Driver intoxication and fatal crashes

Alcohol intoxication as a risk factor for fatal crashes and fatalities: 2016 to 2018

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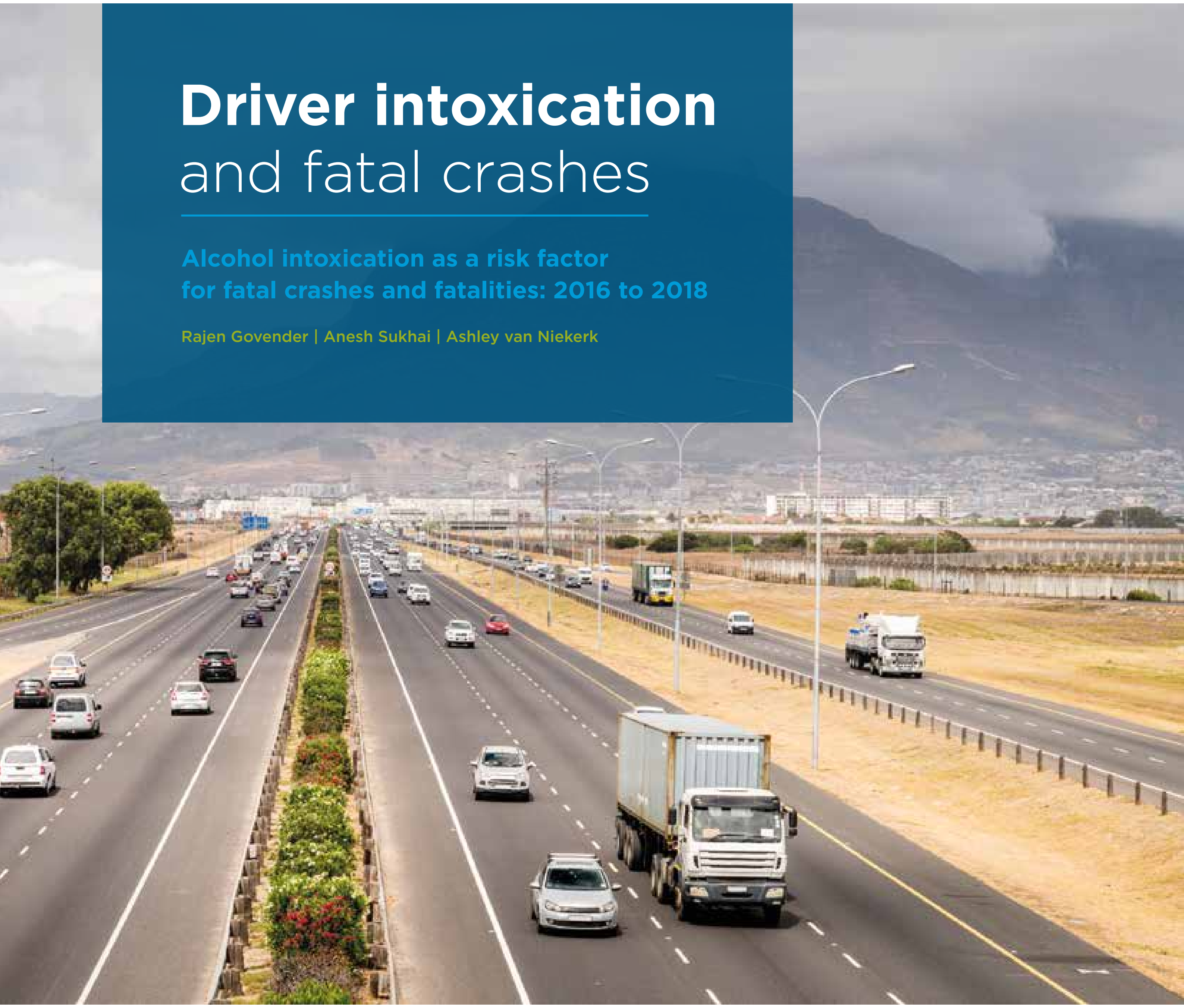

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Executive Summary

Overview

The brief for this research was to investigate and clarify the role of driver alcohol intoxication as a risk factor for fatal road traffic crashes[1] in the country. The study investigated this by examining the absolute and proportionate risk of driver intoxication relative to other identified driver risk behaviours, in both fatal crashes and fatalities, and in the context of associated secondary factors.

Univariate and bivariate descriptive analyses and multivariate analyses (logistic regression modelling) were undertaken to describe, clarify and explain the relationship between alcohol-related fatal crashes and a range of associated secondary variables, *inter alia*, driver behaviour, vehicle type, crash type, and the temporal and spatial characteristics of the fatal crashes. Bivariate analyses focussed on absolute risk using impact factors (IF), defined as a measure of the proportion of fatalities per fatal crash for a specific risk and road user category). The logistic regression modelling focussed on proportionate risk estimates that were adjusted for the influence of secondary factors/variables and expressed the risk of driver intoxication through odds ratios (defined as estimates of the probability of a defined event given the probability of other known events). **Overall, categories of several key analysis variables (driver behaviour, crash type and vehicle type) were reformulated in novel ways to achieve empirical rigour and fulfil the need to yield findings which would have direct practical value in informing road safety practices in the country.**

The findings from this research are based on 13 074 fatal crashes with known driver risk factors that occurred over a 3-year period from 2016-2018, this extraction being a subset of the total of 33 659 fatal crashes due to all risk factors for this period as contained in the RTMC data. Most victims within the dataset of fatal crashes associated with driver risk behaviour were vehicle passengers (49%), followed by vehicle drivers (41%), and more than three-quarters (77%) of the fatal crash victims were male.

Key Findings

Driver Behaviour

Alcohol-attributed crashes accounted for the smallest proportion of cases (5.5%) while the driver behaviours attributed most often as the cause of the crash were speeding[2] (52%), followed by other driver risks (42%). The largest impact factor (across all road users and all driver behaviour risks) was found for alcohol and pedestrian deaths (IF 2.9), indicating that **at an absolute level, pedestrians were three times more likely to die in a crash where the driver was intoxicated**.

[1] *The term "road traffic crash", as used by the RTMC and the SAPS, is aligned with the definition as in SANS/ISO 39001 and is used throughout this report. "Road traffic crash" also imparts the same meaning as "accident" that is used in the National Road Traffic Act, Act 93 of 1996.*

[2] *"Speeding" refers to both excessive and/or inappropriate driving speed, considered too high for circumstances, as determined by the SAPS.*

Crash Characteristics

Just under half of the crashes (47%) were classified as driver only crashes (or crashes that did not involve any other road users), followed by crashes occurring between two or more vehicles (41%). Pedestrians were particularly vulnerable in driver-pedestrian crashes with an impact factor of 8, indicating the proportion of pedestrian deaths from driver-pedestrian crashes to be eight times more than the proportion of all fatal crashes involving pedestrians.

After adjustment for the influence of secondary variables (through logistic regression modelling), the risk for fatal crashes attributed to alcohol (relative to speeding) was significantly greater for crashes between two or more vehicles and between a vehicle and a pedestrian, than for crashes involving only the driver. That is, in contrast to speeding, **driver intoxication significantly increased the risk for crashes which involved both the driver and other road users, either motorists or pedestrians**.

Vehicle Characteristics

Both passengers and pedestrians showed disproportionate vulnerability with public transport. For crashes involving minibuses, passengers had 1.5 times greater likelihood of fatality per fatal crash, and pedestrians had 1.6 times greater likelihood of fatality per fatal crash. In terms of buses and midibuses, passengers experienced 2.1 times more fatalities per fatal crash and pedestrians experienced 1.7 times more fatalities per fatal crash.

After adjustment for the influence of secondary variables, the risk for fatal crashes attributed to alcohol was shown to be significantly greater for crashes involving light vehicles (versus trucks) relative to crashes attributed to both speeding and to other driver risks. This indicates a **clearly significant risk for driver intoxication in light vehicles**. Further, the risk for fatal crashes attributed to alcohol was also significantly greater for crashes involving buses and midibuses (versus trucks) relative to crashes attributed to speeding, indicating **much greater overall risks for driver intoxication amongst public permit vehicles transporting passengers than those transporting goods**.

Temporal Characteristics

Most fatal crashes occurred at night (55%), over weekends (64%), and during non-vacation periods (70%). Relative to the proportional number of days in a year, **fatal crashes were more likely to occur over regular weekends (IF 2.2), followed by long weekends (IF 1.5) and then only marginally so during vacation periods (IF 1.03)**.

After adjustment for the influence of secondary variables, the risk for fatal crashes attributed to alcohol was shown to be significantly greater at night than during the day relative to crashes attributed to both speeding and all other driver risks. Further, the risk for fatal crashes attributed to alcohol was significantly greater during both long weekends and regular weekends than during weekdays relative to crashes attributed to speeding and other driver risks. The risk for fatal crashes attributed to alcohol was also shown to be significantly greater during non-vacation than vacation periods relative to fatal crashes attributed to speeding and other driver risks. Overall, then, compared to any other driver risk behaviour, **driver intoxication played a significantly greater role in fatal crashes occurring at night, during weekends, and during non-vacation periods of the year**.

Spatial Characteristics

Nearly three quarter (72%) of fatal crashes occurred in the jurisdiction of local municipalities as compared to metropolitan municipalities. Gauteng followed by KwaZulu-Natal (KZN) accounted for the largest proportions of fatal crashes (20% and 16%, respectively), however, these proportions were lower than their proportional population sizes (25% and 20%, respectively).

QUICK
FACTS

55%
of most fatal crashes happen at night

64%
of most fatal crashes happen over weekends

70%
of fatal crashes happen during non-vacation periods

Key Recommendations

Improving the Measurement and Capture of Alcohol

Based on findings from a range of local and international studies, in South Africa (SA) **the attribution of only 5.5% of fatal crashes to alcohol intoxication of drivers is deemed to be a gross underestimate**. This implies that the impact and consequences of driver intoxication in terms of fatal crashes and fatalities is also significantly underestimated.

Recommendations are provided for remedying the current situation, specifically for improving RTMC crash and injury recording to more accurately measure and reflect alcohol attribution in fatal crashes. This can be achieved by recording driver intoxication as a category of risk which overlaps other driver risk behaviours rather than it being a mutually exclusive category. In this manner, the role of alcohol intoxication will be manifest regardless of any other driver risk behaviour. Such measurement will also enable proper analysis of the compounding effect of alcohol intoxication, i.e., the manner in which intoxication co-occurs, and exacerbates the risks associated with other driver risks such as speeding, disregarding traffic lights and signs, overtaking, fatigue, falling asleep, and cellphone distraction.

A key recommendation is to assign greater priority to targeting driver intoxication during nights, during weekends, and across the entire year, achieved mainly through roadblocks.

To confirm the current underestimation of fatal crashes related to driver alcohol intoxication, empirically sound data from local sources was used to generate an extrapolated estimate of the likely proportion of such fatal crashes. This extrapolation realised an estimate of 27.1% for the proportion of fatal crashes attributed to driver alcohol intoxication[3].

The extrapolated estimate has important implications for generating reliable costing estimates for alcohol-related fatal crashes in the country. **The current 5.5% alcohol attribution indicates a costing estimate of R 3.7 billion for such fatal crashes. In sharp contrast, the extrapolated estimate of 27.1% realizes a costing estimate of R 18.2 billion.** Put differently, the current estimate underestimates the likely proportion and cost implications by around 80%.

Notwithstanding the improved estimated value, it is acknowledged that the extrapolated estimate itself may be conservative, and that more reliable estimates may be achieved as more robust data sources become available for analysis, particularly from the proposed revised methodology for recording driver intoxication in fatal crash data.

Enforcement

The findings have important practical implications for informing enforcement operations. Firstly, they provide reason to align distinct types of enforcement to specific temporal periods and spatial locations. Secondly, they call for the priority focus on certain vehicle types such as light and public passenger vehicles. Thirdly, they call for greater attention to include other road users, especially pedestrians. Consequently, a key recommendation is to assign greater priority to targeting driver intoxication during nights, during weekends, and across the entire year, achieved mainly through roadblocks. Relatively greater priority should be assigned to the targeting of speeding and other driver risk behaviours during other temporal periods (daytime, weekday, and vacation periods).

Future Research

This research has addressed an important priority area for road safety in the country, one that results in significant human and financial costs. Despite the limitations in measurement of driver intoxication, the current analysis provides important initial pointers for policy development and design of programmatic intervention. Going forward, it is imperative that this work be augmented by additional research so that a comprehensive evidence-based approach is properly clarified and formulated.

In this regard, some key priorities for future research are evident. Firstly, **there is a need for a focussed study of pedestrian vulnerability**, strongly motivated by the very high proportion of pedestrian fatalities in road crash fatalities attributed to all risk factors. To achieve this, robust disaggregated analysis of the RTMC data is required, coupled with triangulation of key contextual data on availability, quality and sufficiency of infrastructure provisioning such as pavements, crosswalks, lighting, etc.

Secondly, and following from the high proportion of fatal crashes attributed to particular driver risk behaviours, **there is a need to account for the currently documented greatest risks for road fatalities, most notably speeding and overtaking** (speeding accounts for more than half of fatal road crashes due to driver error, and overtaking accounts for around one fifth). A better understanding of these risk behaviours, especially with an improved picture of how alcohol intoxication interacts with and compounds these, will help make considerable progress towards addressing the great majority of fatal crashes which are attributed to driver error in South Africa.

