

CRIME SCENE TO JUDGMENT: A REVIEW ON IDENTIFYING GAPS IN CRIME SCENE INVESTIGATION AND IMPLEMENTING SOLUTIONS

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ABSTRACT

Photography is very important in documenting crime scenes especially photographic evidence is crucial in homicide cases, as through images of blood spatter patterns and firearm features, events can be reconstructed. New technologies such as laser trajectory mapping assist in improving the accuracy of these reconstructions. If these measures are put in place, forensic methodologies would be further enhanced: raising training levels for detectives and crime scene technicians, acquiring high-quality cameras, 3D scanning equipment, and increasing the use of forensic photography to raise conviction rates. Recent studies have focused on potential biological markers related to suicidal behaviors. Particularly, one such research compared glucose metabolism parameters among suicide victims and non-suicide victims, demonstrating how a more substantive number of suicide victims bore witness to chronic hyperglycemia, associating regulation dysfunctions in glucose with suicidal behavior. Forensic science in the past decades has successfully moved toward empirical validation and standardized methods. The laneway of DNA evidence near the end of the century paved some crucial paths into forensic techniques, discussion, and finally the scrutiny of techniques that lacked scientific reliability. Still, challenges lie ahead in the form of complete testing, clarity in reporting error rates, and science-based decisions in the legal arena. In Pakistan, the field of forensic science encounters major obstacles, particularly a severe lack of forensic laboratories and professionals. As of July 2024, there were merely five forensic labs across the country, resulting in critical evidence frequently being compromised due to insufficient training and equipment among law enforcement agencies. Experts highlight the urgent need for specialized training, curriculum creation, and the development of extensive forensic facilities that include capabilities in audio-visual analysis, digital forensics, and forensic photography to improve the efficiency of criminal investigations. Ongoing initiatives to tackle these issues are vital to strengthen the integrity of forensic investigations and the overall criminal justice system.

Keywords: Crime scene, Photography, Digital forensic science, Evidence Collection, Documentation, Laser trajectory mapping.

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INTRODUCTION

Forensic science is a multidimensional field consisting of various subfields in it. Some of them are fingerprints, questioned documents, forensic toxicology, forensic biology, forensic ballistics, digital and cyber forensics, preventive forensics, etc. Crime scene investigation is an integral and fundamental part of forensic science [1]. A proper investigation of a crime scene to establish its association with the suspect/s subsequently assists in proving or disproving the crime. An undisturbed crime scene may act as the most vital source of potential information. It is imperative to understand that every crime scene is unique. An examination of

a crime scene usually consists of a series of stages that a forensic expert is required to carry out. After a number of various intervening actions, it culminates with the presentation of evidence in court after beginning with the security of the crime site and, if necessary, offering medical help to a victim. It also covers crime scene management, which is the administration of many instruments, methods, skills, and other elements necessary for a successful scene investigation. An outline of the various facets of crime scene investigation, including its stages, management, and reconstruction [2]. This study mainly focuses on the mini review of Mishandling

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or Gaps created from the stage of crime scene to judgment. High crime rates, corruption, and inefficiency are just a few of the issues facing Pakistan's criminal justice system. Since forensic evidence may be used to identify suspects, connect them to the murder site, and establish guilt or innocence, it has grown to be an important tool for Pakistan's judicial system. However, a number of legal, scientific, and ethical factors—the subject of this study—affect the admissibility of forensic evidence in Pakistan [3]. It is easy to conclude from the analysis of criminal cases in Pakistan that the majority of the cases rely on the initial examination of the crime site and the transfer of the evidence that was gathered there. In the majority of cases, police personnel have failed to maintain the chain of custody and have delayed the transmission of the evidence. Due to the prosecution's failure to cross-examine the police officer or moharrir, the accused has been acquitted by the courts. The laboratories should be set up at district levels so that the samples of evidence could reach for forensic analysis in time and safely. There is a time to check the police department as the police intentionally retains the evidence and fails to transmit the same within time therefore the evidence loses its value in the eyes of law and the report given by the forensic experts become mere nullity. The sending of irrelevant samples and with such delay wastes the time and expense of the forensic agency and incurs extra costs on the litigants [4].

