# "DNA Analysis of Blood Stains on Clothing Post-Crime: A Literature Review"

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**Abstract**

This literature review delves into crime theory, crime scene analysis, evidence, fabric materials, blood spots, and DNA in forensic investigations. Notable findings include a decrease in crime cases in Indonesia, although crime intensity remains high. The significance of physical evidence, especially fabric materials and blood, is emphasized. The review explores DNA's crucial role in personal identification through molecular forensics, including isolation methods and spectrophotometer. The findings contribute to a comprehensive understanding of forensic techniques and their applications in crime investigations.

Keywords: Blood Stains; DNA; Crime Incidents; Spectrophotometer

## 1. Introduction

In recent years, advancements in technology have elevated the significance of DNA profiles as crucial evidence in criminal investigations, offering individualization capabilities. Consequently, the analysis of biological materials derived from crime scenes has gained heightened importance, and efforts to enhance this analysis are ongoing (Ünsal Sapan, Erdoğan and Atasoy, 2021).

In cases involving murder or violence, the identification of bloodstains at crime scenes is pivotal for effective crime scene investigation. Given that violent crimes often dominate crime scene scenarios, blood, and consequently bloodstains, emerge as the most prevalent biological materials (Ünsal Sapan, Erdoğan and Atasoy, 2021).

Throughout the history of forensic science, bloodstains have consistently stood out as one of the most vital bodily fluids for crime research. A meticulous examination of the shape, size, and spatial relationship of bloodstains to surrounding objects can offer crucial insights into the dynamics of a case, facilitating a meticulous reconstruction of events. Morphological examination, particularly the analysis of bloodstain patterns, enables experts to physically reconstruct the incident. Simultaneously, biological examination of blood and stains enables the individualization of the crime to the perpetrator. The efficacy of DNA evidence in forensic

investigations relies heavily on precise sampling methods, encompassing the collection of samples from crime scenes, victims, and suspects. This meticulous approach ensures the reliability and precision of DNA data (Ünsal Sapan, Erdoğan and Atasoy, 2021).

Concurrently, the subsequent processes of DNA extraction, quantification, and amplification contribute to enhancing investigative procedures. These pivotal steps empower forensic scientists to scrutinize and compare DNA profiles, aiding in individual identification, linking suspects to criminal activities, and presenting compelling evidence in legal proceedings. Recent advancements in DNA profiling techniques have evolved into highly sensitive tools, allowing the generation of complete profiles from even minute DNA quantities found at crime scenes. Notably, a comprehensive DNA profile can be derived from just 100 pg of DNA, equivalent to a mere 15-20 human cells. Given the observed instances of not only direct (primary) DNA transfer but also indirect (secondary) transfer from unrelated individuals through potential vectors like objects or individuals, the assessment of DNA transfer activity holds paramount significance in criminal cases (Sessa et al., 2023).

## 2. Crime Incidents

The interpretation of crime theories varies among individuals. Nonetheless, crime theory, in its essence, can be classified into explanations concerning the evolution of criminal perpetrators and the unfolding of crime cases. Current research on crime and its prevention primarily investigates the motives behind individuals committing crimes and explores preventive measures (Eck & Weisburd, 2015).

Understanding crimes committed by perpetrators requires a rational perspective, delving into the motives driving their actions. Perpetrators strategically select victims with specific aims and objectives. Each crime case involves a perpetrator with a unique motive, and a desired target is essential for the occurrence of a criminal incident. Both the perpetrator and the target must be present in the same location simultaneously, without interference from others during the commission of the crime (Eck & Weisburd, 2015).

Recent data from the Central Statistics Agency (2021) signals a decrease in the number of crime cases and the associated risk level in Indonesia. From 2018 to 2020, the number of crime cases decreased from 294,281 to 247,218. The risk level of crime cases also declined from 113 cases per 100,000 population in 2018 to 94 cases. The time interval for crime occurrences increased from 1 minute 47 seconds in 2018 to 1 minute 57 seconds in 2019 and 2 minutes 7 seconds in 2020. This longer time interval indicates a reduction in the intensity of crime incidents. Nevertheless, the overall incidence of crime in Indonesia remains relatively high.

