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Forensics in Policing

BUREAU OF POLICE RESEARCH AND DEVELOPMENT

Ministry of Home Affairs
Government of India

"Promoting Good Practices and Standards"

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"The integration of digital evidence and technology will aid us in fighting terrorism more effectively. New laws now prevent terrorists or terrorist organisations from exploiting legal complexities to their advantage."

Shri Narendra Modi
Prime Minister

"Accurate results are achieved only when there is scientific evidence, and with the help of Forensic Science Laboratories (FSLs), India will soon be among the leading countries in the world in terms of conviction rate."

Shri Amit Shah
Union Home Minister and
Minister of Cooperation



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FOREWORD

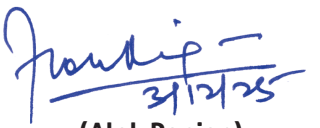
Evolving alongside India's policing landscape, *The Indian Police Journal* has been an enduring platform for informed dialogue, critical inquiry, and the dissemination of knowledge in the field of policing and criminal justice. As one of the oldest professional journals in this domain, it continues to reflect the evolving aspirations of India's law enforcement community, combining field experience with scientific research to strengthen the administration of justice.

This special edition, on the theme of Forensics, comes at a time when forensic science and evidence-based investigation are playing a pivotal role in strengthening justice delivery. With crimes growing more sophisticated and digital offences expanding, policing must evolve through scientific precision and technological innovation. As Hon'ble Union Home Minister Shri Amit Shah said during the ground-breaking ceremony in Rajasthan on 13 October 2025, "In the new criminal laws, provisions have been made for e-FIR and zero FIR, videography has been made mandatory for all seizures, and forensic investigation has been made compulsory for offenses carrying a punishment of more than seven years." This vision underscores the Government's commitment to integrating forensic science across the justice system to ensure greater transparency, efficiency, and scientific integrity in policing.

As policing moves further into an era defined by data, science, and empathy, the Bureau of Police Research & Development remains committed to promoting research-driven policy, scientific training, and inter-agency collaboration. It is our hope that the insights presented

in this edition will inspire police professionals, forensic experts, and policymakers to work collectively towards a justice system that is scientifically robust and socially just.

We express our deep appreciation to Sh. Keshav Kumar, IPS (Retd.), Former DGP Gujarat, for serving as Special Reviewer, as well as to all distinguished authors and reviewers for their valuable contributions, and to our esteemed readers for their continued engagement with The Indian Police Journal. Their sustained support ensures that the Journal remains a vibrant forum for advancing the frontiers of knowledge in policing and public safety.



(Alok Ranjan)

"Promoting Good Practices and Standards"

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EDITORIAL

In an era where crime turns increasingly complex and public scrutiny of law-enforcement practices intensifies, forensic science has become one of the most critical pillars of modern policing. It promises objectivity, precision, and truth-qualities essential in a criminal justice system striving for fairness and transparency. Yet, the promise of forensic science is fully realized only when its tools are applied responsibly, its limitations understood, and its practitioners held to the highest professional standards.

As policing continues to evolve, strengthening the scientific backbone of investigations is not merely an option, it is a legal imperative evolved in Navin Nyaya Sanhitayein'. By championing accuracy, transparency, and accountability, forensic science can help build a system that is not only more effective but also more worthy of public trust.

The advancements in forensic technologies like DNA profiling, digital forensics, facial recognition, and advanced ballistics have transformed investigations from largely intuition-driven processes to evidence-based ones. These tools allow investigators to identify suspects more accurately, exonerate the innocent more swiftly, and reconstruct crimes with unprecedented clarity. In a time where justice replaces punishment, forensic science serves not only as a mechanism of accountability but also as a guardian of civil liberties.

The Indian Police Journal continues to serve as a crucible for ideas that shape the philosophy and practice of modern policing. This edition consists of various articles related to forensic crime.

I extend my appreciation to the authors, reviewers and the Special Reviewer for their significant scholarly contributions and convey my sincere thanks to the editorial team for their meticulous efforts in compiling and presenting this comprehensive edition.



