Differences in the Cast-Off Spatter Produced by Commonly used Instruments on Violent Crimes in Baguio City Utilizing the Developed Trebuchet

[1]Lyka G. Pasinhon, [2]Kyle B. Ta-asan, [3]John Reniel D. Bacani, [4]Karl M. Calpito, [5]Jairus Philip C. Catubig,
[6]Francis Edison D. Ibarra, [7]Jetro Shane B. Napadao, [8]Leighmar P. Resonable, [9]Joanne Mae B. Rondina

University of the Cordilleras- College of Criminal Justice Education Baguio City, Benguet, Philippines.

Abstract:- **Bloodstain Pattern Analysis refers to the gathering, classification, and interpretation of the distribution and shape of bloodstains associated with a crime. Cast-off spatters are a crucial component of a practical, scientific, and medically based reconstruction of a crime since they provide a wealth of information. The focus of the study is to determine and compare the number of primary bloodstains, number of satellite stains, and the length of cast-off trail produced by a bolo, ice pick, butterfly knife, and kitchen knife. A trebuchet was constructed to swing the instrument simulating a person swinging a weapon. The instruments were submerged in pig's blood and then attached to the arm of the trebuchet. The trebuchet was then set in motion and produced the cast-off spatter pattern. The number of primary bloodstains, number of satellite stains, and the length of cast-off trail produced by each instrument were recorded and treated using the randomization method and the ANOVA Test. After the experimentation was carried out, the results were analyzed and yielded the following findings: For the number of primary stains, the bolo exhibited an average number of one hundred thirty-one primary stains, the ice pick yielded an average of fifty-seven primary stains, the butterfly knife had an average of eighty-seven primary stains, and the kitchen knife had shown an average of one hundred and six primary blood stains. For the average number of satellite stains, the bolo had twenty-nine satellite stains, the ice pick had an average of sixteen stains, the butterfly knife showed twenty-eight satellite satins on average, and the kitchen knife has an average number of ten for its satellite stains. For the length of the cast-off trail, the bolo had an average trail length of six hundred forty and five tenths of centimeters, the ice pick had an average trail length of five hundred seventy-one centimeters, the butterfly knife had an average trail length of six hundred nineteen and sixty-seven hundredths in centimeter, and the kitchen knife exhibited a cast-off trail with the average of four hundred nineteen centimeters.**

Keywords: *Cast-off, Blood Spatter, Violent Crimes, Characteristics of Cast-Off Spatter.*

I. INTRODUCTION

As claimed by Pokupic, K. (2017), blood is one of the most important biological traces that are often found on the crime scene. Yielding it for DNA analysis helps identify whose blood it came from. For the origin or where the blood drips or spat off, Bloodstain Pattern Analysis (BPA) refers to the collection, categorization and interpretation of the shape and distribution of bloodstains connected with a crime. These kinds of stains occur in a considerable proportion of homicide cases. According to an article released by Forenscope (2019), blood spatter has three basic types: passive stains, transfer stains and projected or impact stains. As stated by Peschel, O., et al. (2010), projected or impact stains involve cast-off spatters which offer extensive information and are an important part of a functional, medically and scientifically based reconstruction of a crime. In relation to Bloodstain Pattern Analysis, a cast-off spatter pattern is defined as "a bloodstain pattern resulting from blood drops released from an object due to its motion". Similarly, cessation cast-off patterns may result from the sudden deceleration of an object. In this instance, the blood flung from a blood-stained object, such as a weapon, may produce characteristic patterns of numerous individual blood drops forming a curved or straight line. If an object is repeatedly moved, each subsequent swing will result in less cast-off as less blood remains on the object. Bloodstains produced in this fashion can be particularly difficult to interpret as there is a great deal of possible variation in patterns produced. However, according to Jackson, A.R.W. & Jackson J.M. (2011), depending on the nature of the motion of the bloodied object, cast-off blood will at least produce relatively linear stains.

A cast-off spatter pattern often occurs during crimes involving beating or stabbing events. Based on an article released by the Manila Times last August 2022, Baguio City Police Officer Director Colonel Glen Lonogan stated that the index crimes in Baguio City increased by thirty seven percent, in which the crimes for physical injuries increased by sixty seven percent, a significant increase compared to the crime index of Baguio City in 2021. According to the Regional Forensic Unit Cordillera, some instruments such as bolo, ice pick, butterfly knife, and kitchen knife are commonly used for violent crimes in

Baguio City. Involving the sharpness of such instruments, each has the ability to cut down a person which reacts with the blood of the person. The blood from the instruments will produce blood spatter to any surface after waving it away from the person, which is called the cast-off spatter. From the different instruments used, it will be determined if the instruments used will produce accurate measurements for cast-off spatters. Both the range and distance of cast-off spatter and the effect of the instruments will be measured using pig's blood. Additionally, in accordance with Attinger, D. et al. (2018), swine's blood is used since it is closely related to human's blood. As there are no studies conducted locally at Baguio City concerning this field, the result of this study would be of great benefit to the following people: 1) to future researchers who could be interested in this study and utilize it as their reference; 2) to law enforcers who would want to consider using bloodstain pattern analysis as part of investigation; and 3) to educational institutions who would want to expand upon and stress the significance of bloodstain pattern analysis in the Philippines.

II. LITERATURE REVIEW

➢ *Blood and its importance in Crime Scenes*

Blood is an essential forensic tool as it is one of the most critical biological traces at crime scenes. Analysis of bloodstains and their different aspects can lead to the discovery of crucial information and the clarification of the circumstances of the crime that transpired. It can also help direct the criminal investigation to the right track and help determine the appropriate punishment for the criminal offense committed. (Kristina, 2017).

