Chapter 1

BACKGROUND AND STUDY OBJECTIVES

1.1 Introduction

In South Africa, firearm fatalities accounted for the greatest number of homicidal deaths in the year 2000, as well as in 2001, constituting 52 percent and 54 percent of all homicidal deaths, respectively (n = 8 395 [2000] and n = 11 254 [2001]). Suicidal gunshot events accounted for 34 percent of all suicidal deaths in 2000 (n = 1 782) and 29 percent of those in 2001 (n = 2 500), being one of the greatest causes of suicidal death, second only to death by hanging.[1, 2]

When law enforcement agents are called to a scene of a fatal shooting, one of the most important aspects to be addressed is mode of death (that is, whether death was suicidal, homicidal or accidental). Misjudgement of manner of death may cause severe problems and can have far-reaching effects on payments of insurance money, research, and justice. The underreporting of suicides and homicides have already been reported, for example, in cases where suicides were classified as accidents to "make things easier" for the family and oftentimes to prevent an in-depth investigation that requires much input from already overburdened officers.[3, 4]

In South Africa, formal classification of mode of death is *not* the responsibility of the investigating officer, forensic pathologist, or forensic scientist, but rather that of the Court. The investigating authorities are responsible for supplying the Court with evidence, information, and opinions to assist the Court in making its decision.

Every piece of physical evidence must be collected from the scene, however insignificant it may seem. Unfortunately, the opinions of the investigating officers

regarding the manner of death may lead to subjectivity in detecting and collecting evidence. Crucial evidence may be then be overlooked.

The extremely high rate of unnatural deaths in South Africa inevitably leads to a heavily burdened police force. In South Africa – depending on the jurisdiction – detectives are expected to investigate up to one hundred new cases per month, which is an extremely elevated rate of new casework. This, together with the urgency of solving as many cases as quickly as possible, may cause crucial evidence to be overlooked if – at first glance – the manner of death seems obvious. In an effort to save time, or in misjudgement of the evidence at the scene of a shooting, erroneous interpretations may cause misjudgement of the manner of death.

In homicidal shootings deaths where the firearm were neatly placed in to the hand of the deceased, it would be easy for the inexperienced officer to conclude homicide as manner of death, when it was in fact suicide. Here, all other evidence must be analysed and interpreted.

Manner of death in fatal shooting incidences may also be *disguised*.

Suicides disguised as either homicide or accident will allow the family members of the victim to collect insurance money, and to escape the stigma attached to suicide (which may cause family embarrassment).[6] It may even be disguised by the deceased self to gain notoriety as a victim or to lay blame elsewhere.[6] Various other personal, religious, and social reasons may cause the concealment of firearm suicides.

Some homicidal firearm deaths may be concealed to suggest suicide or accident in an attempt to prevent the subsequent investigation into the identification of the perpetrator. It is therefore essential that *all* fatal shootings be investigated with objectivity and thoroughness to prevent wrongful classification of mode of death.

The *multivariate (forensiometric) model* has been developed in the late 1990's by Thor Karlsson[7], to be used as an expert aid in the discrimination between homicidal and suicidal firearm deaths. This model functions by assigning a value to each of fifteen aspects (variables) of a specific case. The variables are then ranked in falling order of correlation with either homicide or suicide.[7]

Some of the variables used in this model include the following:

- Muzzle-target distance (that is, the distance between the muzzle end of the barrel of a gun and the surface of the target).
- Anatomical location of entrance wounds.
- Location of the weapon after the fact.
- Age and gender of the victim.
- The presence of a suicide note.
- Bullet path through clothing.
- Location of body on the scene, etc.[7]

These variables should never be considered to possess evidential value as separate entities, but should always be used *in conjunction with one another*.

Assessment of shooting distance is perhaps one of the most significant components in the process of establishing the manner of death in a fatal shooting. Suicides are committed within contact or near contact range (approximately 97%), while 50% of homicides occur at distant ranges and approximately 75% of all firearm accidents occur at intermediate distances.[8, 9, 10] Determining the muzzle-target distance is therefore a vital tool used to facilitate the forensiometric process of excluding or proving homicide or suicide.

Confirmation of the muzzle-target distance being within contact range may be found in the medical and/or scientific arenas of forensic investigation.

