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Research Article

Investigation of Stain Patterns from Diverse Blood Samples on Various Surfaces

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Abstract

Bloodstain Pattern Analysis (BPA) is a crucial forensic technique in crime scene investigation, employing the interpretation of blood spatter patterns to reconstruct event sequences and determine spatial relationships between victims and surfaces. This study explores BPA's application in forensic science, emphasizing its role in establishing links between crimes and culprits, as posited by Edmond Locard's exchange principle. The research examines how bloodstain shape, size, and distribution reveal critical information about impact angles, areas of convergence, and points of origin, while also providing insights into blood flow direction, force applied, suspect positioning, and weapons used. The investigation delves into various bloodstain types, including void patterns, spikes, and satellite stains, and their formation on different surfaces. To enhance understanding of blood behaviour from various sources, the study compares blood samples from three species: human (Homo sapiens), obtained from a professional doctor from discarded piles with precaution from a government hospital in Laxmangarh, Rajasthan and goat (Capra aegagrus hircus), and chicken (Gallus gallus domesticus), obtained from butcher shops in Laxmangarh, Rajasthan. The experimental setup involves dropping blood from a height of 50 centimetre's and measuring the resulting stain dimensions. This comprehensive approach to BPA research aims to refine crime scene analysis techniques, ultimately contributing to more accurate event reconstructions and enhanced forensic investigations. The study underscores the importance of BPA in modern forensic science while acknowledging the need for its integration with other investigative methods to ensure robust and reliable crime scene interpretations.

Introduction

Blood is the most typically found physically at a crime scene, providing greater proof of the physical encounter at the crime scene. Blood is a liquid that does not have its own shape; it can flow everywhere and is found in various shapes depending on the condition. The capacity of blood flow is feasible due to molecules that can move freely since the shape between the molecules remains constant unless the temperature changes. Examination of Bloodstain Patterns the shape's location and pattern distribution, which explain the physical and genesis. Dr. Paul Jeserich worked on the research of bloodstain patterns at the crime scene. In 1895, Dr. Edward Piotrowski announced a study in bloodstain interpretation that was documented and presented in the Book Concerning Origin Shape Directions and Distribution of the Bloodstain. BPA is unique in that it analyses the shape, size, and distribution of bloodshed events. It also gives the way and the reason for the injured, as well as death-like suicide, homicide, and hit-and-run. BPA is unique in that it focuses on the examination of the size, shape, and distribution of bloodshed events as a way of determining the actions and mechanisms of the course. It also gives the manner and the source of injuries, as well as fatalities that resemble suicide, homicide, and hit-and-run accidents.

A bloodstain pattern is a physical, geometric image created by blood-undertake a surface, or by a surface contacting blood, the geometric images of attentiveness are essentially those created once blood leaves the body. Surface texture and the stain shape, size, and location must be contemplated when determining the direction, dropping distance, and angle of impact of the bloodstain surface texture is of paramount importance, the harder and less porous the surface, the less spatter results the direction of travel of blood striking an object may be discerned because the pointed end of the bloodstain always faces its direction of travel

Physical characteristics of blood

Thicker than water and flows slowly than water 4.5 - 5G/ML VS 1G/ML

TEMPERATURE OF 100.4% - °F (38 °C)

PH 7.35 - 7.45

8% of total body weight

0.85% - 0.9% saline

Blood volume 5 to 6 in average male and 4 - 5 Liters in average female.

The impact angle of blood on a flat surface can be determined by measuring the degree of circular distortion. At the right angle, the blood drop is circular, as the angle decreases, the stain becomes elongated. The origin of a blood spatter in two-dimensional configurations can be established by drawing straight lines through the long axis of several individual convergences of the origin point. In a position of gunshot splatter pattern may be characterized by both forward splatters from an exit wound and back spatter from an entrance wound the location of the injury the size of the wound created and the distance between the victim and the muzzle of the weapon all the amount of back spatter that occurs the cast-off pattern when the blood convert object flings to an arc onto a nearby surface.

A pattern made by the drops or large amounts of blood flowing by the pull of gravity is called flows. A Pool of blood occurs when the blood collects in a level and undisturbed place; a tail pattern is a series of drops that are separate from the other patterns formed by blood dripping off an object.

According to the meticulous bloodstain tests conducted in 1980 by Edward Piotrowski of the University of Krakow, care must be taken when handling human blood as animal blood may carry the risk of infection and sickness. In order to ascertain if different animal blood types specifically, swine, bovine, horse, and porcine should be considered human substitutes, Pitrowski E, et al. [1] investigated the effects and general look of these blood types. Pig blood equivalents can resemble the characteristics of human blood since haemoglobin volume and structure tend to stay constant. As demonstrated by the work of Hulde-Smit, et al. [1,2], several of these factors, such as velocity, surface tension, droplet diameter, and density, may be determined using Reynolds and Weber numbers [3].

