A RETROSPECTIVE STUDY OF THE DEMOGRAPHICS AND WOUND CHARACTERISTICS OF FIREARM RELATED FATALITIES IN LANE COUNTY, 1986 - 2007

by

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A THESIS

Presented to the Interdisciplinary Studies Program: Individualized Program
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Master of Science

December 2010

THESIS APPROVAL PAGE

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Title: A Retrospective Study of the Demographics and Wound Characteristics of Firearm Related Fatalities in Lane County, 1986 - 2007

This thesis has been accepted and approved in partial fulfillment of the requirements for the Master of Science degree in the Interdisciplinary Studies Program: Individualized Program by:

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Degree awarded December 2010

THESIS ABSTRACT

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Master of Science

Interdisciplinary Studies Program: Individualized Program

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The goals of this study are to assess a) the role of mass and velocity on the size of entrance wounds, b) the presence or absence and types of exit wounds, and c) the role of gender in choosing to commit suicide with a firearm.

The results of an ANOVA revealed that the combination of a bullet's mass and the relative velocity of the weapon is the most significant factor in entrance wound size. A logistic regression found that mass plays the most significant role in the presence of an exit wound. When considered separately, velocity had a more significant effect on exit type than did mass.

The study also found that being male increases the odds that a firearm will be chosen to commit suicide. Handguns and the head were the most common choices for weapon and wound location, respectively, in both firearm suicides and homicides.

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ACKNOWLEDGMENTS

I want to thank my advisors for their assistance with this thesis. I know that it has been a long road and I appreciate their patience.

In 2005, I had the good fortune to start work with Lane County Sheriff's Office Criminal Investigation Section and Search and Rescue program, I cannot thank them enough for their guidance and friendship, I have learned more in five years than I could imagine. And to Jeanne McLaughlin, thank you for your friendship and encouragement. I look forward to many more years of research and troublemaking.

Thank you also to Mom, Dad, and Becky, who always take the time to be my cheerleaders and remind me to have fun. And to Zack Almquist, who never hesitated to answer a panicked E-mail. Last, but certainly not least, I want to acknowledge John Boren, who truly is the epitome of patience and understanding.

For my Grandparents – Richard, Shirley, Ray, and Sharon. I could not have come this far in life without the support of grandparents like you.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table Page

CHAPTER I

INTRODUCTION

Violence is an unfortunate fact of life in the U.S. Guns make a major contribution to this ongoing national crisis.
James Messmer

Guns are an American tradition, or as one researcher stated, guns are as American as mom's apple pie (Squires, 2000). Guns have the power to turn people into heroes or into villains. In some form or another guns are a part of our everyday lives, whether it is through watching the news or the guns that we unknowingly pass on the street. Recent studies estimate that at the end of the 20th century, American gun ownership rates were up to approximately 926 guns per 1,000 people (Wellford, Pepper, & Petrie, 2004). According to Oregon's Law Enforcement Data System (LEDS) there are 126,836 concealed handgun permit holders in the state and because gun registration is not required, that is only a fraction of the total number of gun owners (LEDS, 2010). These numbers are important to keep in mind, because as one study points out, there is more than a "casual relationship" between ownership of firearms and firearm related deaths. Granted, "the vast majority of firearm uses do not result in personal injury and are highly valued by many citizens" (Wellford et al.,

2004). However, there is an obvious dark side to the use of firearms that law enforcement and Medical Examiner's Offices deal with on an everyday basis. This thesis will investigate that dark side - the role of firearms in deaths in Lane County.

The purpose of this thesis is two-fold: to paint a picture of who is involved in firearm deaths in Lane County and then to analyze the characteristics of gunshot wounds based on caliber and weapon type. This research will add to the body of knowledge currently available for gunshot wound characteristics, in particular exit wounds, and demographics by examining Lane County Medical Examiner's Office data on all firearm related deaths that have occurred in a twenty-one year period, between 1986 and 2007. These dates were chosen based on the years of death investigation reports currently available.

There are currently studies that have analyzed the demographics of firearm related deaths around the United States, particularly suicides, in individual counties and states, as well as firearm deaths in other countries (CDC, 2004; Cina, Ward, Hopkins, & Nichols, 1999; Druid, 1997; Garavaglia & Talkington, 1999; Molina & Di Maio, 2008; Schmeling, Strauch, & Rotheschild, 2001; Shen, Millet, & Kohn, 2009; Wellford, et al 2004). These include data annually published online by both the State of Oregon and the Center for Disease Control. However, no such study has been done locally using Lane County data. This study will compare local demographics to state and national demographics to uncover any trends or anomalies specific to Lane County firearm related deaths associated with sex or age.

Additionally, this project examines the mechanisms of injury and characteristics of gunshot wounds based on the caliber, the type of firearm, and wound location. The research includes an analysis of past death investigation reports provided by the Lane County Medical

Examiner's Office. This project focuses on analyzing the size of the entrance wounds and the presence and relative size of exit wounds. This study will be used to provide more information for the cases in which caliber and weapon are unknown, providing investigators with more information to draw from when making conclusions about a scene.

What this thesis does not aim to do is draw conclusions about gun control, gun safety, and the role of social status in firearm related deaths. There is a strong sociological component to firearm related violence that lies beyond the scope of this paper.

Objectives

The objectives of this thesis are:

1) to examine the effect of mass and velocity on entrance wound size, through the analysis of cases with known bullet caliber and weapon;
2) to examine the effect of mass and velocity on the presence or absence of an exit wound, through the analysis of cases with known bullet caliber and weapon;
3) to examine the effect of caliber on relative exit wound size;
4) to paint a clearer picture of who is involved in firearm related deaths in Lane County and when these deaths occur. Following the footsteps of previous studies (CDC 2004; Shen et al 2009), this study analyzes the age, sex, and time of year of each firearm related death between the years of 1986 and 2007.

Hypotheses

Hypothesis One

Hypothesis #1 is two-fold. Hypothesis 1a: The larger the caliber and greater the mass of the bullet, the larger the entrance wound will be. Hypothesis 1b: The higher the muzzle velocity, the larger the entrance wound will be.

Hypothesis Two

Hypothesis #2 is also two-fold. Hypothesis 2a: The larger the caliber and the greater the mass of the bullet, the more likely an exit wound is to occur. Hypothesis 2b: The higher the muzzle velocity of the weapon, the more likely an exit wound is to occur.

Hypothesis Three

There will be a significant difference between the exit wound types (complete, partial, avulsed) created by small, medium, and large caliber bullets. Following the definitions of Garavaglia and Talkington (1999), small caliber bullets are .22 and .25 caliber; medium caliber bullets are .32, .357 Magnum, .38 Special, .380, and 9mm; large caliber bullets are those greater than 9 mm. Large caliber bullets will create more avulsed exit wounds.

Hypotheses #1, #2, and #3 are based on the relationship of mass and velocity to the kinetic energy transferred from the bullet to the entrance site on the body. Kinetic energy intensifies with increases in velocity and mass (Heard, 1997). In this case, if mass is doubled then kinetic energy is also doubled, but if the velocity is doubled then the kinetic energy is quadrupled. The equation for this is $KE = \frac{1}{2} mv^2$, where KE represents kinetic energy, m is mass of the moving object, and v is the velocity.

Therefore, amplification of kinetic energy would increase the possibility that enough energy would be retained throughout the bullet's trajectory to result in an exit wound.

Hypothesis #3 is related to the idea that the larger kinetic energy will create a larger temporary cavity, the space created around the bullet as it passes through the body, inside the cranium that will lead to more avulsed exit wound.

Hypothesis Four

The difference between male and female firearm related suicide rates will decrease in significance as the years progress from 1986 to 2007, ending in 2007 with no significant difference. For many years, firearm related suicides have been associated largely with males. However, as one author points out, over the last few decades the use of firearms has become the most preferred method of suicide for females (Di Maio, 1999).

Significance

Guns have been a threat to safety and such a large part of our lives that the information available to law enforcement and medical examiners needs to reflect those facts.

Firearm related injuries are a subset of the larger public health issue of deadly violence against others and against oneself. To adequately address this issue, it is essential for public health agencies, at both a local and national level, to better understand who is committing these actions and what the contributing factors are. Additionally, the study of wound characteristics will add to the growing body of knowledge about wounds in the absence of reliable gun or bullet information. As Berryman and company (1995) point out "bullets may exit and get lost at the scene, may be lost during surgery or may be absent with skeletal remains" (Berryman, Smith, & Symes, 1995). Because of the nature of gunshot wounds, the purpose of this thesis is not to provide absolute answers as to the cause or manner of a specific wound, but rather, to help investigators eliminate a particular caliber or

firearm, and to better understand the likelihood of a particular manner of death based on existing wound and demographic data.

Thesis Structure

Following a background and literature review, this thesis will be organized into three major chapters: a) materials and methods, b) characteristics of wounds and weapons, and c) demographics, followed by a summary and conclusions. The materials and methods section will be divided into three sections: data, variables, and test. The chapter discussing the results of the analysis of characteristics of wounds and weapons will be divided into four subsections- weapons, wound location, exit presence and absence, and wound type and size. The latter two subsections will examine the role that caliber and weapon type play in wound characteristics.

The demographics section will be divided into two subsections - homicide and suicide. Each of these will include an examination of the sex and age groups involved in each manner of death. After the summary and conclusion, there will be a short chapter outlining future research that can build on the results and conclusions of this thesis.

CHAPTER II

BACKGROUND AND LITERATURE REVIEW:

WOUNDS AND WEAPONS

"As long as there are guns, the individual that wants a gun for a crime is going to have one..."
Ronald Reagan

The literature review is divided into two chapters. Chapter two will address wounds, weapons, and ballistics; chapter three will address the demographics of people from the Medical Examiner's Office sample with gunshot wounds. Before proceeding, a few terms should be clarified: cause of death, manner of death, homicide, suicide, and accidental. The **cause of death** is the action that physically led to death, for example, asphyxiation due to ligature hanging, arteriosclerosis heart disease, exsanguination, myocardial infarction, or a gunshot wound to the head. The **manner of death** is the intent belying the cause, and includes homicide, suicide, natural, accidental, and undetermined. The two manners of death this thesis focuses on are homicide and suicide. **Homicide** is an intentional act of violence against another person resulting in his/her death. **Suicide** is an intentional act of violence against oneself resulting in his/her death (CDC, 2004; Shen et al., 2009).

Wound Types

When considering gunshot wounds, a number of factors should be examined. These include relative mass of bullets of different caliber, the relative velocity of the handguns and rifles, and role that body area plays in wounding. This study will not involved shotguns due to the difference in wounding patterns between shotgun rounds and handgun and rifle rounds.

Gunshot wounds can be divided into four different types: contact, near contact, intermediate, and distant range (Di Maio, 1999). The wound analysis portion of this thesis is limited to contact and near contact wounds. **Contact wounds** are created when the muzzle of the firearm is touching the target. **Near contact wounds** are created when the muzzle of the firearm is not in contact with the skin, but is extremely close to the target. The distance is so small that it can mimic a loose contact wound, a contact wound in which the firearm is held loosely against, not pressed into, the skin (1999).

From here, two portions of the wound need to be considered, the entrance and the exit. Every gunshot wound will have an entrance, however not every wound will have an exit. Di Maio (1999) defines gunshot wounds into two types, penetrating and perforating. **Penetrating** wounds will not have an exit, and are wounds that enter the body, but do not have enough energy to exit. **Perforating** wounds do have an exit, which is often larger and more irregular than the entrance wound. This thesis divides perforating wounds into two further categories: complete and avulsed. Complete exit wounds can be measured and retain a relatively circular shape. Avulsed wounds are more extensive and cannot be accurately measured and often result in evacuation of the brain.

As stated earlier, this thesis focuses on contact and near contact wounds, since these are the most common wounds encountered (Molina & Di Maio, 2008). In suicides, contact

wounds are the most common, accounting for 96 percent of wounds in one study. In the same study, distance wounds made up 82 percent of homicides.

