



**WEAPONS OF CHOICE: A STATISTICAL
COMPARISON BETWEEN DIFFERENT WEAPONS AND RESULTING
INJURIES, OPPORTUNIST WEAPON SELECTION AND FORENSIC
AWARENESS**

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A thesis submitted in fulfilment of the requirements for the degree of Master
of Forensic Science (Professional Practice and Research)

In

Medical, Molecular and Forensic Sciences

Murdoch University, WA

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Academic Chair Brendan Chapman (Murdoch)

Semester 1, 2022

DECLARATION

I declare that this thesis does not contain any material submitted previously for the award of any other degree or diploma at any university or other tertiary institution. Furthermore, to the best of my knowledge, it does not contain any material previously published or written by another individual, except where due references had been made in the text. Finally, I declare that all reported experimentations performed in this research were carried out by myself, except any contribution by others, with whom I have worked is explicitly acknowledged.

Signed: Emily Fletcher

ACKNOWLEDGEMENTS

I would like to thank both my supervisors, Dr David Keatley and Mr Brendan Chapman for their continuous support throughout the whole research process, and the guidance they have given me to the finalisation of my master's degree. I have gained unforgettable knowledge being supervised by them.

I would like to also thank my friends, family and fellow classmates for their incredible support over the last couple of years, and their ongoing encouragement for my future endeavours.

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PART ONE

LITERATURE REVIEW

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Masters in Forensic Science Literature Review



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Semester 2, 2021

Words Count: 14,725 words

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LIST OF ABBREVIATIONS

SK – Serial Killer(s).

US – United States.

MO – Modus Operandi.

FAS – Forensic Awareness Strategies.

DNA – Deoxyribonucleic Acid.

SRM – Self-regulation Model.

ITs – Implicit Theories.

OSINT – Open Source Intelligence.

ABSTRACT

Homicide is a known term for the unlawful killing of another person, which can be classified into three subcategories; Mass, Spree and Serial Homicide. Serial Homicide is the chosen focus for this literature review, and the following study to come. A Serial Killer can be described as an individual who takes the life of at least two people, each within a separate event to one another. Specifically, the weapons of choice by these Serial Killers is the main concentration of the study, and how different external variables can change their choosing, as well as the resulting injuries the victim sustains from these weapons. Variables such as victimology of both the offender and the victim, the level of forensic awareness known by the offender and whether the weapon was an opportunist circumstance or not are detailed to identify the changes in weapon choice and injury infliction as these variables change between offenders. The literature review aims to display what information is already present in the field, with the relation of all factors in weapon choice and injuries and if there is already a link between any. The review ultimately defined that there is a big gap in research about weapons of opportunity and the factors which can cause an offender to use an unplanned weapon to cause injury, as well as how the injuries differ between opportunity and planned weapon selection. The review also revealed there is an obvious gap in knowledge linking all of these mentioned variables, to the way the offender inflicts injuries on the victim. The proposed study will hopefully fill these research gaps by comparing victimology, opportunity and planned weapons, forensic awareness knowledge and clean-up to the type of weapon used and the resulting injuries, the hope is to link them all together, as well as identify individual characteristics of each which can change offenders weapon selection.

KEYWORDS

Serial Homicide, Forensic Awareness Strategies, Opportunist weapons, Victimology, Weapons, Injuries.

1. INTRODUCTION

Homicide is a curious occurrence that is witnessed in all societies across the world (Preteca et al, 2020), with an interest by the public and research investigators. Serial homicide is the most uncommon, yet has gained the most public attention out of all the subcategories of homicide. Due to the attention that gaining an understanding behind what, why and how Serial Killers (SK) commit their crimes, a lot of research has gone into attaining the knowledge to recognise these. The main focus of this literature review was to portray the knowledge that already exists in the field of Serial killers' choice of weapons, the resulting injuries from these chosen weapons, their knowledge on Forensic Awareness Strategies (FAS) and if there is a common link between these variables. If the level of FAS from the offender differs their weapon type, and their concurrent injuries created by these weapons, specifically how many injuries and the selected anatomical position which has been inflicted. The use of weapons in an opportunist manner is also a concentration and whether different weapons are more likely to be of opportunist origin or pre-chosen by the offender before the crime. The use of specific weapons allows investigators to build a profile of why the offender chose the weapon, and the process of events that occurred before the offender committed the crime (Chan et al, 2020). Once a link can be made between the FAS of the offender, the weapon of choice, appearance and location of injuries and whether the weapon was opportunist or not, an interchangeable appreciation will be useful in terms of investigations. For example, a selected weapon was

chosen because the offender is aware of the knowledge of fingerprints and DNA, and the specific weapon chosen (not opportunist) reduces the chance of leaving trace evidence behind, and therefore clean-up after the crime had also taken place. There is a gap in the area for opportunist weapons, not much research can be found and therefore this study will be including the findings of weapons selected as detailed as possible to increase the knowledge about this.

2. HOMICIDE

Homicide is known societally as the wilful killing of one human by another individual (Douglas, et al 2013). Generally, homicide is defined as either a non-violent or violent death that cannot be considered a suicide nor an accident, which is ultimately ruled by a Coroner (identification of authority may change depending on location) (Brearley, H.C, et al 1932). Like all other crimes, homicide derives from a standard prior character of the individual, as it developed by a certain level of social organisation that creates routine expectations of what the offender wants from committing the crime, which we know as a motive (Decker, 1996).

2.1 Defining Mass, Spree and Serial Homicide:

Mass, Spree and Serial Homicide are all subdivisions of homicide, each with different identification variables that are used to differentiate them. Firstly, mass homicide is described as the intentional killing of typically more than three individuals within the duration of one criminal event at a single location (Meloy, J.R et al 2004; Brookman et al 2017), with no significant time between each of the killings. A variety of sources have different numerical definitions of the number of killings that is acceptable to be considered a mass homicide. Secondly, Spree homicide is known as the murder of multiple

victims who are killed in different locations within the same timely event (Brookman et al, 2017). Lastly, serial homicide is depicted as the intentional killing of at least two to three individuals during different criminal events, with a significant time between each of the events (Meloy J.R, et al 2004; Daniszewska 2017). The time between each of the killings is commonly known as a “cooling off” period (Meloy J.R, et al 2004; Brookman, et al 2017), which can last several days, weeks or years (Daniszewska, 2017; Hattery et al, 2011) and which can only be related to the events of serial homicide (Hattery et al, 2011). The cooling-off period between crimes is defined as the offender returning to their normal (how they lived before the murders) way of life until they chose to commit another murder (Osborne J.R, et al 2015). Factors such as the victim and offender location, victim selection, and the offender’s level of social involvement during the cooling-off period can influence the length of the killing free duration (Osborne J.R, et al 2015). The amount of killings that defines a serial homicide varies between sources, with several suggesting at least two, whereas others proposing three or four in some cases (Daniszewska, 2017; Osborne J.R et al, 2015). It has been put forward by Meloy, J.R, et al (2004) that it is typical for most serial murders to occur in an up-close and personal way, using weapons as a way to aid in the attack as well as a need for the physical intimacy with the victim, even when the victim and offender are unknown to each other.

Specifically, for serial homicides, it is considered one of the rarest forms of homicide (Hattery et al, 2011), but despite being the least likely to occur, it is the most well-identified in the eyes of society and the most recognisable by investigators, compared to all three subcategories of homicide described above. Despite it being well known, serial homicide is one of the most, if not the most challenging types of homicide to study and predict. The low rate of incidence makes it difficult to accurately report and identify

connections between killings in broad society, especially in international circumstances (Dietz, 1986).

A factor that increases the interest in serial murder to both investigators, as well as the public is the presence of a *modus operandi (MO)* of the offender (Daniszewska, 2017), which can consist of the offenders use of torture, sexual activity, body/crime concealment (if any are existent). There is a consistency present within each of the killings which makes it easier for the murders to be followed and linked. Although it is common for serial murderers to have a consistent MO, it is not deemed a necessary element of serial murder (Daniszewska, 2017).

3. WEAPONS AND INJURIES

An offender's choice of weapon is typically used to create and maintain control against a victim in the circumstances of a physical attack, or this case homicide. Weapons also allow investigators to determine the thought process behind the weapon selection and process before the criminal events occurred (Chan et al, 2020). Cause of death is an aspect within the examination of homicides, which is determined by, in most cases, a physical influence that was used in the circumstance to result in death (Dettmeyer et al, 2013). Generally, a forensic pathologist will establish the anatomical site of the injury(s), the number of injuries as well as their physical characteristics to potentially identify the weapon of choice by the offender (De-Giorgio, et al 2014). Many prior studies (Chan et al, 2016; Chan et al, 2020), have delved into the choice of weapons for serial killers, and the majority have concluded that the reasoning for choosing a specific weapon is based on their intention to kill. The study developed by Chan et al (2016) and Chan et al (2020) also

determined that the motive behind the murder also results in the level of violence used in the attack, ultimately influencing the consequent injuries.

Most of the research which is already present in the field about the offenders choice of weapon is currently psychology and criminology based, investigating why the weapon was chosen by certain offenders, based on motive, whereas the forensic aspect of selection is often avoided and not discussed.

There is a need for understanding the basic physical appearances of different injuries commonly identified in cases of homicide to accurately determine which weapon was used in the offence when it is previously known to investigators through the means of collecting physical evidence at the scene. Significant differences can be seen in a diverse selection of weapons (Chan et al, 2008). An example of a study by Ambade et al (2006) portrays the contrast between both sharp force and blunt force trauma injuries often present in homicide cases and delves into the general number of injuries that are commonly found on each part of the body which has been inflicted, as well as linking the generic type of weapon and trauma which creates the injury. Studies like this, as well as others (Soumah et al, 2012) portray the probability of sharp, blunt or gun weapons being a factor in homicides, although very rarely describe the specific weapon which has been used, as well as detailed characteristics of the injuries, such as size and appearance.

In the case of this study, a variety of weapons have been used in examples of universal serial killer homicides which have been investigated into the injury characteristics resulting from each of the weapons.

3.1 SHARP FORCE TRAUMA

Sharp force trauma is known as a major cause of violent death with over 97% of cases being a fatal result of a homicidal situation (De-Giorgio, et al 2014). Sharp force trauma

can be sectioned into three different categories in terms of specifying the common injuries that can arise from the weapons. Sharp force trauma is a subcategory that includes both stab and incised wounds, semi-sharp trauma is defined as chop wounds, such as saws and axes, and lastly pointed force trauma includes injuries that are resulted from firearms and pointed instruments such as a skewer or ice pick, which are equivalent to puncture wounds (Dettmeyer et al, 2013).

Sharp force trauma is most commonly inflicted into the thorax of the victim by the offender, particularly when the victim only suffers one injury, with thorax injuries belonging to over half (54%) of homicidal circumstances (De-Giorgio, et al 2014). Specifically, the left side of the thorax is believed to be the most targeted region of the thorax as statistically offenders are more likely to be right-handed as well as having the prior knowledge that the heart is positioned on the left (De-Giorgio, et al 2014).

3.3.1 STAB AND INCISED WOUNDS

Dettmeyer et al (2013) state there is a clear distinction between the physical appearance of stab and incised wounds. The general rule that is applied when determining if an injury is a stab or incised wound is as follows:

Stab wound = depth of the injury exceeds the length of the injury

Incised wound = length of the injury exceeds the depth of the injury

Commonly, a stab wound punctures the tissue by means of a pointed object in a perpendicular force in relation to the body, whereas an incised wound (otherwise known as a cut wound) occurs when a sharp edge is in contact with the body at an indirect angle. It is possible for both stab and incised wounds to be found at the same time dependant on the object used to create the injuries and the trajectory of the movements creating the wounds (Dettmeyer et al, 2013).

Stab wounds are most ordinarily inflicted with a knife (in cases of homicide) leaving an almond-shaped, smooth-edged wound at a first glance (Dettmeyer et al, 2013), and which are seen more commonly in cases of homicide compared to incised wounds (Henderson et al, 2005). The almond shape of the stab injury is often seen in homicidal cases as single-edged blades are typically used (Dolinak et al, 2005), although the shape of the resulting injury can change depending on the type of blade being used in the attack. Stab wounds made by a single-edged blade will typically have a sharp and blunt end, meaning that the wound can be slightly gaping, and appear as if the skin is split (Dolinak et al, 2005), commonly in the shape of almond as stated earlier. Stab wounds made by a serrated blade do not always necessarily result in a serrated wound, it can be dependent on other factors such as the type of serrated blade and the angle and depth in which the blade comes into contact with the skin (Dolinak et al, 2005). A stab wound created by scissors results in a wound that physically appears broader than a single-edge blade wound, as the blades of scissors are much thicker, leaving the wound to be larger in width than a single-edge blade (Dolinak et al, 2005).