Additionally, the analysis of blood or bloodstain evidence left at the crime scene can yield DNA profiles, making it possible to get closer to the truth. The shapes and diameter of the blood patterns left at the crime scene can also help the investigators determine the angle the blood was cast from. By measuring the blood's drying time, the investigators can also determine the approximate time the crime was committed. All measurable characteristics of the blood left at the crime scene can be used to determine whether the injuries sustained by the victim were made deliberately and whether the crime was murder or suicide. (Pokupic, 2017).

➢ *Blood Pattern Analysis*

Bloodstain Pattern Analysis pertains to the collection, categorization, and interpretation of the shape and distribution of bloodstains connected with a crime. Most stains found at a crime scene occur in a considerable proportion of homicide cases. Various bloodstain patterns can be distinguished: dripped and splashed blood, projected blood, impact patterns, cast-off stains, and expired and transferred bloodstains. Analysis of bloodstain patterns helps determine and estimate facts concerning the location, quality, and intensity. It may also help establish a sequence of events and answer detailed questions connected with the reconstruction of the crime. Bloodstain Patterns may also reveal whether an incident is an accident, a homicide, or a

suicide. (Peschel et al., 2010). Bloodstain pattern analysis uses the mechanics of bloodstains to estimate the time, nature, and sequence of events at a crime scene. (Wafa et al., 2021).

Different bloodstain patterns show the various shapes and sizes of bloodstains, providing information about an injury's direction and origin upon analysis. The shapes and sizes of bloodstains depend on the weapon's angle of impact. Various tools with different surface areas create distinct blood spatter patterns. (Crawford, 2015).

➢ *Impact and Cast-off Spatter*

The study of Wafa et al. (2021) employed a quantitative methodology by manually calculating the average size of the bloodstains and the synthetic bloodstains to distinguish the impact stain patterns created by different gender and age groups using the two blunt weapons. Using a hammer and a cricket bat, they created impact stains by hitting sponges soaked in blood and synthetic blood. According to the study results, smaller bloodstain sizes were observed in males aged between eighteen and thirty. Blood spatter made using the bat yielded a more significant amount of spatter and distribution of the blood as compared to the blood spatters made using the hammer. Cast-off patterns were studied and were observed to be produced only by the bat, which can be attributed to its higher surface area. (Wafa et al., 2021).

Cast-off blood spatter created during the backswing of violent blows due to the centrifugal force exerted on the blood. The width of the weapon used affects the spatter pattern. Broader weapons tend to produce wider spatters with the blood drops further apart. (Johnson et al., 2021).

Prior studies have identified several factors affecting the characteristics of cast-off spatters produced by different instruments. These factors include drop impact angle (Balthazard, 1939), volume and velocity (Kabaliuk, 2014), centrifugal force and weapon's width (Johnson, 2021), force and texture (Bell, 2019), and height drop (Singh, 2021). In this study and related research, the researchers will use three instrumentsthe bolo, ice pick, and butterfly knife with pig's blood. The measurements will be taken and completed in a controlled environment.

Even with prior studies related to characteristics of cast-off spatter, not all instruments used in committing crimes of beating or stabbing produce accurate measurements. For example, by swinging the same bolo in various positions and centrifugal force, the cast-off spatters produced will have different measurements. Also, two different instruments may produce similar cast-off spatters. It is impossible to determine the instrument used in committing the crime with cast-off spatter alone.

➢ *Different Blood Substitutes*

In a study by Larkin and Banks (2014), they tested the suitability of equine blood as a substitute for human blood in blood pattern analysis studies. They found that animal blood has been concluded as the closest and the most

suitable alternative. However, only porcine blood is the most prominently utilized in current studies. According to their study, equine, porcine, and human blood show no significant difference in their physical properties. Human blood and porcine blood did not show any significant difference in terms of their drop diameters. Due to Alsever's equine blood having low viscosity levels and being inconsistent with human blood, defibrinated human blood was a better substitute. Overall, it can be concluded that defibrinated equine blood is a reliable substitute for human blood. (Larkin and Banks, 2014).

The study by Polacco et al. (2018) explored the use of forensic synthetic blood substitutes for impact pattern simulation and area of origin estimation. The impacts of forensic blood substitutes yielded patterns from which various trajectory analysis methods can accurately estimate the area of origin. The study supports using the forensic blood substitute as a training tool for impact pattern simulation and area of origin estimation. Studies about bloodstains are not always possible to conduct as it needs a large amount of blood to be subjected to ethical clearance. Artificial blood can be an emerging substitute and has proven to be cost-effective and readily available for researchers. (Polacco et al., 2018).

It has been observed within these and other studies that porcine (pig) is the preferred choice of blood, showing reputable applicability to human blood. Safety aspects have to be considered when utilizing human blood; the use of animal blood has been acknowledged as a suitable substitute to human blood, decreasing but not eliminating the risk of coming into contact with pathogens and diseases. Despite the dependable reputation of porcine blood, other animal bloods are still employed. A study carried out by Christman et al. compared various animal blood (swine, bovine, equine and porcine) to determine suitability as a human blood substitute, where impacts and general appearance of the blood were compared. Although this study gives an insight into the functionality of animal blood as a human blood substitute it uses now outdated terminology and suffers from any real statistical analysis which is considered obligatory within the forensic field. It is therefore the purpose of this current study to determine the use and applicability of equine blood, a more commercially available and animal friendly blood, in the interpretation of bloodstain patterns with the use of these newer quantitative BPA approaches.

