Page 3027 - 3041 **DOI:** *https://doi.org/10.63108/IJLMH.12768*

INTERNATIONAL JOURNAL OF LAW MANAGEMENT & HUMANITIES

[ISSN 2581-5369]

Volume 9 | Issue 4

2026

Forensic and Other Modern Tools and Techniques Used in Criminal Investigation: A Comparative Study of Investigation Practices in the Criminal Justice Systems of India, the United States, the United Kingdom, France and Russia

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ABSTRACT

With the evolution of crime, forensic science and other investigative technologies have become necessary to the investigation of offences. Technologies such as DNA profiling, fingerprinting, digital forensics, artificial intelligence, facial recognition and biometrics have improved the reliability, accuracy and efficiency of criminal investigation. This paper analyses the criminal investigation practices followed in the criminal justice systems of India, the United States, the United Kingdom, France and Russia, with particular attention to the adoption of forensic and other modern technologies. It also examines the legal framework governing forensic investigation and the challenges that impede the use of forensic investigative techniques. Finally, it identifies best practices capable of improving scientific investigation in India.

Keywords: *Forensic Science, Criminal Investigation, Modern Investigative Techniques, Comparative Criminal Justice, Digital Forensics, Artificial Intelligence*

I. INTRODUCTION

Scientific and technological change has reshaped the investigative process across the world. Forensic science and modern technologies such as DNA profiling, fingerprinting, digital forensics, artificial intelligence and biometric identification now play an essential part in collecting, analysing and presenting the evidence by which a case is proved.[1]

Each country has developed its own approach to incorporating forensic methods and investigative technology into its criminal justice system. The United States and the United

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[1] THE PRACTICE OF CRIME SCENE INVESTIGATION 25-40 (John Horswell ed., 2004).

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Kingdom rely on advanced forensic laboratories and national databases, while France and Russia follow different models of investigation supported by their own forensic organisations. India has also strengthened scientific investigation through the Bharatiya Nyaya Sanhita, 2023,[2] the Bharatiya Nagarik Suraksha Sanhita, 2023,[3] and the Bharatiya Sakshya Adhiniyam, 2023.[4]

This article compares the use of forensic and other modern tools and techniques in criminal investigation in India, the United States, the United Kingdom, France and Russia. It examines the investigative process in each system, the legal framework governing forensic investigation, and the difficulties and best practices associated with forensic-led criminal investigation.

II. EVOLUTION OF FORENSIC SCIENCE AND MODERN INVESTIGATION TECHNIQUES

Forensic science has grown from a set of conventional techniques of criminal detection into a multidisciplinary field that forms an important part of the modern criminal investigation process. Earlier, crime investigation rested mainly on confessions, witness testimony and circumstantial evidence, and the absence of scientific verification contributed to wrongful convictions. The scientific approach to criminal investigation ultimately changed the administration of criminal justice by making the evaluation of evidence more objective, reliable and accurate.[5]

The nineteenth and twentieth centuries saw considerable developments in forensic science through fingerprint identification, forensic pathology, ballistics, toxicology and DNA profiling. Fingerprinting is among the oldest methods of forensic personal identification, whereas DNA profiling is one of the most recent and most discriminating techniques available to criminal investigation. These innovations have greatly enhanced the reliability of criminal investigation and of forensic evidence in court proceedings.[6]

Advances in technology in the twenty-first century have expanded the field further. Contemporary methods of investigation include digital and cyber forensics, artificial intelligence, facial recognition, biometrics, cloud forensics, blockchain forensics, drone-based surveillance, geographic information systems and three-dimensional reconstruction of the crime scene. These technologies assist in the investigation of complex offences such as cybercrime,

[2] The Bharatiya Nyaya Sanhita, 2023 (Act 45 of 2023).
[3] The Bharatiya Nagarik Suraksha Sanhita, 2023 (Act 46 of 2023).
[4] The Bharatiya Sakshya Adhiniyam, 2023 (Act 47 of 2023).
[5] PAUL L. KIRK, CRIME INVESTIGATION: PHYSICAL EVIDENCE AND THE POLICE LABORATORY 1-15 (John I. Thornton ed., 2d ed. 1974).
[6] RICHARD SAFERSTEIN & TIFFANY ROY, CRIMINALISTICS: AN INTRODUCTION TO FORENSIC SCIENCE 3-20 (13th ed. 2020).

