Investigating the role of alcohol in road traffic collision fatalities in Western Cape, South Africa

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Declaration

I, RIXONGILE MALOMANE, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

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Abstract

Road traffic collisions (RTCs) are a major contributor to unnatural death worldwide, but especially in low-to-middle-income countries (LMICs) where motorised transport has rapidly expanded. A literature review into RTCs and alcohol indicated that it is well recognised that alcohol intoxication is a key risk factor in RTCs and road traffic fatalities (RTFs). It also indicated that literature concerning the role of alcohol intoxication in RTFs in South Africa is limited. Hence, this study aimed to investigate alcohol in RTF victims in five of the major mortuaries (Salt River, Tygerberg, Paarl, Worcester and George) in the Western Cape Province between 1 January 2016 and 31 December 2017. Cases were extracted from the Western Cape Forensic Pathology Service (FPS) internal database, which included demographic and crash information, together with blood alcohol concentration (BAC) results. In total, 2079 cases over the two years were included in the study, with most cases admitted in the metropole of Cape Town (Salt River: n=838, Tygerberg: n=693). The proportion of unnatural deaths were greater outside the metropole (George, Worcester and Paarl) compared to the metropole (Salt River and Tygerberg) areas. The majority of fatalities were male individuals (male to female ratio of 3.52:1), with the average age of 35.2 ± 17.2 years. Most victims were pedestrians (n = 1106; 53.7%) and dark wet roads, and highways were noted as risk factors in RTFs. Blood was submitted for alcohol analysis in 1432 (68.9%) cases, and results were available for 1314 (91.8%) cases. Of the available results, 709 cases (54%) were positive for alcohol (BAC of ≥ 0.01g/100 mL). Of the positive cases, most had a BAC between 0.15 and 0.29 g/100mL and the overall average BAC was 0.20 g/100 mL. Pedestrians and drivers had the highest median BACs, and almost a third of all the positive BAC results were from pedestrian deaths. The findings of this dissertation can contribute to the growing research on alcohol and injury in South Africa, especially as it relates to RTFs. Insight into vulnerable populations within the province is highlighted, together with key risk factors associated with RTFs, as well as safety measures that may be targeted for improvement, especially with regards to driving and walking on the roads while intoxicated.

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%	percentage
BAC	blood alcohol concentration
BrAC	breath alcohol concentration
DUI	driving under the influence
FCL	Forensic Chemistry Laboratory
FPS	Forensic Pathology Service
g	gram
GDP	gross domestic product
GNP	gross national product
L	litre
LMIC	low- and middle-income countries
m	milli
OH	hydroxyl
RSA	Republic of South Africa
RTA	road traffic accident
RTC	road traffic collision
RTCs	road traffic collisions
RTF	road traffic fatality
RTFs	road traffic fatalities
RTI	road traffic injury
UK	United Kingdom
UN	United Nations
USA	United States of America

VAC	vitreous alcohol concentration
WC	Western Cape
WHO	World Health Organization

Chapter 1: Introduction and literature review

1.1. Background

Deaths from injuries incurred in road traffic collisions are a global problem. A reported 1.25 million road traffic deaths occurred during the year 2013 in 180 countries of 195 countries worldwide, with China having the highest RTC deaths at 261,367 deaths, followed by India at 207,551 [1]. These values subsequently increased and road traffic collisions (RTCs) accounted for approximately 1.35 million deaths in 2016 [2]. While the overall rate of road traffic fatalities (RTFs) has stabilised over the years in high income regions such as European and American Nations (approximately 18 deaths per 100,000 population), this is not the case in low- and middle-income countries (LMICs), where the population and motorisation have disproportionally increased [2]. In addition, the United Nations' (UN) Sustainable Development Goal target 3.6, which was to halve the number of RTFs, has not been met. Instead, the World Health Organisation (WHO) reported in 2018 that road traffic injuries (RTIs) were the leading cause of death in individuals aged 5 – 29 years, and the eighth leading cause of death in people of all ages [3]. This was despite progress achieved in some countries in their legislation (e.g. drunk-driving and reckless-driving laws), vehicle standards (e.g. availability of seat belts), planning and design of roads, and improving access to emergency care [2].

LMICs are greatly affected by RTFs, with Africa's mortality rate being the highest in the world (26.6 RTFs per 100,000 population in 2016). In addition, vulnerable road users such as pedestrians and cyclists are greatly affected in RTCs in Africa. Improving progress within road traffic safety initiatives requires that comprehensive data is available and is assessed, particularly to identify risks and trends associated with RTFs.

1.1.1. Alcohol and its effects

Alcohol misuse presents critical worldwide public health and economic problems and greatly affects developing countries, such as South Africa. Alcohol (ethanol or ethyl alcohol) is an organic compound in which a hydroxyl functional group (–OH) is bound to an aliphatic two-carbon chain [4]. It is a psychoactive substance, which largely depresses the central nervous system and has dependence-producing effects [5]. The cardiovascular and respiratory systems are also adversely affected by alcohol intoxication [6]. Alcohol intoxication is a physiological condition that may result in psychological alterations of consciousness [7], and impairment in the physical functioning of an individual. The impairment effects of alcohol are tightly linked to the amounts ingested (the dose), how quickly alcohol is ingested and the BAC reaching the brain and interfering with neurotransmission [8]. Both cognitive and psychomotor functions are impaired by over-consumption of alcohol, which is the underlying cause of many accidents on the roads, in the home and the workplace [9].

Alcohol abuse is a significant public health problem in South Africa [10]. According to the Western Cape Government, alcohol was identified as the fifth leading risk factor for death and disability in South Africa [11]. Given the impairing nature of alcohol intoxication, it has been widely recognised to contribute to morbidity and mortality, especially in road traffic collisions [12,13].

1.1.2. Road Traffic Collisions

RTCs have been defined as collisions that occur on a road or street, open to public traffic, that involve at least one motor vehicle (including a bicycle or motorcycle) and another object, and where one or more persons have been injured or killed [1,14]. This usually excludes other transportation collisions such as those on aircrafts, railways, or ships. It is of paramount importance to define RTCs in a study and to establish the inclusion and exclusion criteria of the sample investigated, as issues may arise in the reporting of RTCs if definitions differ [15]. Conflicting RTC definitions can result in inaccurate reporting of the RTC data, and thus, affect the analysis and appreciation of their severity [16].

In this literature review, RTCs will be defined as previously mentioned. An RTF is defined as a collision on a road involving at least one motor vehicle (including a bicycle or motorbike) and other objects, persons, or vehicles wherein an individual was *killed* [17]. Such individuals include motor vehicle drivers or passengers, motorcyclists, cyclists and/or pedestrians. An injury that is incurred following an RTC will be defined here as a road traffic injury (RTI). These injuries may be fatal or non-fatal depending on their severity.

1.2. The public health burden of road traffic collisions and road traffic injuries

Globally, the burden of RTCs costs more than 3% of the gross domestic product (GDP) and about 5% of the gross national product (GNP) in LMICs [18]. These are costs incurred from hospital bills of RTC victims, insurance claims, and the vehicles lost and damaged in the RTC. RTCs cost the South African (RSA) economy approximately 7.8% of the GDP in 2010 [17] and R306 billion in 2012 [19]. In the Western Cape province alone, approximately R21.7 billion was reportedly spent on the outcome of RTCs in 2012 [19].

In South Eastern Iran, in a single hospital centre, it was established that RTIs accounted for 10.4% of the total expenses of the centre during the study period and accounted for 130 times more than the gross national income per capita [20].This study was done over a one year period, from April 2012 to April 2013 [20]. Each RTI patient cost the centre fifteen times more than the average patient in other sections of the hospital. The costs of RTIs and especially after-crash care are evidently extremely high.

It has been reported that young individuals are at most risk of being injured or dying in RTCs [2,21,22]. In Ga-Rankuwa in RSA, RTF victims were predominantly between the ages of 25 to 34 years [23], and between 18 and 29 in a separate study in Pretoria [24]. In addition, it has been reported that males make up most of the RTC victims, with more than 70% of RTC victims being males in both studies mentioned [23,24]. Men are also more likely to be involved in risky behaviours when it comes to driving [25]. This is a burden to the economy of a country, since the most economically productive young individuals are lost to RTIs [26].

In addition to the burden of RTIs, alcohol abuse was estimated to cost the RSA economy 10% to 12% of the 2009 GDP, which included both tangible and intangible costs [27]. Tangible assets include amongst others, damage to property, insurance claims and medical expenses, while intangible costs include pain, grief and suffering as a result of RTCs. Tangible costs were estimated at R37.9 billion, which is also a great burden to the South African economy. It is evident that RTCs as well as alcohol abuse are a burden to the GDP of many countries and the world. Since RTCs occur mostly amongst the youth, this affects the productivity of the economy and output of businesses as well.

1.3. Legislation regarding alcohol intoxication and driving

Alcohol intoxication negatively impacts one’s ability to drive safely. One means of assessment of intoxication is through interpretation of alcohol concentration in a biological specimen, most commonly blood. In RTCs or traffic stops, a law enforcement officer may measure an individual’s breath alcohol concentration (BrAC) or request the collection of blood to measure their blood alcohol concentration (BAC). These are the concentrations of alcohol in the breath or blood stream measured as the weight of alcohol, in grams, per 210 litres of breath or 100 millilitres of blood [28]. BrAC is often used in road blocks to determine if a driver may be driving drunk due to its non-invasive, quick and inexpensive nature [29].

While alcohol is legal for adult use in most countries, there are laws put in place to regulate acceptable limits of alcohol in one’s system while driving, in order to reduce road traffic collisions that are caused by the substance [30]. Alcohol limit compliance may be tested by breathalysers (most commonly), blood or urine analysis, observational assessment, and sobriety checkpoints [1]. Breath analysis is used in many countries as a preliminary screening procedure by law enforcement agencies and others, while blood is used for confirmation [31]. The volatile nature of alcohol is the reason behind the successful measurement of alcohol concentration in breathalysers.

Breath alcohol testing is very rapid and is non-invasive compared to blood alcohol testing. BrAC tests are typically easier to perform, can be done at the site of a crash or roadblock, and do not require invasive collection of specimens. The traffic offender simply blows into the instrument, which takes less time compared to drawing blood from them when testing for BAC. Breathalysers do need to be calibrated and the method validated according to international guidelines.

In driving under the influence (DUI) of alcohol cases, blood (or breath) is commonly collected to determine the BAC and interpreted against *per se* levels identified in a country or region’s legislation. If above the *per se* level, this evidence may be sufficient for a conviction [32]. These *per se* concentrations vary among different countries [33] . In South Africa, the Road Traffic Act (No. 93 of 1996) indicates that “No person shall on a public road occupy the driver's seat of a motor vehicle the engine of which is running, while the concentration of alcohol in any specimen of blood taken from any part of his or her body is not less than 0.05 gram per 100 millilitres, or occupy the driver's seat of a motor vehicle the engine of which is running, while the concentration of alcohol in any specimen of breath exhaled by such person is not less than 0.24 milligrams per 1000 millilitres" [34]. In South Africa, the current BAC limit is therefore 0.05 g/100 mL for ordinary drivers and 0.02 g/100 mL for professional drivers [34].

Countries like Hungary, the Czech Republic, Libya [35], Morocco [35], Romania and Slovakia have a zero BAC limit [36]. In the United Kingdom (UK), USA, Mexico and Canada, the BAC limit is 0.08 g/100 mL Turkey has a BAC limit of 0.05 g/100 mL for private drivers (individuals driving their own vehicles) and a zero tolerance policy for public drivers (all public transport, bus, taxi, commercial and official transport) [37]. In the USA, the *per se* BAC is 0.08 g/100 mL, while the zero tolerance BAC level varies from state to state, for example, 0.02 g/100 mL in Georgia and 0.00 g/100 mL in the District of Columbia [38]. These levels determine the fines, fees and penalties in different states, and the BAC is a frequent determination in a forensic toxicology laboratory, especially in DUI cases.

While it has been illustrated that there may not be any significant differences between BrAC and BAC ratios [39,40]; there are physiological factors that may alter the BrAC, such as an individual's breathing rate and pattern, the temperature of their breath and also the functioning of their lungs [41]. Due to this, inferring BAC from BrAC is not advisable and may be biased. BrAC may be related to BAC at equilibrium, and conversion ratios of BAC:BrAC is 2000:1, 2100:1 or 2300:1 have been proposed based on the legislation of a country. However, it should be noted that these ratios may have high inter-individual variability. In South Africa, the legal BrAC is 0.24 mg per 1 000 mL, which results in a ratio of BAC to BrAC of 2100:1 in the law.

An offender may face serious criminal charges if found to be driving under the influence of alcohol, hence it is very important that BAC be determined accurately and correctly. It has been suggested that the reduction in BAC legal limit may reduce the number of RTCs that occur in a country. In 2019, Scherer and Fell reported that between 1982 and 2014 in the USA, there was a 10.4% reduction in RTFs after the legal drunk-driving limit was reduced from 0.10 g/100mL to 0.08 g/100 mL [42]. A study conducted by Karakus *et al*. in 2015 have shown that drivers with a BAC level of 0.05 g/100 mL were more likely to be involved in a car accident than drivers with a zero BAC [37].

These *per se* concentrations provide an objective means of determining whether someone is intoxicated according to legislation, despite the understanding that physiological factors such as tolerance (whether functional or metabolic) may result in inter-individual differences in

BAC and/or relative intoxication. Nevertheless, the BAC and BrAC, thus provide means of determining when to prosecute individuals who may be driving intoxicated according to the law.

1.4. Effects of alcohol on driving

Symptoms of alcohol intoxication are largely dose-dependent. At a lower dose this may include euphoria, flushed skin and decreased social inhibition. At higher doses, intoxication may result in impairment of balance, judgement and decision-making ability, as well as nausea and grey- or black-outs [43,44].

With reference to driving; alcohol intoxication affects vision, decreases reaction times, reduces concentration, causes drowsiness and impairs motor functions [45]. It has also been shown to impair judgement and perception, which may result in a driver's failure to obey road rules and engage in risky behaviour [45].

Alcohol intoxication has thus shown to be a risk factor for injuries and fatalities resulting from road collisions [46]. Driving a motor vehicle safely requires clear vision and perception, controlled steering, appropriate processing of information and attention [47]. Different functions may be impair by alcohol in a dose dependent manner, and this is usually correlated with the level of intoxication as measured by the BAC as indicated in Table 1 below [48].

Table 1: Effects of increasing BAC an average individual's physiology and resulting impairment [49]

Blood – Alcohol Concentration (g/100 mL)	Stage of Alcoholic Influence	Clinical Signs and Symptoms
0.01 – 0.05	Subclinical	Effects are not obvious, and behaviour appears normal by ordinary observations Impairment can only be seen through tests
0.03 – 0.12	Euphoria	Increased talkativeness, sociability, 0and self confidence Decreased information processing Decreased efficiency in critical performance skills
0.09 – 0.25	Excitement	Drowsiness, Impaired balance Emotional swings Increased reaction time, decreased rection time
0.18 – 0.3	Confusion	Disorientation, dizziness, Disturbances in vision and perception of colour, motion. Lack of emotion
0.25 – 0.4	Stupor	Vomiting, impaired consciousness, Loss of motor functioning skills
0.35 – 0.5	Coma	Severe depression, unconsciousness, possible death, depressed or abolished reflexes
0.45+	death	Death due to respiratory dysfunction.

A BAC of 0.01 to 0.02 g/100 mL has less noticeable effects compared to a BACs of 0.15 g/100 mL, where there is a loss of balance and substantial impairment in vehicle control. Alcohol is usually associated with RTCs more than all other drugs combined [50]. A review of the effects of alcohol by Moskowitz and Florentino in 2000, showed that alcohol impairs some driving skills at lower concentrations (~0.02 g/100 mL) such as attention and tracking [48]. A BAC concentration of 0.05 g/100 mL showed a significant impairment of driving skills, and 94% of studies reviewed, showed that a BAC of 0.08 g/100 mL may lead to extensive impairment [51].