In the study or Raymond et al. (1996), the surface tension, viscosity and relative density were used as parameters in comparing pig's blood to human's blood. The study showed a remarkable similarity between the two. This means that it is valid to use pig's blood instead of human blood for the re-enactment of a crime scene or for educational purposes, even when the pig's blood is up to two weeks old.

➢ *Violent Crimes*
As stated in the Philippine National Police field manual on investigation of crimes of violence and other crimes (2011), Crimes of Violence or Violent crimes include acts like murder, homicide, kidnapping or abduction, bombings, sexual assault, and other crimes that endanger life and present a significant barrier to the Philippine National Police's capacity for investigation.

➢ *Bolo Knife*
As one of the instruments to be used, the bolo knife of the Philippines is known as legendary due to its lethality, it has been used from the Spanish Colonialism to the Mexican Revolution as well as during World War I and II. Throughout the years, it has long been used as a tool for gardening and agriculture. According to the Knivesguides, bolos usually have a flat top with a curved blade and more commonly have a length of 18 inches. Although for some, it has been used to commit a "knife crime". Knife crime potentially encompasses a very broad range of offenses and thus causes problems in both the definition and determination of its prevalence. Clearly, the production of a knife in the commission of a crime, such as in a robbery or sexual assault, even if not used to cause injury, is a 'knife crime' under any interpretation. But it is less clear whether the term may also be accurately applied to, for example, a burglary during the course of which the perpetrator is arrested and found to be in possession of a knife which was never used. Whatever the meaning, the public and political debate about 'knife crime' would benefit from both an attempt to define what is meant by the term and a more careful, and less sensational, use of it. Disaggregating the offenses that can be termed 'knife crime' such as offenses in which an individual is stabbed or those in which a knife is used in a threatening manner would provide far greater clarity.

The case of Peter Andrada v. the people of the Philippines, G.R. No. 135222, 2005 is an example of how a bolo was used to commit a crime of violence in Baguio City. According to the case, on the 24th day of September 1986, in the City of Baguio, Philippines and within the jurisdiction of this Honorable Court, Peter Andrada with intent to kill, with evident premeditation and with treachery, did then and there willfully, unlawfully, and feloniously attack, assault and hack one Arsenio Ugerio on the head twice with a bolo thereby inflicting upon latter: hacking wound, head, resulting in 1) skull and scalp avulsion vertex; 2) depressed comminuted skull fracture, right parieto occipital with significant brain laceration; operation done; craniectomy; vertex debridement; craniectomy; right parieto occipital; dural repair; debridement, thus performing all the acts of execution which would produce the crime of murder as a consequence thereof, but nevertheless, the felony was not consummated by reason of causes independent of the will of the accused, that is, by the timely medical attendance extended to Arsenio Ugerio which prevented his death.

➢ *Ice Pick*
As one of the instruments to be used, the ice pick is a pointed metal tool used from the 1800s to the 1900s to break, pick or chip at ice. The design consists of a sharp metal spike attached to a wooden handle. According to the

delighted cooking, usually, most modern ice picks are around 8 inches. Because of its availability and ability to puncture the skin easily, the ice pick has sometimes been used as a weapon. It creates a deep, narrow puncture wound. An injury from an ice pick does not bleed externally, rather it bleeds internally.

The stabbing incident of Kenneth Velasco is an example of how an ice pick was used to commit violent crimes in Baguio City. According to the news article by See, D.A., (2016) Kenneth Velasco, a Grade 10 student at Pines City National High School, died after he was robbed and stabbed sixty times on the different parts of his body along Labsan Street, Kayang Extension. Initial police investigation showed that the victim was on his way to school when he was waylaid by the three still unidentified knife-wielding suspects who then allegedly took his cellphone, tablet and his P200 pocket money for school. He was allegedly stabbed by the suspects using an ice pick 40 times around his neck while the other 20 stab wounds were distributed on the different parts of his body.

➢ *Butterfly Knife*
As one of the instruments to be used, the butterfly knife known as balisongs, are one of the most popular knife styles today. The blade consists of two handles that rotate around the pivot and wrap around the blade in the closed position. The Philippines is cited as the birthplace of butterfly knives, where balisongs is a more appropriate term. The legend of the balisong knife goes back to around 800 AD. According to Master Ona, a blades store owner, a typical butterfly knife has a length of 11.4 inches. This style of knife could be opened quickly with one hand and easily used as a weapon that proved a common choice for self-defense and utility uses. However, the butterfly knife was not only used for self-defense, flipping, or other tasks. Regardless, the butterfly knives are rising in popularity due to the fun of "flipping." Flipping involves tossing butterfly knives to perform all kinds of tricks. Even with danger, the community or the collectible appeal, there is no doubt flippers are mesmerizing to watch.

The case of Emiliano Dayrit vs. the people of the Philippines, G.R. No. L-14388, 1960, is an example of how a butterfly knife was used to commit a crime of violence. According to the case, on Harrison Road, Baguio City, Emiliano and his wife were selling cigarettes at about 8:00 PM when four men approached them, one of them was Napoleon Ananayo who bought cigarettes. A subdued conversation took place when suddenly Emiliano drew a "balisong" knife, also known as butterfly knife, and stabbed Ananayo in the neck. Emiliano was guilty of homicide and was sentenced not less than six (6) years and one (1) day of prision mayor and not more than twelve (12) years and one (1) day of reclusion temporal. An appeal was then made on the grounds of mitigating circumstances and was then sentenced to not less than two years, eleven (11) months, and eleven (11) days of prision correccional and not more than eight (8) years, eight (8) months, and one (1) day of prision mayor.