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terrorism, organised crime, financial fraud and transnational crime, where conventional methods of investigation may not be sufficient.[7]

Recognising the increasing significance of scientific investigation, a number of States have strengthened their forensic capacity through forensic laboratories, national DNA databases, automated fingerprint identification systems and, more recently, investigative tools based on artificial intelligence. India has likewise sought to encourage scientific investigation through the Bharatiya Nyaya Sanhita, 2023, the Bharatiya Nagarik Suraksha Sanhita, 2023, and the Bharatiya Sakshya Adhiniyam, 2023.

The development of forensic science therefore illustrates a wider movement from traditional to scientific criminal investigation. These improvements have increased the effectiveness and reliability of criminal justice systems by making the investigation and prosecution of offences more accurate.

III. Forensic and other modern tools and techniques

A. Meaning and scope of forensic science

Forensic science is the application of scientific techniques and principles to the investigation of criminal cases and to the administration of justice. It assists investigating authorities in identifying the perpetrator, examining the evidence, reconstructing the crime scene and presenting scientific evidence in court. Modern forensic science draws on biology, chemistry, medicine, physics, computer science and artificial intelligence in order to make the criminal inquiry accurate and unbiased.[8]

Technological innovation has significantly widened the scope of the discipline. In addition to traditional laboratory-based testing, forensic science now encompasses digital forensics, cyber investigation, biometrics, artificial intelligence and other technology-based investigative techniques.

B. Traditional forensic tools

Traditional forensic tools remain the backbone of the investigative process and are used widely by law enforcement agencies across the world. They assist in gathering, analysing and interpreting the physical evidence found at crime scenes.

[7] Max M. Houck & Jay A. Siegel, Fundamentals of Forensic Science 15-42 (3d ed. 2015).
[8] Houck & Siegel, *supra* note 7, at 3-12.

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DNA profiling is among the most discriminating forensic techniques for identifying suspects and victims from biological material such as blood, saliva, hair and tissue. It is used extensively in cases of murder, rape and kidnapping and in disaster victim identification.[9]

Fingerprinting is among the oldest forensic methods of identifying individuals, and rests on the uniqueness and persistence of friction ridge patterns.[10]

Ballistics involves the scientific examination of firearms, bullets and cartridge cases in order to determine the weapon used in the commission of an offence. It is of particular importance in cases of homicide, terrorism and organised crime.

Forensic toxicology involves the detection of poisons, drugs, alcohol and other chemical substances in the body, and assists in determining the cause of death or the fact of intoxication.

Forensic pathology deals with medico-legal autopsies conducted to determine the cause, manner and time of death.

C. Modern investigative tools and techniques

Advances in technology have improved criminal investigation by producing new investigative tools that make the process more efficient and more accurate.

Artificial intelligence assists investigators in analysing large volumes of data, identifying patterns of offending, narrowing the field of suspects through predictive analysis, and conducting digital investigations.

Facial recognition technology compares facial features drawn from closed-circuit television images or photographs against a database in order to identify suspects or missing persons.

Closed-circuit television surveillance and video analytics have become established investigative tools, since they assist in reconstructing the crime scene, tracking suspects and corroborating the statements of witnesses.

Drone technology is used for aerial surveillance, documentation of crime scenes, border monitoring and search and rescue operations.

Biometric identification uses fingerprints, iris scans, facial scans and voice patterns in the identification and verification of suspects.

Three-dimensional crime scene reconstruction uses specialised software to recreate the scene so that investigators and courts may better understand the sequence of events.

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[9] SAFERSTEIN & ROY, *supra* note 6, at 255-287.

[10] BARRY A.J. FISHER & DAVID R. FISHER, TECHNIQUES OF CRIME SCENE INVESTIGATION 197-220 (9th ed. 2022).