Bivona *et al.* (2015) studied 32 healthy participants whose BAC levels were measured while consuming wine to get to at least 0.05 g/100mL. The driving of the participants was then assessed [30].The authors revealed that at a BAC of at least 0.05 g/100 mL, tonic and phasic alertness, attention and vigilance were significantly impaired. It was concluded from this study that alcohol has a negative effect on driving skills even at BACs of approximately 0.05 g/100 mL, which is the current legal limit in RSA.

1.5. Road traffic collisions and alcohol

Road traffic fatalities are one of the major causes of death worldwide, and alcohol is one of the leading risk factors that contribute to road traffic fatalities [1,49]. In 2002, in the United States of America (USA), 17,419 (41%) of 42,815 RTFs were related to alcohol [22]. A 2011 study by de Carvalho Ponce *et al*. [19] in Brazil, reported that alcohol was associated with nearly half of all road traffic fatalities in Sao Paulo. A Norway report illustrated that in many RTFs, between 20% and 50% of the victims have post-mortem BACs above legislated limits, ranging from 0.15 – 0.18 g/100mL [52].

It should be noted that population sizes and rates of RTFs per 100,000 are not always considered or reported, thus caution is required in comparing these studies. In addition, while it is possible for other drugs, especially central nervous system depressant drugs, to play a role in RTFs, this falls outside of the scope of discussion in this dissertation.

The limited available South African studies do however report similar results. Du Plessis *et al*. [23] reported 50.3% of RTF cases in Ga-Rankuwa had a BAC greater than 0.01 g/100 mL and 92.9% of the positive cases had a BAC > 0.05 g/100mL. In RSA in 2002, 51.9% of 2,372 cases of fatal injury, had elevated BACs greater than 0.01 g/100 mL [53]. This data showed that pedestrians, followed by drivers, had the highest BACs. Drivers had a mean BAC of 0.17 g/100 mL, which was three times the legal limit [53]. Du Plessis *et al.* concluded by mentioning that the high levels of RTFs is a concern in RSA, as well as the high BACs that were found in these fatalities, which exceed the permitted legal limit in South Africa.

1.6. Blood alcohol analysis in post-mortem medico-legal cases

In RSA, the Inquests Act of 1959 specifies that all suspected unnatural deaths must undergo a post-mortem in order to ascertain the cause and manner of death [54]. RTFs are one category of unnatural deaths, and victims of RTFs must undergo an autopsy by an authorised forensic medical practitioner (National Health Act, 2003) [55]. A variety of biological samples may be sampled for post-mortem toxicological analysis in medico-legal investigations, and these include blood (peripheral and central), urine, vitreous humour, gastric contents and tissue (liver, muscle tissue) [56]. For alcohol analysis, femoral blood is recommended, however, vitreous humor is a valuable specimen in cases of decomposition, trauma or exsanguination [57].

An individual's BAC at analysis may not be the same as that at the time of death, as there are several factors and post-mortem artefacts that may alter the BAC. Post-mortem blood specimens are typically collected in 2% w/v sodium fluoride (with potassium oxalate) to prevent bacterial action and act as a preservative, and also refrigerated for preservation. Microbial fermentation and/or contamination may produce alcohol from glucose in the blood after death [58]. Sodium fluoride preservation may reduce the enzymatic or bacterial alteration of glucose to form alcohol and inhibit the degradation of alcohol. Other microorganisms may also break down alcohol and contribute to its elimination from the blood, decreasing post-mortem BAC [58]. It has been suggested that comparison of urine and blood alcohol concentration ratios may assist in determining whether an individual was in a state of absorption or elimination of alcohol around the time of death [57].

Vitreous humour (VH) is commonly used when blood may be contaminated or the body is very decomposed [58]. In a study by Honey *et al.* [59] in 2005, of 322 consecutive cases analysed for BAC and vitreous alcohol concentration (VAC), 71% of the cases had a VAC that exceeded the BAC, which is consistent with the higher ratio of ethanol distribution into the VH at equilibrium. It was suggested that in cases where there may be post-mortem production of alcohol or contamination of the specimen, a higher BAC may be obtained, making VAC a more suitable specimen for determining the concentration of alcohol in victims [59]. VH is anatomically separated from the gut and is less susceptible to bacterial contamination, and is often less prone to the effects post-mortem drug redistribution [60]. VH may be used for alcohol analysis in cases of suspected post-mortem redistribution, post-mortem synthesis (in decomposed cases) as well as in cases where blood cannot be sampled [61]. At equilibrium, and when a person is eliminating ethanol, there is a suggested ratio between vitreous humor and whole blood ethanol concentrations. When this ratio is above one it may suggest an individual is eliminating alcohol whereas if the ratio (VH:WB) is less than one, it may suggest recent ingestion of ethanol, or alternatively, there may have been some post-mortem ethanol synthesis (in a decomposing case for example).

In RSA, only post-mortem blood is routinely collected for alcohol analysis; however, there may be a few cases in which the medical practitioner conducting the autopsy will collect VH for alcohol analysis. It is of paramount importance that specimens of appropriate quality and quantity are sampled for analysis, so to support reliable interpretation of the results [62].

Qualitative and quantitative analysis of BAC (or VAC) in the toxicology laboratory, is typically carried out using headspace sampling and gas chromatography with flame ionisation detection [57]. While this is the global gold standard of testing, it should be noted that even if the result is reliable, it depends on the sample submitted to the laboratory. There may be variation in concentrations of alcohol in blood collected from different sites post-mortem [63]. This may be due to post-mortem redistribution, or even post-mortem diffusion from the stomach if there was recent ingestion of alcohol. Storage and handling considerations are thus extremely important in testing biological samples for alcohol.

1.7. Interpretation of post-mortem alcohol concentrations

Forensic toxicologists are often asked to provide an expert opinion in criminal or inquest cases where the role of impairment with drugs and/or alcohol in an event or death is in question. Interpreting post-mortem BACs does present some challenges, which should be considered in most cases. It must be noted that the alcohol present in blood after death, may be due either solely to ingestion of that alcohol, or some form of microbial synthesis of alcohol, or both [64]. This has triggered the investigation and development of biomarkers to help in the investigation of such cases [59].

Post-mortem samples in forensic toxicological analysis can be numerous and present difficulties compared to clinical specimens, due to putrefaction and autolysis of specimens [56]. There are several factors that can influence putrefaction post-mortem, that may increase or decrease blood alcohol concentration [56]. Factors that decrease alcohol concentration in blood alcohol samples include evaporation, enzyme-mediated oxidation and the activity of microorganisms [65]. It is thus important that the case and individual history, specimen type and handling, analytical techniques and post-mortem artefacts are all assessed before making a conclusion on a case. In the case of RTFs, the cause of death is usually due to the trauma associated with the accident. The role of alcohol intoxication is, however, important for determining the circumstances of the case and becomes particularly important in cases where insurance must be paid out.

1.8. Conclusion

Transportation is an important part of our lives, and the world has become so connected that humans need to travel from one place to another. The development of this technology has costed the world millions of deaths per year, most of which are people in the economically productive age group. There are many factors that cause RTCs, and research has proven that alcohol is one of the major factors that cause morbidity and mortality associated with RTCs, especially for drivers and pedestrians. In South Africa, there is a dearth of literature on the influence of alcohol in RTFs. It was therefore deemed important to further investigate RTFs in key cities and towns in Western Cape, where the largest proportions of RTFs are autopsied and investigated. The outcome of this research can contribute to existing literature and be used when implementing and enforcing laws surrounding drunk-driving in the country. It can also be used to help researchers understand more about the role of alcohol intoxication in RTF victims in this country.

References

1] World Health Organisation, Global status report on alcohol and health 2014, World Heal. Organ. Geneva. 17 (2014) 452–459.

[2] World Health Organization, The Global status report on road safety 2018, World Health Organization, 2018. https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/ (accessed November 2, 2019).

[3] WHO | Global status report on road safety 2018, (n.d.). https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/ (accessed November 2, 2019).

[4] L.G. Wade, alcohol | Definition, Formula, & Facts | Britannica.com, (2018). https://www.britannica.com/science/alcohol (accessed January 23, 2020).

[5] M.J. Quintas, P. Costa, P. Melo, A. Castro, J.M. Franco, H.M. Teixeira, Postmortem in vitro ethanol production—It could be more common than we think!, *Forensic Sci. Int.* 274 (2017) 113–116. https://www.sciencedirect.com/science/article/pii/S0379073817300038#bib0020 (accessed January 20, 2020).

[6] Y.C. Jung, K. Namkoong, Alcohol: Intoxication and poisoning - diagnosis and treatment, in: Handb. Clin. Neurol., Elsevier B.V., 2014: pp. 115–121.

[7] N. Zink, W. Bensmann, C. Beste, A.K. Stock, Alcohol Hangover Increases Conflict Load via Faster Processing of Subliminal Information, *Front. Hum. Neurosci.* 12 (2018).

[8] A.W. Jones, Alcohol, its analysis in blood and breath for forensic purposes, impairment effects, and acute toxicity, Wiley Interdiscip. *Rev. Forensic Sci.* 1 (2019).

[9] M.J. Stampfer, H.K. Jae, J. Chen, R. Cherry, F. Grodstein, Effects of moderate alcohol consumption on cognitive function in women, *N. Engl. J. Med.* 352 (2005) 245–253.

[10] P. Groenewald, T. Vos, R. Norman, R. Laubscher, C. van Walbeek, Y. Saloojee, F. Sitas, D. Bradshaw, Estimating the burden of disease attributable to smoking in South Africa in 2000, *South African Med.* J. 97 (2007) 674–681.

[11] W.C. Government, Department of the Premier Western Cape Government Strategic Programmes Branch Policy and Strategy Chief-Directorate, n.d. https://www.westerncape.gov.za/text/2017/September/white_paper_alcohol-related_harms_reduction.pdf (accessed November 2, 2019).

[12] L. Gicquel, P. Ordonneau, E. Blot, C. Toillon, P. Ingrand, L. Romo, Description of various factors contributing to traffic accidents in youth and measures proposed to alleviate recurrence, *Front. Psychiatry. 8* (2017).

[13] J.L. Martin, B. Gadegbeku, D. Wu, V. Viallon, B. Laumon, Cannabis, alcohol and fatal road accidents, *PLoS One.* 12 (2017).

[14] T. Crawford, D. McGrowder, Road Traffic Injury Epidemic in Jamaica: Implications for Governance and Public Policy, *Asian Soc. Sci.* 4 (2009).

[15] A. Jindal, S. Mukherji, World report on road traffic injury prevention, *Med. J. Armed Forces India.* 61 (2005) 91.

[16] T. Majero, Retrospective analysis of blunt force trauma associated with fatal road traffic accidents in Cape Town (South Africa) over a two-year period, Masters dissertation, University of Cape Town, Cape Town (2018)

[17] World Health Organisation., World report on child injury prevention, 2008.

[18] C. Wangdi, M.S. Gurung, T. Duba, E. Wilkinson, Z.M. Tun, J.P. Tripathy, Burden, pattern and causes of road traffic accidents in Bhutan, 2013–2014: a police record review, Int. *J. Inj. Contr. Saf. Promot*. 25 (2018) 65–69.

[19] Dikobe, B. Martins, Media Briefings | PMG, Min Labour Budg. Speech. (2013). https://www.gov.za/transport-minister-dikobe-ben-martins-saddened-road-accident-and-wishes-injured-speedy-recovery (accessed December 7, 2019).

[20] A.A. Sargazi, A.A. Sargazi, P.K. Nadakkavukaran Jim, H. Danesh, F. Aval, Z. Kiani, A. Lashkarinia, Z. Sepehri, Economic Burden of Road Traffic Accidents; Report from a Single Center from South Eastern Iran., *Bull. Emerg. Trauma*. 4 (2016) 43–7. https://www.researchgate.net/publication/289127920_Economic_Burden_of_Road_Traffic_Accidents_Report_from_a_Single_Center_from_South_Eastern_ (accessed February 2, 2020).

[21] J.J. Kalougivaki, R.P. Goundar, J. JVP Kalougivaki, R.P. Goundar, Retrospective Autopsy Based Study of Fatal Road Traffic Accidents in Fiji, *J Forensic Res.* 5 (2014) 1–6.

[22] K.P. Quinlan, R.D. Brewer, P. Siegel, D.A. Sleet, A.H. Mokdad, R.A. Shults, N. Flowers, Alcohol-impaired driving among U.S. adults, 1993–2002, *Am. J. Prev. Med.* 28 (2005) 346–350. https://www.sciencedirect.com/science/article/pii/S0749379705000073?via%3Dihub (accessed September 29, 2019).

[23] M. Du Plessis, K.K. Hlaise, R. Blumenthal, Ethanol-related death in Ga-Rankuwa road-users, South Africa: A five-year analysis, *J. Forensic Leg. Med.* 44 (2016) 5–9.

[24] U. Ehmke, L. du Toit-Prinsloo, G. Saayman, A retrospective analysis of alcohol in medico-legal autopsied deaths in Pretoria over a 1 year period., *Forensic Sci. Int.* 245 (2014) 7–11. https://doi.org/10.1016/j.forsciint.2014.09.009.

[25] W. Frankenhuis, R. Dotsch, J. Karremans, D. Wigboldus, Male physical risk taking in a virtual environment, *J. Evol. Psychol.* 8 (2010) 75–86.

[26] A. Gamble, The Global Impact, in: The Spectre at the Feast, 2009: pp. 114–140.

[27] R.G. Matzopoulos, S. Truen, B. Bowman, J. Corrigall, The cost of harmful alcohol use in South Africa, South African Med. J. 104 (2014) 127–132.

[28] J. Brick, Forensic Alcohol Test Evidence (FATE) : A Handbook for Law Enforcement and Accident Investigation, 2017.

[29] J.C. Anderson, M.P. Hlastala, Breath tests and airway gas exchange, *Pulm. Pharmacol. Ther.* 20 (2007) 112–117.

[30] U. Bivona, S. Garbarino, J. Rigon, M.G. Buzzi, G. Onder, M. Matteis, S. Catani, M. Giustini, G.L. Mancardi, R. Formisano, Effect of ethylic alcohol on attentive functions involved in driving abilities, *Arch. Ital. Biol.* 153 (2015) 162–9.

[31] R.B. Voas, J.C. Fell, Strengthening impaired-driving enforcement in the United States., *Traffic Inj. Prev.* 14 (2013) 661–670.

[32] J.C. Fell, R.B. Voas, Mothers Against Drunk Driving (MADD): The First 25 Years, *Traffic Inj. Prev.* 7 (2006) 195–212.

[33] L. Zamengo, G. Frison, G. Tedeschi, S. Frasson, Forensic-metrological considerations on assessment of compliance (or non-compliance) in forensic blood alcohol content determinations: A case study with software application, *Forensic Sci. Int.* 265 (2016) 144–152.

[34] Republic of South African National Road Traffic Act 93 of 1996, 1996 (2006) 1–74.

[35] WHO, GHO | By category | Cellphone subscribers - Data by country, WHO. (2014). http://apps.who.int/gho/data/view.main.54600 (accessed April 18, 2018).

[36] European Transport Safety Council, Blood Alcohol Content (BAC) Drink Driving Limits across Europe | ETSC, (2017). https://etsc.eu/blood-alcohol-content-bac-drink-driving-limits-across-europe/ (accessed April 18, 2018).

[37] A. Karakus, N. İdiz, M. Dalgiç, T. Uluçay, Y. Sincar, Comparison of the Effects of Two Legal Blood Alcohol Limits: The Presence of Alcohol in Traffic Accidents According to Category of Driver in Izmir, Turkey, *Traffic Inj. Prev.* 16 (2015) 440–442.

