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FORENSIC FALLIBILITY: UNDERSTANDING HUMAN FAULT LINES IN INDIA'S JUSTICE SYSTEM

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ABSTRACT

The field of forensics is widely regarded as scientific cornerstone of criminal justice system in India. However, it's practical application remains struck between infallibility & scepticism. The motivation behind this research stems from the growing reliance coupled with misplaced scepticism questioning its impact on criminal justice while overlooking how its perceived objectivity can hide the flaws in human judgement & institutional vulnerabilities. Existing scholarship majorly focuses on forensic techniques' scientific accuracy & reliability neglecting the human & institutional limitations that affect their practical use. Addressing this gap, the research seeks to assess perception of legal actors towards forensic errors, interpretation of its evidentiary value, and identifying areas which requires reform to boost the reliability and accountability. The research adopts an empirical methodology using a structured questionnaire administered to individuals, including legal professionals, academicians, law students and police personnel. A mixed-method approach combining quantitative descriptive analysis and qualitative thematic analysis is employed to capture both patterns and deeper insights. The findings suggests that human error particularly contamination on crime scene, lapses in chain of custody, and investigative pressure is perceived as a significant factor affecting forensic reliability. Respondents also highlighted misinterpretation risk which leads to wrongful convictions and revealed the prevalence of misconceptions such as the "infallibility" of forensic science, alongside shortcomings in statistics and scientific knowledge. While there is notable faith in techniques like DNA profiling, but doubts linger about its procedural weaknesses and over-reliance. The research concludes that central issue lies not in forensic science itself, but its application & suggests that strengthening of forensic reliability demands both institutional reforms and improved epistemic capacity among legal actors. While it offers empirical insight into perceptions of forensic fallibility in India, its findings are constrained by a relatively small and purposive sample, suggesting the need for broader, more diverse research in future.

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INTRODUCTION

Forensic Science, often mistaken for criminalistics, is application of scientific methods & principles to investigate crimes or examine evidence for purpose of presenting it in court of law. Field of forensic science being wide, includes many areas like handwriting, drug or DNA profile analysis or fingerprints. These areas help in ascertaining answers to questions like who was at the crime scene? What happened? Who did it? When did it happen & where?

Nobody knows how much accuracy does the opinions & conclusions offered by DNA analysts, blood spatter specialists, firearm examiners, odontologists, document examiner or any other forensic scientists hold. However, courtrooms today deserve more blame for frequently crediting unsupported testimony of forensic experts & precedents on reliability matters instead of demanding proof of reliability from scientific studies.[3]

The empirical research explores level of awareness of legal actors regarding human and institutional vulnerabilities in forensic processes. It aims to analyze understanding of respondents about issues such as crime scene contamination, cognitive bias, technical errors by forensic experts, misinterpretation of forensic results, institutional capacity, constraints and risk of wrongful convictions. This study further seeks to identify the gaps in perception and suggest reforms that may enhance the accountability and reliability of forensic justice. This issue hold significant social relevance as wrongful convictions directly harm innocent individuals and undermine the public trust in justice system. With increasing role of forensic evidence in shaping perceptions & public opinions of guilt, understanding how error occurs is vital for ensuring fairness in investigations.

"It is a capital mistake to theorise before having all the evidence. It biases the judgement"
(Conan Doyle, 1981, p 28)

Legally, the topic is highly relevant as courts have started placing reliance on forensic reports routinely but still there is limited uniformity in standards for judicial evaluation or collection, preservation of such evidence .Identification of gaps in handling and reasoning can reinforce due process, evidentiary reliability and constitutional safeguard under article 20,21,22.This

[3] Koehler, Jonathan J., Forensics or Fauxrensics? Ascertaining Accuracy in the Forensic Sciences (November 8, 2017).
Koehler, J. J. (Winter 2017). Forensics or fauxrensics? Ascertaining accuracy in the forensic sciences. Arizona State Law Journal, 49, 1369-1416. , Available at SSRN: https://ssrn.com/abstract=2773255 or http://dx.doi.org/10.2139/ ssrn.2773255 Accessed on 13.11.25

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research contributes to reforms aimed at improving forensic accountability ,judicial scrutiny and expert testimony standards .

LITERATURE REVIEW

1. **Du, Mingxiao. (2017)** provides systematic examination of various kinds of errors that occurs within forensic science, placed focus as to how these errors impact the credibility, accuracy of forensic evidence in legal systems. This article classifies errors and explains error evaluation mechanisms & their implication for forensic reliability. It recognises the need for standardisation, accreditation & scientific literacy.[4]
2. **Bondarenko (2024)** contributed in understanding techniques of error minimization & strategies by providing in-depth analysis of most frequent errors & framing new approaches to address them. Emphasis was placed on cognitive biases, lack of training among forensic experts & lack of uniform standards along with conveying how introduction of new technologies have helped in reduction of error. While focusing on the ethical aspects of forensic experts' work he stated to be independence, transparency or accountability as main pillars.[5]
3. **Saks & Koehler (2005)** argued that forensic science is on the verge of major paradigm shift from subjective experience to the probabilistic methods. They expressed the view by saying that assumption of uniqueness of forensic science is getting weakened by the evidence of errors in actual cases and proficiency testing. They criticise that the examination of forensic techniques are heavily relied on the examiner judgement instead of measurable scientific standards. They emphasise that cognitive bias, human interpretation, overshadow, scientific rigger, and expose vulnerabilities existing within the system.[6]
4. **D'Anna et al. (2023) :** This paper identified many critical issues in chain of custody related to the seizure of forensic evidence. The issues included in adequate packaging of evidence, poorly sealed packages having holes in sealed evidence, crime scene contamination, and absence of certification requirements. It also mentions about chain of custody maintained via electronic devices and explained how technological progress

[4] Du, Mingxiao. Analysis of errors in forensic science. *Journal of Forensic Science and Medicine* 3.3 (2017): 139-143. https://journals.lww.com/jfsm/fulltext/2017/03030/analysis_of_errors_in_forensic_science.6.aspx (accessed on 12.11.25).
[5] Bondarenko,Valeriia ; Theory and Practice of Forensic Science and Criminalistics. Issue 4 (37) ISSN 1993-0917 eISSN 2708-5171 https://khrife-journal.org/index.php/journ (accessed on 8.11.25)
[6] Saks, M. J., & Koehler, J. J. (2005). The coming paradigm shift in forensic identification science. *Science, 309*(5736), 892–895. https://doi.org/10.1126/science.1111565 (accessed on 17.11.25).