(Ravi Joseph Lokku)
Editor-in-Chief

"Promoting Good Practices and Standards"

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SUMMARY

Forensics in Policing underscores the growing role of scientific investigation and evidence-based methods in strengthening justice delivery. The articles in this edition collectively explore how advancements in forensic science, technology, and analytical methods are reshaping modern policing practices and reinforcing the pursuit of truth within the criminal justice system

Ms. Prachi Sharma Biswas, Research Scholar, Shri Vaishnav Institute of Forensic Science, and Dr. Swati Dubey Mishra, Associate Professor, Shri Vaishnav Institute of Forensic Science in their paper *"Evaluating the Potential of Knuckle Crease Patterns as a Reliable Biometric Identifier,"* explore the viability of knuckle crease patterns as a dependable biometric tool for personal identification

Ms. Anshu Singh, PhD Research Scholar & Assistant Professor, School of Behavioural Sciences & Forensic Investigations and Prof. (Dr) JR Gaur, Former Director & Lifetime Professor, Rashtriya Raksha University, in their study titled *"A Study of Online and Offline Financial Frauds and Forensic Accounting Solutions"* analyse evolving fraud trends and highlight the importance of forensic accounting techniques to mitigate online and offline financial threats effectively

Sh. Yuvrajsinh Parmar, M.Sc., School of Behavioural Sciences & Forensic Investigations and Dr. Ankita Parmar, Assistant Director & Assistant Professor, School of Behavioural Sciences & Forensic Investigations, in their paper *"Development of Latent Fingerprints from Waste Materials. Cigarette Ash Powder, "* demonstrate the successful use of cigarette ash as an inexpensive alternative to commercial fingerprint powders, highlighting its potential for developing latent fingerprints on various surfaces.

Sh. Nidhin SS, Assistant Professor, School of Investigation Science & Technology. Nehru Arts and Science College, and his co-authors, in their article *"Alternative Methods for Extraction of Blood from Different Surfaces for Species Origin Test"* investigate how environmental factors such as temperature, moisture, and wind influence the recovery and analysis of blood evidence

Sh. K. Hemanth Sai Reddy, Visiting Faculty, Karnavati University, and Dr. Priyanka Kacker, Associate Professor, School of Forensic Psychology, NFSU, in *"Corroboration of Evidence in Cases of Theft Using Brain Electrical Oscillation Signature Profiling A Simulation Study"* examine the utility of BEOS profiling as a corroborative forensic tool in theft investigations

Ms. Diksha Thakur, Senior Scientific Officer, NDPS, Forensic Science Laboratory, Madhuban, Karnal Haryana and co-authors, in *"Transition of Conventional Drugs to New Psychotropic Substances (NPS) Abuse Few Basic Concepts and Forensic Analytical Challenges from an Indian Perspective,"* discuss the growing prevalence of new psychotropic substances and the associated analytical difficulties in forensic toxicology

Ms. Chhaya Sharma, IPS, IG, BPR&D, in *"Combating Human Trafficking: Challenges and Measures"* examines human trafficking as a serious human rights violation and transnational organized crime. The article highlights the scale and complexity of trafficking networks and underscores the need for coordinated legal and institutional measures to strengthen prevention and investigation

Sh. Rajashekara N., IPS, DIG, BPR&D and Dr. Abhishek Mishra, Assistant Professor School of Interdisciplinary and Trans-Disciplinary Studies, IGNOU, in *"Beyond OTP and Passwords Strengthening Digital Security Against the Threats of Malicious RATS, Deepfakes, and Cryptocurrencies,"* examine the growing menace of cyber frauds and discuss the utility of national initiatives in combating digital financial crimes

Sh. Salmantaj Patil, IPS. Director, CDTI Hyderabad and Sh. Sonam Kumar, IPS, DCP(W). Agra, in *"3O & Drone-Based Crime Scene Management System (3DD-CSMS),"* present an innovative framework that integrates drones, LiDAR, and virtual reality technologies to improve crime scene documentation and reconstruction

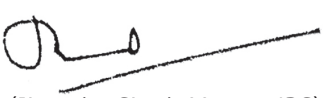
Ms. Sabrin Mariam Philip. Research Scholar, Department of Criminology, Karunya Institute of Technology and Sciences and Prof. P. G. Sunanda Bhagavathy, Department of Criminology. Karunya Institute of Technology and Sciences in *"A Systematic Review of Workplace Issues Faced by Women Traffic Police Personnel,"* review empirical studies on the occupational challenges of women traffic police officers in India and identify systemic gaps in infrastructure, gender equity, and workplace well-being, calling for policy-level interventions

Sh. Sanjay Kumar Jain, IPS, Joint Commissioner, Delhi Police, in *"Crowd Management in Mega Religious Events A Case Study of Navratri at Kalkaji Temple, New Delhi,"* presents a detailed account of crowd management strategies during high-density religious gatherings, highlighting an effective model for large-scale event management through anticipatory governance, smart technology, and inter-agency coordination.