The appearance of *gunshot wounds* can yield important information concerning the muzzle-target distance. However, in some cases it may be impossible to interpret muzzle-target distance based on the appearance of a particular wound. It then becomes imperative to evaluate additional physical evidence to identify the range of weapon discharge.

Examining the bloodstains and spatter at a scene, on or inside the barrel of a weapon or on the clothing of the victim and/or perpetrator can be instrumental in determining the distance of discharge[11, 12, 13], as well as in reconstructing the event.

Bloodstains and spatter from gunshot wounds are produced from both forward spatter (blood spatter laterally ejected from the exit wound) and back spatter (blood and other biological matter ejected in the contrasting direction as movement of the projectile).[14]

When a firearm is *discharged at close range* of the target surface, back spatter may be found on the shooting hand and/or weapon.[4] At intermediate and distant gunshot ranges, the shooting hand and weapon will be beyond back spatter range and will therefore be clear of blood droplets. (It is important to bear in mind that the absence of blood droplets on a firearm does not necessarily imply intermediate or distant firearm discharge. It is the *presence* of blood droplets that serve as confirmatory evidence.)

The *drawback effect* (or blowback effect) is a phenomenon seen mainly in contact and close-range gunshot wounds.[12] It refers to the process in which blood droplets are deposited *inside* the barrel of a weapon after discharge. The cause of this phenomenon has not yet been agreed to, but current theories include the increased pressure in the gunshot wound and the near vacuum in the barrel (created by the discharged gases escaping along with the projectile), which then creates a sucking effect that sucks blood and other biological tissue into the barrel.[15]

The distance that blood droplets and other biological tissue penetrate a barrel of a gun may assist the determination of the *precise distance* (down to one centimetre) between the wound and weapon at the time of discharge[15], but the real relevance of this information is debated[12], as the close proximity of discharge is already confirmed by the mere presence of blood.

A firearm discovered on the scene of a fatal shooting (especially where discharge distance is disputed) should therefore be carefully examined for the presence of blood spatter on the outside and on the inside thereof.

The importance of this information lies in the statistical fact that suicide acts seldom occur at distances greater than a few centimeters.[10] If the muzzle-target distance can be calculated within a certain range, it assists the reconstruction of the event and might facilitate the process of excluding homicide and accident as mode of death by forming part of the forensiometric analysis process.

The aim of this prospective analytical study was to determine the frequency of blood back spatter on the inside of barrels of firearms used in contact gunshot wound events in the Pretoria metropolitan area. In addition, any contributing factors that may have influenced the phenomenon of drawn back blood in the barrels, are discussed.

Problems encountered and some surprising results are also described

1.2 Literature Review

In South Africa, more people are killed with guns each year than by any other means. Suicide by firearm is the second most popular mode of suicide among South Africans.[1, 2] In the United States of America, the incidence of firearm suicides are much greater than all the other methods combined.[16]

Conversely, firearm-related deaths in Europe and Canada, for instance, are much more infrequent than in South Africa or the United States.[17]

A possible explanation for the extremely high rate of firearm deaths in America and South Africa may be the rate of gun ownership in these countries. In Europe and Canada, laws governing the possession of weapons are much more severe than in America, and consequently, there are only a few European families in possession of a firearm.[18, 19] The majority of gun owners in these countries are hunters who generally purchase long guns (that is, rifles and shotguns). As a result of this, the vast majority of suicidal firearm deaths in Europe and Canada are committed with rifles or shotguns.[7] In Sweden, for instance, the majority (35 percent) of all suicides are committed with shotguns. In Canada, 61 percent of suicides are committed with shotguns, and a mere 8 percent with handguns.[7, 18] In the United States, however, 75 percent of all suicides are committed with handguns, and only 25 percent with long guns.[10]

The United States of America has one of the highest rates of firearm suicide and homicide, as well as one of the highest rates of gun ownership in the world. Kaplan and Gering[20] performed a study during the late nineties on the differential impact of gun availability on firearm homicides and suicides in America. They discovered that elevated availability of weapons, and subsequent increased gun ownership, has a stronger impact on suicidal than on homicidal firearm deaths. The study suggested that ready availability of weapons in homes can be associated with increased risk of *suicide* by firearm. This suggestion is supported by separately performed studies[21, 22].

