Mafuyu & Davids, 2011). An Australian study was used to further explain the relationship between social and personality constructs and drink driving (Watling, Hooijer, Armstrong & Watling, 2018). Moreover, only one South African study found that the lack of enforcement of laws, regulations and policies may result in the increased burden to alcohol-related RTCs (Casswell et al., 2018).

Human factors

Nkwana (2018) as well as Pienaar and Nel (2009) explain that as drivers' abilities are impaired by higher blood-alcohol concentrations, their judgment worsens progressively, and drivers believe that they are performing normally or may even feel more confident which in turn may result in taking unnecessary risks. Unexpectedly, Pienaar and Nel (2009) report that drivers with a BAC of up to 0.10g/100ml will not usually show any marked outward evidence of impaired driving capability. They based this finding from a previous study conducted at the University of California, where the driving performance of intoxicated drivers was measured using a driving simulator. It was only when a secondary visual task was added that the evidence of the effects of alcohol became clear (Pienaar & Nel, 2009).

Only one SA study was found to report on the behavioural aspects that may explain why drivers indulge in alcohol use before driving. Phaswana-Mafuyu and Davids (2011) assessed the relationship between drinking and driving among a sample of university students in Limpopo and found that young people who had engaged in risky behaviour previously were more likely to engage in drink driving. Those who had reported to have taken part in gang fights, used illicit drugs, stolen someone's property, been involved in a drink driving accident, taken a car for a ride without permission, driven without a driver's license, driven beyond the required speed limit and indulged in reckless driving were more likely to indulge in drink driving (Phaswana-Mafuyu & Davids, 2011).

An international study conducted by Watling et al. (2018) in Australia, investigated the relationship between social and personality constructs with drink driving among licenced drivers aged 18 to 24 years. The authors used Akers' Social Learning Theory and Behavioural Inhibition System (BIS) and Behavioural Approach System (BAS) to help understand drink driving among young people. Watling et al. (2018) found that several social and personality variables were associated with drink driving. Firstly, anticipated punishment and reward were associated with drink driving. It was found that there was an increase in the likelihood of drink driving if the anticipated punishment was low. Secondly, it was found that social aspects, in terms of peer approval of drink driving, was associated with a greater likelihood of individual drink driving. The results further showed that family constructs were not associated with drink driving suggesting that during early adulthood peer influences are more significant than family influences (Watling et al., 2018). Furthermore, the study found that past and anticipated future positive experiences may increase the likelihood of driving under the influence (Watling et al., 2018).

Social and environmental factors

Like the Australian study, Casswell et al. (2018) identified that the lack of enforcement of policy and legislation, i.e. lack of punishment, often lends itself to risky behaviour in South Africa. Casswell and colleagues (2018) conducted a study concerning the implementation of alcohol policies and regulations and rated the level of enforcement of such policies and regulations. In South Africa, they recognised that alcohol policies and regulations have been implemented. These policies include restriction of the availability of alcohol in relation to the location and density of alcohol use; restrictions in terms of the exposure of alcohol to children; legislations concerning the minimum purchase age of 18 years and legislative restrictions on social supply of alcohol to those under age; drink-drive legislations; and restriction concerning trading hours. However, Casswell and colleagues (2018) further report that these legislations and policies are often not complied with and are not well enforced as there remains several South African alcohol outlets that are unlicensed. Additionally, there is no system for recording offenses against sale restrictions making the access of alcohol more readily available to young people (Casswell et al., 2018).

SEVERITY, HEALTH AND ECONOMIC OUTCOMES OF ALCOHOL-RELATED ROAD TRAFFIC CRASHES IN SOUTH AFRICA

In the following section three points will be discussed namely, the severity of RTCs and RTIs of alcohol-related RTCs and non-alcoholic related RTCs, the health consequences, injury typology and common surgeries as a result RTCs and alcohol-related RTCs, and the economic consequences of RTCs and alcohol-related RTCs.

Severity

Two institutional reports (Cost of Crashes [CoC], 2016; Labuschagne, De Beer, Roux, & Venter, 2016) reported on the severity of RTCs and RTIs in South Africa. One editorial report (Pienaar & Nel, 2009) and one peer reviewed article (Parkinson, Kent, Aldous, Oosthuizen, & Clarke, 2013b) reported on the severity outcomes of alcohol-related RTCs in South Africa.