[3] *Alcohol attribution is used to reflect those fatal crashes where a driver tested positive for alcohol, as determined by the RTMC and SAPS as the main contributor to the crash, although crashes are typically multifactorial in nature.*

Acronyms

BAC	Blood Alcohol Concentration
CHOCOR	Culpable Homicide Crash Observation Report
FCD	Fatal Crash Dataset
FPS	Forensic Pathology Services
IF	Impact Factor
KZN	KwaZulu-Natal
LDV	Light Delivery Vehicle
NHTSA	National Highway Traffic Safety Administration
NIMSS	National Injury Mortality Surveillance System
ODR	Other Driver Risk
OR	Odds Ratio
RTMC	Road Traffic Management Corporation
SA	South Africa
SAMRC	South African Medical Research Council
SAPS	South African Police Services
TADS	Trauma and Drug Study
UNISA	University of South Africa
VIPRU	Violence, Injury and Peace Research Unit
WHO	World Health Organization

In South Africa, and internationally, the impact of alcohol intoxication to all road users has been reported as far-reaching and profound for families, communities, and the economy.

Research Brief and Report Overview

In South Africa there is a recognition of the far-reaching effects of alcohol use and intoxication on road traffic crashes, injury, disability and mortality (Road Traffic Management Corporation, 2018). However, despite global campaigns such as the United Nations Decade of Action and intensive South African efforts, the rate of road traffic injury and mortality death has decreased in 2017 and 2018, but is still high at 25.9 deaths per 100 000 (WHO, 2018).

The Road Traffic Management Corporation, established through the Road Traffic Management Corporation Act, No. 20 of 1999, is constitutionally mandated to coordinate the country's road safety strategic planning, regulation, facilitation and law enforcement at national, provincial and local spheres of government, and to provide a road information management system that supports road safety actions (RTMC, 2019).

In South Africa, and internationally, the impact of alcohol intoxication to all road users has been reported as far-reaching and profound for families, communities, and the economy (Simons, Marais, Hornsby, Swart, Seedat & Van Niekerk, 2019). The RTMC has estimated that the annual cost of such crashes is considerable (Labuschagne, 2016), with the cumulative cost of all road crashes in 2018 estimated at R166 billion[4] and alcohol being a significant contributor. However, despite this likely estimated impact for alcohol in road fatalities, there is limited and variable South African research on the extent and contribution of alcohol to the country's fatal crash burden, thus constraining the necessary policy, prevention and control programming.

In 2018, the RTMC approached the Violence, Injury and Peace Research Unit (VIPRU), to lead research into investigating and understanding the role of alcohol intoxication in the country's fatal crashes. VIPRU is coordinated by the South African Medical Research Council and the University of South Africa to serve as a national hub for research into injury priorities and their prevention. In various discussions RTMC and VIPRU agreed to collaboratively strengthen the local alcohol and road traffic nexus research platform. Consequently, an MOU (Memorandum of Understanding) for this work was signed between the RTMC and the SAMRC. Following from this, VIPRU was commissioned to conduct research to determine the contribution of alcohol intoxication on road traffic crashes, with a specific focus on driver intoxication. The first phase of this work

4 *Based on RTMC data, calculated and provided by D. Roux.*

involved a review of South African research on alcohol and its implications for road traffic crashes (Simons, Marais, Hornsby, Swart, Seedat, & Van Niekerk, 2019). South African studies have variously implicated alcohol in driver mortality, with estimates ranging from 33% to 69%, although, there is a general absence of detailed systematic analyses on the nature of alcohol's effects on road traffic crashes and injuries, and on its associations, if any, with other common risk behaviours such as speeding and reckless driving and the use of safety devices such as seat belts and helmets. This study, being the second phase of this collaboration, seeks to investigate and clarify the role of driver intoxication as a risk factor for fatal crashes.

There is a dearth of detailed systematic analyses on the role and impact of alcohol in road traffic crashes and injuries/fatalities, and the likely associations with other common traffic crash and injury/fatality risk behaviours.

The Research Brief

The research brief from RTMC to VIPRU was to investigate, analyse and clarify the role of driver intoxication as a risk factor for fatal crashes. The analyses are based on RTMC data for the period 2016 to 2018.

The research was structured according to the following terms of reference:

- To achieve this focus on driver intoxication risk relative to all other driver risk behaviours, and ensure congruence in comparison of risk categories, the analysis *will focus exclusively* on all *driver risk behaviours*.
- Given the above, the analysis will *exclude* all cases where the measure of intoxication relates to *pedestrians, cyclists and motorcyclists*.
- Also excluded will be cases which indicate the risk factors related to the *vehicle, road and environment conditions*.
- The analysis will be undertaken on the fatal crash dataset supplied by RTMC to VIPRU for the years 2016 to 2018 *inclusive*.
- The analysis will be *prescribed and constrained by the variables available* in this dataset, and any validity issues attendant to these variables.
- The analysis will investigate and present the *absolute and adjusted risks* of driver intoxication for fatal crashes.
- The principal emphasis in the analysis will be on *adjusted or proportionate risk*, that is, the risk from driver intoxication relative to other identified driver risk behaviours and as variant across defined conditions for other risk variables.
- The analysis will comprise *descriptive analysis for context* and background and to detail the absolute risks associated with specific analysis and risk variables.
- The majority aspect of the analysis will focus on adjusted risk, which will utilise *logistic regression modelling* to determine the proportionate risks for driver intoxication relative to other driver risk behaviours.
- In addition to the analysis of the RTMC Fatal Crash dataset (FCD), the research will attempt a m*ore accurate estimate of the prevalence of driver intoxication* in fatal crashes by extrapolating such prevalence from extant research, including survey and medico-legal laboratory data.
- To the extent possible, the analysis will be utilised to develop *applicable recommendations* to the RTMC for data collection and management, further research, and policy and programme interventions.

Structure of the Report

The report is structured as follows:

- **Research Brief and Report Overview** – an introduction to the research and review of the research brief
- **Background and Literature Review** – a brief review of the relevant literature relating to global and national discourses and trends with respect to fatal crashes, the attribution of driver risk behaviours, and the role of alcohol in driver risk behaviours. This is intended as a focussed rather than a comprehensive literature review.
- **The RTMC Fatal Crash Data** – this section provides an overview of the validation of the RTMC fatal crash dataset and the rationalisation and selection of the analysis sample.
- **The Analysis Variables and Analytic Framework** – this section reviews and discusses all the variables for analysis in the research, including their conceptual formulation and technical transformations for application in the analysis of absolute and adjusted risk, and provides an overview of the framework for analysing absolute and adjusted risk.
- **Context and Absolute Risk** – this section provides a data rich context for the research and presents and discusses the absolute risks associated with driver intoxication and other key analysis variables.
- **Adjusted Risk Assessment** – this section presents the results of the logistic regression modelling and discusses the relative risks associated with driver intoxication across all the risk categories of associated influencing factors.
- **Discussion** – this section discusses the core findings of the research and provides an extrapolated estimate of the likely prevalence of alcohol in RTMC assessed fatal crashes.
- **Recommendations** – this section identifies and proposes several recommendations for programmatic interventions by RTMC, future measurement of alcohol by RTMC, and priority areas for further research.

Background and Literature Review

Internationally and in South Africa, alcohol use and intoxication has been identified as a leading health risk behaviour, and a leading contributor to road traffic mortality (Global Burden of Disease 2016 Alcohol Collaborators, 2018; WHO, 2019).

The contribution of alcohol intoxication, along with human factors, have collectively been identified as comprising the most common contributor to risky driving behaviour and road traffic mortality (Razzaghi, Soori, Kavousi, Abadi, Khosravi & Alipour, 2019) and generally comprising the main cause of three out of every five road traffic crashes (Petridou & Moustaki, 2000). In South Africa, this contribution has been estimated to be even higher, at 90% (RTMC, 2018).

> The contribution of alcohol intoxication, along with human behaviourial risk factors are estimated to contribute to 90% of road traffic crashes. Research on the prevalence of alcohol within this category of human factors is critically absent.

Risky Driving Behaviour

Risky driving behaviour, by definition, refers to those patterns of driving that place drivers and other road users, including passengers and pedestrians, at risk for injury and mortality and that typically also involve legal violations (Jessor, Turbin & Costa, 1997). Risky driving may be influenced by a range of human or behavioural factors. These factors have been described according to those that: (i) reduce capability on a long-term basis (e.g. aging, disease and disability, alcoholism, drug abuse); (ii) reduce capability on a short-term basis (e.g. drowsiness, fatigue, acute alcohol intoxication, short term drug effects, acute psychological stress, temporary distraction); or that (iii) promote risk taking (e.g. dominant masculine attitudes, the overestimation of abilities, habitual disregard of traffic regulations, speeding, non-use of seat belt or helmet, and compulsive acts) (Petridou & Moustaki, 2000). Such factors contribute to risky driving, which refers specifically to reckless and aggressive driving, but also inattentive, distracted driving and driving with significant tiredness (Gold, Müller & Bengler, 2016). There are many different manifestations of risky driving, but those that have generated international concern are speeding and tailgating, cutting in front of cars, moving in and out of traffic across lanes, and crossing red traffic lights (Gold, Müller & Bengler, 2016).

> Alcohol impairs driving ability by either depressing or stimulating the central nervous system. It adversely influences driver attitude, decision-making, alertness, judgement, response, and ultimately, control of the motor vehicle.

Significance of Alcohol Use and Intoxication

> **Globally, driving under the influence of alcohol is reported to be a key human behavioural factor, with international studies implicating alcohol in about a third of crashes that result in mortality.**

Alcohol is globally implicated as a significant contributor to serious traffic crashes that result in mortality. For example, in Australia, 30% of all fatally injured drivers had BACs of 0.05/100ml or above, the legal driving limit there; in Canada 38.3% of all fatally injured drivers had BACs above 0.08/100ml; in China 34% of all fatal road crash victims had BACs between 0.02 to 0.08/100ml (Chen et al., 2016); in Europe 25% of all road fatalities had BACs above the various country limits; and in the United States 29% of all traffic fatalities (with 61% of these drivers) had BACs of 0.08/100ml or higher (National Highway Traffic Safety Administration; NHTSA, 2018).

Alcohol is also considered to impair driving performance in low quantities, i.e. below the country specified legal limits, with an increasing body of research indicating that there is no BAC threshold below which some degree of impairment does not occur (see e.g. Ogden & Moskowitz, 2004). Alcohol, in whatever concentration, is therefore reported to impair driving performance and thus increase not only the probability of a traffic collision, but also the probability of injuries, along with poor clinical and survival outcomes thereafter (Ogden & Moskowitz, 2004).

The use of alcohol is also associated with more risk prone changes in safety attitudes, such as seat belt use, helmet use and speed choice (Heng et al., 2006; WHO, 2014). Thus, those who use alcohol may take further driving risks which might then either directly initiate a crash or increase crash severity (Shyhalla, 2014). Psychologically, drinking and driving has been associated with sensation-seeking, which is also a predictor of other risky driving behaviours, including speeding, unsafe lane changes and passing other vehicles, tailgating or short following distances, and the failure to slow down or stop when appropriate (Jonah, 1997, cited by Shyhalla, 2014).

Alcohol as a Risk Factor for Road Crashes and Fatalities

Alcohol impairs driving ability by either depressing or stimulating the central nervous system. Alcohol may be distinguished from anaesthetic agents that depress all brain functions, as the impact of alcohol is first manifest in those parts of the brain involved in integrated and complex functions, such as skilled driving performance (Ogden & Moskowitz, 2004). The analysis of sensory information, the control of intricate movement patterns and short-term memory are reported to be especially sensitive to alcohol. These effects of alcohol on human skills and performance are also reported at even the lowest measurable BACs, thereafter increasing in an approximate exponential manner (Moskowitz & Robinson, 1988). The effect of alcohol is thus dependent on the quantity consumed, but also the nature of the performance required (Moskowitz, 1985).

Alcohol consumption influences driver attitude, decision-making, alertness, judgement, response, and ultimately control of the motor vehicle (Zhao, Zhang & Rong, 2014). Clinical research has indicated specific aspects of driving performance that are significantly affected with alcohol use and intoxication, notably average speed, speed standard deviation, average lane position and lane position standard deviation (e.g. Zhao et al., 2014). There appears to be no evidence of a specific transition from unimpaired to impaired, with even low levels of BAC demonstrating an impact on driving skills.

Impairment is associated with a deterioration in cognitive functions that include a slower response to stimuli including driving hazards, divided attention, and decreased visual functions and tracking, with these decreases in capacity already noted at low BAC levels (0.01–0.02 g/100ml), i.e. the level reached with one drink.

More controlled and complex tasks (i.e. requiring focussed attention tasks, tracking, and information processing) are reported to be impaired in actual traffic at BAC 0.03–0.049 g/100ml, while more automatic behaviour (i.e. over-learned tasks which require little conscious mental activity) is impaired beyond 0.05 g/100ml (Kruger, 1993; cited from Heng et al., 2006; Moskowitz et al., 1985). Beyond such BAC levels, laboratory studies have indicated that when BACs are 0.08-0.09%, the ability to maintain even constant speed and lane position is compromised (Allen et al. 2009; cited from Shyhalla, 2014).

The decrease of driving performance as BAC levels increase are such that the risk of a fatal crash doubles with each 0.02g/100ml increase. The United States Fatality Analysis Reporting System indicates that with BACs of 0.02 to 0.049 g/100ml, the risk of a fatal crash increases 3 to 5 times compared to sober drivers, and with BACs of 0.05 to 0.079 g/100ml, the risk of a fatal crash increases 6 to 17 times compared to sober drivers (Zador, 1991; cited in Heng et al., 2006).