Blood usually has a density of 1.06 to 1.07 grams per cubic centimetre. Blood flow velocity is dependent on where the circulatory system is located. In arteries, it can range from 20 to 30 cm/s at rest, while in veins, it is typically slower at 10 to 20 cm/s. However, in certain vessels or during physical activity, these speeds can increase significantly. Based on their severity and outside influences, blood stains are divided into three groups. Low-velocity impact: Only gravity can produce blood droplets. It includes blood flowing into blood, drops of blood falling freely, and other things. Impact with a medium velocity: Forces greater than gravity are responsible for the stains. The applied external force differs from High-velocity impact: More than 100 feet per second of external forces are present. This covers explosives and gunshot wounds, among other things 1998, James [4].

Geometric patterns of attention are mainly established when blood leaves the body; a bloodstain pattern is a tangible geometric image created as blood enters a face or comes into contact with blood. When determining the bloodstain's direction, dropping distance, and angle of impact, it is important to take into account the texture of the face as well as the stain's development in terms of size and position. Face texture is important; the firmer and less porous the face, the less likely it is to spatter. Since the bloodstain's anterior end is always facing the direction, it is traveling, it is possible to determine which way the blood is traveling when it impacts a face. Peschel, et al.; James, et al. [4,5]. The impact angle of blood on a flat face can be computed by measuring the degree of indirect deformation. The impact angle of blood on a flat face can be computed by measuring the degree of indirect deformation. The blood drop is indirect at the proper angle because the strain lengthens as the angle decreases. By drawing straight lines through the long axis of many individualities' conjunctions of the originating point, the origin of blood splatter in two spatial configurations can be determined. The pattern of a projectile splatter can be identified by the amount of back splatter that happens, the distance between the victim and the nib weapon, the position of the injury, the size of the crack created, and the combination of these factors. The cast-off pattern is created when blood transforms objects into a bow and splatters onto a nearby face. Gravity pulls cause dribbles or large volumes of blood to move, creating patterns known as flows. When blood collects in one spot and remains undisturbed, a pool of blood forms; an altitudinous pattern is a race of driblets that differs from the other patterns created by blood dripping from an object [6].

Passive behaviour patterns

This type of bloodstain pattern is observed, encompassing patterns such as blood pools, drop stains, flow stains, and serum stains. A drip stain is a drop that falls smoothly and can condense into a sphere without fragmenting into smaller drops. Depending on the angle, bloodstains can give the blood drop a circular or somewhat elongated shape; knowing this helps determine the angle of impact [7]. Sometimes, blunt or trauma injuries, as well as blood flowing from a weapon, result in a substantial volume of blood being discovered at the crime scene [4,5]. Passive behaviour patterns this type of bloodstain pattern is observed, encompassing patterns such as blood pools, drop stains, flow stains, and serum stains. A drip stain is a drop that falls smoothly and can condense into a sphere without fragmenting into smaller drops. Depending on the angle, bloodstains can give the blood drop a circular or somewhat elongated shape; knowing this helps determine the angle of impact [7]. Sometimes, blunt or trauma injuries, as well as blood flowing from a weapon, result in a substantial volume of blood being discovered at the crime scene [4,5].

Altered patterns Bloodstain patterns that demonstrate evidence of a physical revision are known as altered patterns. The investigators mistakenly assumed that the shifts were drip patterns, even though they may also be the result of insects, dilution, prolixity, or physical exertion. But it would leave a peripheral if blood that had previously been present was pulled over the body. The route [4]. Singh, et al. Runner 2 of 7 in the Egyptian Journal of Forensic Lores (2021) 119. Furthermore, at murder scenes, contact prints resembling bloody shoe prints, fingerprints, or the entire win may be set up on clean shells. These prints could help detectives determine what might have happened there. This can assist detectives in connecting any implicit details that could have existed at the scene of the crime. On the other hand, void patterns arise when anything is positioned in between the projection region and the blood source. This suggests that although certain stains might be transferred to the object, they won't be visible in an otherwise continuous bloodstain pattern. This could suggest that an object or person that wasn't on the wall was part of the pattern and, if it was discovered, could have assisted in its completion [4,5].

Additionally, moving across blood can form a unique pattern, the identity of which often stumps investigators. When blood comes into touch with fabric or clothing, it diffuses and spreads, often leaving behind an unpredictable and difficult-to-decipher pattern. The surface might occasionally be gathered and submitted to forensic laboratories for examination [4,5].

During blood pattern analysis, fluid dynamics was also taken into account in order to understand how blood behaves as a liquid in air and the factors influencing the blood's behaviour. The formation of the blood drop. Studies based on velocity in satellites and spiders have also demonstrated the presence of bloodstains [8,9].