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D. Digital and cyber forensic tools

The increase in cybercrime has made it necessary to apply specialised digital forensic tools to the collection and analysis of electronic evidence.

Computer forensics is the extraction and analysis of data from computers and other storage devices, including electronic mail, file contents, browsing history and system logs.

Mobile forensics enables law enforcement agencies to recover call records, messages, photographs, location data, social media communications and deleted data from mobile telephones and tablets.

Cloud forensics concerns the collection and preservation of digital evidence stored on remote servers.

Network forensics analyses network traffic and communication records in order to identify cyber-attacks, intrusions and data breaches.

Blockchain and cryptocurrency investigation assists law enforcement agencies in tracing transactions in virtual currencies connected with money laundering, terrorist financing, ransomware and other cybercrime.[11]

These tools have contributed substantially to criminal investigation by making the gathering of evidence more accurate, enabling scientific analysis and increasing the authenticity of the material placed before the court. Their use nevertheless requires appropriate legal safeguards, qualified forensic experts and compliance with settled procedural standards.

IV. Role of Forensic and Modern Tools in Criminal Investigation

Crime scene investigation. The first step in any criminal investigation is securing and documenting the crime scene. Investigators recover both physical and digital evidence while taking care to avoid contamination. Proper documentation and preservation of the scene is essential to the integrity of the evidence.[12]

Evidence collection and preservation. Using forensic techniques, specialists gather biological traces, fingerprints, weapons, documents, electronic devices and other material, which is then documented, packaged and preserved.[13]

[11] Eoghan Casey, Digital Evidence and Computer Crime: Forensic Science, Computers and the Internet 35-70 (3d ed. 2011).
[12] Fisher & Fisher, *supra* note 10, at 65-108.
[13] Houck & Siegel, *supra* note 7, at 91-118.

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Scientific analysis of evidence. The material gathered is analysed in forensic laboratories through DNA testing, fingerprint examination, ballistics, toxicological testing, forensic pathology and questioned document examination.[14]

Digital and technological investigation. Alongside traditional methods, investigators now employ computer forensics, mobile forensics, examination of closed-circuit television footage, facial recognition, artificial intelligence, cloud forensics and blockchain analysis.[15]

Identification of suspects. Offenders are identified through scientific evidence such as DNA, fingerprints, biometric data, digital footprints and images captured by video surveillance.[16]

Reconstruction of the offence. Forensic science allows the offence to be reconstructed from physical evidence, digital evidence and scientific analysis, which in turn allows investigators to establish the sequence of events.

Forensic science in criminal trials. Forensic reports and the opinions of forensic experts assist courts in evaluating scientific evidence. The admission of such evidence depends on statutory requirements and on established forensic practice.

V. LEGAL FRAMEWORK GOVERNING FORENSIC INVESTIGATION

A. International standards on forensic investigation

Several international instruments and bodies have underlined the importance of scientific investigation, respect for human rights and the quality of forensic evidence. The United Nations Convention against Transnational Organized Crime, 2000, the Convention on Cybercrime, 2001, and the Disaster Victim Identification Guide issued by INTERPOL each promote the use of scientific methods and international cooperation in criminal investigation.[17]

B. Indian legal framework

i. Bharatiya Nagarik Suraksha Sanhita, 2023

The Bharatiya Nagarik Suraksha Sanhita gives forensic science a statutory place in criminal investigation. Section 176(3) requires the officer in charge of a police station, on receipt of information relating to an offence punishable with imprisonment for seven years or more, to cause a forensic expert to visit the crime scene to collect forensic evidence and to cause the process to be videographed. The obligation takes effect from a date to be notified by the State

[14] SAFERSTEIN & ROY, *supra* note 6, at 33-56.
[15] CASEY, *supra* note 11, at 73-105.
[16] HOUCK & SIEGEL, *supra* note 7, at 201-230.
[17] United Nations Convention against Transnational Organized Crime, Nov. 15, 2000, 2225 U.N.T.S. 209; Convention on Cybercrime, Nov. 23, 2001, E.T.S. No. 185; INTERPOL, *Disaster Victim Identification Guide* (2023).