Incised wounds are defined as an injury that is created by a weapon with a sharp edge, similar to the one that also creates a stab wound (Dettmeyer et al, 2013). The weapon is to make contact with the skin and the underlying tissue using the weapon. If the weapon is in contact with the skin at a slanted angle, it can leave one of the wounds edges bevelled, with the other opposing edge undercut. According to Dolinak et al (2005), it is stated that when an incised wound is made on the skin, the injury is well defined, with smooth edges and no tissue bridging present within the middle of the wound.

When an injury caused to an individual is considered an incised or deep stab wound, it is possible that the weapon can cause injury to the bone structures (Dettmeyer et al,

2013). Common causes of death caused by stab wounds is linked to the loss of blood when a major vessel, artery or organ is damaged directly which can ultimately lead to the lungs and heart filling with blood resulting in death (Henderson et al, 2005).

3.3.2 SEMI-SHARP FORCE TRAUMA

The name semi-sharp trauma is defined by Dettmeyer et al (2013) as a term that is used to describe wounds that cannot be categorised as either sharp or blunt force trauma, or which in some occasions are a combination of both.

Chop wounds are a wound characterised by a smooth-edged transection of tissue with abrasions present on the skin around the area (Dettmeyer et al, 2013). The injuries can differ depending on the weight and size of the weapon, the anatomical site in which the injury has occurred, if the bone has fractured, including a combination of all of the above. Chop injuries are typically caused by weapons such as swords, machetes, sabers, axes or hatchets. Dettmeyer et al (2013) also state that uncommon weapons such as airplane and boat propellers can cause an injury similar to that of a chop wound.

The criteria for sharp and blunt force trauma classifications can change depending on the visualisation individualities of the wound. As these can change, some injuries are classified as semi-sharp force trauma. An example of this, explained by Dettmeyer et al (2013), is specific to saws. As explained, the teeth of the saw can cause microtraumas which can be classified by a forensic pathologist as blunt force trauma, whereas the act of sawing supports the ideal of sharp force trauma. Saw teeth create ragged, soft tissue lacerations which usually appear on the victim in a linear pattern unless the saw has been in contact with the bone or has been severed by the saw (Dettmeyer et al, 2013). Therefore, although fatal injuries premortem is a rarity in homicidal cases, the injuries caused by a saw is more likely to be considered semi-sharp force trauma in order to cover

all aspects. The case is also common for injuries created by chain saws and grinders. In conjunction with the larger wounds created by the saw or grinder, small epidermal cuts (similar to fine scratches) can be created on the skin transverse to the cutting direction of the main injury (Dettmeyer et al, 2013).

Bite wounds which are inflicted by humans are also seen as a standard of semi-sharp force trauma which are commonly found in occurrences of sexual assault homicide (Dettmeyer et al, 2013). A typical bite wound is round to egg-shaped in appearance, each bite with individual characteristics as it is produced by the use of the upper and lower jaws of the specific offender. Bite injuries can disturb the skin by producing indentations, abrasions, bruising and perforations to the affected area, with a chance of causing infection due to the bacteria in the offender's saliva (Dettmeyer et al, 2013).

Defensive bites typically involve the epithelium being pinched between the upper and lower jaw, as the victim pulls away from the offender the teeth and the skin are pulling in opposite directions leaving a distinctive mark on the skin (Dettmeyer et al, 2013). A defensive bite can also be the form of a suction bite, where the skin of the victim is drawn into the mouth of the offender, leaving a distinctive mark on the skin.

3.3.3 DEFENSIVE WOUNDS

Defensive wounds are commonly inflicted by a sharp force causing injuries that are present on the individuals extremities, specifically the hands/fingers and the forearms (De-Giorgio, et al 2014; Dettmeyer et al, 2013). A defensive wound is caused by the victim placing his or her hands and arms between the weapon being used in the attack and their body, commonly with attempts to push the weapon away from themselves (De-Giorgio, et al 2014). Defensive wounds are commonly present on the extensor sides of the

forearms and hands, often on the palms, the flexor side of the fingers, spaces within each digit, particularly the thumb, index finger and pertinent metacarpal regions I and II, specifically the first intermetacarpal space (De-Giorgio, et al 2014). According to Dettmeyer et al (2013), the wounds can also be present on the upper arm and the back of the hands, as well as the areas previously stated. The wounds have been found to be present in more than 40% of cases, with some studies reporting the presence of defensive wounds in more than 75% of homicides (De-Giorgio, et al 2014). Often when a single wound is fatal, or the attack is unknown to the victim, there is a lack of defensive wounds present (De-Giorgio, et al 2014).

Dettmeyer et al (2013) state that 'defensive wounds' can be categorised into two different areas depending on at what point of the attack they are inflicted onto the individual. Passive defensive wounds are described as the injuries that occur as the victim was to hold their hand/arm in front of the weapon as a use of protection, resulting in injuries that are commonly present on the extensor side of the forearm and back of the hands. Active defence wounds are defined as the injuries that occur as the victim reaches for the sharp weapon in a struggle. They are commonly present on the flexor side of the fingers and palms of the hands, typically wounding between the thumb and index finger.

3.2 BLUNT FORCE TRAUMA

Blunt force trauma is common in homicides and tends to be more prevalent in countries that have restrictions involving the personal ownership of firearms (Macoveciuc et al, 2017) unlike the United States (Planty et al, 2013). It is possibly the most common documented type of injury for forensic pathologists (Dolinak et al, 2005). Blunt force trauma is characterised as the act of an area of an individual's body colliding with a "blunt"

(anything that is not considered sharp force trauma, or a subcategory such as semi-sharp) object or surface (Dettmeyer et al, 2013) considering both the object coming into contact with the body (such as a weapon or hands and feet used in a situation with an offender present) and also the body coming into contact with an object or surface (such as a fall). As blunt force trauma injuries are inflicted by an outside force, it is common for the external appearance of some injuries to seem more or less extreme than the wound actually is (Dolinak et al, 2005). Different factors can change the physical appearance of the injury, such as the position of the wound, the age of the victim, the object being used to cause the injury, and the amount of time that it is in contact with the body (Dolinak et al, 2005). There is a selection of resulting distinctive injuries resulting from blunt force trauma including, signs of anaemia, intracutaneous and subcutaneous hematomas, abrasions, contusions, lacerations, avulsion, organ tearing or rupture, bone fractures and brain injuries (Dettmeyer et al, 2013; Henderson et al, 2005) and commonly, depending on the object or surface that is creating the impact as well as the site of the body in which is being impacted on, it is likely that an abrasion will arise, either as a patterned or a non-patterned injury (Dettmeyer et al, 2013). An abrasion is described as areas of epidermis becoming raised from the epithelium once the force has impacted the skin at a lateral angle (Dettmeyer et al, 2013), in simpler terms it is known as a graze. Dolinak et al (2005) describe an abrasion similarly although specifies that when the skin and surface are in contact, the friction that is caused when one pulls away, results in the superficial layers of the skin being removed. Intracutaneous and subcutaneous hematomas are described by Dettmeyer et al (2013) as the stretching and resulting tearing of the blood vessels creating a blood pool outside of the vessel within the skin (intracutaneous) and under the skin (subcutaneous). Intracutaneous hematomas are more likely to occur in the situation of an

attack as excessive force is not needed in order for these to arise, unlike subcutaneous and deeper skin tissue hematomas where a moderate to stronger blunt force trauma is required to tear the blood vessels under the skin (Dettmeyer et al, 2013). A contusion, which is ordinarily known as a bruise, is a result of an external force hitting the skin and rupturing the capillaries beneath the surface (Simon et al, 2021), developing a normally visible mark on the epidermis. Typically, a more recent contusion will be red/purple in colour and will go through a series of colour changes with a yellow/green contusion being present on the body for longer periods of time, approximately 18 hours or more from the time of the incident (Langlois et al, 1991). Anaemia can be followed by this generally as the body is not receiving the required levels of haemoglobin within the blood (Stoltzfus, 2001) normal, due to the loss of the blood from the site of injury. Lacerations occur when there is a significant amount of force that impacts the skin, causing the skin of the epidermis to tear separating strands of subcutaneous tissue from the wound (Simon et al, 2021; Dolinak et al, 2005). Blunt impact to any bony area of the body is highly likely to cause a laceration, as a result of the overlaying tissues being compressed against the bone from the external force (Dolinak et al, 2005). Both contusions and lacerations can be present on internal organs as well as the skin. Avulsion is described as the pulling away of tissues from their attachments, such as a bone. It can be seen minorly in a pinpointed area, or in more extreme cases in large areas of the body (Dolinak et al, 2005). Using an example, the skin is torn from the bone, such as the finger resulting in the bone being exposed. Fractures are caused when significant force is applied to the bone causing it to fragment (Simon et al, 2021). The type and severity of the fracture are dependent on the age and bone elasticity and density of the victim (Dogrul et al, 2020). Often fractures are used as a tool of indicating how much blunt force trauma the individual has endured

(Gaudet et al, 2020), although currently it is limited to qualitative descriptions such as mild, moderate or excessive force. Fractures themselves often aren't fatal, although the resulting injuries caused by the fractures is what most likely causes death (Dogrul et al, 2020). For example, rib fractures can cause damage resulting in lung tissue damage, hemothorax, pulmonary contusions and lacerations, etc.

The resulting injuries from blunt force trauma are dependent on the intensity and direction of the impact (Dettmeyer et al, 2013). Unlike a non-patterned wound, a patterned injury can result in the surface and edges of the object being visible within the injury, allowing suggestions to be made about the specific weapon that has been used (Dettmeyer et al, 2013).

Blunt force trauma which has affected the head is generally fatal, often dependant on force and within the company of skull fractures, which ultimately can lead to lacerations, contusions and haemorrhage and death (Passalacqua et al, 2015).

3.3 ASPHYXIATION

According to Dettmeyer et al (2013) asphyxiation is death due to the lack of oxygen reaching the bodies vital organs. Asphyxiation is a general definition of a collective of two different cause of death categories that are relevant to this study, including suffocation and strangulation. Death caused by asphyxia is uncommon (DiMaio, 2000), although it is fairly present in the cases of sexual homicides.

3.3.1 SUFFOCATION

Suffocation is described as death due to failure of oxygen to get to the brain (Dettmeyer et al, 2013), which can include downing, smothering using hands or an object, choking and suffocation of gases. According to sources (Chan et al, 2003; d'Aloja et al, 2011), suffocation in terms of homicidal situations is not generally very common and

suffocation is typically identified by pathologists as an act of suicide, not homicide. Although it is uncommon, does not mean that it is not acknowledged, just infrequent. There does not seem to be an adequate amount of research completed in the area of suffocation and its relevance it has to occasions of homicide, although rare is hardly mentioned. It is mentioned in the deaths of children compared to that of adult victims, specifically in cases of serial homicide.

3.3.2 STRANGULATION

Strangulation is deliberated to be a form of mechanical asphyxia (Suffla et al, 2008) and is generally described as the closure of blood vessels and air passages of the neck (Dettmeyer et al, 2013), which in this case of homicides is focused on ligature and manual strangulation. According to Sharma et al (2011) and Abder-Rahman et al (1999), both hand and ligature strangulation combined accounted for 95% of homicides which are based on asphyxia cause of death rulings. An additional study completed by Singh et al (2003) discovered that out of 111 cases which were studied, strangulation accounted for a total of 11 cases, which is significantly less than that determined by Sharma et al (2011) and Abder-Rahman et al (1999). Suffla et al (2008) determined that strangulation is one of the most common forms of asphyxia in most countries around the world, and reports for roughly 10-20% of general homicide deaths.

3.3.2.1 HANGING

Hanging is defined as the restriction of the victim's major veins and arteries of the neck using a ligature as well as their own body weight as a compressive force (Dettmeyer et al, 2013). With hanging, it is not necessary for the ligature to be fully surrounded around the neck, although frontal constriction is necessary for either laying down, or a sitting/squatting position to cause death. The primary cause of death in a circumstance of

hanging is compression-related circulatory arrest (Dettmeyer et al, 2013), meaning when the blood vessels in the neck are compressed prompt loss of consciousness will occur, which will lead to death if the compression on the neck is not released.

There are two different distinctions of the term hanging, which include typical and atypical hanging (Dettmeyer et al, 2013). Typical hanging is defined as a symmetrical ligature that slants upwards, with the highest part of the ligature present as a knot at the back of the neck, commonly with a complete suspension of the body (Dettmeyer et al, 2013). Atypical hanging is comprehended as an asymmetrical ligature with the highest point of the knot present commonly at the side of the neck (Dettmeyer et al, 2013), including any other position other than the back of the neck existent in typical hanging. According to Dettmeyer et al (2013), atypical hanging is more common than typical hanging, as the majority of hangings are linked to suicide (Chaudhary et al, 2008). In terms of homicide, hangings can be used to disguise ligature strangulation and impersonate a suicide (Dettmeyer et al, 2013; Sharma et al, 2011), although homicide by hanging independently is seen rarely in investigations (Sharma et al, 2011).