Methodology

Burette stain and burette are taken; the places are selected according to the appropriate locations since the angle of the drop is measured with permanent perimeters, ranging from 0/90 degrees to 80 degrees, and the surface is changing. A projector positioned perpendicularly to the top helped set up a clipboard or burette satin when the 50 cm clamp and stain were fastened to the burette. By mentioning the drop of blood, maintaining a constant pressure of 0.05, or three drops every 1 mm, and letting it fall on the desired surfaces such as nonporous ceramic tiles, paper, porous cardboard, wood, wash, and un wash clothes, and angles the clipboard was aligned with the canter of the projector and the edge of the clipboard. To avoid blood clumping and mixing, the clamp was cleaned at each base of fresh blood. Capturing a picture of the blood drop next to its scale, measuring the width and length of each droplet, and writing down the data on a notepad. False blood samples were used as controls. Next, the blood was rinsed and angled, being sure to clean the clamp at every fresh blood base to avoid any clumping or mixing of the blood. Taking a picture of the blood drop next to its scale, measuring the width and length of each droplet, and writing down the data on a notepad. False blood samples were used as controls documentations through photographs an oppo mobile phone model (CPH1938) in pro mode was also used to take a picture of the bloodstain pattern. The ISO and shutter speed were adjusted based on the weather.

The samples were specifically taken with proper permission from the university and the hospital and other vendors. To proceed with the experiments, human blood (Homo sapiens) specimens were given by the professional doctor from the disregarded piles for this examination and were taken from the government hospital in Laxmangarh, Rajasthan. The samples were given in an EDTA tube, some were collected in a beaker with EDTA and a pinch of NaCl. This solution was added to the blood and forcefully stirred to stop the coagulation. 7.5 ml of the solution was added to 5 ml of blood. Other animals' blood samples were acquired at a butcher shop in Laxmangarh, 150 ml each for goat (Capra ibex) and chicken (Gallus Gallus), and the chemical solution was applied immediately after collection. For the control sample, the fake blood Brand Black Blood was purchased from Amazon for compression. To ensure safety when collecting these samples, gloves, masks, and face shields were employed, and each practical was performed after immediately collating the samples.

Result and discussion

Blood's flight is governed by viscosity, surface tension, and a variety of physical elements like as air resistance and gravity. The shape and size of a drop change depending on the distance travelled; this study focuses on drops with a height of 60 cm. The test is performed to observe passive influence using various animals, humans, and control aka fake blood on a variety of surfaces such as porous and non-porous textures. The physical properties of fake blood and human blood differ significantly from those of animal blood in terms of RBC morphometry, diameters, conditions, erythrocyte surfaces, and viscosity. Fluid dynamics, or mechanisms involved in tracking the behaviour of blood motion and phase charges due to liquid contained in the air forces, also cause the charge in the motion of the blood as a fluid, similar to generations of a drop, to travel in the air, impact on solid or liquid surfaces, and cause stains. Physical forces also change as a result of the blood moving as a fluid, including the creation of a drop travel that impacts solid or liquid surfaces and produces stains. Fluid dynamics, or the mechanisms involved in tracking the performance of blood motion and aspect, changes due to the liquid accommodation in the air. When the lines in a group of bloodstains intersect, the convergence point is determined. This common point, on a 2D surface, is over which the directional characteristics of several bloodstains can be related by drowning the lines through the long axis of the group of bloodstains. By charting the distance between the point of origin and the point of convergence as well as the angle at which the blood strikes the target surface, one may produce a picture of the point of origin. As an alternative, the tangent method (TANGENT OF ANGLE = OPPOSITE/ADJACENT OR Z/Y) can be used to determine the point of origin. The place where the blood that forms the bloodstain is organized is known as the site of origin. Another factor to helps determine the area of convergence is directionality. If the stain and impact angle in Tables 1 and 2 are circular, it indicates that the stain impacted at a 90-degree angle. The bloodstain that results will appear extended if the angle of impact is less than 90^0. Furthermore, the droplet's tail will show which direction the stain was affected—that is, the direction opposite to the droplet's original origin. The texture of a surface plays a crucial role in interpreting bloodstain patterns that result from blood seeping off an object. Bloodstains can occur on a variety of surfaces, including tiles, wood, ceramic tiles, and paper. Comparisons between the standard and unknown own are only permitted to measure when the surfaces are of the same type as hard, nonporous surfaces, such as smooth ties in less splatter from rough surfaces, such as wood. These stains are typically irregular in shape and have spiny edges (Tables 3-6).

Fake blood (control sample)

Figure 1 The graphic illustrates fake blood stain patterns on several surfaces, including cardboard, fabric, paper, wood, white tiles, and ceramic tiles. Construct circular stain patterns with spines on cardboard, paper, wood, tile, and ceramic tiles. Some surfaces exhibit the production of satellite droplets. Tiles with an 80-degree surface display a circular stain pattern without spines. Cotton stains irregularly, forming satellite drops, while cardboard has spines. The metal surface displays an incomplete circular stain pattern with uniformly distributed tiny spines.

