

RECENT ADVANCES IN FORENSIC SCIENCE FOR EVIDENCE COLLECTION AND PRESERVATION: INNOVATIONS IN SAMPLE HANDLING TECHNIQUES TO ENHANCE ANALYTICAL ACCURACY AND CASE-SPECIFIC INVESTIGATIONS

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ABSTRACT

This summary gives a general overview of the gathering of evidence, which is crucial to expedite forensic investigations, law enforcement, and academic study. Evidence gathering entails the methodical gathering, preservation, and analysis of analog and digital evidence to establish facts and validate or disprove theories on a certain incident or crime. Key points covered in the abstract are; Importance of Evidence Gathering, Types of Evidence, Evidence gathering difficulties, Technological Developments, Ethics-Related Affairs, Forensic programs, Coordination and Training. In a nutshell, gathering evidence is an essential part of forensic science and law enforcement and affects how investigations and legal cases turn out. This abstract emphasizes the necessity of methodologically sound evidence gathering practices, the difficulties encountered, and the possibility for technological developments to further forensic science.

Keywords: Forensic investigation, Forensic programs, Legal considerations, Testimony, Law enforcement.

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INTRODUCTION

The gathering and preservation of evidence are essential phases in any inquiry that guarantee the accuracy and dependability of the data acquired. The right treatment of evidence is crucial to maintaining its validity and acceptability in a court of law or other decision-making processes, regardless of whether it is a criminal case, scientific study, or any other investigation. Physical items, written papers, digital data, and witness testimony are all examples of evidence. To avoid contamination, manipulation, or information loss, stringent rules must be followed during the gathering and preservation of evidence. Any information or material that can be used in an investigation to support or reject a claim or hypothesis is referred to be evidence. Direct evidence (eyewitness statements, films, etc.) and circumstantial evidence (inferences based on already known facts) are two different types of evidence that can be categorized. The significance of gathering and preserving evidence. For the

following reasons, proper evidence gathering, and preservation are crucial: Fairness stone of a just and fair legal system is accurate and trustworthy evidence. Establishing the truth: The aim of every investigation is to establish the truth, and reliable evidence helps to achieve this goal. Making a strong case: Solid evidence supports the arguments made by both the prosecution and the defense. Evidence Gathering Process: There are various crucial processes involved in gathering evidence, including: Identification: Locating potential evidence at the crime scene or other pertinent areas and identifying it. Completely describing the location, state, and any pertinent observations about the evidence. Utilizing the necessary methods and resources to gather and appropriately store the evidence. To avoid contamination, different sorts of evidence might need to be handled in a particular way. Establishing a clear and uninterrupted chain of custody for the evidence, which records its travel and management

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from the crime scene to the lab or court and all points in between. Evidence Preservation Techniques: Depending on the nature of evidence, there are different proper preservation techniques. However, some general guidelines are as follows: preserving physical evidence by keeping it in airtight containers or suitable bags to prevent contamination and deterioration. Preserving the integrity of biological evidence by storing it in a refrigerator, such as blood samples. Employing write-blocking techniques and storing digital evidence on safe, encrypted devices to prevent tampering. Identifying each piece of evidence with a special code and noting its provenance, date, and collector's name. Legal Considerations: To ensure that the evidence is admissible in court, collecting and preservation must abide by strict legal rules. Evidence may be rejected or disputed if the proper procedures are not followed, the chain of custody is broken, or the evidence is handled improperly. In conclusion, gathering and safeguarding evidence is an essential part of any inquiry or judicial procedure. In doing so, they support the establishment of the truth, the upholding of justice, and the protection of the rights of those concerned. To preserve the reliability of the investigation's results and the integrity of the available evidence, proper processes and principles must be followed [1, 2].

TYPES OF EVIDENCE

Based on its nature, source, and dependability, evidence can be broadly divided into different forms. There are various categories for evidence in the context of legal procedures, but evidence can be divided into the following types.

Direct evidence

This kind of proof establishes a fact directly, without the need for any assumption or inference. It is based on firsthand experience, witness accounts, or physical evidence. Direct evidence includes, for instance, the testimony of an eyewitness who claims to have witnessed an incident [3].

Circumstantial Evidence

Contrary to direct evidence, circumstantial evidence enables for an inference to be made regarding the presence of a fact rather than immediately proving it. It uses a series of events to link the evidence to the conclusion. A suspect's fingerprints, for instance, are circumstantial evidence that may indicate their presence at the scene but does not necessarily establish their guilt.

Documentary Evidence

Evidence that is written or documented, such as contracts, emails, letters, medical records, and official reports, is referred to as documentary evidence. Due to its ability to give a concrete record of transactions, agreements, or actions, documentary evidence can be extremely helpful in legal proceedings [4].