In the early eighties, Markush and Bartolucci[23] researched the statistical increase of suicide with increased gun availability and found a 3.0 per 100 000 population increase in the suicide rate per 10 percent increase in the household prevalence of firearms.

On account of the equally lenient gun laws in South Africa, combined with the notable number of stolen weapons circulating the streets of this country, it may be accepted that the high rates of firearm suicide and homicide in South Africa can be attributed to the high rate of gun ownership – whether legal or illegal.

To combat the increased level of firearm deaths, one may suggest reduction of the aggregate levels of gun availability, which may decrease the risk of gun-related deaths, and especially suicidal firearm fatalities.[20] However, this may have little impact on the vast number of fatal shootings in this country if the investigation of firearm-related deaths is not of highest quality.

When arriving at a scene of a shooting fatality, it becomes essential to detect and examine all aspects that will later clarify manner of death as suicide, homicide, or accident. Many cases of suicide are indisputable and obvious to both law enforcement and the victim's family. In a considerable number of cases, however, manner of death is not as apparent and requires scrupulous examination of all aspects of the case.[24]

The official number of firearm accidents that occur annually in any given country may not always reflect the true statistics, as some accidental shooting deaths are all too freely classified as being suicidal in nature, or vice versa. Lack of knowledge concerning the circumstances of the death, weapons, or a sincere attempt to ease the suffering of family and friends, may result in the wrongful classification of manner of death as an accident.[4]

The accurate classification of manner of death in all firearm-related deaths is of crucial importance. As previously mentioned, insurance companies, family members, and ultimately members of the general community will suffer if these deaths are falsely classified.

Bennett and Collins[24] performed an analytical study of all variables in alleged suicide cases to assist the forensic investigator, pathologist, and the court in accurately assigning cause and manner of death to a suicidal gunshot death. These variables included mutual histories, scenarios, demographics, risk factors, and methods of suicide. They examined age, sex, race of the victims, presence of a farewell letter, time of year, etc.

This study produced interesting statistics and pointed to definite tendencies in suicide by firearm. (In fact, a significant part of their findings correlated with those data produced by Thore Karlsson[7] in his development of the *forensiometric model*, as discussed in the following paragraph).

Earlier, in the late nineties, Thore Karlsson developed the distinguished multivariate "forensiometric" system of analysis.[7, 25] The objective of this *forensiometric model* was to aid the predictions regarding whether a certain fatality exhibits similarities to homicide or suicide. The model was created by complex multivariate projective statistical methods (PCA, PLS-DA) and logistic regression analyses.[25] It employs all available variables from an investigation in a mathematical formula to categorise the specific case as being either homicide or suicide. In this model, the variables are identified and ranked in falling order of correlation with homicide or suicide by firearm.[7]

The variables usually employed in the forensiometric model can be seen in ***Table 1.1***. The variables are arranged in falling order of correlation to homicide or suicide.

Table 1.1: The variables used in Karlsson's forensiometric model.[7]

HOMICIDE	SUICIDE
Other injuries than gunshot injuries	Firearm found close to the body
Entrance wounds in anterior aspect of the chest EXCEPT the precordium	Suicidal ideation
Bullet path through clothing	Victim's age
Entrance wound in the upper extremities	Contact entrance wounds
Female victim	Male victim
Entrance wounds in the abdomen	Suicide note
Entrance wounds in the head EXCEPT in the temples, mouth, and central forehead	Entrance wounds in the mouth, temples, and central forehead

*Entrance wounds in the back	

Continue*

It is clear that the main factors used in forensiometrics to determine manner of death include:

- *Muzzle-target distance* (that is, the distance between the muzzle end of the barrel of a gun and the surface of the target) – the vast majority of suicides are committed within contact range, accidents within close to intermediate range, and homicides within intermediate to distant ranges.[9]

- *Anatomical location of entrance wound* – sites of preferred suicide usually include the temples, mouth, and central forehead.[7]

- *Location of the weapon after the fact* – weapons are usually within reach of the body in cases of suicide and "weapon cleaning" accidents.[4, 7]

- *Age and gender of the victim* – males are more likely to commit firearm suicide, and – dependent on the country – the age range of individuals committing suicide with firearms also fall into a specific group.[7]

- *The presence of a suicide note* – though the absence of a farewell letter does *not* necessarily preclude suicide, the presence of a suicide note is strong indication of suicide.

