Retrospective review of gunshot injuries at Salt River Mortuary, Cape Town, Western Cape

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SUBMITTED TO THE UNIVERSITY OF CAPE TOWN
In partial fulfilment of the requirements for the degree

MPhil (Biomedical Forensic Science)

Faculty of Health Sciences
UNIVERSITY OF CAPE TOWN

February 2022
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ABSTRACT

The use of firearms to inflict fatal trauma is a social, economic, and public health concern globally. In South Africa, firearm-related injuries (FRIs) have become the leading cause of unnatural death. Despite this, few studies have investigated the demographic, geographic and temporal distribution of firearm-related fatalities in South Africa.

The aim of this study was to investigate fatal firearm-related injuries in forensic cases admitted to Salt River Mortuary in Cape Town, South Africa. A retrospective cross-sectional study of fatal FRIs from Salt River Mortuary was conducted for the period 1 January 2017 to 31 December 2017. Autopsy case files were screened for fatalities associated with firearms. The following data were obtained from the database: demographics of the deceased, geographic and temporal distributions of firearm-related deaths, the type of firearm used, projectile calibre, size of the entrance and exit wound, location of the injury, and blood alcohol concentration (BAC) of the deceased.

In 2017, 3 658 autopsies were conducted at Salt River Mortuary in Cape Town, South Africa. More men (75%, *n*= 2 743) were admitted than women (23%, *n*= 843). The rate of firearm-related deaths during the period of investigation was 39.8/100 000 population of Salt River. Men (95%, *n*= 732) were mostly affected by firearm-related injuries compared to women (5%, *n*= 40). The relative risk of firearm-related deaths among men was 5.62 ($p<0.001$. Firearm-related homicide (97%, *n*= 751) was common and suicide cases were rare (2%, *n*= 19). All age groups were affected however, the highest proportion of deaths was identified in those between 21-30 years of age (42%, *n*= 325). Most deaths occurred in the Cape Flats with Mitchells Plain (18%, *n*= 108) as the most affected region. The highest proportion of injuries occurred in the upper limbs of the body (23%, *n*= 1056) followed by the head (22%, *n*= 1013).

This study adds to the growing body of literature on the prevalence and characteristics of firearm-related deaths in South Africa. Firearm violence still appears to be a major public health and safety concern in Cape Town and further interventions should be developed to curb gun violence.

ACKNOWLEDGMENT

First, I would like to thank the Division of Forensic Medicine and Toxicology, University of Cape Town, for the opportunity that was granted to me to complete my master's degree. I want to express my gratitude to the National Research Foundation for founding this study. Thanks to my supervisors, Mr Cale Mole and Dr Elizabeth Dinkele for providing encouragement, guidance, and feedback throughout this project.

I would like to thank the following person who helped me with the retrieval of digital autopsy reports.

Mr Devon Jailers

Division of Forensic Medicine and Toxicology at the University of Cape Town

ABBREVIATIONS

BAC - Blood Alcohol Concentration

FCA - Firearm Control Act

FPS - Forensic Pathology Service

FRIs - Firearm-related injuries

NIMSS - National Injury Mortality Surveillance System

NVCDRS - National Violent Death Reporting System

SA - South Africa

SANDF - South African National Defence Force

SAPS - South African Police Service

SDGs - Sustainable Development Goals

SRM - Salt River Mortuary

UCT - University of Cape Town

UNODC - United Nations Office on Drugs and Crime

USA - United States of America

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CHAPTER 1: INTRODUCTION

Globally, 5.8 million people are estimated to die annually as a consequence of some form of injury (Holder *et al*., 2006). Firearm-related violence is often associated with these injuries. As a result, a greater proportion of individuals succumb to these injuries, and some seek medical care. A study conducted on the cost of treating abdominal injuries in South Africa (SA) indicated that approximately 127 000 victims of firearm-related injuries (FRIs) seek medical assistance from the government annually (Allard & Burch, 2005). The use of firearms to inflict fatal injuries is increasingly common and this has become a social, economic, and public health concern in various countries. Firearms are now a frequent means of inflicting injuries in cases of homicide and suicide and have become a major public health problem concerning social, public, and economic security (Bäckman *et al*., 2020; Goldstick *et al*., 2019; Naghavi *et al*., 2018).

The rate of firearm-related deaths in developing countries is at least double that in developed countries (*Werbick et al*., 2021). The link between lower-income countries, socioeconomic status, and violence-related deaths are well reported (Gibbons, 2014; Mc Evoy & Hideg, 2017; Werbick *et al*., 2021; Wolf *et al*., 2014; UNODC, 2014). In countries like El Salvador, Venezuela, and Honduras significantly higher levels of poverty and lower average gross domestic product have been associated with more than 50% of homicides, relative to countries like the United States of America or the United Kingdom (Mc Evoy & Hideg, 2017). In 2016, FRIs accounted for approximately 251 000 deaths and contributed to just over 50% of unnatural deaths globally (Naghavi, 2018). Approximately 64% of these deaths were attributed to homicide, 27% to suicide, and 9% were accidental (Naghavi, 2018).

In SA, FRIs are not a new phenomenon. South Africa is a developing (low to middle income) country with the rate of firearm-related deaths double that seen in other developing countries. South Africa has one of the higher rates of unnatural deaths globally (Norman *et al*., 2007). It has been suggested that the higher rates of FRIs in SA are associated with conflicts in the society post-democracy since 1994 (Keegan, 2005). A study based on a data survey in 63 countries (including SA) that investigated the relationship between violence and socioeconomic imbalance, indicated that there is a strong association between violence and socioeconomic factors (Wood, 2006). Several socioeconomic factors such as low-socioeconomic status and poverty are

among the factors associated with the higher rate of FRIs (Sammour, 2013). Other than socioeconomic factors, alcohol has been previously associated with FRIs (Branas *et al*., 2009; Branas *et al*., 2016; Branas *et al*., 2011). Approximately 15 000 lives are annually lost as a result of FRIs in SA (Allard & Burch, 2005). Given this statistic, it is unsurprising that FRIs are the leading cause of unnatural deaths in SA (Department of Community Safety, Western Cape Government, 2015). A report by the South African Police service (SAPS) indicated the use of firearms in 41.5% of all homicides in 1994, which later increased to 45.6% in 1997 (Schönteich & Louw, 1999). In 2009, FRIs accounted for a homicide prevalence of 11.2/100 000 population, 1.8/100 000 population of suicide rate, and 0.2/100 000 population of accident death rate (Matzopoulos, 2015). In SA, there are estimated to be millions of unregistered illegal firearms (Department of Community Safety, Western Cape Government, 2015).

The epidemiology of FRIs in Cape Town of the Western Cape province is not well documented. In this city, FRIs are mostly associated with gang-related activities (Geldenhuys, 2022). Gang-related activities are most prevalent in the Cape Flats region. These activities involve the use of firearms and often the conflict is almost always between different gang groups running the illegal operations on the streets (Sammour, 2013). These conflicts threaten the safety of innocent civilians who may be caught in the crossfire. According to data from SAPS based on gang-related activity in the Cape Flats, approximately 137 gangs were in operation, each with about 80 000 to 100 000 gang members (Kinnes, 2000). In 2013, the death rate as a result of FRIs was 24.2/100 000 population (Matzopoulos *et al*., 2018).

The rate of FRIs still extends beyond the safety and health of society thus issues concerning them must be addressed to minimise higher rates of death (Masters *et al*., 2021). Firearm-related injuries are an ongoing public concern in South Africa and there is still a large gap in research and the availability of information regarding FRIs. Therefore, there is a need for research to further investigate and provide insight into different types of FRIs and further assess the risk associated with FRIs for the government to be able to implement applicable measures to improve public safety and reduce the rates of firearm-related deaths.

CHAPTER 2: LITERATURE REVIEW

2.1. Global overview of firearm-related deaths

2.1.1. Trends and patterns of firearm-related deaths across the globe

Naghavi *et al.* (2018) conducted a study to highlight the patterns of FRIs across 195 countries and their subregions which estimated about 251 000 firearm homicides across the globe in 2016. This data indicated a significant increase in firearm homicides since 1990. In 1990, 209 000 were estimated to have died from FRIs (Naghavi *et al*., 2018), while by 2016 there were 251 000 reported as a result of deaths FRIs. In 2004, the global FRIs was about 171 000 and it has increased to 210 000 until 2016 (Mc Evoy & Hideg, 2017).

Global data suggests that FRIs have increased from 2004 to 2016 (Mc Evoy & Hideg, 2017). The National Violent Death Reporting System (NVCDRS) of the United States reported that firearms accounted for 66.5% of homicides and 51.8% of suicides in 2009, and most of these cases occurred in homes (Karch *et al*., 2012). Data from the United Nations Office on Drugs and Crime (UNODC) homicide statistics collected from 108 countries indicates that in 2010, 199 000 firearm-related homicides were reported from a recorded 468 000 estimated homicides (UNODC, 2011). Firearms accounted for approximately 40% of unnatural deaths globally but increased to 44% in 2016 (Mc Evoy & Hideg, 2017). During this year, 81% of firearm-related homicides were intentional, 4% were unintentional (Mc Evoy & Hideg, 2017).

While there has been little change in the role of firearms in violence since 2015, Mc Evoy and Hideg, (2017) revealed that there have been a decrease and an increase in firearm-related deaths in different countries. In the United States of America (USA), 2500 people die each year as a result of FRIs (Cook *et al*., 2017). In some countries, including SA, firearm-related deaths have decreased tremendously from 2015 to 2016. Although in some other countries, such as the Bahamas, Venezuela, Brazil, and Jamaica, firearm-related deaths have increased noticeably from 2015 to 2016 (Mc Evoy & Hideg, 2017).

Data relating to FRIs are limited in African countries as few countries actively survey or publish these data (UNODC, 2011). In SA, the fragmentation between

administration of public safety, public health and the judicial system has resulted in discrepancies in the reported data (Kinnes, 2000).

2.1.2. Regional overview of firearm-related deaths

The variation of FRIs is wide-ranging between regions. In SA, the number of fatalities due to FRIs exceeds other forms of fatalities with about 20 000 FRIs reported annually (Chamisa, 2008). It has been reported that between 2011 and 2016, FRIs were the main cause of death in South America than other regions such as Northern Africa, Eastern Europe, and Micronesia (Mc Evoy & Hideg, 2017). For the regions where FRIs were not the leading cause of death, other means, or weapons other than firearms were used in violence.

Data from 2011 to 2016 indicates that in countries (such as Venezuela, El Salvador, and Honduras) with the higher rates of violence (at least 20/100 000 population), almost half of the violence involves firearms in contrast with other countries (such as Namibia and the Dominican Republic) with the violence rate of about 12/100 000 population (Mc Evoy & Hideg, 2017). The use of firearms is mostly focused on homicide than suicide. In some countries, FRIs accounts for higher rates of suicide (9.81/100 000) than homicide (8.52/100 00) (Lankford, 2016). In these countries, it may be considered that access to firearms in the home is the leading factor contributing to the higher rates of suicides.