The Cost of Crashes (CoC) report (2016) and Labuschagne et al. (2016) both reported that a total of 832 431 RTCs were recorded in South Africa in 2015 (see Table 2 below). Of the total number of RTCs, 11 144 cases were fatal crashes, 40 117 major, 132 609 minor and 648 560 cases resulted in damages alone (CoC, 2016; Labuschagne et al., 2016).

Table 2: Severity of RTCs in 2015

	Fatal	Major	Minor	Damages	Total
Number of RTCs	11 144	40 117	132 609	648 560	832 431

(CoC, 2016; Labuschagne et al., 2016)

In terms of injury outcomes of RTC, CoC (2016) and Labuschagne et al. (2016) reported that a total of 1 708 414 road traffic injuries recorded for 2015 of which there were 13 591 fatalities, 62 520 serious injuries, 202 509 slight injuries and 142 9794 involved in RTCs sustained no injuries (see Table 3 below).

Table 3: Severity of RTIs in 2015

	Death	Serious	Slight	No injuries	Total
Number of people who sustained injuries	13 591	62 520	202 506	1 429 794	1 708 414

(CoC, 2016; Labuschagne et al., 2016)

One editorial article described severity outcomes following alcohol-related RTCs. Pienaar and Nel (2009) argues that drivers who are under the influence of alcohol cause more severe RTCs (Pienaar & Nel, 2009). More severe outcomes can be expected because alcohol-related RTCs are likely to occur at a greater speed and, as a result, at greater impact. The authors maintained that greater impact RTCs result in more damages and greater probability of severe injuries and/or fatalities. Pienaar and Nel (2009) estimated the relative risk of drivers who test positive for alcohol using Bayes' Theory and the 2006 RTC figures reported by RTMC. The authors found that a driver who tests positive for alcohol use is 33.3 times more at risk of dying in an RTC compared to a driver who tests negative (Pienaar & Nel, 2009). Comparably, an international study by Borges et al. (2017) reported the relative risk of RTI when drinking compared to not drinking. The sample consisted of 1119 RTI patients from 16 emergency departments in Argentina, Brazil, Costa Rica, Dominican Republic, Guatemala, Guyana, Mexico, Nicaragua, Panama and Trinidad & Tobago. The study revealed that the risk of sustaining a RTI when consuming alcohol was 5 times higher (odd ratios varied between 2.50-15.00 for different countries) compared to not drinking. The amount of alcohol consumed was related to the risk of sustaining a RTI. A single drink increased the risk of sustaining a RTI by 13% (Borges et al., 2017). For example, the risk of suffering a RTI was 9.52 times higher when between 15.1 to 30 drinks were consumed and the risk of a RTI was 26.50 times higher when between 30.1 to 60 drinks were consumed (Borges et al., 2017).

Only one study (Parkinson, Kent, Aldous, Oosthuizen, & Clarke, 2013b) reported on the severity of injury from road traffic crash patients in South Africa. Parkinson et al. (2013b) reported that a total of 197 injuries were sustained of which 26 patients suffered 3 or more injuries. In terms of the injury severity, 32 patients sustained fatal injuries, 33 severe injuries, 63 moderate injuries, and 192 minor injuries. No difference was found between pedestrian and motor vehicle related RTCs in the number (n=13.63) or severity (n=12.37) of injuries sustained (p=0.5). Eight of the sample were suspected of being under the influence of alcohol, however, differences between BAC positive and BAC negative severity outcomes were not measured.

From the above evidence, it is clear that RTCs result in severe crashes and injuries. However, it is not clear that alcohol-related RTCs result in more severe injuries and crashes than other types of RTCs. A study conducted in the Philippines, O'Connor and Ruiz (2014) examined the role of alcohol in road trauma by examining the medical records of a random sample of RTC patients (n=156). The study revealed that participants who tested positive for alcohol use sustained multiple injuries, and their injuries were found to be more severe than participants who tested negative for alcohol use. The result of the study showed that the average Injury Severity Score (ISS) for alcohol negative patients was 3.58 and the average ISS for alcohol positive patients was 8.3. Although this study provides some support for the increased severity outcomes of alcohol-related RTCs, only 7 of the 156 cases were positive for alcohol use.