CRIME SCENE INVESTIGATION

The effective use of crime scene examiners in investigating common property crimes is also influenced by informal aspects of their professional and organizational culture, particularly the roles they are expected to play [5]. Crime scene investigation is the first step in an inquiry, focusing on locating, identifying, and collecting evidence, as well as documenting the circumstances at the specific location where the crime occurred [6].

The crime scene investigation is done by the CSI in order to confirm or determine: 1. which type of crime is committed; 2. The identification of victim and suspect; 3. The modus operandi [MO] which is the Criminal's signature; 4. The link between victim, suspect and crime scene [7].

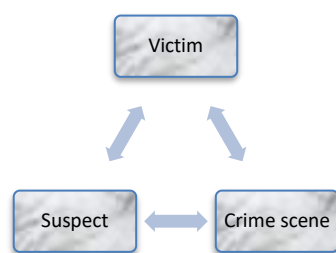


Figure 1: Linkage between victim, suspect and crime scene.

The investigator should have a systematic plan of action before they approach the crime scene. Whether taking pictures, gathering evidence, or exploring a scene, following a known pattern offers a systematic way to complete the work. Several media, including notes, photos, and videos, are used to document the situation. An investigator should do a preliminary walk-through to gain a sense of the site's surroundings, safety, and contents before recording the scene or carrying out additional duties. Taking notes, taking pictures, recording videos, and drawing a sketch or diagram are the fundamental techniques of documentation. Following that, the same sequence of close-up, mid-range, and overview shots should be used in both photography and video, making sure to include the evidence placards in the pictures [8]. In order to ensure competent, quick, and impartial execution of criminal processes tasks as well as application of specialized knowledge in other areas of law-enforcement activity, forensic science institutions are required to cooperate with law enforcement agencies [9]. When investigating a crime scene, handling and documenting evidence correctly is crucial to maintaining its integrity and ensuring justice. Every piece of evidence tells a part of the story, and how it is collected, stored, and recorded can make or break a case [10].

HANDLING AND PACKAGING EVIDENCE

Evidence falls into two main categories: portable and non-portable. Portable evidence includes small, transportable items like bullet casings, hair samples, or drugs. These are carefully collected and packaged in paper or plastic envelopes, depending on the material. Biological evidence, like blood or tissue, is stored in sterile containers to prevent contamination. Non-portable evidence, on the other hand, cannot be removed from the scene. Imagine a murder case where blood is splattered on a wall—investigators can't take the entire wall to the lab. Instead, they use swabs to collect samples. Scraping is generally avoided to prevent damaging or losing critical evidence [11]. Proper packaging and handling ensure that evidence remains untampered with, preserving its credibility in court.

Documenting the Crime Scene

Documenting a crime scene is just as important as collecting evidence. It provides a clear, step-by-step record of what happened, ensuring that nothing is overlooked. The goal isn't just to capture details but to understand their significance in the bigger picture of the investigation [12]. Three main types of samples require documentation:

1. Public health and safety samples – collected to assess any risks to the public;
2. Environmental samples – used for decontamination and restoration efforts;
3. Criminal samples – directly linked to solving the crime [13].

Photography and Sketching

A crime scene is documented in stages: Exterior shots capture the surroundings to establish the location. Mid-range photos show relationships between pieces of evidence. Close-ups [taken at a 90-degree angle] provide detailed views of specific evidence [14]. Investigators create two types of sketches: a rough draft at the scene and a final version later [15]. A bird's-eye view [looking from above] is often used, showing the layout without considering vertical elements like walls or shelves. If necessary, an elevation sketch may be included to display height-based evidence [16]. It has a major role in recreating crime scenes and its use is unprecedented in presenting clear visual evidence in courts. Good images would lessen the necessity for on-site inspection and endorse witness testimonies [17]. were using with material evidence establishes the connection originating from the field to the actual picture and tends to lead to with what happened [18]. By proper photographic documentation, the later analysis of detail remains preserved. Methodically, investigators must take photographs at crime scenes to capture the overall layout with object locations and the most important pieces of evidence. That visual record serves to reconstruct the event and analyze crime patterns [19].