## 3. Crime Scene

A criminal occurrence entails a location, denoted as a crime scene, where the criminal act transpires. The classification of crime scenes is contingent upon the site of the criminal activity. This categorization designates the initial site of the criminal act as the primary crime scene and any subsequent location as the secondary crime scene. It is crucial to note that this classification system does not imply prioritization or significance to the scenes; Rather, it merely indicates their sequential order (Miller, 2002).

## 4. Physical Evidence

Physical evidence undergoes classification based on its physical characteristics, the specific type of crime, the nature of the evidence, its composition, or the specific questions it aims to address. These classifications serve as valuable tools, offering both conceptual insights and practical methodologies for crime scene investigation. Investigators must grasp the significance of physical evidence and its limitations, comprehend the interplay between different crime scene definitions, recognize evidence transfer theory, and understand the appropriate techniques for identifying microscopic crime scenes within more conspicuous macroscopic crime scenes. Crime scene analysis guides investigators in anticipating the types and locations of physical evidence at a specific crime scene. The ability to recognize, collect, preserve, process, and accurately reconstruct the

crime scene is crucial. While investigators commonly focus on forensic evidence such as weapons, bullets, or bloodstain patterns, certain objects in specific cases can emerge as pivotal pieces of physical evidence essential for resolving a crime. In essence, physical evidence encompasses any evidential material that offers valuable insights for investigative purposes (Lee and Pagliaro, 2013).

**5. Fabric Material**

Incidents of criminal activities are prevalent within the Indonesian populace. East Java, in particular, experiences a higher frequency of crime cases, including theft, violent theft, sexual violence, physical violence, and instances of abuse, as reported by the Central Statistics Agency in 2018.

Contemporary society commonly utilizes fabric as a primary material for clothing. In scenarios involving crimes like violent theft, sexual violence, and physical violence, there exists a likelihood of victims sustaining injuries. The contact between blood wounds on the victim and their clothing may result in the presence of bloodstains. Commonly employed fabric materials by individuals encompass cotton, linen, and denim, as noted by Buana.

**6. Blood Spots**

Blood is an intricate fluid, consisting of fluids, cells, and cell particles, circulating through arteries, capillaries, and veins. Constituting 90% water, human blood serves as a tissue fluid, primarily transporting vital oxygen for cellular function. Oxygen is used by cells to generate energy, while red blood cells, containing 90% hemoglobin, act as oxygen distributors, and platelets (thrombocytes), at 0.6-1.0%, facilitate blood clotting. Additionally, leukocytes (white blood cells), at 0.25%, contribute to the immune system by combatting bacteria or viruses (Bahrun, 2012).

The composition of blood is characterized by two main components: blood cells (erythrocytes, platelets, leukocytes), making up 45%, and blood plasma, constituting 55%. Blood, frequently encountered in criminal acts, is a substrate commonly found in crime scenes. Bloodstains, representing a common trace, play a crucial role in forensic investigations. Forensic investigators rely on assessing the age of bloodstains as a significant indicator, especially when bloodstains are the sole available evidence. Confirming the relevance of the bloodstain is possible by determining the time of commitment from other evidence (Bremmer et al., 2012).

**7. Deoxyribo Nucleic Acid (DNA)**

DNA, or Deoxyribo Nucleic Acid, constitutes the hereditary material within humans, found in nearly every cell of the body. While the majority of DNA resides in the cell nucleus, termed nuclear DNA, trace amounts also exist in the mitochondria, known as mitochondrial DNA or mtDNA. Mitochondria, cellular structures, transform food energy into a usable form for cells (Bethesda, 2021).

Every cell in an individual's body, excluding red blood cells and reproductive cells, contains the complete genetic program encoded in DNA. This program relies on four chemical compounds, or bases (Guanine, Cytosine, Adenine, and Thymine), arranged in a lengthy sequence. Groups of three bases, known as codons, encode 20 amino acids, ultimately forming proteins. Additionally, a stop codon signals the termination of an amino acid sequence (Panneerchelvam, 2003).