Testimony evidence

Witnesses, who testify orally or in writing about what they have seen, heard, or experienced are providing testimony. In many legal proceedings, witness testimony can be a vital component.

Physical Evidence

Physical evidence consists of physical goods or objects pertinent to the case. It is often referred to as genuine evidence or object evidence. Weapons, fingerprints, DNA samples, and other tangible artifacts that can connect a person to a crime or incident are some examples [4].

Demonstrative Evidence

During a trial or other legal action, facts are illustrated or clarified using demonstrative evidence. It incorporates visual aids to help people grasp difficult concepts or events, such as diagrams, charts, models, photographs, or video reenactments.

Hearsay Testimony

Hearsay is a remark made outside of court that is used to support a claim by demonstrating its veracity. Hearsay testimony is typically not allowed in court in many jurisdictions because it is regarded as untrustworthy due to the absence of a cross-examination opportunity.

Expert Testimony

Expert witnesses offer specialized information, opinions, or interpretations in fields outside the ordinary person's realm of comprehension. They could be asked to offer their professional judgment on topics like technology, forensics, or medical issues [5].

It's crucial to remember that the admissibility and weight of various sorts of evidence can fluctuate based on the individual legal system and the rules of evidence in a certain country. The reliability of the witnesses and the broader environment of the case might also have an impact on the strength and relevance of the evidence.

LEGAL CONSIDERATIONS

Legal issues must be considered in the field of forensic science since the findings and techniques used can have a big impact on criminal investigations and court cases. Several important legal factors pertaining to forensic science are listed below:

Evidence Admissibility

In order to be used in court, forensic evidence must adhere to specific legal requirements. Judges must decide if the evidence is pertinent, trustworthy, and complies with the applicable jurisdiction's rules of evidence. This frequently entails evaluating the methodology, credentials of the forensic expert, and reliability of the methods employed to gather the evidence.

Chain of Custody

The chronological record of how forensic evidence was handled, moved, and stored is referred to as the

chain of custody. To guarantee the integrity of the evidence and avoid tampering or contamination, which could influence its admissibility and reliability in court, it is crucial to maintain a secure and well-documented chain of custody.

Expert Qualifications

To examine the evidence and testify about it, forensic specialists must meet a set of requirements. In order to prove their credibility, courts frequently demand that experts provide proof of their knowledge, training, and experience in the topic in question.

Peer review and Scientific Validity

Forensic procedures and methodologies must be supported by peer-reviewed research. To ensure their dependability and accuracy, forensic disciplines should be examined before being admitted in court. Different legal systems may use different criteria to determine whether scientific evidence is admissible, such as the Daubert or Frye standards. The trial judge must serve as a "gatekeeper" in judging the validity and applicability of scientific evidence in accordance with the Daubert standard, which is applied in federal courts and many states. The Frye standard, which is used in some jurisdictions, focuses on how well accepted the relevant scientific community's findings are [6].

Ethics

Forensic scientists must conduct their work in accordance with accepted moral principles and industry norms. This entails avoiding conflicts of interest, upholding objectivity, and making sure that their findings are reported transparently.

Limitations and Uncertainties

Forensic scientists should be open and honest about any restrictions or unknowns that may have been placed on their research. This entails recognizing the possibility of bias or inaccuracy and refraining from exaggerating the certainty of conclusions. Opposing parties have the ability to cross-examine forensic specialists during court procedures. Through this procedure, the opposing side is given the chance to contest the expert's methodology, credentials, and conclusions.

Post-Conviction Review

In situations where the use of forensic evidence was crucial to obtaining a conviction, post-conviction reviews may be conducted to evaluate the reliability and validity of the evidence.

Public Perception and Media Influence

Media attention and public interest can be significantly increased in high-profile instances using forensic evidence. This media focus highlights the significance of factual reporting and discourages the renationalization of forensic evidence by having an impact on the general public's perspective, prospective jurors, and the legal process.

In general, legal factors are crucial to preserving the validity and dependability of forensic science as a crucial instrument in the fight for justice. Maintaining high legal standards for forensic evidence helps preserve defendants' rights and improves the fairness of the criminal justice system.[2, 6]

Steps in Evidence Collection

No matter the sort of investigation criminal, accident reconstruction, or other—the gathering of evidence is an essential step. The preservation and integrity of the evidence are ensured through proper evidence gathering, which can have a big impact on the case's conclusion. The steps in gathering evidence are as follows:

Determine the Goals

The investigation's goal and the types of evidence needed to substantiate or refute the allegations or theories should be clearly stated. Ensure the safety and security of the place where the evidence is located by securing the scene. In order to avoid contamination or tampering, only authorized people should have access.