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along with benefits has also led to vulnerabilities of information contained in electronic files.[7]

5. **Brandon et al. (2020)** studied how jurors respond when forensic experts mentions error rates or likelihood ratios during their testimony. The researchers mainly tested 2 forensic evidence; Fingerprint identification & voice analysis. They surveyed 897 mock jurors online & provided them written expert testimony with or without providing additional information about error rates. They found jurors trusted fingerprint analysis presented rather than voice comparison. This research depicted how jurors rely heavily on their pre-conceived notions & prior beliefs about forensic techniques.[8]
6. **Michael J. et al (2015):** This article offers a practical perspective of the challenges faced by judges while interpreting forensic evidence and how in certain cases the legal process failed to recognise differences between the guilty and innocent defendants. Sometimes, impartial testimony admitted also leads to injustice.[9]
7. **Prapti Kothari (2023)** mentions significant challenges which includes outdated forensic setup, inconsistent standards, lack of proper training programs, absence of clear guidelines for handling forensic evidence and accreditation of FSL and these issues results in unreliable results, evidence mishandling and contamination which severely impacts criminal cases outcomes jeopardising justice.[10]
8. **Rokade, S. P., & Shrivastava, G. (2022)** noted that over past 25 years forensic science have undergone many significant changes & tech tools are now more central to crime investigation & prosecution which has also been highlighted by Criminal Justice Reform Committee. In his research, he credited DNA as 'gold standard' stating that it is undoubtedly more reliable than eyewitness testimony and attributed reductionism in third degree to narco-analysis.[11]

[7] D'Anna, T., Puntarello, M., Cannella, G., Scalzo, G., Buscemi, R., Zerbo, S., & Argo, A. (2023). The Chain of Custody in the Era of Modern Forensics: From the Classic Procedures for Gathering Evidence to the New Challenges Related to Digital Data. *Healthcare (Basel, Switzerland)*, *11*(5), 634. https://doi.org/10.3390/healthcare11050634 (accessed on 17.11.25).

[8] Garrett, B.L., Crozier, W.E. and Grady, R. (2020), Error Rates, Likelihood Ratios, and Jury Evaluation of Forensic Evidence. J Forensic Sci, 65: 1199-1209. https://doi.org/10.1111/1556-4029.14323 (accessed on 17.11.25).

[9] Saks, M. J., & Votruba, A. M. (2015). And the courts have been utterly ineffective. Judges' Journal, 54(3), 28-31. https://heinonline.org/HOL/Page?handle=hein.journals/judgej54&id=110&collection=journals&index= (accessed on 15.11.25).

[10] Kothari, Prapti, Exploring the Role of Forensic Science in Indian Criminal Justice System (September 7, 2023). Available at SSRN: https://ssrn.com/abstract=4565177 or http://dx.doi.org/10.2139/ssrn.4565177 (accessed on 7.11.25).

[11] Rokade, S. P., & Shrivastava, G. (2022). An efficacy of forensic technology in crime investigation and administration of justice: Narco analysis and DNA mapping. International Journal of Health Sciences, 6(S3), 6312–6326. https:// doi.org/10.53730/ijhs.v6nS3.7397 (accessed on 5.11.25).

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9. **Yadav PK, et al. (2024)** draws attention towards the significance of technological advancements such as next-generation sequencing (NGS) also known as *high throughput sequencing*, automated-fingerprint identification system & other digital forensic tools which aids in the investigation of sophisticated cybercrimes which improves it's efficiency as well as broadens its scope.[12]
10. **John Alldredge (2015)** argued that the "CSI Effect" leads to a bias in the favour of defence in criminal trials as jurors having been influenced by the forensic media expects to see some sort of forensic evidence and maybe less likely to convict the accused, if such evidence is not presented[13] while **Ling et al. (2021)** examined CSI effect and after empirical study found that there is no evidence of CSI effect in particular. However, Forensic evidence does seem to influence decisions on guilt and punishment indicating it's importance.[14]
11. **Ribeiro et al. (2019)** concluded that people don't blindly trust forensic evidence, opposite of what the CSI effect theory claims. They are of view that forensic evidence includes a lot of human judgement and is error-prone. People also have different beliefs regarding the accuracy of forensic techniques. DNA is considered as highly reliable by people & other methods like fingerprint analysis to be less reliable. To sum up, the study presents the view of jurors being entered into court room with preconceived notions about the accuracy and erroneous nature of forensic science[15].
12. **Edward J. et al.(1983)** concluded that forensic laboratories often produce incomplete or inaccurate results with high error rates in some tests. They suggested that jurors overestimate the reliability of forensic evidence, however, empirical studies show otherwise suggesting that critical scrutiny is done by them.[16]
13. **Dror & Charlton (2006)** conducted field experiment, and presented evidence before fingerprint experts for examination without providing any contextual information.

[12] supra note 1
[13] Alldredge, John (2015) "The "CSI Effect" and Its Potential Impact on Juror Decisions," Themis: Research Journal of Justice Studies and Forensic Science: Vol. 3, Article 6. https://doi.org/10.31979/THEMIS.2015.0306 https:// scholarworks.sjsu.edu/themis/vol3/iss1/6 (accessed on 18.11.25).
[14] Shichun Ling, Jacob Kaplan, Colleen M. Berryessa(2020), The importance of forensic evidence for decisions on criminal guilt,Science & Justice,Volume 61, Issue 2,2021,Pages 142-149,ISSN 1355-0306, https://doi.org/10.1016/ j.scijus.2020.11.004. https://www.sciencedirect.com/science/article/pii/S1355030620303117 (accessed on 17.11.25).
[15] Ribeiro, G., Tangen, J. M., & McKimmie, B. M. (2019). Beliefs about error rates and human judgment in forensic science. Forensic Science International, 297, 138–147. https://doi.org/10.1016/j.forsciint.2019.01.034 (accessed on 18.11.25) .
[16] Imwinkelried, E. J. (1983). The standard for admitting scientific evidence: critique from the perspective of juror psychology. Villanova Law Review, 28(Issues & 4), 554-571. https://digitalcommons.law.villanova.edu/cgi/viewcontent.cgi?article=2405&context=vlr (accessed on 17.11.25).