DNA possesses the critical ability to replicate, generating copies of itself. This property is crucial during cell division, ensuring that each new cell inherits an identical DNA copy from the old cell (Bethesda, 2021). Personal identification in criminal cases heavily relies on molecular forensics utilizing Deoxyribo nucleic acid. DNA specimens, widely obtained from any part of the human body due to the identical DNA sequence in all cells, are commonly extracted from blood or blood spots. It's noteworthy that the DNA in blood spots may undergo degradation (Sandwinata, 2018).

The degradation of DNA quality can result from two factors: endogenous factors, originating from the cells themselves, causing spontaneous damage, and exogenous factors, originating from the environment. Environmental factors such as humidity, temperature, UV rays, or chemicals can contribute to DNA degradation (Sandwinata, 2018).

λ 260 nm and 280 nm. The nucleic acid purity in DNA can be measured using the OD260/OD280 ratio (> 1.75), where OD denotes optical density, approximately equivalent to ±50 µg/ml ds-DNA (Hidayat, 2011).

7.1 DNA Isolation

Before delving into DNA analysis, the primary stage encompasses DNA isolation—a pivotal phase in the series of ensuing techniques such as DNA amplification, PCR, sequencing, and more. The DNA isolation process incorporates proteinase K along with additives like EDTA and detergents including SDS (Sodium Dodecyl Sulphate). Subsequently, DNA extraction is carried out using phenol. In this context, EDTA acts to eliminate divalent cations and hinder DNA-se, whereas SDS plays a role in dissolving cell membranes and denaturing proteins (Hidayat, 2011).

7.2 Spectrophotometer

A spectrophotometer contains two essential components, namely a spectrometer and a photometer. The spectrometer generates light within a specific spectrum and wavelength, while the photometer measures the intensity of transmitted or absorbed light. Consequently, a spectrophotometer integrates these tools to measure energy concerning whether it is transmitted, reflected, or emitted based on wavelength (Hasibuan, 2015).

The operational principle of a spectrophotometer involves illuminating a homogeneous medium with light. Subsequently, some of the incident light is reflected, some is absorbed within the medium, and the remainder passes through. The absorption value represents the retained light and is associated with the sample concentration (Hasibuan, 2015).

In forensic applications, a spectrophotometer finds utility in quantifying DNA. Measurements are conducted at wavelengths λ 260 nm and 280 nm. The nucleic acid purity in DNA can be measured using the OD260/OD280 ratio (> 1.75), where OD denotes optical density, approximately equivalent to ±50 µg/ml ds-DNA (Hidayat, 2011).

This literature review has provided valuable insights into forensic investigations, covering crime theories, crime scenes, evidence, fabric materials, blood spots, and DNA. The findings contribute to a nuanced understanding of forensic techniques and their applications. Noteworthy is the decrease in crime cases in Indonesia, highlighting the importance of physical evidence, particularly fabric materials and blood. The review underscores DNA's pivotal role in personal identification through molecular forensics. Overall, this work contributes to advancing forensic science by offering a holistic perspective on crime investigations.

## 8. Conclusion

This literature review has provided valuable insights into forensic investigations, covering crime theories, crime scenes, evidence, fabric materials, blood spots, and DNA. The findings contribute to a nuanced understanding of forensic techniques and their applications. Noteworthy is the decrease in crime cases in Indonesia, highlighting the importance of physical evidence, particularly fabric materials and blood. The review underscores DNA's pivotal role in personal identification through molecular forensics. Overall, this work contributes to advancing forensic science by offering a holistic perspective on crime investigations.

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**References**

Badan Pusat Statistik.(2018) “Banyaknya Desa/Kelurahan Menurut Tindak Kejahatan Selama Setahun Terakhir Menurut Jenis Tindak Kejahatan”. [online] bps.go.id. Available at: https://jatim.bps.go.id/statictable/2019/10/10/1787/banyaknya-desa-kelurahan-menurut-tindak-kejahatan-selama-setahun-terakhir-menurut-jenis-tindak-kejahatan-2018-.html

Badan Pusat Statistik. (2021) “Statistik Kriminal 2021”. [online] bps.go.id. Available at: https://www.bps.go.id/publication/2021/12/15/8d1bc84d2055e99feed39986/statistik-kriminal-2021.html.