- *Bullet path through clothing* – it has been found that a bullet path through clothing is more prevalent in homicides and accidents than in suicides.

- *Location of body, etc.* – the majority of individuals who commit suicide do so in the privacy of their homes, while the majority of homicides are committed outdoors.[7]

- *Bullet trajectory in the body* – research has found that the trajectory of the bullet can be valuable evidence in a shooting fatality. Suwanjutha[8] (1988) found that direction of a bullet's path in suicides are in an angle of elevation 77 percent of the time, while in homicides they are at a horizontal level 53 percent of the time.

It should again be emphasised that these variables should never be considered to possess evidential value as separate entities, but should always be used *in conjunction with one another*.[7]

The forensiometric model was formulated by compiling data from several police records, autopsies, and toxicology reports and the coherent information from these cases were defined using the projective multivariate analysis system. Consequently, when a new case of firearm-related death is investigated, each variable in the case is ranked according to the model and a mathematical value is assigned to each variable. If – after use of the model's formulae – the total value in the case exceeds 0.5, it is considered to be a homicide.[7]

Karlsson validated the model by employing forensiometric analysis in assigning mode of death classifications to a set of cases that were already classed as homicide or suicide following thorough police and medical examinations. All suicides were classified accordingly by the model and all the homicides, save two, were classified as such. Therefore, Karlsson deducted that his model exhibited 89 percent sensitivity and 100 percent specificity in classifying homicides.[7]

Even though the model may be highly advantageous in the investigation of homicide or suicide, a fixed model for accidental shooting fatalities has not been included in the study. Such a model would be of great assistance, as accidental firearm fatalities are likely to be under- or overreported.[4]

Estimating the *muzzle-target distance* is perhaps one of the most significant elements in the forensiometric model. Careful examination of gunshot wounds may yield important information regarding the range of weapon discharge. Suicidal gunshot wounds, for example, customarily exhibit features characteristic of contact or near contact weapon discharge, unless some device was present to reach the trigger from a greater distance.[10, 19]

However, differentiating between contact and distant gunshot wounds on the basis of examining features of entrance wounds may be hampered by the following factors:

- Decomposition of the body – blackish discoloration of the skin surrounding the defect may simulate or conceal soot deposition. Powder tattooing and soot may be lost if slippage of the skin occurs and dried blood around the edges of the entrance defect may also simulate partly burnt powder particles.[4]

- When a weapon is discharged within soot and smoke range and the projectile moves through clothing, the clothing usually filters out soot and gunpowder. The clothing may then not be available for examination or it may be blood soaked to such an extent that examination for soot and gunpowder becomes impossible.

- Drying of the edges of contact wounds with small calibre weapons may simulate soot deposition[26].

If conclusive information concerning the muzzle-target distance cannot be obtained from the entrance wound, special attention should be given to the *weapon* employed in the act, as it may also yield information pertaining to the range of fire. (It is suggested that such attention be given to the weapon regardless of the appearance of the wounds, seeing as though suicidal deaths are of the most disputed cases and all evidence should be collected for ensuing legal purposes.[27])

The weapon at the scene of a fatal shooting may be a great source of information. It may offer fingerprints or ballistic evidence indicating that the weapon was utilised in a previous crime. The location of the firearm with respect to the body, may also serve as further confirmation of suicide or exclusion of homicide. In addition to this, weapons may possess macro- or microscopic evidence of blood, either on the exterior aspect of the weapon, or on the inside.

Blood on the outside or on the interior of the barrel of firearms is positive evidence that the firearm in question was employed in a contact gunshot event.[10, 11, 12, 28] However, the forensic investigator should keep in mind that the absence of blood on or inside a firearm is *not* exclusive evidence that the weapon was not employed in a contact gunshot event, but is merely *confirmatory evidence* of a contact range discharge.

The question of how blood droplets reach the weapon situated in retrograde position of the entrance wound can be answered with considerable ease if one were to study blood droplets in flight.