[38] G. Andy, State by State Legal Blood Alcohol Limit (BAC), Andygreen Atty. Law P.C. (n.d.). https://www.andygreenlaw.com/dui/state-by-state-bac/ (accessed February 8, 2020).

[39] A. Jurič, A. Fijačko, L. Bakulić, T. Orešić, I. Gmajnički, Evaluation of breath alcohol analysers by comparison of breath and blood alcohol concentrations, *Arch. Ind. Hyg. Toxicol*. 69 (2018) 69–76.

[40] L. Lindberg, S. Brauer, P. Wollmer, L. Goldberg, A.W. Jones, S.G. Olsson, Breath alcohol concentration determined with a new analyzer using free exhalation predicts almost precisely the arterial blood alcohol concentration, *Forensic Sci. Int.* 168 (2007) 200–207.

[41] A.W. Jones, Medicolegal Alcohol Determination - Blood- or Breath-Alcohol Concentration?, *Forensic Sci. Rev.* 12 (2000) 23–47.

[42] M. Scherer, J.C. Fell, Effectiveness of lowering the blood alcohol concentration (BAC) limit for driving from 0.10 to 0.08 grams per deciliter in the United States, *Traffic Inj Prev.* 2019; 20(1): 1–8.

[43] M.A. Schuckit, Comorbidity between substance use disorders and psychiatric conditions, *Addiction*. 101 (2006) 76–88.

[44] L. Vonghia, L. Leggio, A. Ferrulli, M. Bertini, G. Gasbarrini, G. Addolorato, L. Abenavoli, C. D'Angelo, S. Cardone, A. Mirijello, V. Leso, S. Piano, A. Nesci, E. Capristo, N.

Malandrino, F. Caputo, S. Francini, M. Stoppo, T. Vignoli, M. Bernardi, G. Fontana, Acute alcohol intoxication, *Eur. J. Intern. Med.* 19 (2008) 561–567. https://doi.org/10.1016/j.ejim.2007.06.033.

[45] X. Zhao, X. Zhang, J. Rong, Study of the effects of alcohol on drivers and driving performance on straight road, *Math. Probl. Eng.* 2014 (2014) 1–9.

[46] R.D. Blomberg, R.C. Peck, H. Moskowitz, M. Burns, D. Fiorentino, Crash Risk of Alcohol Involved Driving :, 2005. http://www.dunlapandassociatesinc.com/crashriskofalcoholinvolveddriving.pdf (accessed January 25, 2018).

[47] H. Newman, Effects of alcohol on driving skill, *J. Am. Med. Assoc.* 116 (1941) 890.

[48] H. 1925- Moskowitz, D. Florentino, A review of the literature on the effects of low doses of alcohol on driving-related skills, (2000). https://rosap.ntl.bts.gov/view/dot/1677 (accessed February 8, 2018).

[49] J.C. Garriott, Garriott's Medicolegal Aspects of Alcohol, Lawyers & Judges Pub. Co, Arizona. 2008

[50] E.J.D. Ogden, H. Moskowitz, Effects of alcohol and other drugs on driver performance, *Traffic Inj. Prev.* (5)3 2004.185-198.

[51] H. Moskowitz, C.D. Robinson, Effects of Low Doses of Alcohol on Driving-related Skills: A Review of the Evidence (No. DOT-HS-807-280), (1988), United States. National Highway Traffic Safety Administration. https://trid.trb.org/view/297976 .(accessed February 8, 2018).

[52] H. Gjerde, A.S. Christophersen, P.T. Normann, J. Mørland, Toxicological investigations of drivers killed in road traffic accidents in Norway during 2006-2008, *Forensic Sci. Int.* 212 (2011) 102–109. https://doi.org/10.1016/j.forsciint.2011.05.021.

[53] M. Matzopoulos, R., Seedat, M., Cassim, A Profile of fatal injuries in South Africa: National Injury Mortality Surveillance System 2002, *Med. Res. Counc.* Cape T. (2003).

[54] Republic of South Africa, The Inquests Act (Act 58 of 1959) (and its amendments). Pretoria: Government Printer. 1959.

[55] Republic of South Africa, National Health Act, 2003, Regulations rendering forensic pathology service. (2018)

[56] R.J. Dinis-Oliveira, F. Carvalho, J.A. Duarte, F. Remião, A. Marques, A. Santos, T. Magalhães, Collection of biological samples in forensic toxicology, *Toxicol. Mech. Methods.* 20 (2010) 363–414.

[57] F.C. Kugelberg, A.W. Jones, Interpreting results of ethanol analysis in postmortem specimens: A review of the literature, *Forensic Sci. Int.* 165 (2007) 10–29.

[58] J. Markowska, M. Szopa, M. Zawadzki, W. Piekoszewski, Vitreous humour – routine or alternative material for analysis in forensic medicine, *Arch. Forensic Med. Criminol.* 67 (2017) 201–213.

[59] D. Honey, C. Caylor, R. Luthi, S. Kerrigan, Comparative alcohol concentrations in blood and vitreous fluid with illustrative case studies, in: *J. Anal. Toxicol.*, 2005: pp. 365–369.

[60] F. Bévalot, N. Cartiser, C. Bottinelli, L. Fanton, J. Guitton, Vitreous humor analysis for the detection of xenobiotics in forensic toxicology: a review., *Forensic Toxicol.* 34 (2016) 12–40.

[61] H.M. Teixeira, F. Reis, P. Proença, P. Ramos, O. Quińtela, M. López-Rivadulla, E. Marques, D.N. Vieira, Vitreous humour as a complementary sample to blood for the detection/confirmation of diazepam: ante-mortem and post-mortem studies in an animal model, *Hum. Exp. Toxicol.* 23 (2004) 571–577.

[62] S. Kaye, The collection and handling of the blood alcohol specimen, *Am. J. Clin. Pathol.* 74 (1980) 743–746.

[63] P.J. Karhunen and A. Penttilä, Validity of post-mortem alcohol reports, *Alcohol Alcohol*, 25 (1990), pp. 25-32

[64] S. Athanaselis, M. Stefanidou, A. Koutselinis, Interpretation of postmortem alcohol concentrations, *Forensic Sci. Int.* 149 (2005) 289–291.

[65] G.A. Brown, D. Neylan, W.J. Reynolds, K.W. Smalldon, The stability of ethanol in stored blood: Part I. Important variables and interpretation of results, *Anal. Chim. Acta.* 66 (1973) 271–283.

Chapter Two: Manuscript

2.1. Abstract

Road traffic collisions (RTCs) are a major contributor to unnatural death worldwide and alcohol intoxication is a recognised risk factor that contributes to this burden. South Africa is not exempted from this, and the rate of RTCs and associated fatalities continues to rise. Literature on the role of alcohol intoxication in road traffic fatalities (RTFs) in South Africa is limited. This prompted a retrospective assessment of these cases at Tygerberg, Salt River, Paarl, George and Worcester mortuaries in the Western Cape province, South Africa. Case details were obtained from routinely collected data stored in internal Forensic Pathology Service (FPS) databases. This included demographic details, scene information and blood alcohol concentration results. Ethics approval was obtained from the University of Cape Town (HREC: 332/2018) and from the Western Cape Government, Department of Health (WC/201805/045). RTFs admitted to the five mortuaries from 1 January 2016 to 31 December 2017 were included in the study (n = 2079). Male individuals made up the majority of individuals, where the male to female ratio was 3.52:1 and the average age was 35.2 ± 17.2 years. More than half of the victims were pedestrians (n = 1106; 53.7%). There are several factors that were noted as risk factors in RTC, and these included dark and wet roads, as well as highways. Blood was submitted for alcohol analysis in 1432 (68.9%) cases, and results were available for 1314 (91.8%) cases. Of the available results, 709 cases (54%) were positive for alcohol (BAC of $\geq$ 0.01 g/100 mL). Of the positive cases, most had a BAC between 0.15 and 0.29 g/100 mL and the overall average BAC was 0.20 g/100 mL. Drivers and pedestrians were the road user groups with the highest mean BAC. Almost a third of all the positive BAC results were from pedestrians. Research on alcohol and injury in South Africa is growing and the findings of this dissertation can contribute especially as it relates to RTFs. Insight into vulnerable populations within the Western Cape Province is highlighted, together with important risk factors associated with RTFs, as well as safety measures that may be targeted for improvement, especially with regards to driving and walking on the roads while intoxicated.

Key words: alcohol intoxication; blood alcohol concentration; drunk driving; road traffic collisions; Western Cape province

2.2. Introduction

Road traffic collisions (RTCs) are reported to account for approximately 1.35 million deaths worldwide each year [1]. In 2018, road traffic injuries (RTIs) were reportedly the eighth leading cause of death in people of all ages, with young children and adults between 5 and 29 years of age as well as pedestrians, cyclists, and motorcyclists being noted as particularly vulnerable [1]. Low-and middle-income countries (LMICs) are greatly affected by RTCs, and RTI rates are highest within the African region [1]. Common risk factors in RTCs include improper road infrastructure and vehicles, speeding, unsafe driving, and driving under the influence of alcohol and/or other impairing substances [1].

Despite the global efforts made to improve motor vehicle and road safety, and the legislative efforts to address speeding, wearing of seatbelts and drunk driving; RTIs and death rates continue to rise in low income countries [1]. In 2016, Africa was estimated to have the highest continental road traffic fatality (RTF) rate of 26.6 per 100,000 people [1]. Increased development has brought with it an increase in motorisation; however, safety infrastructure and regulations may not have progressed at the same rate. In the Republic of South Africa (RSA), the RTF rate in 2016 was estimated at 25.9 per 100,000 people. Despite adequate legislation, it is evident that the enforcement of safety standards (e.g. seatbelts), speeding and drunk driving laws is inadequate.

Alcohol misuse presents a critical worldwide public health and economic problem. In RSA, the estimated harm of alcohol to the economy in 2009 was 10% to 12% of the gross domestic product (GDP), which included both tangible and intangible costs [2]. Given that ethanol (the psychoactive ingredient in alcohol) affects the central nervous system, it is well known to impair one’s overall judgement, behaviour and driving skill, which may result in one’s failure to obey road rules and engage in risky behaviour on the road [3].

The risk of being involved in an accident increases with alcohol intoxication and further increases when combined with psychoactive drugs. Understanding and combatting the involvement of alcohol in RTFs is therefore a global concern. One means of doing this is through the analysis of alcohol in breath (BrAC) and or blood (BAC) and using the results in legal matters and for insurance purposes. There is a direct correlation between a driver's BAC and their risk of being involved in an RTC, especially as BAC increases above 0.08 g/100 mL [4]. In RSA, the National Road Traffic Act (No. 93 of 1996, section 65(2)(b)) states that a person on a public road is not allowed to occupy the driver’s seat while the engine is running, while the concentration of alcohol in any specimen of blood taken from any part of his or her body is not less than 0.05 g/100 mL, or 0.02g/100 mL for professional drivers [5].

In cases where the RTC is fatal, toxicological analysis for alcohol and other drugs may be performed to identify their role in the collision. This data is extremely important for public health as well as for inquest or criminal court cases. In published studies from Sweden and Norway, approximately 20% to 50% of drivers in fatal RTCs had reported BACs above most legal limits, ranging between 0.15 – 0.18% [6,7]. In RSA, very few in-depth investigations of the role of alcohol in RTFs are available.

The purpose of the current study was to investigate the characteristics of RTFs admitted to five of the major forensic mortuaries in Western Cape (WC) province, RSA, and the role of alcohol intoxication in these cases.

2.3 Materials and methods

Study design and population

This study was a cross-sectional, retrospective review of RTF cases admitted at each of the five of the major mortuaries within the WC province, namely Salt River, Tygerberg, Paarl, George and Worcester mortuaries. The five mortuaries chosen in the study have the highest unnatural death caseloads in the WC.

In RSA, all suspected unnatural death cases must undergo a forensic autopsy by an authorised medical practitioner within the Forensic Pathology Service (FPS) [8,9]. Currently in WC, there are 16 forensic mortuaries, which together receive an annual caseload of approximately 11,000 unnatural death cases [10]. The caseloads include all cases of unnatural deaths, which includes suicide, homicide, accidents, RTF, procedural-related death and other deaths in which death is not natural. The two busiest mortuaries cover the Cape Town metropole, with Tygerberg covering the east metropole and Salt River mortuary covering the west of the metropole. Each of these mortuaries currently admits over 4000 cases per annum. Both facilities are also academic facilities, providing training for undergraduate and postgraduate students at the University of Stellenbosch and the University of Cape Town respectively. Paarl, George and Worcester are the three biggest mortuaries outside of Cape Town, each receiving approximately 300 to 600 cases per annum, and are the major mortuaries covering the West Coast, Eden / Central Karoo, and Cape Winelands / Overberg areas respectively.

Inclusion criteria

For the purpose of this study, a fatal RTC was defined as a collision on a public road involving at least one motor vehicle (including light to heavy vehicles and bicycles), and another object, person, and/or vehicle, wherein an individual was fatally injured. Such individuals included motor vehicle drivers or passengers, motorcyclists, cyclists and pedestrians. Fatalities involving trains were not included within this study. This study included all cases of RTFs admitted to the specified mortuaries between 1 January 2016 and 31 December 2017. In cases where information was not available or missing, the data was indicated as such and excluded when analysing that particular variable.

Data collection and analysis

The data was extracted from the WC FPS internal database in which routinely collected data from all provincial mortuaries is stored. Cases are classified as RTF based on the cause of death as determined by the pathologist based on their examination of the individual and their expertise. Data collected included demographic information about the deceased (sex and age), circumstantial information of the RTC (location and time of incident(s) and scene information), and blood alcohol and toxicological results (where available). Data was made confidential by allocating unique study numbers to the cases included in the study. The data was documented in Microsoft® Office Excel® (Microsoft, Redmond, Washington, US) and transferred to SPSS IBM statistics 25 (Armonk, NY:IBM Corp) for further analysis.

The total number of cases admitted to the five mortuaries was recorded as well as the total number of RTFs recorded in the different mortuaries. Data were descriptively analysed according to age, sex, alcohol concentration, holiday and non-holiday season (holidays were defined as the national public holidays of South Africa, in both years and they excluded Sundays, 2016 holidays were obtained from https://www.timeanddate.com/holidays/south-africa/2016 and 2017 holidays were obtained from https://www.timeanddate.com/holidays/south-africa/2017), months and the condition of the road to investigate the characteristics of road traffic accident fatalities and assess the role of alcohol intoxication in these cases. Categorical data was analysed using Pearson's chi-squared tests to assess any association between characteristic variables. Significance was reported at a p value of 0.05

Ethical approval

Ethical approval was obtained from the University of Cape Town's Faculty of Health Science Human Research Ethics Committee (HREC: 332/2018), as well as the Western Cape Government Ethics Committee (WC/201805/045) before the commencement of the project.

2.4. Results

2.4.1 Overview of data

In the WC province, a total of 18,446 cases of unnatural death were admitted at the five different mortuaries from 1 January 2016 to 31 December 2017, of which 8,898 and 9,548 were admitted in 2016 and 2017 respectively (Figure 1). Of the total cases, 2,079 (11.3%) cases were reported as RTFs over the two years (2016: n=1070; 2017: n=1009). Figure 1 shows the overview of the cases received in both years, cases that were excluded and included in the study, cases where BAC was requested and the results obtained, as well as the number of cases that were positive or negative for BAC. The criteria used to establish significance was a P value of 0.05.

