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Analysis of Variation in Diameter of Blood Spatter in Various Surface from Various Height

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ABSTRACT

Forensic biology is a crucial discipline that applies biological principles to criminal investigations, aiding in the identification of individuals and analysis of biological evidence. This field encompasses DNA profiling, forensic anthropology, entomology, and microbiology to solve crimes and identify remains. Advanced techniques, such as next-generation sequencing and microbial forensics, have enhanced the accuracy and reliability of forensic analyses. DNA analysis, in particular, has revolutionized criminal investigations by enabling precise identification from minimal biological traces. Bloodstain pattern analysis is a crucial aspect of forensic biology, aiding in crime scene reconstruction by determining the dynamics of bloodshed events. This study investigates the variation in blood spatter diameter on different surfaces when dropped from varying heights. Factors such as surface texture, absorbency, and height influence the spread and shape of bloodstains, affecting forensic interpretations. Controlled experiments were conducted using blood droplets on multiple surfaces, measuring spatter diameters at different heights to identify patterns. The findings provide insights into how surface properties and gravitational forces impact bloodstain morphology, enhancing forensic accuracy in crime scene investigations.

Keywords: Bloodstain pattern analysis, blood spatter diameter, forensic biology, surface texture, crime scene reconstruction.

INTRODUCTION

Forensic science is the use of scientific methods to solve crimes and analyze evidence. It’s a multidisciplinary field that includes many specialties, such as DNA analysis, fingerprint analysis, and anthropology.

Forensic science specialties: Bloodstain pattern analysis, Firearms examination, Hair and fibre analysis, Forensic biology, Drug chemistry, Footwear and tire track analysis, Latent print analysis, Forensic toxicology, Trace chemistry.

BLOOD: Blood is a vital bodily fluid that circulates through the cardiovascular system, transporting essential substances such as oxygen, nutrients, hormones, and waste products throughout the body. It is composed of several key components: red blood cells (which carry oxygen), white blood cells (which are involved in immune defense), platelets (which help in blood clotting), and plasma (the liquid portion that carries nutrients, hormones, and waste products).

Blood plays a crucial role in maintaining homeostasis, regulating temperature, and protecting the body against infections and diseases. Its functions are essential for overall health and

COMPONENTS OF BLOOD

1. Plasma
2. Red Blood Cells (RBCs)
3. White Blood Cells (WBCs)
4. Platelets

Legal Framework**:** The Indian Evidence Act of 1872 provides the legal basis for the admissibility of scientific evidence in courts, including forensic evidence.

Challenges: Despite progress, issues like lack of standardized training, inadequate infrastructure in certain regions, and expertise gaps remain challenges in the Indian forensic science landscape.

APPLICATION OF FORENSIC SCIENCE:

In forensic science, blood is defined as a vital bodily fluid that can be used as evidence to help identify individuals, determine cause of death, or reconstruct events in a crime scene investigation. It consists of red blood cells, white blood cells, platelets, and plasma, each of which can provide specific forensic information. Blood evidence can be analyzed for DNA profiling, blood type determination, and the presence of certain substances or toxins. Its presence at a crime scene, along with its patterns or traces, can reveal critical information about the nature of a crime, such as the location of the injury, the type of weapon used, and the position of the individuals involved.

BLOOD SPATTER

Blood spatter refers to the patterns formed when blood is subjected to forces such as impact, gravity, or movement. These patterns can provide valuable forensic information in criminal investigations, helping to reconstruct events that occurred at a crime scene. Blood spatter analysis involves studying the size, shape, distribution, and direction of bloodstains to determine how and why the blood was dispersed. For instance, a high-velocity spatter, often caused by a gunshot, will create small, fine droplets, while a blunt force impact might result in larger,irregular stains. By analyzing these patterns, forensic experts can deduce factors like the location of the victim and assailant, the type of weapon used, and the sequence of events leading to the bloodshed. Blood spatter analysis plays a crucial role in establishing timelines, corroborating or refuting witness statements, and linking suspects to a crime scene.

BLOOD SPATTER ANALYSIS IN FORENSIC SCIENCE:

Blood spatter analysis in forensic science is a critical technique used to examine and interpret bloodstains at a crime scene. This process involves studying the patterns and distribution of blood to reconstruct the events leading up to and following a violent incident. Forensic experts analyze various characteristics of bloodstains, including their shape, size, distribution, and direction, to determine factors such as the point of origin, the type of weapon used, the position of the victim, and the movement of individuals involved in the crime.