3.3.2.2 MANUAL STRANGULATION

Manual strangulation can be executed using the offender's hands, forearms or by standing on or kneeling on the victim's throat (Suffla et al, 2008). Manual strangulation is described as the anterior or posterior compression of the neck using one or both hands, resulting in the constriction of a venous vein slowing the blood flow to the carotid arteries (Dettmeyer et al, 2013). As well as this, it is common that manual compression on the larynx and trachea also obstructs the airways. A study completed by Abder-Rahman et al (1999) stated that manual and ligature strangulation was the most common type of

homicidal asphyxiation, with approximately 95% of deaths resulting from either of these two strangulation types.

3.3.2.3 LIGATURE STRANGULATION

Strangulation by ligature is commonly seen in circumstances of homicide (Maxeiner et al, 2003), defined as the compression of the neck with the aid of a ligature, tightened by an external physical force (Dettmeyer et al, 2013).

In 80% of homicide cases, ligature marks on the victim's body are generally defined and present other skin injuries such as friction abrasions and haemorrhages (Maxeiner et al, 2003). A study undertaken by Maxeiner et al (2003) stated that in 85% of homicidal situations in which the ligature was found with the body, only one ligature was used by the offender, and in the other 15%, two separate ligatures were found. Analysis was conducted into the type of ligature, the number of turns in which was present on the ligature and the number of knots present on the ligature. Within all of the 47 cases investigated, it was found that in 38.2% of occasions a soft material was used as the ligature, and in 31.9% was a thin and strong material that was not specified. Individually, a belt, elastic band and a piece of wire were all used, which each account for 2.1% of the cases. It was found that 59.5% had the ligature turned over one time, twice in 21.2% of the cases, and three times in 4.2% of the cases. The number of turns was not documented in 15% of cases. In 27.6% of cases, the ligature was determined to not have been knotted and was lost when found, and in 2.1% of the cases, a stick was used to aid in a tourniquet. In 34% one knot was found, two knots were present in 19.1% and 2.1% of cases had only three knots. The number of knots was not recorded in 15% of the 47 cases.

3.4 FIREARMS

Firearms have and still do play a significant role in the United States of America's (USA) nation's history and current image, with Americans having the privilege of carrying a weapon if licensed to do, meaning that statically three-fourths of homicides in the United States have been executed with a firearm.

In forensic circumstances, gunshot wounds are commonly seen in cases of suicide, as well as homicide and accidental cases (Dettmeyer et al, 2013). The type of gunshot wound pattern is determined by the type of firearm used, including the different elements of each of the firearms as well as the type of bullets used in the circumstance. The types of firearms which are commonly seen include handguns, long rifle guns, and blank firing pistols (Dettmeyer et al, 2013). Revolvers, pistols and semi/automatic machine guns are all subtypes of handguns that are commonly used in cases of homicide. A revolver is described as a single or double action weapon that can either be cocked manually or can occur when the trigger is being pulled (Dettmeyer et al, 2013). A double-actioned revolver has the potential to be fired between five to nine times. A handgun/pistol is defined as a self-loader weapon, meaning that each time the weapon is fired a reduced amount of energy is needed to fire the gun (meaning it can commonly be fired using only one hand) and the number of bullets can be chosen. A semi/automatic machine gun is outlined as a simple construct weapon that is commonly not adapted to a single shot action, and typically can be shot thirty to fifty times depending on the model. Subtypes of long-range rifle guns include sporting guns which are defined as an individual bullet rifled barrel, often used for hunting and military purposes with an average magazine holding twenty to thirty shots and shotguns which contain a variety of models. A single shotgun is considered a smoothbore firearm, often used in hunting scenarios, a double shotgun

contains a double bore, with a combination rifle barrel where it is possible. Lastly, there are three-barrelled guns which are commonly referred to as drillings containing two shotgun barrels side by side placed above one rifle barrel. Blank firing pistols are a category in which does not have any subtypes, as they are a basic replica of either a revolver or pistol with the same ammunition function.

Rifled barrels, cartridge comparison consisting of caliber size, type of the bullet, primer, shotshells, and the propellant are all components of each category of firearms, not dependant on the type (Dettmeyer et al, 2013). All firearms have a rifled barrel, other than shotguns which are smooth, in order to spin the bullet to stabilise its trajectory once the weapon has been fired. The general cartridges design is made up of a caliber (in millimetres) and the case length of the weapon. The caliber describes the diameter of the barrel of the firearm, in which the appropriately sized bullet will be suitable. The types of bullets are distinguished by the material. The effect that a gunshot has on an individual, is dependent on the amount of force that is behind the movement of the bullet, as well as the anatomical aim of where the bullet reaches the victim. The depth of knowledge needed by investigators in the case of homicide by firearm is highly significant as they are common, especially seen in the United States of America.

A report constructed by Planty et al (2013) associated with the United States (US) Department of Justice, released a shocking statistical representation of the commonality of the use of firearms in the US. It states, in 2011 approximately half a million violent crimes were committed with the aid of a firearm, with ~11,000 of these cases correlated to homicides. As well as this, Planty et al (2013) also indicate that handguns accounted for most of the cases of homicide, with approximately 83% of homicides being caused by handguns, with shotguns and rifles making up the other 17%.

3.5 OTHER

3.5.1 THERMAL DEATH

Homicide resulting from the victim being exposed to thermal environments, such as the heat and/or the cold is partially uncommon when compared to sharp and blunt force trauma as well as the use of firearms. Often, once the homicide has taken place it has been noted that in most cases of thermal death the offender is attempting to burn the body in order to conceal evidence of fatal trauma and the accurate cause of death (Macoveciuc et al, 2017; Dettmeyer et al, 2013). Although homicide caused by thermal injury isn't common, it does not mean that it doesn't happen on occasion. Thermal injuries are most commonly seen in cases of child abuse which has led to the death of the child (Dettmeyer et al, 2013). For the sake of this study, it is focused on heat-based injuries, leaving out cold thermal injuries as stated before it is not generally seen in cases of homicide.

As a result of general common heat injuries, such as heat stroke, sunstroke, and heat exhaustion being caused by the individual themselves lacking the intent of harm, a distinction has been made between these common injuries and other harm which have been caused by the intentional exposure of a particular area of the body to high temperatures (Dettmeyer et al, 2013). These are categorised as scalds and burns. Scalds are defined as injuries caused due to exposure to moist heat such as water or steam, which can be present on a localised area or the whole body, leaving the hair untouched. Burns result from the exposure of the body to dry heat again can be locally or all over the whole body, in the form of high temperatures such as flames and objects, such as cigarette or electrical burns. Death by fires is not as always present on the skin visually as a burn, it has been found according to Dettmeyer et al (2013) that in some cases of smouldering

fires, a gas is released which can cause death without any vital signs of thermal injuries. The individual usually dies of carbon monoxide or cyanide poisoning.

4. VICTIMOLOGY

Victimology is fundamentally the applied study of violent crime victims, in this case, homicide, for the purposes of future investigative and forensic causes (Turvey, 2014). In investigative circumstances, forensic victimology is used to specify a dependable acknowledgement, collection, documentation and preservation of evidence that is present to examiners by victims of a crime. Context is established by enquiring specific questions, which can aid in the process of the investigation (Turvey, 2014). Gaining an understanding of the reasoning behind why the victim was specifically chosen can aid in the identification of the offender, as well as protect possible future victims. The process by investigators involves the exhaustive understanding of the victim's lifestyle, routines and circumstances prior to the incident which can provide a link between the victim and offender. A book written by Turvey (2014) identifies eleven reasons behind the importance of victimology in the case of investigations and court circumstances. Firstly, the victimology discipline is necessary to support the understanding of the elements of the crime, including the relationship and interactions between the victim and offender and similarities in their lifestyles and surrounding environments. Secondly, it aids in the determination of a timeline for the events, by considering the victim's whereabouts and actions prior to the offence. Next, the study of victimology can help define a suspect pool from a larger group of potential offenders. If a link between the victim and offender can be established and comprehended, the suspect pool can be amended to include individuals which support the connection to the variables put forward by the victim.

Victimology can encourage investigative suggestions by providing a direction for investigational purposes, such as interviewing potential offenders and witnesses. Once the investigative suggestions are put into place, this can aid in the crime reconstruction, meaning that there is a general understanding about the timeline of the criminal circumstances and results in investigators gaining a sharper perception of both the crime and the offender, and the behaviours from both during the crime. Leading from this, the history presented by a victim will be progressed into developing contextual information to help support or disprove their statements. Ultimately, one of the main purposes of victimology is to advance the knowledge of the offender's modus operandi (MO), and what the offender's timeline of events is commonly like, what about the victim and their location encouraged the offender to select them. Once a basic MO can be understood, the offenders motive can be implied by investigators as to the reasoning behind the victim selection and the crimes. Then, the importance of an MO is to encourage case linkage, between older and newer cases that may have not been connected previously. If the same behaviours can be seen in separate cases, then a link can possibly be made between them. Leading on from this and the victim selection is comprehended, it allows investigators to assist with keeping individuals in the community safe, whom would match the description of the victim selection MO of the specific offender. Lastly, and perhaps the fundamental reasoning for the study of victimology is to provide evidence in court for a judge or jury, in order to end in prosecution.

It is commonly identified that serial murderers have a specific classification of victims that they are most likely to confront, whether that be the victims age, sex, race, ethnicity, general appearance (hair/eye colour etc), relationship to the offender, location, or

routine. A serial murder can choose just one, or all of these variables in order to select their victim.

A study completed by James et al (2016), stated that serial sexual murderers are more likely to attack victims that are unknown to the offender, and tend to approach the individual when they are alone. Additionally, Abder-Rahman et al (1999) indicated that the majority of the victims murdered by means of asphyxia were generally women and children under the age of one year old.

4.1 LINKING WEAPONS TO VICTIMOLOGY

Many previous studies (Park et al, 2017; Chan et al, 2020) have investigated the most common links between the characteristics of the victim, the type of weapon used and the anatomical area in which the weapon of choice is used to cause injury.

A study completed by Park et al (2017) looked into the data collected from prisons partially containing 276 homicides that had been committed in South Korea between the years of 1987 and 2008, with homicide as a result of either sharp force trauma (222) and blunt force trauma (54). Park et al (2017) discovered that in the majority of these homicide situations victims of sharp force trauma were significantly younger than those of blunt force trauma, with a broad range of victim ages for this category. Victims of sharp force trauma causing homicide ranged between 4 and 81 years ($M = 41.9$, $SD = 12.2$, median = 42, mode = 44), with the offenders of sharp force trauma ranging from 18 to 67 years old ($M = 37.1$, $SD = 10.6$, median = 36, mode = 44). In the case of blunt force trauma, victims ranged from 3 to 89 years ($M = 50.4$, $SD = 18.2$, median = 50, mode = 40), and offenders ages ranging from 16 to 52 years ($M = 34.8$, $SD = 9.2$, median = 34, mode = 29). When looking at the mean of both ages for both sharp and blunt force trauma, it can be understood that the ages differ significantly permitting to the type of weapon that is used

in the homicide. The average age of victims of sharp force trauma was significantly younger than homicides involving blunt force trauma. Another study by Chan et al (2020) investigating homicides of 59 sexual murders in China over the span of 23 years (1994-2016) reported the average age of female victims was approximately 35.5 years, which is significantly lower than the mean age stated by Park et al (2017), although not different enough which a profile could not be made using this research to aid in unknown investigations. According to Planty et al (2013) males (sex as stated in the article) between the ages of 18 to 24 years old are most likely to be the victims of firearm homicide with approximately 30% of all firearm homicides being within this age range, compared to 25 to 34-year-olds with 8.1%. Suffla et al (2008) suggested that there is not a significant difference found between either a male or female (sex as described in the study) being most likely to be the victim of strangulation, with some references suggesting a female victim be more likely, whereas others advocating that there is a higher value of male victims of strangulation.