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Their data represented a trend that providing irrelevant contextual information can lead to biased decisions by experts[17]. However, strikingly different view surfaced in the study conducted by **Stevenage & Bennett (2017)[18]** who found that irrelevant contextual information alone doesn't distorts or creates bias. However, even the knowledge of results of DNA test impacts decisions in fingerprint analysis.

14. **Dror & Hampikian (2011)[19]** presented DNA evidence to 17 forensic experts but didn't provide any contextual information, reached to the conclusion that only 1 out of 17 agreed with forensic experts already exposed to such information. 16 examiners couldn't conclude exclusion of suspect without irrelevant contextual forensic information.

1.2 Identified Research Gap

Indian scholarship disproportionately focuses on the scientific reliability of forensic evidence instead of searching for human, cognitive, and institutional limitations. Very limited work explores how future legal professionals understand forensic vulnerabilities, do they play a important role in evidence interpretation. No structured analysis is there on how understanding forensic evidence contributes to paralysed justice system.

1.3 Research Objectives

1. To assess perceptions of legal actors regarding human & institutional errors affecting the forensic process in India.
2. To examine how interpretation of forensic evidence is done b lawyers, police personnel and other legal actors & how misinterpretation may influence outcomes.
3. To identify gaps and recommend reforms to enhance forensic reliability and strengthen judicial scrutiny.

[17] Dror, I. E., & Charlton, D. (2006). Why experts make errors. *Journal of Forensic Identification*, *56*(4), 600. https:// www.researchgate.net/profile/Itiel-Dror/publication/248440075_Why_Experts_Make_Errors/links/53f356fe0cf2da87974469e5/Why-Experts-Make-Errors.pdf (accessed on 15.11.25).

[18] Stevenage, S. V., & Bennett, A. (2017). A biased opinion: Demonstration of cognitive bias on a fingerprint matching task through knowledge of DNA test results. *Forensic science international*, *276*, 93-106. https://doi.org/10.1016/ j.forsciint.2017.04.009 (accessed on 14.11.25).

[19] Dror, I. E., & Hampikian, G. (2011). Subjectivity and bias in forensic DNA mixture interpretation. *Science & Justice*, *51*(4), 204-208. https://www.sciencedirect.com/science/article/abs/pii/S1355030611000967 (accessed on 18.11.25).

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1.4 Research Questions

1. What are the major human errors with regards to handling and analysing forensic evidence in Indian context?
2. How do judges & jurors do interpretation of forensic evidence, and what epistemically responsibilities do they bear?
3. What reforms are crucial to address the identified institutional and interpretive challenges?

1.5 Key variables & Parameters of Study

VARIABLE TYPE	VARIABLE NAME	PARAMETERS OF STUDY
Independent Variable 1	Human Error in Forensic Processes	Measured through responses on extent of human mistakes,pressure on experts, cognitive bias and misinterpretation due to media influence
Independent Variable 2	Crime Scene & Evidence Handling Quality	Measured by frequency of contamination, mishandling & chain of custody lapses
Moderating Variable	Over-trust or misinterpretation of Forensic Evidence	Measured through responses on legal or judicial over-reliance & CSI Effect
Independent Variable 3	Institutional & Laboratory Capacity	Measured through perceptions of lab errors, systemic failures & need for reform
Dependent Variable	Perceived Forensic Reliability & Risk of Wrongful Conviction	Measured through likelihood ratings of wrongful conviction, trust in techniques & belief in necessity of reforms

2. METHODOLOGY AND SAMPLING

This research adopts an empirical, survey- based design incorporating both quantitative (close ended questions) and qualitative (open ended questions) methods. This combined approach helps in comprehensive understanding of respondent awareness and attitudes.

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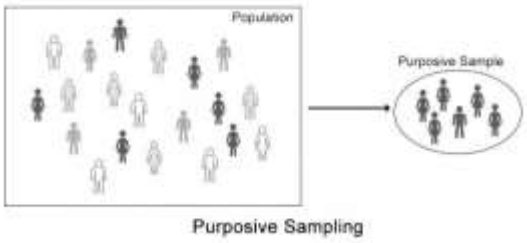
Sampling Method



Purposive Sampling

Purposive sampling approach was used to target individuals having familiarity with forensic science and exposed to legal processes. It included primarily law, students, academicians. Opinion of advocates, legal consultants, Police officials was also taken for high quality-research.

Sample of 50 respondents was taken.

Source : *statisticalaid.com*

3. SURVEY DESIGN AND CODING

3.1 Aim of Survey

The initial step in the survey design was to clearly identify what the study intended to examine.The survey aimed to gather insights on : • how forensic evidence handling is done

- how legal actors interpret forensic evidence & findings
- how procedural or human lapses may contribute to wrongful convictions This made sure only relevant themes are included in the survey.

3.2 Question framing

Number of Questions	15 questions
Type of questions	10 - Close ended & 5 - open ended
Nature of questions	Close ended questions : Likert scale,MCQ based, rating based Open ended questions : Comment based
Precautions taken : (For ensuring validity & reliability)	1. Questions were kept short & simple 2. Complex legal terminologies and legal jargons avoided 3. Each questions addressed only one issue to prevent ambiguity

3.3 Careful drafting

The questionnaire underwent a careful drafting to ensure that no questions were repeated and survey flow was logical. necessary changes were made before final distribution.

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3.4 Mode of Data Collection

The survey was conducted using Google forms which ensured respondent confidentiality and easy distribution. Participation was voluntary and the respondents were informed that their identities would not be disclosed.