In SA, there is a lack of vital data registration and statistics despite higher rates of violence (Bradshaw *et al*., 2003; Norman *et al*., 2007; Norman *et al*., 2006). For instance, firearm-related homicide or suicide may be misclassified as accidental or the rates of firearm-related deaths may be based on limited data. Countries in Africa have large gaps regarding data availability and quality about firearm-related deaths and only a few generate valid and accurate data (UNODC, 2011). Even in many other countries especially those situated in Southern Asia, the Middle East, Sub-Saharan Africa, and North Africa have poor data registration and the validity of the data are uncertain (Naghavi *et al*., 2018).

2.2. Overview of firearm-related deaths in South Africa

South Africa is a democratic country with a unique history. In this country, violence could be traced back to 1652 when the majority of the African native population were colonised (Sammour, 2013). In the cities, many people were forced to settle in townships in the outskirts of the city where poverty, unemployment and poor infrastructure are most prevalent (Matzopoulos *et al*., 2020). Consequently, gang-related violence emerged and was involved in political battles (Sammour, 2013). Although the level of political violence has gradually diminished, there are still increased levels of interpersonal violence. It may be suggested that the higher rates of violence are caused by factors such as densely populated settlements and a continuing socioeconomic difference. In SA, higher rates of FRIs have been associated with low socioeconomic status (Bradshaw *et al*., 1992; Norman *et al*., 2007). In 2000 the rate of interpersonal violence accounted for 46% out of 59 935 injury deaths. In that year, the rate of homicide exceeded that of suicide (14/100 000 population) (Norman *et al*., 2007). However, the rate of suicide was double the rate for Africa as a whole (6.5/100 000 population) and almost equal to the global rate of 14.5/100 000 population (WHO, 2002). In 2017, a significant decrease in homicide rate (2.4 per 100 000 population) and suicide rate (0.95 per 100 000 population) was reported, however the homicide rate was almost equal to the global rate (5.30 per 100 000 population) (Prinsloo *et al*., 2022).

Due to higher rates of violent crime in SA, many individuals own firearms for security purpose with an intend of protecting themselves from crime. Firearm ownership in homes is associated to higher rates of unintentional and intentional firearm-related injuries (Clifford, 2019). The rate of intentional injuries in SA is exceeding injuries inflicted accidentally and is far different from some regions across the globe (Norman *et al*., 2007). According to the National Injury Mortality Surveillance System (NIMSS), a system consisting of data collected mainly from mortuaries in the South African urban areas, FRIs were the main cause of unnatural deaths until 2003 (Burrows *et al*., 2001; Matzopoulos, Seedat & Cassim, 2003; Matzopoulos, 2005). According to the South African Police Service (SAPS) report, there was a decrease in the rate of firearm homicide from 1994 to 2012 (SAPS, 2012).

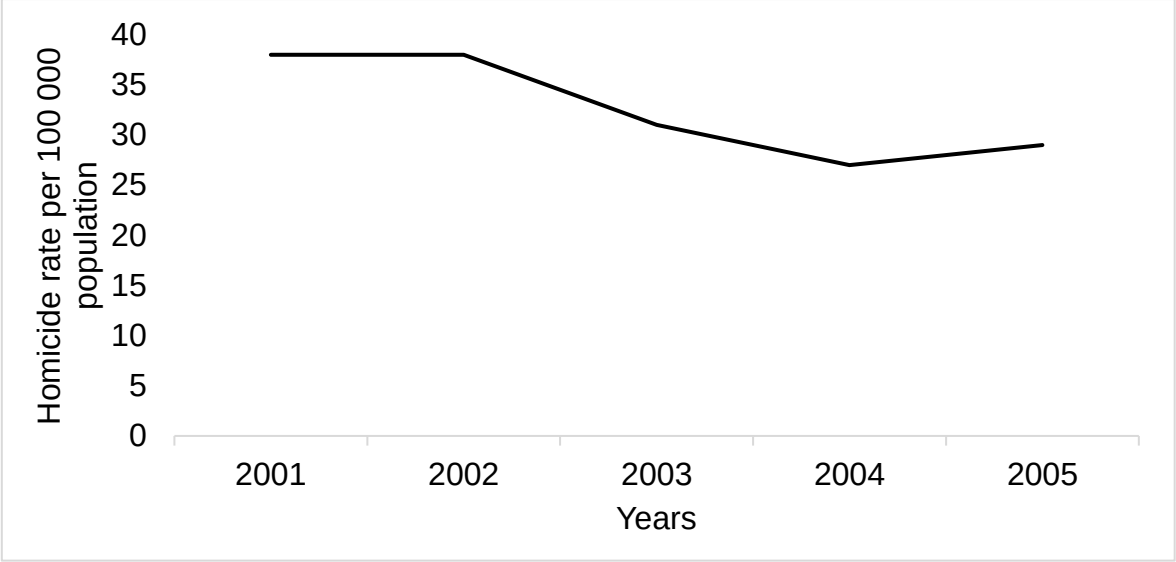


Figure 2.1. Changes in the rate of firearm-related homicide for 5 South African cities (Cape Town, Durban, Johannesburg, Port Elizabeth, and Pretoria) per 100 000 population between 2001 and 2005 (Matzopoulos *et al*., 2014).

This decline was also identified in a study involving data collected from mortuaries across five SA cities over 5 years from 2001 to 2005, in which it was identified that firearm-related homicide decreased from 37.5% in 2001 to 22.5% in 2005 (Matzopoulos *et al*., 2014) (Figure 2.1). This decline coincides with the implementation of the Firearm Control Act (FCA) of 2000 which will be discussed later in this literature review. Furthermore, it may also be suggested that the lower urbanisation rate between 2001 and 2005 is another contributing factor (Roux, 2009). Higher rates of urbanisation tend to increase the population sizes in cities. As a result, densely populated areas such as informal settlements experience higher crime rates, and higher firearm related injuries. By 2010, the rate of firearm-related death was 13.6/100 000 population lower than that recorded in 1999 (Matzopoulos *et al*., 2018). Despite this apparent decline, the rate of firearm-related homicide increased significantly to levels similar to 1999 (Matzopoulos *et al*., 2018).

2.2.1. The impact of strict firearm regulations

The association between the rate of firearm-related deaths and the availability of firearms is well documented worldwide (Meel, 2018; Campbell *et al*., 2013;

Matzopoulos *et al*., 2016; Matzopoulos *et al*., 2014). In Europe, one study indicated that the rate of firearm-related homicide and suicide decreased following the application of stricter gun control legislation (Kapusta *et al*., 2007). Following the changes to firearm laws in Australia in 1999 (The National Firearms Agreement) that included confiscation of particular types of firearms from civilians, there was a decline in the rate of firearm deaths, and in firearm-related homicides involving multiple individuals (Chapman *et al*., 2006; Gilmour, Wattanakamolkul & Sugai, 2018; Ozanne-Smith *et al*., 2004). In the USA, the rates of firearm-related homicide are closely linked to firearm ownership (Siegel *et al*, 2013). Over a quarter of the families (35% to 39%) in the USA own firearms and 25% of individuals report ownership of a firearm (Anglemyer *et al*., 2014).

Firearm Control Act (FCA) was implemented in South Africa in 2000 to regulate the availability and use of firearms in civilians. The FCA was adopted in response to the rising rates of FRIs and the National Crime Prevention Strategy adopted in 1996 (Matzopoulos, Thompson & Myers, 2014). The FCA was intended to prohibit and restrict the circulation of specific types of firearms (Matzopoulos *et al*., 2016). In addition to this, it provided for screening firearm owners to ensure they are physically and mentally capable of responsibly using a firearm (Matzopoulos *et al*., 2016). Unsurprisingly, the implementation of the FCA made it difficult for civilians to legally acquire firearms. Between the adoption of the FCA in 2000 and its complete application in 2004, there was a decrease in firearm access in SA. This period involved the following special operations: firearm amnesties, hand-ins of previously licensed weapons, audit of state-owned firearms, and the recovery and destruction of unlicensed weapons (Matzopoulos *et al*., 2014). Matzopoulos *et al*. (2016) reported that there was a gradual decline in the number of firearm-related deaths from the year 2000 to 2011 which led more than 60% decrease since the rate of firearm homicide peaked in 2000. Interestingly, there was a marked increase in firearm-related deaths between 2012 and 2013 (Matzopoulos *et al*., 2016), which happened to correspond to the SAPS fast-tracking of over a million firearm licence applications and renewals between 2010 and 2011 (SAPS, 2012).

The FCA was initially successful in reducing the rate of FRIs, especially those involving children (Hutt *et al*., 2004; Campbell *et al*., 2013; Matzopoulos *et al*., 2016). However, since 2004, the rate of firearm-related deaths in SA has increased rapidly. Between

2004 and 2011, the SAPS reported theft and loss of approximately 20 429 firearms with only 4 810 firearms recovered (Steenkamp, 2011). It has been reported that over 4 357 firearms and 9 500 000 rounds of ammunition were lost by SAPS in 6 years (Getrude, 2019). The presence of unregistered firearms in South Africa remains a concern as many of these weapons are suspected to be used in unresolved firearm-related crimes (Lindwa, 2019). The government is faced with the challenge of tracking down unregistered FRIs and policing areas where these firearms are commonly used to reduce the rate of deaths in these regions (Matzopoulos *et al*., 2019). Until the geospatial and temporal patterns of firearm related deaths are understood the government cannot begin to effectively manage and prevent FRIs in SA.

2.2.2. Trends and magnitude of firearm-related deaths in Cape Town

Increasing rates of firearm-related homicides and suicides have been occurring in Cape Town since 1986, and now have become a major public concern (Macdonald & Lerer, 1994). From 1999 to 2001, FRIs were the main factor contributing to death in Cape Town and accounted for 44% of homicides during that period (Prinsloo, Matzopoulos & Sukhai, 2003. A study investigating firearm-related deaths and their conviction rates in 1999 and 2009 at Salt River Mortuary (SRM) in Cape Town, found that the frequency of firearm-related homicides was higher (89.29% in 1999 and 86.12% in 2009) than firearm-related suicides (10.71% in 1999 and 13.17% in 2009) (Wichers, 2016). In addition, a retrospective study between 1994 and 2013 identified that at its peak in 2002, firearms deaths accounted for approximately half (49.2%) of all homicide cases recorded in SA (Matzopoulos *et al*., 2018). As previous studies in Cape Town have primarily focussed on firearm-related homicides, published data regarding firearm-related suicides and accidents are limited. A timeline of firearm-related violence between 1994 and 2013 in Cape Town indicate that there was a significant increase in firearm-related homicide from 1994 (19.7/100 000 population) to 2002 (37.8/100 000 population) (Figure 2.2) (Matzopoulos *et al*., 2018). Despite the rapid decrease in these deaths in 2004, FRIs have been increasing significantly since 2004 (19.2/100 000 population) (Figure 2.2.) (Matzopoulos *et al*., 2018).