As well as linking victims ages with the type of trauma, Park et al (2017) presented the most common injury anatomical locations for both sharp and blunt force trauma. According to Park et al (2017), head and face injuries were more likely to be seen in circumstances of blunt force trauma, compared to cases of sharp force trauma which frequently occurred in the torso region. The number of injuries to the neck and limbs did not present a significant difference between sharp and blunt force trauma. Victims of blunt force trauma have been found to be 60 times more likely to sustain head injuries, than victims of sharp force trauma, where head injuries are much less common. A study that supports Park et al (2017), was completed by De-Georgio (2015) which collects over 2,600 homicide cases, specifically looking at the sharp force injury placement of 521

homicides. It was found that injuries were present on the thorax (54.1%), upper and lower limbs (16.1%), abdomen (13.3%), head and neck (15%), back (1.4%) and pelvis (0.4%). De-Georgio (2015) supports the indication that the head and neck are not the most common areas for injuries to occur, and the thorax is most likely to be affected. A study completed by Schmidt et al (2006) shares information found about sharp force injury locations on a sample group of 158 victims aged between 15 and 63 years. It was established that each of the victims had among 1 and 20 single sharp force trauma injuries to different anatomical positions. Out of the 158 victims, over 60% of them had the majority of the trauma concentrated on the posterior of the body, with only approximately 36% present on the anterior side of the body. Roughly 60% of injuries were found on the left side of the body, with the rest present on the right. It could be theorised that this is due to the likelihood of the offender being right-handed, as statistically, an individual is more probable to be right-handed (Masud et al, 2012). Sharp force injuries were located on the thorax (~45%), head and neck (~30%), abdomen (~11%), lower extremities, including lumbar and gluteal areas (~12%). Injuries that were present on the upper arms were most commonly found on the left side of the body. Park et al (2017) stated the occurrence of sharp force trauma to the head and neck was less common than the thorax, which is supported by Schmidt et al (2006), although head and neck injuries are fairly common as presented by other studies (Schmidt et al, 2006). Au et al (2011) studied sharp injury locations also, and stated the mean number of injuries in one area was most common on the face, and did not differ statically between known victims to the offender, also injuries to the face and head decreased when the victim was unknown to the offender. There was no mention of lower extremity injuries by Park et al (2017) unlike Schmidt et al (2006),

detailing each of the injury anatomical sites. This may have been left out on purpose, or a result of the dataset in which Park et al study was based off, but it is unknown.

4.1.1 RELATIONSHIP BETWEEN OFFENDER AND VICTIM

Previous research (Parker et al, 1979; Smith et al, 1980) suggests that there are defined relationships for different levels of closeness between the offender and the victim. A primary relationship is described as an association between close companions such as relatives, lovers and friends. A secondary relationship includes circumstances where the offender and victim have little to no prior knowledge of each other before the crime takes place.

The type of weapon used in a circumstance has been closely related to the relationship of the offender and the victim before the event. As discussed in the study mentioned above, it is stated that general previous research conveyed that a high percentage of blunt force homicides involved family members and known acquaintances to the offender, compared to sharp force homicides. Although, alternative studies delving into sharp force trauma suggested that the number of injuries implicated in the crime increased with the closeness of the victim–offender relationship. The previous research was not referenced in the study. A supportive study that observed the injuries of sharp force trauma based in Hong Kong stated that the number of injuries generally differs proportionally to the relationship of the victim and offender (Au et al, 2011; Park et al, 2017). It was often observed that spouses and acquaintances were inflicted with a higher number of injuries (Au et al, 2011; Melvin et al, 1983) typically in the face and neck as well as the common torso area. A study completed by Pelletier et al (2018) suggests that firearms are mostly used in cases of homicide when the victim is known to the offender. Offenders who confront family members and close friends are more likely to use firearms as the crime

was planned prior to the murder. It was also proposed that the type of weapon used by an offender is an indicator of what is behind their motive. Pizarro (2008) implied that in cases of domestic homicide, firearms are the least likely weapon to be used, which does not support the commonality of the use of firearms in close relationship homicides. Other research (Fox et al, 2014; Mize et al, 2011) has demonstrated that spouses kill their younger wives are more likely to use their hands as weapons, in the case of strangulation, also using knives or drowning, whereas spouses with older wives commonly stray from using these methods and tend to use firearms, blunt weapons and other types of weapons.

Overall there are differences in all variables when comparing sharp and blunt force trauma, Park et al (2017) states homicides under the influence of alcohol are most likely to involve sharp force instruments, rather than blunt force objects. Whereas, the homicide of a parent is more often than not, specifically three times more likely to be caused by blunt force trauma, in relation to sharp force trauma.

5. OPPORTUNIST WEAPONS

A weapon is defined by Abder-Rahman et al (1999) as an instrument that could be used for shooting, stabbing, cutting or other means of injury, in an offensive manner likely to cause death. In order for an offender to use a weapon, it either needs to already have been present at the scene of the crime or carried with the offender. According to Pelletier et al (2018), there is little current knowledge about whether an offender brings a weapon with them to the scene of the crime with a prior intent to use it to cause harm, or if the use of a weapon becomes a circumstance of opportunity at the time of the offender committing the crime.

In spite of the variety of weapons that are very commonly used, in all trauma types, previous research (Planty et al, 2013) has concluded that the most ordinarily used weapon in homicide cases is a firearm (based on US data), which would most likely be owned by the offender themselves, which proposes the likelihood that the firearm is not a weapon of opportunity if the offender uses the weapon registered to their person.

A study completed by Park et al (2017) stated that according to their findings, offenders who commit homicides using a sharp weapon were considerably more prone to preselect their weapon prior to committing the crime, whereas in cases of blunt force trauma the weapons were more likely to be weapons of opportunity. For example, out of 222 murderers caused by sharp force trauma that was used in Park's study, 123 of these were preselected (55.4%), and out of 54 blunt force trauma murders, only 19 of these had their weapons preselected by offenders (35%). Although sharp weapons are most likely to be preselected, Park et al (2017) also discovered that there was an increased percentage of blunt force weapons being left at the scene when the weapons were of opportunity, in addition to a higher chance of a blunt weapon being used in a blitz attack, compared to the probability of sharp force weapons. Contrasting this, offenders using sharp weapons were twice as likely to interact with their victims, as well as threaten them with the weapon compared to victims of blunt force trauma. This could be expected as blitz attacks where prior interactions or threats are not an element in the process are more often than not going to be linked to blunt force weapons. Further results from the study demonstrate that offenders using blunt weapons were more likely to strike their victims, and three times more likely to engage in overkill rather than offenders using sharp weapons. In the case of this study, the term overkill was used for circumstances when the victim received ten or more injuries during the attack. Park et al (2017) suggest that with

the current research in this area, attacks using weapons of opportunity are often associated with the emotion of the offender at the time of the attack.

Weapons are either based on opportunity chance or thought about by the offender before committing the crime and as previously mentioned Pelletier et al (2018), stated that there is very minimal research into this area which has been supported by this review. There seems to be a gap in research, especially focusing on factors that encourage the use of opportunist weapons by offenders, or influences that cause the offender to plan the choice of weapon prior to the crime.

6. FORENSIC AWARENESS

Forensic awareness strategies (FAS) can be defined as the knowledge that the offender has before, during and after committing a crime, in this case, homicide, or attempted. The offenders use strategies that lower the potential of evidence being left behind at a crime scene and therefore result in their identification by police (Beauregard et al, 2010). The majority of research prior has delved into the relevance of forensic awareness in homicides, regularly comments on the presence of fingerprints, DNA, the offender hiding their physical identity using a mask, gloves, etc (Beauregard et al, 2014) which portrays a basic level of knowledge for investigators about what offenders are aware of forensically when committing crimes. Chopin et al (2020) have identified the generally the seriousness of the crime and the level of expertise of the serial killer themselves are the two factors that ultimately change the potential level of forensic awareness portrayed by the offender in the means of their actions before, during and after the crime has been committed. Although other forensic factors are mentioned, such

as fingerprints and the presence of DNA, and/or trace evidence, there is minimal mention of the change in forensic awareness when correlated against the weapon of choice.

According to Beauregard et al (2014) and Storm et al (2010), the increase in the use of forensic evidence from a criminal point of view is a result that stems from the development of scientific advances and analysis techniques over the past 20 years. Appearances of its importance in both the criminal community and in social culture aspects, such as current television shows have increased not only the use of forensic evidence in investigations but also increased the knowledge of its significance to offenders (Beauregard et al, 2014). The knowledge of forensic awareness gained through popular crime dramas by the offender is known as the “CSI effect”, which is hypothesised by researchers to be a direct consequence of the manifested importance of evidence portrayed in the shows (Beauregard et al, 2014). According to Cole et al (2006), it has been stated that the “CSI effect” is not the most concerning for the legal community, and it is common for criminal legal personal to suspect if the effect is real. Alternatively, Cole et al (2006) have suggested that criminals hypothetically learn how to avoid detection from investigative police by watching the crime dramas, providing them with new approaches such as using bleach to clean up the crime scene, using plastic gloves to avoid exposure of DNA, and the removal of items that may leave trace DNA, like cigarette butts. Due to this, most previous research has shown that the identification of suspects, pressing charges and securing convictions has is not directly proportional, an increase in these factors has not been seen (Baskin et al, 2010). According to Beauregard et al (2014), the reason for this is due to the minor role that forensic evidence still plays in investigations and the lack of evidence that is collected but not analysed.

Most murderers who are motivated by sexual drives are aware of at least one forensic awareness strategy, differentiating with the seriousness of the crime (Chopin et al, 2020). Both crime characteristics and the level of expertise of the offender influence the level of forensic awareness most commonly, and Chopin et al (2020) found that there was no difference in the use of FAS by the sexual offender based on the situation, whether the homicide was planned or opportunistic.

A study completed by James et al (2016), found that 67% of a group of 176 serial sexual murderers showed signs of post crime organisation, whether this is cleaning the location of the offense, discarding the body, etc, ultimately attempting to reject any evidence of themselves present or committing the crime. Although, the post-crime organisation was present in the majority of cases, in 36% of cases a weapon was left behind at the scene which contradicts their level of forensic knowledge when finalising their post-crime organisation.

6.1 MODUS OPERANDI

According to Keppel et al (2008) Modus operandi (MO) is defined as the gathering of all the behaviours that are needed for an offender to successfully commit a crime. It is a consistent pattern which the offender relies on, to decrease the potential of being identified and stopped. Factors that can be seen supporting an offender's MO are the choice of a victim (age, gender and race), time and location of the offence, weapons used, anatomical position of the injuries caused, clean up etc. An offender's MO can be made rapidly depending on the impulsiveness of the crime, and tend to change within the coming months after the first offence while adapting to different levels of a crime if needed (Keppel et al, 2008). Decker (1996) proposes that there are two types of motives for offenders; instrumental meaning they are committing the crime in order to gain

something for themselves, or expressive suggesting that the offender is committing the crime out of outrage, and/or emotion.

James et al (2016) argue that as well as observing the offenders actions at the time of committing the physical act of the crime, MO should also delve into the behaviours of the perpetrator at all times of the crime, from initially planning (if the crime was not impulsive) to after the crime has been committed, specifically taking notice of the offender's internal state, their cognitions and emotions, to ultimately understanding the murder and the murderer. It is understood that the behavioural values stated by James et al (2016) are not a part of the universal definition of MO and instead provides the extra context of the offender in order to better understand their MO.

There are many theories that are explained in James et al (2016) which build the framework around the understanding of an offender's MO. The theories are separated into both criminological and physiological categories of sexual-based homicides.

6.1.1 CRIMINOLOGICAL THEORY

Sexual aggression in homicides has only recently been linked to criminological theories which fundamentally state that the basis behind an offender MO is correlated both directly and indirectly to the act of aggression (James et al, 2016), and in the case of this circumstance, sexual aggression. The theory explains that MO is also related to the type of crime that is being committed, and each different crime as a "script" or outline helps develop the MO for the offender. For example, the act of disposing of a body is not a necessary element of a crime of burglary, therefore it would not have to be factored into the offender's MO. According to the criminological theory, MO is constructed by external factors, such as the offender's aggression, lifestyle, beliefs and attitudes.

A study completed by Blanchette et al (2009) has stated that during their study, it was investigated that three profiles were acknowledged relating the offender's MO and their lifestyles. Firstly, Isolated aggressors are characterised as having a lifestyle that lacks interpersonal relationships, whose MO involves a vast variety of sexual acts. Orderly aggressors are defined as having a customarily usual lifestyle, with a consistent and planned MO, for example the an orderly offender will preselect their victim and type of weapon before approaching them. Lastly, Festive aggressors are known to be impulsive with their MO which has not been pre-planned, the act of the offender is often based on drug and alcohol consumption and results in extreme injuries for the victim. Beauregard et al (2005) suggest that MO is not only based on the lifestyle of the offender but also the events in which the offender experiences in the time leading up to the crime. In a study that was completed by Beauregard et al (2005), using sexual assault as an example of MO, it was discovered that there was a relationship observed between circumstantial factors before the assault, such as the offender using drugs or alcohol, and an increased level of injury to the victim. James et al (2016) added their account in suggesting that although the study mentioned above explains what led the offender to make the choices they made, it does not entirely clarify the offenders behaviour during the time of committing their crime.