Health consequences

Two peer reviewed studies (Du Plessis, Hlaise, & Blumenthal, 2016; Matiwane & Mahomed, 2018; Parkinson, Kent, Aldous, Oosthuizen, & Clarke, 2013a) reported common injury typology following RTCs in South Africa and one article (Du Plessis, Hlaise, & Blumenthal, 2016) reported injury typology for BAC positive and BAC negative patients. Two articles (Matiwane & Mahomed, 2018; Parkinson et al., 2013b) reported on the surgeries following RTC injury.

Injury typology following a RTC

Matiwane and Mahomed (2018) and Parkinson et al. (2013a) reported on the common injuries sustained in RTCs. Matiwane and Mahomed (2018) reported that the most common body region injured in RTCs was the head and neck (32%), followed by lower limbs (28%), upper limbs injuries (20%), pelvis and lumber injuries (8%), abdominal (7%), and chest and thorac (5%). Parkinson et al. (2013a) reported the injury patterns for pedestrian crashes and motor vehicle crashes. Overall, the most common injuries were lower limb injuries, head injuries, upper limb injuries, soft-tissues injuries, thoracic injuries, facial injuries, neck injuries, and intra-abdominal injuries. Pedestrians commonly sustained injuries to the lower limb, clavicle and radio-ulnar fractures, head, and thoracic injuries. Whereas, motor vehicle patients sustained humeral, neck and intra-abdominal injuries (Parkinson et al., 2013a).

Injury typology following an alcohol and non-alcohol related RTCs

Du Plessis et al. (2016) compared the injury typology for BAC positive and BAC negative road traffic fatalities and found no differences among BAC or type of road user (drivers, passengers, pedestrian, motorcyclists, and cyclists) for injuries or cause of death. Du Plessis et al. (2016) reported that the most common injuries were external injuries, and injuries to the torso and head. The most prevalent cause of death were multiple injuries, preceded by head injuries.

Common surgeries required following a RTC

Matiwane and Mahomed (2018) and Parkinson et al. (2013b) reported on the surgeries following a RTC injury. Matiwane and Mahomed (2018) reported that in total, 216 injuries were suffered by the 208 RTC patients, 66 of the patients had 3 or more injures, 106 patients required surgery and 7 patients required 3 surgeries. In total, 164 operations were performed. Parkinson et al. (2013b) reported that 62 of the 100 patients required surgery. A total of 90 operations were performed with 15 pedestrians and 17 motor vehicle occupants requiring 2 or more operations.

Health related outcomes following a RTC

Parkinson et al. (2013b) reported health outcomes of a 100 RTC participants admitted to hospital; 4 patients passed away; 4 were permanently disabled; 4 could recover with long-term physical rehabilitation (more than 6 weeks); 52 with short-term rehabilitation (less than 6 weeks); 14 patients were transferred to a different hospital; and 19 patients recovered with no assistance.

In summary, common injury typologies following a RTC included lower limb injuries, upper limb injuries and injuries to the head and neck regions. Pedestrians more commonly sustain injuries to lower limbs, clavicle and head whereas, motorists sustain humeral, neck and intra-abdominal injuries. Surgeries are common following RTCs. South African literature however, does not show differences in injury typology between BAC positive and BAC negative patients.

Economic consequences

Three institutional reports (CoC, 2016; ITF, 2017; Labuschagne et al., 2016) and one published article (Verster & Fourie, 2018) reported on the total cost of RTC in South Africa. CoC (2016), ITF (2017), Labuschagne et al. (2016), and Verster and Fourie (2018) reported that the total cost of RTCs on South Africa's road network in 2015, amounted to approximately ZAR 142.95 billion, which equates to 3.4% of the Gross Domestic Product (GDP). Of the total crash cost, human casualty costs accounted for 69.3%, vehicle repair for 14.9% and incident costs for 15.8%. In South Africa, the cost of RTCs has been equated to 3.4% of the GDP (CoC, 2016; ITF, 2017; Labuschagne et al., 2016; Verster & Fourie, 2018). CoC (2016) reported that the average cost of RTCs in low- and middle-income countries *amounted* to 2.2% of their

GDP while the average for high-income countries is 2.6% (varying between 1.0 and 4.6 per cent), placing South Africa at the higher end of the scale in terms of annual cost to the country.