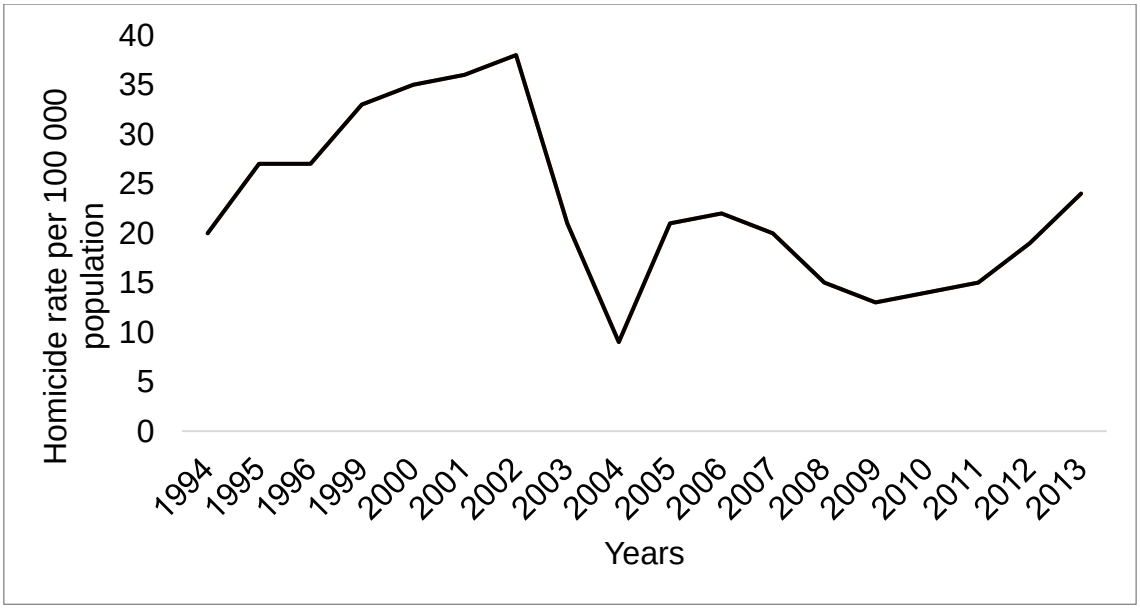


Figure 2.2. Changes in the rate of firearm-related homicide in Cape Town per 100 000 population between 1994 and 2013 (Matzopoulos et al., 2018).

A study based on two mortuaries (Salt River and Tygerberg) serving the Cape Metropole identified that firearms accounted for 1 122 (46.1%) of 2 436 recorded cases of homicides, and was the leading manner of death in 2001 (Prinsloo, Matzopoulos & Sukhai, 2003). Homicide was more prevalent in homes, roads, market areas, boarding settlements, open spaces, and informal settlements, and accounted for 42% of firearm-related deaths (Prinsloo, Matzopoulos & Sukhai, 2003. In addition, firearm-related homicides were more prevalent in suburbs characteristic with middle-low income households (such as Khayelitsha, Philippi, Nyanga, Mitchells Plain, Gugulethu, and Tygerberg). The higher rate of firearm-related homicides (56.3%) compared to non-firearm-related homicides (48.7%) in the Western Cape is of great concern (Prinsloo, Matzopoulos & Sukhai, 2003; Uren *et al*., 2023).

Recently, a survey of cases conducted at SRM over 10 years from 2007 to 2016 identified that 32% of the 32 127 autopsy cases were homicides. Out of all the homicide cases, firearm injuries accounted for 40.4% compared to sharp force injuries (39.4%) and were the dominant method of homicide (Mole, 2019). In addition, the number of homicide cases involving FRIs was less common than sharp force trauma cases from 2007 until 2012. After 2012 there was however a rapid increase in the number of deaths due to FRIs (Mole, 2019).

The distribution of firearm-related deaths in different countries, provinces, and cities has been linked to socioeconomic and unemployment rates (Sammour, 2013). In Cape Town, gang-related violence is one of the leading factors contributing to FRIs. The increase in gang-related activities is believed to be linked to corruption within SAPS, high caseloads among prosecutors and investigators, unemployment rates, and the increased trade and use of illicit drugs. Gangsterism in South Africa has continued to gain momentum in South African, especially in communities riddled with poverty and unemployment (Kinnes, 2004). Limited communication and collaboration between the Department of Justice, Department of Social Development, Department of Corrections and National Prosecuting authorities has prevented effective prevention of gangsterism and firearm-related crimes in South Africa (Kinnes, 2000 & Cruywagen, 2021).

2.2.3. Patterns of firearm-related deaths between sex and by age

Firearm-related deaths are unequally distributed between men and women, and across different age groups (Anglemyer *et al*.,2014). Anglemyer and colleagies (2014) reported that exposure to firearms in young boys and teenagers led to increased risk of involvement in gun-related violence with age. Unsurprisingly, exposure to firearm-related violence has also been associated with the increased risk of suicide in adulthood (Anglemyer *et al*.,2014). Several studies have reported a greater prevalence of FRIs in men than women (Meel, 2018; Senger *et al*., 2011, Uren *et al*., 2023). There is, however, a notable increase in female firearm-related homicide in SA. Mathews *et al*. (2009) indicated that in 1999, the firearm-related homicide rate for women older than 14yrs of age was 7.5/100 000 population (Mathews *et al*., 2009). While men have a higher chance of experiencing firearm-related deaths than women, they are also more likely to be perpetrators of domestic violence and femicide (Siegel *et al*., 2016).

Data from the NIMSS suggested that FRIs were the leading cause of deaths involving firearms for all age groups (e.g., from 5 years old) until 2003 (Burrows *et al*., 2001; Matzopoulos, Seedat & Cassim, 2003; Matzopoulos, 2005). Firearm-related injuries in children are well documented. Firearm-related injuries accounted for about 7 220 homicides in children aged 0 to 14 years in 2016 in SA, with a death rate of 0.4%

(Naghavi *et al*., 2018). In addition, firearm homicides were 2.4 times more common in boys than girls in this age group. A study of paediatric FRIs between 1990 and 2010 in the USA indicated that about 198 FRIs were inflicted on children resulting in an overall death rate of 9.3%, with the highest firearm-related homicide of 20% in children aged between 0 to 4 years (Senger *et al*., 2011). Another study conducted on paediatric patients (0-12 years old) with FRIs between 2001 and 2011 in Cape Town found that 61% of patients were young boys, and only 3 patients died accounting for a 2% death rate (Campbell *et al*., 2013).

Although the pattern of FRIs is different across different age groups, injuries are more prevalent between the age group between 25 to 34 years old (Prinsloo, Matzopoulos & Sukhai, 2003). Among this age group, firearm-related homicides were more prevalent in men (90.2%) compared to women (9.8%) (Prinsloo, Matzopoulos & Sukhai, 2003). In contrast, another study identified that FRIs were more prevalent between 13 to 19 years olds (Knight-Bohnhoff & Burkybile, 1995; Naidoo & Van As, 2011). In addition, in 2016 firearm homicides were higher in men than in women, and these deaths occurred between 20-24-year-olds for both sexes (Naghavi *et al*., 2018). 34 700 firearm homicides were recorded for men and accounted for a death rate of 11.2/100 000 population compared to that of women (1.2/100 000 population) (Naghavi *et al*., 2018).

2.2.4. Characteristics of firearm-related injuries

The extent of FRIs can be determined by several factors such as the structure of the tissue, anatomical site, and the type of weapon used (Stefanopoulos *et al*., 2017). A retrospective review of patients presented with FRIs in Dayton, Ohio, showed that out of 45 patients presented with FRIs to the head and neck region, 11 died. Seventy-two patients were presented with FRIs to the abdomen, 12 of which died from FRIs to the abdomen only or combined FRIs to other anatomical sites. Firearm-related injuries to the abdomen only accounted for 6 deaths and combined FRIs to the chest and abdomen accounted for 3 deaths. Another 3 deaths resulted from combined FRIs to the abdomen and limbs (Fiedler *et al*., 1985).

Between 31 February 2000 and 31 January 2002 in the state of Maryland, US, 786 victims suffered FRIs to the head. Out of all the victims, 712 died and accounted for a

91% death rate (Aarabi *et al*., 2014). In a Scandinavian trauma centre, between 2005 and 2016, 235 patients presented with FRIs were admitted and accounted for a 12.8% (30 patients) 30-day mortality rate. Twenty-four hours after admission 24 patients died. Twenty-three patients were presented with FRIs to the head and neck or chest region, 14 with combined injuries to more than one anatomical site, and 10 with one anatomical site involved. Following the intervention, the total number of deaths increased to 31 accounting for a 13.2% mortality rate. Most FRIs were seen in the limbs however FRIs to the head accounted for a higher mortality rate (Bäckman *et al*., 2018). Aarabi *et al.* (2014) indicated that 76% of victims with FRIs to the head died at the crime scene, and of the 69 victims admitted to the trauma unit, 67% died.

Between April 2006 and March 2010 in Bugando Medical Centre, Tanzania, it was indicated that out of 84 patients injured by the firearm, 7 patients died and accounted for a death rate of 8.3% (Chalya *et al*., 2011). Out of the 7 patients, 3 deaths resulted from FRIs to the head, 2 from chest injuries, 2 from injures in the lower extremity (1 from septic shock and 1 from tetanus) (Chalya *et al*., 2011). In Cape Town, SA, 3 children out of 163 admitted for FRIs died at the Red Cross War Memorial Children's Hospital and accounted for a 2% death rate. These deaths were attributed to FRIs to the head and extreme loss of blood caused by FRIs in the lower extremity, particularly the thigh (Campbell *et al*., 2013). Furthermore, a prospective study conducted in Prince Mshiyeni Memorial Hospital, Durban, indicated that out of 78 patients who were treated for abdominal FRIs, 12 died (Chamisa, 2008).

To date, there is little research conducted in Cape Town regarding firearm injuries, particularly the number, type, and anatomical location of injuries. The socio-economic status in some parts of south SA is significantly different from other parts of the world thus the international data relating to the epidemiology of FRIs cannot be used to determine the risk associated with firearm-related violence. Without local data, it could be difficult to develop preventive measures and policies to address the burden of FRIs. The current study will investigate firearm-related injuries and further assess the impact of the Firearm Control Act of 2000.

2.3. Study aims and objectives

This study aimed to investigate fatal firearm-related injuries in cases admitted to Salt River Mortuary, Cape Town, Western Cape. The aim of the study was achieved by determining the prevalence of firearm-related deaths between 1st January 2017 to 31st December 2017 from autopsy records, evaluating the demographics, geographic and temporal localisation of firearm-related deaths, and the characteristics, extent and, types of FRIs inflicted on different body areas.