3.5 Analysis Plan after data collection

The collected data will be analysed using -

- Quantitative descriptive analysis (percentages, pie charts, coding of closed responses)
- Qualitative thematic analysis (Braun & Clarke method) for opens ended responses.

3.6 Coding

LIKERT SCORE	INDICATOR
5	Strongly Agree/Very High Extent/Very Frequently
4	Agree/High Extent/Frequently
3	Neutral/Moderate Extent/Sometimes
2	Disagree/Low Extent/Rarely
1	Strongly Disagree/No Extent/ Never

4. DATA ANALYSIS AND INTERPRETATION

4.1 QUANTITATIVE ANALYSIS

4.1.1 DESCRIPTIVE ANALYSIS

I have analysed my collected data in two way approach - I have done mean calculation measuring central tendency and for graphical representation used ring charts or bar graphs.

4.1.1.1 Extent to which Human error affects forensic reliability

Likert Score	Meaning	Frequency	Percentage	Score × Frequency
5	Very High Extent	15	27.8%	75
4	High Extent	28	51.9%	112

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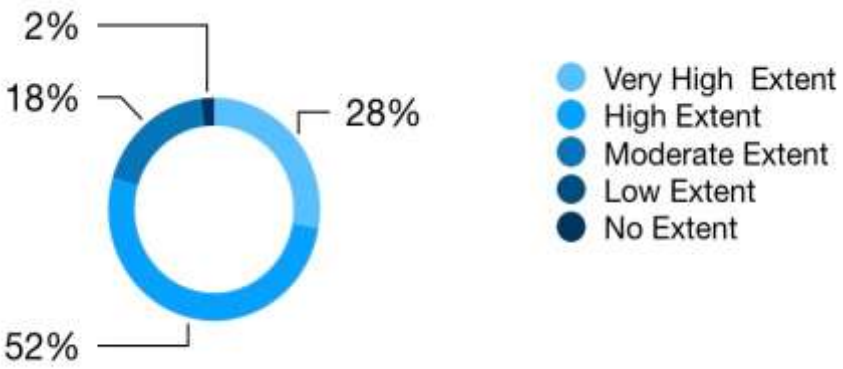
3	Moderate Extent	10	18.5%	30
2	Low Extent	0	0%	0
1	No Extent	1	1.9%	1
TOTAL	-	54	100%	218

Total Respondents = N Mean = Σ (Score × Frequency) / N

Mean = 218/54

= 4.04



A majority of the respondents i.e 79.7%(very high extent - 27.8% + high extent - 51.9%) believes reliability of forensic evidence in question can be attributed to human error. 18.5% feels human error to be the cause to moderate extent.Only 1.9% believes that it is not human error affecting reliability. The calculated mean score is 4.04(out of 5) which indicates that respondents perceive human error as significant factor affecting forensic reliability.

2. Influence of Forensic Media & CSI Effect on legal actors

Likert Score	Meaning	Frequency	Percentage	Score × Frequency
5	Strongly Agree	15	27.78%	75
4	Agree	21	38.89%	84
3	Neutral	15	27.78%	45
2	Disagree	2	3.70%	4

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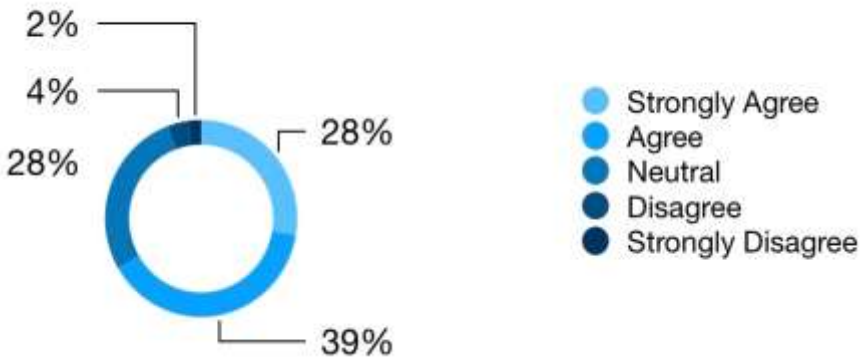
1	Strongly Disagree	1	1.85%	1
TOTAL	-	54	100%	209

Mean= 209/54

= 3.87



The majority of respondents, 66.67% (27.78% Strongly Agree + 38.89%) , are in agreement with the statement . 27.78 % were neither supportive nor against forensic media influence while 5.55% disagreed with the statement. The mean score of 3.87 indicates overall high agreement about popular crime shows creating unrealistic expectations about forensic justice.

3. Frequency of Compromised Crime Scene procedures

Likert Score	Meaning	Frequency	Percentage	Score × Frequency
5	Very Frequently	9	16.67%	45
4	Frequently	33	61.11%	132
3	Sometimes	12	22.22%	36
2	Rarely	0	0%	0
1	Never	0	0%	0
TOTAL	-	54	100%	213

Mean = 213/54

= 3.94

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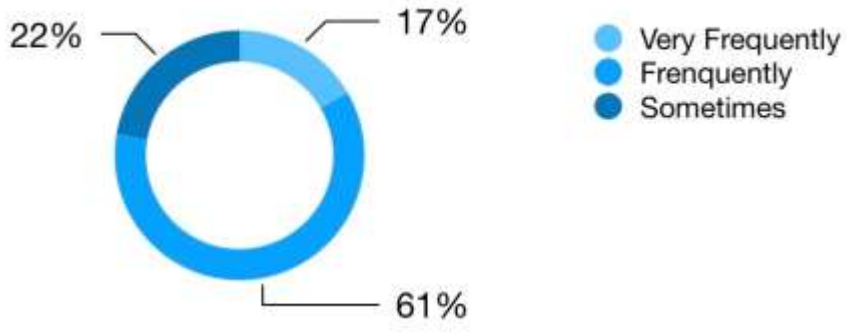
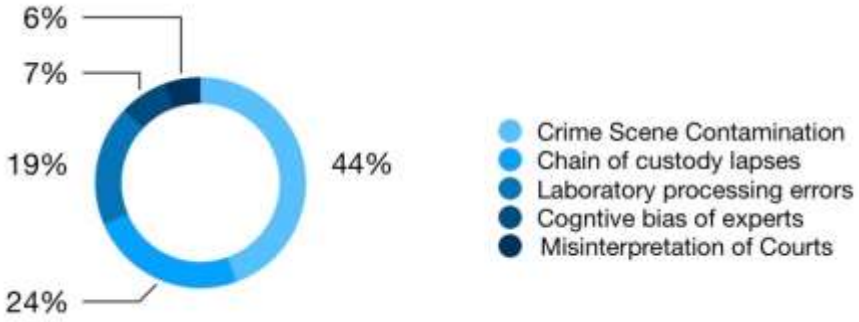