CoC report (2016) and Labuschagne et al. (2016) reported on the per unit cost per RTC and the per unit cost per RTI as seen in Tables 4 and 5. These costs were arranged according to the severity of the accident. These reports revealed that more severe RTCs and RTIs resulted in higher costs. This trend was similarly observed by Parkinson and colleagues (2013c) who conducted a cost analysis of RTCs at Edendale Hospital in Pietermaritzburg, South Africa. The findings revealed that, a higher number of injuries sustained during a RTCs resulted in higher medical costs (Parkinson et al., 2013c).

Table 4: Per unit cost per RTC

Fatal	Major	Minor	Damage	Any severity
R5 435 261	R765,664	R152,244	R48,533	R171,727

(CoC, 2016; Labuschagne et al., 2016)

Table 5: Per unit cost per RTI

Death	Serious	Slight	No injury
R3,916,187	R423,858	R71,352	R1,085

(CoC, 2016; Labuschagne et al., 2016)

Matiwane and Mahomed, (2018) and Parkinson, Kent, Aldous, Oosthuizen, and Clarke (2013c) reported on the hospital cost of RTC related injuries in South Africa. Matiwane and Mahomed (2018) used a bottom-up and top-down approach to calculate direct and indirect costs of inpatient management of RTC injuries in a tertiary hospital located in Mpumalanga, South Africa over a one-year period. The total cost of inpatient management of RTC injured patients equated to R11,014,187 (US $8,15,865) with direct and indirect costs amounting to R5,995,872 (US $444,138) and R5,018,315 (US $371,207). On average, the cost per patient per day for RTIs equated to R256,382 (US $18,991). Parkinson and colleagues (2013c) similarly examined the hospital cost of road traffic related crashes at Edendale Hospital in Pietermaritzburg, South Africa, using a bottom up micro-costing approach over a ten-week period. Operations performed amounted to US $148,230 total cost of theatre time (Parkinson et al., 2013c). A total of 48 patients required at least one orthopaedic implant resulting in US $126,487. The total cost of in-patient hospital care for victims of RTCs over the ten-week period was US $698,850. The average cost of care for a pedestrian victim of an RTC was US $6,789 and for an occupant of a vehicle involved in an RTC was US $7,127 ($p > 0.5$) (Parkinson et al., 2013c). Upper limb injuries were the most expensive, and the largest costs were ward overheads (US $281,681).

The cost of medical care for RTIs in South Africa is vast. The above-mentioned studies by Matiwane and Mahomed (2018) and Parkinson and colleagues (2013c) reported that the total cost of inpatient management of RTC injured patients equated to US $815,865 (over a one-year period) and US $698,850 (over a ten-week period), respectively. There is no South African literature that measures the difference in cost of medical care for BAC positive and BAC negative RTC patients. In international literature, Gómez-Restrepo et al. (2016) performed a cost analysis of medical care for BAC positive and BAC negative patients following a RTC in six different hospitals in Bogota-Colombia. The study reported that the average cost per patient was US $628. The average cost per RTC was valued at US $1,349. The total cost for health care for BAC positive RTC patients were 1.8 times higher than for BAC negative patients.

On peer reviewed article (Wesson, Boikhutso, Hyder, Bertram, & Hofman, 2016) conducted a review of published economic evaluations and compared injury related costs in South Africa to other LMICs. Wesson et al. (2016) conducted a review of published economic evaluations of road traffic injuries-related costs in South Africa and compared the findings with those in other low- and middle-income countries. The analysis revealed that four studies reported the average road traffic injury costs per injured person in terms of total, medical, and loss of productivity costs. The total road traffic injury costs ranged between US$2,980 and US$8,770. The majority of costs were attributed to loss of productivity (63-96% of total costs) and medical treatment accounted for 1-14% of total costs. South Africa's cost estimates were found to be two to four times higher than costs reported from other LMICs such as Jordan, Thailand, Vietnam, and China (Wesson et al., 2016).

RTCs hold great economic consequences for countries all over the world and even more so for South Africa. However, the cost of alcohol-related RTCs in South Africa has largely been unexplored in the SA literature. One article estimated the total cost of damages attributable to alcohol-related RTCs. Matzopoulos, Truen, Bowman, and Corrigall (2014) reviewed primary data (South African based costing literature) or secondary sources (socio-economic and health data) to determine cost estimates of harmful alcohol use in South Africa, including RTCs. Based on Council for Scientific and Industrial Research (CSIR) data Matzopoulos et al. (2014) estimated that in 2009 the cost of RTCs to the national economy was R67,6 billion. This included human casualty costs (56%), healthcare costs, and damage cost (44% or/ R29,7 billion). Matzopoulos et al. (2014) applied an alcohol attributable portion of 27% to the R29,7 billion total damage cost and estimated that R7,9 billion of this cost can be attributed to alcohol-related RTC in SA.