CHAPTER 3: METHODOLOGY

3.1. Ethical consideration

Ethical approval was obtained from the University of Cape Town Human Research Ethics Committee (HREC) (HREC REF: 337/2020) (Appendix A).

3.2. Study design

A retrospective cross-sectional study of fatal FRIs from SRM, Cape Town, Western Cape was conducted for the period 1 January 2017 to 31 December 2017. Two main mortuaries serve the greater City of Cape Town, namely Salt River and Tygerberg medico-legal laboratories. SRM is a level six mortuary, which serves the West Metropole of the City of Cape Town. The Catchment map area for the SRM is highlighted in brown (Figure 3.1). Approximately 1 937 379 people live in this area. It has an average load of 3 000 cases annually (Western Cape Government, Department of Health).

In South Africa, investigations of unnatural deaths are undertaken by the SAPS who are required to investigate these deaths under the Criminal Procedures Act (No 51 of 1977). These investigations require a medico-legal investigation of death as provided for in the Inquests Act (Act 58 of 1959). Forensic Pathology Service (FPS) are tasked with investigations of deaths in individuals who have died unnatural deaths including suicide, accidents, homicides, and procedural-related deaths. The South African National Health Act (2003) regulates the rendering of FPS and stipulated the role of the pathologist in estimating the cause of death, time since death, and reporting information useful in the identification and determination of manner of death. Formal manner of death is determined at inquest by the presiding judicial officer, however, pathologists make note of alleged manner of death until such time as the inquest is complete. Manner of death is recorded as that provided by the pathologist on the autopsy report.

For this study, the firearm-related injury was defined *a priori* to include any injury attributed to a projectile fired from a firearm. This included cases of unnatural deaths (one in which death is a consequence of external causes) where the cause of death

was determined to be as a direct or indirect consequence of firearm-related injury or the combination of firearm-related injury and other forms of injury (sharp and blunt force injuries).

Figure 3.1. Catchment map area for Salt River medico-legal laboratory, Western Cape Province (Calvin Mole, 2020).

3.3. Data collection procedure

The Office Autopsy Database (HREC R036/2014) from SRM was screened to identify autopsy cases with reports of FRIs. Cases were screened based on selection criteria including all cases where the cause of death was attributed to FRIs. The original autopsy reports for all cases included were retrieved from the Division of Forensic Medicine and Toxicology at the University of Cape Town (UCT) and were reviewed in detail for data extraction. The following data were obtained from the database: the type of firearm used, projectile calibre, size of the entrance and exit injury, location of the injury, and blood alcohol concentration (BAC) in the deceased were recorded. The size of the firearm-related injury was reported as the size of the central firearm-related

defect and not the abrasion collar. Blood alcohol data were obtained from forensic toxicology reports.

All data were recorded in Microsoft Excel™ (Microsoft, WA, USA). In this study, the reliability and validity of data were ensured by applying the double-entry technique for data capturing. The supervisor analysed a random subset of cases to check that data was captured correctly. Cases with some missing data were stored in unique codes for maintaining data consistency.

3.4. Data analysis

All statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) Version 27.0. (Armonk, NY: IBM Corporation). The prevalence of firearm deaths and FRIs was calculated in terms of total unnatural death cases seen at SRM and per 100 000 population in the population which is approximately 1.9 million.

Descriptive statistics were computed for sex, ages, manner of death, location of body recovery, geographical location of the body at death, the day and month of death. Chi-squared tests of association were used to assess the association between categorical variables. Grouping of cases according to the geographical location was assessed by mapping the cases. In addition, cases in which data was missing or not clear for a specific analysis were excluded from the relevant analysis.

CHAPTER 4: RESULTS

4.1. Prevalence of firearm-related deaths

In 2017, 3 658 autopsies were conducted at Salt River Mortuary in Cape Town, South Africa. More men (75%, *n*= 2 743) were admitted than women (23%, *n*= 843). About 21% (*n*= 772) of these autopsies were firearm-related deaths and the prevalence of firearm-related deaths was 39.8/100 000 population of Salt River.

4.2. Demographics of firearm-related deaths

Firearm-related deaths were more prevalent in men (95%, *n*= 732) than women (5%, *n*= 40) in 2017 (Figure 4.1). The relative risk of firearm-related deaths among men was 5.62 ($p<0.001$), indicating the distribution is not due to the higher intake of men in the mortuary. Age was categorised into 6 categories, namely: 1-10 years, 11-20 years, 21-30 years, 31-40 years, 41-59 years, and ≥60 years. Figure 4.2 illustrates the total number of deaths in each age category. A large proportion of cases of firearm-related deaths (42%, *n*= 325) was recorded in the age group 21-30 years. This was followed by 27% (*n*= 208) in the age group 31-40 years and 14% (*n*= 109) in the age group 11-20 years. The age group 21-30 years accounted for the highest rates of firearm-related deaths (16.8/100 000 population) compared to the age groups 31-40 (10.7/100 000 population) and 11-20 (5.6/100 000 population).

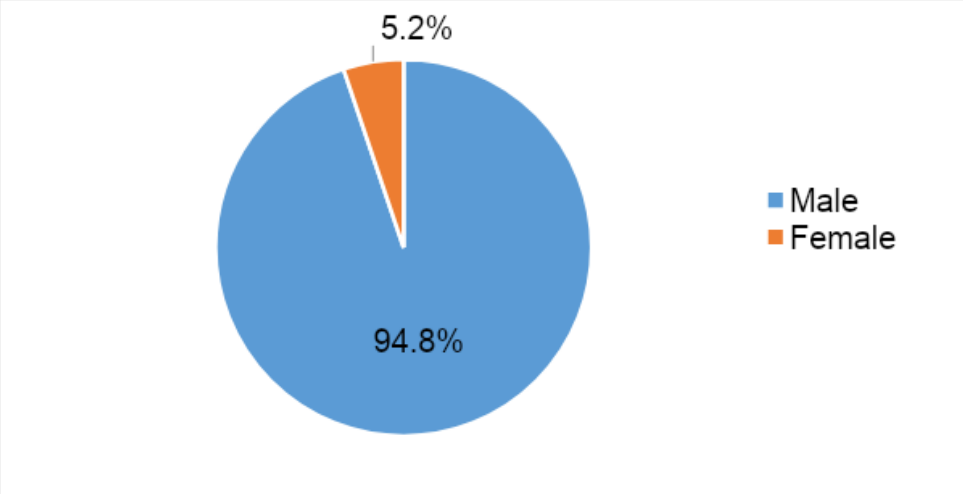


Figure 4.1. Percentage of firearm-related deaths assessed at the Salt River Mortuary in 2017, according to sex.

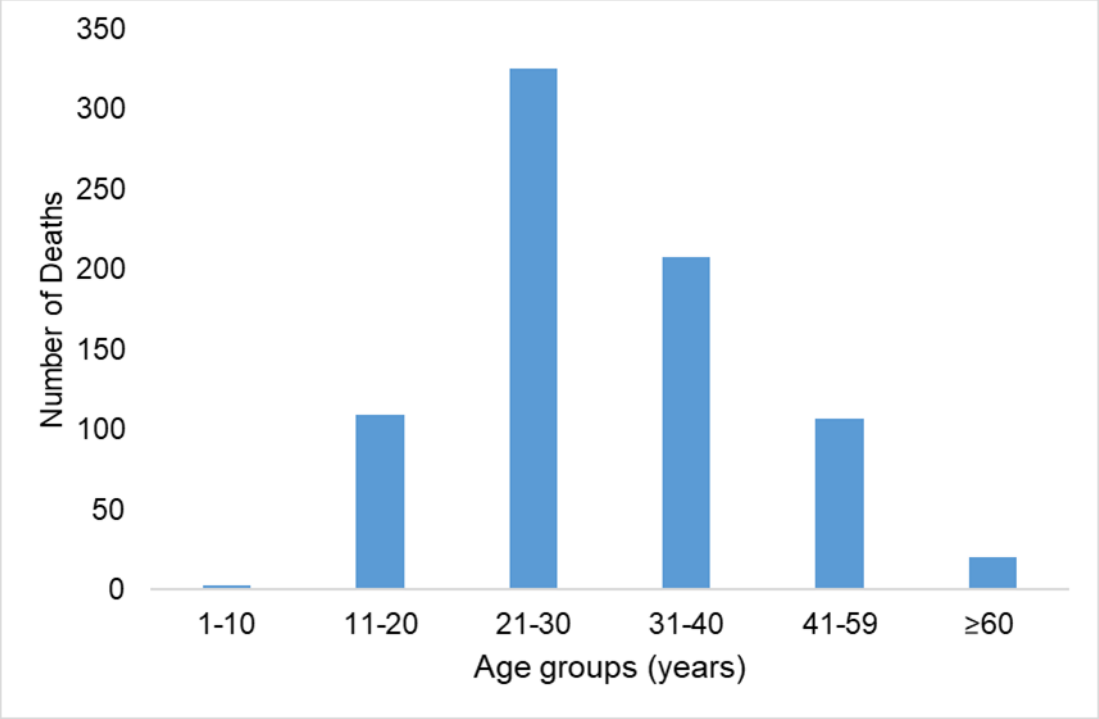


Figure 4.2. Distribution of firearm-related deaths assessed at the Salt River Mortuary in 2017, according to age groups.

Firearm-related deaths were distributed over a wide age range (Figure 4.2). The mean age was 31 years (sd = 10.77; range = 4-81 years).

The mean age in men was 31 years and in women was 33 years (Table 4.1). Statistical significance was tested for mean age in men and women using an independent sample t-test. The was no significant difference identified between mean age in men and women (p= 0.234). In this study, manner of death was representative of four categories: homicides, suicides, accidental shootings, and unknown. Homicide was the most prevalent manner of death, (97%, n= 751) followed by suicide (2%, n=19). More men were identified as victims of homicide (95%, n= 713) than women (5%, n= 38). In suicide cases, men accounted for 89 % (n= 17) compared to women (11%, n= 2).

Table 4.1. Frequency distributions of firearm-related deaths according to the sex, age, and manner of death at the Salt River Mortuary in 2017.

		Sex		***Total***
		Male	***Female***	
Mean age (SD) (Years)		31 (10.64)	33 (12.70)	***31 (10.77)***
Manner of death (n%)	***Homicide***	713 (97)	38 (95)	***751 (97)***
	Suicide	17 (2)	2 (5)	***19 (2)***
	Accident	1 (0.1)	0 (0)	***1 (0.1)***
	Unknown	1 (0.1)	0 (0)	***1 (0.1)***
Total		***732***	***40***	***772***
SD- Standard Deviation; n- number of individuals; %- percentage individuals. Percentages were calculated by columns.				

