

THE ROLE OF FORENSIC SCIENCE IN CRIMINAL INVESTIGATION IN INDIA

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Abstract

A Complex knot of lawlessness and fear, including violent crimes, cybercrime, terrorism, and financial fraud has increased the importance of forensic science within the criminal justice system. In this context, the paper investigates the impact forensic technologies are having in the contemporary era of criminal investigations which include the use of DNA profiling, digital forensics, toxicology, ballistics, and fingerprinting. It documents the development of forensic science in India, evaluates important legislative documents, and examines the landmark changes made by BNSS (Bhartiya Nagarik Suraksha Sanhita) and BSA (Bhartiya Sakshya Adhiniyam) in 2023.

In India, the forensic ecosystem is still evolving, facing challenges like insufficient infrastructure, a lack of qualified personnel, and large backlogs of cases. The research brings forward the global best practices from the USA, UK, Germany, and Japan, points out the use of platforms like machine learning, standardized practices, and emergence in the centralized national database.

At last, the paper suggests actionable steps to improve India's forensic framework with an emphasis on creating educational and ethical privacy-centric boundaries regarding genetic information, quality control, and instruction. Improvements in forensic capabilities not only aid in the prompt and precise delivery of justice, but also in rejuvenating and solidifying the public's reliability in the legal system

Keywords- Criminal Justice System, DNA Profiling, Digital Forensics, Forensic Infrastructure, Criminal Law Reforms in India

1. Introduction

Forensic science has an important position in criminal investigations through offering methods for sorting out evidence, thereby aiding both crime prevention and detection. India has witnessed an upsurge in complex crimes, which include violent crimes, financial crimes, cybercrimes, and terrorism, necessitating the use of forensic methods like DNA identification and digital forensics in the country's investigative and judicial systems. The judiciary is increasingly accepting the significance of forensic evidence in attaining morality.

However, issues like inadequate infrastructural support, case backlogs, and untrained professionals persist. The integration of forensic science in India dates to the colonial period, although it has gradually grown since independence. The construction of the first forensic science laboratory in Kolkata in 1952, and the Fingerprint Bureau in 1897 enhanced the capabilities of forensic science. Legislative legislation like the IEA and the IT Act of 2000 have increased the use of forensic evidence in court. Recent advances to penal laws, such as the BNSS and the BSA, 2023, are historic legislation that ushers in a new era in the growth of forensic science, particularly within the judiciary. Other proposals, such as the planned DNA Technology Regulation Bill, seek to accelerate the country's forensic infrastructure development. This study looks at India's forensic framework, methodologies, significant legal developments, and recommendations for improving forensic science in criminal investigations.

India's early contributions to forensic science hold considerable historical importance. The Kolkata Fingerprint Bureau, established in 1897, was the world's first fingerprint bureau, and the classification system developed principally by Indian sub-inspectors Azizul Haque and Hemchandra Bose was subsequently adopted by Scotland Yard in 1901, becoming the global standard for fingerprint identification for the next century.¹ The Central Forensic Science Laboratory was subsequently established in 1957 under the Ministry of Home Affairs, expanding the range of forensic services available nationally to encompass biology, serology, chemistry, and ballistics across regional laboratories.²

¹ 'Historical Development of Forensic Law in India' (Legal Bites, 7 October 2024) <<https://www.legalbites.in/forensic-law/historical-development-of-forensic-law-in-india-1070170>> accessed 19 June 2026.

² Indian History of Forensic Science (Forensic's Blog) <<https://forensicfield.blog/indian-history-of-forensic-science/>> accessed 19 June 2026.

2. Legal Aspects in reference to Forensic Science in India

The Indian law concerning forensic science has a properly defined structure which helps in the meticulous application and integration of scientific methods into criminal investigations and court proceedings. The appeal of forensic science is supported in Indian law and judicial system owing to some fundamental legal statutes, governing provisions, and notable judicial decisions.

2.1. Bhartiya Sakshya Adhiniyam, 2023

The BSA, 2023 repeals the Indian Evidence Act, 1872 and provides sweeping reforms aligned with technological changes, effective from July 1, 2024. Key provisions dealing with forensic science include:

2.1.1. Section 39 --Expert Opinion

This allows the court to admit expert evidence on topics outside of the court's expertise, such as medicine, science, or art. In the field of forensic science, for example, this helps judges welcome the opinions of experts in DNA profiling, ballistics, toxicology and cyber forensics so they can clarify the technical aspects associated with the evidence presented³.

2.1.2. Section 90 – Reports of Government Scientific Experts: This provision authorizes the forensic report created by the constituted scientific experts of the government through Central or State Forensic Science Laboratories to be placed in the court as evidence. Such reports can be submitted without the expert being called in court, unless the court deems it necessary for cross-examination or providing clarity⁴.

2.1.3. Sections 33-39(1)- Admissibility and Use of Expert Testimony: These provisions set out the standards for the admissibility of expert testimony in court. They emphasize that the expert must be an expert in their field and the methodology of their forensic analysis must be valid and accepted by the scientific community. This allows only reliable and credible expert dependent opinions to be used in judicial decisions⁵.

