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BRIDGING SCIENCE AND LAW: STANDARDIZATION OF FORENSIC PROCEDURES

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ABSTRACT:

The reliability and integrity of forensic evidence form the cornerstone of modern criminal justice systems. As forensic science becomes increasingly central to judicial proceedings, the absence of rigorous, universally accepted protocols creates grave risks of wrongful convictions, miscarriages of justice, and systemic erosion of public trust. This chapter undertakes a comprehensive and comparative examination of the standardization of forensic evidence protocols, exploring the theoretical and institutional frameworks that govern the collection, preservation, analysis, and admissibility of forensic evidence.

The chapter analyses the fundamental rationale for standardization, including the imperatives of accuracy, consistency, and judicial reliability. It then undertakes a detailed comparative study of admissibility standards in two mature common law jurisdictions -the United States of America and the United Kingdom examining landmark judicial decisions and legislative developments. The chapter culminates in a critical analysis of the Indian scenario, engaging with colonial-era statutory frameworks such as the Indian Evidence Act, 1872 (now superseded by the Bharatiya Sakshya Adhiniyam, 2023), the Code of Criminal Procedure, 1973, and the evolving jurisprudence of Indian courts on forensic evidence.

The chapter argues that India stands at a critical juncture demanding comprehensive legislative and institutional reform to ensure that forensic evidence meets consistent standards of scientific reliability, constitutional fairness, and procedural integrity.

Introduction:

Few developments in legal history have been as consequential as the rise of forensic science as a central instrument of criminal justice. The forensic investigator, the forensic laboratory, and the forensic expert witness have become indispensable to the determination of guilt and innocence in modern criminal proceedings. As Mnookin and colleagues have argued, the

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forensic sciences lack the research culture that would enable courts and parties to assess their reliability with confidence a deficiency that demands systematic reform.[3]

The standardization of forensic investigation protocols the establishment and enforcement of scientifically validated, legally recognized procedures governing every phase of forensic investigation, from the crime scene through the forensic laboratory to the expert witness stand is not merely a technical matter of laboratory management. It is a fundamental condition of the rule of law. Comparative study of exclusionary rules demonstrates how different legal systems have grappled with the tension between forensic investigation efficacy and constitutional rights of accused persons.

Pattenden's analysis of expert evidence law across common law jurisdictions illustrates how forensic science has been admitted into courts under different doctrinal frameworks, each with its own strengths and vulnerabilities.[4] The Law Commission of India's 185th Report on the Indian Evidence Act, 1872 identified the need for comprehensive revision of the statutory framework governing expert and forensic evidence, a reform that has been partially realized through the Bhartiya Sakshya Adhiniyam, 2023.

This paper is organized into four principal sections. They analyse the components of standardization of forensic investigation protocols, examining crime scene management, chain of custody, laboratory accreditation under ISO/IEC 17025, method validation, cognitive bias, and reporting standards. It also does comparative analysis regarding norms forensic evidence.

Ensuring Accuracy and Consistency through Standardization of Forensic Protocols

The Forensic Investigation Process: An Overview

Before considering standardization requirements, it is necessary to map the forensic investigation process itself. Roberts and Zuckerman identify five sequential phases that constitute a complete forensic investigation: crime scene recognition and preservation; evidence documentation and recovery; packaging, labelling, and transport; laboratory examination and analysis; and reporting, interpretation, and expert testimony. Each phase is vulnerable to error, contamination, and bias, and each demands its own set of standardized protocols. The integrity of every downstream phase depends critically upon the integrity of the

[3] JL Moonkin et al., The Need for Research Culture in Forensic Sciences,58 UCLA Law Review,725.
[4] R Pattenden, The Law of Expert Evidence (Oxford University Press, 2012).

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preceding one. A DNA profile generated in the most advanced laboratory is worthless and potentially worse than worthless if the biological sample from which it was extracted was contaminated or mislabelled at the crime scene.