Accidental firearm-related deaths only occurred in one male in the sample. The statistical association was assessed between the manner of death and sex using a Pearson's Chi-square test. There were no significant associations identified between the manner of death and sex (p= 0.234).

4.3. Geographic and temporal localisation of firearm-related deaths

In this study, recovery locations were grouped into two categories namely: unknown incident scene (police stations, fire stations, ambulance admissions, undertaker

admissions, and medical centres) and known incident scene (residential property, public area, outdoor, vehicle) (Table 4.2).

Table 4.2. Body recovery location by manner of death for the scene of incidents.

Manner of death		***Known scene of the incident***				
		Residential property n (%)	***Public Area n (%)***	***Outdoor n (%)***	***Vehicle n (%)***	***Total n (%)***
Homicide	***n (%)***	156 (30)	27 (5)	293 (56)	32 (6)	***508 (97)***
Suicide	***n (%)***	14 (74)	1 (5)	2 (11)	1 (5)	***18 (3)***
Accident	***n (%)***	0 (0)	0 (0.)	0 (0)	0 (0)	***0 (0)***
Unknown	***n (%)***	0 (0)	0 (0)	0 (0)	0 (0)	***0 (0)***
Total		***170***	***28***	***295***	***33***	***526***

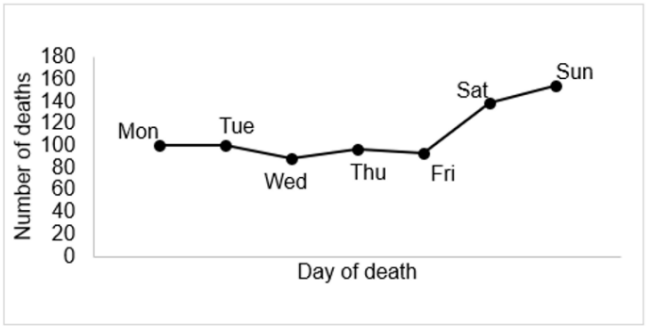
Manner of death		***Unknown scene of the incident***					
		Police Station n (%)	***Fire Station n (%)***	***Medical Centre n (%)***	***Ambulance admission n (%)***	***Undertaker admission n (%)***	***Total n (%)***
Homicide	***n (%)***	1 (0.5)	1 (1)	202 (95)	8 (4)	1 (1)	***213 (99)***
Suicide	***n (%)***	0 (0)	0 (0.0)	1 (100)	0 (0)	0 (0)	***1 (0.5)***
Accident	***n (%)***	0 (0)	0 (0)	1 (100)	0 (0)	0 (0)	***1 (0.5)***
Unknown	***n (%)***	0 (0)	0 (0)	0 (0.)	0 (0)	1 (100)	***1 (0.5)***
Total		***1***	***1***	***204***	***8***	***2***	***216***
Percentages were calculated by rows. %-percentage.							

In cases of firearm-related deaths at known scenes, a large proportion of cases occurred outdoors (56%, *n*= 293) followed by residential properties (30%, *n*= 156), and vehicles (6%, *n*= 32). Most deaths due to suicide occurred at residential properties (74%, *n*= 14) followed by outdoor scenes (11%, *n*= 2). There was only one accidental firearm-related death observed and it was observed in cases admitted to the medical

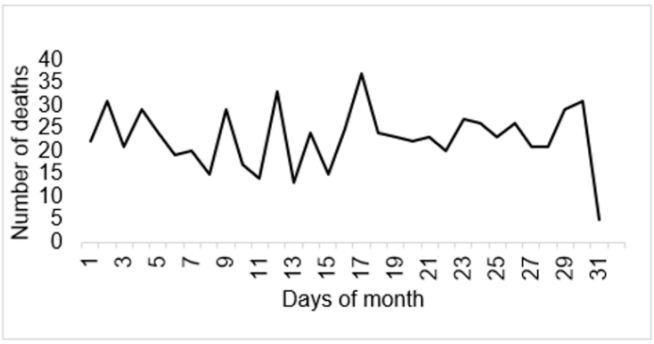
centre (100%, *n*= 1). The statistical association between the manner of death and the location of recovery was assessed using Pearson's Chi-square test. There were significant associations identified in the manner of death and the location of recovery (*p*= 0.000).

Trends in firearm-related deaths over days of the week, days of the month, and months of the year were examined. Approximately 62% (*n*= 479) of firearm-related deaths occurred during weekdays from Monday to Friday and 38% (n= 293) occurred during the weekend (Saturday-Sunday) (Figure 4.3 A). Firearm-related deaths occurred more commonly on Sundays (20%, *n*= 154) than Saturdays (18%, *n*= 139). Most deaths occurred on the 17th day of the month (5%, *n*= 27) and the lowest number of deaths was observed on the 31st day of the month (1%, *n*= 50) (Figure 4.3 B).

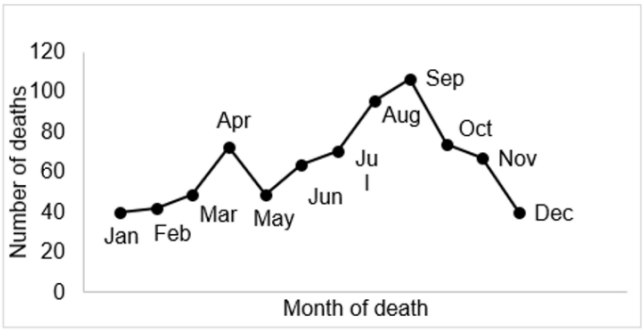
The distribution of firearm-related deaths over twelve months for one year was investigated (Figure 4.3 C). Most firearm-related deaths occurred in September (14%, *n*= 107) followed by August (12%, *n*= 96). The lowest number of deaths occurred in January and December, and during both months the same number of firearm-related deaths were observed (5%, *n*= 40). A rapid increase in the number of firearm-related deaths was identified in May and September 2017. A rapid decrease in the number of deaths was detected from September until December 2017.



A: Changes in the number of firearm-related deaths over days of the week.



B: Changes in the number of firearm-related deaths over days of the month.



C: Changes in the number of firearm-related deaths over 12 months.

Figure 4.3. Trends in firearm-related deaths plotted relative to days of the week (A), days of the month (B), and months of the year (C) at Salt River Mortuary in 2017.

Figure 4.4 illustrates the distribution of firearm-related deaths according to geographical regions. A large proportion of cases occurred in the regions of Mitchells Plain (18%, *n*= 108) followed by Philippi (17%, *n*= 106), Nyanga (12%, *n*= 75), Hanover Park (8%, *n*= 49), Gugulethu (8%, *n*= 48), Manenberg (5%, *n*= 29), Atlantis (4%, *n*= 26), and Lavender Hill (2%, *n*= 22) (Figure 4.3). It was noted that in other regions the number of firearm-related deaths was comparatively low (0.2%, *n*= 1).

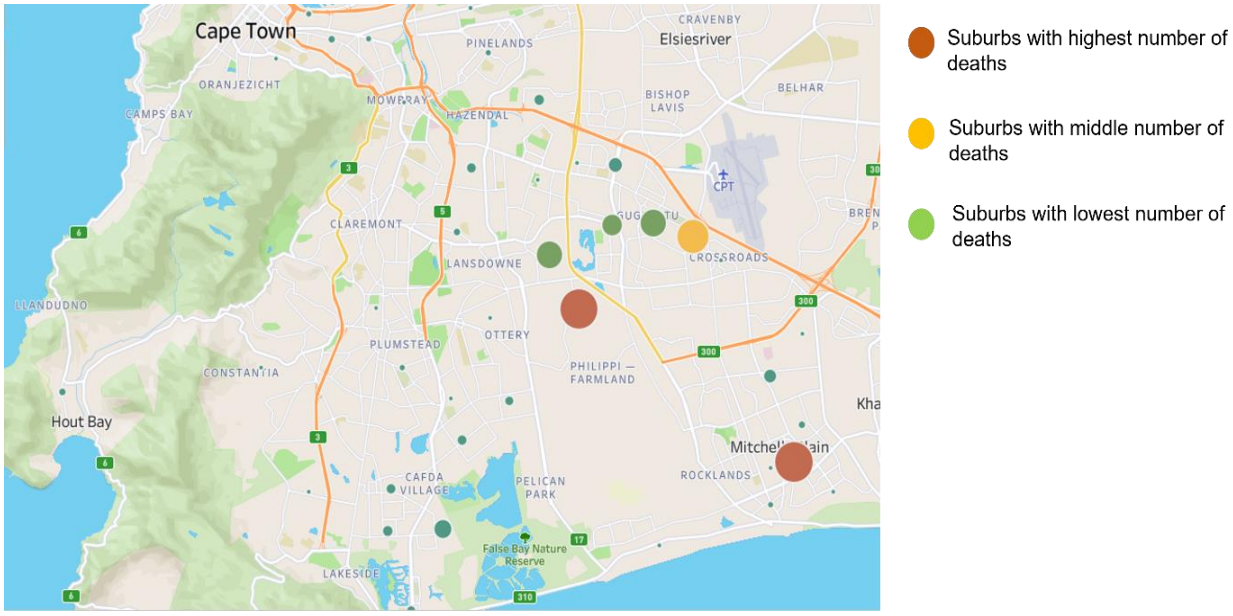


Figure 4.4. Geographical distribution of firearm-related deaths examined at Salt River Mortuary in 2017. The prevalence of deaths due to firearms are represented on the map using red circles. The highest number indicates areas with 100 or more firearm-related deaths, the middle number indicates areas with firearm-related deaths between 50 and 100, and the lowest number indicates areas with less than 50 firearm-related deaths (map created using Tableau version 2020.1).

4.4. Anatomical localisation of firearm-related injuries

The weapon used was known in 53% (*n*= 408) of cases. Of these cases, a handgun was used in 99 % (n= 403) of the total cases followed by shotguns (1%, *n*= 3) and machine guns (0.5%, *n*= 2) (Table 4.3). The projectile/projectile fragments were retrieved in 48% (*n*= 349) of the cases at autopsy. The projectile calibre was known in 52% (*n*= 402) of cases. The 9mm calibre was the most common type of projectile calibre used handgun (95%, *n*= 384) followed by the 9.652mm calibre (3%, *n*= 12).

Table 4.3. The total number of weapon types and calibre size.

Weapon Type	***Projectile calibre***						
	9mm n (%)	***5.58mm n (%)***	***9.65mm n (%)***	***11.43mm n (%)***	***7.5mm n (%)***	***Unknown n (%)***	***Total***
Handgun n (%)	384 (95)	0 (0)	12 (3%)	3 (1)	0 (0)	4 (1)	***403***
Shotgun n (%)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (100)	***3***
Machine Gun n (%)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (100)	***2***
Unknown n (%)	75 (21)	1 (0.3)	1 (0.3)	0 (0)	1 (0.3)	286 (79)	***364***
Total	***459***	***1***	***13***	***3***	***1***	***295***	***772***
Percentages were calculated by rows. mm-millimetre; %-percent.							