Blood spatter patterns can be classified into several types, including passive stains (caused by gravity, such as drops or pools), transfer stains (left when a bloodied object comes in contact with a surface), and impact stains (resulting from forceful contact like a beating or shooting). Additionally, experts can determine the angle of impact and the direction of travel of blood, which helps in determining the position of the victim and the assailant during the event.

Through blood spatter analysis, forensic scientists can provide valuable insights that contribute to the reconstruction of a crime scene, potentially confirming or refuting witness testimony, establishing timelines, and linking suspects to the scene. This form of analysis is an essential tool in forensic investigations, offering a scientific method to interpret the often chaotic and violent events of a crime.

SPECIES IDENTIFICATION:

Blood species identification is a method used to determine the species of origin of a blood sample.

It's used in forensic science, veterinary medicine, and wildlife preservation. Methods

Enzyme-linked immunosorbent assay (ELISA): Uses a monoclonal antibody to identify human blood. It can detect human immunoglobulin G (IgG) in bloodstains that are up to 16 months old.

Raman spectroscopy: Analyzes the spectral components of blood to differentiate between species.

Uhlenhuth test: Also known as the antigen–antibody precipitin test, this test looks for characteristic proteins in the blood.

Peptide mass fingerprinting: Analyzes the mass pattern of peptide fragments generated from hemoglobin to identify species.

Principal component analysis (PCA): Analyzes the variance in blood spectra to categorize species.

Single nucleotide polymorphism (SNP) analysis: Analyzes DNA to differentiate between individuals.

Applications:

- Identifying the species of origin of a bloodstain at a crime scene
- Identifying the species of origin of blood in a wildlife sample
- Identifying the species of origin of blood in a veterinary sample

BLOOD GROUPING:

Blood grouping is the process of determining a person's blood type based on the presence or absence of antigens on the surface of red blood cells. The most common blood groups are A+, A, B+, B-, O+, O-, AB+, and AB-.

Blood grouping is based on agglutination, which is the clumping of red blood cells (RBCs) into masses. Agglutination occurs when an antigen is mixed.

BLOOD TYPE:

Blood type is determined by the genes inherited from parents. The two major classifications of blood are the ABO system and the Rh system.

BLOOD TYPING IMPORTANCE:

Blood typing is important for safely receiving a blood transfusion or transplant. If the blood types don't match, the recipient's immune system will attack the donated red blood cells.

IDENTIFICATION OF BLOOD FROM CRIME SCENE:

Blood at a crime scene can be identified using color tests, DNA profiling, and bloodstain pattern analysis.

- Colour tests

- Kastle-Meyer test : A common test that uses phenolphthalein, which reacts with hemoglobin to turn from colorless to pink
- Benzidine reaction : A solution of benzidine and sodium perborate is sprayed on the stain, and if it turns dark blue, it indicates blood
- Leuco-malachite green reaction : A reagent of leuco-malachite green and sodium perborate is applied to the stain, and if it turns intense green, it indicates blood
- Luminol test : A solution of Luminol is sprayed on the stain in a dark room, and if it gives off a strong blue fluorescence under UV light, it indicates blood

Tetramethyl benzidine (TMB) Test for Blood:

The Tetramethyl benzidine (TMB) presumptive test for blood is a catalytic test which is based on the peroxidase-like activity of haemoglobin. TMB is derived from the tetramethyl derivative of benzidine which is used as a screening test. It gives a characteristic blue-green color when reacting with hemoglobin.

Principle of TMB: When heme in the blood reacts with tetramethyl benzidine in the presence of an H2O2, oxidation of TMB takes place. As a result, blue green coloured products are formed**.**

OBJECTIVES

1. To investigate the relationship between the height of blood drop and the diameter of the blood splatter.
2. To compare the blood splatter patterns on various surfaces (e.g., smooth, rough, porous) and analyse the variation in splatter diameter.
3. To determine the effect of surface texture and porosity on the dispersion of blood splatter.
4. To quantify the variation in splatter diameter in relation to different drop heights and surface characteristics.