The UNODC's guidance for the provision of forensic science services to criminal justice systems recognises this sequential dependency and recommends that quality management frameworks for forensic investigation must span the entire process rather than focusing exclusively on laboratory analysis. The Forensic Science Regulator's Codes of Practice and Conduct in England and Wales operationalize this principle by prescribing standards for each phase of forensic investigation across all major disciplines.

Phase I: Crime Scene Recognition, Preservation, and Documentation Scene Preservation Protocols in Forensic Investigation

The crime scene is the primary source of physical forensic evidence. Standardized crime scene protocols serve three fundamental purposes: preservation of evidence against loss, degradation, or contamination; documentation of the scene in its original condition; and the systematic recovery of forensic exhibits. Scene preservation begins with the establishment of a physical perimeter typically two concentric cordons: an inner cordon surrounding the immediate scene, access to which is strictly limited to the Senior Investigating Officer and specialist forensic investigators; and an outer cordon providing a buffer against unauthorized access. All persons entering the inner cordon must wear personal protective equipment (PPE) disposable coveralls, gloves, overshoes, and face masks to prevent secondary transfer of biological material from investigators to the scene. Every entry and exit must be logged in a scene access register.

The FSR Codes of Practice specify these scene preservation requirements as mandatory standards for forensic crime scene examination in England and Wales. The absence of comparable binding standards in India was specifically noted by the Supreme Court in Tomaso Bruno v State of Uttar Pradesh, where the Court observed that the manner in which forensic evidence is collected in India falls far short of acceptable scientific standards and called for urgent remedial measures.[5]

Discipline-Specific Evidence Recovery Protocols

(a) Biological Evidence and DNA Forensic Investigation

Biological material-like blood, semen, saliva, hair roots, epithelial cells is the most sensitive

[5] Tomaso Bruno v State of Uttar Pradesh, (2015) 7 SCC 178.

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category of forensic evidence. As Dror and Hampikian's research demonstrates, the integrity of biological forensic evidence is vulnerable not only to environmental degradation but also to cognitive factors affecting interpretation.[6] Recovery demands sterile sampling tools used once and discarded; double packaging in paper bags (not plastic, which promotes bacterial growth and DNA degradation); cold chain storage; and scrupulous avoidance of cross-contamination. The Locard Exchange Principle that every contact leaves a trace operates bidirectionally: the suspect may have deposited biological material at the scene, but so may the investigator through secondary transfer, a phenomenon with significant implications for interpretation.

The SWGDAM Interpretation Guidelines address precisely these interpretation complexities, providing best-practice standards for the treatment of DNA mixtures, low template samples, and contamination scenarios in forensic DNA investigation. The Interpol forensic genetics guidelines further provide a framework for harmonising DNA forensic investigation practices across jurisdictions, building upon the foundational scientific framework established by the National Research Council's seminal reports on DNA technology in forensic science.[7]

(b) Fingerprint Evidence Recovery

Latent fingerprint recovery employs a range of techniques depending upon the surface: powder development for non-porous surfaces; cyanoacrylate fuming; ninhydrin, DFO, and physical developer for porous surfaces such as paper. Cole's historical study of fingerprinting illustrates how the discipline developed without the empirical validation framework that modern forensic science demands. The Forensic Science Regulator's Codes govern fingerprint recovery and analysis in England and Wales, including the ACE-V (Analysis, Comparison, Evaluation, Verification) methodology and the qualifications required of fingerprint examiners.

(c) Digital Forensic Investigation

Digital forensic evidence presents unique challenges. The first principle of digital forensic investigation is preservation of the original device without alteration. This requires write-blocking hardware or software that prevents any data being written during examination. Forensic images bit-for-bit copies of original storage media are created using validated imaging tools, with integrity verified through cryptographic hash values (MD5, SHA-256). The

[6] I E Dror and G Hampikian, Subjectivity and Bias in Forensic DNA Mixture Interpretation, 51 Science and Justice 204 (2011).
[7] National Research Council, The Evaluation of Forensic DNA Evidence, (National Academies Press, 1996).