Record the Scene

Make a thorough description of the scene, complete with pictures, sketches, and notes. Keep track of the evidence's position, any potential points of entry or escape, and any other pertinent information. Create a chain of custody by meticulously documenting every person who comes into contact with the evidence from the time it is collected until it is presented in court. The integrity and admissibility of the evidence depend on this chain of custody. Identifying and gathering physical evidence entails gathering all pertinent physical objects that might be used as proof. This can include things like firearms, clothing, paperwork, fingerprints, bodily fluids, and more. To prevent contamination, use the right instruments, such as gloves and evidence bags.

Preserve Digital Evidence

If the investigation makes use of digital equipment, such as computers, cellphones, or video surveillance, follow the correct procedures to preserve this evidence without tampering with it or harming it [7]. To examine and interpret the evidence, it may be essential in some circumstances to seek the advice of specialists in the relevant domains (such as forensic scientists or accident Reconstructionist).

Obtain More Proof

Compile any pertinent papers, information, or records that can support or elucidate the gathered proof [8]. Evidence should be packaged and labeled correctly before being transported and stored to ensure that it is kept clean and undamaged. Keep the evidence in a safe, secure environment [9].

Examine and Consider the Evidence

Apply the proper forensic and scientific methods to a thorough investigation of the gathered evidence.

Write Up the Analysis

Note the outcomes of the evidence analysis, as well as any interpretations or conclusions that were made.

Explain the Evidence

If the case is taken to court or another appropriate forum, clearly and concisely explain the evidence to support the investigation's conclusions. Keep meticulous records of all evidence gathered, examined, and presented, along with the chain of custody, in order to support any ensuing inquiries or legal challenges [10].

Preservation techniques

In a number of disciplines, including law enforcement, forensic science, and scientific research, evidence preservation is essential. The evidence must be preserved properly to remain undamaged and allow for correct analysis and interpretation. Here are a few methods used frequently to preserve various kinds of evidence:

Physical Evidence (Weapons, biological samples, prints, and other tangible proof)

Packaging

Place the evidence in the proper receptacles, such as paper bags, envelopes, or glass or plastic containers made of non-reactive materials [1].

Labeling

Clearly write down the case number, date, location, and a brief description of the evidence on each item.

Seal

To prevent unwanted access or tampering, seal the containers using evidence tape or tamper-evident seals.

Chain of Custody

Keep a thorough record of all individuals who touched the evidence, along with the times they did so [2].

Digital Evidence: (Computers, smartphones, storage devices, and other digital evidence)

Create a duplicate of the digital evidence using forensic imaging so that you can work on it instead of the original. Use write-blocking software or hardware to stop any alterations to the original data during analysis. To ensure the integrity of the data, generate and record the original and duplicate pieces of evidence's cryptographic hash values [7].

Chemical proof (drugs, poisons, and traces of evidence)

Chemical evidence should be kept in airtight, properly labeled containers to avoid contamination and evaporation. Controlled temperature storage or refrigeration is necessary to preserve the stability of some chemical evidence. Use the proper personal protective equipment when handling dangerous chemicals to protect the investigator's safety [11].

Documentary proof (documents, images and records)

To preserve paper documents and photos for archiving, place them in acid-free folders or sleeves. Digital preservation: To avoid data loss, keep digital

documents in safe storage systems with regular backups. Scan physical papers and photos to create digital copies that can be easily accessed and analyzed [4].

Biological proof (DNA samples, saliva, and blood samples)

Keep biological evidence refrigerated or frozen to stop it from degrading and stopping bacteria from growing. Store biological samples in sterile containers to prevent contamination and maintain the validity of the data. Maintain a transparent chain of custody for biological samples, just as you would for other sorts of evidence [12, 13].

Trace evidence (hair, fibers, paint and glass shards)

Safe packaging: To avoid infection and guarantee preservation, use clean, sterile containers or envelopes. Utilize clean instruments, such as forceps, while gathering and packaging traces of evidence to prevent contamination. Reduce handling as much as possible to protect the integrity of sensitive or easily lost material, avoid treating trace evidence excessively [14, 15].

Laboratory Analysis of Evidence

In many disciplines, including forensic science, medical research, environmental studies, and others, laboratory analysis of the evidence is an essential stage. To obtain factual, scientific data that can be utilized to support investigations or make conclusions, it entails the methodical inspection and testing of numerous sorts of evidence. The following are the main steps in the laboratory analysis of the evidence.