Weapons and Ammunition

For the purpose of entrance wound analysis, this study divides weapon types into three categories – revolver, pistol, and rifle. For comparison of weapon choice this study divides weapon types into three different, more general categories – handguns, rifles, and shotguns. This is to remain consistent with the design of previous studies and divides the weapons up into general categories based on velocities, as table 1 demonstrates (page 15) (Messmer, 1998).

This thesis also examines the role of mass in wounding and separates bullets into three size categories based on caliber – small, medium, and large. The **caliber** of a bullet refers to the diameter of a bullet, as well as the gun barrel, and is measured in inches (e.g., .357, .45, .44, etc.) or millimeters (e.g. 9 mm). The **grain** of a bullet refers to the weight of the bullet and can be converted to pounds or grams (Rinker, 2000). Both caliber and grain are usually used to describe a bullet.

Multiple studies have shown handguns to be the top weapon choice in suicides in the United States (Cina et al., 1999; Ross, 1995; Kohlmeier, McMahan, & Di Maio, 2001; Garavaglia & Talkington, 1999). For weapons besides a handgun, men were found more likely to use a rifle or shotgun than women. One study showed that men and women used a handgun 76.1 and 87.4 percent of the time, respectively. Of these, a .38 special was the most popular (Kohlmeier et al., 2001). Oregon studies show that 68 percent of firearm related suicides were committed with a handgun (Shen et al., 2009). Another study done in Berlin, primarily studying the location of the weapon after the incident, found that men and women

combined used handguns 73.3 percent of the time with medium caliber bullets proving to be the most used projectile (Garavaglia & Talkington, 1999). In a study using cases from Albuquerque, New Mexico and Charleston, South Carolina, large caliber handguns predominated in 63 percent of firearm related homicides and 58 percent of firearm related suicides, respectively. This same study showed that long guns (rifles and shotguns) were used in 13 percent of homicides and 15 percent of suicides (Cina et al., 1999).

However, in Druid and associates' study (1997), two-handed weapons (rifles and shotguns) were more common than single-handed weapons (handguns). Schmeling (2001) commented that this is consistent with studies in Britain, Scandinavia, and Canada demonstrating shotguns are the weapon of choice, possibly because of the gun laws in place in those countries, just as the more liberal gun laws of the United States may contribute to the high percentage of handgun usage.

Previous studies, such as Berryman and colleagues' (1995) study on the "Diameter of Cranial Gunshot Wounds as a Function of Bullet Caliber," have focused on the correlation of caliber and wound size, not appearing to take into account distance or velocity. In this study researchers focused on three different calibers, .22, .25, and .38, citing them as the some of the most commonly used calibers. Their results showed that .38 caliber bullets caused larger diameter wounds than both the .22 and the .25. However, the study leaves room for further investigation, as there were overlapping diameters for all three calibers and no significant difference between the diameter of wounds caused by .22 and .25 caliber bullets (Berryman et al., 1995).

The results of the Berryman study strengthen the arguments for studying velocity, when weapon information is available, in addition to studying caliber alone. A number of caliber

bullets are similar sizes, and more than one weapon type can fire the same caliber bullet, therefore it would be helpful to know the effects of differences in velocity between weapon types, such as handguns and rifles.

There are two types of bullets to consider, jacketed and partially jacketed. **Jacketed bullets** are used in the military, and have a thin covering of gilding metal (Di Maio, 1999). These bullets do not use up their kinetic energy by expanding, and penetrate further into the target (Rinker, 2000). **Partially jacketed bullets** leave some portion of lead exposed, depending on the manufacturer. These bullets are very common and include hollow-point bullets, or "expanding" bullets, and fragmenting bullets. The tips of these bullets will either increase in size or break into smaller pieces. These are designed to use energy to expand and stop (Di Maio, 1999; Padrta, Barone, Reed, & Wheeler, 1997).

Expanding bullets are something that should be considered. While this type of bullet may start at a certain caliber, it will expand upon impact, increasing in size and increasing wound diameter from what is normally expected at that caliber. A study by J.C. Padrta and company (1997) showed that .45 caliber expanding bullets created larger wounds than their .45 jacketed counterparts. This is an issue that could affect the reliability of measurements taken, especially if there is a case that involved an expanding bullet, but it was not noted in the report. Any wounds noted to have been caused by expanding bullets were not considered for this study. Padrta's study on expanding bullets also provides the study framework of this project, taking into account not only bullet type, but also bullet velocity, mass, and kinetic energy.

Terminal Ballistics

Ballistics deals with the study of the motion of projectiles, and can be divided into three specific areas of study: internal, external, and terminal ballistics. Because this thesis deals with close range cranial gunshot wounds, the specific area of interest is terminal ballistics, which is concerned with the study of the penetration, motion, and effects of the projectile in the body (Berryman et al., 1995; Fackler, 1988; Heard 1997; Ross 1995).

As shown in figure 1, when a bullet enters the body it creates two cavities – temporary and permanent – before exiting, assuming there is enough kinetic energy to do so. A **temporary cavity** is created as the kinetic energy from the bullet pushes aside tissue as it passes through. It lasts only milliseconds and then shrinks and stabilizes, forming a **permanent cavity,** or wound track. Both can be much larger than the bullet itself, depending on the elasticity of the tissue that was penetrated, but it is unclear how much larger (Di Maio, 1999; Fackler, 1988). The size of the bullet, the velocity, and the tissue type are all factors in the size of the temporary cavity and all of these are elements of kinetic energy.

Kinetic energy is directly related to mass and velocity as governed by the physics equation, $KE = \frac{1}{2} mv^2$, where KE is kinetic energy, m is mass and v is velocity. Because w = mass x gravity, another way of measuring kinetic energy is $KE = \frac{1}{2} wv^2/g$, where w is weight and g is gravitational acceleration (Denton, 2006; Di Maio, 1999; Ross, 1995; Heard, 1997). Doubling the mass will increase the kinetic energy two-fold. However, doubling the velocity will quadruple the kinetic energy. Previous studies (Denton, 2006; Messmer, 1998) point out that the amount of tissue damage that occurs is proportional to the amount of kinetic energy. Quatrehomme and Iscan (1999) state that the velocity of a bullet has to be greater than 70 meters/second to break through bone, depending on the bone's thickness. Another study

cautiously states that to break through bone with the thickness of the cranial vault, four to six millimeters, velocities between 80 and 90 meters/second are required (Di Maio, 1999). High velocity missiles (>914 meters/second) will cause more extensive damage during temporary cavitation. Velocity is based on the type of weapon used, which is why this thesis separates rifles and handguns. In general, rifles have a higher velocity. A "high velocity bullet fired into the skull quickly imparts a tremendous amount of kinetic energy…[resulting] in an explosive failure of the bone" (Berryman et al., 1995; Berryman and Symes, 1998).

In addition, Quatrehomme and Iscan (1999) observe that kinetic energy largely affects the size of the entrance wound. If kinetic energy is fully absorbed by the bone, there will be an absence of radial fractures; if kinetic energy is not fully absorbed by the bone, secondary fractures are evident, and can lead to a fragmenting of bone.

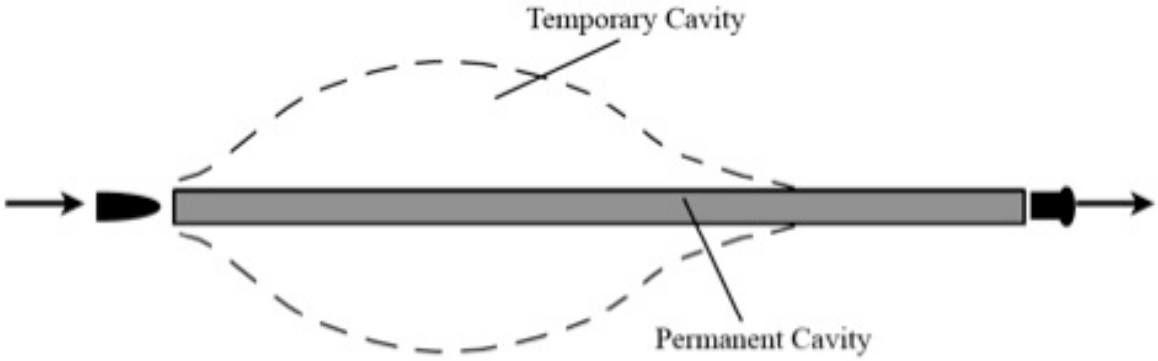

Figure 1: Temporary Cavity Formation (adapted from Heard 1997)

This in contrast to an article published by Fackler (1998), in which he argues that the impact of kinetic energy is not as straightforward as many researchers believe. He argues that depending on the ratio of mass and velocity, kinetic energy will impart differing types of

damage; large, slow projectiles will cause more crushing damage and small, fast projectiles will cause more stretching damage.

Kinetic energy is also based on the mass of the bullet, which is related to the caliber of the bullet. Depending on the maker and purpose of the bullet, bullets of the same caliber could have slightly different masses. Hollerman and company (1990) cite this as a reason that similar caliber weapons may not create similar sized wounds. However, grouping calibers into three general categories – small, medium, and large, can compensate for this fact. Table 1 shows that, in general, mass will increase as the caliber of the bullet increases.

There are other factors that should be considered including fragmentation, the bullet's orientation as it enters the body, referred to as bullet yaw, distance to the target, and varying density and elasticity of body parts (Berryman and Symes, 1998; Fackler, 1988; Fatteh, 1976; Messmer, 1998; Quatrehomme and Iscan, 1999).

Table 1: Relative Mass (adapted from Di Maio 1999)

Cartridge	**Bullet Weight (grains)**
Handguns	
.25 Auto	50
.32 ACP	71
.380	95
9-mm Parabellum	124
.40 S& W	155
.45 Auto	230
Rifles	
5.56 x 45	55
.243	100
.270	130
7.62 x 39	124
.30-30	150

However, this does not negate the validity of a study based on kinetic energy. In Lane County, most gunshot wounds seen by the Medical Examiner's Office are self-inflicted, which is consistent with the national difference between self-harm and assault injuries. Self-inflicted wounds are overwhelmingly close range, which will limit factors such as bullet yaw outside the body, the loss of velocity from distance and large intermediate targets. Some factors will not be limited, such as fragmentation and bullet yaw within the skull. Bullet yaw and deformation within the skull will increase the exact size of the exit wound, which is why this thesis will examine the *relative* size of exit wounds – partial, complete, and avulsed.

Wound Location

The lethality of cranial gunshot wounds may be one of the major reasons for the head being a common location for firearm deaths. Injuries to the brain that can result from a gunshot wound include, but are not limited to, "acute pressure on the brain stem, cerebral edema, and/or creation of secondary missiles" (Cina et al., 1999).

Wound location is an important fact to consider when addressing the size of entrance wounds and the presence or absence of an exit wound. This is due to the role that density and the amount of bone the bullet encounters play in the wounding process. The human cranium is made up of numerous bones of varying density; for example, the occipital bone in the back of the head is thick, while the upper portion of the temporal bone on the side of the head is very thin (Lynnerup, 2001). The importance of tissue density was tested in Ann Ross' master's thesis (1995) for the University of Tennessee and was found to be a significant factor in entry wound characteristics. Bony entrance wound size was found to be related to both caliber and bone thickness.

Wound location should also be a fact to consider when making judgments about the manner of death. Granted, it should one of many considerations, for example, Messmer (1998) found that thirty-eight percent of gunshot wounds of homicides were in locations typical of suicides. On the other hand, that same study showed that intraoral and submental injuries were only seen in suicides. Another study showed that a significant number of both suicides and homicides were temporally located while another showed that the majority of homicidal single gunshot wound were in "other head locations" when compared to right and left temporals (Molina & Di Maio, 2008; Stone, 1992). Wounds to the back of the head may be indicative of homicide, 29 percent of homicides in rifle related homicides in Bexar County, Texas but are not unheard of in suicides (Molina & Di Maio, 2008). In fact, in 2009, Lane County encountered a suicide that was committed with a handgun wound to the back of the head (Personal Experience). Druid and colleagues (1997) assert that the importance lies not only in the placement of the wound, but also the path the bullet takes.