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FSR's Digital Forensics Interim Report identified serious quality concerns across UK digital forensic investigation providers, including use of unvalidated tools, inadequate documentation, and inconsistent reporting practices. The UNODC guidance addresses digital forensic investigation capacity building for developing countries, including India, recommending mandatory write-blocking and hash verification as non-negotiable minimum standards.

(d) Ballistic Evidence

Projectiles and cartridge cases recovered from scenes must be packaged in rigid containers to preserve toolmark evidence. Chemical primer residue (FSR) analysis requires rapid sampling within six hours of discharge. The Identification of Prisoners Act, 1920 now supplemented by the Criminal Procedure Identification Act, 2022 provides the legal authority for taking various forensic samples from accused persons in India, but neither statute specifies the forensic investigation procedures to be followed in collecting them.

Phase II: Chain of Custody in Forensic Investigation

The Legal and Scientific Significance of Chain of Custody

The chain of custody is the cornerstone of forensic evidence integrity. It is the documented, unbroken record of every person who has had possession of, or access to, a forensic exhibit from the moment of recovery through laboratory analysis to production in court. Without an intact chain of custody, it is impossible to exclude the possibility that a forensic exhibit has been tampered with, substituted, or contaminated and the probative value of any forensic analysis performed upon it is fundamentally impugned. This dual scientific and legal function is comprehensively analysed in treatment of the authentication requirement for physical evidence.

The Law Commission of India's 185th Report emphasized the inadequacy of existing statutory provisions for protecting the continuity of forensic evidence, recommending amendments to the Indian Evidence Act to incorporate express chain of custody requirements. These recommendations have only been partially incorporated in the Bharatiya Sakshya Adhiniyam, 2023, and the gap between legislative aspiration and investigative practice remains substantial, as the NCRB data consistently demonstrates.

Judicial Development of Chain of Custody Doctrine in India: Indian courts have developed, through a substantial body of jurisprudence under the Code of Criminal Procedure, 1973 and the Indian Evidence Act, 1872, highly specific requirements for the sealing and custody of

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forensic exhibits. In Ram Bihari Yadav v State of Bihar[8], the Supreme Court held that the prosecution must establish that forensic exhibits were despatched to the FSL in a sealed condition and that the seal was intact upon receipt. In State of Rajasthan v Teja Ram[9], the Court held that failure to seal forensic exhibits immediately upon recovery creates a serious doubt about the integrity of the forensic investigation. In such one similar case, the accused was acquitted in part because of the prosecution's failure to properly seal and document the forensic exhibits recovered from the crime scene.

Phase III: Forensic Laboratory Analysis Standards for Accuracy Laboratory Accreditation

Accreditation is the formal third-party validation that a forensic laboratory meets defined competence and quality standards is the internationally recognized mechanism for ensuring laboratory quality. The global benchmark is ISO/IEC 17025:2017, which specifies requirements for the competence, impartiality, and consistent operation of testing and calibration laboratories. Forensic-specific accreditation bodies apply ISO/IEC 17025 supplemented by discipline-specific technical requirements. In the United States, ANAB provides accreditation for forensic laboratories; in the United Kingdom, UKAS provides accreditation under the ISO/IEC 17025 framework, further regulated by the FSR's Codes of Practice. In India, the National Accreditation Board for Testing and Calibration Laboratories (NABL) provides accreditation, but a substantial number of state FSLs remain unaccredited, a persistent deficiency documented by the Bureau of Police Research and Development.

Validation of Forensic Methods

Beyond laboratory accreditation, the specific methods used in forensic analysis must be empirically validated. The NAS 2009 report found that several commonly used forensic disciplines including bite mark analysis, hair microscopy, and footwear analysis lacked adequate scientific validation. The PCAST 2016 report went further, finding that multiple feature-comparison disciplines did not meet foundational validity standards, and that the known error rates for disciplines such as fingerprint comparison and firearms toolmark analysis were insufficiently characterized. Saks and Koehler predicted this paradigm shift in their landmark 2005 article, arguing that the forensic identification sciences would face a fundamental methodological reckoning. Raghavan's survey of forensic science in India

[8] Ram Bihari Yadav v State of Bihar (1998) 4 SCC 517.
[9] State of Rajasthan v Teja Ram (1999) 3 SCC 507.