Only external (entry and exit injuries) injuries were considered for analysis. A total of 4 631 injuries were recorded and analysed across the 772 cases. This was divided into 2 482 entrance injuries and 1806 exit injuries. The average number of injuries per case was 3 (range= 18-1) for entrance injuries and 2 (range= 15-1) for exit injuries. Out of 710 cases analysed, cases in which a single injury was observed accounted for a large proportion (35%) followed by cases in which more than five injuries were observed (27%) (Figure 4.5). Out of the total entrance and exit injuries, entrance injuries accounted for a larger proportion on both the head (13%, *n*= 577) and the upper limbs (12%, *n*= 509) compared to exit injuries to the head (9%, *n*= 382) and upper limbs (10%, *n*= 430) (Figure 4.6).

The association between the number of entrance wounds and manner of death by the location of projectile wound was performed. All suicides had single-entry wounds. Injuries to multiple locations were observed for homicide. All injuries in suicide cases (n=19) were directed at the head and chest. Head injuries (95%, n=18) accounted for greater proportion compared to the chest (5%, *n*=1).

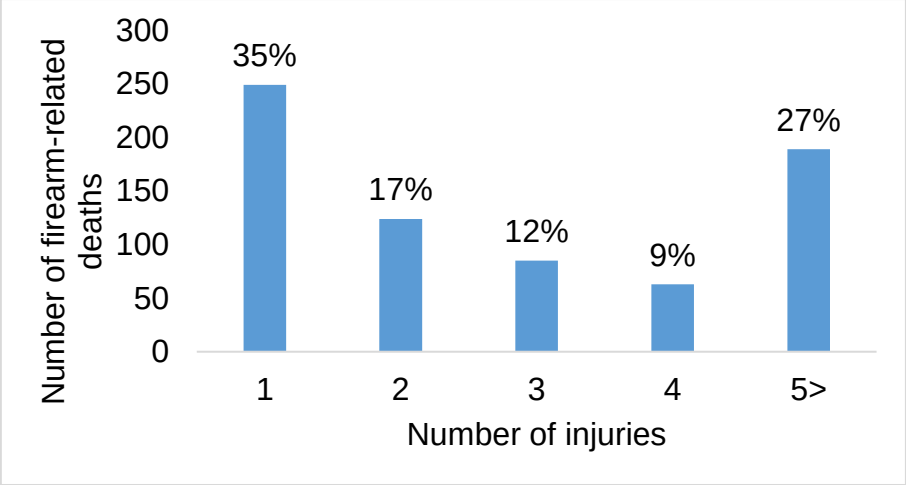


Figure 4.5. Distribution of the number of injuries in all cases observed.

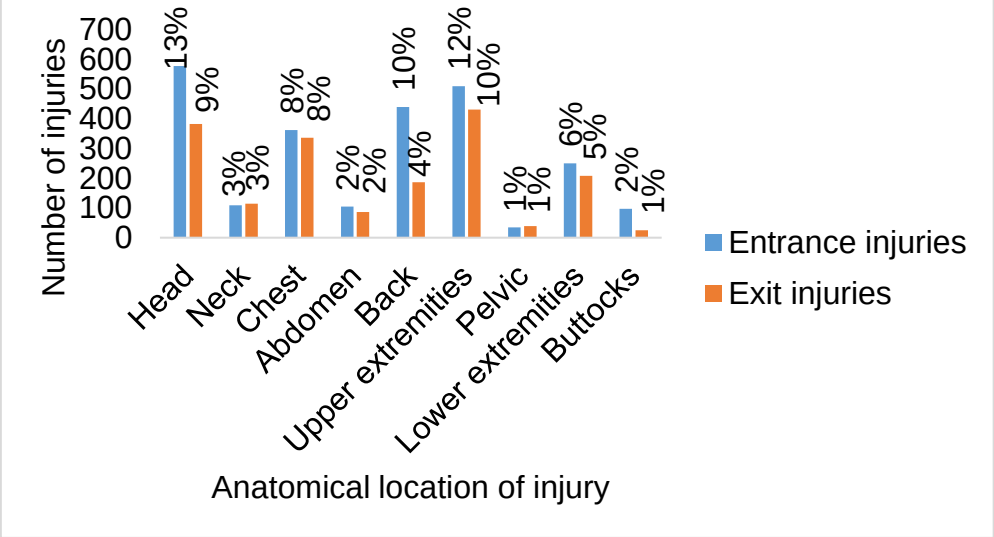


Figure 4.6. Percentage anatomical distribution of firearm-related entrance and exit injuries.

For homocides, the location of projectile injuries was categorised into injuries to the head, neck, chest, abdomen, back of the body, pelvic, buttocks, upper limbs, and lower limbs. A higher number of injuries were inflicted on the upper limbs (23%, *n*= 1056) than the head (22%, *n*= 1013) and the chest (16%, *n*= 749) (Figure 4.7). The lowest injuries observed were inflicted to the pelvic region (2%, *n*= 86) and buttocks (3%, *n*= 129).

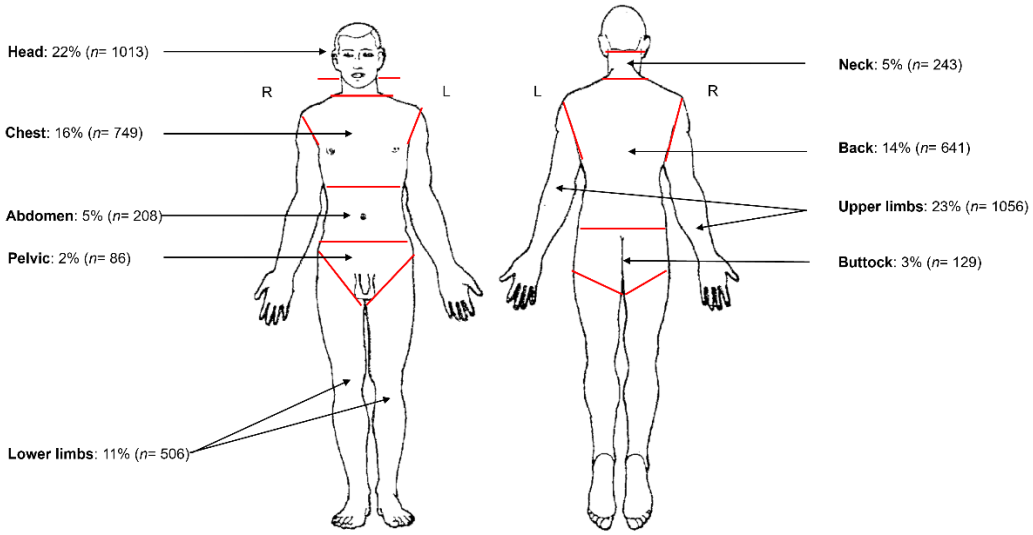


Figure 4.7. Percentage anatomical distribution of firearm-related injuries.

In this study, different projectile injury shapes were observed. Projectile injury shapes observed included circular, oval, rectangular, slit-like, elliptical, and stellate. Injuries that appeared round (56%, *n*= 906) were most common followed by Projectile injuries that appeared oval (20%, *n*= 313), and irregular in shape (11%, *n*= 179) (Figure 4.8).

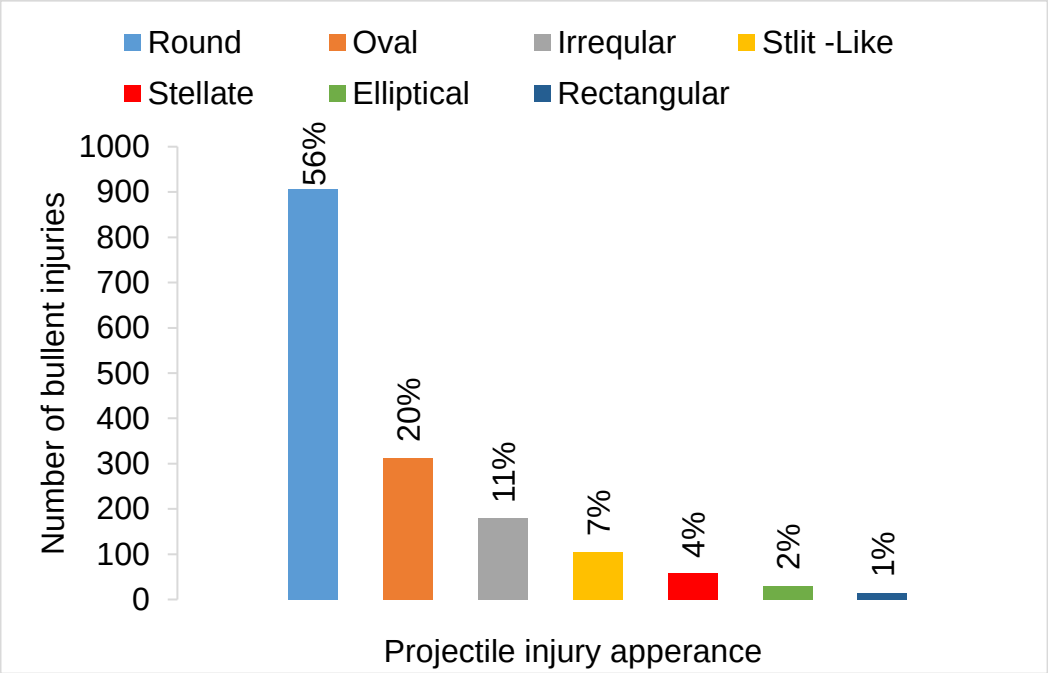


Figure 4.8. Distribution of the shape and appearance of the projectile injury.

The mean entry injury size (7.27mm (SD=0.71)) was significantly smaller than the mean exit injury size (11.50 mm (1.30)) ($p \leq 0.0001$) (Table 4.4). This was detected for all regions, and, notably, the exit and entrance injury sizes of injuries in the head were larger than any other region assessed. ($p<0.005$).

Table 4.4. Mean entry and mean exit firearm-related injury size according to an anatomical region.

Anatomical region	***Mean entrance injury size (SD) (mm)***	***Mean exit injury size (SD) (mm)***
Head	8.11 **(**8.55)	13.96 (10.69)
Neck	7.07 (4.30)	12.32 (13.48)
Chest	6.99 (4.38)	11.13 (14.14)
Abdomen	7.24 (3.54)	10.07 (4.71)
Back	6.83 (5.32)	9.99 (5.74)
Pelvic	7.80 (4.02)	12.53 (12.21)
Buttocks	5.79 (2.55)	10.34 (5.84)
Upper limbs	7.73 (7.30)	11.62 (11.44)
Lower Limbs	7.87 (6.14)	11.52 (6.49)
Mean Average	***7.27***	***11.50***

4.5. Blood alcohol analysis

The association between blood alcohol level and firearm-related deaths was assessed. Blood alcohol analysis was requested in 86% (*n*= 667) of the firearm-related deaths in this study (Table 4.5). Blood alcohol was positive in 30% (*n*= 184) of cases analysed.