The head was shown to the be the most common location of suicidal gunshot wounds for both men and women, however women are more likely to deviate from this pattern and shoot themselves in the chest or abdomen (Kohlmeier et al., 2001; Schmeling et al., 2001; Stone, 1992). Studies have found that the right temporal region is the more common choice for firearm related suicides. Cina et al (1999) reported that 47 percent of all wounds to the head were in the temporal region. Messmer (1998) confirmed this, stating that the majority of wounds examined were to the right side of the head. However, this may be weapon dependent, as a study specifically regarding rifles wounds revealed that intraoral wounds were just as common as temporoparietal wounds (Molina & Di Maio, 2008). After the head,

the chest and then the abdomen follow as the most common wound locations (Messmer, 1998; Molina & Di Maio, 2008).

This study will investigate these four topics – wound types, weapons and ammunition, terminal ballistics, and wound location – as they apply to Lane County. It will determine if firearm fatalities in Lane County are consistent with other studies. Additionally, this study will examine the demographics of Lane County firearm fatalities and how those differ from demographics in other areas.

CHAPTER III

BACKGROUND AND LITERATURE REVIEW:

DEMOGRAPHICS

It is a widely accepted idea that, historically, men are more likely to commit suicide or be in situations that precipitate homicides, specifically firearm related suicides and homicides. As far as suicide is concerned, women are thought to be averse to the idea of a "messy" death, choosing methods such as overdose and asphyxiation over firearms, assuming a responsibility to continue to be beautiful and demure, even after death. However, some authors assume methods of suicide will change as a result of the equalization of sex roles in modern society (Schmeling et al., 2001).

United States

According to a national surveillance of fatal and nonfatal injuries in the United States that occurred in 2001, firearms were the leading cause of fatal injuries for males. Information for the fatality portion of the study, conducted by the Center for Disease Control and Prevention, was collected from the National Vital Statistics System. Firearms were the top mechanism of death for the total population over the age of 15 years. There were 9,842 male

and 1,829 female fatal firearm assaults. These accounted for 61.8 percent and 38.4 percent of male and female assaults fatalities, respectively. Assaults included both perpetrators and unintended victims. This is consistent with this thesis' classification of homicide, since there is no delineation between murder and self-defense as far as Medical Examiner Office records are concerned. Additionally, there were 14,758 male and 2,111 female firearm deaths classified as "self-harm," accounting for 59.8 and 35.5 percent of male and female self-harm fatalities respectively (CDC, 2004).

In Bexar County, Texas the ratio for male to female suicides is five to one. The highest frequency of firearm suicides occurred in the age group between 20 and 29 years (Molina & Di Maio, 2008). A study of 120 firearm related deaths in Albuquerque, New Mexico and Charleston, South Carolina focused on wound placement for homicides and suicides, also reported on the demographics for the sample. Homicide victims were slightly younger on average than suicide victims, 33.7 years versus 39.2 years of age, respectively (Cina et al., 1999). Bexar County showed similar, though slightly younger, age averages for homicides at 32.8 years for males and 31.8 years for females. This same county showed similar ages for suicides as well, 42.4 years for males and 37 years for females (Molina & Di Maio, 2008).

State of Oregon

The Oregon Violent Death Reporting System, which tracks violent deaths in Oregon, includes the following in their report: homicides, suicides, deaths of undetermined intent, deaths resulting from legal intervention, and deaths related to unintentional firearm injuries. This report tracks non-firearm and firearm related deaths, including poisoning, hanging, sharp trauma, falls, blunt trauma, drowning, fire, vehicles, and shaking (shaken baby

syndrome). Violent deaths ranked as the second leading cause of death in Oregon in 2007 among those 15-34 years of age and 8th among all Oregonians, accounting for 33 percent of all deaths (Shen et al., 2009). Firearms accounted for 50 percent of the violent deaths, making it the most common mechanism of death.

Overall, the ratio of male to female violent deaths is 2.9 to one. When compared to the total number of deaths, 79 percent (462) of male deaths and 63 percent (128) of female deaths were ruled suicide. Of all suicides, 78 percent were male and 22 percent were females. The 329 total firearm related suicides accounted for 60 percent of male suicides and 32 percent of female suicides.

On the other hand, the percentages for firearm related homicide between males and females is slightly closer then those for suicides. Firearm related homicides accounted for 59 percent of male homicides and 47 percent of female homicides.

In Oregon, the majority of suicides occurred among those between the ages of 25 and 64. Unfortunately, no age information was available for firearm related suicides specifically.

Homicides in Oregon showed a U-shaped trend, the first peak occurring among infants and the second peak among males ages 20-44. Eight percent of homicides were children less than 15 years of age, 17 percent were between 15-24, 40 percent were between 25-44, 29 percent were between 45-64, and 6 percent were 65 years of age or older (Shen et al., 2009).

While reference to the larger picture is helpful, it is also necessary to take a look at more comparable populations, such as other counties within and outside the State of Oregon. Counties that offer detailed reports comparable to this thesis include Jackson County, Oregon and Bexar County, Texas. In Jackson County, suicides account for 27 percent of deaths,

while homicides only account for two percent and accidents account for 35 percent of deaths. Fifty percent of the suicides were firearm related and only one of four homicides was firearm related.

Other Countries

In addition to other counties, one study offered insight to data in firearm related fatalities in Berlin, Germany. This study focused specifically on female suicides, and found that ages ranged from 21 to 88 years, and fifty percent of these women were between 20 and 40 years (Schmeling et al., 2001).

Two surveys of international firearm homicides and suicide rates (per 100,000 people) in the years 1991 through 1995, the United States showed the highest suicide rate at 6.3, followed by Finland with 5.78. In the same study, the United States was fourth highest in homicides with a rate of 7.07, following Brazil, Mexico, and Estonia. Additionally, the United States had, by far, the highest rate of firearm ownership at 39 percent of households. The nation closest to this was Norway at 31 percent (Wellford et al., 2004).

CHAPTER IV

DATA COLLECTION

With the permission of the Lane County Medical Examiner's Office, this study utilized death investigation reports from a twenty-one year span (1986 – 2007). Annual Excel worksheets of deaths provided demographic information about the subjects of firearm deaths. Many reports provided information on the weapon involved and the subsequent wounds. As outlined by both a letter of agreement with the Lane County Medical Examiner's Office and the requirements of the human subjects committee, no information that would identify subjects was used in this thesis.

A database was created in Microsoft Access 97 to maintain and code the desired information from each report. The information entered into the database is listed in Table 2. Each case was assigned its original case number in the database, for the ease of referencing cases as needed during research. To easier compute data, categories were coded, as shown in Table 3. Bullet calibers and exit wound diameters were all converted to inches, in order to have consistent units of measure. Raw data was transferred from Microsoft Access to Microsoft Excel. Basic descriptive analysis, including rates, basic comparisons, and

corresponding graphs, was completed in Microsoft Excel. Statistical analysis was completed with R, a widely used freeware statistical package program (http://www.r-project.org/).

Table 2: Database Categories

Database Categories	Explanations
ID	Medical Examiner case number
Month	Month of the year incident occurred
Day	Day of the month incident occurred
Year	Year incident occurred
Sex	Sex of the individual
Age	Age at death
Weapon Type	Handgun, Rifle, Shotgun
Weapon Name	Make and model, if provided
Bullet Brand	Make and model, if provided
Bullet Caliber	Caliber, if provided
Muzzle Velocity	Initial velocity of specific gun
Bullet Mass	Mass of bullet only, if brand is specified
Entrance Diameter	Maximum diameter of entrance wound
Entrance Type	Shape of bony wound
Entrance Location	Cranial or post-cranial
Cranial Entrance Location	Specific area of cranium
Exit Wound	Present or not present
Exit Type	Partial, Complete, or Avulsed
Exit Diameter	Maximum diameter of exit wound
Exit Location	Cranial or post-cranial
Cranial Exit Location	Specific area of cranium
Miscellaneous Comments	Any additional information

Table 3: Database Codes

Category	Codes
Sex	0 – Unknown, 1 – Male, 2 – Female
MOD	0 – Suicide, 1 - Homicide
Weapon Type	0 – Unknown, 1 - Revolver, 2 - Pistol, 3 – Rifle, 4 – Shotgun, 5 – Unspecified handgun
Entrance Type	0 – Unknown, 1 – Circular, 2 – Keyhole,

	3 - Oval
Entrance Location	0 – Cranial, 1 – Chest, 2 – Abdomen, 3 - Other
Cranial Entrance Location	0 – None, 1 – Submandibular, 2 – Intraoral, 3 – Forehead, 4 – Left side, 5 – Right side, 6 – Top of head, 7 – Back of head, 8 - Face
Exit Wound	0 – Absent, 1 – Present, 2 - Unknown
Exit Type	0 – Unknown, 1 – Partial, 2 – Complete, 3 – Avulsed
Exit Location	0 – Cranial, 1 – Post Cranial
Cranial Exit Location	0 – None, 1 – Submandibular, 2 – Intraoral, 3 – Forehead, 4 – Left side, 5 – Right side, 6 – Top of head, 7 – Back of head, 8 - Face

CHAPTER V

ANALYSIS: WEAPONS AND WOUND CHARACTERISTICS

"The forensic fable still persists that women seldom commit suicide by shooting themselves in the head."
Irving C. Stone, Ph.D.

Materials and Methods

Data

The wound analysis section of this study has variable sample sizes depending on the number of cases that had information available that was relevant to a particular hypothesis. Wound information was collected from death investigation reports provided by the Lane County Medical Examiner's Office. Due to the differing circumstances of each case, some reports do not include a detailed description of the wound, such as wound size and shape. Using a sample that has already been analyzed does bring up an issue of interobserver reliability, since for practical reasons measurements were not and could not be retaken. The fact that Lane County has had the same handful of investigators over the years, all trained in the same manner, reduces the significant effect of analyzing previously recorded measurements.

For the analysis of wounds (Hypotheses 1, 2, and 3) a number of factors needed to be available, further constricting the sample sizes. These factors were caliber, weapon type, manner of death, and cranial entrance location. For hypothesis one, examining entrance wounds, the size of the entrance wound was required as well.

For hypotheses two and three, information regarding the exit wound – presence and type was included. The presence or absence of an exit wound was determined from the description of the body and the final ruling on the cause of death. For example, any case that had a cause of death described as a "perforating gunshot wound to the head" was considered to have involved an exit wound, even if there is no formal description if an exit wound included. Any case that had a cause of death described as a "penetrating gunshot wound to the head" was considered to not involve an exit wound, based on the definitions provided in chapter two.

In an effort to reduce the number of variables related to the wounds in the study, each case included in wound analysis had to meet the following criteria:

1. Deaths involving known modified weapons were not included in the study.
2. For the purposes of wound size analysis, firearm type was limited to handguns or rifles.
3. The gunshot wound(s) must be a close range or contact cranial wound, which limits the sample to cranial suicides.

These criteria did not apply for cases used in demographic analysis, since that analysis provides an overview of subjects involved in these incidents, not the wounds caused.

The first criterion is based on the strong relationship between firearm architecture and velocity. If a firearm has any after market modifications to it, there is no way to know to what extent the velocity has been affected. For example, changing the length of a barrel

effects the velocity of the bullet and the bullet yaw, both of which affect the shape and size of the resulting wound (Di Maio, 1999). This study will be limited to handguns and rifles so that differences in projectile type can be limited. Fragmenting rounds and shotgun shells contain pellets, which may result in more than one entrance and exit wound. Lastly, cases in the study have been limited to suicide and close range wounds to reduce the variable of distance. A large distance between firearm and victim will affect the velocity and trajectory of the bullet and is a factor in bone fracturing (Quaterhomme & Iscan, 1999).