GAPS IN CRIME SCENE INVESTIGATION

Procedural Gaps

There are various insufficiencies in securing crime scene such as the gloves need to be replaced right away if they are torn or punctured. To avoid any allergic reactions, appropriate eye and face precautions must be used during the collecting of dried blood stains. This can also be ensured by using goggles and protective eyewear. It is necessary to employ leak-proof, puncture-resistant packaging for the transportation of sharp-edged items to the labs, such as broken glass shards, used syringes, and acupuncture needles. The vessels need to include a label that gives the person using them important cautions. The shipment should clearly indicate warnings like "biohazardous material" and directions that the container should not be bent, recapped, or opened. It should also notify the recipient of the existence of sharp objects and other resources. Food, drink, and tobacco use should be forbidden at crime scenes to avoid coming into contact with infectious elements, especially while there is still human waste present. Gloves and any other protective equipment should be thrown away to avoid contaminating other clothing, and hands must be cleaned after disposing of covers. After usage, equipment must be cleaned using the appropriate, medically advised disinfectants. Regardless matter whether it contains a corpse, bodily fluids, or other materials, documents must be

wrapped appropriately to reduce the risk of contamination throughout the transfer process [20].

Technological Gaps

One major issue was that forensic specialists might not be able to efficiently gather and examine evidence if they are not taught how to use modern technologies. Other items, meanwhile, were deemed inconsequential. If there is a lack of forensic specialists who are skilled in using new technology, it may be challenging to evaluate evidence and solve crimes. Additionally, new technologies are prejudiced and may produce false results, which could negatively affect the investigation. Forensic specialists may find it challenging to gather and examine evidence from crime scenes incorporating modern technology if those technologies are costly and sophisticated, making them hard to comprehend.

ISSUES OF PREVENTING TRACE FORM DNA EVIDENCE CONTAMINATION

Contamination of trace DNA can occur anytime during the collection, handling or analysis processes, all of which require utmost attention. If any problems occur, such contamination can greatly affect the forensic investigation, and judgment can be muddled. With the task at hand, understanding the various elements responsible for contamination to aid trace DNA evidence, It is also important to comprehend the need of maintaining strict protocols that need to be followed to prevent contamination from occurring. The most basic form of contamination comes from human sources for instance, skin, hair, saliva or sweat. Any one of these elements can easily be left behind on evidence and contaminate the process. One solution to prevent this is for forensic professionals who work in the field are advised to always wear masks, gloves, or any other protective clothing to seal their body. In addition to that, there are proper methods of storing and transporting materials to reduce the exposure to external DNA. Some of the other ways trace contamination can occur is through nonliving components, like dust, dirt, and skin left behind by various organisms. During the very act of collecting samples or transporting and storing, nonliving components can be staining these samples that can then result in inaccurate findings. In order to alleviate the chances of contamination, forensic professionals need to utilize sterile instruments, take samples from well controlled environments, and store them in non- permeable containers that do not allow contamination. Another form that is between the two is Cross-contamination. This one contamination form occurs when DNA, either from one sample or more than one, touches the other sample without any control. Such acts can occur due to incorrect Clarke construction, cognate processing or even through improper evolution, manipulation, and analysis.

Table 1: Problems with the Technological Aspect of Crime Scene Investigation.

Indicators	Verbal Interpretation	Rank
If new innovations are intricate and challenging to comprehend, it might be Forensic experts find it challenging to gather and examine evidence from crime scenes integrating the latest technology.	Minor challenge	4.5
If there are no any broadly recognized criteria for using new technology in crime scene investigations, information sharing might be challenging.	Minor challenge	6
If new technologies are biased, it may lead to inaccurate results, which can have a negative impact on	Minor challenge	2
If forensic experts are not trained on how to use new technologies, they may not be able to collect and analyze evidence effectively.	Serious challenge	1

Legend: 4.50 – 5.00 = Serious Challenge; 3.50 – 4.49 = Minor Challenge; 2.50 – 3.49 = Undecided; 1.50 – 2.49 = Moderate Challenge; 1.00 - 1.49 = Not a Challenge.