South African studies have identified alcohol in 33% to 69% of selected driver samples in various geographic and clinical settings. These results are reported for samples of drivers, and not for fatal crashes.

Alcohol Related Traffic Offences and Fatalities in South Africa

Driving under the influence of alcohol with a BAC concentration of 0.05 g/100ml and higher, or 0.02 g/100ml in the case of professional drivers, is currently prohibited under Section 65 of the National Road Traffic Act (Act No. 93 of 1996). South African studies have reported that alcohol is implicated in 33% to 69% of selected driver samples in various geographic and clinical settings (Ehmke et al. 2014; Du Plessis et al., 2016; Matzopoulos et al., 2013; Marais, Sukhai & Donson, 2004; Wesson et al., 2016).

Non-Injured Drivers

In terms of non-injured drivers, Matzopoulos et al. (2013) reported that 28% of 261 drivers tested positive for breath alcohol as part of routine roadblock operations by law enforcement agencies in Gauteng and the Western Cape. This study reports that alcohol-impaired driving is most prevalent from early evening at 17h00, peaking around midnight and declining in the early hours of the morning. Other South African research has revealed that 113 (11.4%) of a representative sample of 1006 motorists in Durban reported that they drove under the influence of alcohol and most (81) also reported consumption of alcohol at levels above the legal blood alcohol limit (Sukhai & Seedat, 2008). The reported frequency for driving under the influence of alcohol was 3.9/10 when there was opportunity to do so. Further, driving under the influence of alcohol was shown to be a significant predictor of both victimisation and perpetration of extreme forms of driver aggression such as getting out of one's vehicle to argue or hurt another driver, deliberately colliding with or damaging another motorist vehicle, threatening another motorist with a firearm, or shooting at another motorist (Sukhai & Seedat, 2008).

Non-Fatal Injuries

A Trauma and Drug Study (TADS) conducted over 3 years on trauma patients at five health care facilities in three sentinel sites (Cape Town, Durban and Port Elizabeth) reported that 394 (20.4%) patients were injured in transport collisions. Of the transport-related injuries, half of all drivers and pedestrians tested positive for alcohol, compared to one-third of passengers. Furthermore, over the three years, between 24.3% and 41.0% of the transport-related victims were assessed as exhibiting problem drinking or alcohol dependence (Marais, Sukhai & Donson, 2004).

QUICK

FACTS

Driver intoxication in:

28%
enforcement operations

50%
non-fatal injuries

60% – 63%
fatal injuries

24% – 41%
Alcohol dependency in drivers

Fatally Injured Drivers

A Ga-Rankuwa investigation on mortuary data over a five-year period from 2007-2012 reported that drivers were the largest proportion of road traffic crash victims with a positive BAC (60.4%), followed by pedestrians (55.6%) and motorcyclists (55.0%) (Du Plessis, Hlaise & Blumenthal, 2016). The mean BAC for all road fatalities was 0.20 ± 0.13 g/100ml with 91.7% of the drivers with a positive BAC level reporting BAC levels ≥ 0.05 g/100ml. Similarly, for a 1-year period in Pretoria, Ehmke, du Toit-Prinsloo and Saayman (2014) reported 63% of drivers in Pretoria testing positive for alcohol with 89% of them having a BAC ≥ 0.05 g/100ml. The mean BAC of the BAC positive driver cases was 0.17 ± 0.09g per 100ml.

In terms of gender, du Plessis et al. (2016) reported male victims to be more likely than females to test positive for alcohol (56.8% vs 27.2%, respectively). However, the mean BAC for females was substantially higher for female than for male drivers (0.24 g/100ml and 0.18 g/100ml, respectively). Female pedestrians also had a slightly higher mean BAC than male pedestrians (0.26 g/100ml and 0.25 g/100ml, respectively).

In terms of age, Du Plessis et al. (2016) found the BAC-positive victim ages to range from 35 to 44 years (60.4%) with most victims younger than 18 years having a negative BAC (four victims under 18 years tested positive for alcohol of which one was a vehicle driver). With temporality, Du Plessis et al. (2016) found a highest incidence of road traffic fatalities with positive BAC occurred during from 19h00 to 22h00, during weekends, and mostly during Spring.

In summary, both global and national research has consistently demonstrated alcohol to be a risk factor in traffic crashes and injuries and fatalities both above and below the legally prescribed limits, as well as through its association with other risk behaviours relating to use of seat belt, helmets, speeding and reckless driving. In this manner, the impact of alcohol is linear, with greater concentrations producing higher risk, and both direct and indirect in that alcohol directly compromises the ability to use the vehicle and road and indirectly increases risk of injury and fatalities by increasing the propensity for other forms of risky behaviours, with these in turn directly increasing vulnerability to injury and fatality.

Both global and national research has consistently demonstrated alcohol to be a risk factor in traffic crashes and injuries and fatalities both above and below the legally prescribed limits.

The RTMC Fatal Crash Dataset

In this section the treatment and management of the RTMC Fatal Crash Dataset (FCD) is presented and discussed. The preparatory work outlined here is deemed critical to the overall research as it attests to the integrity of the final analysis dataset and, consequently, the confidence invested in the results obtained from the analysis of this final dataset.

A rigorous process of vetting and validation was undertaken to prepare the data for analysis, including rationalisation of the measurement variables across the three review years. Identified categories of several key analysis variables (driver behaviour, crash type and vehicle type) were reformulated in novel ways to achieve empirical rigour and fulfil the need to yield findings that inform road safety practices in the country.

Data Vetting and Validation

To begin with, the fatal crash dataset as supplied by RTMC was subject to a rigorous process of validation. Broadly speaking, validation is a process whereby the dataset is investigated for quality and accuracy prior to application of the data to the analysis. As the dataset was supplied directly by the RTMC based on the standard data collection forms and process, and without VIPRU access to this process and collection forms, the accuracy of the data could not be directly verified. Rather, the accuracy of the data as supplied by the RTMC was accepted at face value.

In terms of data quality, the validation process entailed examination of the data to assess errors which might impact the analysis and distort obtained results. These errors could be manifest in several ways. Firstly, they may occur through the coding of the variables, which would render a poor fit to the analysis. Secondly, data errors may be manifest in the distribution of missing data for specific variables, which would introduce systematic bias into the analysis, thereby skewing results for the descriptive analysis and the logistic regression modelling.

Data validation was achieved by conducting a detailed investigation of all potential analysis variables contained in the RTMC FCD. This investigation identified several issues for specific variables, mainly relating to coding of the same variables across different calendar years and/or the completeness of these variables in terms of missing values. For variables where coding errors were identified, remedial action was undertaken to ensure a better fit of the variables for the analysis. Appendix A provides a detailed description of each variable, the coding errors identified for each of these, and the remedial action undertaken to ensure inclusion of these into the substantive analysis.

The RTMC dataset as supplied comprises 33 659 cases of fatal crashes for the three year period. Of these, 28 159 cases implicate human factors as the attributed cause for the fatal crash.

In the case of missing values, a detailed missing values analysis was undertaken to verify the reasons for such missing values. In the instance where missing values were due to substantive reasons, such as the non-applicability of variables for specific cases, these were addressed through variable recoding. In the instance where data was missing for unaccounted reasons, the cases for which this was applicable were removed from the analysis dataset.

Overall, the validation revealed few significant issues which could not be addressed through appropriate remedial action such as variable transformations and recodes, thereby ensuring that the larger portion of the variables and the cases contained in the supplied dataset could be retained for the substantive analysis.

Sample Definition and Extraction

The research brief supplied to the SAMRC required an investigation of driver intoxication risks relative to all other driver risks. To this end, the final dataset for substantive analysis could therefore only contain cases for which driver risk behaviours were directly indicated as attribution for the fatal crash. This meant that the original dataset had to be scaled down to exclude all variables and cases for which driver risk behaviours were either not measured or applicable. For clarity purposes, a case refers to an instance of a fatal crash, while variables refer to specific analysis descriptors applicable to each case.

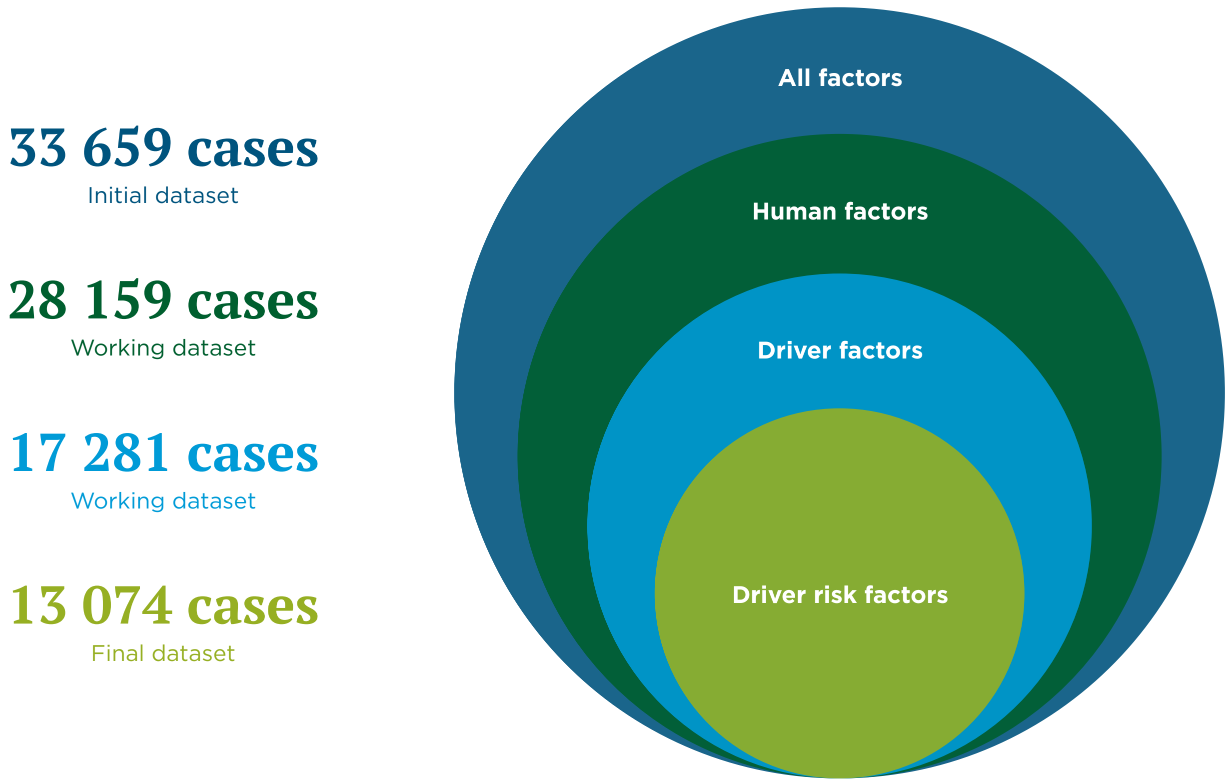
To begin with, the sample comprised all cases in the RTMC FCD, namely 33 659 cases of fatal crashes. This original dataset as supplied contained 102 cases for which there was no data at all on the likely attribution for the crash, and these were excluded from the dataset. The remaining set of 33 557 cases were then separated into three distinct subsets, the first containing only cases for which Human Factor was indicated as attribution for the fatal crash, and the remaining two subsets containing cases for which the attribution for the fatal crash was listed as either Vehicle Factor or Road and Environment Factor. The latter two subsets were then excluded from the working dataset, which now contained only crashes for which Human Factor was applicable, accounting for 28 159 cases.

Within the Human Factor working dataset, several subsets were identified and separated, each accounting for a specific human factor, driver and otherwise (pedestrian, cyclist, motorcyclist, etc.). This dataset was rationalised by exclusion of all cases which did not indicate driver risk, thereby realising a working dataset of driver risk factors comprising 17 281 cases. Inspection of this dataset revealed that the majority of cases reflected attribution of driver risk behaviours such as speeding, alcohol intoxication, overtaking and so forth, while a minority portion reflected the attribution as Hit and Run. While Hit and Run is logically a valid category for the legal purposes, it has minimal validity for a behavioural analysis as it does not accord conceptually with the other driver risk categories such as speeding and overtaking, all of which reflect risk behaviours that are likely causal attributions for the fatal crash in the first instance. Accordingly, this category of cases was excluded from the working dataset, thereby realising a final working dataset comprising 13 074 cases. These 13 074 cases were those for which a specific defined driver risk behaviour was assessed to have been the likely cause of the fatal crash, and which provides the conceptually valid basis for comparing the risks of driver intoxication to other driver risk behaviours.

The RTMC dataset as supplied comprises 33 659 cases of fatal crashes for the three year period. Of these, 28 159 cases implicate human factors as the attributed cause for the fatal crash. The specific focus on driver factors returned a total of 17 281 cases. After excluding cases where driver risk is not clearly documented, the final sample for the analysis comprised 13 074 cases.

This dataset of 13 074 cases provides the basis for all the analysis detailed in this report. A schematic overview of the sample definition and extraction is provided in the Figure 1.

Figure 1: Sample Definition and Extraction



Analysis Variables and Analytic Framework

The RTMC FCD, as indicated previously, was subject to a stringent validation process. One key component of this validation process was to determine the relevance and applicability of the variables to be entered into the substantive analysis. The variable selection was informed by a combination of research and data considerations.