A strong consensus is there, with 77.78% of respondents (16.67% very frequently + 61.11% frequently) choosing answer in higher end of scale (score > 3), believing that contamination occurs frequently or very frequently. The mean score of 3.94 is significantly above the scale's midpoint of 3.0/5 , indicating an overall belief that because of mishandling and contamination , crime scene procedures are frequently compromised.

4. Belief regarding most common source of forensic error

Since, this question is categorical, mean & likert score are not applicable.

Source of Forensic Error	Raw Frequency	Percentage (%)
Crime scene contamination	24	44.44%
Chain of custody lapses	13	24.07%
Laboratory processing error	10	18.52%
Cognitive bias of experts	4	7.41%
Misinterpretation of courts	3	5.56%



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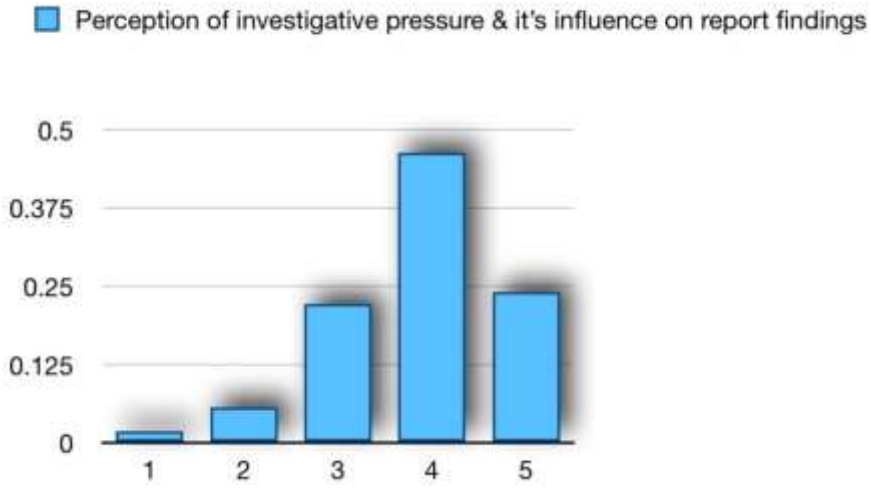
The most commonly believed forensic error source considered is crime scene contamination, selected by 44.44% of the respondents. The second most common source is lapses in chain of custody, accounting for 24.07% responses, hinting upon procedural issue on crime site and during transfer are considered major failure points. 18% of the respondents believes that laboratory processing of forensic evidence is prone to errors while some believe (7.41%) that it is cognitive bias of experts being root of all cause. Very few respondents (5.56%) believes courts misinterpretation to be the main cause.

5. Pressure Factor on investigators influencing report findings

This was rating based question analysed in form of bar graph.

Rating	Percentage (%)
1	1.9%
2	5.6%
3	22.2%
4	46.3%
5	24.1%



Combined, 70.4% of the respondents have rating of 4 or 5 exerting agreement & strong agreement. The highest single response was 46.3% for rating of 4 , indicating strong consensus that pressure is a factor. Only a very small percentage of respondents i.e 7.5 % (1.9% + 5.6%) having rating 1 & 2 showed disagreement. A substantial portion , 22.2% took a neutral stance. Overall, widespread perception among respondents suggests pressure from investigators or quick case closure demands significantly influence findings & interpretation u forensic experts.

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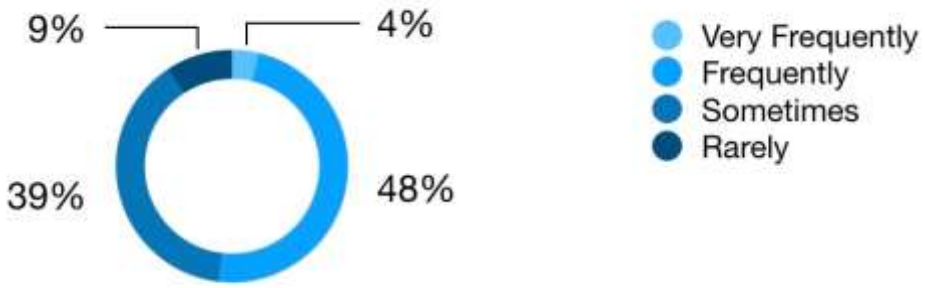
6. Assessing views regarding over- trustfulness on forensic science

Likert Score	Meaning	Frequency	Percentage	Score × Frequency
5	Very Frequently	2	3.70%	10
4	Frequently	26	48.15%	104
3	Sometimes	21	38.89%	63
2	Rarely	5	9.26%	10
TOTAL	-	54	100%	187

Mean = 187/54

= 3.46



Substantial majority of respondents considers over - trustfulness as frequent issue.Combined % for those who perceive it to occur frequently or very frequently is 51.85% (48.15% + 3.70 %) . The single largest category is “frequently” at 48.15% suggesting this as prevailing view. 38.89% of the respondents believe that only sometimes over reliance is placed & only a small minority of 9.26% selected “rarely”. Surprisingly, no respondent selected score lower than 2. The calculated mean score of 3.46 confirms perception of over- trustfulness in forensic science.