➢ *Kitchen Knife*
As one of the instruments to be used, a kitchen knife, more specifically a chef's knife, is one of the most useful knives to have in a kitchen according to Kamikoto Knives (2018). Sizes of chef's knives ranges from 6 to 12 inches or 15 to 30 cm. It is a multi-purpose knife with a broad and sharp blade that is used for a range of kitchen duties such as cutting meat, dicing vegetables, disjointing some cuts, slicing herbs, chopping nuts and more. A chef's knife's blade is often constructed of ceramic, carbon steel, stainless steel, or a laminate of the two metals. Typically, this knife has a prominent edge with a sloping curvature which makes use of the knife's distinctive rocking motion for easier cutting.

The case of Benjamin Ocampo vs the People of the Philippines, G.R. NO. 177753, 2009, is an example of a crime of violence where a kitchen knife was used. According to the case, while the victim and his wife were buying garlic chips from a local store at Old Market Building, Baguio City, the appellant suddenly surfaces and pushed himself between the two then proceeds to stab the victim at the right side of his neck with a stainless kitchen knife. After the incident, appellant then walked away from the scene. Post mortem examination showed that incised wounds in the neck located near the anterior midline. The court finds the accused, Benjamin Ocampo, guilty of Murder and is sentenced to suffer the penalty of reclusion perpetua.

➢ *Mechanical Swing*
In a study by Lucas and Horners (2010), they constructed a trebuchet to find out which factors limit the distance traveled by the projectile fired from a small-scale tabletop trebuchet and determine the conditions necessary for its optimum range. They anticipated that the greatest range of the trebuchet would be achieved when there was a large ratio of counterweight mass to projectile mass. The projectile's mass is constant while the counterweights' mass increases. They built the trebuchet with three different holes, which allowed it to be elevated to three heights above the ground level. It also showed that using a heavier counterweight is suggested since the more significant the counterweight's mass, the greater its gravitational potential energy as it is suspended in the air before being released. By following the Evening Woodworker's (2020) instructions in building a trebuchet, the researchers can use the machine as a device to perform the cast-off spatters.

The researchers would like to conduct the study to determine more about the distinctions of cast-off spatters and their patterns produced by various tools and weapons used in the commission of violent crimes in various velocities. The scarcity of local research regarding cast-off blood spatter leaves room for questions regarding the shapes and patterns of the blood spatter. Testing and researching about the cast-off blood spatter emitted with the common weapons used in violent crimes in Baguio City at constant velocity would help the researchers and its target audience to distinguish the characteristics and differentiate it better from other types of blood spatters.

> *Primary Stains*

Primary blood stains are the stains known to change depending on the angle of its impact, its velocity, the distance it travelled, and the type of surface it impacted in. In addition, primary blood stains can also be "parent stains" that satellite stains originate from (OSAC, N.D.). Bell (2019) stated that cast-off blood stains come in a variety of shapes, sizes, and numbers. The variations depend on the volume of blood impacting the surface, the force used in the impact, and the surface's texture being affected by the blood. With all variables being constant, researchers would like to know if the number of primary stains produced is also constant.

> *Satellite Stains*

Satellite stains, according to the team of Forensic experts from the FR Author Group (2023), are the small drops of blood that were distributed around the perimeter of the drops of blood that were produced as a result of the blood hitting a target surface. Singh P., et al. (2021), stated that the distance of satellite stains arising from the fake blood spots rose along with the height of dropping fake blood. In addition, satellite stains were discovered to be inversely correlated with spines, while blood stain height was directly correlated with satellite stains. Researchers can use the characteristics of satellite stains produced in the cast-off pattern as a characteristic to be observed.

> *Cast-off Trail*

Johnson (2021) said that due to the centrifugal force applied to the blood during the backswing of a strong blow, a cast-off spatter is produced. In his study, it has been established that a weapon's width and length impact the pattern of spatter.

> *Statement of the Problem and Hypothesis*

This study aims to determine the characteristics or pattern of the cast-off spatter produced by a bolo, an icepick, a butterfly knife, and a Kitchen Knife. Specifically, the following research questions need to be addressed:

- What are the differences in the cast-off spatter produced by a bolo, ice pick, butterfly knife, and kitchen knife in terms of the number of primary bloodstains?
- What are the differences in the number of satellite stains between the cast-off spatter made by a bolo, ice pick, butterfly knife, and kitchen knife?
- What are the differences between the length of the cast-off trail created by a bolo, ice pick, butterfly knife, and kitchen knife?

> *Hypothesis:*

There is no significant difference between the cast-off spatter pattern produced by the different instruments. The cast-off spatter patterns from the Bolo, Ice Pick, Butterfly Knife, and Kitchen Knife are not noticeably different from one another.

III. METHODOLOGY

> *Research Design and Methodology*

The researchers used an experimental research design. Experimental design is a method where the technique of doing research in a methodical, controlled manner ensures that accuracy is maximized and that inferences about a hypothesis statement can be made. (Bell). Specifically, this research used Quasi-Experimental research design as it manipulates independent variables without assigning the participants to conditions at random. Quasi-experimental research does not remove the problem of the confounding variables due to not involving random assignment to conditions. (University of Minnesota, 2016). The research also used the randomized block research design to assign the results of similar characteristics to a group in order to form blocks that makes it easier to compare and where the treatment of data is randomly assigned to. (Choueiry, 2021). Generally, the purpose is to establish the number of bloodstains, satellite stains, and the length of the cast-off trail produced by a bolo, an ice pick, a butterfly knife, and a kitchen knife.