2.2. Bhartiya Nagarik Suraksha Sanhita (BNSS), 2023

The **BNSS** introduces significant reforms to enhance the role of forensic science in India's criminal justice system. Key provisions related to forensic evidence include:

³ Bhartiya Sakshya Adhiniyam, § 39, No 47 of 2023, Acts of Parliament 2023 (India).

⁴BSA (n 2) § 90.

⁵ BSA (n 2) §§ 33-39(1).

2.2.1. Section 53 – Examination of Arrested Person by Medical Officer

This provision mandates that any arrested individual must undergo a medical examination by a government medical officer or, if unavailable, by a registered medical practitioner. For female arrestees, the examination must be conducted by or under the guidance of a female healthcare professional. This provision ensures the prompt medical assessment of arrested individuals, which can be crucial for collecting forensic evidence such as blood samples or documenting injuries⁶.

2.2.2. Section 176 – Forensic Investigation: This section explains how the police shall proceed when they receive information about a cognizable offense. It requires the officer in charge to immediately report the matter to a Magistrate and to personally investigate or direct an appropriate subordinate officer to do so. Especially for offenses which carry imprisonment of 7 years and more the scope of the section provides that a forensic expert needs to visit the scene of crime for evidence collection and the same has to be video graphed using electronic devices⁷.

2.2.3. Section 329 – Reports of Government Scientific Experts: This section allowed reports which were prepared by designated government scientific specialists to be admissible as evidence in court. The court also has the option of calling and interrogating the expert about the contents of the report⁸.

2.3. Information Technology Act, 2000

One of the most important laws to deal with crimes in cyberspace and the law regarding electronic evidence is the IT Act, 2000. With the rise of cybercrimes, financial frauds and digital offenses, forensic science is instrumental in investigating and cracking these offences.

2.3.1. Section 4: Electronic Records Are a Legal Consensus

This provision establishes the legal validity of electronic records and treats them on par with physical documents. This Act provides those electronic records not necessarily be inadmissible in the evidence, thus facilitating the use of digital documentation in courts.⁹

2.3.2. Section 66: Computer Related Offences

⁶ Bhartiya Nagarik Suraksha Sanhita, § 53, No. 46 of 2023, Acts of Parliament, 2023 (India).

⁷ BNSS (n 5) § 176.

⁸ BNSS (n 5) § 329.

⁹ Information Technology Act, § 4, No. 21 of 2000, Acts of Parliament, 2000 (India).

This part pertains to offences like hacking and illegal entry into computer systems. It lays down the punishment for such cybercrimes, including up to three years of imprisonment, a fine up to five lakh rupees, or both¹⁰.

2.3.3. Section 67: Dissemination of Indecent Material in Digital Form

Under this provision, it is a crime to publish or transmit obscene matter in electronic form. It contains prison and fine provisions, seeking to deter dissemination of lewdness on the internet.¹¹

2.3.4. 79A — Examiner of Electronic Evidence

The section gives power to the Central Government to notify any agency etc. as 'Examiner of Digital Evidence'. October 2023: Such bodies are entitled to give an expert opinion in electronic evidence in legal proceedings, which involve proper examination and interpretation of digital data.¹²

2.3.5. Cyber Forensics and Digital Evidence

Information stored in electronic format, as in emails, data logs, and digital files, is legally recognized as acceptable evidence. Cyber forensics specialists, who study computers, mobile devices and online records, are crucial in the evidence-gathering process when police have opened a cybercrime investigation.¹³

3. Judicial Precedents on Forensic Science in India

3.1. State of Karnataka v. Selvi (2010)

The SC affirmed that involuntary infusion of science-based methodologies like narco-analysis test, polygraph test and brain mapping would contravene Article 20(3) of Constitution to the degree of prohibition towards self-disclosure. Furthermore, by emphasizing the importance of consent (and mental privacy) in the employment of forensic means in investigations, the Court set ethical boundaries on forensic methods in investigations.¹⁴

3.2. State of Maharashtra v. Damu (2000)

¹⁰ IT Act (n 8) § 66.

¹¹ IT Act (n 8) § 67.

¹² IT Act (n 8) § 79A.

¹³ United Nations Office on Drugs and Crime, Handling of Digital Evidence, UNODC (2019)

<<https://www.unodc.org/e4j/en/cybercrime/module-6/key-issues/handling-of-digital-evidence.html>> accessed 14 April 2025.

¹⁴ *State of Karnataka v Selvi* [2010] 6 SCC 411.

The Apex Court has sanctioned consideration of DNA and DNA evidence in a court of law for the purpose of considering it as a fact in a trial. The Court also noticed while deliberating on the applicability of Section 27 of the Indian Evidence Act that by its doctrine of confirmation by subsequent events, the said provision enables the discoveries made on the basis of information connected with the accused to be accepted as credible evidence¹⁵.

3.3. State of Haryana v. Krishna Kumar Malik (2011)

The Supreme Court put emphasis on the need for the forensic examination, including DNA test, in case of sexual assault. No body, no evidence: The Court noted that scientific evidence is essential to reinforce the victim's testimony and facilitate a detailed investigation¹⁶.