Gunshot wounds are frequently associated with high-velocity blood spatter. This implies a high-velocity force (the projectile in flight) striking a source of blood (the body). High-velocity blood spatter generally presents as a mist-like spray of minute droplets, although droplets of greater diameter usually accompany the mist-like dispersion of blood. With the dynamic creation of entry and exit wounds, tiny high-velocity droplets (usually less than 0,1 mm in diameter) are transferred onto the surroundings.[29]

Blood spatter (including other biological material, such as bone and tissue) originating from an exit wound is known as *forward spatter* and generally travels in the same direction as the source of energy (exiting projectile).[29]

Similarly, ejection of biological matter from a gunshot *entrance wound* can also be observed. This ejection of blood, bone, and other tissue, occur in the opposite direction of projectile movement and is known *back spatter*. This back spatter is propelled towards the weapon and the shooter, and the presence of biological matter on a weapon is especially associated with close-range discharge of a firearm.[29] Factors creating no or diminished back spatter include gunshot wounds to the chest or abdomen, distant muzzle-target ranges, and clothing.[15]

The phenomenon of back spatter – consisting of both micro- and macro-back spatter – were extensively researched by Karger et al.[30, 31] in the mid-nineties. Macro-back spatter describes blood back spatter droplets with diameter of greater than 0,5 mm and micro-back spatter droplets with diameter smaller than 0,5 mm.

In their research they attempted to measure the distances of back spatter by shooting into the heads of nine live calves at distances ranging between 0 and 10 cm. They performed this experiment in duplicate. It was discovered that macro-back spatter could be detected at distances of 72 to 119 cm from the entrance wounds. Micro-back spatter occurred approximately 69 cm from the wounds. Both experiments were conducted with 9 mm Parabellum ammunition[30, 31].

Macro-back spatter is known to travel at greater distances than micro-spatter due to the former's greater mass[15].

It was also reported that, the greater the muzzle-target distance, the fewer the blood droplets and the shorter the distance that the back spatter droplets will travel in retrograde direction of the movement of the bullet. This confirms the close-range weapon discharge needed to produce significant back spatter.[30]

Type and calibre of weapon employed in a shooting also influence the presence of back spatter. Large calibre weapons and ammunition are more likely to produce large quantities of back spatter than smaller calibre firearms. [10, 11, 30, 31]

Karger et al. reported that possible *causes* of back spatter in especially gunshot wounds to the head, include the following:

- A rapid expansion of gas trapped between the elastic skin and the skull with resulting backwards stream of escaping gas.[28, 30]
- Increased intracranial pressures created by the temporary cavitation.[30]
- Tail splashing (blood retrogradely ejected when the projectile enters the body).[30]

Back spatter due to the gas effect will correspond to the maximum range of hot expansion in front of the muzzle, but that back spatter from the remaining two factors are independent of the shooting distance.[30]

The quantity of back spatter depends on a variety of ballistic and anatomical considerations. Some of these considerations include:

- Close range – back spatter occurs in greater quantities when the projectile enters the body within close range.[28]
- A gunshot into a liquid-filled cavity inside the body. [30, 31]
- A gunshot by large-calibre weapons and ammunition. [30, 31]
- The presence of a bony structure immediately beneath the skin (as found in the head with underlying skull), assisting the development of a pocket-like subcutaneous space.[32]

Karger et al.[30, 31] (1996) believed that back spatter is *not* – as previously believed – caused by the spin of the bullet or a momentary suction effect of the barrel aspiring material into the barrel of the weapon.

Although the research of Karger et al. elucidated the properties and significance of back spatter, it must be taken into consideration that certain anatomical differences

between the heads of calves and humans exist. Calves have a much smaller brain volume and a wider subcutaneous space than humans do and this might affect the ability to extrapolate the results on humans.

Stone[11] tested 397 firearms (discharged at contact or near contact range) for the presence of blood on and inside the barrels. He found that several variables influenced the positive finding of blood on or inside weapons. He noted that – as in the case of Karger et al.[30, 31] – the type and calibre of the weapon affected the outcome of the tests accordingly. For example, it was found that shotguns (a much more powerful firearm than a 9mm pistol, for instance) were more likely to have blood both on and inside the barrel and that the incidence of such blood being found increased as the calibre increased.

In later studies Stone[33] reported that other factors might significantly affect detection of blood on or inside the barrel of firearms. These factors include the presence of clothing or hair and the anatomical site of entry wounds[10].