Table 4.5. The total number of tests performed, and specimens collected.

Blood alcohol test	***Type of specimen***			
	Blood	***Vitreous humour***	***None***	***Total***
Yes n (%)	665 (99.7)	2 (0.3)	0 (0)	***667***
No n (%)	0 (0%)	0 (0%)	105 (100)	***105***
Total	***665***	***2***	***105***	***772***
Percentages were calculated by rows.				

In this study, blood alcohol concentration (BAC) was divided into three categories namely: 0.00 g/100 mL, 0.01-0.04 g/100 mL, and ≥0.05 g/100 mL. The mean blood alcohol concentration was 0.04 g/100 mL (SD=0.08). Out of the total cases where blood alcohol analysis was performed 70% (*n*= 423) had a BAC of 0.00 g/100 mL, followed by 0.01-0.004 g/100 mL (5%, *n*= 32), and >0.05 g/100 mL (25%, *n*= 153) (Figure 4.9). Thus, it is evident that a large proportion of victims who suffered firearm-related death in this study tested negative for alcohol.

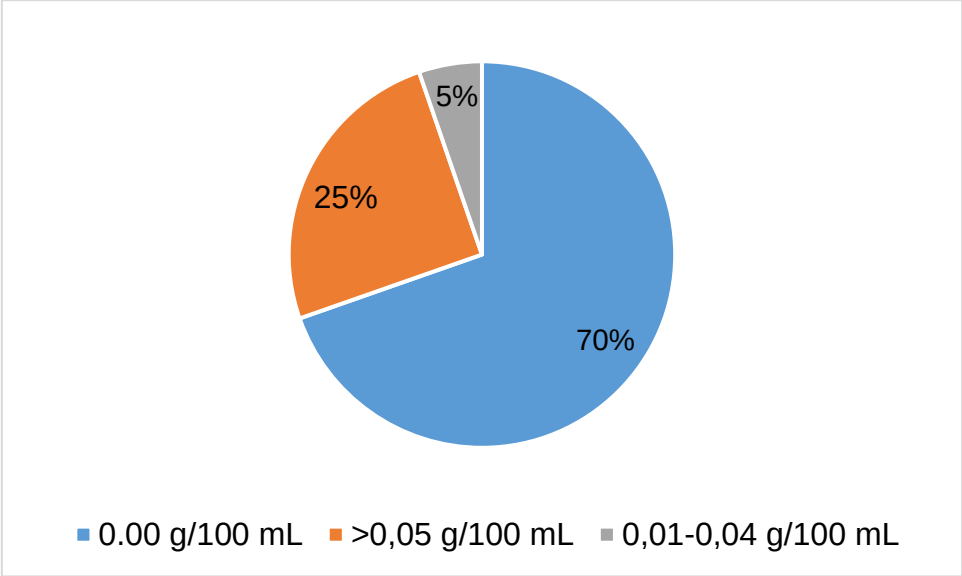


Figure 4.9. Distribution of blood alcohol concentrations by alcohol groups.

The highest number of autopsy cases with a BAC of 0.00 g/100 mL was observed in homicide cases (70%, *n*= 414) followed by suicide (56%, *n*= 9). It was also noted the number of suicide cases with a BAC of 0.00 g/100 mL (53%, *n*= 9) was higher compared to suicide cases with a BAC of 0.05 g/100 mL (41.2%, *n*= 7) (Table 4.6). The statistical association between alcohol categories and manner of death was performed and there was no statistical association observed (*p*= 0.239).

Table 4.6. Distribution of alcohol per alcohol level and manner of death.

BAC (g/100 mL)	***Manner of Death***			***Total***
	Homicide	***Suicide***	***Accident***	
0.00	414 (70%)	9 (53%)	0 (0.0%)	***423***
0.01-0.04	31 (5%)	1 (6%)	0 (0.0%)	***32***
>0.05	145 (25%)	7 (41%)	1 (100%)	***153***
Total	***590***	***17***	***1***	***608***
Percentages were calculated by column.				

CHAPTER 5: DISCUSSION AND LIMITATIONS

5.1. Discussion

Firearm-related injuries are a burden accounting for a large proportion of unnatural deaths worldwide. According to Van der Spuy (1996) violence was the leading contributor to fatalities and accounted for 34.3% of all trauma fatalities in SA in 1996. In the Cape Metropole, violence accounted for 53.2% of all trauma fatalities (Van der Spuy, 1996). An epidemiological study based on the analysis of trauma cases admitted to Groote Schuur medical centre indicated that out of 8 445 trauma cases admitted, 35% were due to violence (Schuurman *et al*., 2015). The aim of our study was to investigate fatal firearm-related injuries in forensic cases admitted to Salt River Mortuary, Cape Town, Western Cape. A retrospective, cross-sectional survey of autopsy records at the SRM was used to assess the demographics and distribution of firearm-related deaths in the Cape Town Metropole.

The rate of firearm-related deaths was 3.4/100 000 population globally in 2016 (Naghavi *et al*., 2018). In that year in SA, the rate of firearm-related deaths was double the global rate at 6.9/100 000 population (Naghavi *et al*., 2018). At SRM, in 2017, the rate of firearm-related deaths was 39.8/100 000 population. When comparing this rate to the global rate and the rate reported for SA in 2016, it was noted that the prevalence of firearm-related deaths reported in this study was considerably higher than both the global and the national rates. The rate of firearm-related deaths in the current study exceeds that reported in 2013 (24.2/100 000 population) and is greater than that reported between 2001 and 2005 in Pretoria (15.9/100 000 population) and Port Elizabeth (16.2/100 000 population) (Matzopoulos *et al.,* 2014; Matzopoulos *et al*., 2018). It could be suggested that the higher rate of firearm-related deaths in Cape Town compared to the other major cities in SA could be associated with gang-related activity. In the Western Cape, especially Cape Town, gang-related violence involving firearms contributes significantly to the number of mortalities and is the likely reason for the higher prevalence of FRIs (Mlamla, 2020).

Most studies into firearm-related deaths in Cape Town mainly focused on firearm-related homicide. The rate of firearm-related homicides in Cape Town has been fluctuating since the implementation of the FCA in 2000 its full application in 2004.

Matzopoulos *et al*. (2018) found that firearm-related homicide increased annually by 13% from 1994 through 2000. Later in 2003, firearm-related homicide decreased annually by 15% and since 2010, there was a 21% increase in firearm-related deaths (Matzopoulos *et al*., 2018). In this study, firearm-related homicide was more common than any other manner of death. It may be suggested that the higher rates of firearm-related homicide are linked to gang-related activities in the Cape Flats. Previously, it has been reported that the largest number of gang-related activities are predominant in the Cape Flats with an estimate of 100 000 gang members (Cruywagen, 2021).

The most severely affected suburb was Mitchells Plain. In this area, the population is densely packed, and the people experience economic and social hardship (Haefele, 2011). Factors such as poor socioeconomic conditions, drug abuse, gang-related activity and drug trafficking are predominant in this region and may all contribute to the higher rates of interpersonal violence in the community (Haefele, 2011). Some of these incidents may have been linked to sporadic protests or taxi-related killings but exploring the link between social unrest and FRIs was beyond the scope of this study. Several studies have investigated the association between the manner of death and FRIs. A study investing the association between the purchase of firearms and manner of death indicated that the risk of homicide was higher in firearm owners than suicide (Cummings *et al*., 1997). While the association between FRIs and geographic localisation of homicides seen in our study may be linked to family history of gun ownership, the abundance of unregistered firearms in SA makes confirming this challenging.

The spatial location of death may depend on the events surrounding shootings in this study. The fact that most cases of firearm-related deaths occurred outdoors suggests that firearm-related deaths are more likely to be caused by individuals that are outside their homes than those in their households (i.e. possibly not related or known to the deceased). Furthermore, this finding suggests that the perpetrators are most likely outside their homes in the community.

The demographic of firearm-related deaths for sex and age were assessed. In this study, firearm-related deaths were most prevalent in men compared to women (male/female ratio=19:1). The proportion of firearm-related men victims (95%) was greater than the admission proportion of both men (75%) and women (23%), and is

an indication that men are likely to be victims of FRIs than women. These findings are consistent with previous studies (Werbick *et al*., 2021; Onuminya & Ohwowhiagbese, 2005). In addition, according to a small arms survey by the World Health Organisation (WHO), a higher number of firearm-related deaths was identified in men (80.0%) than women (WHO, 2001). Another study conducted in Nigeria reported that firearm-related deaths were more prevalent in men (92.1%) than women (7.9%) (male/female ratio=12:1) (Onuminya & Ohwowhiagbese, 2005). According to an injury mortality survey conducted in 2017, firearm related homicide was greater in males (33.4%) compared to females (25.5%) (Prinsloo *et al*, 2022).

Men are at a higher risk of firearm-related homicide than firearm-related suicide. In this study, a firearm-related homicide occurred mostly in men (94.9%) compared to women (4.3%). In firearm-related suicide deaths, men accounted for 89.5% compared to women (10.5%). Approximately 7 (2%) in 732 men and 2 (5%) in 40 women were victims of firearm-related suicide, suggesting woman are at greater risk of suicide by firearm than men. These findings are consistent with an injury mortality survey conducted in 2013 in which it was reported that men accounted for the higher number of firearm-related deaths in homicide followed by suicide compared to women (Matzopoulos *et al*., 2013).

Given that gang-related violence is likely linked to this and more men than women are involved in gun-related gang incidents in SA, this finding suggests that men are likely both the perpetrators and victims of firearm-related violence. This differs somewhat from other public safety pandemics, like sexual assaults and physical assaults where women are more frequently victims of these attacks. Several psychological studies suggest that men are commonly more risk-averse and are less deterred by life-threatening situations than women (Campbell, 1999; Kerr & Vlaminkx, 1997; Pawlowski *et al*., 2008). Furthermore, men may take greater risks than women and are more likely to respond to alleged threats aggressively than women, thus altercations may escalate to the level of gun violence (Mäkitie & Pihlajamäki, 2002).

As young men become gang members their loyalty to civil society and the justice system is replaced by loyalty to the gang. According to Wegner *et al.* (2016) young men have only been involved in gang-related activities in the hope of achieving improved financial status, gaining a sense of belonging and desire for identity and

greater social power within one's community. While the reasons that young men commonly engage in gang-related activities differ, it is believed that this is directly linked to the violent culture of masculinity in many low-income areas in SA. Research suggests that gang-related violence is closely linked to toxic masculinities and institutionalised violence. Toxic masculinities are views about masculinity and manhood that are harmful to men and those around them (women, children, and other men) (Ndhlovu & Tanga, 2021). A study into gun-related violence in an informal settlement in SA found that in the absence of socio-economic opportunities, recreational facilities and cultural networks, many men use the powers provided by gangs to enact masculine norms of power, control, and aggression (Ndhlovu & Tanga, 2021).