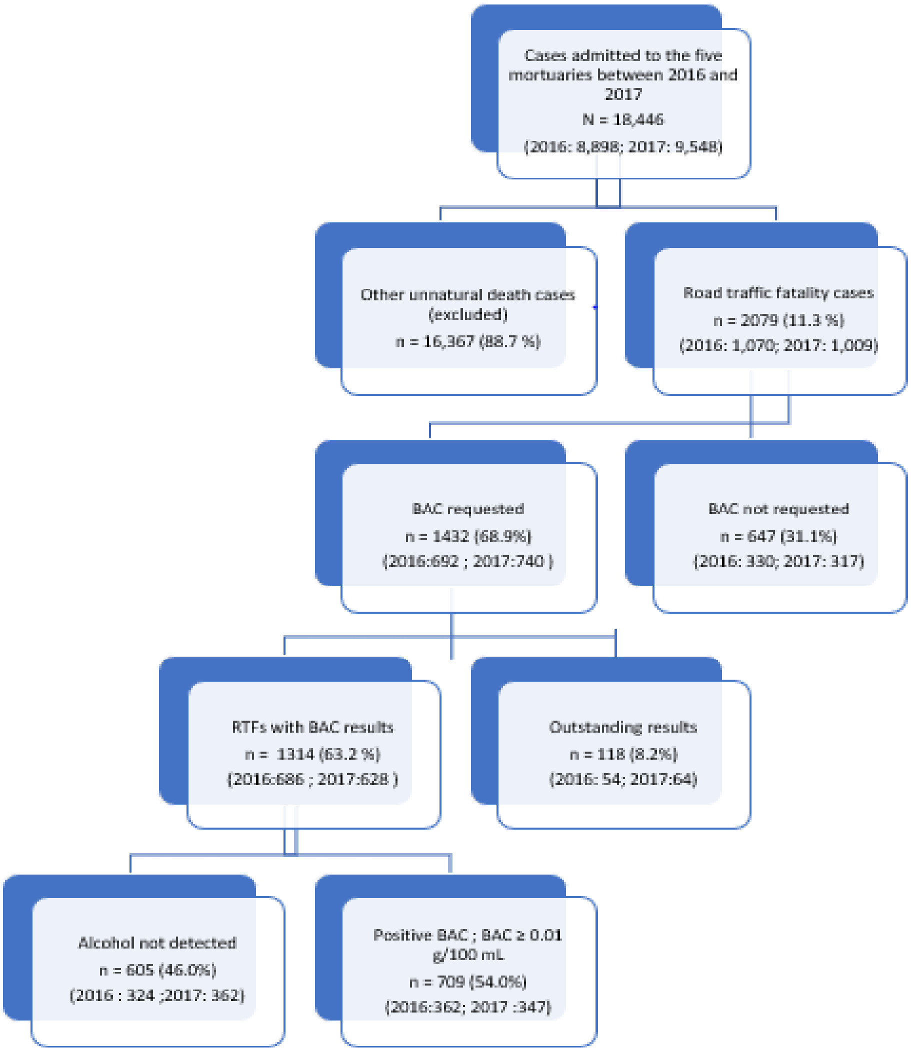


Figure 1: Overview flow chart showing the breakdown of the number of cases received in each year, the number of cases where BAC was requested and the results received versus those outstanding*.

*Outstanding results were cases where BAC was requested but the results were not yet received.

Table 1 illustrates the total number of cases admitted in each of the five WC mortuaries and the total number of RTFs admitted in each of these mortuaries over the period of 2016 and 2017. The west (Salt River mortuary) and east metropole (Tygerberg mortuary) of the city of Cape Town both had the highest total mortuary admissions as well as RTF cases. Despite having the lower-case intakes, Paarl, Worcester and George had the higher proportion of RTFs in relation to their overall caseload over the two years (16.7%, 21.7%, and 13.7% respectively). The total mortuary admissions fluctuated between the years; however, RTFs were higher in overall number in 2016. There were significantly less RTFs in 2017 ($p < 0.0001$), but no significant difference was observed in the proportion of RTFs between the mortuaries in 2016 and 2017 (additional results can be seen in Appendix A).

Table 1: Number of cases admitted to the five major Western Cape forensic mortuaries and the percentage of road traffic fatalities as a proportion of total relative cases over 2016 and 2017.

Mortuary Name (Area covered)	2016		2017		Combined years
	Total admissions (n)	Total RTFs (%)	Total admissions (n)	Total RTFs (%)	Overall total admissions / RTFs (%)
Salt river (West metropole)	3649	346 (9.5%)	3880	347 (8.9%)	7529 / 693 (9.2%)
George (Eden / Central Karoo)	316	44 (13.9%)	303	41 (13.5%)	619 / 85 (13.7%)
Paarl (West coast)	519	90 (17.3%)	591	95 (16.1%)	1110 / 185 (16.7%)
Tygerberg (East metropole)	3765	428 (11.4%)	4143	410 (9.9%)	7908 / 838 (10.6%)
Worcester (Cape winelands / Overberg)	649	162 (25.0%)	631	116 (18.4%)	1280 / 278 (21.7%)
Total	8898	1070 (12.0%)	9548	1009 (10.6%)	18,446 / 2,079 (11.3%)

2.4.2 Demographic data

Demographic data was analysed based on the total number of RTFs admitted in both years (n=2079), except where indicated. The sex was unknown in one of the cases in Salt River mortuary.

Table 2: Overall number of road traffic fatalities showing the number of victims (male versus female) within different age groups and according to the specific mortuary

	Salt River		Tygerberg		Worcester		George		Paarl	
Age (Years)	M / F* (% M of total)	Total Cases	M / F* (% M of total)	Total Cases	M / F* (%M of total)	Total Cases	M / F* (%M of total)	Total Cases	M / F* (%M of total)	Total Cases
0-12	40/19 (68)	59	46/15 (75)	61	23/10 (70)	33	6/3 (67)	9	5/3(63)	8
13-17	8/4 (67)	12	23/3 (88)	26	6/5 (54)	11	2/0 (100)	2	6/0 (100)	6
18-25	105/28 (79)	133	140/36 (80)	176	28/15 (65)	43	11/3 (79)	14	21/10 (68)	31
26-35	162/38 (81)	200	170/44 (79)	214	49/15 (76)	64	17/4 (81)	21	43/8 (84)	51
36-45	101/16 (86)	117	118/29 (80)	147	48/12 (80)	60	8/3 (73)	11	19/6 (76)	25
46+	127/44 (74)	171	165/49 (77)	214	45/22 (67)	67	22/6 (79)	28	54/10 (84)	64
Total	**543/149 (78)**	**692**	**662/176 (78)**	**838**	**199/79 (72)**	**278**	**66/19 (78)**	**85**	**148/37 (80)**	**185**

*M / F: male to female counts; %M of total: percentage of male cases to total cases within that mortuary for the specific age group.

2.4.2.1 Sex

Most RTFs in the study involved males (77.8%, n = 1618) compared to females (22.2%, n = 460) (1 case of unknown sex). George had the highest percentage of male victims at 84.2%, and Salt River had the lowest percentage of male victims at 78.3% compared to other mortuaries. There was no significant difference in the ratio of each sex between the mortuaries (p = 0.875). Table 2 shows the proportion of males to females, placed in specific age ranges and according to each mortuary. Males in general were the most frequent victims.

2.4.2.2 Age

The mean age across all mortuaries was 35.2 ± 17.2 years. The age was unknown in one case in 2017, whereby only skeletal remains were recovered. Of the remaining 2078 cases, the minimum age admitted was one year and the maximum age was 102 years, both from Tygerberg mortuary. Both sexes had the least number of victims under the age of 17 years, which increases between the ages of 18 – 35 years old. Table 2.2 shows that the ages of 13 to 17 years had the least number of victims compared to all other age groups across all the mortuaries. This age group had the least number of victims and thus the authors of this research acknowledge that it is a limitation. The age group of 26 to 35 years old formed the highest percentage across all the mortuaries and was the most vulnerable to RTFs in this study.

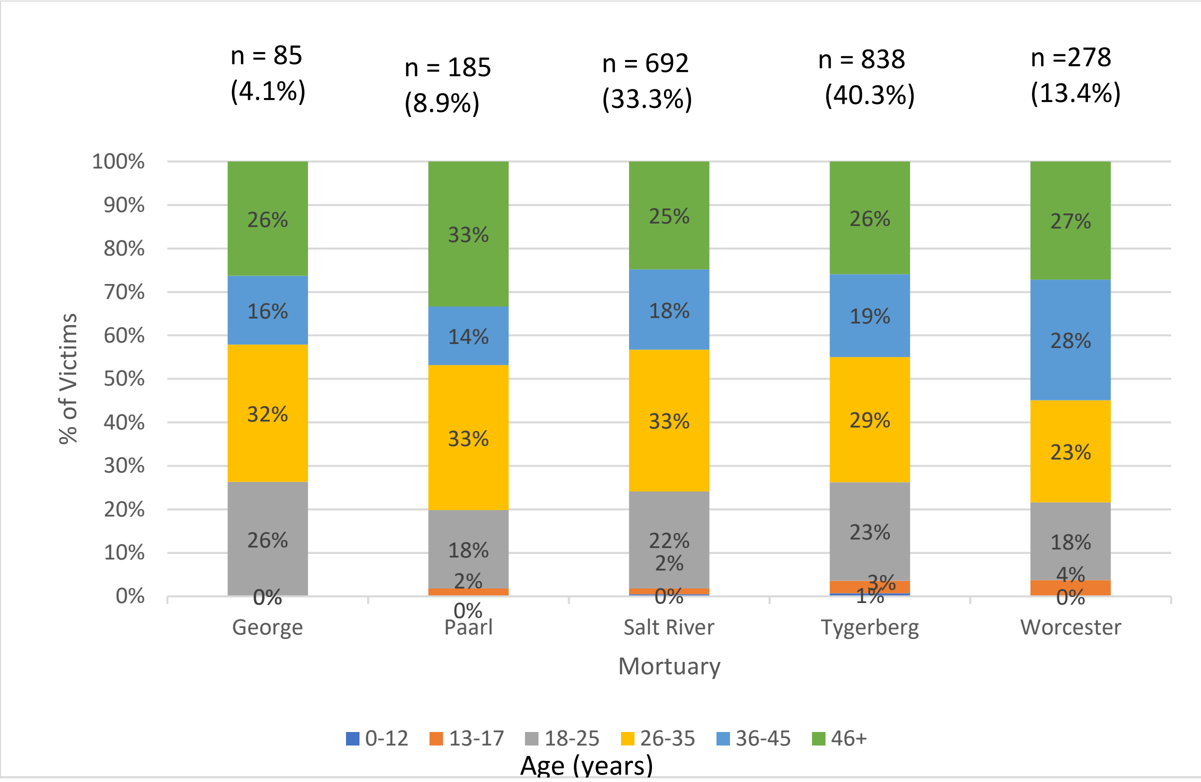


Figure 2: Distribution of victim age group by mortuary, in relation to specific mortuary intake between 2016 and 2017. Each age group in each mortuary is represented by a percentage based on the total number of cases in the mortuary.

Figure 2 illustrates that the age group of 26 – 35 years old was highest in all mortuaries except for Worcester. The age group that was highest in Worcester was 36-45 years old, followed by 46+ years old. The distribution of road traffic fatalities in the respective age groups was relatively even amongst the mortuaries. The victims in the metro areas typically appear to be younger victims.

2.4.3 Road user

This study included six road user groups (Table 3). More than half of the RTF victims were pedestrians (1106; 53.7%). Drivers and passengers followed at 382 (18.4%) and 410 (19.7%) respectively. The remaining 11.2% consisted of motorcyclists, cyclists and “other” road users. “Other” road users included people that fell off a utility vehicle (truck), minibus taxi users, truck users and an unidentified road user group, where the victim was not reported as any of the above-mentioned road user groups.

Table 3: Table of type and number of road traffic fatality victim (percentages of total cases per mortuary) according to the mortuary admission over 2 years (2016-2017) [N = 2079]

Mortuary	Cyclist [n (%)]	Driver [n (%)]	Motorcyclist [n (%)]	Other [n (%)]	Passenger [n (%)]	Pedestrian [n (%)]	Total [n (%)]
George	2 (2.4%)	18 (21.2%)	3 (3.5%)	6 (7.1%)	24 (28.2%)	32 (37.6%)	85 (100.0%)
Paarl	10 (5.4%)	51 (27.6%)	7 (3.8%)	5 (2.7%)	38 (20.5%)	74 (40.0%)	185 (100.0%)
Salt River	17 (2.5%)	108 (15.6%)	47 (6.8%)	2 (0.3%)	113 (16.3%)	406 (58.6%)	693 (100.0%)
Tygerberg	6 (0.7%)	143 (17.1%)	54 (6.4%)	10 (1.2%)	139 (16.6%)	486 (58.0%)	838 (100.0%)
Worcester	2 (0.7%)	62 (22.3%)	6 (2.2%)	4 (1.4%)	96 (34.5%)	108 (38.8%)	278 (100.0%)
Total	37 (1.8%)	382 (18.4%)	117 (5.6%)	27 (1.3%)	410 (19.7%)	1106 (53.2%)	2079 (100.0%)

Figure 3 shows the percentage distribution of victims by age groups and road user type. Pedestrians were the most common victims in all age groups. The percentage of driver victims was similar in the ages between 18 – 25 and 36 to 45, as well as 26 – 35 and 45+. There were no drivers below the ages of 18, which is consistent with the legal driving age. There were also no motorcyclists under the age of 18, despite the permitted age of driving a motorbike is that of 16 years.

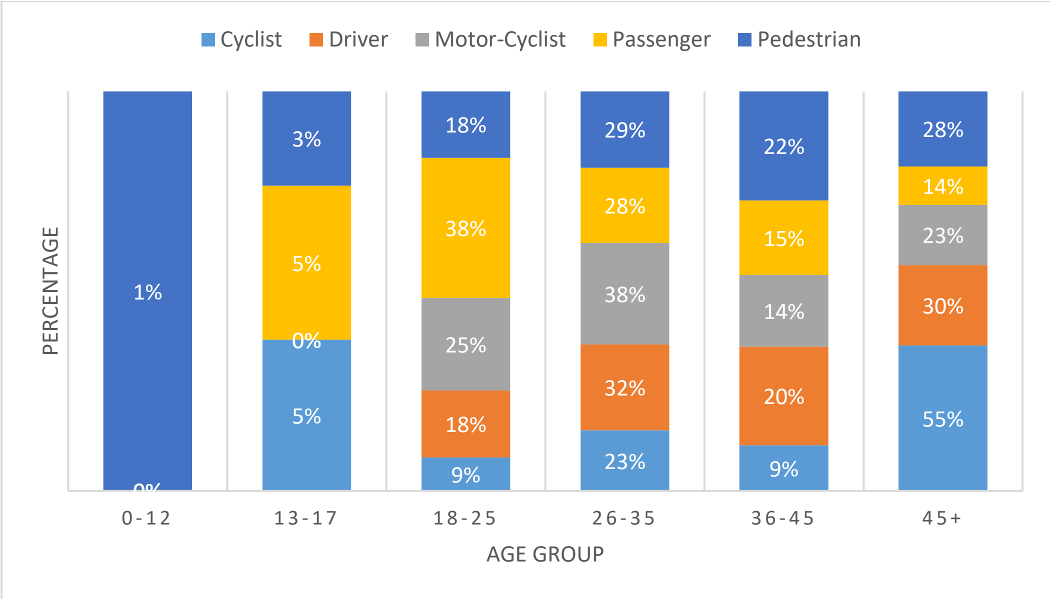


Figure 3: Percentage distribution of victims by age group* and victim type (2016-2017)

2.4.4 Temporal analysis

The data obtained in its secondary form was not specific or detailed enough to determine the occurrence of RTFs during the day or at night. The first quarter comprised of January, February, and March. The second quarter comprised of April, May, and June. The third quarter comprised of July, August, and September. The fourth quarter comprised October, November, and December. The fourth quarter of the year had the greatest number of RTFs recorded (27%). The third quarter (July to September) had approximately 25% and the second quarter had the least number of accidents, with approximately 23%.