The research consideration accounted for existing research literature which highlighted the role of specific risk behaviours in fatal crashes, while the data consideration accounted for the specific formulation and measurement of the identified variables in the RTMC FCD. To ensure convergence between substantive research validity and the constraints of the existing data, variables for analysis were first identified for inclusion from the existing dataset on the basis of their measurement validity and thereafter subject to transformation to ensure better representation of substantive risk categories that would be relevant to investigating and clarifying the role of driver intoxication relative to other driver risk behaviours. This process realised the key analysis variables discussed in this section.

Core Analysis Variable – Driver Intoxication Relative to Other Driver Risk Behaviours

The core analysis variable relates to the overall purpose of this research, which is to assess the proportionate risk for driver intoxication relative other identified driver risk behaviours. This variable is based on the Driver Factor variable provided in the RTMC FCD, which contains the following categories of attribution:

- **Driver Intoxication** – detection of alcohol in the driver
- **Making a Turn or U-Turn** – execution of a turn or U-turn which lead to the crash
- **Speeding** – speed inappropriate for the context
- **Overtaking** – overtaking another vehicle
- **Followed Too Closely** – following another vehicle at an inappropriate distance
- **Fatigue/Fell Asleep** – driver was fatigued or fell asleep while driving
- **Disregard for Traffic Lights/Signs** – driver disregarded traffic lights or applicable traffic signs
- **Cellphone Distraction** – driver was distracted by use of his/her cellphone

As this is the core analytic variable, driver intoxication is compared to all other categories, so all other categories are reference categories.

However, upon review of the research brief, this variable was deemed to constitute several conceptual and measurement challenges for the analysis. Firstly, and substantively, the value in comparing driver intoxication to all other known driver risk categories was not clear given that the comparisons are driven mainly by the availability of these categories in the dataset rather than compelling reasons which justify the comparison from a behavioural perspective. Secondly, and in terms of measurement, the retention of this variable with the existing categories would lend to exploring complex and unmeaningful relations with other analysis variables. Furthermore, for the analysis to be valid, the model must contain cases for each level of this variables across every level of all the other variables, and this is difficult to achieve in instances where the number of cases is already very small, such as for the categories of Fatigue/Fell Asleep and Cellphone Distraction, both of which have very small frequency of occurrence (less than 2%). The net effect would be too few cases for comparison in the logistic regression modelling, thereby rendering the models unstable and invalid.

To address both the conceptual and measurement issues, a new formulation for this core analytic variable was proposed. The new formulation is grounded on a logical behavioural grouping of analysis categories for this variable which we believe will add value in terms of the behavioural analysis as well as assist the RTMC in terms of directing specific policy and programmatic interventions to address the identified risks. The new formulation rationalises the existing driver risk behaviours into three categories as follows:

- Driver Intoxication
- Driver Speeding
- All Other Driver Risk Behaviours (Turn/U Turn, Overtaking, Followed too closely, Fatigue/fell Asleep, Disregard for Traffic Lights/Signs & Cellphone Distraction)

The formulation identifies three distinct categories for which the following interventions are indicated:

- **Driver Intoxication** – Roadblocks
- **Driver Speeding** – Speed Monitoring
- **All Other Driver Risk Behaviours** – Visible Mobile Policing

We believe this formulation improves both the conceptual and measurement of the core analytic variable. It rationalises the driver risk behaviours into three domains which are relevant to programmatic interventions and alleviates the measurement issues involved in having categories with very low frequency of cases. For the purposes of the logistic regression modelling, the risk for a fatal crash with driver intoxication as attribution is compared to the risk of a fatal crash with either Speeding or Other Driver Risks (ODR) as attribution.

Headline Outcome Indicators

The three core headline outcome indicators relate to the road users involved in the crashes being either a driver, a passenger or a pedestrian. These are all continuous variables and are applied in the analysis in their original format. The core headline indicators are thus:

- Driver Fatalities
- Pedestrian Fatalities
- Passenger Fatalities

Risk Variables

These variables comprise indicators which differentiate the risk of a fatal crash according to various categories, with each category reflecting some defined condition. These are categorical variables for which there are categories of interest and a reference category as applied in the logistic regression modelling. The final set of risk variables applied in the analysis are as follows:

Crash Type

As detailed in the RTMC dataset, the crash type comprises categories which reflect specific characteristics of the type of incident which resulted in the fatalities. The original formulation of this variable lists the following categories:

- Accident with animal
- Accident with cyclist
- **Accident with fixed object**
- **Accident with pedestrian**
- Accident with train
- Approach at angle
- **Head-on**
- Head-rear
- Hit and run
- Jack knife
- **Overtaking and overturned**
- Person fell off
- Sideswipe opposite direction
- Sideswipe same direction
- **Single vehicle left the road**
- **Single vehicle overturned**
- Unknown

In discussions with the RTMC, the research team was directed towards the use of the categories in **bold** font, with the remaining categories to be excluded from the analysis. A detailed frequency analysis of these categories indicated too few cases for analysis, thereby justifying their exclusion.

The abbreviated formulation realised a total of five categories as follows:

- Accident with pedestrian
- Single vehicle overturned left road
- Head-on/sideswipe same direction
- Head-rear/sideswipe opposite direction
- Accident with fixed object

In reviewing these categories, the research team concluded that there was scope for further rationalisation of the measurement of the Crash Type variable, to account for behavioural dimensions which are not properly accounted for in this five-category formulation. Specifically, it was decided that this variable would examine the categories of crash type based on the degree of complexity in the contextual environment within which the fatal crash occurred and the opportunities for intervention, as follows:

- **Driver-Only** – this category reflects the situation where the complexity of the context is minimal as it does not involve other road users and the risk behaviour relates only to that of the drivers themselves, as is the case of a single vehicle which overturns or leaves the road or when the driver collides with a fixed object. This is a low complexity context and was set as the reference category in the logistic regression.
- **Driver-Pedestrian** – this context has a higher level of complexity than the above as the driver now has to negotiate the use of the road with another person, specifically a pedestrian. However, the pedestrian is moving at a slower speed than a driver, hence this is a moderate complexity context.
- **Driver-Driver** – this third type of context is the most complex as the driver is negotiating use of the road with other drivers, all of which are travelling similar or varying speeds than the drivers themselves. This is the high complexity context.

Differentiating the crash type by level of complexity was deemed important as there is a wealth of literature which indicates the ability to negotiate complexity in any given context is compromised by the intake of alcohol and the level of intoxication.

Vehicle Type

The original formulation of this variable in the RTMC dataset comprises multiple categories reflecting mainly the type and to some extent the nature of ownership of the vehicle listed as the primary vehicle in the fatal crash, including but not limited to private vehicles, LDVs, public transport, trucks, minibuses, busses and articulated trucks.

In reviewing this variable, the research team elected to move beyond the designations for vehicle type provided by the data and reconsider what typology would add value to the work of RTMC with respect to interventions and campaigns. Based on this it was decided that this variable should account for the degree to which different classes of vehicles are regulated, as a basis for assisting the RTMC in designing interventions which reflect the risks associated with the different levels of regulation.

A further consideration, based on available research was to differentiate the category of public transport vehicles into two distinct categories of minibuses and Midibusses/large busses. On this basis, we have resolved to reframe the variable to consider classes of vehicles which will be congruent with specific interventions and modes of policing, such as more intensive monitoring of busses, more regular roadblocks for minibuses, etc. This formulation also resolves the dilemma of dealing with cases where the vehicle is designated as commercial because it is a LDV, when in fact the vehicle is actually a light truck or double cab truck used for private purposes. Accordingly, the vehicle variable was reformulated as follows:

- Light Vehicle – comprising all private cars and LDVs
- Public Transport – comprising only Minibus taxis
- Public Transport – comprising Midibusses and Busses
- Good Transport – comprising trucks and all commercial vehicles with a Gross Vehicle Mass exceeding 3 500 kg

Day Period

The day period variable reflects the time of day in a 24-hour period when the fatal crash occurred. While there is research evidence to indicate specific hourly intervals as the greatest concentration of all crashes, for the clarification of driver intoxication risk for fatal crashes it was decided in discussion with the RTMC to differentiate the 24 hour period into two 12 hour intervals as follows:

- Night: 7 pm to 6 am
- Day: 7 am to 6 pm (Reference Category)

Vacation Period

This variable covers all school vacation periods for the years 2016, 2017 and 2018. Additionally, and based on available evidence of recreational activities, especially those involving alcohol, there is reason to regard public holidays as vacation periods, and they are thus included in the variable accordingly. The vacation period variable is measured as:

- Non-Vacation
- Vacation (Reference Category)

Week Period

This variable separates the weekday from the weekend. The weekend begins at 4 pm on Friday and ends at 5 am on Monday, consistent with the period for many recreational activities associated with the weekend. However, there is a strong case to be made for the importance of a distinction between regular two-day weekends and long weekends of either three or four days length, especially since there is evidence to indicate that alcohol consumption in general spikes on such long weekends. Accordingly, we revisited the data and recoded all long weekends for the three years, and the variable was reformulated. For the analysis, a weekend was designated as the period which begins at 4 pm on the day preceding the weekend and ends at 5 am on the day following the weekend. The final variable is measured as follows:

- Long Weekend
- Regular Weekend
- Weekday (Reference Category)

The Analytic Framework

As discussed previously, the purpose of this research is to investigate and clarify the fatal crash risks associated with driver intoxication as compared to other driver risk behaviours, specifically speeding and all other driver risks. To achieve this, the analysis was framed along two core dimensions. The first examined the absolute risk of specific driver risk and risk variable categories, and the second examined the adjusted risk for driver intoxication when compared to other driver risks and while accounting for all other risk variables. In both instances, the assessed risk is used to develop a measure of the influence of alcohol in two ways:

01 **The outcomes of the fatal crash with respect to the increased risk for driver, passenger and pedestrian fatalities.**

02 **The alcohol related risk of the fatal crash under specific circumstances, defined by the type of crash, vehicle type and temporal period in which the crash occurred.**

This measure of influence is indicated in the report as an impact factor (IF), and indicates the likely impact of alcohol on changing the risk parameters associated with the fatality outcomes and specific crash type, vehicle type, and time of day, week period and vacation period in which the crash occurred. The impact factor thus indicates if driver intoxication increases or decreases the risk of these fatalities and the likelihood of the fatal crash being of a specific crash type, involving specific vehicle types, and occurring during specific time periods. An impact factor value greater than one indicates a greater risk by driver intoxication and a value less than one indicates a lesser risk. The comparison categories against which driver intoxication is assessed vary depending on whether the risk considered is absolute or relative in nature, as is discussed hereafter.

This report utilises Impact Factors (IF) to better assess and clarify the influence of alcohol in fatal crashes. The IF indicates the likely impact of alcohol in changing the risk parameters associated with a fatal crash. This is measured either in terms of the number of road user fatalities associated with the crash or any of the other crash characteristics, such as specific crash type, vehicle type, and time of day, week period and vacation period. In all instances, an IF greater than one indicates a heightened influence of alcohol.

Absolute Risk

Absolute risk is the likelihood of an event occurring for a group of people under defined conditions, and when the other external conditions of influence are not accounted for. That is, the risk measured is absolute to the category of interest, and there remains the likelihood that this absolute risk may change when other factors which influence the fatal crash are considered.

A simple form of absolute risk is the risk of driver, passenger and pedestrian fatalities relative to the proportion of driver intoxication attributed fatal crashes in the dataset. As will be seen in the next section, driver intoxication accounts for 5.5% of all fatal crashes. If the risk for driver, pedestrian and passenger fatalities in such crashes is also 5.5% of the total amount of fatalities, then the risks for these three categories of fatalities is equivalent to the proportion of driver intoxication crashes and there is no distinctive heightened risk for any of drivers, passengers and pedestrians when the driver is intoxicated. However, as will be seen later, this is not the case, and there is a heightened risk for pedestrians when driver intoxication is indicated.

Absolute risk is important as it provides the initial basis for assessment of the likely risks associated with driver intoxication across all the other relevant analysis categories. This provides the initial assessment of driver intoxication as a prelude to the second set of analysis which examines how this absolute risk may change when other influencing factors are properly accounted for by inclusion in the modelling. Put differently, absolute risk considers what are regarded as unadjusted risks, that is risks which are not yet properly adjusted for the influence of other associated influences. The absolute risk analysis in the research is undertaken through frequency and proportion analysis.

Adjusted Risk

To properly account for the changes in absolute (or unadjusted) risks when other influences are considered, we need to analyse for adjusted risks. Adjusted risk examines the likelihood of an event occurring compared to another event, and across different categories of other influencing factors. For instance, examining the likelihood of pedestrian fatalities from driver intoxication as compared to pedestrian fatalities from speeding, across either the night or day period. This type of analysis provides considerably more granularity and specificity to the risks being assessed as it adjusts the absolute risk of the analysis variable by assessing and accounting for the influence on this analysis variable by some other influence factor.

The analyses examined both the absolute risk and adjusted risk for alcohol in fatal crashes. Absolute risk indicates the role of alcohol in fatal crashes while not considering other secondary intervening or extenuating factors which also impact the fatal crash. Adjusted risk formally accounts for the influence of such intervening or extenuating factors, and is much more robust as it locates any alcohol-related risks within the broader context of these key secondary influences. The adjusted risk is measured using a risk ratio, referred to as an Odds Ratio (OR), which is similar in interpretation to the Impact Factor.