METHODOLOGY

Particulars	**Methods**
Signification of Study	This study will help to recreate the crime scene and by measuring the blood droplet it is able to find the blood is dropped from which height.
Universe of the study	This study has been conducted with the help of **Psyforex** a Forensic Organization udy done at Mylappuram at Malappuram District.
Sample Collection	Study included with animal blood collected from poultry shop, poured uniformly in 4 different surfaces for analysis. In total 12 samples were there. Surfaces including: Tiles Concrete Wood Glass

Research Design	Explorative and Descriptive
Tools of the Study	pe, Measuring Scale, Dropper
Limitations	This study is conducted in animal blood, but if it is done in human blood, it will help more to relate in a real crime scene scenario.

RESULT

Surfaces Used for blood spatter analysis, Tiles Concrete Glass and Wood,

1. Tiles: When a blood is dropped from 100 cm, the diameter of the blood spatter is 2.5 cm and from 150cm, the diameter of the blood spatter is 3 cm. When a blood is dropped from 200 cm, the diameter of the blood spatter is 3.5 cm.

Reason for the diameter changes: Tiles are smooth, non-porous, and have low absorbency. When blood falls from a greater height, it has more kinetic energy upon impact, leading to greater spread. Since the tile does not absorb blood, the drop spreads outward, increasing the diameter.

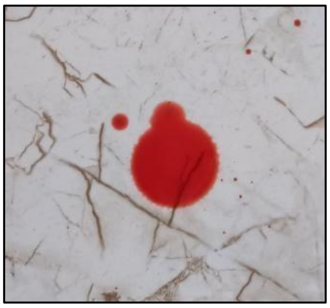
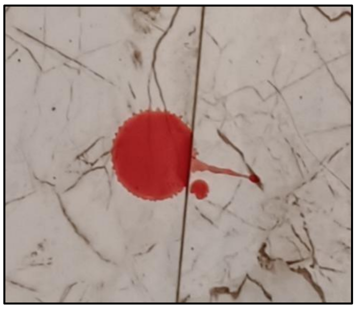


FIG 1A (100 cm)



F IG 2B (150 cm)

FIG 3C (200 cm)

Figure 1: Blood spatter on Tiles

Concrete: When blood is dropped from 100 cm, the diameter of the blood spatter is 3cm.When a blood is dropped from 150 cm,the diameter of the blood spatter is 2.5 cm and from 200 cm of height ,the diameter of the blood spatter is 2cm.

In the concrete surface the diameters were decreased when the height was increased. Concrete is rough and porous, which means it absorbs some of the blood upon impact. When blood hits from a lower height, the liquid has less force and remains on the surface, forming a larger drop.From a greater height, the impact force causes the blood to be absorbed more quickly into the rough surface, reducing the visible diameter.

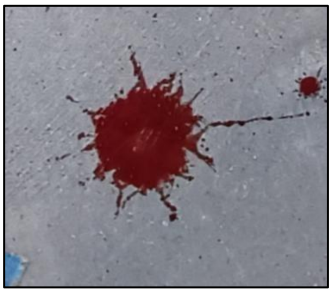


FIG 2A (100 cm)

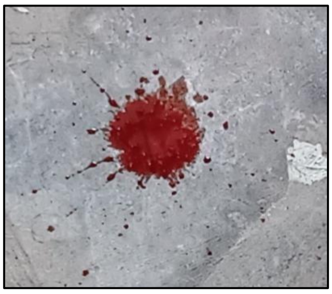


FIG 2B (150 cm)

FIG 2C (200 cm)

Figure 2: Blood spatter on concrete

Glass: When a blood is dropped from 100 cm of height, the diameter of the blood spatter is 2cm. When a blood is dropped from 150 cm of height, the diameter of the blood spatter is 1.5 cm and from 200 cm of height, the diameter of the blood spatter is 1 cm. Glass is smooth and nonporous, but it also has low surface friction. At lower heights, the blood spreads more, creating a larger drop. At higher heights, the impact is stronger, causing the blood to bounce or scatter more, leading to a smaller measured diameter. Some of the blood may break into smaller droplets, affecting the diameter of the main drop.