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Government within five years, and the proviso directs a State that lacks the necessary forensic facility to notify the use of the facility of another State until its own is developed. The provision seeks to improve the quality of investigation by placing the collection of evidence, and its scientific examination, on a statutory footing.[18]

ii. Bharatiya Sakshya Adhiniyam, 2023

The Bharatiya Sakshya Adhiniyam restates the law of evidence and gives statutory recognition to electronic and digital records.

Section 2(1)(d) defines a document so as to include electronic and digital records.

Sections 61 to 63 recognise electronic records as documentary evidence, section 63 prescribing the conditions of admissibility and the Schedule prescribing the form of the accompanying certificate.

Section 39 provides that the opinion of an expert, including a forensic expert, is a relevant fact in judicial proceedings, the class of experts having been widened to include persons specially skilled in any other field.

Together these provisions govern the evidentiary treatment of forensic reports, DNA profiles, digital records and expert opinion.[19]

iii. Bharatiya Nyaya Sanhita, 2023

While the Bharatiya Nyaya Sanhita deals principally with offences and punishments, many of the offences it defines, including murder, rape, terrorist acts, cybercrime and organised crime, in practice call for scientific investigation through DNA profiling, digital forensics, ballistics and allied forensic techniques if a prosecution is to succeed.

C. Admissibility of forensic and electronic evidence

The admission of forensic evidence depends on its relevance, authenticity and reliability and on a properly maintained chain of custody. Electronic evidence must in addition comply with the requirements of the Bharatiya Sakshya Adhiniyam, 2023. Courts act on forensic reports where the scientific examination has been properly conducted and the material has not been tampered with during the investigation.[20]

[18] The Bharatiya Nagarik Suraksha Sanhita, 2023 (Act 46 of 2023), s. 176(3) and proviso.
[19] The Bharatiya Sakshya Adhiniyam, 2023 (Act 47 of 2023), ss. 2(1)(d), 39, 61-63 and sch.
[20] The Bharatiya Sakshya Adhiniyam, 2023 (Act 47 of 2023), ss. 61, 63.

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D. Judicial decisions

In *Anvar P.V. v. P.K. Basheer*, the Supreme Court held that an electronic record adduced as secondary evidence is not admissible unless the statutory certificate is furnished, and emphasised the authenticity and reliability of such evidence.[21]

In *Arjun Panditrao Khotkar v. Kailash Kushanrao Gorantyal*, a three-judge Bench affirmed that position, holding the certificate to be a condition precedent to the admissibility of an electronic record adduced as secondary evidence, while clarifying that no certificate is required where the original device is itself produced.[22]

E. Rights of the accused and privacy concerns

Forensic and other modern investigative practices must be reconciled with constitutional rights. Investigating agencies are under a duty to ensure that the techniques they employ are consistent with the right to privacy, the right to a fair trial and the procedural safeguards contained in Articles 20, 21 and 22 of the Constitution of India.

In *Justice K.S. Puttaswamy (Retd.) v. Union of India*, the Supreme Court held that the right to privacy is a fundamental right protected by Article 21 of the Constitution of India, a holding of direct significance for biometric collection, surveillance and the retention of forensic data.[23]

VI. Investigation practices in India

A. Criminal investigation procedure

Criminal investigation in India is carried out principally by the police under the Bharatiya Nagarik Suraksha Sanhita, 2023. It begins with the registration of the First Information Report and proceeds through examination of the crime scene, collection of evidence, forensic examination, identification of suspects, arrest and the filing of the final report before the competent court. Scientific investigation has become an indispensable part of that process, particularly in serious offences.