Ms. Ipsita Ojal, PhD Research Scholar, School of Law, Lovely Professional University in *"Retrospective Application of Victim Compensation in India,"* explores the legal and ethical aspects of applying victim compensation schemes retrospectively, enriching the discourse on restorative justice

Dr. Atanu Saha, Assistant Professor, Post Graduate Department of Physiology, Hooghly Mohsin College, in *"Ergonomical and Occupational Health Problems amongst Police Personnel A Review of Health Implications,"* synthesizes global research on police health challenges, highlighting stress, musculoskeletal issues, and cardiovascular risks while advocating institutional measures to enhance well-being.

The articles in this edition reaffirm that modern policing increasingly relies on forensic science, technological innovation, and human-centered approaches. By combining scientific rigor with ethical responsibility, this issue of *The Indian Police Journal* aims to inspire meaningful discussion, informed reflection, and progress in evidence-based policing in India.



(Jitendra Singh Meena, IPS)
IG/Director (R&CA & SPD)

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Evaluating the Potential of Knuckle Crease Patterns as a Reliable Biometric Identifier

Prachi Sharma Biswas*
Dr. Swati Dubey Mishra**





ABSTRACT

Knuckle crease patterns are gaining recognition as a distinctive biometric trait with significant potential for forensic and identification applications. Unlike fingerprints, which are commonly used for identification, knuckle crease patterns offer an alternative with less susceptibility to deliberate alteration and environmental and occupational wear, making them especially useful for individuals with compromised fingerprints. This study analyzed 600 finger images collected from 60 individuals, examining three primary crease patterns per finger, resulting in a total of 1,800 creases. The reliability of a modified manual classification system, incorporating six distinct crease types, was evaluated in terms of consistency and applicability. Intra-observer and inter-observer reliability assessments were conducted. The intra-observer analysis demonstrated a very high agreement of 91.4%, with a Kappa value of 0.8600. In the inter-observer test, three independent observers classified the patterns, yielding 75.1% agreement and a Kappa value of 0.6402 according to Fleiss' Kappa test. Statistical analyses confirmed minimal variability in intra-observer classifications, while some discrepancies were observed in the inter-observer analysis. This study highlights the relevance of manual methodologies in forensic and identification contexts, offering a dependable alternative to conventional biometric systems. Establishing standardized classification criteria and improving observer training could enhance the reliability of manual classification systems, enabling more effective utilization of knuckle crease patterns in forensic investigations and personal authentication. This method may also contribute to the identification of unknown individuals and serve as credible supporting evidence in legal proceedings.

Keywords: *Knuckle crease pattern, Biometric trait, Forensic Applications, Forensic Science*

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INTRODUCTION

The growing demand for dependable and innovative biometric identifiers has fuelled extensive research within forensic science. While traditional methods such as fingerprint analysis remain dominant, they face limitations related to wear, damage, and occupational factors. These challenges have encouraged the exploration of alternative biometric traits that are more resilient and consistent across diverse conditions. Various modalities such as anthropometry (Randolph-Quinney et al., 2011), dactyloscopy (Sharma, 2019), lip prints (Verma et al., 2015), iris patterns, and palm prints (Kaur & Jindal, 2012) have been examined, yet concerns about their reliability and consistency persist.