To be included in the descriptive analysis of the weapon choices for firearm related deaths, a case needed only to contain sex, weapon type, and manner of death. This sample had 533 subjects.

To be included in the descriptive analysis of the wound location choice for firearm related deaths, a case only needed to contain sex, manner of death, and wound location, which resulted in a sample size of 445 subjects for suicidal gunshot wounds (388 males and 57 females) and 66 subjects for homicidal gunshot wounds. To be included in an analysis of cranial wound locations, the cases needed to have the above information and a cranial location available. This created a smaller sample of 392 subjects (342 males and 50 females).

Variables

Due to the fact that kinetic energy is based on mass, and bullets of the same caliber can have differing masses, the bullets were divided into three groups of relative mass: small, medium, and large, based on previous studies (Garavaglia & Talkington, 1999). Due to the absence of weapon information and the differing velocities from one gun to another, weapons were divided up into two categories: handguns and rifles. Exit wounds were divided into three categories based on the descriptions provided in the death investigations reports. These

categories are: partial, complete, and avulsed. This variable remained categorical since two of the categories, partial and avulsed, do not involve ordinal measurements.

Tests

To determine the role of mass and velocity in the size of an entrance wound, an analysis of variance (ANOVA) was used. This was chosen because the response variable, the maximum diameter of the cranial entrance wound, is an ordinal variable. This measurement was only used when recorded in the death investigation report.

A logistic regression was used to determine how the explanatory variables, mass and velocity affect the response variable, the presence or absence of an exit wound. This was chosen because of the binomial nature of the response variable.

The effect of mass and velocity on the type of exit wound was determined with a multinomial logistic regression, due to the categorical nature of the response variable, exit type. Exit type was divided into three categories instead of remaining as an ordinal variable, since not all exit wounds were measured, or in some cases, the wound was not measurable.

Results

Weapons and Ammunition

Overall, a review of cases showed that a handgun was the preferred weapon for both men and women who commit suicides, at rates of 60 and 77 percent, respectively (Figures 2 and 3). Figure 4 combines male and female weapon choice. The category of handgun included pistols, revolvers, and unspecified handguns. Men showed a higher rate of choosing a shotgun at 12 percent compared to the women's two percent.

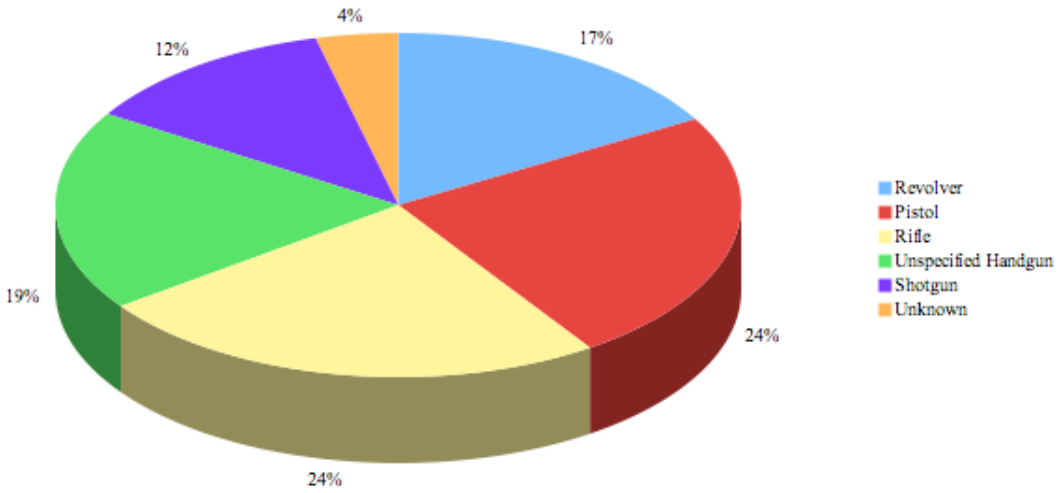

Figure 2: Male Suicide Weapon Preference

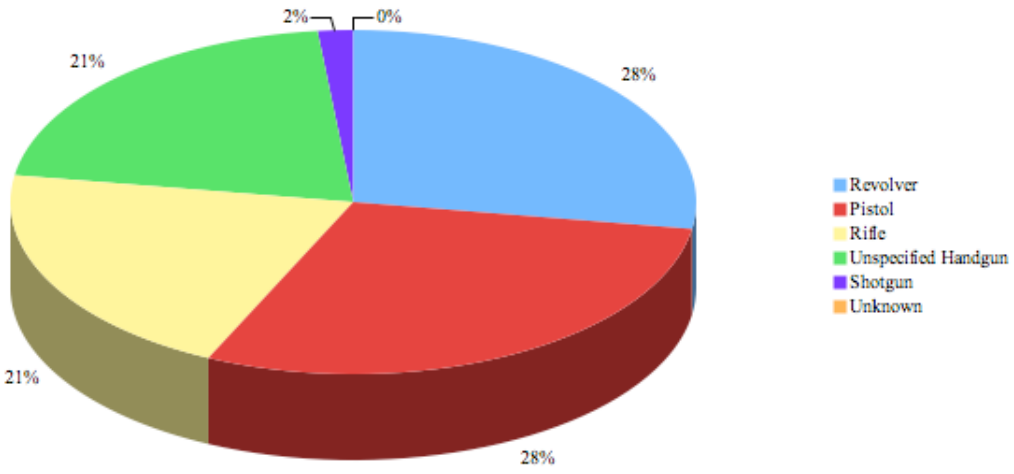

Figure 3: Female Suicide Weapon Preference

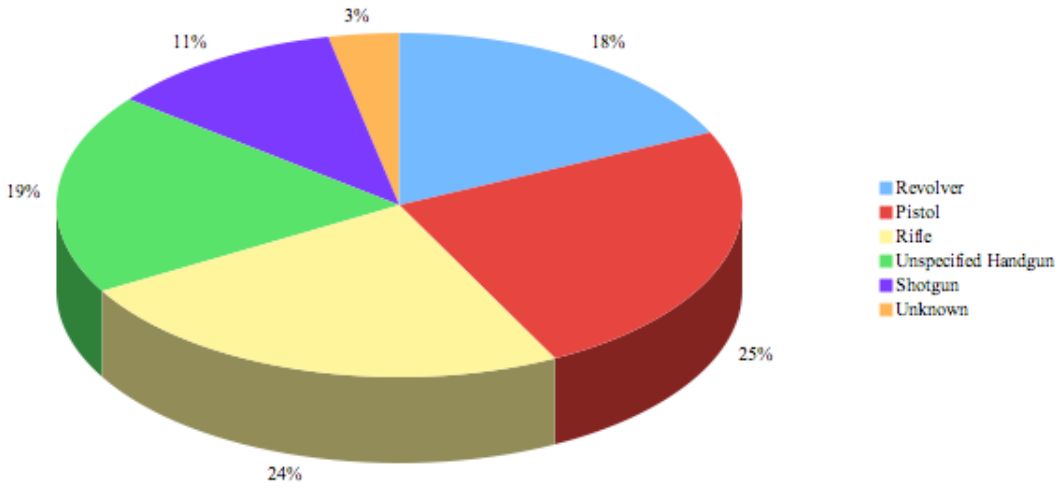

Figure 4: Total Suicide Weapon Preference

Terminal Ballistics

Hypothesis One: Mass, Velocity, and Entrance Wound Diameter

An analysis of variance shows that bullet mass with a $p < 0.001$, followed by the interaction variable of bullet mass and muzzle velocity, with a P-value of 0.003 have the most significant affect on the diameter of an entrance wound (Table 4). The low P-Values for each of these variables indicates that there is a significant difference in the maximum diameter of the entrance wound between each variable category.

Table 4: ANOVA Results for Mass, Velocity, and Entrance Wound Diameter

Variable	Mean Square	P-Value
Bullet Mass	5.894	1.3 e -05
Muzzle Velocity	1.589	0.02
Bullet Mass x Muzzle	5.022	0.0003
Cranial Entrance Location	2.160	0.007

Hypothesis Two: Presence and Absence of Exit Wounds

A logistic model was created to determine the relationship between the presence of exit wounds and the relative mass of the bullet, the relative velocity of the gun, and the cranial entrance location. The model used was:

$$\text{Log } (p/1\text{-}p) = ß_0 + ß_1(\text{Muzzle Velocity}) + ß_2(\text{Medium Bullet Mass}) + ß_3(\text{Large Bullet Mass})$$

where is the proportion of cases with an exit wound present, 1-p is the proportion of cases with an exit wound absent, $ß_0$ represents the intercept, $ß_1x_1$ represents the variable for relative velocity and its coefficient ($ß_1$), $ß_2x_2$ represents the variable of medium bullet mass and its coefficient ($ß_2$), and $ß_3x_3$ represents the variable of large bullet mass and its coefficient ($ß_3$). Because of the use of categories in this model, the results are relative to baseline variables, which are: a) use of a handgun, which is slower than a rifle, and b) the use of a small caliber bullet. The results of the logistic regression are shown below in table 5. When cranial entrance location was considered in the model, all entrance sites showed high p-values and in one case a very high standard error (882.7437) and did not appear to have a significant effect on the presence or absence of an exit wound. For these reasons, it was left out of the final model.

Table 5: Results of Logistic Regression for Presence and Absence of Exit Wounds

Coefficient	Estimate	P-Value
$ß_0$	-1.5203	2.08 e -07
$ß_1$	0.9180	0.01
$ß_2$	2.3549	1.59 e -12
$ß_3$	2.6155	1.83 e -06

This model reveals that mass and velocity have significant effects on the presence of an exit wound. In terms of relative velocity, a rifle is 0.92 times more likely to cause an exit

wound than a handgun. When mass is considered, medium bullets and large bullets are 2.35 and 2.62 times more likely to cause an exit wound than small bullets. When looking at each bullet size, choosing a medium bullet increases the odds that an exit wound is present by 10.54 and a large bullet increases the odds by 13.68 times. Using a rifle will increase the odds by 2.50 times.

Hypothesis Three: Exit Type

Hypothesis three proved to be difficult to test due to the distribution of exit types over the three bullet masses and two muzzle velocities. Sample sizes for larger bullet masses and larger exit types were very small. A chi-squared analysis (Table 6) was done on both muzzle velocity and bullet mass to determine if there was any significance in their relationship to the three exit types, partial, complete, and avulsed. There was a significant relationship between muzzle velocity and exit type and a significant relationship at the 0.05 level for bullet mass and exit type.

Table 6: Chi-Squared Test Results for Exit Wound Type

Variable	Chi-Squared	P-Value
Muzzle Velocity	50.184	< 0.001
Bullet Mass	10.4773	0.03311

Since both showed significance, a multinomial logistic regression model was created with both muzzle velocity and bullet mass considered. This type of model tests the odds of an alternative outcome (Alt 2: complete or Alt 3: avulsed wounds) happening when compared to a baseline alternative (Alt 1: partial). Because of the small sample size for large caliber bullets, this category was folded into a single category with medium caliber bullets. The models that developed were:

Equation One

Log (prob of Alt 2 / prob of Alt 1) = Alt 2: $ß_0$ + Alt 2: $ß_2$(Muzzle.Velocity of a Rifle) + Alt 2: $ß_3$ (Bullet.Mass of medium & large bullets)

Equation Two

Log (prob of Alt 2 / prob of Alt 1) = Alt 2: $ß_0$ + Alt 2: $ß_2$(Muzzle.Velocity of a Rifle) + Alt 2: $ß_3$ (Bullet.Mass of medium & large bullets)

Table 7: Results of Logistic Regression for Exit Wound Type

Coefficient	**Estimate**	**P-Value**
Alt 2: $ß_0$	0.44586	0.43
Alt 3: $ß_0$	-4.40436	6.12 e -05
Alt 2: $ß_2$	1.56764	0.19
Alt 3: $ß_2$	5.82679	2.46 e -05
Alt 2: $ß_3$	2.03507	0.0038
Alt 3: $ß_3$	4.40245	6.41 e -05

A significant effect is observed for muzzle velocity and bullet mass on an avulsive wound, as well as a significant effect on a complete exit wound by bullet mass (Table 7). What this tests shows is that a rifle is approximately 1.6 times more likely to cause a complete exit wound instead of a partial wound when compared to a handgun (coefficient: Alt 2: $ß_2$). A medium or large bullet is 2.04 times more likely to cause a complete wound instead of a partial wound when compared to a small bullet (coefficient: Alt 2: $ß_3$).