Adjusted risk provides much stronger results because it formally accounts for influences of associated variables, and this helps qualify any risks observed by consideration of other key secondary influences. In the case of this analysis, the research examines the risk of driver intoxication fatal crashes relative to speed and ODR while simultaneously accounting for the type of crash which occurred, the vehicles involved in the crash, and the time of day, period of week and vacation period in which the crash occurred. As with absolute risk, the adjusted risk is measured using a risk ratio otherwise known as an impact factor.

The adjusted risk analysis is conducted in the research using logistic regression modelling. Logistic regression is a suite of statistical techniques for examining the relative likelihood associated with specific categories of a variable of interest (in this case, comparing the categories of driver intoxication to that for speeding and ODR) while accounting for the impact of other variables on these comparisons (in this instance controlling for the crash and vehicle type, and the time period in which the crash occurred). To conduct a logistic regression analysis, it is necessary to set what are known as the category of interest and the reference category. In our case the superordinate category of interest is driver intoxication and the two superordinate references categories are speeding and ODR. Additionally, the other analysis variables are also designated as categories of interest and reference categories. These will be clarified in the sections that follow.

Context and Absolute Risk

Over the 2016-2018 3-year period, a total of 13 074 fatal crashes with known driver risk factors were identified and considered for analyses. The 13 074 fatal crashes involved 19 748 vehicles and resulted in 17 706 fatalities.

The overall fatality-to-crash index was 1.5, meaning that each crash resulted in an average of 1.5 fatalities, with 74.7% of crashes involving only one fatality each, 12.5% accounting for 2 fatalities each and 7.4% accounting for three of more fatalities per crash. The remaining 5.4% of crashes did not record the actual number of fatalities, which we regarded as measurement error. These cases were nevertheless retained in the overall analysis as they are undoubtedly crashes involving fatalities. Most victims of fatal crashes were vehicle passengers (48.7%) followed by vehicle drivers (40.7%), and more than three-quarter (76.8%) of the fatal crash victims were male.

QUICK

FACTS

13 074
total of fatal crashes of a 3 year period

19 748
vehicles involved in fatal crashes

17 706
total fatalities in crashes

74.7%
of crashes involved only 1 fatality

Absolute Risks for Fatal Crashes

Absolute risk was assessed using selected variables within the dataset that served as proxies for "exposure" and was used towards the calculation of impact factors and crash severities. As indicated earlier, impact factors reflect the proportion of fatalities for the key headline indicators in relation to the proportion of fatal crashes for each of the risk categories. In addition, for the temporal risks, impact factors were also derived from the proportion of fatal crashes relative to the proportional number of days over the three-year period. Risk categories with impact factors of 1.5 and greater were deemed as notable and are reported on below. The crash severity is a simple ratio of the overall number of fatalities to the total number of crashes for each of the risk categories.

Table 1 shows the absolute risks for the different road users in relation to the risk factors considered and Table 2 presents the absolute risk data disaggregated by gender. The key findings are discussed thereafter.

Table 1: Risk factors for fatal crashes by road user

	Driver		Passenger		Pedestrian	
	n (%)	**IF***	**n (%)**	**IF***	**n (%)**	**IF***
Driver behaviour						
Alcohol	256 (3.7%)	0.7	383 (4.6%)	0.8	290 (16.1%)	2.9
Speeding	3 429 (49.6%)	0.9	4 090 (49.4%)	0.9	667 (37.1%)	0.7
Other Driver Risks	3 227 (46.7%)	1.1	3 810 (46.0%)	1.1	841 (46.8%)	1.1
Crash type						
Driver-Driver	3 415 (51.7%)	1.3	3 938 (51.9%)	1.3	78 (5.2%)	0.1
Driver-Pedestrian	08 (0.1%)	0.01	10 (0.1%)	0.01	1 361 (90.9%)	8.0
Driver Only	3 178 (48.1%)	1.02	3 637 (47.9%)	1.01	59 (3.9%)	0.08
Vehicle type						
Light vehicle	5 514 (83.3%)	1.03	6 177 (76.2%)	0.9	1 174 (76.0%)	0.9
Minibus	369 (5.6%)	0.7	961 (11.9%)	1.5	200 (13.0%)	1.6
Bus & Midibus	79 (1.2%)	0.7	290 (3.6%)	2.1	43 (2.8%)	1.7
Truck	661 (10.0%)	1.1	678 (8.4%)	0.9	127 (8.2%)	0.9
Day period						
Night	4 088 (59.1%)	1.1	4 489 (54.2%)	0.98	983 (54.7%)	0.99
Day	2 824 (40.9%)	0.9	3 794 (45.8%)	1.02	815 (45.3%)	1.01

	Driver		Passenger		Pedestrian	
	n (%)	IF*	n (%)	IF*	n (%)	IF*
Week period						
Long Weekend	831 (12.0%)	0.9	1 203 (14.5%)	1.1	246 (13.7%)	1.1
Regular Weekend	3 612 (52.3%)	1.02	4 365 (52.7%)	1.03	880 (48.9%)	0.96
Weekday	2 469 (35.7%)	0.98	2 715 (32.8%)	0.9	672 (37.4%)	1.03
Vacation period						
Non-Vacation	4 926 (71.3%)	1.01	5 601 (67.6%)	0.96	1 246 (69.3%)	0.99
Vacation	1 986 (28.7%)	0.97	2 682 (32.4%)	1.1	552 (30.7%)	1.03
Municipality type						
Local	5 115 (74.0%)	1.03	6 639 (80.2%)	1.1	1 054 (58.6%)	0.8
Metro	1 797 (26.0%)	0.9	1 644 (19.8%)	0.7	744 (41.4%)	1.5
Province						
Eastern Cape	695 (10.1%)	0.9	1 027 (12.4%)	1.2	202 (11.2%)	1.05
Free State	521 (7.5%)	1.1	660 (8.0%)	1.1	90 (5.0%)	0.7
Gauteng	1 373 (19.9%)	0.97	1 194 (14.4%)	0.7	483 (26.9%)	1.3
KwaZulu-Natal	1 009 (14.6%)	0.9	1 353 (16.3%)	1.01	402 (22.4%)	1.4
Limpopo	923 (13.4%)	1.02	1 317 (15.9%)	1.2	149 (8.3%)	0.6
Mpumalanga	961 (13.9%)	1.2	1 077 (13.0%)	1.1	146 (8.1%)	0.7
Northern Cape	223 (3.2%)	0.96	341 (4.1%)	1.2	34 (1.9%)	0.6
North West	625 (9.0%)	1.1	674 (8.1%)	1.01	99 (5.5%)	0.7
Western Cape	582 (8.4%)	0.9	640 (7.7%)	0.9	193 (10.7%)	1.2

* *Impact Factor*

Table 2: Risk factors for fatal crashes by gender

	Male		Female		Total Fatalities		Total Crashes	
	n (%)	IF*	n (%)	IF*	n (%)	IF*	n (%)	CS^
Driver behaviour								
Alcohol	734 (5.5%)	0.99	210 (5.2%)	0.9	949 (5.4%)	0.97	725 (5.5%)	1.3
Speeding	6 711 (50.0%)	0.96	1 849 (45.5%)	0.9	8 666 (48.9%)	0.9	6 838 (52.3%)	1.3
Other Driver Risks	5 975 (44.5%)	1.1	2 003 (49.3%)	1.2	8 091 (45.7%)	1.1	5 511 (42.2%)	1.5
Crash type								
Driver-Driver	5 546 (46.5%)	1.1	1 877 (49.9%)	1.2	7 548 (47.4%)	1.1	4 752 (41.3%)	1.6
Driver-Pedestrian	1030 (8.6%)	0.8	343 (9.1%)	0.8	1 383 (8.7%)	0.8	1 312 (11.4%)	1.1
Driver Only	5 363 (44.9%)	0.9	1 542 (41.0%)	0.9	6 981 (43.9%)	0.9	5 443 (47.3%)	1.3
Vehicle type								
Light vehicle	10 012 (79.6%)	0.98	3 046 (76.8%)	0.9	13 210 (78.9%)	0.97	9 880 (81.2%)	1.3
Minibus	1060 (8.4%)	1.04	497 (12.5%)	1.5	1 578 (9.4%)	1.2	987 (8.1%)	1.6
Bus & Midibus	233 (1.9%)	1.1	183 (4.6%)	2.8	418 (2.5%)	1.5	203 (1.7%)	2.1
Truck	1 271 (10.1%)	1.1	238 (6.0%)	0.7	1 533 (9.2%)	1.01	1 100 (9.0%)	1.4
Day period								
Night	7 692 (57.3%)	1.04	2 024 (49.8%)	0.9	9 844 (55.6%)	1.01	7 195 (55.0%)	1.4
Day	5 728 (42.7%)	0.9	2 038 (50.2%)	1.1	7 862 (44.4%)	0.99	5 879 (45.0%)	1.3
Week period								
Long Weekend	1 747 (13.0%)	1.03	577 (14.2%)	1.1	2 371 (13.4%)	1.1	1 659 (12.7%)	1.4
Regular Weekend	7 028 (52.4%)	1.03	2 039 (50.2%)	0.98	9 169 (51.8%)	1.01	6 673 (51.0%)	1.4
Weekday	4 645 (34.6%)	0.95	1 446 (35.6%)	0.98	6 166 (34.8%)	0.96	4 742 (36.3%)	1.3
Vacation period								
Non-Vacation	9 423 (70.2%)	0.99	2 749 (67.7%)	0.96	12 307 (69.5%)	0.99	9 183 (70.2%)	1.3
Vacation	3 997 (29.8%)	1.00	1 313 (32.3%)	1.1	5 399 (30.5%)	1.02	3 891 (29.8%)	1.4

	Male		Female		Total Fatalities		Total Crashes	
	n (%)	IF*	n (%)	IF*	n (%)	IF*	n (%)	CS^
Municipality type								
Local	9 867 (73.5%)	1.02	3 160 (77.8%)	1.1	13 195 (74.5%)	1.04	9 408 (72.0%)	1.4
Metro	3 553 (26.5%)	0.9	902 (22.2%)	0.8	4 511 (25.5%)	0.9	3 666 (28.0%)	1.2
Province								
Eastern Cape	1 412 (10.5%)	0.98	528 (13.0%)	1.2	1 953 (11.0%)	1.03	1 405 (10.7%)	1.4
Free State	928 (6.9%)	0.98	353 (8.7%)	1.2	1 309 (7.4%)	1.1	918 (7.0%)	1.4
Gauteng	2 609 (19.4%)	0.95	660 (16.2%)	0.8	3 302 (18.6%)	0.9	2 670 (20.4%)	1.2
KwaZulu-Natal	2 131 (15.9%)	0.98	671 (16.5%)	1.02	2 842 (16.1%)	0.99	2 120 (16.2%)	1.3
Limpopo	1 856 (13.8%)	1.1	565 (13.9%)	1.1	2 439 (13.8%)	1.1	1 708 (13.1%)	1.4
Mpumalanga	1 734 (12.9%)	1.1	473 (11.6%)	0.96	2 245 (12.7%)	1.1	1 578 (12.1%)	1.4
Northern Cape	459 (3.4%)	1.01	149 (3.7%)	1.1	612 (3.5%)	1.02	441 (3.4%)	1.4
North West	1 105 (8.2%)	1.02	341 (8.4%)	1.04	1 460 (8.2%)	1.02	1 055 (8.1%)	1.4
Western Cape	1 186 (8.8%)	0.98	322 (7.9%)	0.9	1 544 (8.7%)	0.97	1 179 (9.0%)	1.3

* *Impact Factor*

^ *Crash Severity*

Driver Behaviour Characteristics

Of the 13 074 fatal crashes included in the analysis, as recorded by SAPS and reported to RTMC, alcohol-attributed crashes accounted for 5.5%, while the driver behaviours attributed most often as the cause of the crash was speeding (52.3%), followed by other driver risks (42.2%).

Among drivers and passengers, speeding accounted for the largest proportion of crashes (49.6% and 49.4%, respectively) while for pedestrians, other driver risks accounted for the largest proportion of crashes (46.8%).

Among the driver behaviours, the highest crash severity was found for other driver risks (1.5), meaning that on average, each crash attributable to other driver risk behaviours resulted in 1.5 fatalities.

The largest impact factor (across all road users and all driver behaviour risks) was found for alcohol and pedestrian deaths (2.9), indicating that the proportion of pedestrian deaths attributable to driver intoxicated crashes was assessed to be nearly three times more than the proportion of all fatal crashes that occurred as a result of alcohol. That is, at an absolute level, pedestrians were three times more likely to die in a crash where the driver was intoxicated.

> Irrespective of the type of driver risk behaviour, pedestrians were particularly vulnerable. The Impact Factor for alcohol related crashes in pedestrian deaths was 2.9, meaning that pedestrians were three times more likely to die in a crash where the driver was intoxicated.

Crash Characteristics

Crash Type

In terms of crash characteristics, most crashes (47.3%) were classified as being driver only (i.e. not involving other road users), followed by crashes occurring with other vehicles (41.3%).

Among the different types of crashes, the largest crash severity was found for Driver-Driver crashes (1.6), indicating that on average, each Driver-Driver crash type resulted in 1.5 fatalities. This finding relates to the relatively higher number of road users that would generally be involved in such crashes.

Pedestrians were particularly vulnerable in Driver-Pedestrian crashes with an impact factor of 8, indicating the proportion of pedestrian deaths from Driver-Pedestrian crashes to be eight times more than the proportion of all fatal crashes involving pedestrians.