The Rational Choice Perspective is a concept which focuses on the decisions made by an offender throughout the crime (Cornish et al, 1987; Cornish et al, 2014). It is commonly understood that the choices made by offenders before, during and after the crime has been committed are rational selections, which have been thoroughly constructed in order to satisfy the goal, such as avoiding being detected by police (James et al, 2016). These choices can include acting out sexual fantasies, obstructing the identification of the victim

from police, involving burning fingerprints, or dismembering the body. A study completed by Chéné et al (2007) determined that all circumstances of the crime, including the choices made leading up to the crime (e.g. Consumption of drugs and alcohol), the relationship between the offender and the victim, choice and use of a weapon, the fight of the victim are all factors of the MO. The involvement of the criminal theory in research of sexual aggression in homicides has aided the understanding of the consequences that contextual and situational factors have on the directive of crimes (James et al, 2016).

6.1.2 PHYSIOLOGICAL THEORY

Physiological theories of the MO include the cognitive, behavioural, incitement and situational factors which lead the offender to sexual aggression (James et al, 2016), these theories are stemmed from the Self-Regulation Model (SRM). According to James et al (2016), the concepts currently in the physiological theories division of sexual aggression seen in homicides include; approach explicit, approach automatic, avoidant active, and avoidant passive. Firstly, approach explicit is defined as the type of offender who wilfully plans their assault prior to committing the crime, which is commonly fuelled by either sexual fantasies and arousal, as well as their anger. Therefore, the offender's mental state prior to the crime determines the boundaries of the MO. The feelings of gratification that the offender develops after committing a crime, leads them to plan further offences as they look to increase the relationship between their fantasies and the crimes. Approach automatic concept is characterised as the male offender having resentment and misogynist views towards women prior to the attack, with their MO based on the use of violence towards the victim. After the crime has been committed, these offenders tend to feel prepared for the next opportunity. Lastly, both avoidant active and avoidant passive are models defined as the offender relying on other factors to commit the offence,

rather than sexual aggression. Factors include the consumption of alcohol or drugs, or instead do not have any strategies for the offence. The crimes committed by these individuals are often dictated as a result of their personal states of mind, such as experiencing anxiety or depression, and their MO is formed based on the use of sexual aggression satisfaction as a way of coping with their mental health issues. These types of offenders tend to pay no attention to their victims or their suffering during the offence. The difference between avoidant active and passive, is based on their amount of planning. Avoidant active are commonly opportunistic offenders and do not tend to plan their crimes, whereas avoidant passive offenders engage in specific planning for their crime.

According to Ward, depending on multiple studies, sexual aggressors cognitive thoughts and leading offences are an expression of implicit theories (ITs) (Ward, 2000). Polascek et al (2002) suggest that the ITs allows the offenders to express themselves and allow for the actions of others to be predicted. The ITs are seen to be suggested by male offenders, but often are not directly expressed. It is proposed that there are five ITs that have been observed in cases of sexual offenders against women, which include; 1) Women are mystifying, as they are different to males in their behaviours and therefore are difficult for male offenders to understand; 2) woman are sex objects and are constantly responsive to the need of males, but are not always consciously aware that they are; 3) the male sex drive is uncontrollable and women should provide men with reasonable sexual approach; 4) males are entitled compared to women and have a right to discipline women that think otherwise; 5) the world in which we live in is dangerous and there is a constant threat present. These theories could possibly be recognised largely as an excuse for offenders to reason their crimes. A study completed by Beech et al (2005) identified three main groups of sexual murderers on the basis of the ITs, determining the

MO's for each of the three groups. Group one sexual murderers include the ITs of three and five. The male sex drive is uncontrollable, and the world we live in is dangerous. Group one's MO is determined to be based on sadistic sexual fantasies and the need to control and kill their victim. They tend to preselect a victim who is commonly a stranger, and most of the time inflicts pain on the victim before killing. Beech et al (2005) define group one as the typical serial sexual murderer. Group two hold just the dangers would IT and their MO is characterised by extreme anger towards their victim, who is known to the offender. The offender attacks with intense violence, often using multiple weapons and increasing the level of violence proportional to the extent of resistance the victim feeds. Beech et al defines this group as more criminal minded due to commonly having an extensive criminal record of both sexual and non-sexual crimes. Finally, group three is linked with IT three, that the male sex drive is uncontrollable, and their MO is based on the offenders desire to have a sexual relationship. Generally, the crimes are opportunist and the offender will have no previous history of violence against women; murder will solely be a result to lessen the chance of being identified within an investigation.

According to James et al (2016), the research into the psychological theories presented above and their link to the MO of offenders are determined by the individual's cognitive processes and their personal reasoning as to why they are committing the crime. James also states there are only a few studies relying on these theories, which have additionally explored the relationship role of external factors of the crime (e.g. victim, location, weapons) and the internal factors of the offender (e.g. alcohol or drug use, mental illnesses etc) in the growth of their MO, meaning, therefore, there is a gap in research for this specific area, based on the influence of psychological factors in the offender's development of MO.

7. PROJECT AIM, HYPOTHESIS AND DESIGN

The aim of the research is to provide statistical analysis and comparison of the consequences of the type of weapon, including sharp and blunt force, guns and other weapons (incorporating manual homicide, thermal homicide, and other forms of weapons which cannot be categorised into any other grouping), and how the resulting injuries are inflicted with different levels of forensic awareness known to offenders. Looking into the overall physical and unique features to each of the injuries, the number of injuries which have been inflicted, where the injuries are located anatomically on the victim and the size of the injury (diameter and length) can lead to the identification of which specific weapon has been used.

The research also aims to look into the selection variables of the choice of weapon used, such as MO, accessibility to different weapons etc, to ultimately determine whether the weapon was used in an opportunist scenario or if the weapon was specifically chosen by the offender and taken to the scene of the crime. The study will also explore if there are any consistencies, specifically the level of forensic understanding that the offender portrays through their choice of weapon, location and number of resulting injuries, and the presence of clean-up at the scene after the crime has been committed. Does the weapon being brought to the scene by the offender or not (opportunist weapons) change the circumstances of injury appearance and location as well as the presence of forensic awareness clean-up? After the study has been completed, it is a hope that there will be a general understanding of the link between the type of weapon being used and the location and number of injuries, to how these are to change with different levels of forensic awareness of the offender, in conjunction of whether the weapon being used in

the crime is of opportunist origin or organised prior to the crime. If there are differences present, the results from the study may be used in investigative circumstances.

7.1 HYPOTHESIS BEING TESTED

Hypothesis 1

H₁: A statistical correlation can be made of the specific weapon type to the number of injuries present on known anatomical areas of the body, exclusively looking at 50 serial killers active between the years of 1950-2008 (approximately). Sharp force trauma will commonly affect areas of the torso, whereas blunt force trauma will most likely affect the head and limbs.

H₀: There will be no statistical correlation to be made of the specific weapon type to the number of injuries which are present on anatomical areas of the body, exclusively looking at 50 serial killers active between the years of 1950-2008 (approximately). Sharp force trauma will not commonly affect the torso area, and blunt force trauma is not likely to affect the head and limbs.

Hypothesis 2:

H₁: There will be different forensic aspects identified using statistical analysis to determine that a weapon was not taken to the murder and can be determined a weapon of opportunity.

H₀: There will be no difference in forensic aspects identified using statistical analysis to determine that a weapon was not taken to the murder scene and cannot be determined as a weapon of opportunity.

Hypothesis 3:

H₁: There will be a relationship and statistical correlation (including chi-square, t-tests, ANOVA tests) between the specific weapon of choice and the knowledge of forensic

awareness and clean-up from 50 serial homicide offenders active between 1950-2008 (approximately). Change in the choice of weapon will change the level of forensic clean-up.

H₀: There will be no relationship or statistical correlation (including chi-square, t-tests, ANOVA tests) between the specific weapon of choice and the knowledge of forensic awareness and clean-up from 50 serial homicide offenders active between 1950-2008 (approximately). Change in the choice of weapon will not change the level of forensic clean-up.

7.2 METHODOLOGY DESIGN

7.2.1 Data Collection

50 randomised serial killer names will be selected from a developed database consisting of 82 sexually motivated, male (as termed in the database) serial murders active between the years 1950-2008 (approximately), with individuals selected from a variety of different countries. The database has been provided by Dr David Keatley in association with Dr Reid. Serial killer names will be selected by using a random number generator, and each number will correspond to a number and name in the database. The database will include an assortment of variables that relate to the murderer themselves, the victim and elements of the crime, some will be irrelevant to aspects of this study but are still included in the original database. A range of variables that will be taken from the database will include; weapon of choice for each of the murders (as serial murderers have more than one victim, and their choice of weapon may change as their MO develops), number of injuries to each part of the body on the victim, clean-up circumstances for each of the murder scenes (if any), if the weapon was identified as an opportunist weapon or was planned by the offender to bring to the scene prior to committing the crime (if present),

additionally any generalised victimology which is available in the database, for example age and sex of both the victim and the offender. Any variables that are not available through the given database will be composed from Open Source Intelligence (OSINT) and relevant pathology reports. All data that is needed, whether it be taken from the database or out sourced, will be taken, transferred and stored in a Excel spread sheet (in order to keep the given dataset as an original), as well as any outside information will be added to the spread sheet. Inclusion and exclusion criteria made for the identification of subjects both present in the given database and variables gathered from OSINT that is not already present in the database include;

Inclusion Criteria:

Offenders must be Serial Killers (killed two or more victims, which has been recorded in the database), Serial Killers must have been active between 1950-2010, Serial Killers can be located anywhere within the world, Serial Killers must be male.

Exclusion Criteria:

Female Serial Killers (none present in the database, as an individual SK), couple Serial Killers – must be a single SK

7.2.2 Statistical data analysis

Each of the variables which are either extracted from the given dataset or gathered by OSINT are used in comparison to each other in order to support or disprove the research aims and hypothesis'. The data collected will be compared and analysed using statistical methods, to determine if there are any significant difference or statistical correlation between all variables for each of the 50 serial killers. The analysis of the data will be done by using a selection of basic evaluations, such as mean and standard deviation, as well as more complex statistical techniques, for example, Chi-square tests,

ANOVA tests, and t-tests. The range of statistical techniques may change, with some being retracted or added to the list of potential tests, dependant on the extra information which can be identified and compared. All results from the data analysis will be presented in the manuscript findings.

8. CONCLUSION

Overall, it is very evident from the literature presented in the review that some areas of interest are lacking previous in-depth research that specifically identifies the relationship between weapon selection, resulting injuries, forensic awareness and opportunist weapons. Various studies have explored the resulting injuries from each of the types of weapons and their trauma, as well as how the victimology of both the victim and the offender can suggest the type of weapon to most likely be used on specific areas of the victim's body. There is currently an adequate amount of research delving into the amount of knowledge the offender has on forensic awareness strategies, and how this understanding can influence them to make specific decisions when committing the crime, which we now know as an MO. There is very little knowledge about opportunist weapons at all, therefore future study is definitely needed. The proposed study will be investigating all of these individual variables, and observe if there is a present relationship between, possibly all of them, and how together they would influence the weapon choice made by the offender, but specifically the injury location and severity (including the number of injuries, depth and width of each of the injuries, and anatomical position). The study will also uncover any future study which is needed in specific areas or needs more attention.

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PART TWO

MANUSCRIPT

WEAPONS OF CHOICE: A STATISTICAL COMPARISON
BETWEEN DIFFERENT WEAPONS AND RESULTING INJURIES,
OPPORTUNIST WEAPON SELECTION AND FORENSIC
AWARENESS

Masters in Forensic Science Manuscript



**Weapons of Choice – A Statistical Comparison
Between Different Weapons and Resulting Injuries,
Opportunist Weapon Selection and Forensic Awareness**

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Semester 1, 2022

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List of Abbreviations

SK – Serial Killer

FAS – Forensic Awareness Strategies

OSINT – Open Source Intelligence

MO – Modus Operandi

DNA – Deoxyribonucleic Acid

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1. ABSTRACT

Homicide is a term known for the unlawful killing of another individual. In the case of this study, all subjects have committed and been prosecuted for homicide. In this study, these are Serial killers. A serial killer can be described as an individual that intentionally takes the life of at least two people within the span of their lifetime. The individuals have to have been killed at different times from each other. This study has been conducted to identify any significant statistical relationships between the choice of weapon by the offender and the relevant circumstances that follow that choice. The study aims to identify variables that may alter the choice of a weapon being chosen by specific offenders, as well as resulting variables that occur after the fact. It is hopeful that there is an obvious relationship between the weapon of choice and the level of forensic awareness by the offender and other variables that are consistently a part of homicide investigations such as weapons of opportunity, injury placement and severity. The overall aim of the study is to fill in current research gaps by statistically comparing victimology, opportunity and planned weapons, forensic awareness knowledge, evidence minimisation, types of weapons and resulting injuries. The need for this is to identify a link that can be used in investigative circumstances where there are only one or two variables known to investigators.