Sample Preparation

Before analysis, the evidence may need to be processed or prepared once it arrives at the lab. To obtain acceptable samples for testing, this procedure may entail cutting, grinding, extraction, or other techniques. Different analytical methods are utilized depending on the sort of information needed and the nature of the evidence. Typical methods used in laboratories for analysis include: Utilizing microscopes to investigate the morphology and structure of substances like fibers, hair, and particles [16].

Spectroscopy

Using several kinds of spectroscopy, such as nuclear magnetic resonance (NMR) spectroscopy, infrared spectroscopy, or mass spectrometry, to examine the chemical makeup of items [17].

Chromatography

A technique for separating and identifying the various components of a mixture that is frequently employed in toxicology and drug analysis.

DNA Analysis

DNA analysis is used in forensic investigations to identify people or establish relationships between people.[12]. Toxicology is the study of poisons, medicines, and other toxic compounds in biological samples.

Ballistics

Examining weapons and ammunition to determine their connection to certain crimes.

Fingerprint Analysis

Identifying suspects by comparing fingerprints discovered at crime scenes with known prints [18].

Quality Control

To guarantee the correctness and dependability of the results, quality control procedures are carried out at every stage of the analysis process. Utilizing suitable standards, controls, and validation processes is part of this [2].

Results Interpretation

After the analysis is finished, the findings are interpreted by qualified experts who take into account the particulars of the case as well as the techniques' limitations.

Reporting

A thorough and understandable report is produced, detailing the procedures followed, the outcomes attained, and the inferences made from the study. Laboratory analysts may be called to testify in court as experts to explain their findings and respond to inquiries from the prosecution, defense, or judge [6].

Challenges and Controversies

In any inquiry or judicial procedure, the gathering and preservation of evidence is essential. But there are a number of issues and problems surrounding this procedure that could affect the validity and admissibility of the evidence. The following are some of the major issues and conflicts surrounding the gathering and preservation of evidence:

Contamination

The possibility for evidence to become tainted during collection, handling, or storage is one of the main challenges. Mishandling, inappropriate packaging, or even cross-contamination between distinct pieces of evidence are just a few ways that something can get contaminated. The credibility and integrity of the evidence may be substantially jeopardized as a result [14].

Chain of Custody

The chronological history of the evidence from the time it is gathered until it is presented in court is shown by the documented trail known as the chain of custody. To prove that the evidence has not been tampered with or changed, it is crucial to maintain a transparent and uninterrupted chain of custody. Any omissions or discrepancies in the chain of custody may raise questions about the veracity of the evidence [2]. Rapid technological improvements have led to a rise in the use of digital evidence in many investigations, such as electronic records, computer data, and surveillance footage. However, processing and maintaining digital evidence can be challenging due to its complexity. To protect the admissibility of digital evidence, adequate gathering and preservation must be ensured using specialized techniques and knowledge [19].

Privacy Issues

The gathering of evidence may frequently entail the acquisition of personal data about persons, which poses privacy issues. It can be difficult to strike a balance between the requirement for proof and the protection of people's privacy rights, especially when digital evidence and surveillance data are involved [20]. Evidence loss or destruction can happen unintentionally or due to human error. Critical evidence can be lost as a result of natural disasters, carelessness, or deliberate manipulation, which can have a negative effect on the investigation or legal procedures [21].

Subjectivity and Bias

The process of gathering and preserving evidence can be affected by the subjectivity and prejudice of the investigator, which could result in mistakes or favoritism. This subjectivity may emerge during the identification and gathering of the evidence and may have an impact on its preservation and presentation.

Public Opinion and Media Sway

Controversies about the gathering and preservation of evidence can arise in high-profile cases or those that receive substantial media coverage. Increased scrutiny brought on by public perception and media influence may affect the validity of the evidence or the way the investigation is handled.

Lack of Resources and Training

Law enforcement organizations and investigators may struggle to adequately gather and preserve evidence if they lack the resources and training necessary. Inadequate training and resources could lead to the improper handling or omission of vital evidence, which would affect the investigation's results [22].

Legal Admissibility

The legal acceptability of evidence is a crucial matter. There may be disputes regarding the admissibility of particular forms of evidence in court, such as hearsay or evidence collected illegally. Rules and criteria for evidence admissibility vary between jurisdictions [5].

International Cooperation

Collecting and preserving evidence across borders might present difficulties in instances involving numerous jurisdictions. The process might become more difficult and generate questions of jurisdiction and sovereignty as a result of legal and cultural differences between nations [23].