A promising alternative to traditional biometric methods is the analysis of skin crease patterns found on the dorsal surface of the proximal interphalangeal joints of the fingers, commonly referred to as knuckle crease patterns. These patterns are considered to be permanent, unique, and classifiable (Charles, 1997; Chattopadhyay & Sukul, 2012; Sharma Biswas & Dubey Mishra, 2024a). Unlike the palmar surface, which is frequently exposed to wear and distortion, the dorsal surface is less affected by external factors. This makes knuckle crease patterns particularly advantageous for contactless and non-invasive biometric identification, especially for populations with compromised fingerprints, such as individuals engaged in manual labour whose palms and fingers are subject to significant wear and roughness. The adoption of knuckle crease pattern analysis could revolutionize forensic identification, offering an additional tool for identification, particularly in cases where other biometric methods may not be applicable.

Knuckle crease patterns have already demonstrated practical applications in forensic investigations. For example, in the UK, knuckle crease images of the culprit played a very important role in securing convictions in high-profile cases such as the Dean Hardy case (Black et al., 2009), the Neil Strachan case (Carrell, 2009), and the Davin Whitefield case (Kadane, 2020). In these cases, the comparison of hand images led to the positive identification of offenders, emphasizing the potential of knuckle crease patterns as reliable biometric evidence in legal proceedings.

As forensic science and security increasingly advocate for contactless identification methods, knuckle crease patterns have emerged as a viable and reliable alternative. Advances in automated systems for pattern recognition and matching have shown significant progress in this domain (Kumar & Ravikanth, 2009; Nanni & Lumini, 2009; Kumar, 2014; Trabelsi et al., 2020). Research has primarily focused on two areas: developing commercial devices for the accurate capture of knuckle crease patterns and creating innovative software to implement sophisticated algorithms for feature extraction and recognition. These advancements have notable implications for civil applications, enhancing authentication systems and adding an extra layer of verification in areas like security check-ins and personal identification.

Despite significant advancements in automated systems for knuckle crease pattern recognition, manual classification frameworks remain crucial in forensic investigations, providing critical human judgment, particularly in complex cases. Only a few manual studies have been reported in Knuckle crease patterns analysis to date. Baines (2011) proposed 11 initial knuckle crease patterns for the left

index finger, but only three demonstrated consistent observer agreement, highlighting the challenges of systematic classification. Chattopadhyay and Sukul (2012) identified five distinct ridge configurations suitable for individual identification. Dakshinamurthy (2018) conducted a validation study on Baines' classification and observed low levels of both intra- and inter-observer agreement. John (2021) investigated sexual dimorphism, i.e., the differences in knuckle crease patterns between males and females. More recently, Dan et al. (2023) explored the impact of finger flexion on crease morphology, and Sharma Biswas & Dubey Mishra (2024) identified an additional pattern to the five-pattern classification system given by Chattopadhyay & Sukul (2012) and further confirmed sexual dimorphism in knuckle crease patterns. These studies emphasize the individuality and permanence of knuckle crease patterns, reinforcing their potential as reliable biometric identifiers. However, the absence of standardized classification systems and the lack of rigorous statistical validation have limited their broader application.

To assess the effectiveness of knuckle crease pattern classification, it is essential to evaluate the reliability of the classification system through both intra-observer and inter-observer consistency. Reliability refers to a method's ability to consistently differentiate between items, minimizing observational errors. For forensic evidence to be reliable in legal contexts, it must be stable, accurate, and reproducible. Variability in human observations can introduce errors, compromising the validity of the evidence.

Reliability is of two types: Internal and External. Internal reliability refers to testing the consistency of measurements within a single item, while external reliability examines how much one measure differs from another. Internal reliability is typically assessed using the split-half method, whereas external reliability is evaluated through test-retest (intra-observer) and inter-observer methods. This study specifically focuses on assessing intra-observer and inter-observer reliability. Intra-observer reliability measures the consistency of a single observer over time, ensuring consistent results despite factors like mood or time of day. It is tested using test-retest procedures. Inter-observer reliability evaluates the agreement between different raters. It is quantified using Cohen's Kappa (for two raters) or Fleiss' Kappa (for more than two raters), adjusting for chance agreement.

This study aims to evaluate knuckle crease patterns as a dependable biometric tool, especially in situations where traditional methods may be ineffective. It validates a modified classification system and assesses its consistency through intra-observer and inter-observer reliability analyses. With strong statistical support, the findings advocate for the inclusion of knuckle crease analysis in forensic identification and personal authentication, offering a novel approach in complex or compromised biometric scenarios. As biometric systems evolve, incorporating knuckle crease patterns could improve identification processes in situations where conventional methods may fail.