When considering avulsive wounds, a rifle is 5.8 times more likely to cause an avulsive wound than a partial wound when compared to a handgun (coefficient: Alt 3: $ß_2$) and a medium or large bullet is 4.4 times more likely to cause an avulsed wound than a small bullet (coefficient: Alt 3: $ß_3$).

Wound Location

Of the 445 suicides that had wound location information available (Figure 5), 89 percent (392) of the wounds were located at the head. Nine percent (42) of the suicidal wounds were located at the chest and two percent (11) were located in other body locations. Both males and females showed a tendency to commit suicide with wounds to the head, particularly the right side or intraoral. Males chose the right side 31 percent (106) of the time and an intraoral shot 23 percent of the time (77) (Figure 6). Females actually showed a higher tendency towards these locations at 46 percent (23) and 28 percent (14) (Figure 7), respectively. Combined, this made the right side of the head the most common location for a suicidal gunshot wound to the head at 33 percent (129), as shown in figure 8.

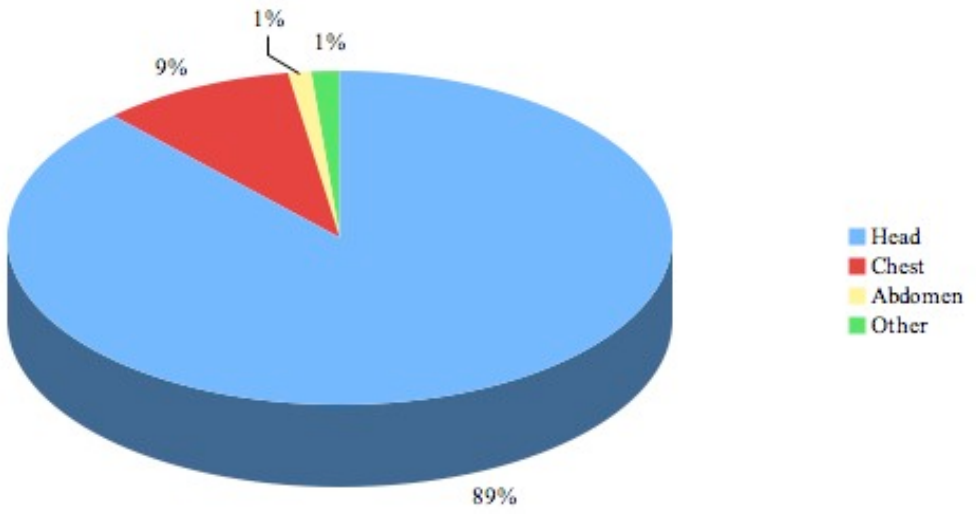

Figure 5: Total Suicide Wound Locations

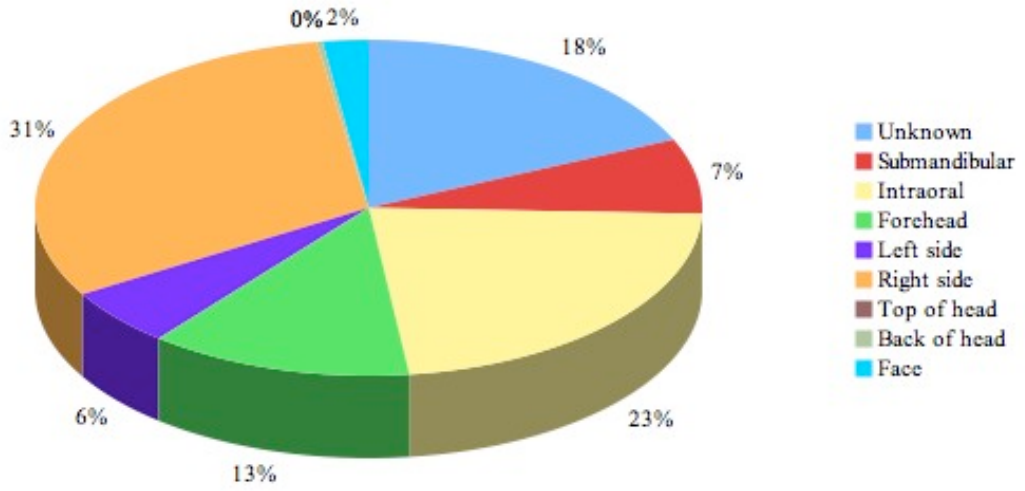

Figure 6: Male Suicide Cranial Wound Locations

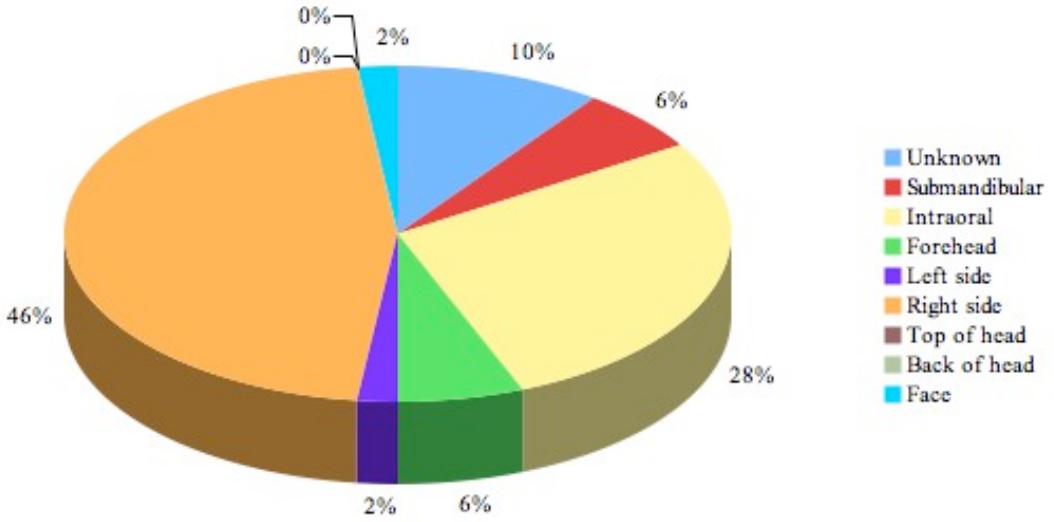

Figure 7: Female Suicide Cranial Wound Locations

Of the 74 homicides with wound location information available, (Figure 9), 64 percent (42) were located at the head. Twenty-four percent (16) were located at the chest and

six percent (4) were located in the abdomen region. Six percent (4) occurred in other body locations.

Forty-two percent of the homicide wounds to the head were not described in the death investigation report with a cranial location. Of those that were described, the most common cranial locations were fairly evenly split between the left side, right side, and forehead (figure 10), at 13 percent, 15 percent, and 13 percent, respectively.

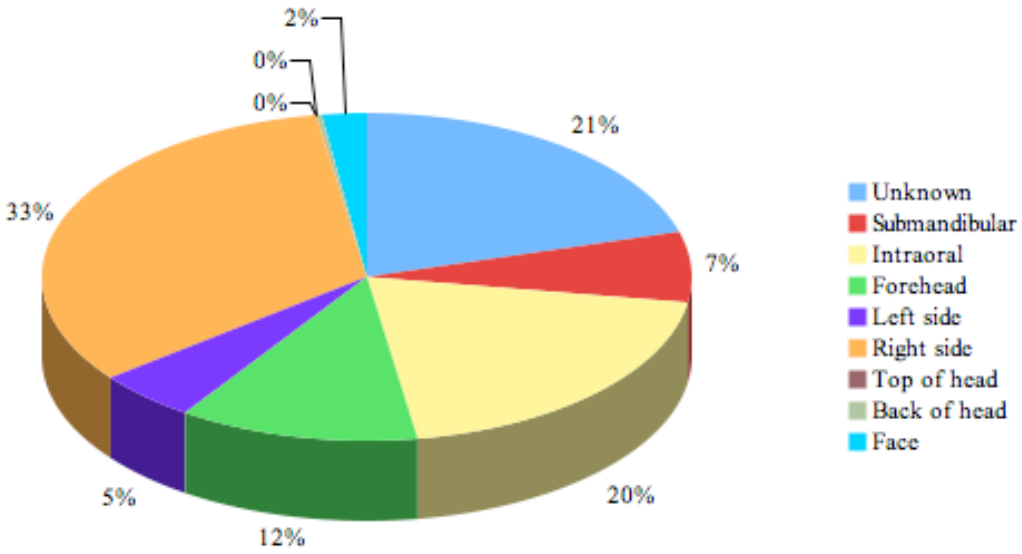

Figure 8: Total Suicide Cranial Wound Locations

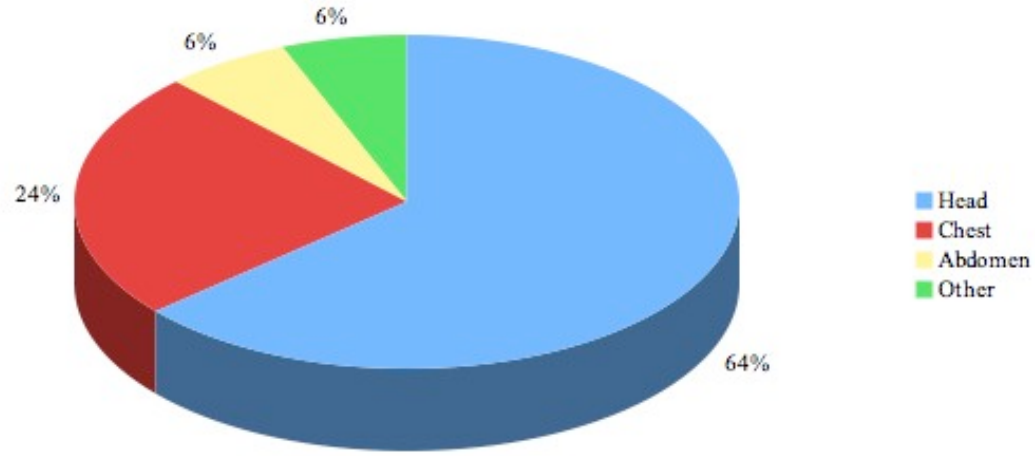

Figure 9: Total Homicide Wound Location

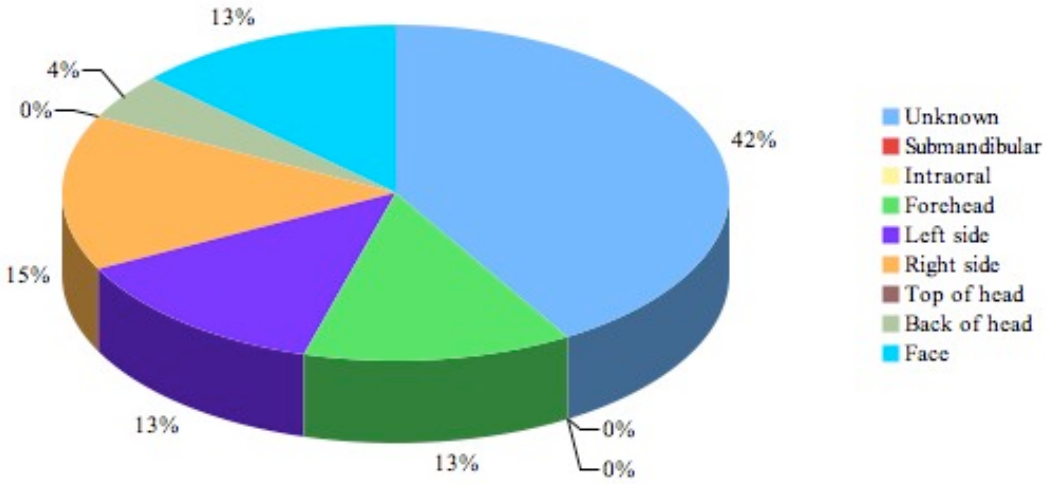

Figure 10: Homicide Cranial Wound Locations

Summary and Discussion

This chapter analyzed the weapons and wounds of firearm related suicides in Lane County. Handguns – pistols, revolvers, and unspecified - are overwhelmingly the preferred type of weapon for both homicides and suicides. This was the case for both male and female suicides, although men showed a higher rate of selecting other forms of firearms, including a much higher rate of choosing a shotgun.