PROPOSED METHODOLOGY FOR AI-AUGMENTED DIGITAL FORENSICS

Data Gathering and Preparation

The basis of digital forensics is collecting electronic data from various sources such as computers, smartphones, cloud storage, and social media. With its extensive and frequently unstructured nature, this data must be carefully preprocessed to ensure accuracy. Important steps in this process are: Data Cleaning, Standardization,, Duplicate Removal, Noise Reduction

Pulling Out and Refining Key Features

To render digital evidence viable for AI-driven investigations, key information needs to be pulled out, such as:

Timestamps, IP Addresses, User Behavior Data, Metadata. This simplifies AI models, enhances processing efficiency, and refines the precision of forensic analysis.

AI-Powered Automation in Digital Investigations

AI powers digital forensics by automating lengthy tasks such as Keyword Detection, Metadata Analysis, Automated Report Generation. Through performing mundane tasks, AI allows forensic professionals to concentrate on intricate analysis and decision-making, enhancing both speed and accuracy. AI is able to detect trends and make predictions about criminal activity based on sophisticated data modeling. Some uses are: Cybercrime Prevention, Suspect Profiling, Intelligence-Led Policing. AI is capable of decrypting hidden or encoded messages and thus becomes an essential instrument in cybercrime investigations.

While AI transforms forensic investigations, it has to be used responsibly. Some of the most important considerations are Privacy Protection, Bias Mitigation, Transparency & Accountability. To make AI-based evidence robust in court, forensic experts, lawyers, and policymakers need to come together in developing clear guidelines for ethics and law.

Ongoing Education and Integrating AI with Forensics

As the technology is constantly evolving, the forensic experts will need to take regular education

and training. The frequent workshops, industry partnerships, and knowledge sharing about AI innovations are necessary in order to keep up with the digital forensics. To successfully integrate AI into forensic investigations, the following measures must be followed: Diverse Data Sourcing – Gathering data from various digital sources (computers, phones, cloud storage, social media).

MODERN TECHNIQUES OF CRIME SCENE DOCUMENTATION

3D Laser Scanning: Increasingly, law enforcement agencies adopt 3D scanners to provide detailed precision of crime scenes. This technology builds up a thoroughly detailed reconstruction that can be assessed later on as well as in courts. 3D scanning has been undertaken so that the most exhaustive evidence is gained without contaminating the site [22]. Photogrammetry allows investigators to measure and analyze specific crime evidence in the scene. It is useful for reconstructing events based on the state and location of physical evidence [23]. This procedure ensures that crime scene documentation is in line with the scientific investigation requirements. Detailed photos of blood patterns may help forensic experts determine the scenario leading to the crime. Other bloodstains may be visible using special lighting or chemical treatments, and must be photographed for further analysis [24]. It is possible to picture ballistic evidence, including bullet trajectories, shell casing locations, and gunshot residue patterns. Much more particularly, newer techniques such as laser trajectory mapping can photo document firearm evidence [25].

FUTURE ADVANCEMENT IN FORENSIC SCIENCE

Research does indicate that disordered glucose metabolism might have a biological basis for suicidal behavior. The mechanism is not understood but could lead to the conclusion from this research that long-term hyperglycemia may play a role in the depression and in the idea of suicide itself and that it may be an identifiable risk marker for suicide. Enough with the training data up till October 2023. The last few years have seen forensic science in academic life change rapidly. Most of the 20th century bore witness to courts admitting forensic

evidence, as if it were settled without needing cross-examination: usually on expert testimony from law-enforcement-affiliated types who had the barest scientific training. These were unchallenged by his claims of accuracy; and forensic techniques were admitted into evidence based on tradition and trust rather than on rigorous scientific validation. Such claims were rarely disclaimed, and if they were, it usually was to no avail.