7. Likeliness of misinterpretation leading to wrongful conviction

Likert Score	Meaning	Frequency	Percentage	Score × Frequency
5	Very Likely	5	9.3%	25
4	Likely	28	51.9%	112

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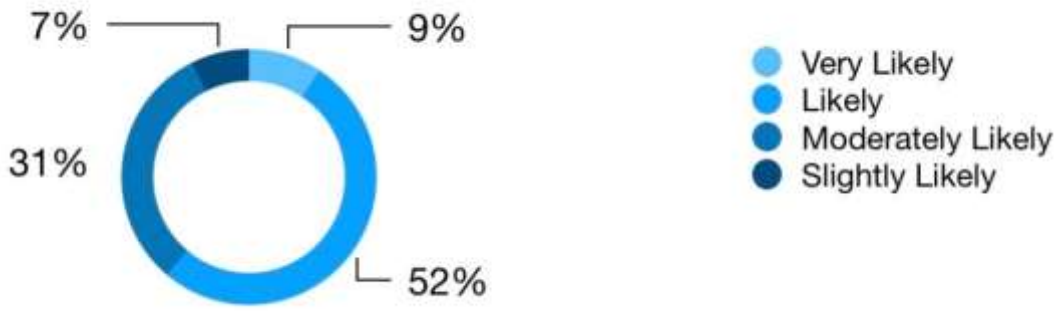
3	Moderately Likely	17	31.5%	51
2	Slightly Likely	4	7.4%	8
TOTAL	-	54	100%	196

Mean = 196/54

= 3.63



A significant 61.8% of respondents believe it is likely or very likely (score > 3) that misinterpreting forensic evidence leads to wrongful conviction.The most frequent response was likely (51.9%). Only 7.4% respondents believe it to be less likely. The overall mean score is 3.63 which indicates strong belief misinterpretation of forensic evidence contributes to wrongful convictions.

8. Reduction of evidentiary value due to chain of custody lapses

Likert Score	Meaning	Frequency	Percentage	Score × Frequency
5	Strongly Agree	21	38.9%	105
4	Agree	19	35.2%	76
3	Neutral	13	24.1%	39
1	Strongly Disagree	1	1.9%	1
TOTAL	-	54	100%	221

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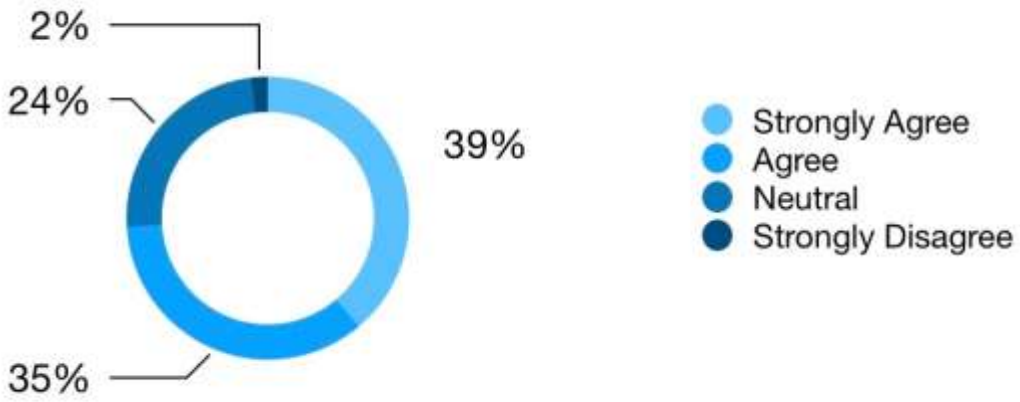
Mean = 221/54

= 4.09



Combined, 74.1% of the respondents (38.9% strongly agree + 35.2% agree) believes lapses in chain of custody reduces evidentiary value. 24.1% of the respondents have neutral stance & only 1.9% strongly disagree with the statement. The calculated mean score of 4.09 indicates overall high agreement that evidentiary value of forensic samples decreases because of compromised chain of custody.

9. Most reliable forensic techniques

This was a "check- all boxes" question. Mean & likert scores are not applicable. The % is calculated based on total number of respondents who answered this question.(N= 54)

Forensic Technique	Raw frequency	Percentage (%)
DNA Profiling	36	66.67%
Post mortem examination	21	38.89%
Digital Forensics	18	33.33%
Fingerprint	16	29.63%
Ballistics	14	25.93%
I do not consider any single technique highly reliable	6	11.11%

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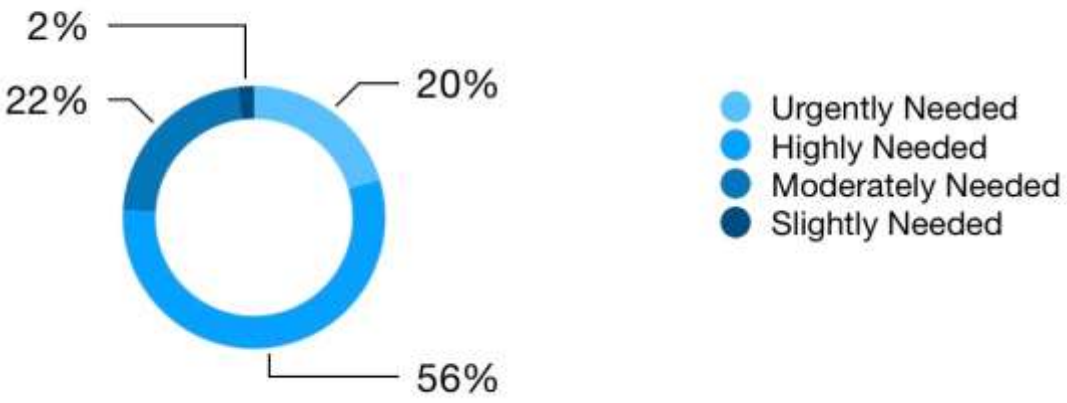

DNA Profiling is considered the most reliable technique as per 66.67% of respondents.The next most favoured techniques are Post mortem examination (38.89%) & Digital Forensics(33.33%). A notable portion of 29.63% place reliance on fingerprint technique & 25.93% on ballistics. However,

11.11% of the respondents do not consider any single technique as highly reliable.