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confirms that comparable validation deficits affect many of the methods employed by Indian FSLs.[10]

Cognitive Bias in Forensic Examination

A critical and under-appreciated threat to the accuracy of forensic investigation results is cognitive bias the systematic distortion of an examiner's judgments resulting from prior knowledge, expectations, or contextual information. An influential experimental study demonstrated that experienced forensic DNA examiners' interpretation of mixture profiles was materially influenced by irrelevant case context a striking demonstration of contextual bias in an ostensibly objective forensic discipline. Thompson's comprehensive analysis of the legal implications of cognitive bias research argues that courts must develop procedural safeguards including information management protocols ('linear sequential unmasking') and blind verification procedures to mitigate the effects of bias on forensic investigation outcomes.[11]

Forensic Reporting Standards

The forensic investigation process culminates in the expert report. The FSR Codes of Practice prescribe the required contents of expert reports in England and Wales, including the method used, its validation status, quality controls applied, the results and critically, the significance of those results, expressed with appropriate indication of uncertainty. The PCAST report recommended that forensic examiners adopt probabilistic or likelihood ratio reporting rather than categorical match/exclusion conclusions, a recommendation endorsed in the SWGDAM guidelines for DNA forensic interpretation. India has yet to develop any formal guidance on reporting standards for forensic investigations, and the range of language and certainty levels employed by Indian forensic experts varies enormously.

Admissibility Standards for Forensic Evidence in the United States of America

1. The Regulatory and Institutional Context

The admissibility of forensic investigation results in American courts is governed by a complex interplay of federal and state evidentiary rules, constitutional provisions, and specific

[10] R K Raghavan, Forensic Science in India: State of the Art ,3 NALSAR Law Review 1, (2011)
[11] W C Thompson, How Should the Law Treat Cognitive Bias in Forensic Examiners? (M M Meijer et al.), The Cognitive Psychology of Expert Testimony (Springer, 2021).

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legislation addressing particular forensic disciplines. The United States lacks a single national regulatory authority for forensic science comparable to the UK Forensic Science Regulator. Regulation occurs through voluntary accreditation, discipline-specific federal programmes. The DNA Identification Act, 1994 authorises the CODIS national database and imposes mandatory ANAB accreditation upon all DNA laboratories participating in CODIS, the most comprehensive federal forensic investigation quality standard in American law.

Murphy's investigation into the forensic DNA system reveals the paradox of the American approach: DNA forensic investigation, backed by the NRC reports and robust quality assurance standards, is a model of regulated forensic investigation; yet other forensic disciplines operate with minimal regulatory oversight, a disparity that the NAS 2009 report found to be systemically damaging to the integrity of forensic evidence.

2. The Frye Standard: Forensic Methods and Scientific General Acceptance

The first judicially developed standard for the admissibility of forensic scientific evidence in the United States emerged from Frye v United States. In Frye, the District of Columbia Circuit excluded testimony based on a systolic blood pressure deception test (an early form of polygraph used in the forensic investigation of a murder charge), holding that the scientific principle underlying a forensic method must be 'sufficiently established to have gained general acceptance in the particular field in which it belongs.' The Frye standard's appeal lay in its deference to scientific consensus. Its weakness was its conservatism: it potentially excluded novel but reliable forensic methods that had not yet gained community consensus, while admitting established but unreliable methods that enjoyed consensus without scientific merit.[12] Analysis illustrates how the 'general acceptance' standard for fingerprint forensic evidence was established through a circular process of judicial acceptance generating scientific acceptance, rather than through independent empirical validation. This insight that legal acceptance of a forensic method does not guarantee its scientific reliability is central to the critique developed by Saks and Koehler and given institutional form in the NAS and PCAST reports.