Chicken blood

Figure 2 demonstrates the patterns of bloodstains left by chicken blood on a variety of porous and non-porous surfaces. Blood stains have circular stain patterns with long spines and tiny satellite droplets on thick, smooth paper and cardboard. Paper, tile, and wood all exhibit circular stain patterns, with the wood and paper displaying tiny, uniformly spaced spines. The cloth displays a small number of satellite droplets surrounding the core stain.

Human blood

Figure 3 exhibits the patterns of stains left by human blood on different surfaces. There are hardly any spines

Table 1: Shape of the blood stain on the surfaces.

Sl.no	Surfaces	Control	Human blood	Goat blood	Chicken blood
1	Tiles	Circular, wavy margins	Circular	Circular	Circular, wavy margins
2	Cloth	Irregular satellite droplets	Irregular satellite droplets	Irregular satellite droplets	Irregular satellite droplets
3	Cardboard	Circular spiny margins	Circular spiny margins	Circular spiny satellite droplets	Circular spiny margins
4	Ceramic tiles	Circular satellite droplets	Circular satellite droplets	Circular less satellite droplets	Circular satellite droplets
5	Paper	Circular spiny	Circular spiny	Circular spiny satellite droplets	Circular spiny edges
6	Wood	Circular wavy margins	Circular	Circular	Circular wavy margins

Table 2: Angle of impact effect on the surfaces.

Sl no.	Angle of impact	Plain of the target
1	90 degree drop	Spines satellites and scallops are very distributed
2	80 degree drop	Spines satellites and scallops are very distributed
3	70 degree drop	Spines satellites and scallops are very visible
4	60 degree drop	Spines satellites and scallops are more moderate around the stain
5	50 degree drop	Spines satellites and scallops are focused around one side
6	40 degree drop	Spines satellites and scallops are mainly on the side opposite the impact
7	30 degree drop	Spines satellites and scallops are located on the side opposite the impact
8	20 degree drop	Spines satellites and scallops are located on the side opposite the impact
10	10 degree drop	Spines satellites and scallops are located on the side opposite the impact and indicating directionality

Table 3: Control sample (Fake blood)

Surfaces	90 W/L	80 W/L	70 W/L	60 W/L	50 W/L	40 W/L	30 W/L	20 W/L	10 W/L
Paper	1.4mm 1.9mm	2.3mm 1.8mm	2.3mm 0.7mm	1.7mm 1.8mm	1.5mm 0.5mm	1.6mm 1.9mm	1.1mm 2.3mm	1.0mm 2.8mm	1.9mm 3.6mm
Cardboard	1.4mm 2.0mm	1.5mm 1.6mm	1.5mm 1.3mm	1.2mm 1.9mm	1.5mm 0.6mm	1.9mm 2.0mm	1.2mm 2.4mm	0.9mm 3.2mm	1.0mm 3.0mm
Tile	1.2mm 2.2mm	2.7mm 1.6mm	1.6mm 1.9mm	1.9mm 2.3mm	3.2mm 1.0mm	1.7mm 2.2mm	1.5mm 3.0mm	1.3mm 3.2mm	2.0mm 1.0mm
Ceramic tile	1.6mm 1.5mm	2.4mm 1.6mm	1.7mm 2.1mm	1.9mm 1.3mm	2.5mm 1.1mm	2.4mm 2.0mm	1.7mm 3.1mm	1.6mm 3.5mm	0.7mm 4.1mm
Cloth	1.3mm 1.6mm	1.5mm 1.2mm	1.5mm 1.9mm	1.3mm 1.5mm	1.6mm 1.9mm	1.7mm 0.9mm	0.9mm 2.2mm	0.7mm 4.3mm	0.9mm 1.2mm

Table 4: Chicken blood at 50cm.