No significant differences were observed between the two years with regards to the month of incident ($p<0.05$). It is observed from figure 4 that approximately 15% of RTFs occur during the holiday periods. Holidays were defined as the national public holidays of South Africa, in both years and they excluded Sundays.

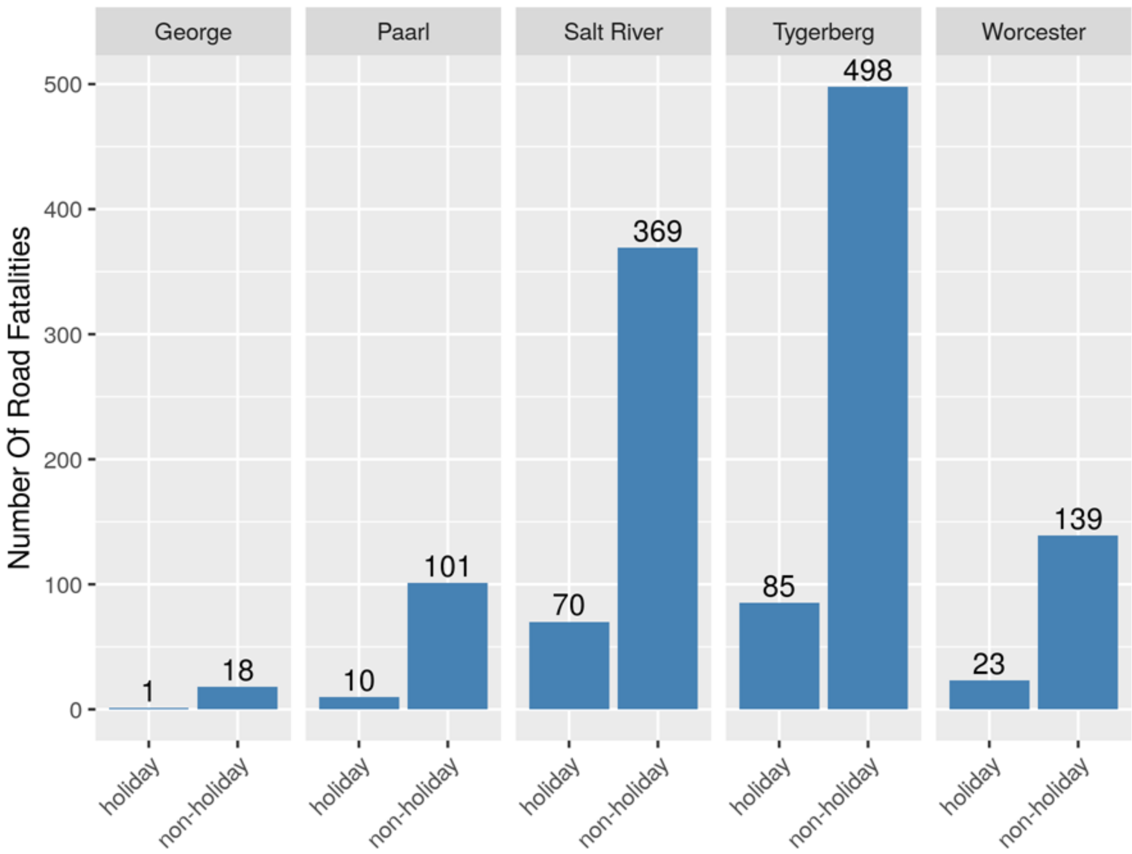


Figure 4: the number of RTFs occurring on holidays and non-holidays where BAC was collected and results received. (n = 1314).

2.4.5 Road conditions and weather

Figure 5 illustrates the associations between the different road conditions and the different mortuaries. Dimension 1 and Dimension 2 show the coordinates needed to specify the points of association. The closer the different mortuaries are to the conditions indicated on the map, the closer the association of the mortuary to the road and weather conditions. From the map we see high association of dark roads and incidents occurring in George. Tygerberg mortuary deaths (mortuary with highest RTF incident rate) is associated with highway roads. Salt River mortuary deaths (second highest RTF incident rate) is associated with good lighting but wet roads. Conditions were obtained for routinely collected data by the forensic pathology officers.

The conditions (weather, road) are based on information obtained from the Lab27 form, which is used to capture the details of the case, therefore differences may exist in the definitions used by individuals completing the form.

Figure 5*: Correspondence map of area and road condition.

*The closer the items are together the higher the association. Conditions categories used were taken from the data base. The data was tabulated in a contingency table, with the mortuary forming part of the rows and road type forming part of the at the columns. The rows and columns are then spread out on the diagram along the axis.

2.4.6 Blood alcohol concentration data

2.4.6.1 Blood alcohol concentration results

Blood alcohol concentrations (BACs) equal or greater than 0.01 g/100 mL were considered as a positive BAC. Collection of post-mortem specimens for ancillary tests such as toxicology is the prerogative of the medical practitioner and depends on the case circumstances. Blood for BAC analysis may not be collected in cases exhibiting advanced decomposition, where there is not enough blood, or if the victim was an infant. Of the 2,079 RTF cases admitted, BAC was requested in 1,432 (68.9%) cases. From the cases where BAC was requested, results were available for 1,314 (91.8%) cases (Figure 2.1). The results for the remaining 118 (8.2%) cases were still outstanding at the time of this study. Cases where BAC results were not available were excluded from further analysis.

Of the total 1,314 cases where BAC was received, alcohol was detected in 709 (54%) of these cases (2016: n=362, 51.1%; 2017: n=347, 48.9%). In the cases where BAC was positive (>0.01 g/100 mL), the maximum BAC was 1.20 g/100 mL and the mean was 0.20 g/100 mL with a standard deviation of 0.10g/100mL. There was no significant difference between the mean BAC in 2016 and 2017 (p = 0.2413). The mean BAC in both 2016 and 2017 was 0.11 g/100 mL and the standard deviation was 0.56g/100mL. The majority of victims (55.6%) had a BAC of 0.15 – 0.29 g/100 across the mortuaries in positive BAC cases, which made up 55.6% of the positive cases.

Table 4: Distribution of blood alcohol concentration results across the different mortuaries, showing the BACs requested, and the results of those received.

	George n (%)	Paarl n (%)	Salt River n (%)	Tygerberg n (%)	Worcester n (%)	Total n (%)
BAC requested (% of total RTFs per mortuary)	37 (43)	160 (86)	461 (66)	609 (73)	165 (59)	1432 (68)
BAC results received (% according to no. requested)	19 (51)	111 (69)	439 (95)	583 (96)	162 (98)	1314 (92)
Not detected	6 (32)	45 (41)	198 (45)	279 (47)	77 (48)	605 (46)
0.01-0.049 g/100 mL	0 (0)	4(4)	18 (4)	21(4)	2 (1)	45 (3.4)
0.05-0.09 g/100 mL	0 (0)	4 (4)	15 (3)	33 (6)	1 (1)	53 (4.1)
0.1-0.149 g/100 mL	0 (0)	8 (7.2)	34 (8)	42 (7)	13 (8)	97 (7.4)
0.15-0.19 g/100 mL	0 (0)	20 (18)	45 (10)	60 (10)	20 (12)	145 (11)
0.2-0.29 g/100 mL	9 (47)	19 (17)	88 (20)	101 (17)	32 (20)	249 (19)
0.3-0.39 g/100 mL	3 (16)	10 (9)	35 (8)	43 (7)	14 (9)	105 (8)
0.4 + g/100 mL	1 (5)	1 (1)	6 (1)	4 (1)	3 (2)	15 (1.1)
TOTAL	19	111	439	583	162	1314

Table 4 shows the different BACs, and the breakdown of the number of victims that had a certain BAC. The minimum BAC in George was 0.2 g/100 mL. Forty-five cases across all mortuaries (6.3%) had a BAC between 0.1 and 0.05 g/100 mL. In total, 650 cases (49.5%) where BAC was requested, and results were obtained had a BAC <0.05 g/100 mL. In Paarl, Salt River, Tygerberg and Worcester, the BAC level for the majority of victims was 0.2 – 0.29 g/100 mL.

As shown in Figure 6, amongst the outstanding results, 2.4% of these cases were from Paarl, making it the mortuary with the highest number of outstanding cases, followed by Tygerberg at 1.3%. The two mortuaries where there was a high number of cases where BAC was not requested compared to the other categories were Worcester and George, with 5.4% and 2.3% respectively.

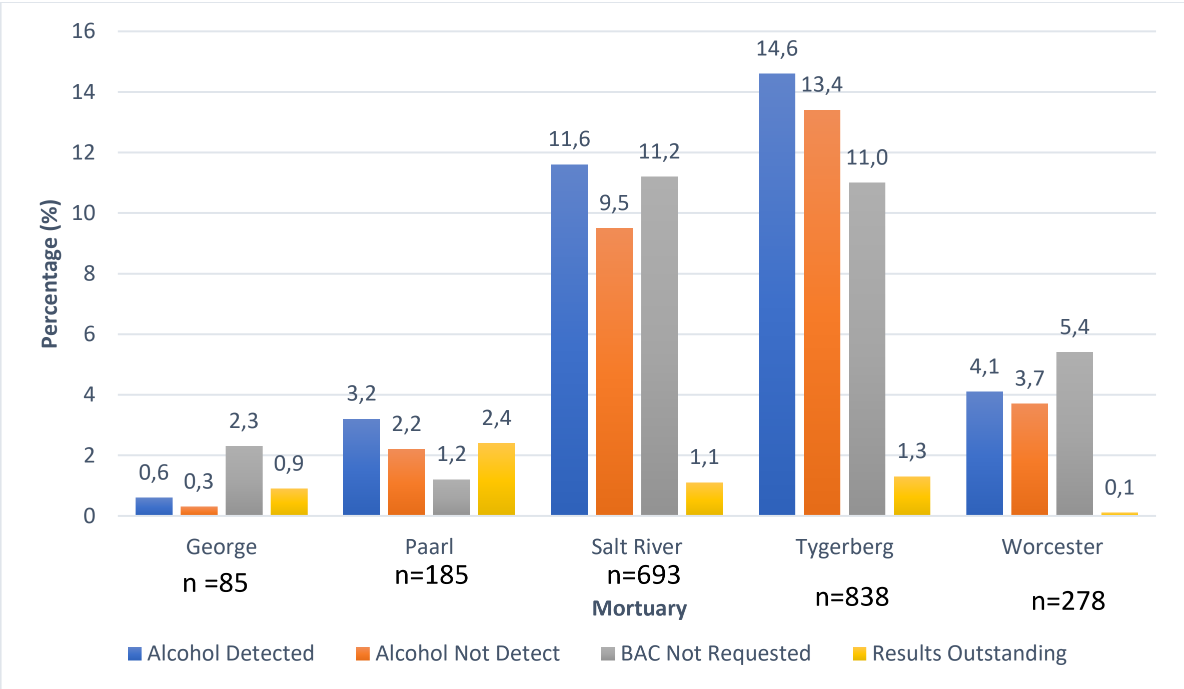


Figure 6: Distribution of alcohol results (% Road Traffic Fatalities) across mortuaries (N=2079)

2.4.7 Blood Alcohol Concentration in the different mortuaries

Greater than 50% of the victims where blood was collected for BAC had a positive BAC in all the mortuaries in both years. Most victims had a BAC which fell in the ranges between 0.15 and 0.29 g/100 mL in both years (Figure 7). George had the highest rate of positive BAC cases (68.4%), compared to all the mortuaries, and 47.4% of the victims had a BAC between 0.2 and 0.29 g/100 mL. There was very little variation in BAC in the other mortuaries investigated. Tygerberg mortuary was the only mortuary with a median BAC that was less than 0.05 g/100 mL (median BAC of 0.03 g/100 mL). There was one outlier in Salt River mortuary, with a BAC of 1.2g/100ml. This was a 70 years pedestrian. The RTF was at night and the weather condition was partly cloudy.

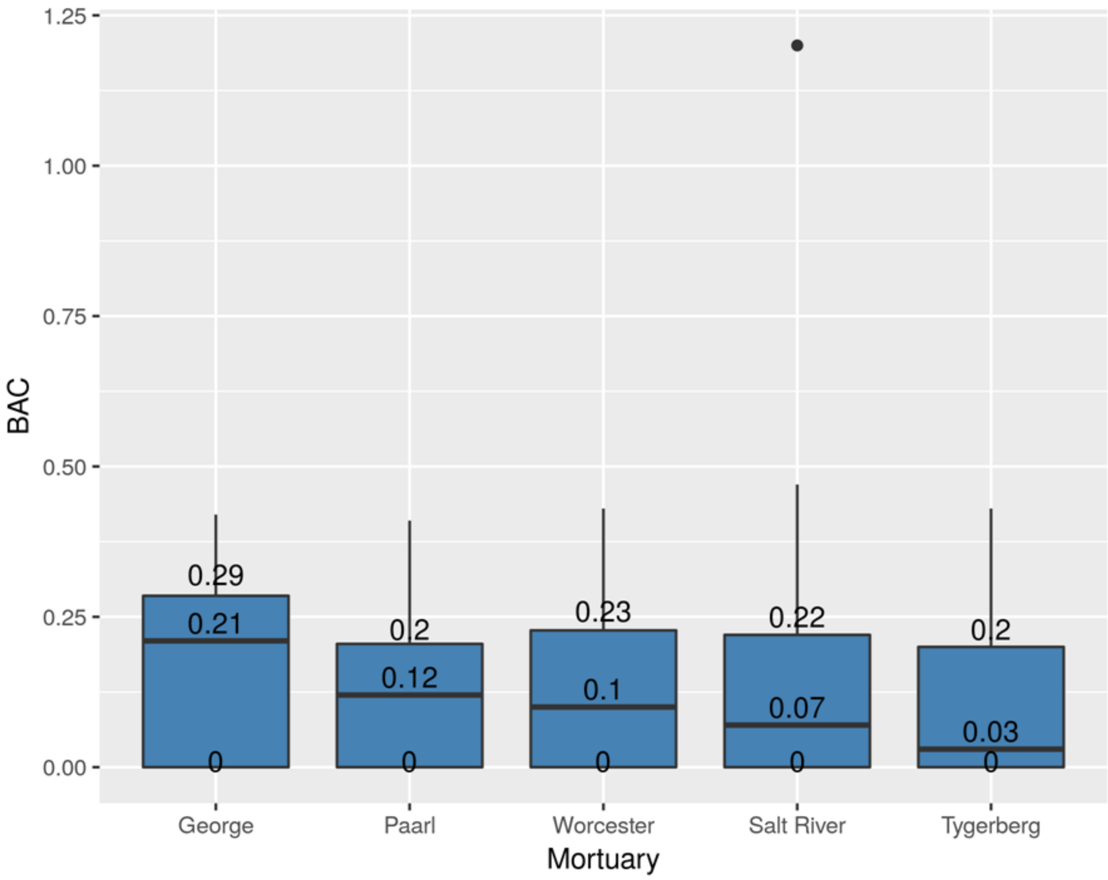


Figure 7: Box plot depicting median blood alcohol concentration per mortuary. In Salt River, there was one outlier. It is very unlikely that a BAC of 1.2 g/100 mL is plausible, therefore this can be associated with an analytical or laboratory error.

2.4.8. Alcohol and road user group

Drivers and pedestrians recorded higher median BACs (Figure 8) than other road users. Almost all cyclists were found to have no alcohol in their blood. There was no significant difference in the median BAC in the road user group between mortuaries. There was one an outliner case, which was a pedestrian, and had a BAC of 1.20g/100 mL. The pedestrian was a 70 years old male from Salt River.