2. INTRODUCTION

Homicide is a common occurrence that is present in all aspects of the world (Preteca et al, 2020), with serial homicide being the most uncommon, despite being the most well-known out of the three subcategories. These subcategories include mass, spree and serial homicide.

There is unlimited research already present in the forensic field and some parts of criminal psychology, pertaining to what, why and how Serial Killers (SK) commit their crimes, although there is research missing in more specific areas, and collective areas, including Forensics view on aspects of what has occurred in the situation of a murder, looking at more than one aspect at a time. These include linking Forensic Awareness Strategies (FAS) of the offender, their weapon of choice, appearance and location of injuries, and whether the weapon is of opportunist decent or not. Once a connection between all the forensic awareness strategy aspects can be made, it can be used to aid investigations where the related variables are unknown. For example in investigative circumstances, a selected weapon would be chosen by the offender based on their knowledge of FAS, possibly leaving fingerprints and traces of Deoxyribonucleic Acid (DNA) either on the weapon or at the crime scene. This specifically chosen weapon (not-opportunist) reduces the chance of leaving trace evidence behind, and therefore an aspect of clean-up after the crime has also taken place (assuming the weapon is not left behind). For a weapon to have been specifically chosen by an offender before the crime, it cannot be considered an opportunist weapon. If the weapon is by chance of opportunity, there is a possibility that the level of the offender's forensic awareness allows them to partake in a clean-up routine after the crime has been committed.

Little is currently known about the choice an offender makes when a weapon is determined as being of an opportunist nature or not, and what aspects follow their choice of weapon. Currently, the only confirmatory check that is possibly used for determining whether the weapon used in the case of homicide is an "opportunity weapon" or not, is corroboration by either the victim (only liable if the victim survives) or the offender, which in all successful homicides carried out by the offender is not possible. An aspect of this study is to more specifically determine which weapons are more often opportunist, and which are commonly

brought to the scene by the offender. As well as this, there is an investigation into the study to whether there is any link between weapon and other aspects of the crime, such as evidence minimalization, location of injury, number of injuries etc. If this can be determined, investigations may not be able to base their determination on the statistics in relation to future investigations, and at least it can give the forensic investigation team a starting direction using commonalities.

It is hopeful that there will be an established link between the offender's choice of weapon, and their known level of forensic awareness. Resulting in the concurrent injuries of this weapon choice, specifically how many injuries and where on the body these injuries are inflicted. Additional information is aimed to be found in comparing all variables, including weapon choice and injuries, location and severity, and whether a weapon was chosen prior to or at the time of the crime by the offender. A relationship between each of the variables will be identified or disproven.

3. METHODOLOGY

3.1 Data Collection

A previously developed database consisting of 82 sexually motivated, male (as termed in the database) serial murderers active between the years 1950-2008 (approximately), with the individuals selected from numerous different countries and murder patterns. Serial killers were chosen from this data based on the fact that they were single motivated killers (couples were excluded), presented as male in the literature, and had at least two victims that they were convicted of murder. From this selection criteria, 49 randomised SK names were selected from this database and used in the terms of this study. The database was provided by Dr David Keatley in association with Dr Reid. Each of the 49 SK

names was selected using a random number generator found on Google, and each number between 1 and 49 was correlated with an SK name. The database included an assortment of already known variables that relate to the serial killer, the victim and elements of the crime, most general data will be irrelevant to aspects of this study but are still included in the original database. All the data that was required for this study, either gathered from the given database or collected from outside sources, was taken, transferred and stored in an Excel spreadsheet. Data was only collected and utilised in the circumstances that the murders had been confirmed through the persecution of the offender, and in some circumstances where the offender had been charged, it was a requirement that the victim did not survive the attack. If any individual victim murders did not fit this criterion, they were removed from the dataset (other confirmed victims from the same offender were still included).

3.2 Variables

An assortment of variables was investigated in order to present a possible comparison between the selected serial killers and each individual murder. These variables included the weapon of choice by the offender (in some cases more than one), the number of injuries inflicted on the victim prior to and post-death, the injury location, (any evidence of) clean-up and forensic evidence minimisation by the offender, choice and chance of using opportunist weapons (or not), and age and sex of both the victim and the offender. The variables were gathered from the previously composed database, with other required variables not available through the database being identified using Open Source Intelligence (OSINT), and relevant pathology reports that could have been found, which in this case were very minimal. The majority of OSINT collections that were used in this

study were based on literature research and articles that had already been presented in the field.

When completing the database of necessary variables for the study, there were assumptions of a range of variables that were not accurately represented in the literature or information identified, that needed to be categorised by likelihood. In the case of was is represented as the mechanism of murder, and the classification of weapon there were many examples of being categorised. Representatively, if a victim was found to have been stabbed as the mechanism of murder and when no specific classification of weapon was not identified, it was assumed to have been sharp force trauma involving a knife. The same rules were applied in cases of strangulation, if not specified were recorded as being manual strangulation using hands. In the case of firearms, if they were not specified in a subcategory, they were simply labelled as a gun, compared to for example shotgun or pistol. Any information that could not be found was marked as unknown in the data, this is representative of information that was unknown due to it not being found in literature as well as data that may always be unknowable in some circumstances. Any information that is not existent was marked as n/a, which typically occurred in duplicate data columns used for more than one weapon, for example.

3.3 Statistical analysis

All data which has been collected is compared and analysed using multiple statistical methods, determining a possible significant difference or statistical correlation between the variables stated above. A selection of basic evaluations, such as mean and standard deviation will be identified (may not be stated), and these will be carried out using Microsoft[®] Excel software (2022). Complex statistical techniques including Chi-square tests and t-tests (both individual and paired) were performed using IBM[®] SPSS Statistics

28.0 Software (2022). The threshold for significant data was set at $p < 0.050$. Expected cell count was also identified, but was not the final result in determining significance. Chi-square tests were the preferred test. It was determined that some of the Chi-square results were violated by the threshold, these were determined as not significant.

4. RESULTS AND DISCUSSION

4.1 Mechanism of death and weapons

The mechanism of injury was the first data set that was obtained and investigated, to determine a general understanding of the Modus Operandi (MO) of the offender in relation to all of their victim cases, this also allows a basic pattern to be established of similarities.

The collection data for the mechanism of death was completed in a duplicate of three, meaning that at least one offender inflicted three different mechanisms of injury upon the victim. Mechanism of death (1) determined there were 14 different categories of mechanisms of death, with mechanism (2) containing 13 categories, and mechanism (3) only containing three categories. It can be determined by these that majority of victims were murdered using only one mechanism.

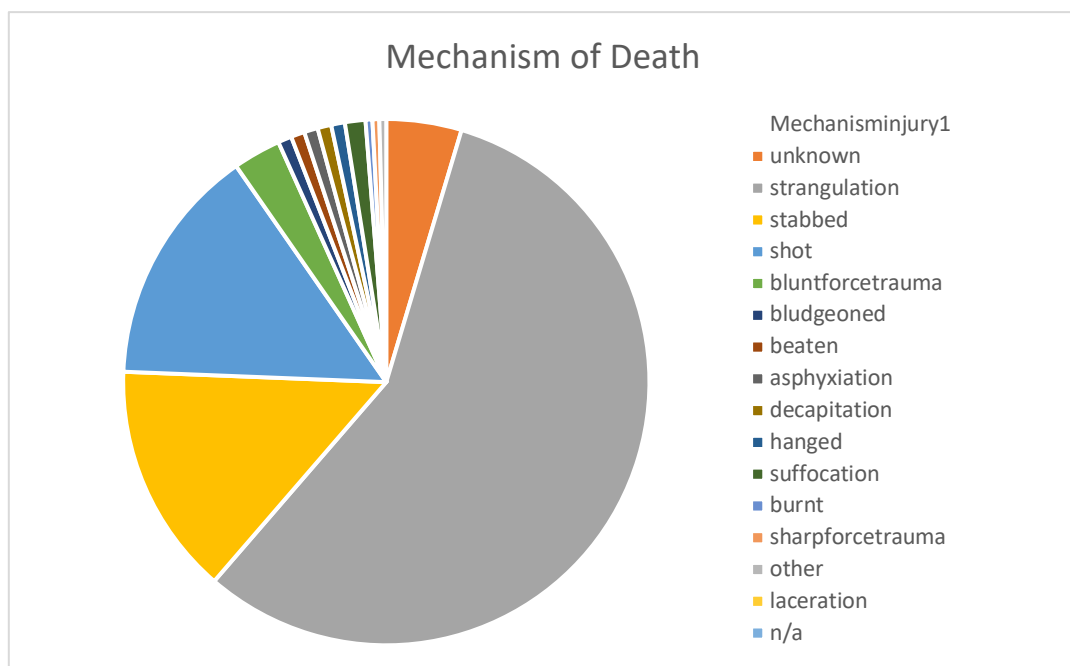


Figure 2: Pie chart of Mechanism (1) of death of a total of 335 victim cases.

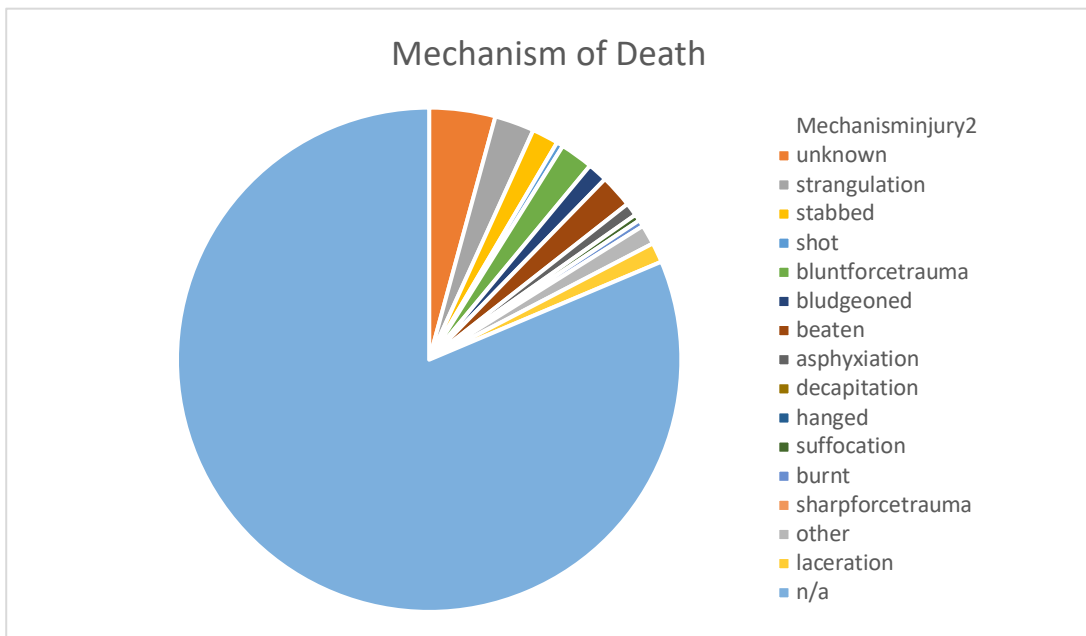


Figure 2: Pie chart of Mechanism (2) of death of a total of 335 victim cases.

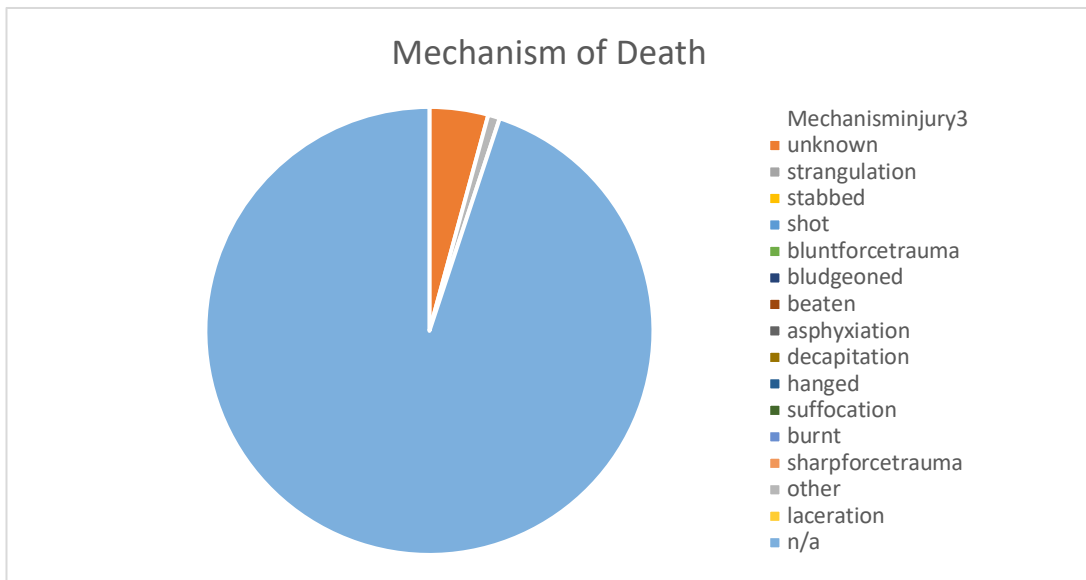


Figure 3: Pie chart of Mechanism (3) of death of a total of 335 victim cases.