Experimental research design was used because of the accuracy with which one can determine how variables relate to one another and to make that analysis as impartial as possible. It is ideal for this study because it describes the relationship between cast-off blood patterns produced by a bolo, an ice pick, a butterfly knife, and a kitchen knife under a controlled environment. This study was conducted using a combination of documentation analysis and observation.

> *Locale of the Study*

The locale of the study is at #323 Poliwes, Kennon Road, Baguio City. The study is carried out in an enclosed room that has no windows in order to accommodate the cast-off of blood for the experiment and data collection.

> *Data Gathering Tool*

- *Blood*

Prior to extraction, the researchers have taken the approval of the City Veterinary and Agriculture Office for the extraction of pig's blood from the Baguio slaughterhouse. The researchers further seek the approval of the University of the Cordilleras Research Ethics Committee.

Additionally, Acetic acid was bought from a local store for the mixture of the blood.

- *Trebuchet*

For the machine that held and casted the instrument, a trebuchet was constructed, as seen in figure 2, utilizing the design of The Evening Woodworker (2020) as a base. The trebuchet was constructed using a ¾ inch steel pipe, 2x4 and 2x2 wood planks, 3-inch bearing, elastic strand, cement, and nails. In addition, mounts, for the instrument and additional counterweights, speedometer, and sensor were attached.
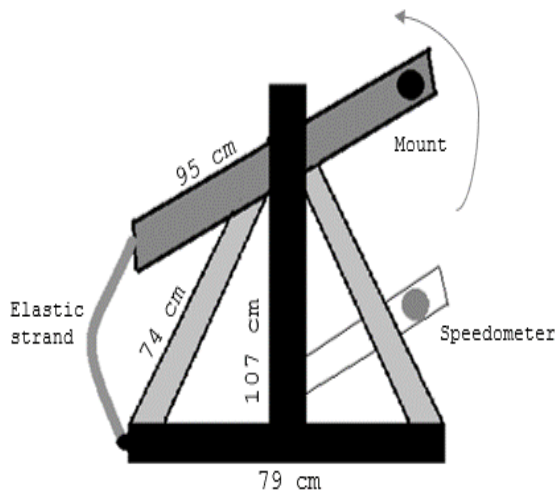
Fig 1 Sketch of the Trebuchet

For the surface where the blood pattern was produced, white cartolina papers with dimensions of 11.25 x 14.25'' were attached to the wall, floor, and ceiling in front, below, and above the machine at a height of six feet and seven inches from the floor, the length of six feet and three inches, and the paper's width being two feet.

For this study, the researchers used four instruments used for violent crimes in Baguio city, namely, a bolo, an ice pick, a butterfly knife, and a kitchen knife as the experimental materials. The length of the bolo used was 18 inches while the thickness of the blade was 4.1 millimeters. For the ice pick, its length was 8 inches and had a blade thickness of 4.5 millimeters. The butterfly knife had a length of 11.4 inches and a blade thickness of 3.5 millimeters while for the kitchen knife, it had a length of 12 inches and 1.1 millimeters of blade thickness.

A cup was also used to submerge blood into the blade of each instrument. The cast-off patterns were photographed using a camera for documentation. A tape measure was used in measuring the size of the bloodstain patterns.

➢ *Data Gathering Procedure*

• *Blood Preparation*
The pig's blood that was acquired from the slaughterhouse within Baguio City hours before the experiment was mixed with acetic acid with the mixture of ninety nine percent pig's blood and one percent acetic acid. In other words, in a 100ml mixture, 99ml is pig's blood while 1ml is acetic acid.

• *Instruments*
The bolo, ice pick, butterfly knife, and kitchen knife were prepared in a safe manner and their length and width were precisely measured and recorded.

• *Machine*
The researchers prepared a ¾ inch steel pipe, 2x4 and 2x2 wood planks, 3-inch bearing, elastic strand, cement,

and nails, and proceeded to construct the trebuchet, the machine to be used for the experiment, as seen in figure 2. After the construction of the main frame of the machine, the mounts, the speedometer, and the sensor were attached to the trebuchet.

• *Room Preparation*
White papers with dimensions of 11.25 x 14.25 inch were placed across a section of the wall in the designated experimentation room in one of the researchers' households at a height of six feet and seven inches from the floor, the length of six feet and three inches, and the paper's width being two feet.

• *Computation of Velocity*
Using Rober's 40-mile blanket design, an improvised 6-mile blanket design was used. After that, an instrument was attached to the trebuchet, set in motion, and was filmed by a camera that can shoot 240 Fps in slow motion was used to capture the swinging motion of the trebuchet. The video was analyzed, and the velocity of the swing was known using Rober's design. If the speed was not 3.8 meter per second, the tension of the elastic strand was adjusted. The procedure was repeated until a 3.8 meter per second velocity was achieved.

• *Production of Cast-off Spatter*
The instrument was attached to the trebuchet. Then, the blades of the instruments that were used (bolo, ice pick, butterfly knife, and kitchen knife) were submerged in pig's blood. The trebuchet was set in motion and produced the cast-off spatter pattern. After the production of the cast-off spatter, the bloodstain patterns were documented and measured. The procedure was repeated for each instrument and another computation of velocity was performed before the actual casting of the instruments.

The experimental materials were attached to the arm of the trebuchet. The swinging motion was in a vertical plane. The arm, which the instrument was attached to, started at an angle of 135 degrees and moved counterclockwise up to an angle around 0 degrees while maintaining a constant speed of 3.8 m/sec which was used by the study of Kunz (2016). By following the study of McCleary (2021), the distance between the instruments and wall is 2ft. The blade of each instrument used was submerged in pig's blood. These conditions were maintained after each instrument. After the experiment, samples were documented by taking photographs and data was recorded.