3.4. State v. Santosh Kumar Singh (2010)

The details provided in the case from day one showed that the use of DNA evidence was key in getting a conviction. The Supreme Court relied most heavily on forensic evidence when it was ruling on guilt, which emphasizes how greatly scientific methods can affect the outcome in the more complex criminal cases¹⁷.

3.5. State of Tamil Nadu v. Murugan @ Settu (2011)

In this case, Supreme Court dismissed the plea and upheld conviction for the offence of rape & murder. It stressed the necessity of forensic evidence to ascertain the submission of all such other evidence submitted on behalf of the prosecution. It said that if one weigh any single hypothesized cogent chain of forensic circumstantial evidence, in and of itself was sufficient to prove the guilt beyond reasonable doubt¹⁸.

3.6. Anvar P.V. v. P.K. Basheer and Others (2014)

In Anvar v. Basheer, the Supreme Court laid down the general parameters stipulating the circumstances under which the electronic evidence will be accepted; stating that any electronic record found in the documents presented shall necessarily conform with the requirements provided in section 65B of the Indian Evidence Act. These decisions are intended to provide better use of digital evidence in judicial proceedings¹⁹.

3.7. State of Madhya Pradesh v. Manoj (2023)

¹⁵ *State of Maharashtra v Damu* [2000] 6 SCC 269.

¹⁶ *State of Haryana v Krishna Kumar Mallik* [2011] 3 SCC [Cri] 61.

¹⁷ *State v Santosh Kumar Singh* [2010] 6 SCC 773.

¹⁸ *State of Tamil Nadu v Murugan @ Setu* [2011] 2 SCC (Cri) 842.

¹⁹ *Anvar P V v P K Basheer and Others* [2014]10 SCC 473.

While hearing this proceeding, the apex court expounded on the necessity of DNA profiling in criminal matters. The Court analyzed the mechanism of precision testing of DNA results and its role in the detection of definitive involvement of the accused in the offences.²⁰.

3.8. State of Kerala & Anr. v. Abdul Nassar. (2024)

Once again, the Supreme Court has reiterated the significance of forensic evidence in securing convictions. As the Court notes, discussed below are the forensic evidence collected by The Investigating Officer and recoveries made upon disclosure statements of the accused relied for the conviction.²¹.

4. Forensic Techniques in Criminal Investigations

4.1. Forensic Ballistic

Forensic Ballistics examines firearms, associated ammunition, and related evidence to establish their role in a crime. An expert analyzes weapons to ascertain the use of a specific weapon in a given crime by comparing the collected bullets to the test-fired ones. The unique lines and marks that are formed when a bullet or cartridge is fired become its identifying characteristics. The main use of forensic ballistics is firearms identification and its application to law enforcement, assisting police agencies in the maintenance of peace and order. The purpose is to determine the perpetrators of crimes and associate them with specific crime locations and instruments²².

Split screens have been employed to have forensic ballistics specialists look at bullet and cartridge cases visually. After comparison, the examiner may provide an expert opinion as to whether the bullets match; however, the power of the evidence cannot be expressed statistically. NIST is building approaches that help investigators provide their testimony with purpose, statistically significant confidence level. This composite includes the NIST Standard Cartridge Case and NIST Standard Bullet. These are painstakingly created reproductions of fired bullets and cartridge cases with known ballistic fingerprints, not actual bullets or cartridge casings. These criteria are used by crime labs to calibrate their equipment and thus ensure that their exam results are accurate.²³.

4.2. Forensics Toxicology

²⁰ *State of Madhya Pradesh v Manoj* [2023] 9 SCR 452.

²¹ *State of Kerala & Anr v Abdul Nassar* [2025] 2 SCR 1.

²² B Kraft, 'Critical Review of Forensic Ballistics' (1931) 2 *The American Journal of Police Science* 55.

²³ National Institute of Standards, *What Is Forensic Ballistics?*, NIST.gov
<<https://www.nist.gov/topics/forensic-science/firearms-and-toolmarks>> accessed 15 April 2025.

Forensic toxicology is the study of harmful substances in biological samples including blood, urine, and tissues. In cases of drug overdose, poisoning, and alcohol intoxication, this field is critical. Impairment levels in DUI situations are usually assessed using blood alcohol concentration (BAC) testing; toxicologists can also find illegal narcotics, heavy metals, and pesticides in suspected poisonings²⁴.

Some of the analytical methods used to isolate and identify hazardous chemicals are chromatography, spectroscopy, and immunoassays. These methods give vital information for determining the reason of death, examining drug use, and looking into poisoning incidents, therefore supporting legal procedures.²⁵

4.3. Forensic Odontology

Focusing on the identification of human remains and bite mark analysis, forensic odontology uses dental science to criminal investigations. Especially in situations involving decomposition, burns, or mass tragedies, dental data, X-rays and charts among them, help forensic professionals match unidentifiable bodies with missing people²⁶.

Bite mark analysis is the process of judging impressions remains on victims and even on certain objects and matching them to a suspect's dental structure. Though scientific concerns have cast doubt on its dependability, bite mark evidence has been used for a very long time in criminal cases. Notwithstanding this, forensic odontology is still a crucial identifying instrument in forensic situations²⁷.