Like other studies, this study revealed the similarities in wound placement between homicides and suicides. The head, particularly the right side of the head, is the most common location for both manners of death. As for the "forensic fable" Irving Stone alludes to, it is indeed false in Lane County, as the most common suicidal wound location for both men and women is the head. While homicides do show higher variability in wound location, the head was still the most common wound location at 64 percent.

An analysis of entrance wounds showed that bullet mass and the interaction of bullet mass and velocity were the most significant factors in the size of an entrance wound. However, the mass could be masking a larger effect by the caliber of the bullet itself, since it is the measure of the bullet diameter. Further tests with actual masses would better explain that relationship. Mass was used in this case in an effort to study the effect of kinetic energy on the entrance wound.

When considering the presence or absence of an exit wound, this study showed both mass and velocity significantly increase the chances that an exit wound will be present. These results are to be expected, since mass and velocity are intimately related to kinetic energy, which is required for a bullet to perforate the skull. The results of which factor has a

more significant effect should be further investigated with actual mass measurements and velocities, as there could be a problem of the categorical variables being collinear.

Taking the role of mass and velocity in exit wounds one step further, a multinomial logistic regression resulted in finding significant effects of mass and velocity on the type of exit wound that occurs. According a chi-squared test, both mass and velocity showed a significant difference between exit types. Then a logistic regression reveled that the greatest significant effect occurred from high velocities and high mass on the odds of an avulsive wound occurring. Just as before, this result should be observed with caution, however does make sense due to the large amount of energy increase that occurs with a velocity increase followed by a smaller increase from mass.

Further research should be done on these areas that incorporate the variables ordinal counterparts. Categories decreased the power of these tests and only give a general picture of what is occurring in each case.

CHAPTER VI

ANALYSIS: DEMOGRAPHICS

Materials and Methods

The sample size for demographic data (age and sex) is 1016 cases. However, between the years 1987 and 1988, there was limited information available regarding sex, causing these years to not be considered since a complete sample could not be obtained (Table 8). Demographic data that was collected includes the manner of death, the cause of death, the age, and the sex of the subject. The data was collected from a compilation of the Lane County Medical Examiner's Office's excel files of annual demographics of deaths. This reflects the data that has been collected in previous studies of the demographics of firearm deaths (CDC, 2004; Shen et al., 2009; Molina & Di Maio, 2008).

The logistic regression test was used to analyze the demographic data because of the binomial nature of the response variable, choosing or not choosing a firearm. This test produces the odds that an individual will choose a firearm to commit suicide. Four different logistic regression models were analyzed for the total demographic data: a) sex only, b) age only, c) sex and age, and d) intercept only. The AIC for each model was used to determine

which model was the most appropriate to explain the factors involved in the odds that an individual will choose to commit suicide with a firearm. Sex was determined to be the most significant factor in determining the odds an individual will choose a firearm.

To analyze the significance of the relationship between sex and firearm choice, a chi-squared test was used. To obtain a large enough sample size, years were divided into three-year blocks, and a chi-squared test was conducted to determine if there were significant differences between the rate men choose firearms and the rate women choose firearms for each block of years.

Table 8: Demographic Sample Size by Year

Year	Sample Size
1986	50
1989	51
1990	39
1991	41
1992	40
1993	36
1994	52
1995	56
1996	48
1997	61
1998	56
1999	49
2000	51
2001	64
2002	46
2003	52
2004	58
2005	59
2006	54
2007	53

Results

Homicide

Male and Female Firearm Related Homicides

Figure 11 demonstrates the percentage of homicides committed with a firearm each year for both males and females. There does not appear to be any particular pattern to the rate of firearm use in homicides from one year to another. Most years show men having the higher rate of firearm homicides, which is reflective of also having the corresponding majority of total homicides.

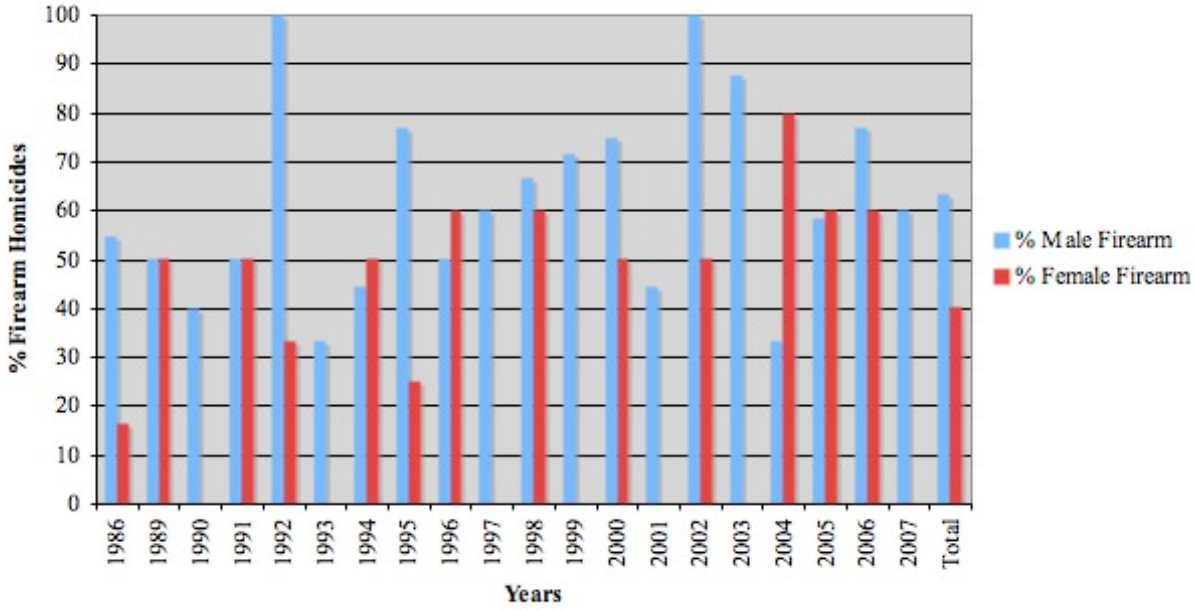

Figure 11: Rates of Homicides Committed with Firearms

Homicide Ages

Male homicides occurred from five months to 91 years and thirteen years to 86 years for male gunshot homicides (Table 9). The age range for female homicides had an age range of three months to 86 years and one year two months to 61 years for female gunshot homicides (Table 9). The average age for total suicides and gunshot suicides for both sexes

was in the mid-thirties, except for women who showed a higher average at 39 years for total homicides.

Table 9: Homicide Age Summary

	Minimum Age	**Average Age**	**Maximum Age**
Male Homicide	0.42	35.94	91
Male Firearm	13	34.23	86
Female Homicide	0.25	39.13	86
Female Firearm	1.2	35.2	61

Figures 12 and 13 illustrate the trend of how many firearm related homicides and non-firearm related (NF) homicides occur in each age group. There is a large difference between the number of firearm related homicides and non-firearm related homicides for males under the age of 35. Figure 14 then illustrates this data as a proportion of firearm related homicides to total homicides and shows very erratic trends for both males and females. Knowing information about the perpetrator and the circumstances of the homicide would probably offer a better understanding of the pattern. There does not appear to be an age-associated trend for either male or female homicides, which differs from the trends found in suicides, as demonstrated in the next section.

Suicide

Male and Female Firearm Related Suicides

An initial analysis of the rates of firearm choice for suicides (Figure 15) reveals that men have a relatively consistent higher rate than women over the course of the twenty-one year study period, 1999 being the exception.

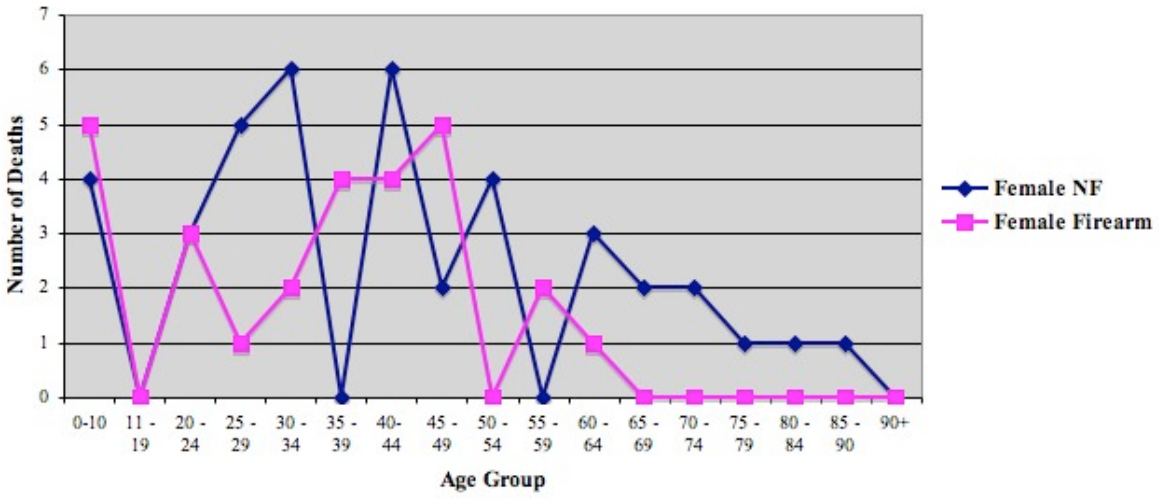

Figure 12: Female Homicide Ages

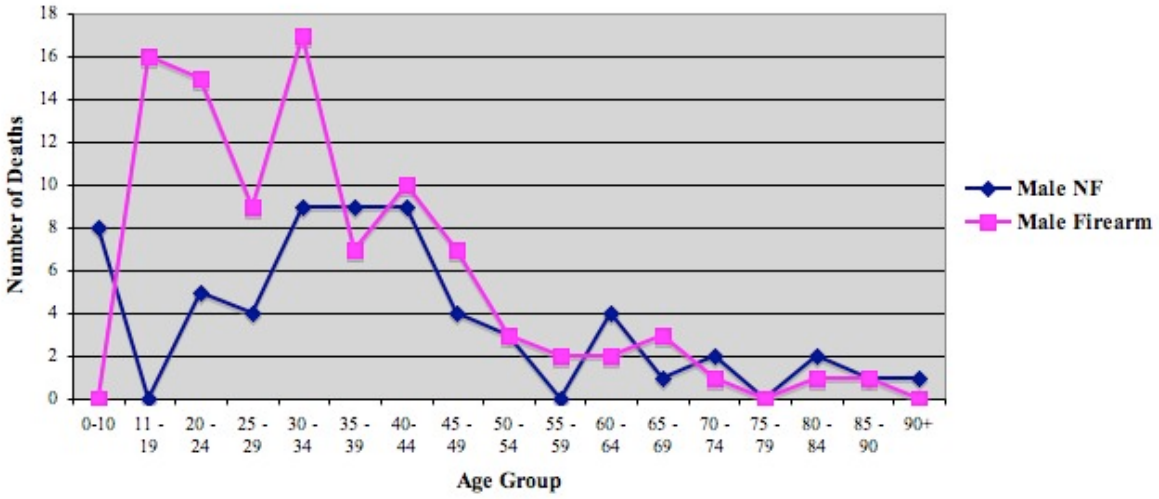

Figure 13: Male Homicide Ages

Hypothesis number four asserts that there is a decreasing significant difference in the proportion of firearm suicides to total suicides between men and women as the years progress from 1986 to 2007, ending in 2007 with no significant difference between men and women. To address hypothesis number four, a logistic regression was run to determine the factors and the significance of those factors involved in the likelihood that an individual will choose a firearm, given that the person will commit suicide.