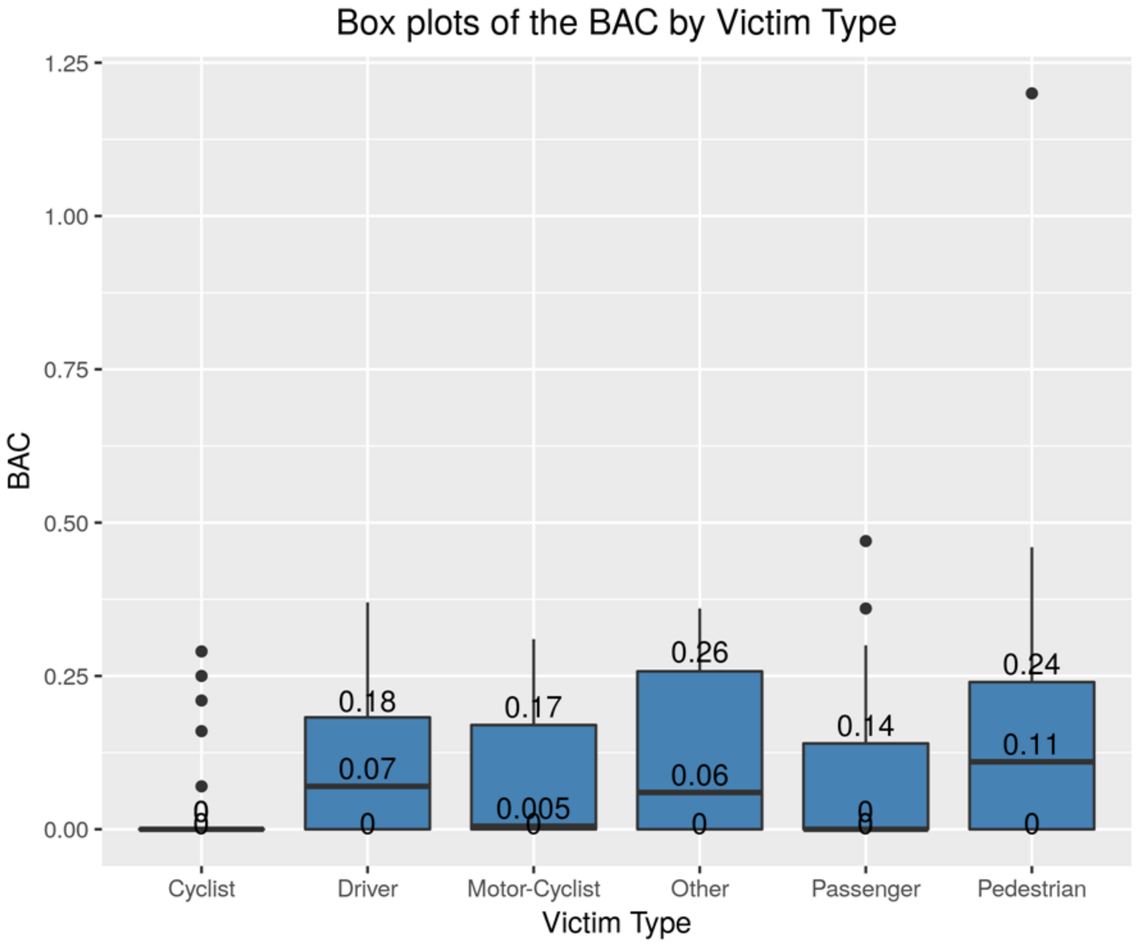


Figure 8: Box plot showing the median blood alcohol concentration and inter quartile range (IQR) in each victim type category. The cyclist user group has five outliers, with higher than the mean BAC. Passengers also show two outliers, while the pedestrian user group shows one outlier, which is a possible analytical or laboratory error.

There was a significant difference in the median BAC between the pedestrian road user group and the cyclists, motor-cyclists and passengers. No significant difference was observed in the median BAC between the pedestrians, drivers and the other road user group ($p = 0.13$).

2.4.9 Blood alcohol concentration related to legislation

BACs were compared to the legislation in driving under the influence of alcohol (DUI) cases, for which the legal *per se* limit is 0.05 g/100 mL. Figure 9 shows level of per se intoxication according to victim type and mortuary. This was to compare the level of intoxication of road users, and the relation that the BAC compared to that of the national BAC legal limit in drivers.

In Figure 9, 29.2% of all the fatal RTAs involved pedestrians with BACs >0.5 g/100 mL. Drivers and pedestrians were the road user groups where more victims were intoxicated (BAC > 0.05 g/100 mL) according to the legal limit. In the other category, the percentage of intoxicated victims was similar.

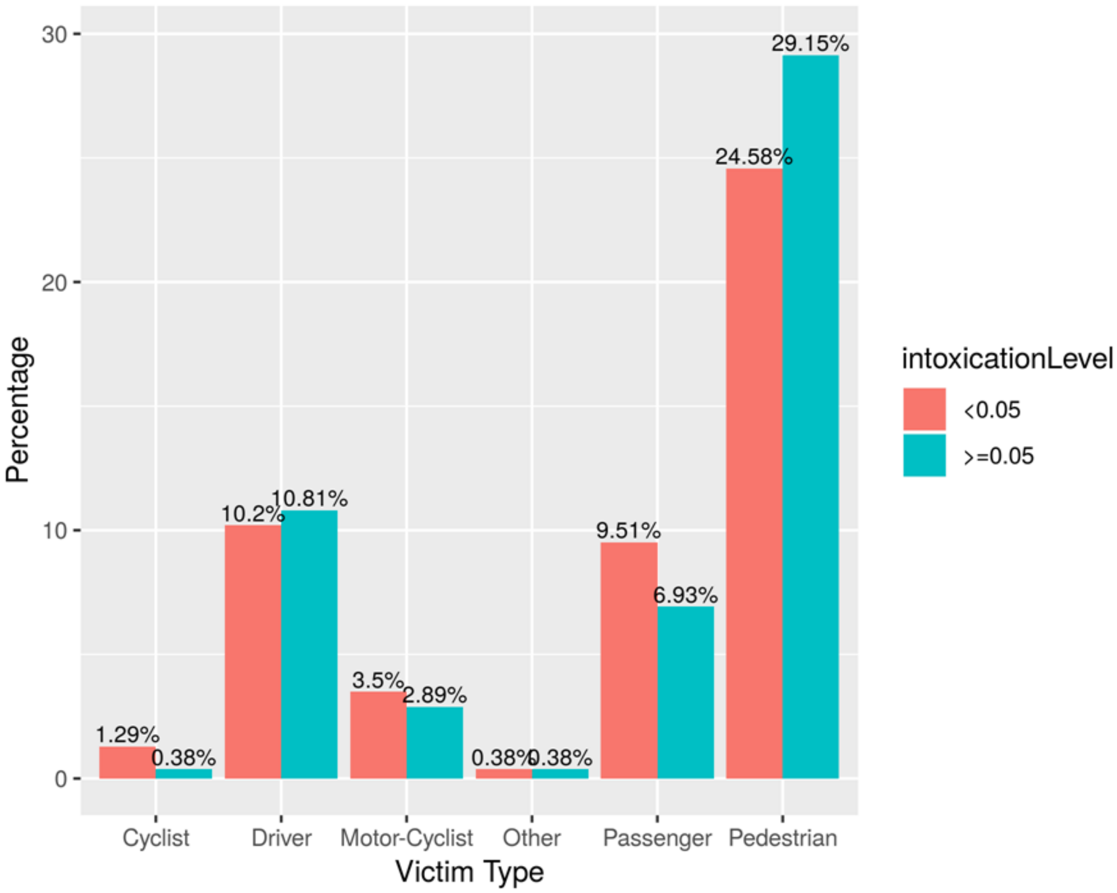


Figure 9: Intoxication level according to victim type. The intoxication level <0.05 g/100 mL does not include cases where BAC was not detected (0.0 g/100 mL)

2.5 Discussion and Conclusions

Driving under the influence of alcohol is a key risk factor in RTCs, which may result in disability as well as death [11]. Alcohol intoxication while driving increases the risk of being involved in a road traffic fatality. In the Western Cape province, it has been established that RTFs constituted 9% of all deaths [12]. In this study, RTFs accounted for approximately 11.3% of all deaths in the regions investigated. There are very few studies relating to RTFs in RSA, especially in the Western Cape Province, hence comparing this study with other studies was challenging. In a study done in Salt River in 2013 and 2014, RTFs constituted 9.4% and 8.7% respectively [13]. However, the study in Salt River only comprised one mortuary and did not give a reflection of other mortuaries in the province.

Table 1 illustrated that the west metropole (Salt River mortuary) and east metropole (Tygerberg mortuary) in the study had the highest mortuary admissions of 7529 and 7908 RTCs respectively compared to the other mortuaries. The two metropoles serve a larger area in the province, with a larger population density. In the metropoles, the overall total RTF percentages were lower compared to other mortuaries, and that could be due to multiple factors including increased intake of homicides in the metropole compared to the outer regions.

The current study found that approximately 78% of the RTCs examined in the study involved males and 22% involved females (ratio 3.5:1). This is in accordance with the study done in Ga Rankuwa and Pretoria where the male victims were approximately 78% and females were 22% [14]. In a study done in Mthatha in the Eastern Cape province in South Africa, the male to female ratio was 2.6:1, which was lower than the ratio in this study [15]. The study done in Mthatha used medical records in one hospital from January 1993 to December 2004 and this data must have increased since then, since there has been an increase in RTFs worldwide [16] and as a result the difference in the RTF male to female ratio.

Males naturally take more risks than females, which may involve driving under the influence of alcohol and driving at very high speed. Males are over four times more likely to die from all accidental causes than are females [17]. The proportion of male to female victims who were involved in RTFs did not differ between the different mortuaries.

The mean RTF age for all victims was 35 years. The mean RTF age amongst the male victims was 35.35 ± 16.70 and the mean RTF age amongst the females was 34.78 ± 18.61. According to the WHO, in the year 2000 and 2012, RTFs mostly affected people between the ages of 30 and 49 years and the second group affected by RTFs was between the ages of 15 and 29 years [18]. Although the age category used in this study is different from the WHO classification, which makes it a challenge to compare the two groups, the age group mostly affected in this study was between 26 and 35 years (Figure 2), which is within the two mentioned categories. Findings in this study coincide with the global findings of more than half of RTFs being amongst people between the ages of 15 and 44 years [18].

The mean age in this study is different from the study by De Carvalho Ponce *et al*. [19], where the mean age of the male RTF victims was slightly younger than the female RTA victim. The difference could be due to the number of victims in the study. We can see from both studies that the majority of the victims were young. Young drivers are generally not likely to obey the road speed limits and are also less likely to change their driving behaviour to accommodate the conditions of the road [21]. This is different to a study done in China, where older adults were more likely to die in RTFs than young people [22].

RTF victims with the highest BAC were between the ages of 36 and 45 years old. A study in Sao Paulo had a similar result to that found in this study, with the victims being 35 to 44 years old and an average age of 37.8 ± 18.1 years [19]. Conversely, the study by Papalimperi et al. [20], found that younger drivers (21 – 30 years of age) with a positive BAC were more likely to be involved in RTFs. According to De Carvalho Ponce et al. in 2011, the economically active status of this age group most likely makes them vulnerable [19]. They are also the most mobile age group compared to people below the age of 21 and above the age of 40 years, which makes them more vulnerable to road traffic accidents. Studies often refer to percentages or whole numbers of cases without taking population size into account. This can hinder comparison between studies and the effect of population size is often not considered.

In this study, more than half of RTF victims were pedestrians, followed by passengers and drivers. Among the pedestrians the highest number of victims were likely to be intoxicated. There are limited tools that govern pedestrians under the influence of alcohol who pose a danger to themselves and others by walking on or near roads [12]. This happens especially in informal settlement areas where pedestrians attempt to cross highways without using the bridges between their houses and drinking establishments. Pedestrians also sustain more severe injuries compared to other road user groups [23]. In most cases, pedestrians cannot be arrested for public drunkenness unless their intoxication is visible, or they are committing other crimes [12]. It is evident that more needs to be done to curb the number of pedestrians involved in RTFs. It has been suggested by Hutchinson et al. that breathalysers to detect drunk driving are the only potential effective policy option to reduce RTFs that involve pedestrians as well as to make roads safe for all pedestrians (sober and intoxicated) [24].

Most positive BACs were obtained in drivers above the age of 18 years (the legal driving age in RSA). In the Western Cape, part of the initiative to reduce alcohol related harm is to persuade the national government to implement graduated alcohol limits for drivers with a zero limit for drivers who have recently obtained their drivers license [12]. This has the potential to reduce the number of lives lost due to RTFs, but it may also increase the laboratory case load to levels that could not be handled.

Unfavourable road conditions, such as dark and wet, slippery roads were identified as common risk factors. RTFs investigated at the George mortuary were predominantly associated with dark roads, which are deemed hazardous environmental factors [25]. Other mortuaries did not show which distinctive characteristic they were associated with between highway roads, lighting, tar roads and wet roads. RTFs occurring in good environmental conditions and good road structures show that there are other factors that cause the high rate of RTFs, such as speed and alcohol intoxication. Regular maintenance and development of roads and educating drivers on how to adjust their driving behaviour at night could help decrease fatal RTCs [26].

The highest rate of RTFs in this study occurred between October and December (27%), which may be associated with the festive season in December. In the month of December, most South African businesses close, and people travel to different provinces for leisure and to visit family and friends, hence December is a busy time. A study by Foster et al. [27] of young Swiss men found that alcohol related accidents were highest on Christmas, New Year and on the evening of national holidays. Given the numerous factors that affect the occurrence of RTFs (darkness, alcohol consumption, abnormal weather conditions), it is difficult to identify specific seasonal effects on RTFs [28].

In this study, BAC results were received in 91.8% (n = 1314) of the cases where BAC was requested. Over half (54%, n = 709) of these cases had a BAC ≥ 0.01 g/100 mL, which indicates a high prevalence of alcohol detection in these cases. In Ga-Rankuwa (Pretoria), 50% of the cases examined had a BAC ≥ 0.01g/100 mL [14]. Another study in Pretoria found that 52% of the RTA victims had a positive BAC [29]. Although these studies were done in different parts of South Africa, it can be suggested that there is a relatively high prevalence of positive alcohol detection in RTFs, and alcohol should be considered as a risk factor in RTFs involving all road users.

The mean BAC in this study was 0.20 g/100 mL, which is three times more than the BAC legal limit. Other RSA studies reported mean BACs of 0.20 g/100 mL ± 0.13 g/100 mL [14] and 0.17 ± 0.09 g/100 mL [29]. This shows that a large proportion of fatal RTCs are well over the per se limit, and it is very likely in these cases that alcohol played a contributing role in death. While one must consider that it is a post-mortem result, a BAC of 0.20 g/100 mL would cause substantial impairment of vehicle control, attention to driving/walking and necessary visual and auditory information processing. It also illustrates that there are many individuals (especially drivers) who are driving over the *per se* limit. If the legal limit is changed to zero, then it would be worth monitoring these cases going forward to isolate any changes in this pattern.

Drinking and driving is a problem in the Western Cape province and the rest of South Africa, with 29.15% of victims found in this study with a BAC of more than the legal driving limit of 0.05 g/100 mL. In 2016, the Western Cape province accounted for 9% of all RTFs in South Africa [12]. The Western Cape Government aims to reduce the harm done by alcohol by increasing research and data collection to monitor and evaluate systems related to alcohol [30]. Among other alcohol reduction measures, law enforcement, involving the community and educating people of the harms caused by alcohol are some of the ways in which the Western Cape government aims to reduce RTFs caused by alcohol [30].