B. Role of the police and forensic science laboratories

Police officers secure the crime scene and collect physical and digital evidence with the assistance of forensic scientists. The material is then sent to Forensic Science Laboratories for scientific examination. Those laboratories carry out DNA profiling, fingerprint examination,

[21] *Anvar P.V. v. P.K. Basheer*, (2014) 10 SCC 473.
[22] *Arjun Panditrao Khotkar v. Kailash Kushanrao Gorantyal*, (2020) 7 SCC 1.
[23] *Justice K.S. Puttaswamy (Retd.) v. Union of India*, (2017) 10 SCC 1.

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ballistic analysis, toxicological analysis, cyber forensic analysis and questioned document examination, and so assist the investigating agency in establishing the facts of the case.[24]

C. Use of forensic and modern investigative tools

Indian investigating agencies increasingly rely on DNA profiling, fingerprinting, ballistics, toxicology, video analysis, cyber and mobile forensics, facial recognition supported by artificial intelligence, and the documentation of crime scenes by drone.

D. Legal recognition of scientific investigation

The Bharatiya Nagarik Suraksha Sanhita, 2023 has strengthened forensic-led investigation by requiring, once the State Government has issued the necessary notification, the attendance of a forensic expert at the scene of an offence punishable with imprisonment for seven years or more, and by requiring the collection of evidence to be videographed. The provision reflects a legislative intention to improve the quality and reliability of criminal investigation through scientific methods.

The Bharatiya Sakshya Adhiniyam, 2023 has in turn recognised the value of expert opinion and of electronic records, which facilitates the presentation of forensic and digital evidence in criminal cases.

E. Landmark judicial decisions

Indian courts have given close attention to scientific evidence. In *Selvi v. State of Karnataka*, the Supreme Court held that the involuntary administration of narcoanalysis, the polygraph test and the Brain Electrical Activation Profile test on an accused person violates Articles 20(3) and 21 of the Constitution, and that such techniques may not be administered without consent.[25]

Mukesh v. State (NCT of Delhi), arising out of the Delhi gang rape of December 2012, illustrates the weight that DNA profiling, forensic examination and medical evidence may carry in a capital trial.[26]

F. Challenges in India

Notwithstanding recent legislative change, several difficulties persist in the forensic system in India. They include a shortage of forensic experts, delay in the delivery of laboratory reports, the inadequacy of forensic facilities in some States, gaps in the training of investigating officers,

[24] DIRECTORATE OF FORENSIC SCIENCE SERVICES, MINISTRY OF HOME AFFAIRS, GOVERNMENT OF INDIA, *Forensic Science Laboratories in India*.
[25] *Selvi v. State of Karnataka*, (2010) 7 SCC 263.
[26] *Mukesh v. State (NCT of Delhi)*, (2017) 6 SCC 1.

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and the growth of cybercrime, which calls for specialised forensic knowledge. These difficulties must be addressed if criminal investigation is to be conducted properly.

VII. Comparative study of investigation practices in selected countries

The table below sets out the principal features of investigation practice in the five jurisdictions considered in this article.

Particulars	India	United States	United Kingdom	France	Russia
Criminal justice system	Adversarial	Adversarial	Adversarial	Mixed, with an inquisitorial pre-trial phase	Inquisitorial in character at the pre-trial stage
Principal investigating agency	State police, Central Bureau of Investigation, National Investigation Agency, Directorate of Enforcement	Federal Bureau of Investigation; State and local police	Territorial police forces; National Crime Agency	*Police judiciaire* acting under the *procureur de la Republique*; a *juge d'instruction* conducts the investigation where a judicial investigation is opened, which is compulsory for the most serious offences	Investigative Committee of the Russian Federation, together with investigators of the Ministry of Internal Affairs and of the Federal Security Service, jurisdiction being allocated by article 151 of the Criminal Procedure Code
Investigation process	First Information Report, crime scene examination, collection of evidence, forensic analysis, arrest, charge sheet, trial	Complaint, crime scene processing, scientific examination, federal or State investigation, prosecution	Crime report, investigation, forensic examination, review by the Crown Prosecution Service, trial	Investigation conducted under the supervision of the prosecutor or, where opened, the investigating judge, scientific examination, judicial inquiry, trial	Investigation opened by the competent investigative body, forensic examination, review by the prosecutor, trial
Role of the police	Collect evidence, question suspects and coordinate with Forensic Science Laboratories	Police collect evidence; the Federal Bureau of Investigation investigates federal and serious offences	Police investigate offences and work with accredited forensic laboratories	Police collect evidence under the supervision of the prosecutor or the investigating judge	Police assist investigators; major investigations are conducted by the investigative bodies