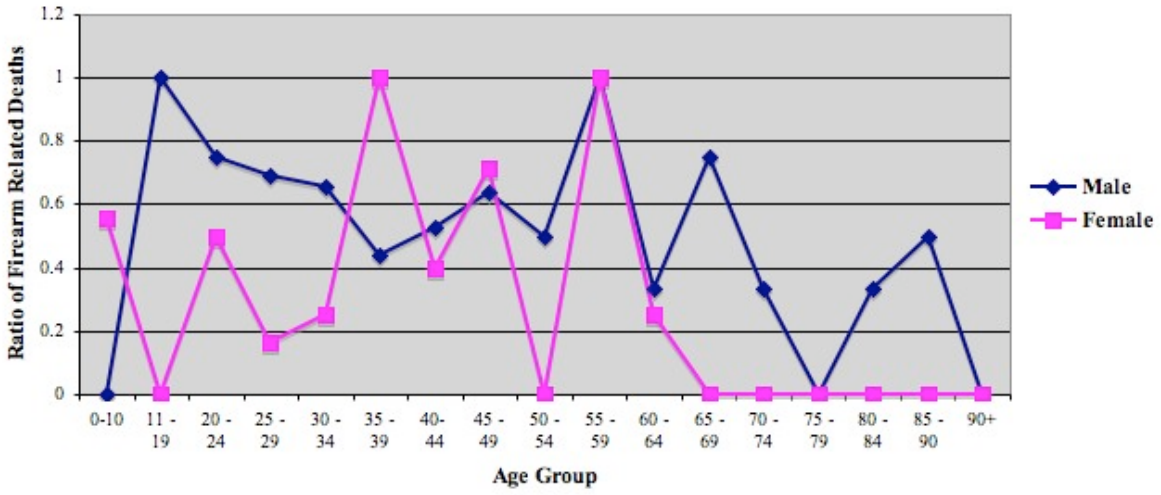

Figure 14: Proportion of Firearm Related Homicides to Non-Firearm Homicides

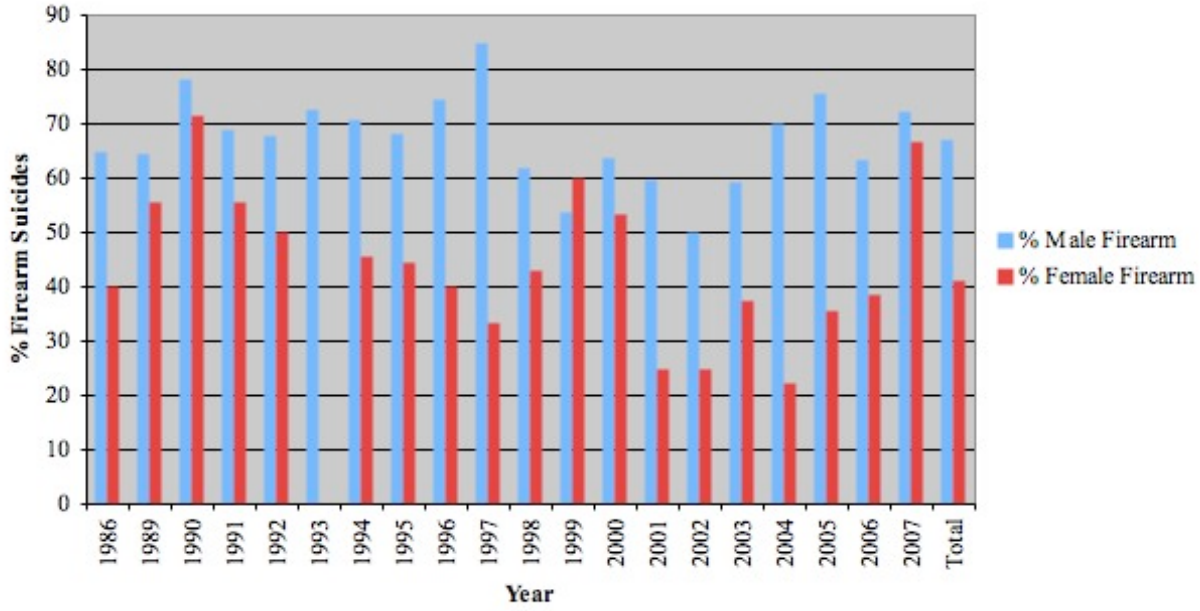

Figure 15: Rates of Suicides Committed with Firearms

Then a chi-squared test was run for three-year blocks to determine if the significance between sex and firearm choice decreases.

For the total sample of 1016 individuals, four models were tested for fit. The model that included only sex had the lowest AIC, demonstrating that it is the best fit of all four for explaining the chances that a person will choose a firearm to commit suicide. Below is the

model that was derived from all demographic data as a best-fit model, where $ß_0$ is the intercept and $ß_1$ represents the coefficient related to the variable, x_1, whether the individual is male or female.

$$\text{Log } (p / 1\text{-}p) = ß_0 + ß_1(\text{sex of the individual})$$

The results of the regression (Table 10) indicated that being male has a positive effect on the probability of choosing a firearm and the effect of sex on the probability was statistically significant at a .001 level. Using the data provided by the test, males and females have a sixty-six percent and forty-one percent chance, respectively, of committing suicide with a firearm. Males are twenty-five percent more likely to choose a firearm to commit suicide than women.

Table 10: Results of Logistic Regression for Sex and Firearm Choice

Coefficient	Estimate	P-Value
$ß_0$	0.67646	< 2 e -16
$ß_1$	-1.03430	7.92 e -11

The results of the chi-squared test, shown in table 11, are inconclusive as to whether or not there is a decreasing significance between sex and the choice of a firearm.

Table 11: Chi-Squared Test Results for Sex and Firearm Choice

Year Block	Chi-Squared	P-Value
1989 – 1991	0.5003	0.4794
1992 – 1994	5.6191	0.01777
1995 – 1997	9.7869	0.001758
1998 – 2000	0.5603	0.4542
2001 – 2003	7.8467	0.005091
2004 – 2007	19.378	1.072 e -05
All Years (1986 – 2007)	43.1238	5.1238 e -11

Suicide Ages

The age range for female suicides had an age range of 14 years to 92 years and 14 years to 80 years for female gunshot suicides (Table 12). Male suicides occurred between the ages of 14 years to 96 years and 7 years to 96 years for male gunshot suicides (Table 12). The average age for total suicides and gunshot suicides for both sexes was in the mid-forties, with women having a slightly younger average.

Table 12: Suicide Age Summary

	Minimum Age	**Average Age**	**Maximum Age**
Male Suicide	14	46	96
Male Firearm	7	48.55	96
Female Suicide	14	45.68	92
Female Firearm	14	43.79	80

Figures 16 and 17 illustrate the number of firearm related suicides that occur in each age group for females and males. The proportions of firearm suicides to total suicides show similar trends for males and females until the 55 years to 59 years age range, where the proportion for females drops suddenly, followed by a sharp rise (Figure 18). The drop may be related to the drop in suicide that occurs around that age range. The two peaks in the proportion of firearm suicides at the age ranges of 50 to 54 and 75 to 79 coincide with the two peaks in the number of female firearm suicides (Figure 16). Interestingly, these are the only two times that firearm suicides outnumber other causes of suicidal death for females.

Males consistently choose firearms over other methods of suicide in all age groups, except for the age group 45 to 49, where the rates in method choice are similar, but non-firearm related suicides are slightly higher.

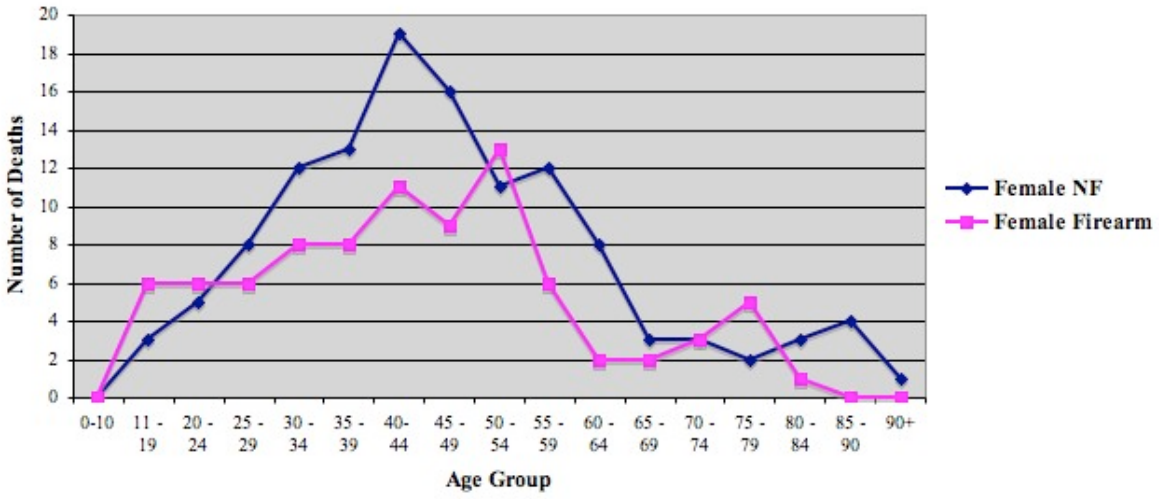

Figure 16: Female Suicide Ages

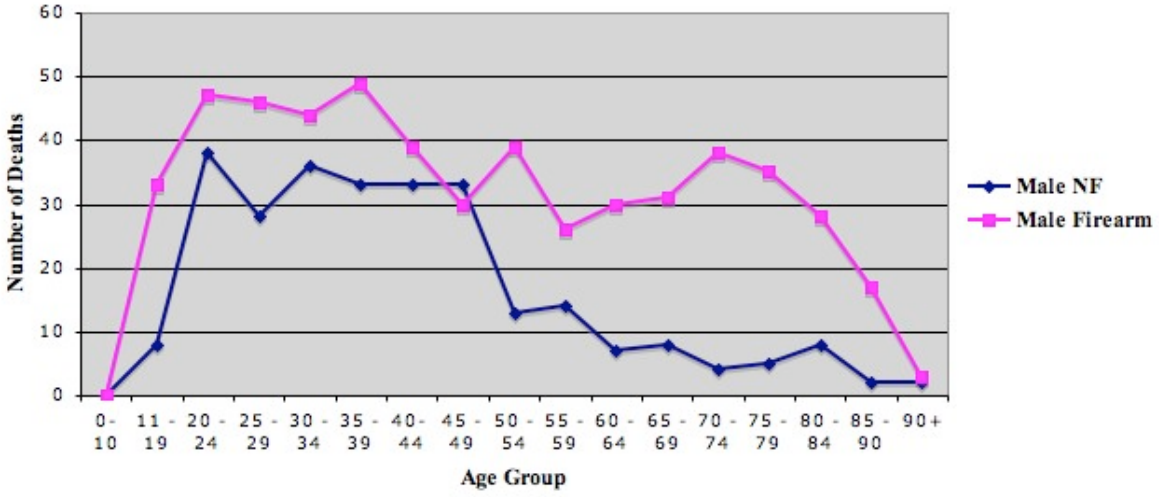

Figure 17: Male Suicide Ages

Interestingly, while the total number of suicides occurring generally decreases for both males and females as age increases, the use of firearms to commit suicides slowly increases.