CASE STUDY: THE IMPORTANCE OF EVIDENCE COLLECTION AND PRESERVATION

Background

Investigators gathered a variety of evidence from the crime site in a well-known murder case, including fibers, DNA samples, and fingerprints. However, crucial evidence was tainted by inappropriate methods of gathering and preserving it, which resulted in a legal dispute over its admissibility.

Problems Found

Cross-Contamination

DNA from one sample contaminated another because investigators handled different objects with the same gloves on.

Inadequate Packaging

A few biological samples underwent deterioration as a result of being exposed to air and moisture and not being adequately packed.

Insufficient Records

The evidence's integrity was called into question due to careless chain of custody management.

How to Avoid Contamination through Protocols and Training

Make certain that everyone working on the evidence collection process has received the appropriate training. Create and adhere to uniform procedures for gathering and managing evidence.

Application of personal protective equipment

To avoid getting contaminated by the skin, hair, or other substances of investigators, put on gloves, a mask, and protective clothes. Put on new gloves when working with various pieces of evidence.

Suitable Packaging

Use the proper containers for each sort of evidence, such as plastic containers for powders and paper bags for biological samples. Securely seal goods to stop contamination and deterioration.

Record-keeping

Keep a precise chain of custody for every evidence, recording the identity of every person who handles it and including time and date stamps. To keep track of each item's location and condition, use evidence labels and logs.

Environmental Regulators

Evidence should be kept in regulated spaces with temperature and humidity monitoring. If applicable, take into account freezing or refrigerating biological samples.

Frequent Reviews and Audits

To find and fix any potential flaws in the processes, conduct routine audits of the evidence gathering and preservation procedures. By putting these precautions in place, forensic teams can drastically lower the possibility of contamination, guaranteeing the accuracy of the evidence and upholding the fairness of the legal system.[24]

DISCUSSION

In forensic science, gathering and preserving evidence guarantees its dependability and integrity. Certain processes must be followed to prevent contamination or deterioration, which might jeopardize investigations and legal conclusions.

Collection entails painstakingly obtaining tangible evidence from crime scenes, such as biological samples, fingerprints, and trace elements. Forensic experts employ specific methods and instruments to guarantee that proof is gathered while preserving its original significance and background.

Preservation

The goal of preservation is to keep the evidence in a state that permits precise analysis. Using the proper packing materials, managing humidity and temperature, and recording the chain of custody to keep track of who handled the evidence and when are a few examples of how to achieve this.

It is impossible to exaggerate how crucial it is to gather and preserve evidence correctly as any mistake might make it impossible to use it in court, which could hinder the administration of justice. To maintain the standards of the industry, forensic practitioners must be trained and follow defined processes.

Collection and preservation of evidence is not just about collecting and preserving evidence it also includes documentation of evidence, making sure to record its details and transferring it to the main authority intact. As we are developing in science and technology we are also improving in preserving evidence for a long time. New technologies are introduced day by day so it will be easier to preserve and collect evidence.

CONCLUSION

To sum up, evidence gathering and preservation are critical components of the criminal justice system that have a big impact on how investigations and trials turn out. Ensuring the integrity of evidence and its admissibility in court requires careful treatment, which is essential to maintaining the values of justice and equity. As we've seen, protecting the integrity of evidence depends on several things, including using cutting-edge technology, adhering to established rules, and providing law enforcement professionals with the appropriate training. Furthermore, the dynamic field of forensic science emphasizes how crucial it is to stay up to date on advancements and best practices. Specialized knowledge and abilities are needed for evidence collection techniques including biological sampling and digital forensics. Thus, ongoing instruction and training are essential for investigators to adapt to novel obstacles and technological advancements.

Furthermore, the need for accurate recordkeeping cannot be emphasized enough. Keeping accurate records of the gathering, processing, and storage of evidence is essential to creating a transparent chain of custody. In addition to safeguarding the integrity of the evidence, this openness upholds the legitimacy of the investigation process. A mismanaged or inadequately documented piece of evidence can result in erroneous convictions or the suppression of important facts, eroding public trust in the legal system.

Moreover, developing a unified strategy for evidence management requires cooperation between law enforcement, forensic specialists, and legal experts. These stakeholders can better handle the challenges of gathering evidence and guarantee that the highest standards are upheld throughout the

investigation process by encouraging communication and collaboration.

Ultimately, the administration of justice and the defense of individual rights depend on a strong framework for the gathering and storage of evidence. All parties concerned must stay watchful and dedicated to maintaining these standards as the criminal justice system develops. We can promote fair trials, strengthen public confidence in our legal system, and improve the trustworthiness of the evidence via further education, technical innovation,

and cooperative efforts. Justice is based on the integrity of the evidence, which is more than merely a procedural need.

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