As presented in Figure 1, 40.3% (n= 135) of the 355 victims that were investigated were murdered by means of strangulation, with the next most represented mechanism of death being shooting with 10.4% (n= 35), closely aligned with stabbings at 10.1% (n= 34). The least common mechanism of murder was lacerations and other both with 0.3% (n=1). When determining the information presented in Figures 2 and 3, the majority of the data is annotated as n/a (Figure 2; 57.3%, n= 192, Figure 3; 66.9%, n= 224) meaning that the victim was murdered using only one mechanism of death. When n/a is used in the case presenting the data of this study, it is defining data that it is not applicable for that specific section of the

dataset, as explained above using only one mechanism of death, but there are a total of three groups, therefore in the last two it is marked as n/a. The unknown is used when the information could not be found in data collection or is simply unknown to the dataset.

The mechanism of death can be used to determine a pattern of MO of the offender, although an investigation into the weapon linked to the mechanism of death is as important in determining offender and choice of weapon relationships.

The type of weapon that was chosen by the offender was categorised into ten groupings, including unknowns and n/a groups. Similar to the mechanism of death, there were three separate classification data sets, presented in the same way as above, meaning that at least one victim would have to have been killed using two different weapon choices. Weapon classification (1) data was finalised with ten different categories of weapon subgroups, and weapon classification (2) with eight subgroups.

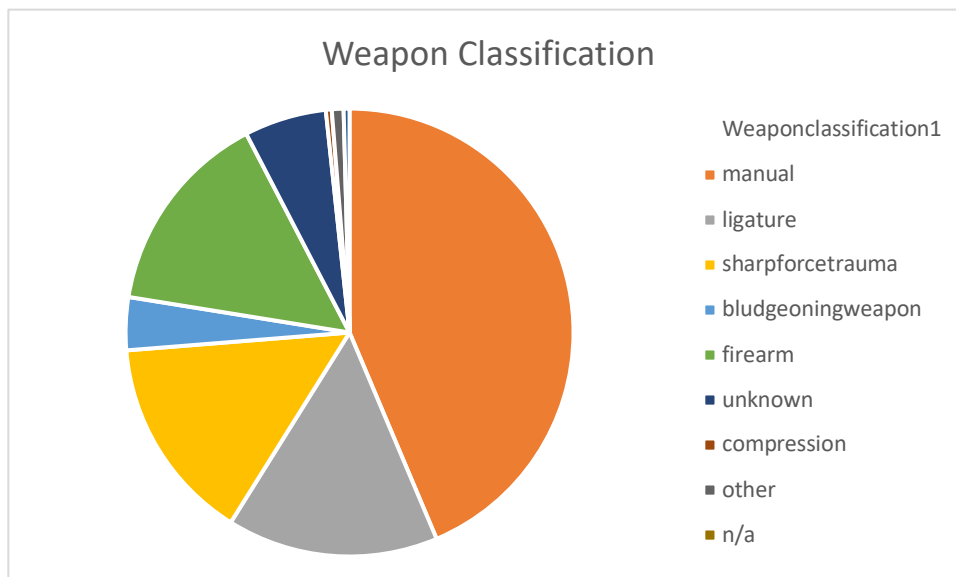


Figure 4: Pie chart of Weapon classification (1) of 335 victim cases.

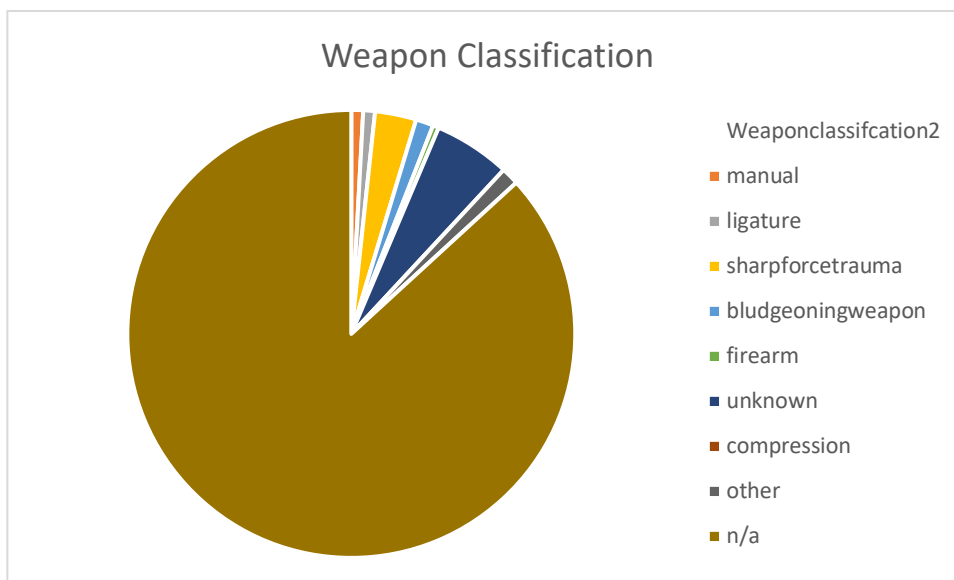


Figure 5: Pie chart of Weapon classification (2) of 335 victim cases.

As represented in Figure 4, the most common weapon classification that has been determined is manual (strangulation) identifying 30.7% (n= 103) of the total cases. There are no other weapon classifications that have a similar dataset amount compared to manual strangulation. Again presented in Figure 4, the second most represented weapon classification is the use of ligatures occupying 10.7% (n= 36) of the dataset. The use of sharp force trauma and firearms are similar in occurrence (10.4%, n= 35). The least known weapon types used by offenders in these cases, is compression of the neck (determined to be different than strangulation) and the use of poison, both occurring at a 0.3% (n= 1) chance by the offender.

Furthermore, gaining information about the general weapon category that has been chosen by the offender at the time of their crime is an extended step in determining MO. This detail was explored at a deeper level with determining the specific type of weapon used by the offender. When determining the exact weapon type, the same method was used as previously stated resulting in three datasets for weapons (datasets 1, 2 and 3), again determining that at least one victim was killed using a variety of up to three weapons, chosen by the offender. A total of 19 categories were used to place the weapons, including unknown and n/a.

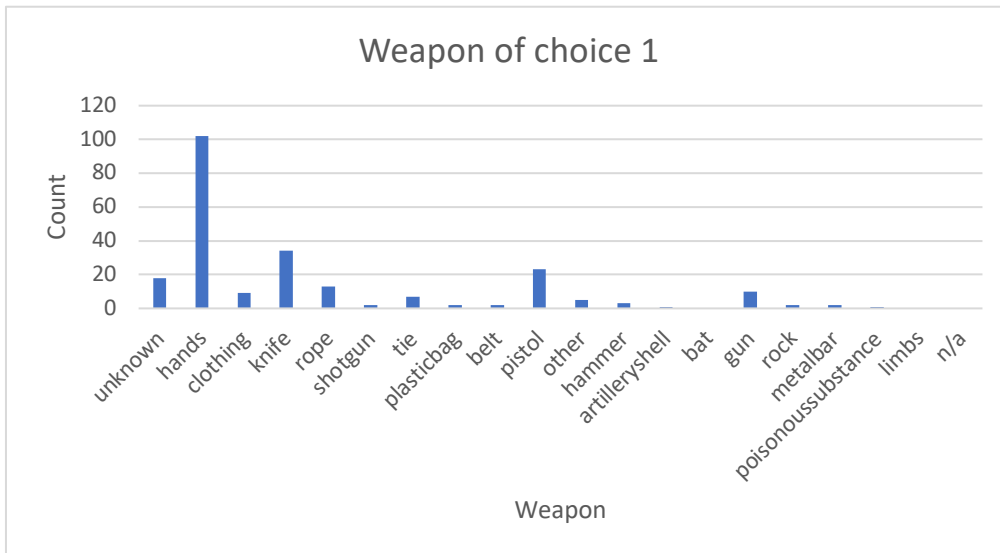


Figure 6: Bar graph representing Weapon (1) of choice by the offender within 335 victim cases.

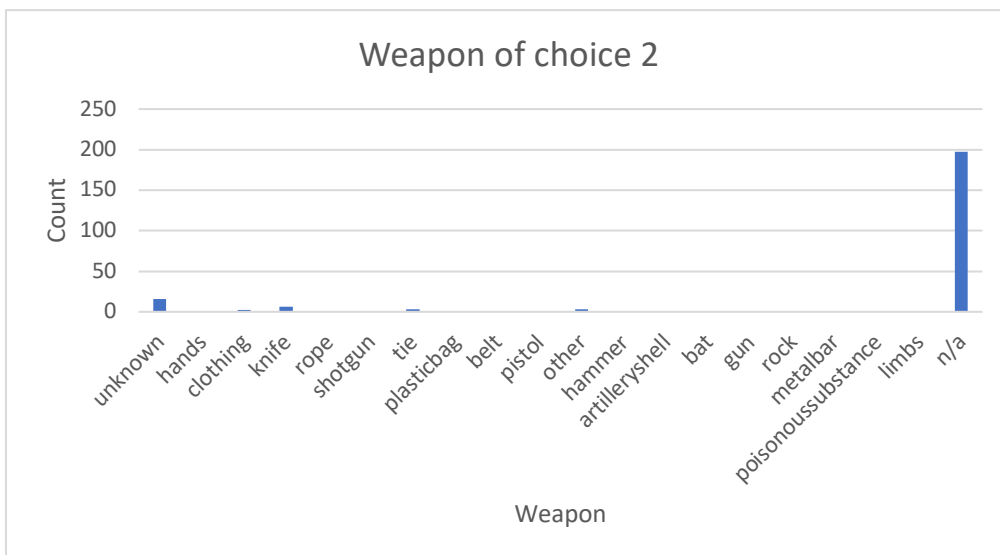


Figure 7: Bar graph representing Weapon (2) of choice by the offender within 335 victim cases.

As represented visually in Figure 6, compared to Figure 7, the majority of the victims were killed with the use of only one weapon. The most common choice of weapon for this study was hands (30.4%, n= 102), which supports the findings presented above in Figures 1 and 4, showing the most occurred mechanism of death being strangulation and weapon classification of manual strangulation. The use of knives (10.1%, n= 34) and pistols (6.9%, n= 23) are also relevantly used as a chosen weapon, compared to the rest of the weapons presented in the above figures. To be included in the dataset, the weapon would have to have

been used by at least one offender, although it was commonly found that a one-time use was the maximum.

Statistical analysis, specifically chi-square analysis was undertaken to determine a relationship between the mechanism of death and weapons. Firstly, just by interpreting the data visually, there could be an assumption made that there is a statical correlation between the mechanism of death and the weapon classification chosen by the offender, as there is a large amount of death by strangulation correlating with the high representation of manual strangulation as the weapon of choice. Despite this being represented in previous studies (Dettmeyer et al, 2013) and a significant correlation between the two has already been established in the literature, the relationship analysis was undertaken in the circumstances of this study. A chi-square test was accepted in the relation between the mechanism of death and the weapon, resulting in a high statistical significance between the two variables ($P = 0.001$). A paired t-test was also determined which produced the same result ($P = 0.001$). This presents a statistical relationship between, death by strangulation specifically being associated with manual strangulation, death by stabbing being associated with sharp force trauma, and death by shooting specifically relating to firearms, as examples. These relationships might be seen as expected and commonly understood, although are still necessary in the case of this study to build relationships and comparison. Weapon classification and specific weapons were determined to be highly significant using a paired t-test ($P = 0.001$), as well as this being visually hypothesised. Using examples of the variables from this data, there was a relationship between the classification, for example This presents a statistical relationship between strangulation and the offender's hands, death by sharp force trauma and knives, also ligature strangulation and the use of the victim's clothing.

Another statistical analysis was undertaken using variables from above, with others that will be mentioned next.