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Particulars	India	United States	United Kingdom	France	Russia
Role of forensic laboratories	State and Central Forensic Science Laboratories and regional laboratories analyse physical and digital evidence	The Federal Bureau of Investigation Laboratory and State crime laboratories provide forensic services	Accredited public and private forensic laboratories assist investigations, subject to the Forensic Science Regulator's codes	The Service National de Police Scientifique, which since 2021 has taken over the functions of the Institut National de Police Scientifique, and the Institut de Recherche Criminelle de la Gendarmerie Nationale	The Forensic Centre of the Ministry of Internal Affairs and the Russian Federal Centre of Forensic Science under the Ministry of Justice
Traditional forensic tools	DNA profiling, fingerprint examination, ballistics, toxicology, forensic pathology	DNA profiling, fingerprint analysis, firearms identification, toxicology	DNA profiling, fingerprint examination, ballistics, pathology	DNA analysis, toxicology, ballistics, pathology	DNA profiling, fingerprint analysis, ballistics, toxicology
Modern investigative tools	Artificial intelligence, facial recognition, drones, closed-circuit television, biometrics	Artificial intelligence, facial recognition, predictive policing, drones, biometric systems	Artificial intelligence, facial recognition, automatic number plate recognition, closed-circuit television surveillance	Digital reconstruction, facial recognition, investigation assisted by artificial intelligence	Surveillance assisted by artificial intelligence, biometric identification, cyber investigation
Digital and cyber forensic tools	Mobile forensics, computer forensics, cloud forensics, blockchain analysis	Digital forensics, network forensics, cloud investigation, cryptocurrency tracing	Digital forensic laboratories and cybercrime units	Digital forensics and cyber investigation units	Cyber forensic laboratories and digital intelligence systems
DNA database	Expanding use; no comprehensive nationwide operational database	Combined DNA Index System (CODIS)	National DNA Database (NDNAD)	Fichier National Automatise des Empreintes Genetiques (FNAEG), governed by articles 706-54 and following of the Code de procedure penale	Federal genomic information database established under the Federal Law on State Genomic Registration in the Russian Federation, 2008

Particulars	India	United States	United Kingdom	France	Russia
Fingerprint system	National Automated Fingerprint Identification System (NAFIS)	Next Generation Identification (NGI), which replaced the Integrated Automated Fingerprint Identification System (IAFIS)	IDENT1	Automated fingerprint identification system	National fingerprint identification system
Crime scene management	Police and forensic experts jointly examine and preserve evidence	Dedicated crime scene investigation teams	Specialist crime scene investigation units	Scientific police acting under judicial supervision	Specialised forensic response teams
Artificial intelligence	Emerging use in facial recognition, crime analytics and surveillance	Extensive use in predictive policing, digital investigation and data analytics	Used in facial recognition, video analytics and intelligence gathering	Limited but increasing use	Integrated with surveillance and cyber investigation
Electronic evidence	Governed by the Bharatiya Sakshya Adhiniyam, 2023	Governed by the Federal Rules of Evidence	Governed by the Police and Criminal Evidence Act 1984 and related legislation	Governed by the Code de procedure penale	Governed by the Criminal Procedure Code of the Russian Federation
Legal framework	Bharatiya Nyaya Sanhita, 2023; Bharatiya Nagarik Suraksha Sanhita, 2023; Bharatiya Sakshya Adhiniyam, 2023	Federal Rules of Criminal Procedure; Federal Rules of Evidence	Police and Criminal Evidence Act 1984; Criminal Procedure and Investigations Act 1996	Code de procedure penale	Criminal Procedure Code of the Russian Federation, 2001