Vehicle Type

Light vehicles were involved in more than three-quarter (81.2%) of the fatal crashes. Notably, marginally more trucks than minibuses were involved in fatal crashes (9.0% and 8.1%, respectively).

Among the different types of vehicles, the largest crash severity was found for bus and midibus crashes (IF 2.1), meaning that on average, each bus and midibus crash resulted in 2.1 fatalities. This finding is to be expected given the relatively high passenger occupancy and exposure from these vehicles.

Both passengers and pedestrians showed disproportionate vulnerability with public transport. With crashes involving minibuses, passengers had 1.5 times more fatalities to fatal crashes and pedestrians had and 1.6 times more fatalities to fatal crashes. In terms of buses and midibuses, passengers had 2.1 times more fatalities to fatal crashes and pedestrians had 1.7 times more fatalities to fatal crashes.

Additionally, females also showed disproportionate vulnerability with public transport having 1.5 times more fatalities than crashes involving minibuses and 2.8 times more fatalities than crashes involving buses and midibuses.

Temporal Characteristics

Most fatal crashes occurred at night (55.0%), over weekends (63.7%), and during non-vacation periods (70.2%). Slightly higher crash severities were found for crashes occurring during the night, over regular and long weekends, and over vacation periods (1.4 each). Notably, all types of road users showed minimal differences in the proportion of fatalities to fatal crashes which occurred during vacation as compared to non-vacation periods.

Relative to the proportional number of days in a year, impact factors over the 3-year period were 1.5 for long weekends (90 days, 8.2%), 2.2 for regular weekends (258 days, 23.6%), and 1.03 for vacation periods (105 days, 28.8%). That is, fatal crashes were more likely to occur over regular weekends, followed by long weekends and then marginally so during vacation periods.

Spatial Characteristics

Municipality

Nearly three quarter (72.0%) of fatal crashes occurred in the jurisdiction of local municipalities as compared to metropolitan municipalities. Fatal crashes in local municipalities were observed to have a higher crash severity than metropolitan municipalities (1.4 vs 1.2). That is, on average, each fatal crash occurring in a local municipality resulted in 1.4 fatalities, whereas each fatal crash in a metropolitan municipality resulted in 1.2 fatalities.

While all road users showed a higher proportion of fatal crashes for local municipalities, particularly high proportions were found for drivers and passengers (74.0% and 80.2%, respectively). Pedestrians were particularly vulnerable in metropolitan municipalities, registering 1.5 times more fatalities to fatal crashes.

Province

Gauteng accounted for the largest proportions of fatal crashes (20.4%), followed by KwaZulu-Natal (KZN) (16.2%). Both these proportions were however lower relative to the population sizes of the two provinces (Gauteng 25.3% and KZN 19.6%).[5]

Of note is that Gauteng and KwaZulu-Natal also had the largest proportions of fatal crashes involving pedestrians (26.9% and 22.4%, respectively) in comparison to all other provinces.

In terms of crash severity, the lowest proportion of fatalities to crashes was found for Gauteng (1.2), meaning that on average, each fatal crash occurring in Gauteng resulted in 1.2 fatalities.

[5] *Mid-sample estimate, based on StatsSA mid-year population data for 2017.*

Adjusted Risk

The previous section examined the absolute risk for various key analysis variables. The absolute risk analysis, while instructive in many respects, is limited by the fact that the calculated risks do not account for the role of secondary variables in mediating or moderating the relationship between the two variables of interest.

To account for the effect of secondary variables, the data was subject to modelling using logistic regression techniques. The purpose of this analysis was to investigate the degree of risk for key analysis variables *while controlling for the influence of secondary variables which may or may not impact this degree of assessed risk*. In this way, the unique contribution of each risk variable is isolated and understood.

To enable the logistic regression modelling, the variable of interest (analysis variable) is compared to a reference variable or variables. In all analysis the primary category of interest was alcohol attributed fatal crashes and the reference categories were 1) fatal crashes attributed to speeding and 2) fatal crashes attributed to all other driver risks. Additionally, at the lower level of analysis, there are categories of interest and reference categories based on the specific variable under analysis, e.g., for day period the interest category is night compared to the reference category which is day. Similarly, for type of vehicle the categories of interest are light vehicles, minibuses and midibusses/busses as compared to the reference category of trucks.

Findings from the logistic regression modelling showed that several statistically significant risk effects remain after having controlled for the effects of the various secondary variables. These adjusted risks are provided as Odds Ratios (OR), which indicate the odds (probability) that a risk variable is associated with an analytic category of another variable while the effects of all other analysis variables on this variable of interest is controlled. Put plainly, the Odds Ratio expresses whether or not the risk associated with any analysis category of a variable is greater or less than what we would expect due to chance, that is, what we would expect if there was no actual substantive relationship between the variables under assessment. A value of 1 is considered the neutral value, and it indicates no substantive relationship between the analysis variables. A value greater than one indicates an increased risk, while a value less than one indicates a diminished risk. Finally, to give empirical validity to the analysis, all results were assessed in terms of their statistical significance, to ensure that the outputs are robust. This engenders greater confidence in obtained results and interpretations thereof.

Table 3 shows the adjusted Odds Ratios for the variables included in the model. The analysis variable in each instance is that of Alcohol Attributed Fatal Crashes, as compared to fatal crashes where Speeding and Other Driver Risks are the key attributed reasons. Odds Ratios which were found to be statistically significant in the logistic regression modelling are reported in bold typeface. These are the only results which merit interpretation, as they meet the threshold of empirical rigour.

Road User Characteristics

In terms of the different road users, the analysis revealed minimal differences in the risk for fatalities for drivers, pedestrians and passengers in alcohol attributed crashes when compared to crashes attributed to speeding and all other driver risks. That is, all types of road users were at equivalent risk for fatality across all types of driver risk behaviours, the sole exception being a marginally reduced risk for driver fatalities in alcohol related crashes when compared to crashes involving all other driver risk behaviours (OR 0.8).

Table 3: Adjusted Odds Ratios for fatal crashes

	Alcohol compared to: **Speeding**		Alcohol compared to: **Other Driver Risks**	
	Odds Ratio (OR)	**Significance (P)**	**Odds Ratio (OR)**	**Significance (P)**
Road user fatality				
Driver	0.876	.206	**0.811**	.046
Passenger	0.776	.88	1.034	.450
Pedestrian	1.228	.288	1.02	.32
Crash type				
Driver-Driver	**3.21**	.000	**0.13**	.000
Driver-Pedestrian	**7.76**	.000	0.669	.088
Driver Only (Reference)	–	–	–	–
Vehicle type				
Light Vehicle	**1.58**	.028	**1.62**	.018
Minibus	1.351	.244	1.246	.389
Bus & Midibus	**2.69**	.011	1.800	.099
Truck (Reference)	–	–	–	–
Day period				
Night	**1.42**	.000	**1.36**	.001
Day (Reference)	–	–	–	–
Week period				
Long Weekend	**1.9**	.000	**2.17**	.000
Regular Weekend	**1.9**	.000	**2.04**	.000
Weekday (Reference)	–	–	–	–
Vacation period				
Non-Vacation	**1.34**	.004	**1.33**	.004
Vacation (Reference)	–	–	–	–

Crash Characteristics

Crash Type

Relative to speeding, alcohol showed to be a greater risk factor for crashes with other drivers (OR 3.2) and a substantially greater risk factor for crashes with pedestrians (OR 7.8), when compared to crashes involving drivers only (i.e. not involving other road users). In other words, alcohol related crashes involving multiple drivers and/or both drivers and pedestrians were far more likely to lead to fatalities while crashes attributed to speeding carried a greater risk for fatalities in crashes involving only the driver. Relative to all other driver risks, alcohol related crashes carried a much lower risk for crashes with multiple drivers (OR 0.13) as compared to those involving only drivers. That is, crashes involving drivers only carried a higher risk for fatalities when alcohol was not present.

There was a significantly greater risk for fatal crashes involving intoxicated drivers of light vehicles. Additionally, and worryingly given their transportation of multiple persons, driver intoxication was almost three times more likely in fatal crashes involving public transport vehicles such as busses and midibusses as compared to cargo vehicles.

Vehicle Type

Relative to speeding and all other driver risks, crashes involving alcohol presented greater risk for fatalities for light vehicles (OR 1.6) as compared trucks. That is, crashes involving light vehicles presented greater risk when alcohol was involved as compared to any other type of driver related risk. Additionally, and relative to speeding, alcohol showed to be a greater risk for crashes involving buses and midibuses (OR 2.7), compared to crashes involving trucks.

Temporal Characteristics

Relative to both speeding and other driver risks, alcohol showed to be a greater risk factor for crashes occurring at night (OR 1.4 each), compared to crashes occurring during the day. That is, the risk for fatal crashes involving alcohol rather than speeding and all other driver risks was significantly greater at night. This implies that the risk for fatal crashes involving speeding or other driver risks is significantly higher during the day period.

Relative to both speeding and other driver risks, alcohol showed to be a greater risk factor for crashes occurring over regular weekends (OR 1.9 and OR 2.0, respectively) and for crashes occurring over long weekends (OR 2.0 and OR 2.2, respectively), compared to crashes occurring during weekdays. Put differently, the risk for fatal crashes involving speeding or other driver risks was greater during the regular week, while alcohol related crash risk increased significantly over the weekend, regardless of whether it was a regular or long weekend.

Further, relative to both speeding and other driver risks, alcohol also showed to be a greater risk factor for crashes occurring during non-vacation periods (OR 1.3 each), compared to crashes occurring during vacation periods. This implies that fatal crashes attributed to speeding and all other driver risks were more likely to occur during the vacation periods.

Driver intoxication played a significantly greater role in fatal crashes occurring at night, during weekends, and during non-vacation periods of the year. This effect is consistent and robust despite the type of vehicle, type of crash and fatality outcomes.

Discussion

Following the multivariate logistic regression analysis, the statistically significant adjusted effects relating to crash type, vehicle type and temporality, are discussed below along with notable effects emerging from the unadjusted absolute risk analyses pertaining to victim vulnerability and crash location.

Driver Behaviour and Alcohol Attribution

As indicated earlier, crashes attributed to alcohol accounted for only 5.5% of all fatal crashes occurring over the 3 years from 2016-2018. Research in the South African setting, described earlier, point to considerable variance in the estimated prevalence of alcohol in road crashes in various South African settings, with some estimates as high as 63% for driver fatalities in Pretoria (Ehmke et al., 2014). A preliminary audit was undertaken of available information, comprising previous research as well as datasets, that may help with such an estimate and in addition, provide additional perspectives to the burden of driving under the influence of alcohol in the South African context.

Based on findings from a range of local and international studies, the attribution of 5.5% of fatal crashes to driver alcohol intoxication in South Africa is deemed to be a gross underestimate. This implies that the impact and consequences of driver intoxication in terms of fatal crashes and fatalities is also significantly underestimated. Empirically sound data from local sources was used to generate an extrapolated estimate of the likely proportion of such fatal crashes. This extrapolation realised an estimate of 27.1% for the proportion of fatal crashes attributed to driver alcohol intoxication. The current figure underestimates the likely proportion of alcohol related fatal crashes by around 80%, and consequently, underestimates the impact of driver intoxication in fatality outcomes for all road users.

The 5.5% alcohol-attribution derived from the RTMC data is deemed to be a gross underestimate of the true prevalence of alcohol-relatedness among fatal crashes in the country.

A key limitation of the various estimates derived from South African research is that they reflect on specific geographical entities that are not nationally representative. The SAMRC-UNISA National Injury Mortality Surveillance System (NIMSS), however, currently provides the most comprehensive national data of fatal injuries in the country. The NIMSS may also be regarded as providing a generally fair representation of both rural and urban fatal injuries in the country. In 2005, the NIMSS had good participation from several mortuaries in predominantly rural settings of the Eastern Cape, North West and Northern Cape provinces, as well as full coverage of fatal injuries for four of South Africa's largest cities (Johannesburg, Durban, Cape Town and Tshwane/Pretoria).

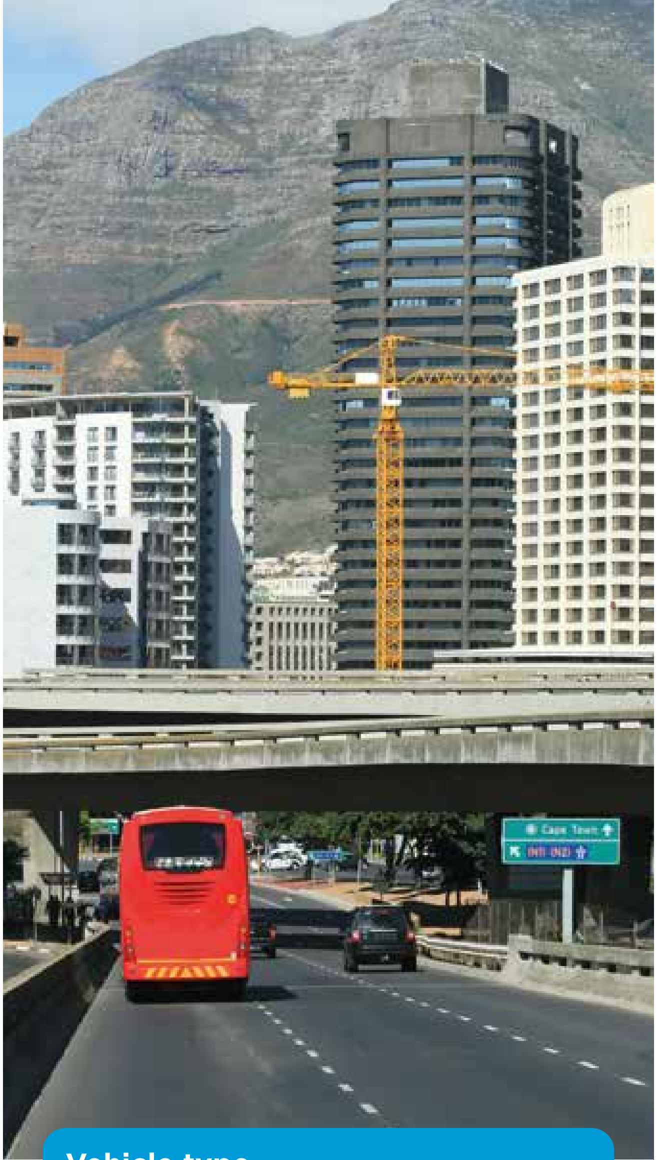
> We estimate alcohol to be implicated in at least 27.1% of all fatal crashes involving driver error of any type.