Surfaces	90 W/L	80 W/L	70 W/L	60 W/L	50 W/L	40 W/L	30 W/L	20 W/L	10 W/L
Paper	1.9mm 2.2mm	1.9mm 1.9mm	1.8mm 1.9mm	1.9mm 2.2mm	1.7mm 1.9mm	1.7mm 2.4mm	1.4mm 2.8mm	1.2mm 3.3mm	1.1mm 3.1mm
Cardboard	1.9mm 1.6mm	1.8mm 1.7mm	1.5mm 2.0mm	1.9mm 2.0mm	1.8mm 2.5mm	1.7mm 2.3mm	1.6mm 3.2mm	1.7mm 4.2mm	0.9mm 4.2mm
Tile	2.2mm 2.2mm	2.1mm 2.6mm	2.1mm 1.7mm	2.0mm 2.6mm	1.8mm 2.5mm	1.9mm 3.0mm	5.6mm 3.8mm	1.9mm 4.0mm	1.1mm 4.3mm
Ceramic tile	1.9mm 2.1mm	2.2mm 2.6mm	2.0mm 2.1mm	2.0mm 2.4mm	1.9mm 2.9mm	1.9mm 3.1mm	1.6mm 3.8mm	14mm 3.9mm	1.1mm 4.2mm
Cloth	0.9mm 0.9mm	1.5mm 1.9mm	1.2mm 2.1mm	1.5mm 2.6mm	1.9mm 1.4mm	1.2mm 2.1mm	0.9mm 1.6mm	1.6mm 2.9mm	1.9mm 2.6mm
Wood	2.0mm 1.9mm	1.8mm 1.7mm	2.1mm 2.3mm	2.1mm 2.6mm	1.9mm 2.9mm	1.7mm 2.3mm	1.7mm 2.7mm	1.8mm 3.8mm	1.7mm 5.3mm

Table 5: Goat blood at 50cm.

Surfaces	90 W/L	80 W/L	70 W/L	60 W/L	50 W/L	40 W/L	30 W/L	20 W/L	10 W/L
Paper	1.9mm 2.1mm	2.0mm 1.8mm	1.9mm 1.3mm	2.0mm 2.1mm	1.8mm 2.4mm	1.7mm 2.6mm	1.3mm 3.3mm	1.7mm 3.6mm	1.0mm 4.6mm
Cardboard	1.8mm 2.1mm	1.8mm 2.1mm	1.9mm 2.2mm	1.9mm 2.3mm	2.7mm 2.3mm	1.8mm 3.3mm	1.5mm 2.8mm	1.8mm 4.0mm	1.1mm 4.1mm
Tile	2.1mm 2.3mm	2.1mm 2.3mm	3.4mm 2.8mm	2.0mm 2.4mm	2.0mm 2.3mm	2.0mm 3.2mm	1.7mm 3.4mm	1.4mm 3.1mm	1.2mm 4.5mm
Ceramic tile	2.1mm 2.3mm	2.1mm 2.3mm	2.2mm 2.4mm	2.1mm 3.6mm	2.1mm 2.9mm	1.9mm 3.1mm	1.5mm 3.6mm	1.2mm 3.4mm	0.9mm 4.5mm
Cloth	0.9mm 1.3mm	0.9mm 1.3mm	1.9mm 1.9mm	1.2mm 1.6mm	0.8mm 0.9mm	1.2mm 1.6mm	0.9mm 2.9mm	1.0mm 2.3mm	0.9mm 1.9mm
Wood	2.0mm 2.1mm	2.0mm 2.1mm	2.1mm 2.6mm	2.1mm 2.7mm	2.1mm 2.4mm	1.8mm 2.3mm	1.7mm 2.8mm	1.5mm 3.5mm	1.4mm 4.2mm

Table 6: Human blood at 50cm

Surfaces	90 W/L	80 W/L	70 W/L	60 W/L	50 W/L	40 W/L	30 W/L	20 W/L	10 W/L
Paper	1.6mm 1.6mm	1.5mm 1.5mm	1.4mm 1.8mm	1.8mm 1.7mm	1.5mm 2.0mm	1.8mm 1.7mm	1.1mm 2.3mm	1.0mm 2.8mm	0.9mm 3.6mm
Cardboard	1.7mm 1.6mm	1.5mm 1.7mm	1.8mm 1.9mm	1.6mm 1.9mm	1.8mm 1.5mm	1.8mm 2.1mm	1.2mm 2.4mm	0.9mm 3.2mm	1.0mm 3.0mm
Tile	1.9mm 1.8mm	1.8mm 1.9mm	1.9mm 2.2mm	1.8mm 2.4mm	1.7mm 2.6mm	1.6mm 3.1mm	1.5mm 3.0mm	1.3mm 3.2mm	4.0mm 1.0mm
Ceramic tile	1.8mm 1.9mm	1.7mm 1.9mm	1.4mm 1.2mm	1.8mm 2.3mm	1.6mm 2.3mm	1.5mm 3.1mm	1.7mm 3.1mm	1.6mm 3.5mm	0.7mm 4.1mm
Cloth	1.0mm 1.0mm	1.1mm 0.8mm	1.1mm 1.2mm	0.8mm 0.9mm	0.9mm 1.5mm	0.9mm 1.5mm	0.9mm 2.2mm	0.7mm 1.9mm	0.9mm 2.1mm
Wood	1.7mm 1.8mm	1.7mm 1.8mm	1.8mm 2.0mm	1.7mm 2.1mm	1.6mm 2.2mm	1.6mm 3.4mm	1.5mm 3.4mm	1.3mm 3.3mm	1.1mm 4.3mm