10. Assessing need for reforms to strengthen forensic accountability & accuracy

Likert Score	Meaning	Frequency	Percentage	Score × Frequency
5	Urgently Needed	11	20.4%	55
4	Highly Needed	30	55.6%	150
3	Moderately Needed	12	22.2%	48
2	Slightly Needed	1	1.9%	3
TOTAL	-	54	100%	256

Mean = 256/54

= 4.74

There is exceptionally high level of agreement , with 76% of respondents urgently(20.4%) or highly needed(55.6%). 22.2% feels reforms are moderately needed. While only1.9% feels

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slight need of reforms & no respondents is in favour of no reforms at all. The calculated mean score of

4.74 shows overwhelming consensus favouring reformation for better forensic accountability.

II. Qualitative Analysis

II.1 Thematic Analysis

For thematic analysis, I have used Braun & Clarke's method of thematic analysis .

Braun & Clarke's Six Phases (Reflexive TA):

Familiarization → Generating Initial Codes → Searching for Themes → Reviewing Themes → Defining and Naming Themes → Producing the Report

After reading the data, verbatim coding was done.When developing codes, one of the two approaches can be followed : Top-down(deductive) & Bottom-up(Inductive) approach, I followed Inductive approach whereby code emerge organically from the data & isn't predetermined.

5 themes identified are:

1. Typology & frequency of procedural errors
2. Root Causes of Forensic unreliability
3. Mechanisms of Evidentiary Harm & injustice
4. Institutional Reforms & Accountability
5. Enhancing Legal Actor scientific & cognitive literacy **Colour Coding :**

COLOUR			
WHAT IT INDICATES ?	Most frequent response	Frequent response	Less frequent response

1. TYPOLOGY & FREQUENCY OF PROCEDURAL ERRORS

Question : *In your view, what types of human procedural errors most commonly affect forensic investigations ?*

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Code Category	Initial codes framed	Exemplar quotes from data	Frequency (Count)	Percentage (%)
Crime Scene & physical handling Failures	Contamination,Improper collection,Poor scene , management,Improper packaging	"Police pack things without gloves." "People sometimes step on footprints or touch items leading to contamination "	28	52%
Documentation & chain of custody lapses	Missing signatures,Poor records,Gaps in documentation	"Poorly or unsigned parcels" "Improper documentation"	17	31%
Cognitive & interpretation bias	Confirmation Bias,Pre - conceived notion bias,contextual Bias,Assumptions,subjectivity	"Cognitive bias of investigators", "Preconceived bias which every human prone to"	10	17%

The analysis of human procedural errors depicts that greatest vulnerability in forensic investigations is physical integrity & administrative handling of evidence. The major issue identified was crime scene & physical handling failures (52%) reflecting strong concerns. This is followed by documentation & chain of custody lapses (31%).While physical error dominates, sub theme of cognitive & interpretation bias (17%) remains limited concern.

2. ROOT CAUSES OF FORENSIC UNRELIABILITY

Question: *What misconceptions/ biases do you think influence how forensic science evidence is understood in the Justice system?*

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Code Category	Initial codes framed	Exemplar quotes from data	Frequency (Count)	Percentage (%)
The 'Infallibility' Misconception	CSI Effect, Forensic Science always perfect/ final,overestimating accuracy	"I feel biggest misconception is CSI Effect"	20	40%
Cognitive & Contextual Biases	Confirmation bias,contextual bias,Interpreting to fit beliefs	"Confirmation bias- interpreting evidence to fit existing beliefs or theories"	15	30%
Statistical misunderstanding & over-reliance	Overconfidence in experts,Misunderstanding probabilities, confusing possibility with certainty	"Misinterpretation of forensic testimony can overshadow exculpatory evidence pushing courts towards wrongful guilt."	15	30%

The findings suggests that forensic evidence understanding in justice system is influenced by external myths & internal psychological errors.The primary factor of distortion is Infallibility misconception (40%) , widely linked to CSI Effect, where people overestimate the conclusive Ed's & speed of forensic justice.The external myth combines with 2 significant challenges, collectively making up 60% of responses : Contextual & Cognitive Biases(30%) and Statistical misunderstanding & over-reliance(30%) . The last category highlights a crucial gap where courtrooms often demand a definitive black & white truth, leading to misinterpretation of probabilistic evidence.

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3. MECHANISM OF EVIDENTIARY HARM & INJUSTICE

Question: *How can mishandling or misinterpretation of forensic evidence contribute to wrongful convictions?*

Code Category	Initial codes framed	Exemplar quotes from data	Frequency (Count)	Percentage (%)
Distortion of Judicial Certainty	Creates False certainty,Courts overestimate certainty, Exaggerated Testimony	Misinterpretation of probabilistic evidence often transform uncertainty into perceived fact	24	45%
Misdirection of Investigation & Focus	Contamination falsely implicates innocent, points to wrong suspect	"These mistakes may reinforce existing biases,cause alternative leads to be ignored."	16	30%
Undermining Adversial Justice	Overshadows exculpatory evidence,acquittal of guilty,conviction of innocent	"Misinterpretation of forensic testimony can overshadow exculpatory evidence pushing courts towards wrongful guilt."	14	25%

Respondents (45%) identified distortion of judicial certainty as the primary mechanism through which errors contribute to wrongful convictions. This mechanism involves faulty analysis or exaggerated testimony which create a false sense of certainty. This distortion is often coupled with misdirection of investigation and focus(30%) & undermining Adversial justice(25%) , highlighting danger that false evidence can jeopardise the rights of accused.

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4. INSTITUTIONAL REFORMS & ACCOUNTABILITY

Question : *What reforms or systemic changes do you believe are necessary to improve reliability & accountability of forensic processes in India ?*

The most urgent reform proposed as the need for structural oversight and independence(45%). This reform is driven by a consistent call for an autonomous forensic regulatory body assigned for oversight & mandatory accreditation. To enforce objectivity, this must be coupled with Standardization & Transparency (35%) , which includes adoption of unified National forensic code . Lastly, Infrastructure & capacity building (20%) recognise the need to address chronic issues like staff, shortages, backlogs, and inadequate funding to improve the timeliness of forensic output.