In 1992 Stone[10] performed another study in which he recorded the presence of blood inside the barrels of weapons according to their type and calibre. It was again found that blood detection increased as calibre increased and that 53% of revolvers yielded positive tests for blood in the muzzles, compared to the 57% of pistols. He found that 85% of shotguns had blood inside the barrels and that 85% of rifles displayed positive tests for the presence of blood in the barrels, again proving the heightened probability of shotguns retaining blood.

Stone[10] confirmed the valid point first made by MacDonnell and Brooks[12] that presence of "drawn back" blood in the barrel of a handgun places that weapon within close range of the intended target.

In his research Stone also noted that the absence of blood inside the barrel is not necessarily an indication that an intermediate or distant shot were fired. Approximately half of the weapons used in close-range shots were "negative" for the presence of blood. Therefore, the absence of blood inside barrels possesses no evidential value, while the

presence of blood serve as confirmatory evidence that discharge occurred at close range.[10]

Results from experiments done by Suwanjutha[8], indicated that suicides are mostly committed at tight contact ranges (54%) compared to the rare occasion that tight contact discharge of weapons occur in homicides (7%). In 2001 Kohlmeier et al.[34] noted that of 1704 cases of suicide 97,9% were contact wounds and merely about 2% were intermediate range shots. Cina et al.[9] also reported the ranges of firearm discharge in different modes of death. His results are summarised in ***Table 1.2***[9].

Table 1.2: Muzzle-target distances on the basis of different modes of death.[9]

	Suicide (n = 86)	**Homicide (n = 30)**	**Accident (n =4)**
Contact Shots	97%	10%	25%
Intermediate Shots	3%	75%	3%
Distant Shots	0	50%	0

Research on the subject of drawback blood spatter in determining the *exact* muzzle-target distance was performed by Herbert MacDonnell and Brian Brooks[12] in 1977. By carefully analysing the depth of back spatter penetration into the barrels of the weapons, they concluded that a correlation exists between the depth of blood droplet penetration into the barrel and the distance of discharge. They also noted the higher penetration depth of higher calibre and higher energy load weapons (e.g. magnum weapons) compared to those of smaller calibre and energy load.

Results obtained from the research of MacDonnell and Brooks revealed that penetration depth of small calibre weapons like .22 calibre revolvers, ranged from 1 to 1,5 inches (2,53 to 3,8 cm). The depth of detectable blood droplets in higher calibre guns such as 12-, 16-, or 20-gauge shotguns reached up to 5 inches (12,65 cm) and for handguns approximately 3 inches (7,6 cm) [12].

Although their research contributed greatly to the literature of forensic science, contrasting opinions exist to the practical application of their research. Detection of blood inside a firearm already places that weapon within close range of the target. Is there really distinction in calculating the exact distance in centimetres if presence of blood already testifies close range discharge?

As Yen et al.[33] so rightfully stated, one should be very careful in analysing any blood spatter evidence, whether it is on hands, weapons, or blood covered adjacent objects. Seepage, dripping, secondary traces, and ricocheting blood spatter should all be taken into consideration when scrutinising bloody evidence.

The importance of the present study therefore lies therein that accurate estimations of muzzle-target distances may be possible and might assist in the precise reconstruction of a fatal shooting. This study will aim to determine the frequency of drawn back blood in weapons used in contact firearm fatalities. The relative influences of certain variables such as the type and calibre of weapon is also discussed.

Determining the precise depth of penetration of blood droplets into the barrels falls beyond the scope of this study. The mere presence of blood is to be detected and correlated with different variables.

The results of this study will hopefully add to forensic literature and might assist the forensic scientists in South Africa in evaluating whether a case of a firearm fatality is homicidal, suicidal or accidental in nature, by indicating muzzle-target distance, and employing this in a forensiometric model. Since suicides are most likely to be committed within a near-contact or contact range, it would be another useful tool in the forensiometric analysis of gunshot events to prove suicide.[9, 10]

1. 3 Aims of Study

1. To determine the frequency of blood back spatter on the inside of barrels of firearms used in events of contact gunshot wounds in the Pretoria metropolitan area.

2. To indicate any possible influences that the following variables might have on the phenomenon of "drawn back" blood:

- Type and calibre of weapon
- Anatomic location of entrance wounds
- Clothing, hair, etc.