4.4. Fingerprint Analysis

Fingerprint analysis is one of the most common forensic procedures for personal identification. Fingerprint analysis is critical in criminal investigations since each person's fingerprint is unique. Fingerprints are classified by forensic professionals into three basic patterns: arches, loops, and whorls, each with its own set of ridge characteristics²⁸.

²⁴ Sol Bobst, 'Chapter 35 – Forensic Toxicology' in Philip Wexler (ed), *Information Resources in Toxicology* (5th edn, 2020) 387 (originally authored by Peter Stout).

²⁵ Ibid.

²⁶ Jayakrishnan, Jijin Mekkadath, Jagat Reddy and R B Vinod Kumar, 'Role of Forensic Odontology and Anthropology in the Identification of Human Remains' (2021) 25(3) *Journal of Oral & Maxillofacial Pathology* 543.

²⁷ Anoop K Verma, Sachil Kumar and Sandeep Bhattacharya, 'Identification of a Person with the Help of Bite Mark Analysis' (2013) 3(2) *Journal of Oral Biology & Craniofacial Research* 88.

²⁸ INTERPOL, *Fingerprints*, INTERPOL <<https://www.interpol.int/en/How-we-work/Forensics/Fingerprints>> accessed 13 April 2025.

To discover latent fingerprints, forensic experts employ powder dusting, chemical reagents such as ninhydrin, and advanced imaging techniques employing lasers and other light sources. Automated Fingerprint Identification Systems (AFIS) allow for quick comparisons of fingerprints with large databases, considerably increasing the efficiency of investigations²⁹.

4.5. DNA Profiling

DNA profiling, also known as genetic fingerprinting, is a forensic method used to detect individuals based on their unique genetic make-up. While 99.9% of human DNA is identical among humans, the other 0.1% consists of polymorphisms, with each person carrying mutations that differ from each other. Forensic scientists are especially interested in areas which are variable, namely Short Tandem Repeats (STRs), which are patterns of two or more nucleotides repeated with different repeat numbers in individuals³⁰.

Polymerase Chain Reaction (PCR) method generates millions of DNA sequences from specified genetic areas to amplify a DNA sample for analytical reasons during small sample analysis³¹.

Through Short Tandem Repeat analysis, DNA laboratories identify certain gene areas marked by sequence repeat. Individuals have unique genetic profiles due to the number of DNA sequence repeats detected at specific locations. Using this technology allows for incredibly sensitive identification of individuals. DNA profiling has revolutionized forensic investigations by allowing suspects to be identified, innocent people to be released, and paternity ties to be investigated. Crimes become more solvable as national DNA databases are built for the DNA profiling approach³².

India presently lacks a dedicated legislative framework for governing forensic DNA databases. The DNA Technology (Use and Application) Regulation Bill, 2019, which proposed the establishment of a National DNA Data Bank and Regional DNA Data Banks, was formally withdrawn from Lok Sabha in July 2023, with the government citing coverage of its provisions under the Criminal Procedure (Identification) Act, 2022.³³ Critics argued that the withdrawal effectively sidestepped

²⁹ Melinda Gal et al, 'New Fluorescent Electrospun Polymer Materials Containing Phenothiazinyl Carboxylate Metal Salts for Versatile Latent Fingerprint Detection' (2023) 211 *Dyes & Pigments* 111085 <https://doi.org/10.1016/j.dyepig.2023.111085>.

³⁰ Law Commission of India, *271st Report on Human DNA Profiling – A Draft Bill for the Use and Regulation of DNA Based Technology* (2017).

³¹ *Ibid*.

³² Nwawuba Stanley Udogadi et al, 'Forensic DNA Profiling: Autosomal Short Tandem Repeat as a Prominent Marker in Crime Investigation' (2020) 27 *Malaysian Journal of Medical Sciences* 22.

³³ 'DNA Technology Bill Withdrawn from Lok Sabha' *Deccan Herald* (24 July 2023) <<https://www.deccanherald.com/india/dna-technology-bill-withdrawn-from-lok-sabha-1240108.html>> accessed 19 June 2026.

the robust privacy safeguards recommended by the Parliamentary Standing Committee on Science and Technology, leaving significant regulatory gaps in the governance of forensic DNA profiling in India.³⁴

4.6. Digital Forensics

The field of forensic science which deals with electronic data puts emphasis on both retrieval and reporting of the data along with evidence analysis and identification procedures and data acquisition from digital storage environments. Digital forensics helps law enforcement investigate all forms of contemporary criminal acts which today inevitably contain electronic evidence. Law enforcement can discover evidence in digital form through a diverse set of equipment including computers, smartphones, remote storage, unmanned aerial systems, maritime equipment along with other sources. The primary mission of digital forensics entails extracting digital information from electronic evidence followed by information processing into actionable data that leads to case evidence for prosecution. The usage of sound forensic techniques during all processes serves to guarantee court admission of the findings³⁵.