5. ENHANCING LEGAL ACTOR SCIENTIFIC & COGNITIVE LITERACY

Question : *What training or awareness measures should be taken by legal actors for better evaluation of forensic evidence ?*

The analysis reveals that scrutnizing critically becomes the first primary step as agreed by 45% of the respondents. This requires judges & lawyers to move away from passive acceptance, demanding clear explanations acting as gatekeepers. This proactive approach must be supported by Scientific literacy & Bias Training (35%) which advocates mandatory education on forensic basics , error rates. The remaining essential step is the regional verification(20%) , emphasising that all legal professionals must verify compliance with protocols, especially chain of custody to ensure integrity of the evidence.

5. FINDINGS AND DISCUSSION

5.1 Correlating finding with research objectives

The first major objective was to assess the perceptions of legal actors regarding human and institutional errors is confirmed by qualitative the where typology of errors & root causes were asked. Responses regarding over- trustfulness of forensic science clearly demonstrated interpretative challenges and examined how the legal actors interpret forensic evidence. Findings reveal overwhelming support form reform which directly satisfy one of our objectives.

5.2 Insights on legal awareness, perceptions or compliance

5.2.1 Legal awareness among respondents is partial but not comprehensive

Respondents clearly understand that scene contamination, human error & chain of custody

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issues are genuinely risks. They are fully aware as to how forensic evidence having "probabilities" is prone to misinterpretation. They also know about ground realities as to how pressure from investigation officers & hurry to wind up that case influence forensic outcomes. However, awareness is weaker regarding statistical literacy & cognitive biases as only small proportion of respondents were able to identify it.

5.2.2 Perceptions shows high reliance but no high confidence

Respondents shows trust in forensic techniques like DNA Profiling(66.67%) , yet simultaneously believe that

- Over- trustfulness is common
- Misinterpretation can lead to wrongful conviction

This duality depicts a nuanced but inconsistent perception as forensic science is seen as valuable but fragile in practice.

5.2.3 Procedural Compliance is seen as weak

Respondents indicate that crime scene

- Crime scene management protocols are "frequently compromised".
- Forensic reporting is also influenced by investigative pressure.

It shows that awareness of procedural compliance failure is high, signalling systemic scepticism among future legal actors.

5.3 Gaps or misconceptions reflected in data

5.3.1 Underestimation of Judicial errors:

Only 5.56% felt courts misinterpret evidence but preliminary data gathered before research & other after analysing empirical works already done, judicial errors due to lack of forensic science knowledge or late discovery of new facts often leads to erroneous decisions & misinterpretation.

5.3.2 Over-reliance on DNA Profiling

Though 66.67% considers it "most reliable", qualitative data shows limited awareness of laboratory contamination, sample mix-ups & low quality DNA pitfalls.

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6. CONCLUSION AND RECOMMENDATIONS

The study aims to investigate the extent to which institutional, human & cognitive errors influence the reliability of forensic science and how risk is perceived by legal actors. The findings clearly shows that while forensic science is widely acknowledged as a important evidentiary tool, its actual implementation in India remains quite fragile. The collected empirical data reveals a justice system where coexistence of scientific certainty with systemic weaknesses is there like contamination of crime scene, gaps in maintaining chain of custody, limited laboratory capacity, investigative pressure, and misconceptions like the CSI effect. Respondents overwhelmingly agree that one of the significant contributor to forensic inaccuracy is human error and that forensic result misinterpretation can directly contribute in wrongful convictions. It is quite visible that legal stakeholders depicts varying degrees of scientific literacy with limited knowledge of error rates, and restricted understanding of probable reasoning. These findings highlights a disconnect between what role forensic science plays in courtrooms and legal proceedings & what it receives in practice. The research affirms that the present institutional framework marked by fragmented protocols, absence of unified national standards, inadequate oversight, and restricted judicial gatekeeping are inadequate to safeguard forensic reliability. Legal actors acknowledge the urgent necessity for reforms, specifically increased standardization, infrastructural strengthening, and capacity building in forensic evaluation.

Overall, the study emphasises that enhancing forensic justice in India demands both structural changes to institutions and epistemic reforms that is, changes in mindset of judges, lawyers, and investigators regarding with scientific evidence. Ensuring reliability in forensic science is constitutional imperative not merely a technical exercise connected to the right to due process,fair trial and prevention of wrongful convictions.

RECOMMENDATIONS

1. Establishment of National Forensic Science Regulatory Authority (NFSRA)

An autonomous statutory body should be created for better oversights, accreditation, audits, and review of disciplinary proceedings. It should be made sure that is independent from police influence to avoid conflict of interest. Uniform national standards should be created, which cover every step of forensic process like handling of evidence, laboratory functioning and expert testimony.

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2. Standardize Crime Scene and Chain of Custody Protocols

With technological advancements today, it is wise to use it for better efficiency like making 'digital chain of custody logs' mandatory. By adopting a unified national Forensic Evidence Handling Code, handling will be systematised. Usage of tamper-proof packaging & traceable sealing systems should be encouraged. Presence of trained Scene of Crime Officers (SOCOs) should be made mandatory in every investigative proceedings.

3. Reform Expert Testimony Standards

Whenever contentions are raised regarding expert testimony standards, the major concern remains to be the mandatory disclosure of the error rates, limitations of methods. Disclosure regarding confidence intervals & conveyance of alternative interpretations should be made. Statutory consequences in case of misleading expert testimony should be introduced.

4. Build Firewall Between Police and Forensic Laboratories

One of the recommendation for avoiding the official pressure is keeping functional & administrative control separate.Enabling independent communicative & reporting channels for forensic experts will allow them to work freely without any pressure of case closure.

5. Continuous Judicial Education & Police Personnel Training

It is important to distinguish perceived and real risk & for that training programs for both judicial & police officials should be conducted. For judicial officers, mandatory CPD (Continuing Professional Development) , so that they could understand forensic limitations in a better way and expert testimony avoiding the cognitive biases. for police officials and investigative agencies, training in proper collection, preservation, and documentation of evidence will increase the credibility and reliability of forensic evidence.