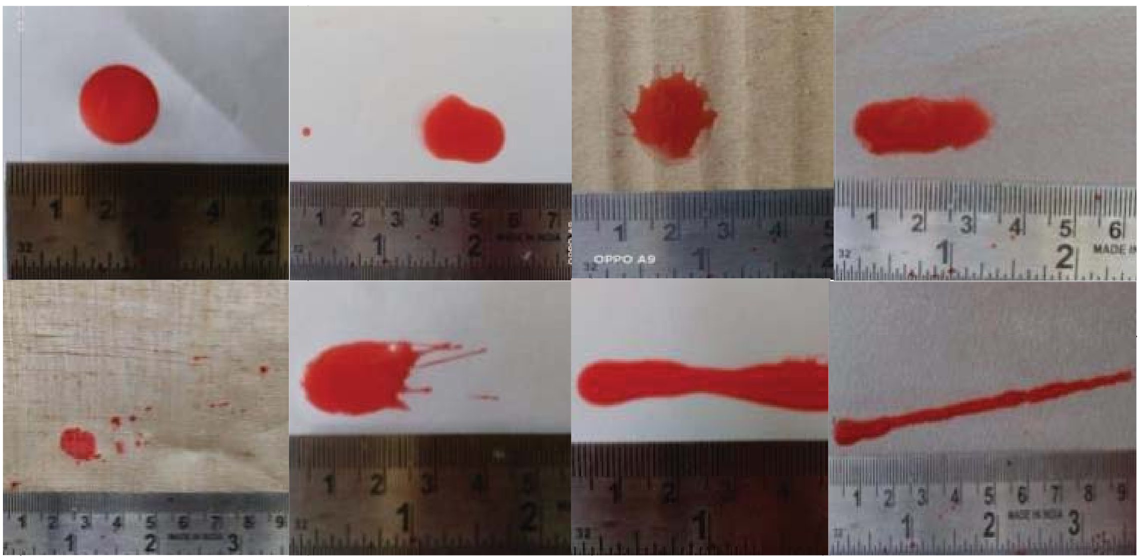

Figure 1: Blood splatter analysis by fake blood on different surfaces.