Overall, the results indicated that more severe crashes also result in more costs. In addition, medical costs related to RTCs increase with the number of injuries sustained. The largest medical costs were found to be ward overheads. South Africa's cost estimate is estimated to be 2 to 4 times higher than comparable low- to middle-income countries (Wesson et al., 2016). Lastly, the cost of alcohol-related RTCs are largely unknown in South Africa.

CONCLUSION AND RECOMMENDATIONS

International and South African research reported alcohol use as a leading risk factor in RTCs as it impairs driving ability, influences the drivers' attitude, decision-making, alertness, judgment, response and controlling of the motor vehicle (Matzopoulos, Lasarow, & Bowman, 2013; Matzopoulos, Lasarow, & Bowman, 2013; Wesson et al., 2016). This study aimed to explore the relationship between alcohol and road traffic crashes and posed three research questions.

1. What is the extent and epidemiology of alcohol-related road traffic crashes in South Africa?
2. What are the risk factors that contribute to the magnitude of alcohol-related road traffic crashes in South Africa?
3. What is the severity, health and economic outcomes of alcohol-related road traffic crashes in South Africa?

Findings of the present study revealed that drivers are the largest proportion of victims with positive BAC, with an overrepresentation of males, and that alcohol-related RTCs most likely occurred during the early evening and during spring. Furthermore, human factors appeared to play a significant role in the likelihood of driving under the influence as studies found that young adults who engaged in previous risky behaviours were most likely to engage in drink driving. Moreover, the results revealed that the lack of laws, regulations and policy enforcement may result in the increased alcohol-related RTCs burden. With regards to the consequences of alcohol-related RTCs, the results indicated that more severe crashes result in more costs and that medical costs related to RTCs increases with the number of injuries sustained. The largest medical costs were found to be ward overheads. South Africa's cost estimate is estimated to be 2 to 4 times higher than comparable low- to middle-income countries. Lastly, the cost of alcohol-related RTCs are largely unknown in South Africa.

Despite these results, there remains a lack of research which focuses on alcohol and its implications for road traffic crashes conducted in South Africa. Several studies were limited in terms of geographical constraints and many of the included studies were not comparable due to methodological differences. Only a few studies reported on the extent of alcohol-related road traffic crashes, revealing that this phenomenon remains neglected, with a relatively limited research platform on alcohol and RTCs circumstances.

Recommendation: it is proposed that the local research platform be strengthened in order to develop interventions and strategies to prevent alcohol use while driving. Future research should focus on the analysis of existing alcohol data, especially that related to RTCs in South Africa, to identify the scope, demographics, circumstances of occurrence and the risk factors which exacerbate the burden.

With regards to the consequences, the exact severity, health and economic outcomes that are attributable to BAC positive RTCs are not adequately explored in the present scope of South African RTC literature. RTC related outcomes are generally reported in terms of all crashes and not specifically BAC positive crashes. Evidence revealed that there is limited research in the South African context that examines the difference between injury severity of BAC positive and BAC negative RTCs. When injury severity is measured, group differences between BAC positive and BAC negative is not measured or the population size of BAC positive patients is insufficient. The same goes for difference in injury typology or number of injuries sustained between BAC positive and BAC negative RTC patients.

Recommendation: It is recommended that more research be conducted to assess the severity of injury and crash outcomes between BAC positive and BAC negative RTCs. Additionally, it is recommended that further research be conducted on causes of death, type of injuries, and number of injuries sustained as a result of alcohol-related RTCs.

The cost of alcohol-related RTCs are largely unknown in South Africa. Research, however, revealed that more severe crashes also result in higher economic costs and that the medical costs related to RTCs increase with the number of injuries sustained. Research has revealed that the cost to economy damages attributable to BAC positive RTCs is vast but there is a lack of evidence to suggest why. It may be that more severe crashes, multiple cars involved, or more property damaged.

Recommendation: it is proposed that future research should focus on economic costs attributable to BAC positive RTCs and how and why these costs differ compared to BAC negative RTCs.

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