3. The Daubert Framework

The Frye standard was superseded in federal courts by the Supreme Court's landmark decision in Daubert v Merrell Dow Pharmaceuticals, Inc.[13] The case arose from the attempted admission of expert testimony on the teratogenic effects of the drug Bendectin in forensic investigation proceedings, where the plaintiffs' experts relied upon studies that enjoyed neither publication nor general scientific acceptance. The Supreme Court held that the Federal Rules of Evidence

[12] Frye v. United States, 293F.1013(D.C. Cir.1923).
[13] Daubert v. Merrell Dow Pharm.,509 U.S.579 (1973).

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Rule 702 had displaced Frye, and that the trial judge bears responsibility as a 'gatekeeper,' ensuring that expert testimony is 'not only relevant, but reliable.'

The Court identified four non-exhaustive factors relevant to the reliability of a forensic method: (i) whether the theory or technique has been empirically tested; (ii) whether it has been subjected to peer review and publication; (iii) the known or potential error rate and the existence of standards controlling the technique's operation; and (iv) whether it enjoys general acceptance within the relevant scientific community. As Edmond has observed, the Daubert framework represents a significant epistemological advance over Frye in its insistence upon the empirical norms of science as the benchmark for legal reliability.

The current text of Federal Rule of Evidence 702, as amended with effect from December 2023, requires the proponent of expert forensic testimony to demonstrate to the court, by a preponderance of the evidence, that: the expert's knowledge will help the trier of fact; the testimony is based on sufficient facts or data; the testimony is the product of reliable principles and methods; and the expert's opinion reflects a reliable application of those principles and methods to the facts. The 2023 amendment's clarification of the preponderance burden places the affirmative onus squarely on the prosecution in criminal cases to establish the reliability of each forensic investigation method relied upon.

Daubert Applied to Specific Forensic Investigation Disciplines

DNA Forensic Investigation : DNA forensic evidence occupies the most secure position under the Daubert framework. The molecular biology and population genetics underlying DNA identification were thoroughly evaluated by the NRC in 1992 and 1996, providing the scientific foundation for universal acceptance of properly conducted DNA forensic investigations. The DNA Identification Act, 1994 mandates ANAB accreditation for all CODIS-participating laboratories and requires compliance with FBI Quality Assurance Standards, creating a comprehensive quality framework for DNA forensic investigation. Daubert challenges to DNA evidence are rarely successful where standard collection and analysis procedures have been followed, although chain-of-custody challenges and contamination arguments in individual investigations continue to be raised.

The Innocence Protection Act, 2004 introduced a statutory right to post-conviction DNA testing for federal prisoners, enabling individuals convicted on the basis of faulty forensic investigations including investigations conducted before modern DNA standards were developed to seek exoneration. Murphy's work documents the broader systemic implications of DNA exonerations for the assessment of all forensic evidence, not just DNA, in criminal

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proceedings.

Fingerprint Forensic Investigation under Daubert: Fingerprint identification has a long history of courtroom acceptance predating Daubert, but the discipline has faced growing reliability scrutiny since the NAS 2009 report. The PCAST 2016 report found that while latent fingerprint analysis has a foundational validity based on the individuality of friction ridge skin, the subjective comparison step (the ACE-V process) lacked adequate empirical data on examiner reliability and error rates.

Digital Forensic Investigation under Daubert: Digital forensic evidence presents particular challenges under the Daubert framework. The tools and methods of digital forensic investigation are generally well-validated by their manufacturers and subjected to peer review in the discipline's literature. However, the pace of technological change creates a continuous validation gap: new devices and operating systems emerge faster than forensic tools designed to examine them. Analysis of law and technology in India highlights how these challenges are amplified in developing country contexts where digital forensic investigation capacity is limited and tool validation is inconsistently documented. The Daubert framework's requirement that the proponent demonstrate method reliability is particularly important for digital forensic investigations involving novel applications of established tools or emerging analytical techniques.