FIG 3A (100cm)

FIG 3B (150 cm)

FIG 3C (200cm)

Figure 3: Blood spatter on glass

Wood: When a blood is dropped from 100 cm of height, the diameter of the blood spatter is 2 cm. When a blood is dropped from 150 cm of height, the diameter of the blood spatter is 1.7 cm and from 200 cm of height, the diameter of the blood spatter is 2.1cm.

Wood has some porosity but also a relatively smooth surface. At lower heights, blood stays more concentrated. As height increases, the kinetic energy increases, and since wood does not absorb blood as quickly as concrete, the drop spreads outward, increasing the diameter.

FIG 4A (100 cm)

FIG 4B (150cm)

FIG 4C (200 cm)

Figure 8: Blood spatter on wood

The variations in blood spatter diameters across different surfaces and heights occur due to differences in surface texture, absorbency, and impact force. On smooth, non-porous surfaces like tiles and glass, blood spreads more as the height increases due to higher kinetic energy, resulting in larger drops. Concrete, being rough and porous, absorbs some blood, reducing the spread, especially at higher heights, where the blood is absorbed more quickly. Wood, with a combination of smoothness and slight porosity, shows a mix of smaller and larger drops depending on the height, as it absorbs blood more slowly than concrete. These surface characteristics and the kinetic energy from varying heights explain the observed differences in blood spatter size.

DISCUSSION

The study of variations in the diameter of blood splatter from various heights and different surfaces is essential in forensic science for understanding the dynamics of bloodshed at crime scenes. Bloodstains can provide crucial insights into the circumstances surrounding an event, such as the height from which blood was dropped, the type of surface it landed on, and the force of impact. By analyzing how blood splatter patterns change with height, researchers can estimate the position and movement of individuals involved in the incident. Additionally, surface texture influences the shape, size, and spread of blood drops, which can help determine whether the splatter resulted from a blunt force impact, a stabbing, or another mechanism. This study is significant for creating more accurate reconstructions of crime scenes, ultimately aiding in criminal investigations and legal proceedings.

Various surfaces like concrete, tiles, glass and wood are used for analysis of variations in diameter of blood from various heights from various surfaces. On tiles, the spatter diameter increases from 2.5 cm at 100 cm to 3.5 cm at 200 cm, due to its smooth, non-porous surface, which allows greater spread as the height increases. Concrete, being rough and porous, shows a decrease in spatter size from 3 cm at 100 cm to 2 cm at 200 cm, as it absorbs more blood at higher heights. Glass, similarly smooth, also results in smaller diameters from 2 cm to 1 cm due to increased scattering. Wood shows varied results, with diameters decreasing to 1.7 cm at 150 cm, but increasing again to 2.1 cm at 200 cm, as it absorbs blood less than concrete but still has some porosity.

The limitations of this study Include the lack of control over external environmental factors such as temperature, humidity, or airflow, which could influence the behavior of blood splatter. The surfaces tested may not fully represent all possible surface types found in real-world crime scenes. Additionally, the study does not account for the varying viscosity or composition of blood, which can differ in actual situations. The impact angle and shape of the blood drops were not controlled, which could affect the accuracy of diameter measurements. Only a limited range of heights was used, and other factors like force or blood volume were not considered. Furthermore, the study assumes that the blood splatter behaves consistently across each surface without accounting for potential irregularities in texture or surface wear. Finally, the study did not explore the effect of different blood drop sizes or multiple impacts on surface areas.

CONCLUSION

The study demonstrated that the diameter of blood splatter varies significantly depending on both the height from which the blood is dropped and the type of surface it impacts. On smooth, nonporous surfaces like tiles and glass, the spatter diameter increased as the height grew, as the higher kinetic energy caused the blood to spread outward. Glass showed a decrease in spatter diameter at higher heights due to the blood scattering and breaking into smaller droplets, while tiles maintained a steady increase in spread.

On rougher, porous surfaces like concrete and wood, the results were more variable. Concrete absorbed some of the blood, leading to a smaller spread as the height increased, while wood, with moderate porosity, showed an increase in spatter diameter at the highest drop. These findings underline the importance of surface properties and impact height in blood spatter analysis, which can be critical in forensic investigations and crime scene reconstruction.

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Future studies should explore a wider range of surfaces, include variations in blood composition, and consider additional factors such as temperature, humidity, and the angle of impact. This would offer a more comprehensive understanding of how different conditions affect blood spatter patterns in real-world scenarios.

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