Characteristics were recorded, and measurements were taken with the use of a Vernier Caliper and a tape measure. The following were considered:

✓ The number of primary blood stains produced by the cast-off spatter patterns of the bolo, the ice pick, the butterfly knife, and the kitchen knife.
✓ The number of satellite stains produced by the cast-off spatter patterns of the bolo, the ice pick, the butterfly knife, and the kitchen knife.

✓ The length of the cast-off trail produced by the cast-off spatter patterns of the bolo, the ice pick, the butterfly knife, and the kitchen knife.

To guarantee that the averaged results are more accurate than those of a single trial, the experiments were conducted three times under the same conditions.

➢ *Treatment of the Data*

For the randomization, Permuted block randomization, a technique for assigning participants at random to treatment groups while preserving balance across groups (Zack, 2020), was used, as seen in table 1.

More specifically, the study used Random Number Generation by Randomly generating a number for each instrument then ranking the generated numbers from highest to lowest. The randomization is required to determine the order of casting of the bolo, the ice pick, and the butterfly knife. The procedure was done by assigning randomly generated numbers from 1 to 100 to each of the three instruments. Using a number generator, the order was chosen by the highest chosen number to the lowest chosen number of each instrument, with the highest number generated being casted first and the lowest being casted last. Since the experiment was carried out three times, this method would be repeated three times.

Table 1 Permuted Block Randomization on Cast Order of the Instruments

Trial 1	Number Generated	Order to be casted
Bolo	1	4th
Ice Pick	92	2nd
Butterfly Knife	98	1st
Kitchen Knife	48	3rd
Trial 2	**Number Generated**	**Order to be casted**
Bolo	45	2nd
Ice Pick	20	3rd
Butterfly Knife	2	4th
Kitchen Knife	76	1st
Trial 3	**Number Generated**	**Order to be casted**
Bolo	8	4th
Ice Pick	55	2nd
Butterfly Knife	44	3rd
Kitchen Knife	83	1st

After the sheets dried, observations were chartered, and measurements were taken using millimeters. The ANOVA (Analysis of Variance) was used for the analysis of the three instruments. The ANOVA test aims to evaluate multiple mutually exclusive theories based on the hypothesis made by the researchers. It will be done by comparing the three independent variable means to determine if there is statistical support that the three mean differences are statistically significant. The three categorical groups in which the independent variables are organized should each yield three or more observations where the means of the samples are compared. (Mackenzie, 2018).

The Scheffe Test or the Scheffe's Procedure was used in the analysis of variance as a post-hoc test for the data. After conducting the ANOVA test and getting significant statistics, Scheffe Test is used in order to find out whether pairs of data means are significant and corrects the alpha in order to compare more than one pair of means simultaneously with complex mean comparison. (Glen, 2020). In the study, the statistic means of the instruments used in the experiment were compared to each other and between all pairs simultaneously in order to see if each instrument is significantly different from each other based on the data results gathered.

IV. RESULTS AND DISCUSSIONS

➢ *Number of Primary Blood Stains*

In table 2, all the experimental instruments exhibited different number of primary blood stains in the three trials each instrument were subjected to. The Bolo had an average number of one hundred thirty-one primary blood stains, the Icepick had the average of fifty-seven primary blood stains, the average number of primary blood stains for the Butterfly knife was eighty-seven, and the Kitchen Knife had an average of one hundred and six primary blood stains. Moreover, the table presents the t-computed value of 0.016 which is less than 0.05 level of significance which indicates the rejection of the null hypothesis and interpreted as significant. There is a significant difference on the number of primary bloodstains produced by the different instruments used in various crimes.

Post Hoc analysis indicates that there is a significant difference between ice pick and bolo. On the other hand, there is no significant difference between and among the different instruments used with regards to the number of primary bloodstains which shows the failure to reject of the null hypothesis showing a not significant interpretation. As seen in table 2.1, the homogenous subsets, bolo's mean score is only in subset 2 exhibiting letter "a" and ice pick's mean score is only in subset 1 exhibiting letter "b" while the rest exhibits letter "ab" because there mean scores is seen in both subsets.

Table 2 Number of Primary Blood Stains

Instrument	T1	T2	T3	Avg	F-value	P-value	Decision
Bolo	100	142	151	131 a	6.486	0.016	Reject Ho
Ice Pick	74	32	65	57 b			
Butterfly Knife	68	97	96	87 ab			
Kitchen Knife	84	119	115	106 ab			

Table 3 Homogenous Subset for Number of Primary Blood

N	Subset for alpha = 0.05	
	1	2
a		131.00
b	57.00	
ab	87.00	87.00
ab	106.00	106.00
Sig.	127	182

The data of the number of primary bloodstains exhibited significant difference between and among the instruments used for the experiment in terms of the ANOVA test. After subjecting it to the Scheffe Test, it was shown that only the comparison between the bolo and the ice pick has a significant difference while the rest of the comparisons yielded no significant differences. It can be concluded that the number of primary bloodstains can be used during investigations as a preliminary indicator on whether the possible weapon used was akin to a bolo or an ice pick.

Bell's study in 2019 about cast-off blood stains said that the stains come in a variety of numbers due to the differences in the volume of blood impacting the surface, the force that was used in the impact, and the texture of the surface being impacted. Although the volume of blood that impacted the chosen surface of the study was not thoroughly controlled, based on the data gathered by the researchers, the number of primary stains produced by the four experimental instruments being tested did not have any significant difference. Therefore, the variation in number of blood stains produced in a controlled and equal environment would yield results that are not far apart from each other. Further research is recommended to make a better comparison using controlled volume of blood.