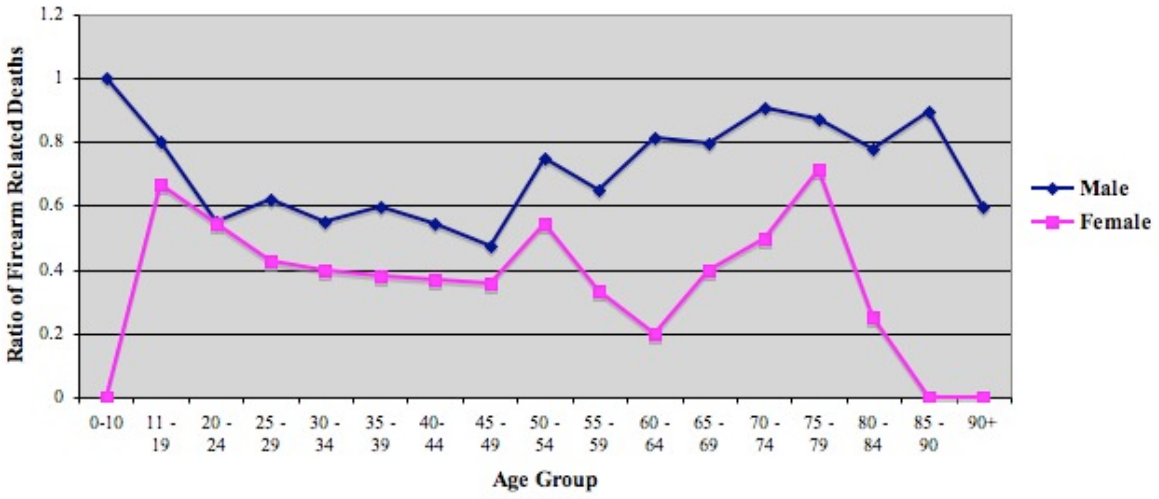

Figure 18: Proportion of Firearm Related Suicide to Total Suicides by Age

Summary and Discussion

This chapter analyzed the sex demographics of firearm related fatalities, with a particular focus on suicides. The results show that the Lane County demographics reflect those found in other areas, including the state and other counties. Men not only make up the majority of suicide cases, but also show higher rates of choosing to commit suicide with a firearm (Figure 16). When both age and sex are considered, sex is the most significant factor in the odds that an individual will choose to commit suicide with a firearm.

Hypothesis four stated that there was a possibility the rate of women choosing a firearm could catch up to the rate men choose a firearm. This assertion was tested with a series of chi-squared tests to determine if the significance sex decreased over the course of the 21-year period. The results of these chi-squared tests were inconclusive, but did show that there was no clear decrease in significance.

The age of individuals who commit suicide did show an interesting trend, as the rate of firearm use increased with age. This could be related to a number of factors, including lifestyle, drug use, firearm availability, and a change in the prevalence of issues precipitating

suicides such as financial hardship and illness. This is very different from the erratic appearance of the age analysis of homicides. Further study into the perpetrators and circumstances should be done to better understand the association between age and firearm choice in homicides.

In general, men choose a firearm to commit suicide at a higher rate at all ages, while females only chose a firearm more often in two age groups, 50 to 54 and 75 to 79. Again, these anomalies could be reflective of the lifestyle differences at these ages that are listed above.

Knowing this information about those who choose to take their own life should provide a start to further research, beyond the scope of this thesis, about the socio-economic status, emotional state, and motivating factors of suicidal subjects. This will help services continue to evolve and address this public health issue.

CHAPTER VII

CONCLUSIONS

The initial goals of this thesis were to provide law enforcement a better picture of possible differences in homicides and suicides. However, it may be a better evaluation to say that this thesis reveals the similarities of firearm related fatalities into harsh relief.

Hypothesis One

Hypothesis one asserted that the larger the mass and the higher the velocity, the larger the entrance wound created. An ANOVA test was used to determine if there was a significance relationship between the explanatory variables and the response variable. The interaction variable of mass and velocity had a significant effect on the size of the entrance wound. However, this could be compromised by a significant relationship between caliber and entrance size. As stated in the summary and discussion of this hypothesis, further analysis should be done with actual masses. From that data, there is a possibility that a linear regression could develop an equation that could be used to associate masses and velocities with entrance diameters. This could help to narrow a search for a specific bullet brand and type by offering an idea of the specific mass associated with the suspect bullet.

Hypothesis Two

Hypothesis two put forth that the larger the caliber and the higher the velocity, the higher the probability that an exit wound occurs. This study found that mass and velocity both had significant effects on the presence of an exit wound. A logistic regression showed that mass had a larger effect, however making a concrete conclusion should be done with caution. The categorical variables can affect the power of the test, so further analysis should be done on actual mass and velocities.

Hypothesis Three

Hypothesis three went one step further than the second hypothesis and analyzed the type of exit wound, partial complete or avulsive. It postulated that the larger the mass and the higher the velocity, the more avulsive the exit wound that will occur. According to a chi-squared test, velocity showed a greater significant difference between exit types than mass. Then a multinomial logistic regression reveled that the greatest significant effect occurred from high velocities and high mass on the odds of an avulsive wound occurring. Just as before, this result should be observed with caution, however it does make sense due to the large amount of energy increase that occurs with a velocity increase followed by a smaller increase from mass.

Hypothesis Four

Hypothesis four moved from wound characteristics to demographics, specifically the sex of the individuals involved in firearm suicides. Current attitude suggests that men are more likely to choose the disfiguring method of gunshot wounds. This thesis upheld that position and found that men in Lane County are more likely to choose a firearm to commit suicide. A chi-squared test was run on sets of three years, from 1989 to 2007, and the

significance of the relationship between sex and choosing a firearm as the years continued on.

Other areas that demographic areas that were observed were the age of those involved with firearm related fatalities. The age of individuals who commit suicide showed an intriguing trend, as firearm related suicides increased with age, particularly for males.

Additional Data

Weapons and wound location were studied in this thesis and it was found that handguns were the most common weapons involved in all firearm related fatalities. The number of unknown weapon types hindered breaking the handguns down into any further categories such as pistols or revolvers. While both males and females chose handguns the most often, males had a higher percentage of rifle and shotgun use. The head was overwhelmingly the most common location for suicidal wounds, specifically the right side, followed by intraoral wounds.

Research has shown that kinetic energy influences gunshot wounds, however the relationship of kinetic energy to exit wounds specifically has not been extensively studied. This thesis investigated that relationship and began to draw conclusions about the affect of mass and velocity on exit wounds. A future study with exact mass and velocities will allow for equations to be created to better estimate the mass of the bullet and velocity of the gun for cases where these are unknown**.**

Future Research

While this study opens the door to a better understanding of the role of kinetic energy in exit wounds, further research is needed. The next step would be a prospective, multi-county study examining specific masses and velocities. This would require access to police

records and/or more detailed reports provided by the Medical Examiner's Office. The data needed would be brand name, type, and caliber of the ammunition, and the brand name and type of weapon. This information should be adequate to determine the exact mass of the ammunition and muzzle velocity of the weapon. Additionally, measurements of the dimensions of bony wounds, including exact thickness of the bone, at the site of entry and exit would be beneficial.

To better align with studies done in the State of Oregon and the United States, further research into the socioeconomic status, mental state, and presence of alcohol should be conducted, in addition to the age and sex of the individual.

REFERENCES CITED

Berryman, H.E., Smith, O.C., & Symes, S.A. (1995). Diameter of cranial gunshot wounds as a function of bullet caliber. *Journal of Forensic Science*, 40(5), 751-754.

Berryman, H.E., & Symes, S.A. (1998). Recognizing gunshot and blunt cranial trauma through fracture interpretation. In K. Reichs (Ed.), *Forensic Osteology* (333-351). Springfield, IL: Charles C Thomas.

Centers for Disease Control and Prevention. (2004). Surveillance summaries. *Morbidity and Mortality Weekly Report*, 53(SS-7).

Cina, S.J., Ward, M.E., Hopkins, M.A., & Nichols, C.A. (1999). Multifactorial analysis of firearm wounds to the head with attention to anatomic location. *American Journal of Forensic Medicine and Pathology,* 20(2), 109-115.

Denton, J.S. (2006). Practical pathology of gunshot wounds. *Archives of Pathology & Laboratory Medicine*, 130, 1283-89.

Di Maio, V.J.M. (1999). *Gunshot wounds: Practical aspects of firearms, ballistics, and forensic techniques*. New York, NY: CRC.

Druid, H. (1997). Site of entrance wound and direction of bullet path in firearm fatalities as indicators of homicide versus suicide. *Forensic Science International*, 88(2), 147-162.

Fackler, M. (1998). Wound ballistics: A review of misconceptions. *Journal of the American Medical Association*, 259, 2730-2736.

Fatteh, A. (1976). *Medicolegal investigation of gunshot wounds*. Philadelphia, PA: Lippincott.

Garavaglia, J.C., Talkington, B. (1999). Weapon location following suicidal gunshot wounds. *The American Journal of Forensic Medicine and Pathology*, 20(1), 1-5.

Heard, B.J. (1997). *Handbook of firearms and ballistics: Examining and interpreting forensic evidence*. Chichester, England: J. Wiley.

Hollerman, J.J., Fackler, M.L., Coldwell, D.M., Benmenachem, Y. (1990). Gunshot wounds I: Bullets, ballistics, and mechanisms of injury. *American Journal of Roentgenology*, 155(4), 685-691.

Kohlmeier, R.E., McMahan, C.A., Di Maio, V.J.M. (2001). Suicide by firearms: A 15-year experience. *The Journal of Forensic Medicine and Pathology,* 22(4), 337-340.

Law Enforcement Database System (2010). Lane County Sheriff's Office.

Lynnerup, N. (2001). Cranial thickness in relation to age, sex, and general body build in a Danish forensic sample. *Forensic Science International*, 117, 45-51.

Messmer, J. (1998). Radiology of gunshot wounds. In Brogdon, B.G. (Ed.), *Forensic Radiology* (209-223). Boca Raton, FL: CRC Press.

Molina, D.K., Di Maio, V.J.M. (2008). Rifle Wounds: A review of range and location as pertaining to manner of death. *The American Journal of Forensic Medicine and Pathology,* 29(3), 201-205.

Padrta, J.C., Barone, J.E., Reed, D.M., Wheeler, G. (1997). Expanding handgun bullets. *Journal of Trauma*, 43(3), 517-20.

Quatrehomme, G., Iscan, M.Y. (1999). Characteristics of gunshot wounds in the skull, *Journal of Forensic Science*, 44(3), 568-78.

Rinker, R.A. (2000). *Understanding firearm ballistics: Basic to advanced ballistics: Simplified, illustrated, and explained.* Apache Junction: Mulberry House Publishers.

Ross, A.H. (1995). *Caliber estimation from cranial entrance measurements*. (Masters Thesis). University of Tennessee: Knoxville, TN.

Schmeling, A., Strauch, H., Rotheschild, M.A. (2001). Female suicides in Berlin with the use of firearms. *Forensic Science International*, 124(2), 178-181.

Shen, X., Millet, L., Kohn, M. (2009). *Violent deaths in Oregon: 2007.* Oregon Department of Human Services, Portland, OR.

Squires, P. (2000). *Gun culture or gun control: Firearms, violence and society*. London, England: Routledge.

Stone, I.C. (1992). Characteristics of firearms and gunshot wounds as markers of suicide. *The American Journal of Forensic Medicine and Pathology,* 13(4), 275-280.

Wellford, C.F., Pepper, J., and Petrie, C. (2004). *Firearms and violence: A critical review*. Washington, DC: National Academies Press.