The scale of cybercrime in India makes the development of robust digital forensics infrastructure particularly urgent. According to the National Crime Records Bureau, cybercrime cases in India rose sharply from 52,974 in 2021 to 86,420 in 2023, representing a 63.14 per cent increase over just two years.³⁶ In response, the Ministry of Home Affairs established the National Cyber Forensic Laboratory under the Indian Cybercrime Coordination Centre in New Delhi in February 2019 to provide early-stage cyber forensic assistance to investigating officers across the country.³⁷

4.7. Brain Mapping

P-300, also known as Brain Mapping or Quantitative Electroencephalography (QEEG); is a method for measuring the electrical activity of the brain. This test produces data on brainwave patterns, by placing electrodes on the scalp, to analyze and plot the brain's activity. This data is used for multiple purposes, such as assessment of neurological disorders, evaluating brain function, and understanding neurocognitive functions. In some studies, the cerebral mapping Test is used

³⁴ 'What's in DNA Technology Bill Withdrawn by Modi Govt and Why House Panel Wanted Safeguards in Place' The Print (25 July 2023) <<https://theprint.in/india/governance/whats-in-dna-technology-bill-withdrawn-by-modi-govt-why-house-panel-wanted-safeguards-in-place/1685328/>> accessed 19 June 2026.

³⁵ INTERPOL, *Digital forensics*, INTERPOL< <https://www.interpol.int/en/How-we-work/Innovation/Digital-forensics>> accessed 13 April 2025.

³⁶ 'NCRB Data on Cyber Crimes Dated, Not Indicative of True Picture: Experts' BOOM (6 October 2025) <<https://www.boomlive.in/news/ncrb-report-notes-sharp-rise-in-cyber-crimes-in-india-29662>> accessed 19 June 2026, citing National Crime Records Bureau, Crime in India 2023 (Ministry of Home Affairs 2024).

³⁷ Ministry of Home Affairs, Press Information Bureau (17 March 2026) <<https://www.pib.gov.in/PressReleasePage.aspx?PRID=2241339>> accessed 19 June 2026.

to study brain activity associated with a mental state or disorder. It gives a rough guide to how the brain works but there is no guarantee. Because the data can be subject to so many variables, such as the frame of mind they are in when it is taken, it is hard to make firm decisions about their health as a result.³⁸

4.8. Polygraph Tests

Pulling blood pressure measurements and other physiological responses from individuals during questioning is what polygraph tests generally known as lie detector tests accomplish. Polygraph depends on the principle that deceitful responses produce detectable bodily changes which differ from a person's natural baseline patterns. The testing equipment measures heartbeat and blood pressure changes through sensors during an assessment to determine whether these changes indicate stress signals from someone who might be untruthful. The signs of deceptive discomfort are revealed through abnormal breathing patterns and increased skin conductivity which results from higher perspiration levels. The accuracy of polygraph tests faces ongoing skepticism from experts because physical responses during tests can be negatively impacted by elements that disprove deception including nervousness as well as health problems and environmental stress. The accuracy rates range between 70% to 90% in most polygraph tests although examiner experience and testing conditions greatly affect outcome precision. The application of polygraph tests continues throughout criminal investigations as well as employment screening processes and national security evaluations yet legal courts view their results as supporting evidence rather than final proof.³⁹

5. Challenges in Forensic Science Application in India

The role of forensic science in India forms a pivotal part of the criminal justice system, assisting with key components of criminal investigations and helping to provide evidence for court trials. Moreover, several factors stand in the way of its optimal and productivity, culminating in public dissatisfaction.

The country faces a prominent gap in monotonous forensic infrastructure with no modifiable or alternative support for rapid technological advancement in information and technology. A fiscal shortage of forensic laboratories lacking facilities with high performance owing to lack of

³⁸ Free Law, *Brain Mapping Test - Narco Analysis Test in India*, FREE LAW (6 September 2024) <https://www.freelaw.in/legalarticles/Brain-Mapping-Test-Narco-Analysis-Test-in-India-> accessed 13 April 2025.

³⁹ American Psychological Association, *The Truth About Lie Detectors (aka Polygraph Tests)*, APA (5 August 2004) <https://www.apa.org/topics/cognitive-neuroscience/polygraph> accessed 13 April 2025.

sophisticated practs derives comprehensive analysis of evidence. With widened gaps in forensic examination, judicial processes are severely restricted. Laboratory Science in Forensic Examiners reported more than 22,000 pending cases in October 2023 which demonstrates the extent at which justice is delayed⁴⁰.

In addition to restriction, deficiency of trained forensic scientists adds extensive difficulty for infrastructure. Studies reported that around 40% of 3,211 positions assigned in 26 laboratories were left unwanted. Two-thirds of these words are from scientific fields needed to conduct forensic examination or termed as Scientific Officer and Laboratory Analysts Noteworthy. The remaining staff bears the burden of increased workload and diminished standard of qualitative during forensic studies⁴¹.