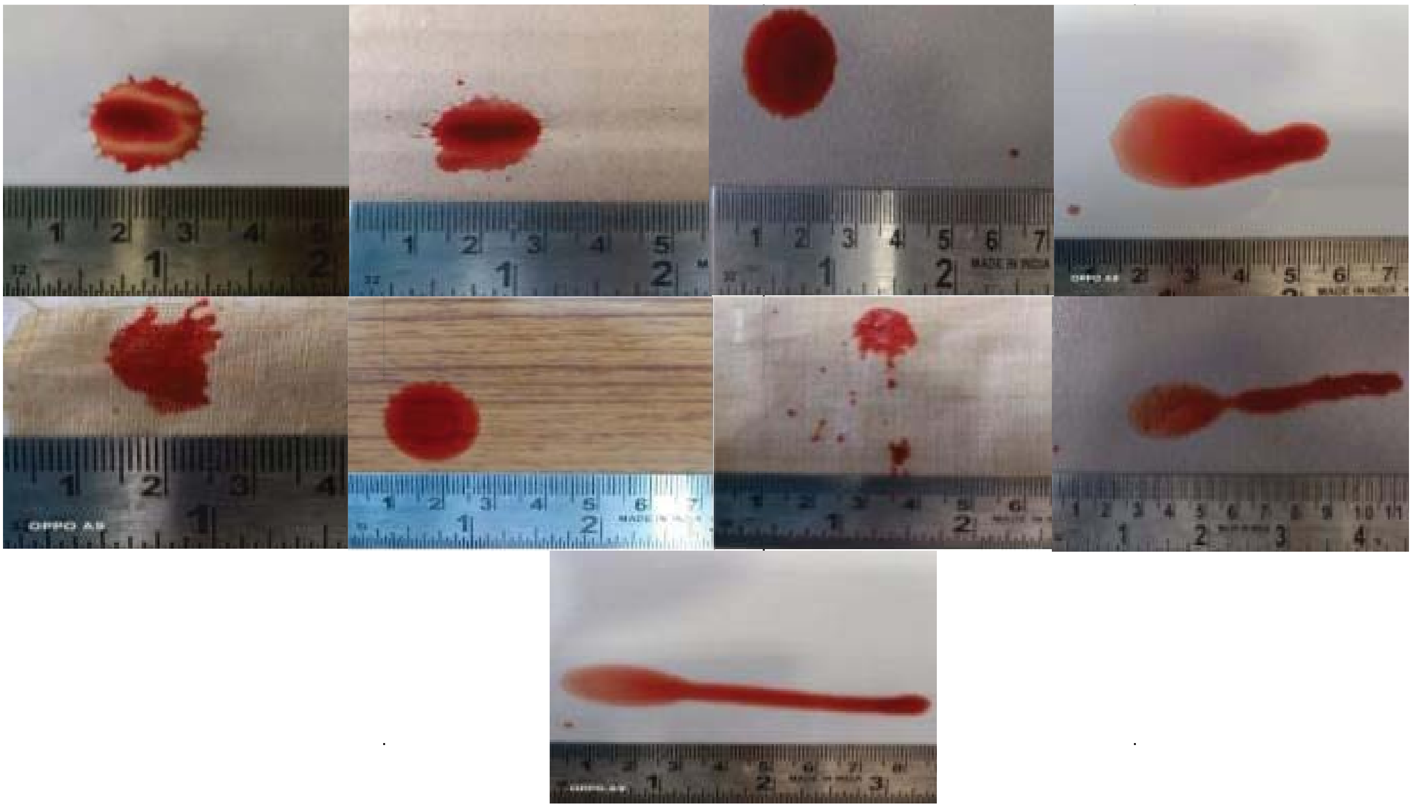

Figure 2: Blood splatter analysis by a chicken blood on different surfaces.

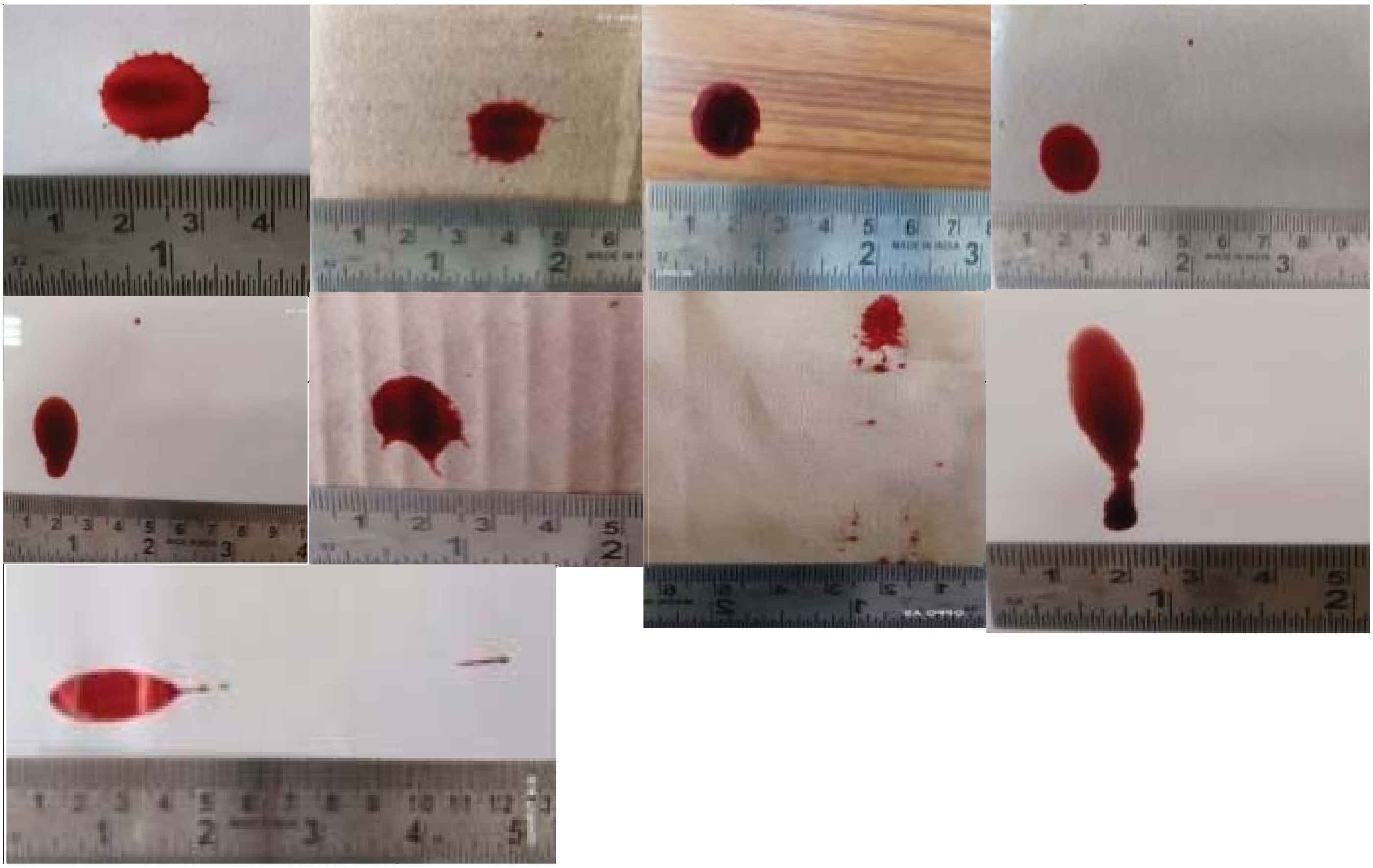

Figure 3: Blood splatter analysis by human blood on different surfaces.