The George mortuary had the lowest admission numbers; however, more than 68.4% of the victims had BAC that was greater than 0.05 g/100 mL. However, just under half of the cases sent for BAC analysis did not have a report. The low number of cases, together with the missing data could provide some reasons as to why this was observed. Under 50% of cases were submitted for BAC analysis and it may have been that there was a history of drinking in those cases, and therefore the pathologist took blood for analysis.

2.6. Limitations

Limitations in this research included the fact that the data used in this study was secondary data, which means that the data was not compiled by the researcher and the researcher did not have control over errors that could have been made during data capturing. The conditions (weather, road) are based on information obtained from the Lab22 form, which is used to capture the details of the case, therefore differences may exist in the definitions used by individuals completing the form. There was missing data due to the lack of recording at the time of the accident, which is unfortunately the nature of retrospective studies. Another limitation is that some of the values were entered incorrectly, which resulted in exaggerated BAC levels. These cases had BAC results greater than 1g/100mL, which is not possible in humans.

Analysing this data against the demographic population data of all unnatural death admissions within the various mortuaries was not performed as this was outside the scope of the project. This could assist in determining whether the prevalence of males or particular age groups are higher in the overall case intake of unnatural deaths (i.e. there are more males in general that are dying unnaturally).

Almost 10% of the cases did not have BAC results returned. This is because the results were not yet available before the conclusion of this project. The blood alcohol cases are analysed by The National Department of Health Forensic Chemistry Laboratory (mandated to provide toxicological testing for state mortuaries and FPS). In addition, just over 30% of cases did not have blood collected for volatiles analysis. This has the potential to skew the data.

2.7. Future research

There are very few studies done on the contribution of alcohol to RTFs in South Africa. More research in this area would enable a broader view of these cases. A continuation of this study in the form of routine data collection and reporting would support public health and government initiatives through data-driven decision making. It is recommended that all mortuaries be included in future studies and that specific data, such as time and date of death, the type of vehicle, speed limit and conditions be recorded. This is data that is obtained by FPS for the inquest or criminal case, but is not necessarily routinely recorded, and thus was not available for this project.

2.8 Conclusions

This study indicates that alcohol intoxication does play a role in RTFs in five key mortuaries in the Western Cape, as more than 50% of the cases with BACs requested were found to be positive for alcohol. In addition, a great proportion of these cases had a BAC that was greater than 0.05 g/100 mL, which is the legal drunk driving limit in South Africa. This data supports other published studies indicating that males and particularly the youth are at risk for RTFs. It also highlights the issue of alcohol intoxication in pedestrians and the need for greater efforts in providing more secure and easily accessible walkways for pedestrians. Monitoring the location of specific alcohol selling establishments and their relation to the location of pedestrian deaths could play an important role in this. The use of mortuary data is of relevance in implementing public health strategies and this study illustrates its use in investigating RTFs and the presence of alcohol in these cases.

References

[1] World Health Organization, The Global status report on road safety 2018, World Health Organization, 2018. https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/ (accessed November 2, 2019).

[2] R.G. Matzopoulos, S. Truen, B. Bowman, J. Corrigall, The cost of harmful alcohol use in South Africa, *South African Med. J.* 104 (2014) 127–132.

[3] X. Zhao, X. Zhang, J. Rong, Study of the effects of alcohol on drivers and driving performance on straight road, *Math. Probl. Eng.* 2014 (2014) 1–9.

[4] R.D. Blomberg, R.C. Peck, H. Moskowitz, M. Burns, D. Fiorentino, The Long Beach/Fort Lauderdale relative risk study, *J. Safety Res.* 40 (2009) 285–292.

[5] South African Government, National Road Traffic Act 93 of 1996, 1996 (2006) 1–74.

[6] H. Gjerde, A.S. Christophersen, P.T. Normann, J. Mørland, Toxicological investigations of drivers killed in road traffic accidents in Norway during 2006-2008, *Forensic Sci. Int.* 212 (2011) 102–109.

[7] A.W. Jones, F.C. Kugelberg, A. Holmgren, J. Ahlner, Five-year update on the occurrence of alcohol and other drugs in blood samples from drivers killed in road-traffic crashes in Sweden, *Forensic Sci. Int.* 186 (2009) 56–62. https://doi.org/10.1016/j.forsciint.2009.01.014.

[8] Republic of South Africa, Inquests Act, Gov. Gaz. 1963 (1959) 5–7. http://www.justice.gov.za/legislation/acts/1959-58.pdf (accessed February 2, 2020).

[9] Republic of South Africa, National Health Act, 2003: Regulations regarding the rendering of forensic pathology service, 2007. https://www.greengazette.co.za/notices/national-health-act-61-2003-regulations-regarding-the-rendering-of-forensic-pathology-service_20180323-GGR-41524-00359 (accessed February 2, 2020).

[10] Western Cape Department: Health, Western Cape Injury Mortality Profile 2010-2016, (2016).

https://www.westerncape.gov.za/assets/departments/health/mortality_profile_2016.pdf. (accessed November 30, 2019).

[11] A. Simons, L. Marais, N. Hornsby, L.-A. Swart, M. Seedat, A. van Niekerk, Alcohol and its implications for road traffic crashes in South Africa phase A-review, n.d. (accessed November 30, 2019).

[12] Western Cape Government, Western Cape Alcohol-Related Harms Reduction Policy Green Paper, Alcohol-Related Harms Reduct. Policy Green Pap. (2016). https://www.westerncape.gov.za/assets/departments/premier/prov-gazette-extra_7681-alcohol-harms-19sep-16.pdf (accessed November 30, 2019).

[13] T. Majero, Retrospective analysis of blunt force trauma associated with fatal road traffic accidents in Cape Town (South Africa) over a two-year period. Masters dissertation, Univesity of Cape Town, Cape Town, (2018) .

[14] M. Du Plessis, K.K. Hlaise, R. Blumenthal, Ethanol-related death in Ga-Rankuwa road-users, South Africa: A five-year analysis, *J. Forensic Leg. Med.* 44 (2016) 5–9.

[15] B. Meel, Fatal road traffic accidents (RTA) in Mthatha area of South Africa | Meel | South African Medical Journal, South African Med. J. 98 (2008) 716–719. https://www.ajol.info/index.php/samj/article/view/13999 (accessed February 10, 2020).

[16] World Health Organisation, Global status report on road safety 2013, World Heal. Organ. Geneva. (2013) 318. https://www.who.int/violence_injury_prevention/road_safety_status/2013/en/ (accessed October 30, 2019).

[17] J.E. Veevers, E.M. Gee, Playing It Safe: Accident Mortality and Gender Roles, 1986.

[18] World Health Organisation, WHO and related publications , Health statistics and information systems, World Health Organization, 2018.

[19] J. De Carvalho Ponce, D.R. Muñoz, G. Andreuccetti, D.G. De Carvalho, V. Leyton, Alcohol-related traffic accidents with fatal outcomes in the city of Sao Paulo, *Accid. Anal. Prev.* 43 (2011) 782–787.

[20] A. Papalimperi, S. Athanaselis, A. Mina, I. Papoutsis, C. Spiliopoulou, S. Papadodima, Incidence of fatalities of road traffic accidents associated with alcohol consumption and the

use of psychoactive drugs: a 7-year survey (2011-2017), *Exp. Ther. Med.* 18 (2019) 2299–2306.

[21] L. Gicquel, P. Ordonneau, E. Blot, C. Toillon, P. Ingrand, L. Romo, Description of various factors contributing to traffic accidents in youth and measures proposed to alleviate recurrence, *Front. Psychiatry*. 8 (2017).

[22] L. Wang, P. Ning, P. Yin, P. Cheng, D.C. Schwebel, J. Liu, Y. Wu, Y. Liu, J. Qi, X. Zeng, M. Zhou, G. Hu, Road traffic mortality in China: analysis of national surveillance data from 2006 to 2016, *Lancet Public Heal*. 4 (2019) e245–e255.

[23] J. Oxley, M. Lenné, B. Corben, The effect of alcohol impairment on road-crossing behaviour, *Transp. Res. Part F Traffic Psychol. Behav.* 9 (2006) 258–268.

[24] T.P. Hutchinson, C.N. Kloeden, V.L. Lindsay, Countermeasures to the problem of accidents to intoxicated pedestrians, J. *Forensic Leg. Med.* 17 (2010) 115–119.

[25] K.B. Lankarani, S.T. Heydari, M.R. Aghabeigi, G. Moafian, A. Hoseinzadeh, M. Vossoughi, The impact of environmental factors on traffic accidents in Iran, *J. Inj. Violence Res.* 6 (2014) 64–71.

[26] M. Jalilian, H. Safarpour, J. Bazyar, M. Keykaleh, L. Malekyan, A. Khorshidi, Environmental related risk factors to road traffic accidents in Ilam, *Iran, Med. Arch.* 73 (2019) 169.

[27] S. Foster, G. Gmel, N. Estévez, C. Bähler, M. Mohler-Kuo, Temporal patterns of alcohol consumption and alcohol-related road accidents in young swiss men: Seasonal, weekday and public holiday effects, *Alcohol Alcohol.* 50 (2015) 565–572.

[28] M. Sivak, During which month is it riskiest to drive in the United States?, *Traffic Inj. Prev.* 10 (2009) 348–349.

[29] U. Ehmke, L. du Toit-Prinsloo, G. Saayman, A retrospective analysis of alcohol in medico-legal autopsied deaths in Pretoria over a 1 year period., *Forensic Sci. Int.* 245 (2014) 7–11.

[30] W.C. Government, Department of the Premier Western Cape Government Strategic Programmes Branch Policy and Strategy Chief-Directorate, n.d. https://www.westerncape.gov.za/text/2017/September/white_paper_alcohol-related_harms_reduction.pdf (accessed November 2, 2019).

APPENDICES

Appendix A: Extended results

Appendix A shows the proportion of RTF with different variables.

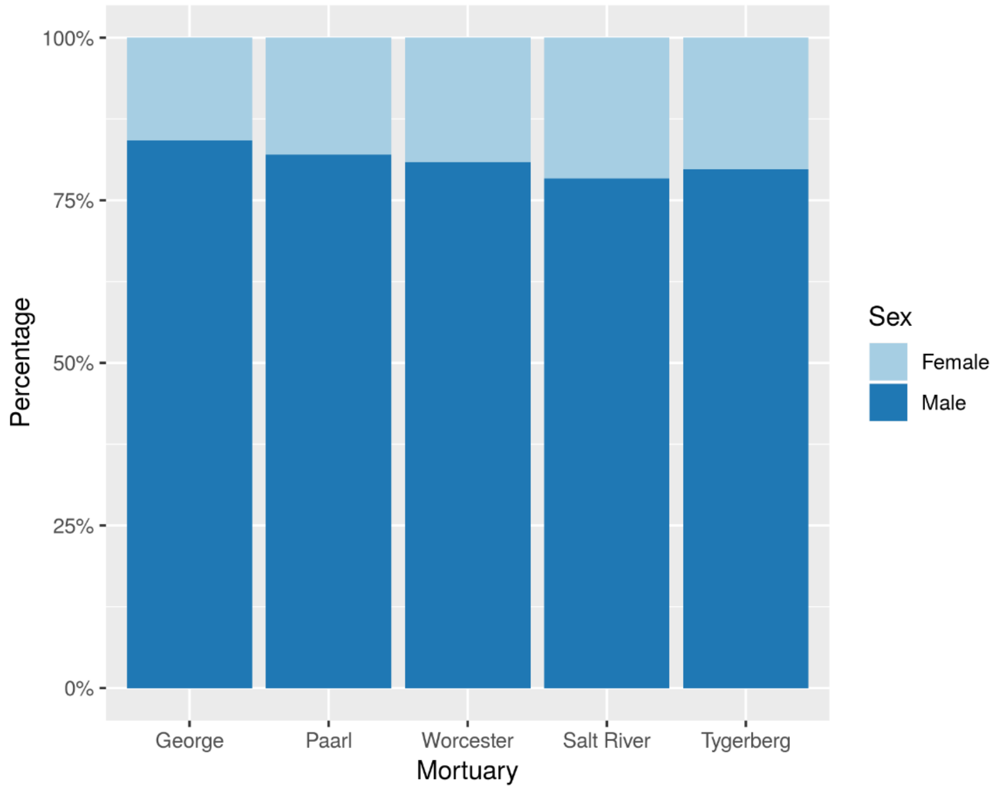


Figure A1: Proportion of RTF by mortuary and sex

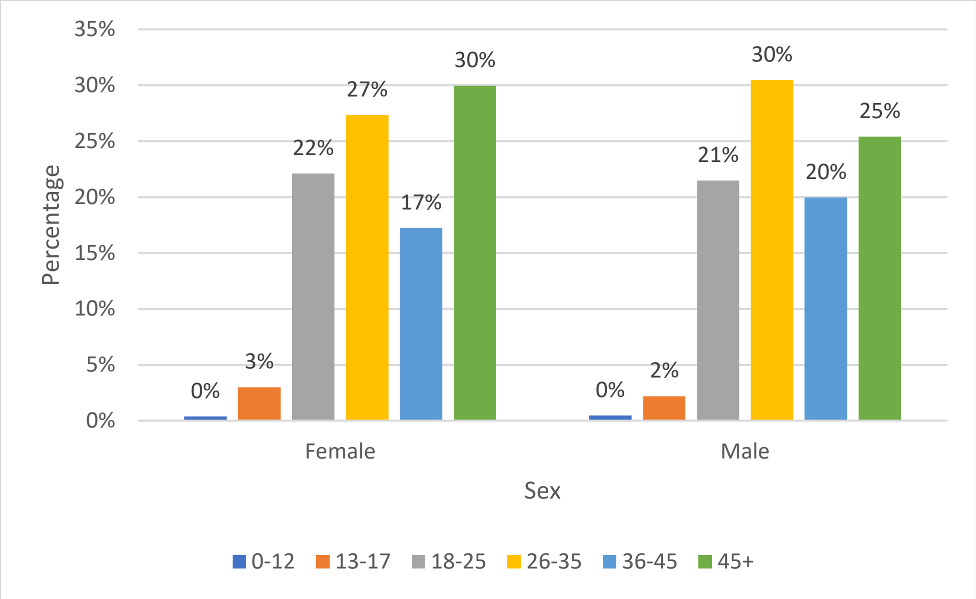


Figure A2: Percentage distribution of sex by age group

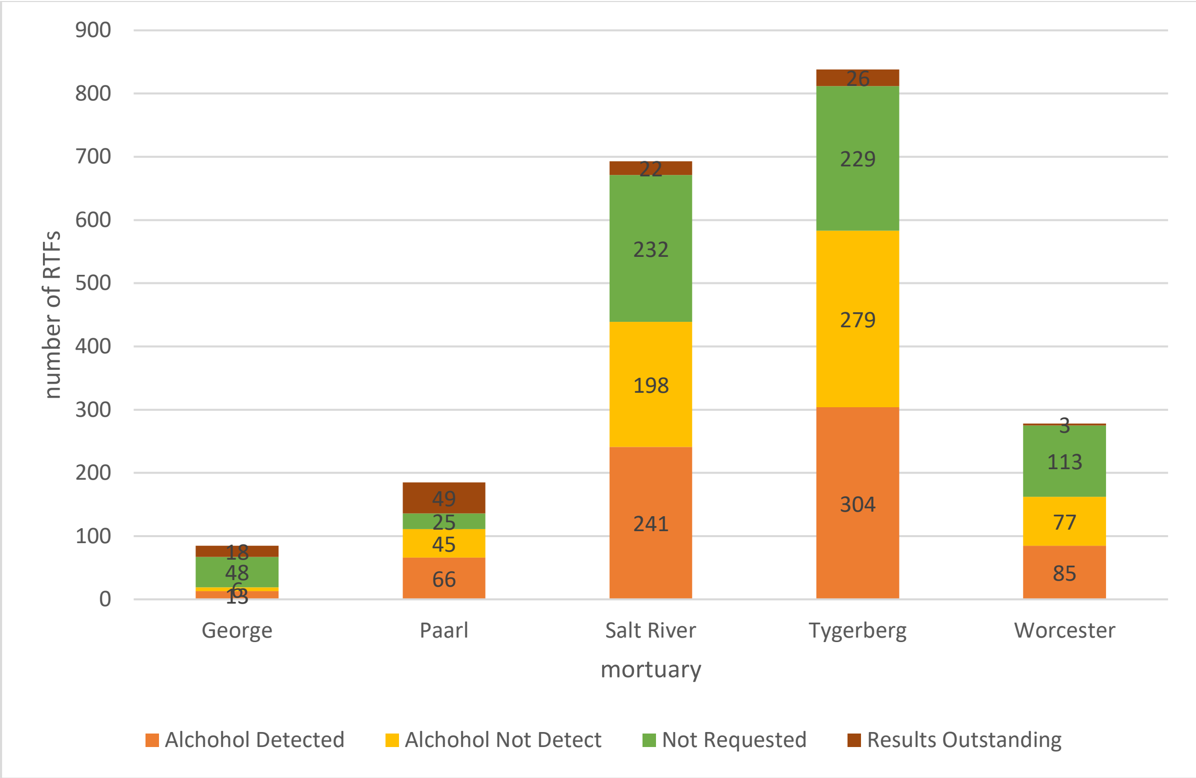


Figure A3: Number of RTF cases across the five different mortuaries.