The lack of appropriate infrastructure and the unavailability of skilled personnel has led to a considerable backlog of cases awaiting forensic analysis. These postponements not only extend the duration of the legal process but also erode the reliability of the general public in the criminal justice system for example, the Delhi Forensic Science Laboratory's backlog of more than 22,000 cases has been cited as a major obstacle to the expeditious conduct of trials, with cases being adjourned for long periods of time because of waiting for forensic reports.⁴²

Compounding these structural deficiencies is a systemic failure in chain of custody protocols across India's forensic evidence handling infrastructure. Research synthesising studies from 2021 to 2024 has identified improper crime scene management, documentation errors, equipment shortages, and inconsistent procedures across states as recurring failures that critically compromise the evidentiary integrity of forensic samples.⁴³ The absence of uniform national standards for forensic laboratories further aggravates this problem: without standardised operating procedures, diverging methodologies between laboratories produce discrepancies in forensic reports that courts are frequently required to navigate, with consequential risks for both the prosecution and the fair trial rights of the accused.⁴⁴

⁴⁰ Abhinav Rajput, '22,000 Reports Pending at FSL, Justice Gets Delayed', *Times of India* (26 November 2023) <https://timesofindia.indiatimes.com/city/delhi/reports-pending-fsl-justice-delayed/articleshow/105505774.cms> accessed 13 April 2025.

⁴¹ Ibid.

⁴² Rajput (n 35).

⁴³ 'Evidence Mishandling and Chain of Custody Failures in India' (2024) International Institute of Research and Consultancy Journal <<https://iircj.org/wp-content/uploads/81-Evidence-Mishandling-and-Chain-of-Custody-Failures-in-India.pdf>> accessed 19 June 2026.

⁴⁴ Luhar Kirtikumar Vishnuprasad, 'Critical Analysis of Admissibility of Forensic Evidence and Reports in the Criminal Justice System of India' (White Black Legal) <<https://www.whiteblacklegal.co.in/details/critical-analysis-of-admissibility-of-forensic-evidence-and-reports-in-the-criminal-justice-system-of-india-by---luhar-kirtikumar-vishnuprasad>> accessed 19 June 2026.

It is essential to develop comprehensive skills by mentoring materials for law enforcement officials and judicial officers in the field of forensic science. Ignorance of forensic methodology may result in the wrongful collecting, preserving, and interpreting of evidence which can have dire consequences on investigations and trials. The effective use of forensic science in the criminal justice system starts with educating these stakeholders, therefore enhancing their knowledge and skills is a necessity⁴⁵.

Profound ethical and legal debates arise with the implementation of modern forensic techniques such as DNA profiling, as they have drastically transformed criminal investigations in India. While aiding law enforcement, these techniques can pose serious privacy hazards and the potential to misuse genetic information, which necessitates robust legal safeguards. Legal scholars, including those cited by Aequitas Victoria, argue about the manipulative power of DNA databases in collection, storage, and access that could violate individual rights, thus calling the need for advanced policing frameworks to protect civil liberties. In India, these frameworks can be best applied by adopting a multi-faceted strategy that strengthens the role of forensic science, such as modernizing forensic laboratories to enhance technological capabilities, streamline analyses, reduce backlogs, and implement training for law enforcement to improve comprehension and treatment of forensic evidence in judicial processes of forensic science upholds fundamental rights and privacy, thereby contributing to a fairer and more effective criminal justice system. Moreover, addressing the understaffing issue can be met by hiring more skilled forensic experts, complemented with lucrative benefits and advancement opportunities. Changes in law are similarly vital to set uniform standards for the use and presentation of forensic evidence in judicial proceedings. Just as essential is trust, which can be cultivated by raising public awareness and setting strict ethical boundaries concerning the use of forensic technology⁴⁶.

6. Comparative Analysis: Forensic Science in Other Jurisdictions

6.1. The United States (US)

The US has a complex forensic facility, with the Federal Bureau of Investigation (FBI) playing a critical role. The FBI Laboratory provides a vast range of forensic services, such as DNA analysis, fingerprint examination, digital forensics, cryptanalysis, document examination, trace evidence, latent prints, and chemistry. These services benefit both federal and local law enforcement

⁴⁵ Srishti, 'The Impact of Forensic Science on the Legal System in India' (2025) 9 *Journal of Forensic Science Research* 1.

⁴⁶ Ibid.

authorities⁴⁷. To maintain standardized procedures throughout jurisdictions, the FBI's Handbook of Forensic Services contains detailed instructions for collecting evidence and preservation. This handbook provides information on safe and effective procedures for gathering, conserving, packaging, and shipping evidence, as well as descriptions of forensic exams conducted by the FBI's Laboratory Division⁴⁸.

Moreover, the Federal Bureau of Investigation supervises the Combined DNA Index System (CODIS), which allows, federal, state, and local forensic laboratories to share and correlate DNA linking serial violent crimes and identifying offenders⁴⁹.

These resources and systems contribute to the effectiveness and efficiency of forensic investigations in the United States of America.

6.2. The United Kingdom

The Forensic Information Databases Service (FINDS), a branch of the Home Office, established extensive databases in the UK. FINDS handles the administration of the National DNA Database (NDNAD), National Fingerprint Database (IDENT1), and National Footwear Database. These databases enable faster monitoring of offenders by linking forensic evidence from crime scenes to rewards. FINDS manages the UK National Missing Persons DNA Database (MPDD), which helps correlate DNA and fingerprints from missing or vulnerable individuals with crime scene evidence, aiding the investigative process⁵⁰.