➤ *Number of Satellite Stains*
For table 4, all four experimental instruments exhibited the presence of satellite stains in the three trials each instrument were subjected to. The Bolo had an average number of twenty-nine satellite stains, the Icepick had the average of sixteen satellite stains, and the average number of satellite stains for the Butterfly knife was twenty-eight. The Kitchen Knife was also subjected in three trials and had an average of ten satellite stains. In addition, the table shows that there is a significant difference between and among the various instruments used in crimes with regards to their number of satellite stains with a t - significant value of 0.038 which is less that the 5% level of significance. Therefore, the null hypothesis is rejected and defined as significant.

However, Post Hoc analysis indicates the failure to reject null hypothesis and defined as not significant at 0.05 level of significance. However, the table reveals that there is no significant difference between and among the instruments used in various crimes in terms of the number of satellite stains. Table 5, homogenous subsets, exhibits that all mean scores are seen in subset 1 indicating there is no significant difference between and among the instruments.

Table 4 Number of Satellite Stains

Instrument	T1	T2	T3	Avg	F-value	P-value	Decision
Bolo	21	30	37	29.333	4.532	0.038	Reject Ho
Ice Pick	17	9	21	15.667			
Butterfly Knife	18	33	32	27.667			
Kitchen Knife	7	17	12	12			

Table 5 Homogenous Subset for Number of Satellite Stains

N	Subset for alpha = 0.05
	1
3	29.333
3	15.667
3	27.667
3	12.000
Sig.	0.092

Using the Scheffe test as the post-hoc test for the study guarantees that if the overall ANOVA is statistically significant, then at least one comparison or contrast between one mean to another is statistically significant. However, since Scheffe test has less power than other tests like the Tukey or Dunnett test, the significant difference between the mean comparisons of the study's data may have inconsistencies. It is possible that these inconsistencies give you a result which rejects the null hypothesis in the ANOVA test and still be unable to reject the null hypothesis in the Scheffe test. (Page 217, Maxwell and Delaney, 2nd Edition)

Meanwhile, the data exhibited under the number of satellite stains for each instrument can be used as a basis to help identify the instrument used in the commission of a violent crime. Although the Scheffe test had shown that, when individually compared, there are no major differences between the results of each instrument, the ANOVA test results had exhibited that there are still variety in the ranges of the number of satellite stains produced by each weapon. The ranges for each instrument are different from each other, but the ranges of the weapons used for the study are close to each other. It can still help narrow down the possible weapons used in the commission of crimes.

According to the study of Boos et. Al (2019), the number of satellite stains increase due to the increased drop number and the velocity of impact of blood spatters. The study of Bell (2019) also indicates that the number of blood stains are influenced by various factors such as the volume of blood on impact, the force of the impact, and the surface texture. Using a constant velocity of 3.8 meters per second in all the trials done with the instrument yielded more satellite blood spatters in the results garnered by the researchers. There is a significant difference between the data interpreted, meaning that if all four of the instruments used in the research experiment were compared at once, the number of satellite stains show great variation. However, if the data gathered for each instrument were compared between each other (i.e., Bolo vs Ice Pick, Bolo vs Butterfly Knife, Butterfly Knife vs Kitchen knife), there are no significant differences between and among the

instruments used in various crimes when it comes to the number of satellite stains produced. This shows that although the number of satellite stains showed variation, the stains produced by each instrument are not that far apart from each other.

➢ *Length of Cast-off Trail*

In table 6, the four experimental instruments exhibited the different measurement on the length of the cast-off trails that were produced in the trial. For the Bolo, the average cast-off trail length is six hundred forty and five tenths of centimeters. For the Ice Pick, the average length is five hundred seventy-one centimeters. For the Butterfly Knife, the average is six hundred nineteen and sixty-seven hundredths in centimeters. The kitchen knife also underwent the same trials as the other three experimental instruments did and had an average of four hundred nineteen centimeters. In addition, table below displays the significant difference of the observed characteristics of the cast-off spatter produced by a Bolo, Ice Pick, Butterfly Knife, and kitchen knife in terms of the length of the cast-off-trail. This further exhibit the rejection of the null hypothesis with a t-computed value of 0.0001 which indicates a significant difference between and among the instruments used in various crimes in Baguio City.

Furthermore, post hoc analysis indicates that there is a significant difference on the length of cast-off-trail between and among bolo and ice pick (0.025), bolo and kitchen knife (0.000), ice pick and kitchen knife (0.000) and, butterfly knife and kitchen knife (0.000) all with a t-computed significant values less than 0.05 which are interpreted as significant. On the other hand, there is no significant difference of the length of the cast-off-trail between and among bolo and butterfly knife (0.701) and ice pick and butterfly knife (0.120) which indicates the failure to reject null hypothesis at 5% level of significance. Table 4.1, Homogenous subsets, indicates that the bolo's mean score is only in subset 3 exhibiting letter "a" while ice pick's mean score is only in subset 2 exhibiting letter "b". Butterfly knife's mean score is in both subset 2 and 3 exhibiting letter "ab" while kitchen knife's mean score is only in subset 1 exhibiting "c".