MATERIALS AND METHODS

Sample Collection

This study was conducted on 600 finger images collected from 60 Indian individuals, comprising 30 males and 30 females. All participants were healthy individuals aged between 18 and 60 years and had no known

genetic or acquired deformities that could affect the visibility or morphology of knuckle creases. Photographs of all ten fingers were taken, and three major creases from each finger were analyzed, resulting in a total of 1,800 crease patterns. For intra-observer analysis, all 1,800 crease patterns were examined across two trials. For inter-observer analysis, 30 images (totalling 90 crease patterns) were randomly selected from the 800 samples and given to each observer for independent analysis.

Classification System

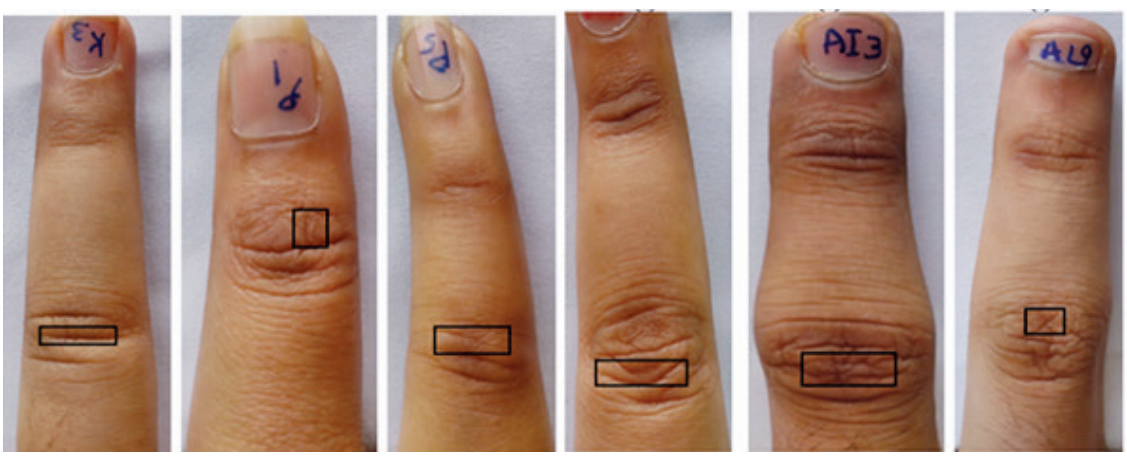
One researcher and three independent observers analyzed the samples and classified them according to an adopted classification system (Chattopadhyay & Sukul, 2012; Sharma Biswas & Dubey Mishra, 2024) consisting of six pattern types. The initial classification, given by Chattopadhyay and Sukul (2012), grouped knuckle creases into 5 types of patterns. Later, Sharma Biswas and Dubey Mishra (2024b) identified a new crease pattern named 'Cross pattern' in addition to the five-pattern classification system given by Chattopadhyay and Sukul (2012).

Six types of crease patterns are as follows:

1. **Horizontal:** Parallel creases across the knuckle.
2. **Vertical:** Perpendicular creases along the finger axis.
3. **Oblique:** Diagonal creases.
4. **Semilunar:** Curved creases forming a semi-circle.
5. **Mixed:** A combination of two or more patterns.
6. **Cross:** Intersecting creases forming a cross-like shape.

Each pattern is further classified into 7 subtypes according to the branching patterns.

Each pattern was further classified into seven subtypes based on branching patterns, such as Body Proximal (BP), Body Distal (BD), Body Proximal & Distal (BPD), Terminal Radial (TR), Terminal Ulnar (TU), Terminal Radial and Ulnar (TRU), and Combined (C). (Chattopadhyay & Sukul, 2012). For this study, branching patterns were analyzed only for intra-observer analysis, as a higher level of expertise is required to assess them reliably in inter-observer comparisons.