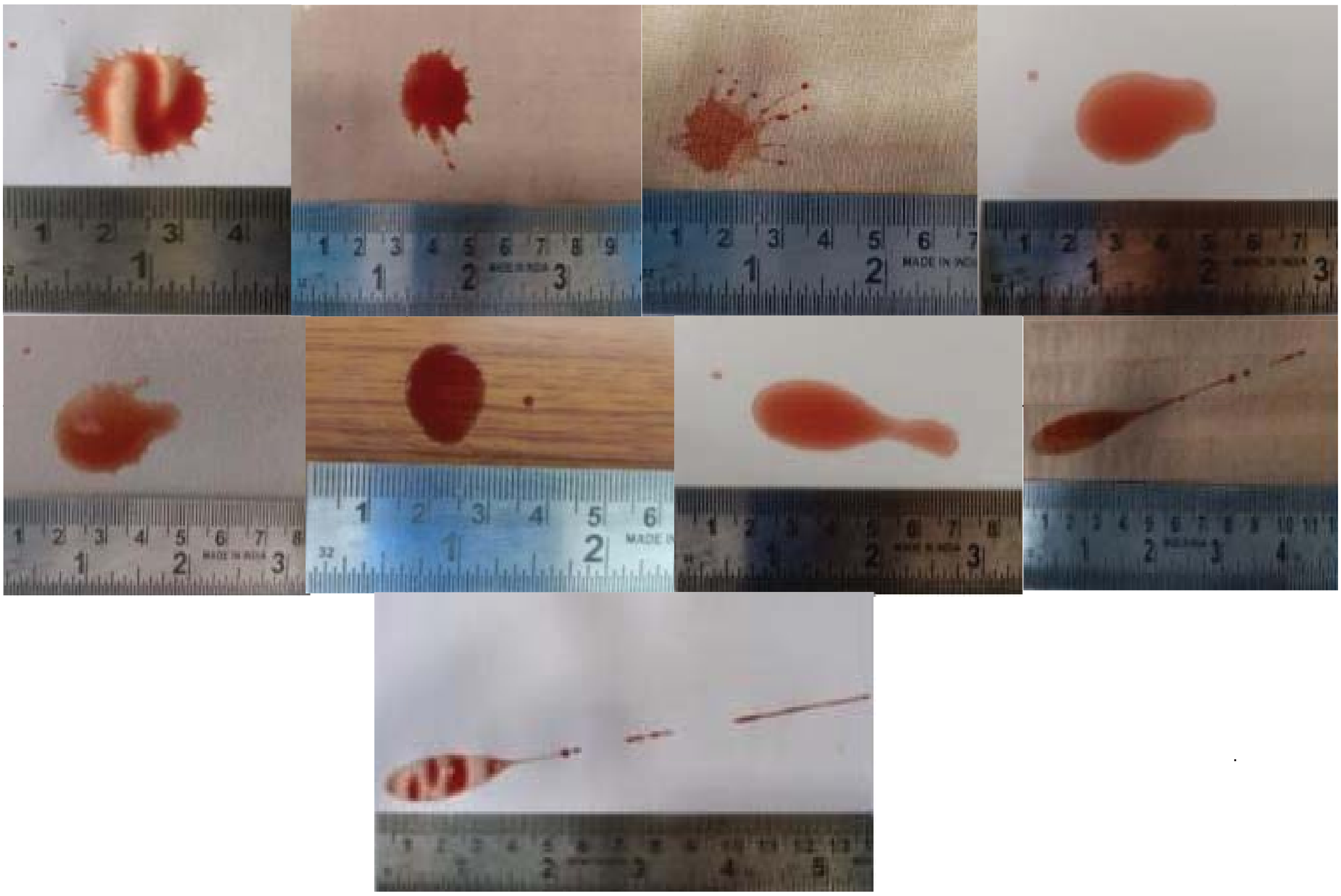

Figure 4: Blood splatter analysis by a goat blood on different surfaces.

surrounding the stain on CARDBOARD. Satellite patterns with distorted stain patterns are visible on the fabric. White tile leaves circular marks on the wood, with tiny spines forming around the stain's edge. Regularly spaced little spines can be observed on thin paper, and maximum satellite droplets with spines spaced regularly form on the floor.

Goat blood

Figure 4 demonstrates how various surfaces affect the patterns that goat blood leaves on the skin. A circular stain pattern forms on the wood. Paper and cardboard exhibit a circular stain pattern with tiny satellite droplets and maximal spines. Around them, cardboard and fabric create a more sporadic and discrete design. The stain split in 20 and 10 on cardboard and paper.

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