Pattern Evidence Disciplines: Bite Marks and Hair Microscopy: The Daubert framework's most dramatic impact has been on pattern-matching forensic disciplines that were accepted for decades without adequate validation. The PCAST 2016 report found that bite mark analysis a forensic discipline widely used in American criminal investigations had not been scientifically validated as a foundational discipline, and that available studies demonstrated significant false positive rates. Mnookin and colleagues specifically identified bite mark analysis as an example of the broader failure to develop a research culture within forensic science. Similarly, the NAS report found that microscopic hair analysis used extensively in American forensic investigations lacked adequate validation, leading to a landmark FBI review of cases and widespread exonerations.

These systemic failures confirm the central argument that wrongful convictions attributable to flawed forensic investigations are not merely individual tragedies but symptoms of systemic forensic evidence quality failures that post-conviction review mechanisms are ill-equipped to remedy.

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The Indian Scenario: Forensic Evidence, Forensic Investigation, and the Law

Overview: The State of Forensic Investigation in India

India's forensic investigation landscape is characterized by vast scale, significant regional diversity, severe infrastructural limitations, and a statutory framework that, until 2024, predated modern forensic science by a century and a half. The NCRB's Crime in India reports confirm that India's criminal justice system processes tens of millions of cases annually, a significant proportion involving physical evidence requiring forensic analysis. Yet the forensic investigation infrastructure available to support this caseload is grossly inadequate: the Bureau of Police Research and Development has consistently documented chronic understaffing, outdated equipment, and severe caseload backlogs across state FSLs.

Understanding the Indian forensic investigation scenario requires examining four interconnected dimensions: the statutory framework governing forensic evidence admissibility; the institutional architecture of forensic investigation; the jurisprudence of Indian courts on forensic evidence; and the constitutional constraints on forensic investigation methods. The entry into force on 1 July 2024 of the Bharatiya Nyaya Sanhita, 2023, the Bharatiya Nagarik Suraksha Sanhita, 2023, and the Bharatiya Sakshya Adhiniyam, 2023 marks the most significant legislative modernization of India's criminal law architecture since independence, with profound implications for forensic investigation practice.

Critical Challenges in the Indian Scenario

1. **Legislative Gaps:** India lacks dedicated legislation on forensic science standards comparable to the DNA Identification Act (USA) or the Forensic Science Regulator Act (UK). The BSA and the BNSS, while representing a significant modernization of the evidence and procedure framework, do not establish a comprehensive standard-setting mechanism for forensic science. The lapse of the DNA Technology Regulation Bill is a significant missed opportunity. There is a pressing need for comprehensive forensic evidence legislation that establishes admissibility criteria, mandates laboratory accreditation, regulates the qualifications of forensic experts, and creates an independent regulatory body with enforcement powers.
2. **Resource Constraints and Manpower Deficits:** The operational challenges facing Indian forensic science are inseparable from the broader challenges of under-resourced criminal justice institutions. State FSLs are chronically understaffed, equipped with

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outdated technology, and subject to inadequate training budgets. The salary and service conditions of forensic scientists in government service are often not competitive with private sector alternatives. The cumulative effect is a serious shortage of qualified, experienced forensic personnel, which directly impairs the quality and timeliness of forensic analysis.

3. **Judicial Awareness and Cross-Examination:** Even where forensic evidence is properly collected and analysed, its effective use in adversarial proceedings requires judges and advocates who are capable of critically evaluating scientific claims. The level of scientific literacy in the Indian bar and judiciary varies enormously. Defence counsel in many cases lack the resources to retain independent forensic experts to challenge prosecution forensic evidence, creating a significant asymmetry in adversarial effectiveness. Judicial training programmes on forensic science, currently offered on a limited basis by the National Judicial Academy, need to be substantially expanded and systematized.
4. **The Constitutional Dimension:** Right Against Self-Incrimination is the constitutional dimension of forensic evidence collection in India intersects with Article 20(3) of the Constitution, which guarantees that no person accused of an offence shall be compelled to be a witness against himself. The Supreme Court in Selvi v. State of Karnataka (2010) 7 SCC 263 held that the administration of narcoanalysis, brain mapping (P300 BEAP), and polygraph tests without the consent of the accused violates Article 20(3) and the right to privacy under Article 21. The Court drew a careful distinction between testimonial compulsion (prohibited) and physical compulsion (generally permitted for identification purposes). The implications of Selvi for forensic evidence collection are significant. While the judgment does not affect the compulsory collection of fingerprints, blood samples, or DNA under the Identification of Prisoners Act and the BNSS, it restricts psychophysiological techniques that purport to reveal the contents of an accused's mind. The Court also emphasized that any forensic test performed on an individual requires standardized, scientifically validated protocols and independent expert oversight to be constitutionally permissible.