Table 6 Length of Cast-Off Trails

Instrument	T1 (cm)	T2 (cm)	T3 (cm)	Avg	F-value	P-value	Decision
Bolo	631.50	648	642	640.50 a			
Ice Pick	589	531	593	571 b	67.327	0.0001	Reject Ho
Butterfly Knife	594	633	632	619.67 ab			
Kitchen Knife	416.50	423.50	417	419 c			

Table 7 Homogenous Subset for Length of Cast-off Trails

N	Subset for alpha = 0.05		
	1	2	3
a			640.50
b		571.000	
ab		619.667	619.667
c	419.0		
Sig.	1.0	.120	.701

The length of the cast-off trails mostly exhibited that there are significant differences between and among the instruments used in the study when it comes to the characteristic. The only exception is when the butterfly knife is compared to the results of the bolo instrument and the ice pick instrument. The length of the cast-off trail is the most optimal characteristic to use during an investigation regarding violent crimes as it shows the most distinguishing ranges, factors, and data between and among the instruments as a whole and if compared individually to other instruments. The major differences between the ranges found for the length of the cast-off trail could sufficiently narrow down or identify which weapon was most likely used in the commission of the crime.

In 2021, Johnson discovered that a weapon's width and length affects the outcome of blood spatters. He said that when a centrifugal force is applied to the blood during the backswing of a strong blow, cast-off spatters are produced. Using constant circumstances, except for the volume of blood in the casting, the researchers found that there are significant differences in the data results between some instruments while other comparisons between certain instruments yielded no significant difference. For the weapons that yielded significant differences, it was between and among bolo and ice pick, bolo and kitchen knife, ice pick and kitchen knife, and butterfly knife and kitchen knife. Meanwhile, the comparison between and among bolo and butterfly knife, and ice pick and butterfly knife indicate no significant differences in terms of the cast-off blood trail they produced. The ice pick and the butterfly knife are roughly instruments with similar lengths, while in terms of the bolo and the butterfly knife, the two has the same width-to-size ratio or similarities, which would explain why the length of the cast-off trails they produced do not have any significant differences. The other instruments, when compared between and among themselves, have huge differences when it comes to their length and width making their data results significantly different even with having the same circumstances they were subjected to.

V. CONCLUSIONS AND RECOMMENDATIONS

➢ *Conclusions*
Considering the findings of the study, the following are the conclusions:

- Only the data of the bolo and the ice pick have exhibited a major variance wherein their set values are distinguishable and makes the range of both instruments distinct from each other in terms of the number of primary bloodstains produced in a commission of violent crimes.
- The number of satellite stains exhibited that each instrument has their own range of data which are not too far apart from each other but can be used to help narrow down the possible instruments used for the commission of a violent crime.
- The ideal characteristic to use during an investigation regarding violent crimes is the length of the cast-off

spatter as it is distinct between and among each instrument in terms of its range, factors, and set data.

➢ *Recommendations*
After a thorough assessment and considering the foregoing findings and conclusions of the study, the following recommendations are suggested by the researchers:

- Law enforcement may use the number of primary bloodstains as a preliminary characteristic to see if the weapon used was a bolo or a butterfly knife and then use the number of satellite stains and the length of the cast-off trail to narrow down or determine the weapons used in the commission of the crime during an investigation.
- Infographics from this study may be used by educational institutions and other agencies to emphasize the significance of bloodstain pattern analysis and to better explain its applicability as evidence in court.

Future researchers who could be interested in this field can utilize this study as their reference and follow other recommendations such as:

- *Human Blood*
It is recommended that future researchers may consider the usage of fresh human blood. Although studies have suggested that porcine blood is a viable alternative to human blood in conducting forensic simulations, there are limited studies comparing the cast-off spatter produced by fresh human blood and porcine blood.

- *Controlled Volume of Blood*
It is also recommended to use a controlled volume of blood to further distinguish the characteristics of the cast-off spatter pattern. As stated in the study of kunz (2016), 0.5 mL of blood can be used by future researchers.

- *Different Velocity*
It is recommended that the future researchers who would like to use a different velocity to consider a person's physical build, specifically the person's power, could give a variety of data results. Moreover, it is recommended to future researchers to consider getting an average speed of no less than 20 people with different gender and different weight in order to maximize the applicability and flexibility of this study.

- *Different Instruments*
Aside from the instruments used in this study, several weapons that may be bladed, pointed, or blunt such as the machete, dagger, cleaver knife and axe, can also be used as future references for cast-off spatter studies. Researchers may consider that any object can be used as an instrument to commit a crime, and these can have different lengths, widths, textures, surface areas and weights, which affects the cast-off spatter.

- *Different Surface*

It is recommended for the future researchers to consider the surface area where cast-off spatter will be produced. The texture of a surface, whether porous or nonporous, in which size and shape could make an impact on the research. Primarily, porous surfaces, such as drapes, carpet, cardboard, and more, form a spatter formation for angle impact while nonporous surfaces such as Glass, metal, plastic, and more, forms a circular stain pattern or flows down depending on its position.

- *Different Plane of Motion*

It is recommended that the future researchers may consider different planes of motion. In the study of Kunz, they have utilized transverse inferior plane of motion, specifically from 90 degrees to 270 degrees. Different types of planes can also be utilized.

- *More Trials*

To establish a more reliable range of results for each instrument used in the commission of violent crimes, the researchers recommend that future researchers who would like to conduct the same study to increase the number of trials for the casting of blood. Experimenting with more trials for the casting of blood would give more results that would create a more definitive range for the data to be better compared and analyzed with.

- *Observe Other Characteristics*

The researchers also recommend studying other characteristics of primary and satellite stains such as the length, width, and displacement of each stain. This information enables the determination of the distance, proximity, and force at which the blood was cast. In addition, characteristics of secondary stains could also contain vital information about crime commissions if analyzed.

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