The 2005 NIMSS data showed alcohol to be detected in 53.5% of a selected sample of driver fatalities tested. Extrapolating this data to the RTMC dataset, and accounting for the proportion of driver fatalities relative to that of passengers and pedestrians, we estimate alcohol to be implicated in at least 27.1% of all fatal crashes involving driver error of any type. As stated, there are other data sources in South Africa which suggest a greater prevalence than this of driver intoxication in fatal crashes (as is the case with the research in Pretoria cited above), but these are constrained by several limitations of measurement methodology and sample definition, both of which restrict the degree of generalisability from sample to population. In addition, this figure also differs from the 58% reported for South Africa by the Global Status Report on Road Safety (WHO, 2018), as the latter is the NIMSS estimate that is based only on selected drivers that were tested and was not extrapolated to all drivers. Accordingly, we believe that the extrapolation of 27.1% is the most empirically valid estimate.

It is useful to give greater consideration to the estimate of 27.1%. Firstly, based on the extrapolation methodology, it is likely that the estimate is a conservative one, meaning that the actual prevalence of alcohol related driver attributed fatal crashes could be greater, though it is unclear to what magnitude. This remains a matter to be determined by triangulation with other more robust data sources as and when they become available. Secondly, even at the conservative estimate of 27.1%, it is clear that the current attribution in the RTMC dataset of 5.5% alcohol related fatal crashes underestimates the prevalence of alcohol among driver attributed fatal crashes by 79.7%. Stated differently, the RTMC data captures only one-fifth of estimated scope of influence of alcohol in fatal crashes involving driver error or risk.

> **The extrapolated estimate of 27.1% for driver intoxication in fatal crashes has important implications for properly determining the costs of alcohol-related fatal crashes in the country arising from driver error. Based on an estimated costing by the RTMC of R67.3 billion for fatal crashes in 2018, the current 5.5% alcohol attribution indicates a costing estimate of R 3.7 billion. In sharp contrast, the extrapolated estimate of 27.1% realizes a costing estimate of R 18.2 billion.**

The research results and statistically significant effects observed and presented from this research, including the Odds Ratios, are based on the underestimated value of alcohol prevalence in driver risk fatal crashes. Should the prevalence be set at the estimated value of 27.1%, it is likely that many of these results and statistically significant effects would be of considerably greater magnitude. In other words, the alcohol-related impact and effects found in this analysis are likely to be considerably larger had the subset of alcohol-attributed driver cases been 27.1% rather than 5.5%. For this reason, it is imperative that the RTMC take every feasible step to improve the measurement of alcohol in driver related fatal crashes as soon as is realistically possible.



Vehicle type

Alcohol showed to be a greater risk for crashes involving both light vehicles and buses (including Midibuses). Of note is that this effect was not evident for crashes involving minibus taxis, which may relate to anecdotal evidence pointing to relatively higher usage of drugs (especially methamphetamine and the "tik" variant) rather than alcohol by minibus taxi drivers to enhance driver and operational performance.

Of note too, is the relatively low involvement of minibuses in fatal crashes (being less than trucks), especially given their substantially higher time and distance exposure in the traffic environment. This is also a finding that warrants greater attention and focus.

Crash Type

Alcohol (relative to speeding) showed to be a greater risk factor for crashes involving other road users (drivers and pedestrians) as compared to driver crashes that did not involve other road users.

This finding bears on the dynamic and complex nature of the road traffic environment, requiring of motorists, on an ongoing basis, to process this complexity, make quick judgements on risk, and respond to potential hazards optimally. The negative effects of alcohol on the psychomotor and cognitive skills of drivers as well as the increased crash risk with drink-driving is well documented and has been discussed earlier.

The substantially higher risk found for pedestrians may relate to the complexity inherent in drivers and pedestrians needing to negotiate use of common road space but at significantly differential speeds along with the higher injury severities for pedestrians from such crashes. Additionally, it may reflect the added complexity for drivers to negotiate the unpredictability of pedestrian behaviour, especially in relatively informal settings with inadequate pedestrian infrastructure for walking and crossing and conditions where lighting is poor

Whilst pedestrians were shown to be especially vulnerable to alcohol-intoxicated drivers (based on unadjusted absolute risk), this finding does not account for the added complexity of the possible intoxication of pedestrians themselves. This remains a matter for further investigation.

Temporal Effects

The higher burden and risk (relative to the proportional number of days in a year) shown for fatal crashes during night and weekend periods is consistent with several previous fatal crash and injury analyses undertaken in South Africa, including those based on the NIMSS and RTMC datasets.

In terms of vacation periods however, absolute risks (based on both the proportional number of days in a year and the proportion of fatalities to fatal crashes) showed very little variation between the occurrence of fatal crashes during vacation and non-vacation periods. Intuitively, whilst one may expect a higher risk of fatal crashes during vacation periods due to increased leisure activities and associated consumption of alcohol, this risk may be offset with decreased travel exposure resulting from alcohol consumption occurring principally within the (family and friend) residential context. In fact, when adjusted for the effects of other variables in the dataset, alcohol showed to be a greater risk factor for crashes occurring during non-vacation periods (along with being a greater risk factor for crashes at night and over weekends). This finding of a significantly smaller alcohol-related crash effect during vacation than non-vacation periods, may, however, also point to some favourable effects of campaign-related interventions that are generally concentrated during vacation periods.

Also of note is that these temporal high-risk periods were also associated with higher crash severities, pointing to the likely co-occurrence of excessive driving speeds.

Vulnerable Road Users: Pedestrians and Females

Pedestrians and females were shown to be particularly vulnerable (based on their relatively higher impact factor ratios) in crashes involving public transport vehicles (including both minibuses and buses/ midibuses) and may relate to a general absence of safe dedicated stopping areas for public transport within the road infrastructure, and to public transport operators collecting and dropping of passengers in unsafe areas along with the associated challenge of pedestrians needing to negotiate complex traffic environments. The effect for females may relate to a generally higher exposure and vulnerability from both pedestrian and passenger travel.

Pedestrians also showed relatively higher vulnerability in crashes occurring in metropolitan municipalities. This finding is consistent with international research showing a general higher risk for pedestrian injury in urban areas (Scheiner & Holz-Rau, 2011; Spoerri et al., 2011). This finding was also demonstrated in the South African setting where a general increasing trend in population-based fatality rates with increasing levels of urbanisation was shown

QUICK FACTS

5.5%
current attribution of alcohol in fatal crashes involving driver error

R3.7 billion
current costing of alcohol-related fatal crashes involving driver error

27.1%
revised attribution of alcohol in fatal crashes involving driver error

R18.2 billion
revised costing of alcohol-related fatal crashes involving driver error

for pedestrians, measured through several area- and population-based measures of rurality (Sukhai et. al., 2009). Whilst the elevated risk to pedestrians is likely to be related to a general lack of safe pedestrian-related infrastructure, pedestrians also engage in a range of activities in the urban environment that lends to higher exposure to pedestrian-vehicle conflict. In addition, injury-related crashes involving older pedestrians have also been shown to be directly related to the availability of alcohol outlets (LaScala et al., 2000).

Spatial Effects

Local municipalities were shown to account for nearly three quarter of fatal crashes with slightly higher impact factors for drivers and passengers, and to also have a higher overall crash severity or fatality-to-crash ratio than metropolitan municipalities.

Typically, local municipalities tend to have larger areas characterised as being rural. Several studies in international settings have shown rurality, commonly measured using area-based population density to be inversely related to road traffic fatalities, suggesting higher levels of fatalities in rural areas (Noland & Quddus, 2004; Scheiner & Holz-Rau, 2011; Spoerri et al., 2011).

This inverse association between rurality and RTFs was also demonstrated in the South African setting where population density was shown to be a significant predictor of RTFs in S.A, and also having the strongest magnitude effect to the geographical variability in RTFs after adjusting for the effects of a range of explanatory variables relating to physical, environmental and socio-demographic characteristics (Sukhai & Jones, 2013).

Higher fatality rates in rural areas may be attributed to higher travel exposure from longer distances travelled, to faster speeds along with relatively unsafe roads that result in more severe collisions and injuries, and to poorer injury outcomes owing to sub-optimal access to quality pre-hospital and advanced in-hospital trauma care.

Recommendations

The following are core recommendations emanating from this research which speak to key outcomes in terms of programmatic interventions and priority areas for future research.

Enforcement to Mitigate Risk of Driver Intoxication

The specific implications for prevention and control emerging from this research relate to enforcement operations of driver risk behaviours and is consistent with the conceptualisation of driver behaviours aligned with the three key intervention-focussed categories of driver intoxication, speeding, and other driver risks. In terms of interventions, whilst speeding and other driver risks rely on mobile speed and visible patrol operations, respectively, driver intoxication relies principally on stationary roadblock or similar enforcement operations. The analysis has yielded important findings on driver intoxication linked with temporal effects and vehicle types that would inform strategies for roadblock operations.

> **A key recommendation is to assign greater priority to targeting driver intoxication during nights, over weekends (both regular and long weekends), and across all the non-vacation periods of the year. This can be achieved mainly through roadblocks. Relatively greater priority should be assigned to the targeting of speeding and other driver risk behaviours during other temporal periods (daytime, weekday, and vacation periods), this being achieved by other enforcement methods.**

In terms of temporal effects, roadblock operations targeting driver intoxication should be prioritized during nights, during weekends, and throughout the year (rather than focusing on mainly vacation periods). In addition, long weekends should be treated as regular weekends (rather than vacation periods), and non-vacation periods (including regular weekends) should receive relatively higher priority than vacation periods for alcohol-related enforcement. During other temporal periods (daytime, weekday, and vacation periods), enforcement operations may benefit from a relatively larger focus on speeding and other driver risk behaviours through mobile speed and visible patrol operations. The above is also evident with the recent 2019/2020 festive season where the RTMC intensified roadblock operations, increasing the national number of roadblocks three-fold from 775 in the previous 2018/2019 period to 1 924 but resulting in only marginal decreases in both the number of fatal crashes and fatalities (Njilo, 2020). Fatal crashes decreased from 1 438 to 1 390 and fatalities from 1 789 to 1 617 during the last 2019/2020 period compared with the previous 2018/2019 period. Of note too was that 40% of all fatalities were pedestrians. Following the festive season findings and based on our findings, there clearly needs to be a greater focus on speeding and other moving violations (rather than principally alcohol) during the festive season, along with greater priority afforded to pedestrian vulnerability.

Roadblock enforcement strategies should also provide for the targeting of specific vehicles, whereby the location of such enforcement operations may be aligned with the popular or high-risk routes related to these. Findings from this study have shown the need to afford relatively higher priority for testing drivers of light vehicles, prioritizing private vehicles, as well as drivers of midi-buses and buses.

In addition, the proportion of prosecutions has also been documented to be very low (Munwana, 2019), which is a further priority requiring urgent attention.

Improving the Measurement of Alcohol Intoxication in Fatal Crashes

Given the gross underestimation of the influence of alcohol with the RTMC data (described earlier), we recommend that alcohol attribution be reflected separately from all other driver risks in the various instruments used to capture road traffic crashes and injuries, including the RTMC "Accident Report" and "Culpable Homicide Crash Observation Report" (CHOCOR) forms. In doing so, the presence of alcohol will be captured regardless of any other driver risk behaviour, and not disregarded in instances where another driver behaviour is deemed more influential and indicated as the cause of the crash. In addition, this will also allow for an assessment of the role of alcohol in relation to all other driver risks, which is critical to more accurately assessing both the direct and indirect impact of alcohol intoxication on fatal crashes and fatalities.

Another key recommendation is that driver intoxication needs to be recorded in fatal crash data as a category of risk which overlaps other driver risk behaviours, rather than as a mutually exclusive category. In this manner, the role of alcohol intoxication will be manifest regardless of any other driver risk behaviour. This will also enable proper analysis of the compounding effect of alcohol intoxication, i.e., the manner in which alcohol intoxication co-occurs, and exacerbates the risks associated with other driver risks such as speeding, disregarding traffic lights and signs, overtaking, fatigue, falling asleep, and cellphone distraction, etc.

Figures 2 and 3 illustrate this transformation with Figure 2 showing the proportional contributions for the various driver risk behaviours and Figure 3 the hypothetical alcohol-relatedness for each of the driver risk behaviours.