6.3. Germany and Japan

Germany and Japan were early adopters of artificial intelligence (AI) and automation in forensics laboratories, which improved the efficiency and accuracy of forensic analyses. The agreement between these countries aims to use AI technology to automate complex processes in forensic investigations, reducing manual workloads and minimizing human errors. The Airport project, a collaboration between Germany and Japan, aims to advance human-oriented AI technology⁵¹.

⁴⁷ Federal Bureau of Investigation, *Science and Technology*, FBI <https://www.fbi.gov/how-we-investigate/science-and-technology> accessed 13 April 2025.

⁴⁸ Ibid.

⁴⁹ FBI (n 40).

⁵⁰ Home Office, *Forensic Information Databases Service*, GOV.UK <https://www.gov.uk/government/groups/forensic-information-databases-service> accessed 13 April 2025.

⁵¹ Deutsches Forschungszentrum für Künstliche Intelligenz, *AI in Production – Project AIRPoRT promotes German-Japanese Innovations*, DFKI (20 December 2019) <https://www.dfki.de/en/web/news/airport-ki-production/> accessed 13 April 2025.

The Integration of AI in forensic science, digital forensics, anthropological forensic, forensic taphonomy. Artificial Intelligence has been implemented to support the identification of individuals and species and digital evidence analysis operations with greater accuracy and lower cost. Nonetheless, these advancements warrant vigilant scrutiny, particularly regarding ethical and legal ramifications around privacy, data protection, and the stability of AI systems⁵².

The experiences of Germany and Japan demonstrate the potential benefits of incorporating AI and automation into forensic laboratories, while also emphasizing the significance of tackling associated issues to ensure responsible and effective adoption.

7. Case Studies

7.1. Nirbhaya Case (2012)

The country was set ablaze with protests after the gruesome gang rape and murder of Jyoti Singh, aka Nirbhaya, took place in December 2012. The accused were linked to the crime through forensic evidence, most importantly, DNA profiling. The samples obtained from the survivor's body and the crime scene matched those to that of the accused. The court, in siding with the prosecution, underscored the need for forensic evidence and handed down the death sentences. The Supreme Court, for its part, concurred with this position⁵³.

7.2. Aarushi Talwar Case (2008)

Possibly one of the high-profile cases in India is the double murder case of Aarushi Talwar and her domestic worker, Hemraj, which occurred in 2008. The case drew scathing critiques due to the lack of proper filing and tampering with forensic evidence, such as the absence of documentation and contamination. While DNA evidence was present, due to no definitive proof emerging DNA evidence was deemed inconclusive, leading to the accused being set free. The case puts into perspective the need for proper forensic protocols⁵⁴.

7.3. Sheena Bora Murder Case (2012)

The mystery surrounding Sheena Bora, daughter of the renowned Indrani Mukerjea, a media executive, disappeared in 2012 remained unsolved until 2015 when forensic science confirmed human remains found in a forest were indeed, Sheena. The link between the remains and Indrani

⁵² Ibid.

⁵³ *State for NCT of Delhi v Mukesh & Anr* [2020] 1 SCR 761.

⁵⁴ *Dr Rajesh Talwar & Anr v CBI* 2013 (2) ALL LJ 295.

was proven through DNA, leading to her arrest. The premise of this case illustrates the capacity of DNA analysis to resolve intricate murder mysteries⁵⁵.

7.4. Bhiwani Murder Case (2023)

The killing of a woman in Bhiwani, Haryana, in 2023 was resolved through normal forensic methods. The use of fingerprinting and gunshot residue analysis aided in the identification and conviction of the perpetrator. The fingerprint at the crime scene was identified as belonging to the perpetrator, and gunshot residue analysis confirmed the weapon was his. The case demonstrated forensic⁵⁶

8. Recommendations for Strengthening Forensic Science in India

Forensic science development in India is important for effective administration of justice and enhancement of law enforcement. They need to modernize forensic laboratories, which became a critical issue, cause old institutions are still using outdated equipment, impeding the speed and the quality of forensic examinations. The Indian government has also approved the ₹2,254.43 crore National Forensic Infrastructure Enhancement Scheme (NFIES) cash commitment for the period of 2024-2029. This initiative aims to revolutionize the forensic landscape. These include the establishment of nine off-campus facilities of the National Forensic Sciences University (NFSU) and seven new Central Forensic Science Laboratories (CFSLS) under the Directorate of Forensic Science Services (DFSS), which would enhance the country's forensic capacity tremendously⁵⁷.

Reforming operations heavily depends on the implementation of training and capacity development measures. Law enforcement officers together with judicial staff and forensic scientists show deficient knowledge of advanced forensic approaches both educationally and through consistent training. NFIES bridges this educational deficiency through its establishment of training academies and accreditation programs for colleges linked with NFSU. The educational facilities seek to provide specialized education along with practical training which ensures

⁵⁵ Rebecca Samervel, 'CBI Names Peter's Ex-Wife, Sheena's Two Friends Among 69 Priority Witnesses', *Times of India* (12 March 2025) <https://timesofindia.indiatimes.com/city/mumbai/cbi-names-peters-ex-wife-sheenas-2-friends-among-69-priority-witnesses/articleshow/118902305.cms> accessed 14 April 2025.