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Particulars	India	United States	United Kingdom	France	Russia
Distinctive feature	Section 176(3) of the Bharatiya Nagarik Suraksha Sanhita, 2023 requires a forensic expert to attend the scene, and the collection of evidence to be videographed, in offences punishable with seven years or more, from a date to be notified by the State Government within five years	Extensive forensic infrastructure supported by integrated national databases	Extensive closed-circuit television coverage and a statutory forensic regulator	Judicial supervision of the investigation where a judicial investigation is opened	Centralised investigation supported by State forensic institutions
Principal challenges	Delay in laboratory reports, shortage of experts, inadequate infrastructure	Privacy concerns, algorithmic bias, cybersecurity threats	Budgetary constraints, privacy concerns, management of digital evidence	Length of judicial investigations and procedural complexity	Concerns as to independence, and modernisation of forensic infrastructure

Table 1: Investigation practices in India, the United States, the United Kingdom, France and Russia

VIII. COMPARATIVE ANALYSIS

A. Similarities

Each of the five jurisdictions recognises the significance of forensic science in criminal investigation. All employ DNA profiling, fingerprint analysis, ballistics and digital forensics, and all rely on forensic laboratories for the collection and analysis of evidence. Scientific evidence increases the accuracy of investigation and, in consequence, the reliability of the criminal process.[27]

B. Differences

The United States and the United Kingdom possess extensive forensic infrastructure and national databases and make considerable use of artificial intelligence. France places the more serious investigations under judicial supervision, while Russia concentrates investigation and forensic examination in centralised State institutions. India has strengthened its forensic

[27] SAFERSTEIN & ROY, *supra* note 6, at 22-40.

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framework through the Bharatiya Nagarik Suraksha Sanhita, 2023, but continues to develop its forensic infrastructure and technological capacity.[28]

C. Best practices for India

India could improve its criminal investigation process by drawing on international practice, in particular by establishing further forensic laboratories, recruiting additional forensic experts, applying artificial intelligence to forensic work, improving coordination between the police and forensic experts, ensuring the timely delivery of forensic reports, and promoting international cooperation in cross-border investigation.

IX. Challenges in the application of forensic and modern technologies

Considerable as the advances in forensic science have been, several difficulties hinder their effective application in criminal investigation.

Insufficient forensic capacity. Forensic laboratories face delay arising from inadequate infrastructure, ageing instrumentation and case backlogs.

Shortage of skilled experts. The want of trained forensic scientists affects both the quality and the speed of investigation.

Technological difficulties. The rapid development of cybercrime, artificial intelligence, encrypted communication and virtual currencies presents continuing problems for investigators.

Legal and privacy concerns. Facial recognition, artificial intelligence, biometric collection and digital surveillance raise questions of privacy and of the protection of fundamental rights. Investigating agencies must ensure compliance with Articles 20 and 21 of the Constitution of India and with the Bharatiya Sakshya Adhiniyam, 2023.

Cross-border offences. Cybercrime and transnational organised crime frequently involve more than one country and therefore require cooperation between States.

X. Conclusion

Forensic science and modern investigative technology have become essential to effective criminal investigation. DNA profiling, fingerprint analysis, digital forensics, artificial intelligence and facial recognition improve the accuracy of investigation and assist courts in deciding cases on reliable evidence.

[28] HOUCK & SIEGEL, *supra* note 7, at 45-68.

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This comparative study shows that India, the United States, the United Kingdom, France and Russia all rely on forensic science, but that their methods of investigation and their technological capacities differ. The United States and the United Kingdom possess extensive forensic infrastructure and national databases, while India has strengthened scientific investigation through the Bharatiya Nyaya Sanhita, 2023, the Bharatiya Nagarik Suraksha Sanhita, 2023, and the Bharatiya Sakshya Adhiniyam, 2023.

India nevertheless continues to face inadequate forensic infrastructure, a shortage of trained experts, delay in the delivery of forensic reports and a rising incidence of cybercrime. By adopting international best practices and investing in modern forensic technology, India can further improve the quality of criminal investigation and strengthen its criminal justice system.

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