Figure 2: Alcohol-related information available based on current data structure

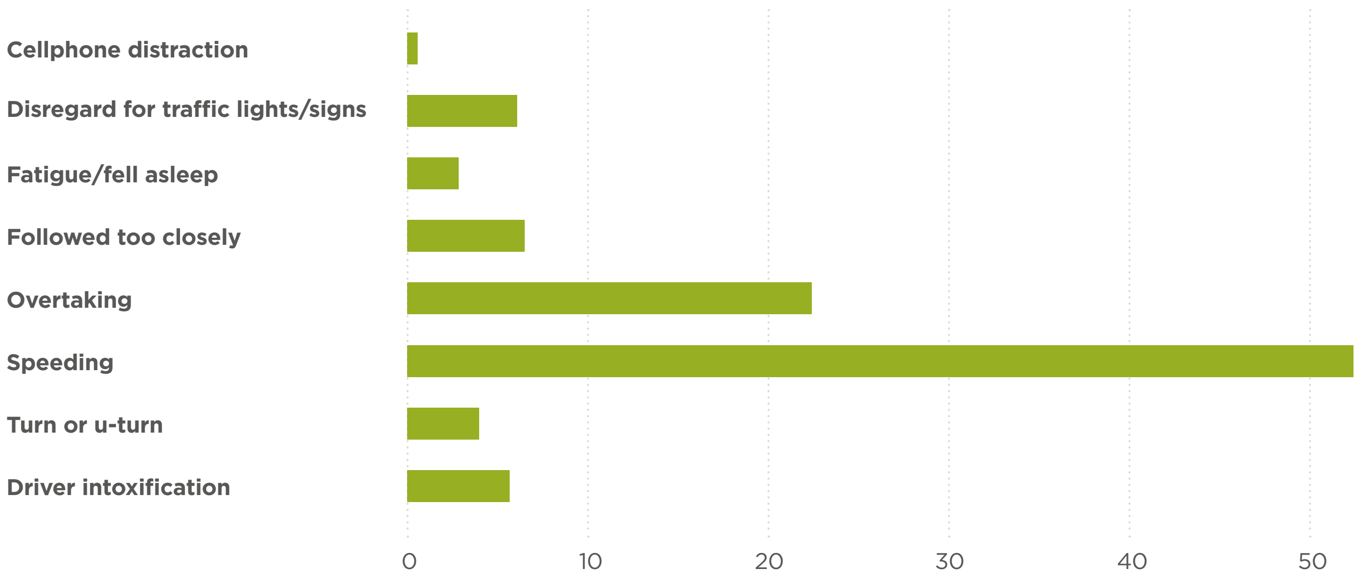
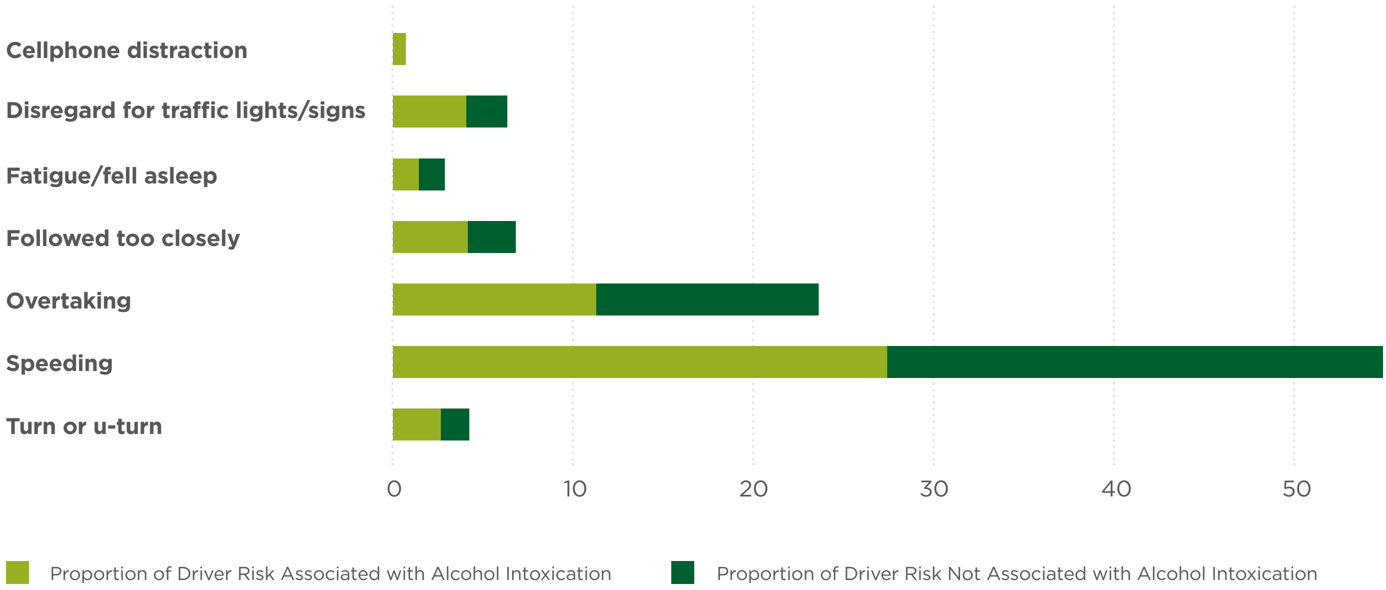


Figure 3: Alcohol-related information that would be possible based on proposed data structure



This research emphasises the importance of strengthening efforts to align alcohol findings from the RTMC with BAC test results from forensic pathology (FPS) laboratories, while additionally also identifying and achieving other novel collaborative opportunities in the face of backlogs and operational challenges with the FPS laboratories.

A further opportunity is to explore and obtain a detailed understanding to the causes for low attribution of alcohol by enforcement personnel, which may include, *inter alia*, the responding officer's inability, lack of confidence, or general reluctance, to attribute cases to alcohol. In this regard, enhanced training may help equipping enforcement personnel detect signs of alcohol consumption as part of both routine enforcement operations and at the scene of crashes involving injuries.

Priorities for Further Research

This research, whilst adding important evidence on driver intoxication as a risk factor in the South African setting, also lays the platform for investigating the role of other key driver risk behaviours including speeding and overtaking, and for expansion to incorporate other vulnerable road users, especially pedestrians. Such an expanded focus is necessary to allow for a comprehensive assessment of road traffic epidemiology and risk in the country, thereby facilitating comprehensive and integrated evidence-based approaches for intervention. In addition to additional research, it is also important to undertake a systematic evaluation of current road safety initiatives of the RTMC, including policy analyses of RTMC strategic and operational planning as well as outcome and impact evaluations of current interventions.

Apart from alcohol intoxication, two other key priorities for research are critical. Firstly, the high proportion of pedestrian fatalities amongst all road user fatalities requires greater attention and more focussed investigation. Secondly, the driver risk behaviours of speeding and overtaking account for almost three quarters of all driver risk associated fatal crashes, and this also requires more research, particularly to understand how alcohol co-occurs and amplifies the risks associated with these driver risk factors.

Pedestrian Research

Pedestrians were shown to be particularly vulnerable, being involved in more than half the fatal crashes due to driver error, and in more than one-quarter the fatal crashes involving all human factors. The NIMSS has also documented the large burden of pedestrian-related injuries, shown in 2011 to account for 41.2% and 29.2% of all transport-related deaths for Gauteng and Mpumalanga provinces respectively. Disaggregated analyses (as indicated for speeding) and analyses integrated with road infrastructure will be important to understand and explicate pedestrian vulnerability and risk in the South African context.

Speeding and Overtaking

Based on data from this research, speeding was shown to account for just over half (51.6%) of all driver risks. Overtaking is also closely linked with relatively higher driver speeds, although, depending on the traffic system and vehicle flows, other risks may also be involved such as from exposure to crashes with oncoming vehicles. Overtaking accounted for the majority of other driver risk behaviours in this research and for nearly one-quarter (22.4%) of all driver risk behaviours.

In addition, based on the substantial proportion of all fatal crashes (47.3%) that did not involve other road users, such as crashes where vehicles overturned or that crashed into other fixed objects, more than three-quarters (83.4%) were attributed to speeding.

Of note too is that speeding is overrepresented in fatal crash data in relation to the proportional contribution based on enforcement data. For example, during a 22-month period from 2013-2015 and based on traffic law enforcement data collected from all nine provinces in the country, speeding was shown to account for 34.8% of all traffic offences (RTMC, 2015).

Vehicle travel speed is well known to increase the risk of a collision as well as the severity of injuries, which may be due to factors such as decreased reaction times, decreased ability to negotiate curves and obstacles and increased distance required to stop a vehicle in response to a hazard. For example, travelling at just 20 km/h above a 60 km/h speed limit has been shown to have a relative risk of being involved in an injury-related crash equivalent to driving with a blood alcohol concentration (BAC) of about four times the legal alcohol limit of 0.05 g/100 ml (McLean & Kloeden, 2002).

Future work will benefit from robust research on speeding-related fatal crashes disaggregated by key risk factors relating to driver, vehicle, road characteristics and aligned with temporal and spatial effects.

Conclusion

This research has generated important findings relating to driver risk factors, focussed on the role of driver intoxication. It is imperative, however, that this work be supplemented with additional research that would inform a comprehensive and integrated strategy for addressing road safety in the country.

A further priority is to undertake a systematic evaluation of current road safety initiatives of the RTMC, including policy analyses of RTMC strategic and operational planning as well as outcome and impact evaluations of current interventions, to be conducted in conjunction with analysis of the RTMC fatal crash data.

Whilst some of the findings presented here may be already known intuitively, their confirmation in an empirically valid manner provide key quantitative evidence to support decision-making and prioritization of resources focussed on operational programming and enforcement, especially with roadblock operations. For example, these findings may provide valuable support across various levels of strategic and operational programming for the general "365 plan" that has been embraced by the RTMC and SAPS over recent years. An opportunity in this regard is to use the evidence from this research (along with that from proposed additional research opportunities) to bring all provinces on board with the strategy, and simultaneously leverage greater cooperation with road safety efforts, including support with strengthening the RTMC's national road safety information systems through the routine submission of quality accident report and CHOCOR form data, along with non-fatal crash data towards a comprehensive national crash information system.

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Appendix A

Validation of the RTMC FCD 2016 to 2018

Data issues: labelling, coding and response formats

Variable	Issue	Remedial action
Case User ID	Variable has different format across different years. Also, some years do not have data. Multiple cases per single data point, hence variable cannot be used as a unique identifier.	Variable cannot be used for management of cases and dataset.
Province	Differing coding for same province across calendar years (e.g.: LP versus LIM).	Recoded to same descriptor for all years
Month	Month identified in alphabetic characters for all years except for 2018 when they are listed in numeric characters	Recode months for 2018 using alphabetic characters
Week of Month	Values should be in admissible range of 1 to 5, but are actually listed as week of year, with range from 1 to 52 (there are actually week 1 to week 53, not sure what last category is). As weeks shift across years, it is difficult/impossible to establish week of month for all years.	Variable not used in analysis
Time of Day	All hourly intervals in order except for last one, reflected as 23.00-24.00 in some cases and 23.00-00.00 in other cases	Recode for this hour interval into single format using interval 23.00-00.00
Day of Week	Cases coded as full or abbreviated names of days for different years	Recoded all to reflect abbreviated names of days
Road Type	Different descriptors used for the same road surface across different years	All descriptors recoded to reflect consistent categories
Surface Condition	Multiple descriptors used across calendar years and across cases within single calendar year.	Recoding of all cases to reflect consistent descriptors
Crash Type	Multiple descriptors used across different calendar years and across cases within a single calendar year.	Recoding of all cases to reflect consistent descriptors
Vehicle Caught Fire	Data missing for 69% of cases. The variable is thus not fit for further analysis.	Variable not used in analysis
Municipality Type	Multiple formats for local and metro municipalities across different years.	Recode all to consistent descriptors of municipality type
Passenger Witness	No data in all cases	Variable not used in analysis

Variable	Issue	Remedial action
Independent Witness	No data in all cases	Variable not used in analysis
Total Fatalities (Persontype)	Has missing data for some cases, hence not as complete as other variable on Fatalities	Variable not used in analysis
Total Fatalities (Race)	Has missing data for some cases, hence not as complete as other variable on Fatalities	Variable not used in analysis
Total Fatalities (Gender)	Has missing data for some cases, hence not as complete as other variable on Fatalities	Variable not used in analysis
Vehicle 1	Multiple descriptors used for the same vehicle type across years and across cases within a single year.	All descriptors rationalised into common set within and across years
Vehicle 2	Multiple descriptors used for the same vehicle type across years and across cases within a single year.	All descriptors rationalised into common set within and across years
Vehicle 3	Multiple descriptors used for the same vehicle type across years and across cases within a single year.	All descriptors rationalised into common set within and across years
Vehicle 4 to Vehicle 16	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 5	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 6	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 7	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 8	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 9	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 10	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis

Variable	Issue	Remedial action
Vehicle 11	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 12	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 13	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 14	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 15	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Vehicle 16	Multiple descriptors used for the same vehicle type across years and across cases within a single year. High proportion of missing values (>95%)	Variable not used in analysis
Human Factor	Multiple descriptors used across and within calendar years Hit and Run listed as category, overlaps with Crash Type, hence need for separation of cases	All descriptors rationalised into common set within and across years
Vehicle Factor	Multiple descriptors used across and within calendar years	All descriptors rationalised into common set within and across years
Road Factor	Multiple descriptors used across and within calendar years	All descriptors rationalised into common set within and across years
Other Factor	Variable contains inadmissible characters and cannot be properly imported	Variable not used in analysis

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