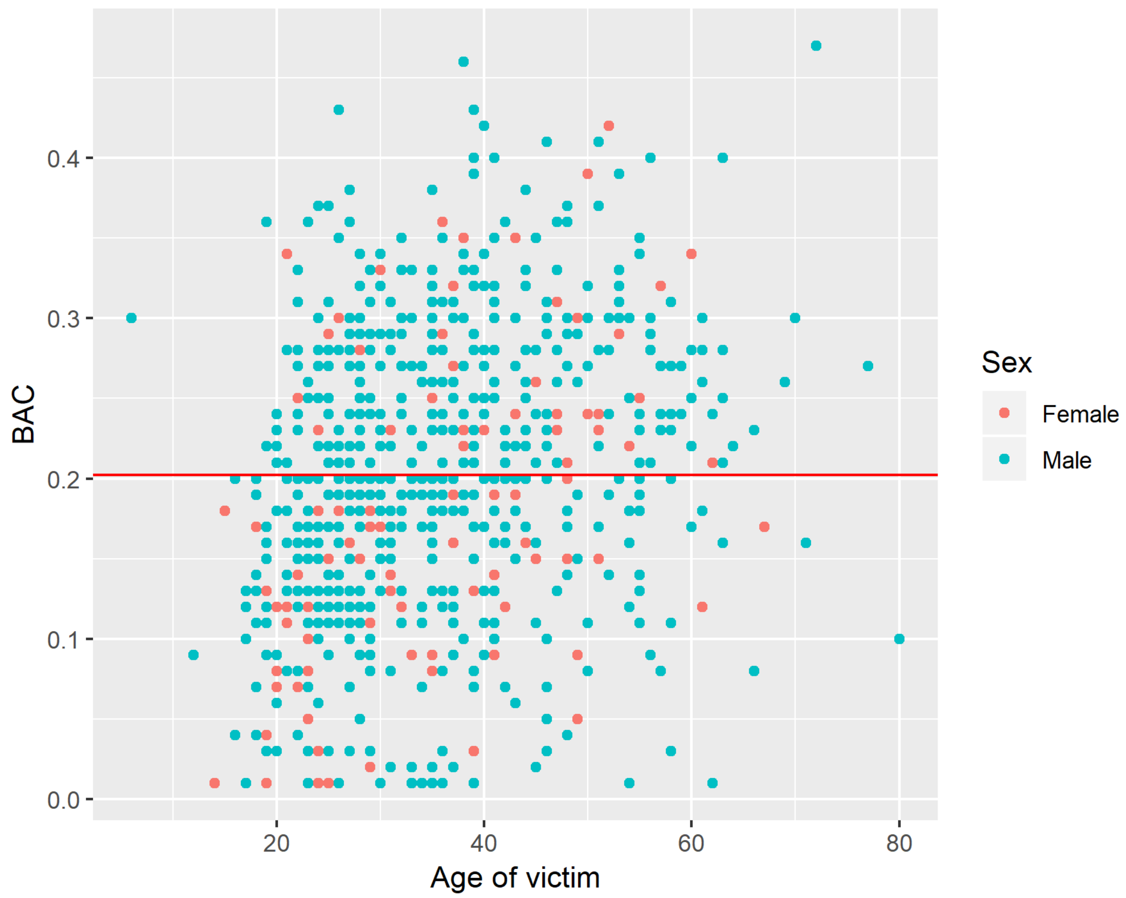
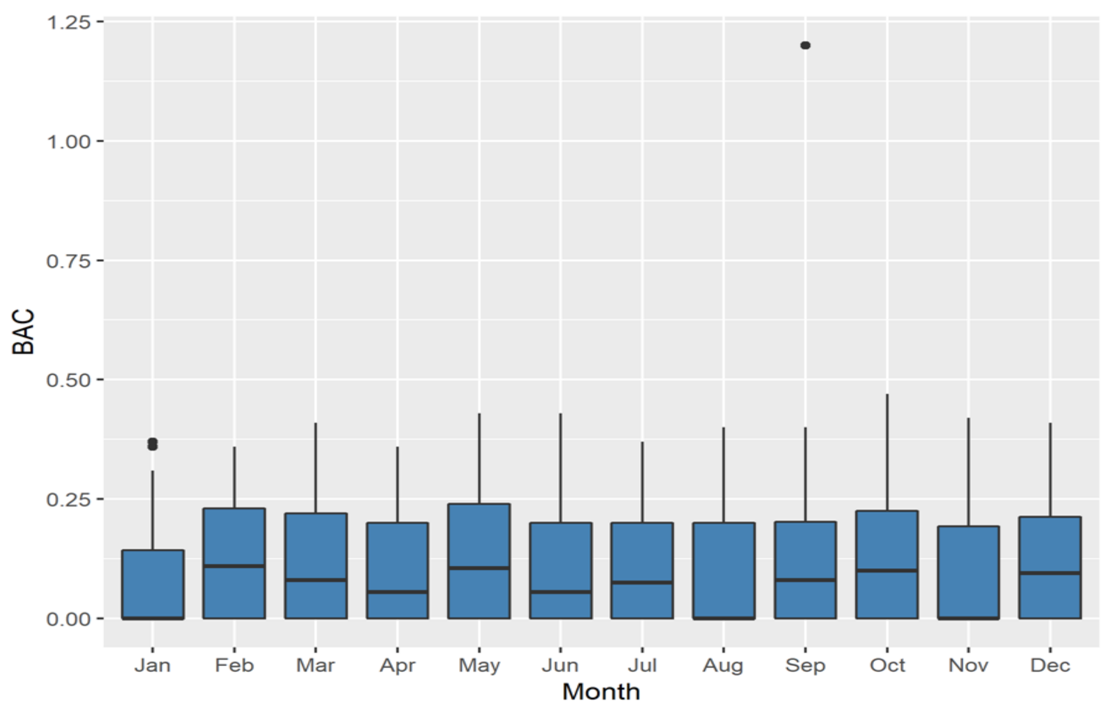


Figure A4: Scatter plot depicting the correlation of BAC and age



Appendix B: Ethics letters

Human Research Ethics Approval Letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethlcs Committee
Room "3-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [0211 406 6626
Email:
ähuremthnmn@uüc.za Website:
www.health.uct.ac.za/fhs/research/humanethics/forms

18 May 2018

HREC REF: 332/2018

Ms Bronwen Davies
Pathology
Forensic Mediclne and Toxicology
Room 5.04, level 5, Entrance 3
Falmouth Bulldlng

Dear Ms Davies

PROJECT TITLE: INVESTIGATING THE CHARACTERISTICS OF ROAD TRAFFIC ACCIDENT FATAUTIES IN FOUR MAJOR WESTERN CAPE CITIES, AND ASSESSING THE ROLE OF ETHANOL INTOXICATION IN THESE CASES-(MPh11-candidate-Ms R Malomane)

Thank you for submltting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It Is a pleasure to Inform you that the HREC has formally approved the above-mentloned study.

Approval is granted for one year untll the 30 May 2019.

Please submlt a progress form, using the standardlsed Annual Report Form If the study contlnues beyond the approval period. Please submit a Standard Closure form If the study is completed wlthln the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethlcs/forms)

Please quote the HREC REF In all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsiblllty of the prlnclpal investigator.

Please note that for all studies approved by the HREC, the principal Investigator obtain appropriate instltutlonal approval, where necessary', before the research may occur.

Appendix C: Western Cape Government Ethics Approval Letter

Western Cape Government
Health

Health impact Assessment
Sub-Directorate: Health Research

Health.Research@westerncape.gov.
za tel.• +27 21 483 0866: fax: +27 21 483 9895 5th Floor, Norton Rose House,, 8 Riebeek Street, Cape Town, 8001 www.capegateway.gov.za)

REFERENCE: WC 201805 045
ENQUIRIES:
JIRIES: Dr Sabela Petros Dr
Sabela Petros

University of Cape Town
Division of Forensic Medicine and Toxicology
Anzio Road
Observatory
Cape Town
7925

For attention: Ms Bronwen Davies, Mr Calvin Mole, Ms Rixongile Malomane

Re: Investigating the Characteristics of Road Traffic Accident Fatalities in Four Major Western Cape Cities, and Assessing the Role of Ethanol Intoxication in these Cases.

Thank you for submitting your proposal to undertake the above-mentioned study. We are pleased to inform you that the department has granted you approval for your research.

Please contact the following person to assist you with any further enquiries in accessing the following site:

FPS Data	Mr Michael Vismer	021 928 1518

Kindly ensure that the following are adhered to:

1. Arrangements can be made with managers, providing that normal activities at requested facilities are not interrupted.

Appendix D: Author guidelines

FORENSIC SCIENCE INTERNATIONAL

An international journal dedicated to the applications of medicine and science in the administration of justice.

AUTHOR INFORMATION PACK

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ISSN: 0379-0738

DESCRIPTION

Forensic Science International is the flagship journal in the prestigious Forensic Science International family, publishing the most innovative, cutting-edge, and influential contributions across the forensic sciences. Fields include: forensic pathology and histochemistry, chemistry, biochemistry and toxicology, biology, serology, odontology, psychiatry, anthropology, digital forensics, the physical sciences, firearms, and document examination, as well as investigations of value to public health in its broadest sense, and the important marginal area where science and medicine interact with the law.The journal publishes:Original Research Papers (Regular Papers) Review Articles Rapid Communications Technical Notes Case Reports Letters to the Editor Commentaries

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Toxicologists, Scientists in Legal and Social Medicine, Questioned Documents and Jurisprudence

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3. INTRODUCTION

Forensic Science International is a peer-reviewed, international journal for the publication of original contributions in the many different scientific disciplines comprising the forensic sciences. These fields include, but are not limited to, forensic pathology and histochemistry, toxicology (including drugs, alcohol, etc.), serology, chemistry, biochemistry, biology (including the identification of hairs and fibres), odontology, psychiatry, anthropology, the physical sciences, firearms, and document examination, as well as the many other disciplines where science and medicine interact with the law.

3.1.1. Types of paper

1. Original Research Articles (Regular Papers)
2. Review Articles
3. Rapid Communications
4. Technical Notes
5. Forensic Anthropology Population Data
6. Case Reports
7. Preliminary Communications

8.Letters to the Editor

9. Book Reviews
10. Commentaries

Please note that all contributions of type 4 to 7 will be published as e-only articles. Their citation details, including e-page numbers, will continue to be listed in the relevant print issue of the journal's Table of Contents.

Announcement of Population Data: these types of articles will be published in Forensic Science International: Genetics, only. Please submit these articles via https://www.evise.com/profile/api/navigate/FSIGEN.

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- Sexing
- Aging sub adult skeletal remains
- Aging adult skeletal remains
- Aging living sub adults and adults
- Determining ancestry
- Stature estimation
- Facial reconstruction
- Non metric trait distribution, pathology and trauma
- Positive identification of human skeletal remains
- Positive identification of the living

Forensic Anthropology Population Data articles will be published in abridged form in print (a clear, descriptive summary taken from the abstract), and the full length article will be published online only. Full citation details and a reference to the online article, including e-page numbers, will be published in the relevant print issue of the journal. All submitted manuscripts will be evaluated by a strict peer review process.

Case Reports will be accepted only if they contain some important new information for the readers.

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Papers for consideration should be submitted by topic. Editors and their topic specialty are listed below.

C. Cattaneo (Co Editors-in-Chief):

Tel: +39 02503 15679

E-mail: cristina.cattaneo@unimi.it

C. Jackowski (Co Editors-in-Chief):

Tel: +41 (0)31 631 84 12

E-mail: Christian.Jackowski@irm.unibe.ch

B. Ludes: Forensic Genetics. E-mail: ludes@unistra.fr

P. Margot: Questioned Documents and Physical Science: ballistics, tool marks, contact traces, drugs analysis, fingerprints and identification, etc. Tel: +41 21 692 4605

Fax: +41 21 692 4605

E-mail: pierre.margot@unil.ch

O.H. Drummer: Toxicology

Tel: +61 3 9684 4334

Fax: +61 3 9682 7353

E-mail: olaf.drummer@vifm.org

S. Matuszewski: Entomology

Tel: +48 61 82 94 292

E-Mail: szymmat@amu.edu.pl

3.1.4. Submission checklist

You can use this list to carry out a final check of your submission before you send it to the journal for review. Please check the relevant section in this Guide for Authors for more details.

Ensure that the following items are present:

One author has been designated as the corresponding author with contact details:

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- Full postal address

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- Referee suggestions and contact details provided, based on journal requirements

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Regardless of the file format of the original submission, at revision you must provide us with an editable file of the entire article. Keep the layout of the text as simple as possible. Most formatting codes will be removed and replaced on processing the article. The electronic text should be prepared in a way very similar to that of conventional manuscripts (see also the Guide to Publishing with Elsevier). See also the section on Electronic artwork.

To avoid unnecessary errors you are strongly advised to use the 'spell-check' and 'grammar-check' functions of your word processor.

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State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

Material and methods

Provide sufficient details to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized, and indicated by a reference. If quoting directly from a previously published method, use quotation marks and also cite the source. Any modifications to existing methods should also be described.

Results

Results should be clear and concise.

Discussion

This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Conclusions

The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

5.1.6. *Essential title page information*

- ***Title.*** Concise and informative. Titles are often used in information-retrieval systems. Avoid abbreviations and formulae where possible.

- ***Author names and affiliations.*** Please clearly indicate the given name(s) and family name(s) of each author and check that all names are accurately spelled. You can add your name between parentheses in your own script behind the English transliteration. Present the authors' affiliation addresses (where the actual work was done) below the names. Indicate all affiliations with a lowercase superscript letter immediately after the author's name and in front of the appropriate address. Provide the full postal address of each affiliation, including the country name and, if available, the e-mail address of each author.
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[3] W. Strunk Jr., E.B. White, The Elements of Style, fourth ed., Longman, New York, 2000.

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[4] G.R. Mettam, L.B. Adams, How to prepare an electronic version of your article, in: B.S. Jones, R.Z.Smith (Eds.), Introduction to the Electronic Age, E-Publishing Inc., New York, 2009, pp. 281–304.

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[5] Cancer Research UK, Cancer statistics reports for the UK. http://www.cancerresearchuk.org/aboutcancer/statistics/cancerstatsreport/, 2003 (accessed 13 March 2003).

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