This began to change during the late '80s to early '90s with the onset of DNA evidence. Initially, the courts were quite eager to accept DNA analysis, but soon questions of how to infer and express these in legal lab settings emerged. Leading scientists, amongst them geneticists and statisticians, debated crucial issues such as error rates, population genetics, and accurate communication of forensic findings. As a result of this discussion, evidence started being regarded in a more scientifically rigorous manner, most notably endorsed by important Supreme Court rulings in the 1990s. These decisions stressed that judges must act "gatekeepers" to ensure that expert testimony is soundly based on science [26, 27]. Until 2000 when the first signs of divergence were thus indicated, the forensic science of the present is probably moving away from examiner expertise toward a method-driven approach. Instead of convincing everyone that forensic techniques could never err, the experts became advocates for standardized protocols and empirical testing with conclusions being measured. Some forensic disciplines, however, like bullet lead analysis, had to fall by the wayside after scientific scrutiny indicated that they had no reliability. Other techniques applied in forensics, like microscopic hair analysis, had to dilute less expansive claims. Examples include how some techniques like bit tooth analysis, significantly criticized by science, and remained [28].

Certain forensic broad domains like those dealing with single-source DNA analysis have proven not just to withstand the test of scrutiny. Fingerprint analysis is still very much accepted but has learned to concede some ground to human error and subjectivity. Firearm identification is now under scrutiny more than before with empirical bases, which show inadequacies in its methodology and reporting practices. Part of the development of forensic science has been to the push for empirical testing under real-world conditions. Historically, courts accepted forensic techniques without requiring proof of their accuracy. Many forensic experts testified with absolute certainty, claiming zero error rates despite a lack of supporting data. Judges rarely required proficiency testing or validation studies before any forensic evidence could be admitted to court. A change in this approach was instituted by DNA evidence. At the outset, DNA profiling received a parade of praises on its entry in courtrooms. Events like *People v.*

Castro brought to the fore the mounting issues surrounding interpretation of DNA findings peer courts. Studies commissioned by the National Academy of Sciences [NAS] highlighted the value of rigorous testing and error rate assessment in the studies towards their objectives. The first NAS report recommended regular blind proficiency testing for forensic laboratories, but these recommendations were ignored by the forensic community and courts.

Following on to those reports were others that recommended increased empirically based testing, particularly a 2009 NAS report indicating that almost all non-DNA forensic disciplines had insufficient scientific validation. This was followed by a 2016 report from the President's Council of Advisors on Science and Technology which laid emphasis on the very fact that forensic evidence without known error rates would be worthless in scientific terms. These reports did spur change, and in recent years, forensic domains such as fingerprint, firearms, and footwear act on their results in accuracy studies, attempting to better understand the reliability of their techniques.

One continuing issue in forensic science is the question of how "inconclusive" results are factored into calculations of error rates. Traditionally, forensic experts have been able to report findings beyond simple identification or exclusion-beyond "probably the same" or "probably different" using terms such as "high degree of association," "limited association of class characteristics," and so forth. Some researchers say that under certain circumstances, inconclusive results must be treated as errors, especially if other examiners could confidently reach the conclusion. Others take the view that inconclusive findings should not be counted as mistakes. Generally, however, such progress has been and continues to be made. Unfortunately, many courts still do not apply sharp-science scrutiny to forensic evidence. The legal system must experience the vigor of rigorous testing, clear error rate reporting, and science-based decision-making to place forensic evidence on as solid a ground in reality as possible.

CONCLUSION

Crime scene investigation is a vital component of the criminal justice system, as it allows for the collection, preservation, and analysis of forensic evidence critical to court cases. However, significant flaws in procedural efficiency, technological advancement, and forensic science still impede the efficiency of investigations, particularly in countries such as Pakistan, where forensic infrastructure is limited. This review highlights critical concerns such as evidence mishandling, forensic examination delays, non-standardized procedures, and technological deficits, all of which result in undermined prosecutions and wrongful acquittals. Addressing them requires substantial investment in

forensic training, state-of-the-art equipment, and the use of innovative technologies like AI-based digital forensics and 3D crime scene reconstructions.

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