⁵⁶ Suresh Foujdar, 'Bhiwani Double Murder: Monu Manesar, 20 Others Named in FIR', *Hindustan Times* (22 May 2023) <https://www.hindustantimes.com/india-news/bajrang-dal-member-named-in-abduction-and-murder-of-two-muslim-men-in-bharatpur-case-police-name-21-suspects-in-fir-101684694598061.html> accessed 14 April 2025.

⁵⁷ Ministry of Home Affairs, *National Forensic Infrastructure Enhancement Scheme*, Press Information Bureau (31 July 2024) <https://pib.gov.in/PressReleasePage.aspx?PRID=2039061> accessed 13 April 2025.

stakeholders gain the required skills for effective ethical handling of forensic evidence in real-world scenarios⁵⁸.

The existing backlog of forensic cases needs immediate expansion of both operational personnel and facility resources in order to decrease it. The forensic laboratories in Kerala hold more than 62,000 unaddressed cases while toxicology and excise and narcotics concerns account for 98.7% of these cases. The large backlog of forensic cases creates prolonged judicial waiting periods which negatively affects public trust in criminal justice systems. NFIES resolves the issue by both creating new laboratories along with recruiting more skilled experts to help achieve quicker results and enhanced evidence examination.⁵⁹

Mandatory accreditation of forensic science laboratories offers a practical and internationally recognised mechanism for improving quality assurance. The National Accreditation Board for Testing and Calibration Laboratories, operating under the Quality Council of India, accredits testing laboratories in accordance with ISO/IEC 17025, the international standard governing the competence of testing and calibration laboratories, and holds Mutual Recognition Arrangements with the International Laboratory Accreditation Cooperation.⁶⁰ Requiring all government forensic science laboratories to obtain NABL accreditation as a condition precedent for the admissibility of their reports in criminal proceedings would create measurable quality incentives, reduce methodological inconsistencies across laboratories, and substantially strengthen the evidentiary credibility of forensic science in Indian courts.⁶¹

For forensic evidence to achieve credibility in legal proceedings both legislation and reforms play an essential role. Courts struggle to admit scientifically valid forensic techniques because of inconsistent procedures and insufficient standardization practices. The legislative framework needs strengthening through precise standards which determine whether forensic evidence will be accepted by courts alongside its quality-based validation processes for establishing its valid weight in trials. National quality standards along with standard operating procedures need development to establish foundational criteria for forensic laboratories.

Public education about forensic technology together with maintaining ethical practices in its usage remains essential for valid enforcement. The powerful method of DNA profiling brings invaluable

⁵⁸ Ibid.

⁵⁹ Rajput, (n 35).

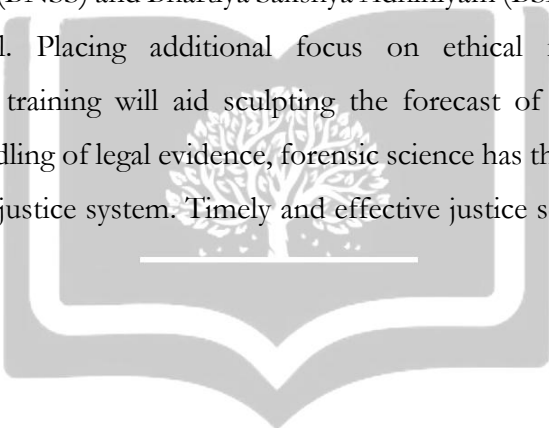
⁶⁰ National Accreditation Board for Testing and Calibration Laboratories, 'Frequently Asked Questions' (NABL India) <<https://nabl-india.org/faq/>> accessed 19 June 2026.

⁶¹ Alok Jain and Prapti Singh, 'Laboratory Accreditation Framework in India (QCI/NABL)' (2024) Training and Capacity Building Cell, Quality Council of India <<https://tcb.qcin.org/wp-content/uploads/2024/05/Laboratory-Accreditation-Framework-in-India.pdf>> accessed 19 June 2026.

productivity to investigations yet causes crucial privacy dilemmas about how data is cared for and misused. The community of legal scholars together with human rights advocates calls for methods which require transparency and accountability when implementing these practices. Public understanding of forensic science boundaries along with ethical supervision of investigative practices will strengthen community trust and protect citizens' individual rights during criminal proceedings⁶²

9. Conclusion

The investigation of justice has been made easier through forensic data science. It uncovers dormant secrets using fingerprints, DNA, and even digital relics. This research details the development of forensic methodology in India, even as there are concerns about the lack of infrastructure, understaffing, and ethical practices. The introduction of new laws like the Bhartiya Nagarik Suraksha Sanhita (BNSS) and Bhartiya Sakshya Adhiniyam (BSA) are indicators of change, despite being superficial. Placing additional focus on ethical frameworks, foundational infrastructure, as well as training will aid sculpting the forecast of forensic science in India. Through the accurate handling of legal evidence, forensic science has the ability to single-handedly restore faith in a nation's justice system. Timely and effective justice serves the greater good and reassures the public.

The logo features a stylized tree with roots and branches, set within a shield-like shape. Below the shield is a wide, open book. The entire emblem is enclosed in a rectangular border.

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⁶² Udogadi (n 31).