4.2 Resulting Injuries

When an individual is attacked, it is commonly assumed that there will be at least one visible injury which in most circumstances can be used to determine the cause of death when it is unknown. A relative area of the presence of injuries is the anatomical location of the injury on the victim's body. Knowing this information can help determine what weapon had been used and other forensic aspects of the crime which this study is trying to determine. The placement of injuries was a part of the study's dataset with the body being split into general areas to determine where the injury occurred. These areas include the head, neck, trunk, upper limbs, lower limbs, genitals, and whole body. The whole body subcategory was determined when there was no specific region mentioned but was described as multiple areas of the body. Subcategory, Unknown was also used.

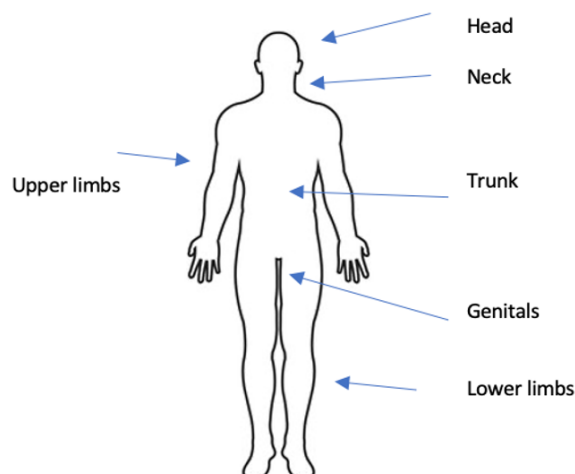


Figure 8: Anatomical representation of the human body. Displays where the labels were determined.

It was determined that 43.9% (n= 147) of the injuries were placed in the neck region of the victim, which supports the findings from the previous data, presenting manual strangulation as being the most occurred mechanism of death/weapon. Surprisingly, the

likelihood of sustaining the injury to the trunk (5.7%, n= 19) was more common than an injury to the head causing death (4.8%, n= 16). Injuries to the whole body accounted for 0.9% (n= 3) of the 335 cases, whereas no injuries to the genital area were determined as a result of the use of a weapon.

Statistical analysis was undertaken to determine a potential relationship between the specific type of weapon used and the placement of the resulting injury. It was concluded, through a chi-square test that they were statistically significant (P = 0.001). This presented the correlation between manual strangulation present on the neck, ligature strangulation with the use of clothing targeting the neck also, and knives and firearms were most likely to target the trunk, as examples. The same test was commenced to determine the significance between the mechanism of death and injury location, as well as the classification of the weapon and injury location. Like before, they were both found to be statistically significant (P = 0.001). The results for the classification of the weapon were similarly identical to the results for specific weapon types, which would ideally be expected.

The number of injuries that are inflicted on the victim is also an important aspect of determining injuries forensically. In the case of this study, more than half of the victims (51.3%, n= 172), only had one injury that was found at the time of their death (for this study, if only one injury descriptively was mentioned it was noted as 1). Surprisingly, the subgroup containing more than 3 injuries was the second-highest occurring amount of injuries (6.6%, n= 22). For the use of simplification of the data, any circumstances where there were more than 3 injuries on the victim, were placed together in the subcategory. The range for this subgroup ranges from 4 to < 250.

A chi-square test was performed to present any significant relationship between the placement of injury and the number of injuries. It was determined these were highly

significant ($P = 0.001$). In the majority of cases where there were multiple injuries, they were located in the trunk area of the anatomical positioning of the body. Injuries which were at a maximum of one, for example a strangulation, were typically located in the neck or head regions.

The presence of post-mortem injuries was a category that was added in this study as an additional concept to provide more information. It was determined that out of the 355 cases in the dataset, only 8 (2.4%) of victims have been confirmed to have post-mortem injuries present. The rest of the 327 cases were determined as being unknown, this could be due to the literature not presenting the existence of post-mortem injuries correctly, there is no mention of post-mortem injuries so it is determined by the reader that there were none, or it is an element of the crime which is completely unknowable, for example, the body is never found or too degraded to determine injuries. Although there is not much information on this area, an independent t-test analysis was undertaken to investigate if there is any significance on the data that was able to have been collected. It was determined that they weren't statistically significant ($P = 0.121$).

4.3 Opportunist weapons

It is known in previous literature (Pelletier et al, 2019) that it is possible in cases of murder that the offender does not always bring their choice of weapon with them to the scene of the crime, and therefore use a weapon that they collect from the scene itself. This is determined as an opportunist weapon. The data collected in this study determined whether the weapon used in the case of each individual murder was either bought to the scene by the offender, a weapon that was found at the scene or if it was unknown to be either. A general dataset of a yes or no to the weapon being of opportunist decent was completed first. This determined

that 34.3% (n= 115) of the cases were a weapon of opportunity, 17% (n= 57) of the weapons were bought to the scene by the offender and 18.5% (n= 62) were concluded to be unknown.

The origin of the weapon was placed into subgroups of unknown, scene, bought and hands. Hands were kept separate from the others due to the unconfirmed understanding of what category these fit into.

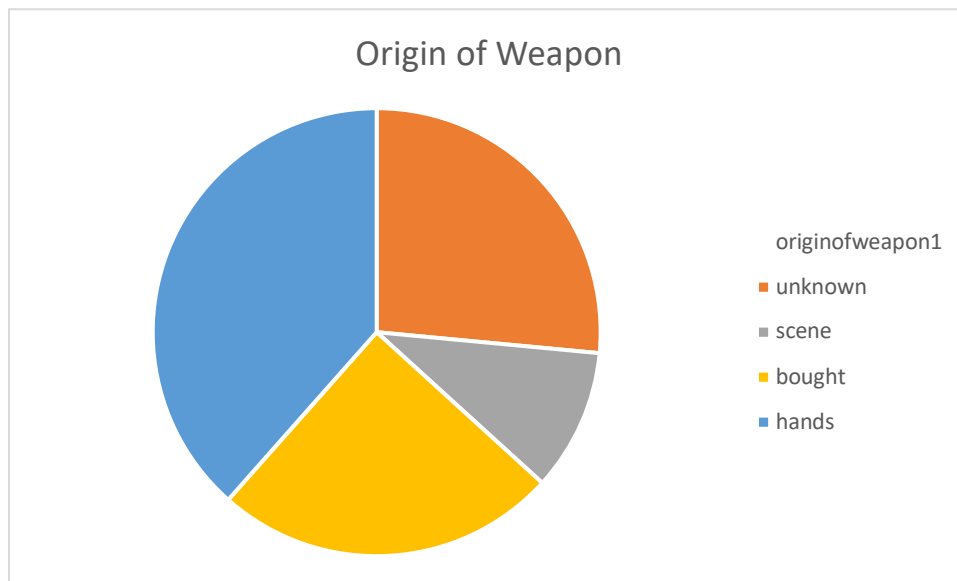


Figure 9: Pie chart representing Origin of weapon of 355 victim cases.

As represented in Figure 9, it can be determined that the most common origin for a weapon is in the hands of the offender (26.9%, n= 90). With this being the highest occurring origin of the weapon, it can be seen as decreasing the value of determining whether a weapon is of opportunist decent or not. With hands being used as a weapon, there is no current level of understanding to establish if it is an opportunity weapon or not, with the possibility of change from case to case. Other than this, it was found that 17.3% (n= 58) of the data was determined to have bought the weapon to the scene, and 7.2% (n= 24) of the weapons were found at the scene and determined to be opportunist. A total of 18.5% (n= 62) was unknown.

A chi-square test was undertaken to find significance between the opportunist weapon and the origin of the weapon. It was determined that they were highly statistically

significant ($P = 0.001$). The relationship determined when the weapon was found at the scene, it is determined to be of opportunist decent, and when bought to the scene it is not. The origin of the weapon was also tested with the data from the mechanism of death through chi-square analysis establishing a statistical signification ($P = 0.001$). For example a prominent finding, was the relationship between mechanism of death strangulation and origin of weapon in the case of hands. It is still uncertain in current research if manual strangulation is considered opportunist or not.

4.4 Forensic Evidence

4.4.1 DNA

In the aspects of forensic investigations, the presence of Deoxyribonucleic Acid (DNA) is highly informative in determining crimes. DNA is possibly the most valuable evidence that can be found at a crime scene, with the objective of identifying the offender at the scene. In the case of this study, evidence of DNA at the scene was marked as yes, no evidence was marked as no and there was also an unknown subgroup. It was determined out of all the victim cases, the highest subgroup was the unknowns, with 43.9% ($n = 147$). DNA was found in the least amount of cases compared to all of them, with a small 6.3% ($n = 21$) of the cases having DNA present at the scene/found on the victim. No presence of DNA was confirmed in 19.7% ($n = 66$) of the cases.

More than one chi-square analysis was undertaken using these subgroups. Firstly, the presence of DNA was found to not have a statistically significant relationship with weapon classification ($P = 0.167$). Another chi-square was undertaken to find the significance between the presence of DNA and the mechanism of death. They were determined to not be statistically significant ($P = 0.653$). Lastly, a chi-square analysis determined that the presence of DNA and the origin of the weapon is as well not statistically significant ($P = 0.355$).

Once there was confirmation that there was DNA that was found at the scene, it is needed to be determined where the origin of the DNA has come from, and where it was found. In the case of this study, there was only one victim case that had a known origin of the DNA. This was from a sexual assault. 19.1% (n= 64) of the data was not applicable, as there was no DNA found. The rest of the data were unknown.

A chi-square was undertaken to determine the significance between the origin of DNA and weapon classifications. It was determined that they were not statistically significant (P = 0.897).

4.4.2 Evidence Minimisation

It is known from previous research (Beauregard et al, 2010; Beauregard et al, 2014; Chopin et al 2020) that forensically aware offenders know what investigators look for when looking into a crime. Therefore, when the offender has this knowledge, most do what they can to defer investigators from identifying them. The minimisation of evidence by the offender has been determined in this study, with relatively expected results. 25.7% (n= 86) of the cases did go to lengths to clean up possible forensic identifiers before leaving the scene. 5.1% (n= 17%) of the data did not minimize any evidence from the scene. The rest of the data was consistent with unknowns, this could be a collection of it being found but not stated in the literature, or there was no evidence of Forensic awareness strategies (FAS) by the offender and again not mentioned in the literature. Forensic awareness strategies include DNA, fingerprints, footprints, disposing of the body, use of gloves, masks etc (Beauregard et al, 2014)

Two chi-square analyses were undertaken in relation to evidence minimisation. Firstly, evidence minimisation was determined to be statistically significant to the choice of weapon. It was found to be statistically significant with P = 0.006. Next was the relationship between

evidence minimisation and the mechanism of death. This was found to not be statistically significant ($P = 0.352$).

Similar to the collection of DNA, the study also determined if there was any forensic evidence collected from the scene, which is not restricted to DNA, but included anything that could be forensically useful in investigations. Any evidence that was collected from the scene was marked in the study as yes, resulting in 9.3% ($n = 31$) cases finding some aspect of forensic evidence. Any confirmed no's were recorded as that, with 3.3% ($n = 11$) of the cases not finding any forensic evidence at the scene. All others that were not confirmed as yes or no were recorded as unknowns (57.6%, $n = 193$). Unknown attributed for more than half of the data.

Once it was determined that there was forensic evidence collected from the scene, it needed to be established the category of the evidence. It was determined that more than half (58.2%, $n = 195$) of the collected evidence was of unknown category, meaning it wasn't suggested in the literature. 6% ($n = 20$) was determined to be the DNA collection, with 1.5% ($n = 5$) of the evidence collection being the victim's body, still at the scene or found at a secondary scene. The presence of fingerprints (0.6%, $n = 2$) and the weapon (0.9%, $n = 3$) were similar in their occurrence of collection.

5. CONCLUSION

Overall, the aim of this study was to determine if the choice of weapon by an offender would alter the other decisions or reactions that would have been made after the weapon had been selected. The study initially created a database that included the choice of weapon, the mechanism of death, resulting injuries, and a variety of forensic aspects that are important aids when investigating crime, specifically homicides. Generally, it was determined that there was a statistical relationship between most investigative variables, with and

without the choice of weapon being a variable. It was found that many of the variables had a significant relationship to each other which could be used in investigative purposes. It was determined that six out of thirteen statistical analysis were rejected.

5.1 Limitations

There were many limitations related to this study. Firstly, the information collected and used in the analysis for this study was that of crimes that the offender had been convicted for only. This does not account for all the murders that may be still unknown to an investigation, as well as any others that the offender was not prosecuted for. A huge limitation found throughout the collection of the data was the lack of descriptions in the literature. The wording of the references is basic and does not specify details that were needed for the data. For example, the literature describes someone as being stabbed but does not specify what weapon caused the stabbing. In cases like this, it was assumed to be a knife. This happened on many occasions as represented in the methods. The biggest limitation that has been identified in the field, would be recording and documentation issues. Aspects of crime are being recorded wrong or not being documented at all, resulting in studies like this one lacking important information that could ultimately change the final analysis results.

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