Comparative analysis

A comparative examination of the forensic evidence frameworks of the United States, the United Kingdom, and India reveals both a shared common law heritage and significant structural divergences. All three jurisdictions share the fundamental principle that forensic

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expert opinion is admissible as a category of relevant evidence, and all three rely upon the adversarial system as the primary mechanism for testing the reliability of such evidence. However, beyond these shared foundations, the approaches diverge significantly.

The United States, through the Daubert trilogy and Rule 702 FRE, has developed the most explicit and procedurally structured reliability analysis for forensic evidence. The trial judge functions as an active gatekeeper whose Daubert rulings are substantive legal decisions reviewable on appeal. This framework, however, has been criticized for producing inconsistent results across circuits and jurisdictions, and for its limitations in addressing the systemic quality problems identified by the NAS and PCAST.

England and Wales occupy an intermediate position: lacking the explicit codification of Daubert, but increasingly moving toward a reliability-based analysis through the Criminal Practice Directions, the Forensic Science Regulator's standards, and the developing common law. The statutory empowerment of the Forensic Science Regulator through the 2021 Act represents an institutional innovation that has no equivalent in the United States or India, and provides a regulatory backstop to the court-based admissibility analysis.

India, with its vast and varied forensic science infrastructure, complex federal structure, and colonial-era legislative foundations, presents the most acute challenges. The BSA and the BNSS represent a significant legislative modernization, and Section 105 BNSS's mandatory forensic investigation requirement is an innovative provision that, if properly implemented, could transform the quality of forensic investigation in India. However, without an independent statutory regulator, mandatory accreditation requirements, and a judicial reliability threshold, the systemic problems of inconsistency, under-resourced laboratories, and unqualified experts will persist.

Conclusion

The standardization of forensic evidence protocols is not a technical regulatory matter tangential to the concerns of law and justice; it is a foundational prerequisite of a just criminal justice system. In system where forensic evidence increasingly determines the outcome of criminal trials, the absence of rigorous, enforced standards for the collection, analysis, and presentation of such evidence poses an existential threat to the reliability of verdicts and the legitimacy of judicial institutions.

The comparative study undertaken in this chapter demonstrates that mature common law jurisdictions have, over decades of legislative development and judicial refinement, created increasingly structured frameworks for ensuring the reliability of forensic evidence. The

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Daubert framework in the United States, though imperfect, has sensitized American courts and parties to the scientific dimensions of forensic evidence in a way that has no equivalent in India. The Forensic Science Regulator model in England and Wales represents an institutional innovation of considerable promise, providing a statutory backstop to the admissibility analysis and a proactive quality assurance mechanism.

India stands at a critical juncture. The entry into force of the BSA and the BNSS in July 2024 represents the most significant reform of the Indian evidence and procedure framework since independence. The BNSS's mandatory forensic investigation requirement in serious cases is an innovative and potentially transformative provision. But legislative innovation alone cannot remedy the systemic failures of infrastructure, manpower, and institutional culture that afflict Indian forensic science. Without a statutory Forensic Science Regulator, mandatory laboratory accreditation, minimum expert qualification standards, and a judicially-enforceable reliability threshold for forensic evidence, the structural vulnerabilities of the Indian system will persist, and innocent individuals will continue to suffer wrongful conviction while the guilty evade justice.

The time has come for Parliament to enact comprehensive Forensic Science legislation that establishes India's forensic science infrastructure on a constitutionally sound, scientifically rigorous, and internationally comparable footing. The justice of the criminal process and the rights of every person who enters the Indian criminal justice system as accused, victim, or witness demands nothing less.