Firearm-related deaths occurred in all age groups in this study, although they were most prevalent in young adults (21-30 years) compared to the young (1-10 years) and elderly adults (≥60 years). These findings are consistent with previous studies which found that young adults were more likely to be victims and perpetrators of FRIs (Baliso *et al*., 2019; Chalya *et al*., 2011; Naghavi *et al*., 2018; Prinsloo, Matzopoulos & Sukhai, 2003). Young adults have been found to engage in more risky behaviour (Galambos & Tilton-Weaver, 1998). In Irrua (Nigeria) for example, the age group 21-30 years accounted for the higher number (48.7%) of firearm-related deaths compared to other age groups, and the lowest number was observed in the age group 0-10 years (1.3%) and ≥60 years (1.3%) (Onuminya & Ohwowhiagbese, 2005). In SA, the fact that young adults are prone to death could be linked to unemployment and psychological desire for acceptance (Sammour, 2013).

The demographics of firearm-related deaths for the day of the week, day of the month, and the month of the year were explored. In this study, firearm-related deaths were consistent during the week (62%) with the increase of cases over the weekend. Similar trends have been observed in another study on FRIs in Durban (Shamase *et al*., 2021). In our study, most cases of FRIs occurred on a Sunday (20%), which differed from Shamase *et al*.(2021) who found most FRIs on Saturdays. It could be suggested that this trend is due to increased movement of people to places of employment from Monday to Friday compared to weekends, resulting in a smaller probability of interpersonal violence during the weekdays than at weekends. Several have

speculated the role of alcohol in interpersonal violence reported more commonly on weekends in Cape Town. (Shamase *et al*., 2021).

During the weekend most people are intoxicated, and violence is expected to be higher. Approximately 67% of domestic violence incidents reported on weekends in the Cape Town Metropolitan area are suspected to be related to alcohol (Rwafa, 2016). Surprisingly, our study found no significant association between BAC and firearm-related deaths. It may be suggested that when most people are off duty and at home on weekends the probability of violence is higher.

Although socioeconomic factors are strongly associated with FRIs, alcohol is another factor that is associated with FRIs (Branas *et al*., 2016). Branas *et al*., (2009), identified that individuals who are heavy consumers of alcohol are 2.67 times more likely to be victims of FRIs than non-consumers of alcohol. In addition, alcohol consumption was found to be associated with a higher risk of suicide (Branas *et al*., 2011). The fact that alcohol-related homicides in Cape Town occur more commonly due to stabbings than shootings, may suggest that other factors such as socioeconomic conditions, gang-related violence may contribute more significantly to FRIs (Branas *et al*., 2011).

In addition, most firearm-related deaths occurred in the middle of the month compared to the end of the month. It was difficult to assess this trend because there are limited studies concerning the monthly incidence of FRIs. Firearm-related deaths spiked in September (14%) and then decreased rapidly until December. This trend may be attributed to the drought conditions experienced in the Cape Town Metropolitan in 2017. Due to the drought, severe water restrictions were imposed in various regions, the burden of which was felt disproportionately by those in informal settlements and townships who were limited in the litres of water they could collect on a daily basis (South African Government, 2015). The prevalence of firearm-related deaths in Cape Town may be due to increased social tensions and socioeconomic pressures experienced due to the drought in 2017.

Our study found that handgun was the most commonly used weapon in firearm-related death, with the 9 mm projectile calibre most frequently recovered. As expected, machine guns and shotguns FRIs were rare events, and it is likely due to limited access of these weapons to civilians in SA (Bopape, 2008). No cases involving hunting rifles were observed. It should however, be considered that the current study

investigated a metropolitan area. In more rural areas or other provinces this pattern may be altered due to the increased potential of farmers owning shotguns/rifles. The findings in this study are consistent with a study that indicated that handgun was the most common type of firearm used with the 9 mm calibre in all types of manner of deaths (Matzopoulos *et al*., 2016; Solarino *et al*., 2007).

Our study found that more round and oval-shaped gunshot wounds than slit-like or stellate wounds were detected. The shape of a firearm-related injury may be related to either the entry or exit injury. As round and oval injuries are common in near, intermediate, and distant ranged gunshots, little can be deduced from the shape of the injury in our study (Quatrehomme & İşcan, 1998).

The anatomical location of the firearm-related injury is somewhat related to the nature of the incident. In this study, firearm-related injuries were most common in the upper limbs. In contrast, a study investigating the anatomical location of FRIs indicated that the most commonly affected anatomical site of firearm-related injuries is the lower limbs (Bäckman *et al*., 2018). In addition, the head was the second most affected anatomical location. In the West Metropole of Cape Town, firearm-related gang activity is commonly violent and the battle for control over territories leads to murders. The fact that FRIs were mostly localised to the head and upper limbs may be an indication of the intent to commit homicide or suicide (Suwanjutha, 1988). However, the range of gunshot which may be an indication of execution style shooting was not investigated in this study.

Firearm-related violence became one of the leading causing of death in Cape Town. Individuals are at a higher risk of losing their lives as a result of illegal possession, ease of access and improper use of firearms. In addition, illegal selling of firearms by corrupt police officers may lead to increased access to firearms and consequently increased rates of firearm-related deaths (Baadjies, 2015; Serrao, 2013; Serrao, 2015; Serrao & Maphumulo, 2013). Although some police officers are killed by criminals with the intention of stealing the firearm (Noxhaka, 2019). As previously mentioned in the literature review, the FCA was implemented with an intent to strictly regulate and limit firearm ownership to decrease FRIs.

With the recent increase in FRIs in Cape Flats, it is evident the FCA is not effective and efficient in decreasing firearm-related deaths. It could be because it targets mainly

legal firearms and does not consider illegal firearms which are more commonly used to commit crimes than licensed firearms. Since the implementation of the FCA, the process of acquiring a firearm is long. As a result, firearms tend to be acquired illegally (Sammour, 2013). It is thus, important to implement stricter and more active policing in areas where FRIs are common to decrease the rates of firearm-related deaths. Our findings suggest that increasing policing of these areas on Saturdays and Sundays may significantly impact firearm-related deaths which are more common on weekends. Previous studies have indicated a decrease in firearm-related deaths after the implementation of the FCA (Campbell *et al*., 2013; Matzopoulos *et al*., 2016; Matzopoulos *et al*., 2014). However, that was not the case in the current study as there was once again an increase in the rate of firearm-related deaths.

5.2. Limitations

This study was retrospective and involved the collection and review of autopsy records from the database from a single mortuary. Human error may cause inaccurate capturing of data on the database. The data is based entirely on the Forensic Pathologist's observations and it may not always be accurate. The data from the database may be captured incorrectly as a result of human error and it may not always be accurate as it depends entirely on the Forensic Pathologist's observations. This limitation was addressed by double-checking data in the database with that in the autopsy report and subsequent double-entry validation for data extracted in this study.

Many of the cases in this study were still under investigation and awaiting prosecution. As a result, there was limited information available and accessible about the location of the incident and manner of death. The distance of gunshots and the nature of the FRIs could not be compared because data on the distance of the gunshot based on the size, shape and tattooing of the entrance wound was not collected. Data regarding survival time in hospital and drug test was not collected and it was therefore not possible to analyse such characteristics. Future work into the correlations between these factors in reported autopsy reports and presented in investigation dockets may yield interesting results. It is acknowledged that the current study only focused on one year, thus the trends of firearm-related deaths in this study may not be a true representation of these trends over multiple years.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

Firearm-related injuries may pose a long-term challenge to the health care system, the safety of civilians, and the economy. Few studies in SA or Cape Town have investigated the demographic, geographic, temporal, and anatomical characteristics of FRIs. The current study has investigated the prevalence of FRIs, and the characteristics of those injuries across all age groups in both men and women in the western metropole of the City of Cape Town over one year from 1 January 2017 to 31 December 2017. The findings in this study indicated that firearm-related deaths are prevalent in densely packed suburbs with poor socioeconomic status. The higher number of deaths occurred outdoors and were most prevalent in men and young adults.

With regards to the anatomical site of implication, firearm-related injuries were higher in the upper limbs followed by the head region, suggesting the intent commonly being a fatality. Further work is needed to characterise the range and type of shootings that cause deaths seen in mortuaries in the Western Cape. Handgun, with a 9 mm calibre, was the most used weapon to inflict injuries. Although firearm legislation has been implemented in the past to control the availability and use of firearms, our study suggests that firearm-related deaths remain common, and the impact of firearms is still felt in SA.

The reduction of FRIs requires more active policing in areas where the rates are higher. Our study reported an increased prevalence of FRIs on Mitchells Plain more commonly occurring on Saturdays and Sundays. Active policing of firearms in these areas on high-risk days may significantly reduce the frequency of FRIs. Firearm-related injuries are likely to be reduced if measures to address factors such as gang-related activities, unemployment and overcrowding are implemented. The government should ensure that the public are well-informed about the risks of firearms, how to protect themselves from shootings and how to report the possession of illegal firearms in their communities.

It is also important for the information surveillance systems to carefully capture data relating to all firearm-related deaths. This could be achieved by the proper interaction between different parties (i.e., SAPS, Forensic Pathology Service, Healthcare system,

etc) to ensure that data regarding each case is exchanged, captured, and stored. Without reliable surveillance, it is difficult to assess the risk and therefore, difficult to implement preventive measures within the affected regions.

Future research should be conducted to further investigate FRIs over several years in SA and Cape Town. Factors such as the day of the week, day of the month, and month of firearm-related death should be investigated in detail to provide a clear understanding of the trend of these injuries. In addition, future research must focus on preventive measures for regions at higher risk of FRIs. Lastly, researchers should investigate FRIs across high-risk regions across SA to inform public safety and policing measures.

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APPENDICES

Appendix A: Ethical approval certificate

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room G50- Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6492
Email: hrec-enquiries@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

25 June 2020

HREC REF: 337/2020

Mr Calvin Mole
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Anzio Road
Observatory
7925
Email: Calvin.mole@uct.ac.za
Student: RMNJON002@myuct.ac.za

Dear Mr Mole

PROJECT TITLE: RETROSPECTIVE REVIEW OF GUNSHOT INJURIES AT SALT RIVER MORTUARY, WESTERN CAPE-MASTERS CANDIDATE-MR JONATHAN RAMONYAI

Thank you for submitting your application to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

This approval is subject to strict adherence to the HREC recommendations regarding research involving human participants during COVID -19, dated 17 March 2020.

Approval is granted for one year until the 30 June 2021.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the student: Mr Jonathan Ramonyai will also be involved in this study.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

Signed by candidate

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
NHREC-registration number: REC-210208-007

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use: Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH 2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI), and Declaration of Helsinki (2013) guidelines. The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.