Bahrun, dkk. (2012) “Rancangan Bangun Alat Ukur Kadar Hb dan Oksigen dalam Darah dengan Sensor Uximoter secara Non Invasive”. Jurusan Teknik Elektro-FT, UNSRAT-Manado.

Bethesda. (2021) “What is DNA?”. [online] medlineplus.gov. Available at: https://medlineplus.gov/genetics/understanding/basics/dna/.

Bremmer, R.H., De Bruin, K.G., Van Gemert, M.J., Van Leeuwen, T.G. and Aalders, M.C. (2012) “Forensic quest for age determination of bloodstains”. Forensic science international, 216(1-3), pp.1-11. [online] doi.org. Available at: https://doi.org/10.1016/j.forsciint.2011.07.027

Buana, Mira. Jenis Kain yang Sering Digunakan untuk Bahan Pakaian. [online] academia.edu. Available at: https://www.academia.edu/35983393/Jenis_Kain_yang_Sering_Digunakan_ untuk_Bahan_Pakaian.

Eck, J. and Weisburd, D.L. (2015) “Crime places in crime theory”. Crime and place: Crime prevention studies, 4. [online] citeseerx.ist.psu.edu. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.362.1293&rep=rep1&type=pdf.

Hasibuan, E. (2015). Pengenalan spektrofotometri pada mahasiswa yang melakukan penelitian di laboratorium terpadu fakultas kedokteran USU. [online] dupakdosen.usu.ac.id. Available at: https://dupakdosen.usu.ac.id/bitstream/handle/123456789/61183/Spektrofotometri.pdf?sequence=1

Hidayat. (2011) “Teknik Isolasi DNA dari Darah. Departemen Biokimia Fakultas Kedokteran Universitas Sumatera Utara”. [online] dupakdosen.usu.ac.id. Available at: https://dupakdosen.usu.ac.id/bitstream/handle/123456789/28634/Teknik%20Isolasi%20DNA%20dari%20Darah.pdf?sequence=1.

Lee, H.C. and Pagliaro, E.M. (2013) “Forensic evidence and crime scene investigation”. Journal of Forensic Investigation, 1(2), pp.1-5. [online] avys.omu.edu.tr. Available at: https://avys.omu.edu.tr/storage/app/public/kokdener/122127/1.pdf.

Miller, M.T. (2002) “Crime scene investigation. In Forensic science”. (pp. 143-164). CRC Press. [online] cbsd.org. Available at: https://www.cbsd.org/cms/lib07/PA01916442/Centricity/Domain/1908/CSI%20Text%20Marilyn%20Miller.pdf.

Panneerchelvam, S. and Norazmi, M.N. (2003) “Forensic DNA profiling and database”. The Malaysian journal of medical sciences: MJMS, 10(2), p.20. [online] ncbi.nlm.nih.gov. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3561883/.

Sandwinata, M.F. (2018) “Analisis DNA dalam Kasus Forensik”. Teknosains: Media Informasi Sains dan Teknologi,12(1). [online] journal3.uin- alauddin.ac.id. Available at: https://journal3.uin-alauddin.ac.id/index.php/teknosains/article/download/7863/6245.

Sessa, F., Pomara, C., Esposito, M., Grassi, P., Cocimano, G. and Salerno, M. (2023). Indirect DNA Transfer and Forensic Implications: A Literature Review. Genes, [online] 14(12), p.2153. doi:https://doi.org/10.3390/genes14122153.

Ünsal Sapan, T., Erdoğan, I.T. and Atasoy, S. (2021). Human identification from washed blood stains. Bulletin of the National Research Centre, 45(1). doi:https://doi.org/10.1186/s42269-021-00600-3.