(a) (b) (c) (d) (e) (f)

Figure 1: *Different types of crease patterns. (a) Horizontal, (b) Vertical, (c) Oblique, (d) Semilunar, (e) Mixed, (f) Cross*

Intra-observer analysis

Intra-observer reliability was assessed by the researcher, who possessed prior expertise in classifying knuckle crease patterns, as well as a strong understanding of forensic practices, anatomical structures, and morphological terminology. The study evaluated the consistency of repeated classifications by observing changes in the kappa value. Over a two-week period, the researcher classified all 600 finger images, which included 1,800 knuckle patterns, using standardized criteria. After the two-week interval, the same process was repeated for all the images. The percentage agreement between the two trials and Cohen's kappa statistic were then calculated to assess reliability.

INTER OBSERVER ANALYSIS

Three volunteers were randomly selected as participants for this study. Prior to data collection, they underwent a 3-hour training session, which included 2 hours of lecture-based instruction followed by 1 hour of practical demonstration and hands-on experience with standardized methods. Each participant was provided with a set of materials, including finger images, classification charts, and consent forms. All three participants were given the same set of 30 finger images (representing a total of 90 knuckle crease patterns), which were randomly selected from a dataset of 1800 finger samples previously compiled by the researcher. The images were identical for each observer to ensure consistency across classifications. The participants were briefed on the study's objectives and instructed to focus specifically on prominent knuckle crease lines, avoiding the identification of faint or intricate creases. Each observer independently classified all the images based on the provided guidelines. They were allowed ample time to review the procedural instructions, ask any clarifying questions, and complete the classification task. No time limit was imposed for completing the task.

For the intra-observer reliability test, Cohen's Kappa statistics (for two trials) were performed, and the Kappa coefficient was calculated. For the inter-observer reliability test, Fleiss Kappa statistics (for 3 raters) were performed, and the kappa coefficient was calculated. All the tests were performed in Microsoft Excel.

The Kappa coefficient (k) quantifies the degree of agreement between raters while accounting for chance agreement. The formula is:

$$\text{Kappa coefficient, } k = \frac{Po-Pe}{1-Pe}$$

Where Po = Observed agreement, and Pe = Expected agreement by chance.

Kappa values range from -1 (no agreement) to 1 (perfect agreement), with 0 indicating agreement no better than random chance.

RESULT AND DISCUSSION

The study analyzed 1,800 knuckle crease patterns, categorized into six distinct types by three independent observers. The distribution of crease patterns and the reliability of the classification system were assessed through both intra-observer and inter-observer agreement analyses. Among the total 1,800 observed crease patterns, the Horizontal pattern was the most frequently classified by all three observers, followed by Semilunar, Oblique, Vertical, Cross, and Mixed patterns.

The interpretation of kappa values was done according to Cohen's kappa interpretation of value, as depicted in Table 1.

Table 1: ***Cohen's Kappa Interpretation of values.***

Kappa value (k)	Interpretation
<0	Poor Agreement / Less than Chance Agreement
0.0– 0.20	Slight Agreement
0.21 – 0.40	Fair Agreement
0.41 – 0.60	Moderate Agreement
0.61 – 0.80	Substantial Agreement
0.81 – 1.00	Almost perfect Agreement

INTRA OBSERVER RELIABILITY TEST

The intra-observer analysis involved the classification of 1,800 knuckle crease patterns by a trained researcher. The same classification process was repeated after a two-week interval. The observed agreement was 91.4%, with a Kappa value of 0.8600, indicating "Almost Perfect Agreement". Detailed results are presented in Table 2.

Table 2: ***Cohen's kappa statistics for the intra-observer reliability test. Observed Agreement (Po): 0.9144, Expected Agreement (Pe): 0.3888, Cohen's Kappa (K): 0.8600 (Substantial agreement).***

No. of Observers	No. of Trials	No. of Knuckle Crease Patterns classified	Kappa coefficient	Interpretation
1	2	1800	0.8600	Almost Perfect Agreement

The intra-observer reliability test demonstrated near-perfect agreement, highlighting the consistency of the classification process when performed by a trained observer. This suggests that the classification method is robust and repeatable under controlled conditions. The high Kappa value of 0.8600 confirms that the likelihood of agreement beyond chance is significantly strong. Such a high level of consistency indicates that the trained observer was able to replicate their classification decisions with minimal variation.

INTER-OBSERVER AGREEMENT

Interobserver reliability was evaluated to assess the level of agreement among three observers in classifying 90 knuckle crease patterns. Fleiss' Kappa statistics were computed and interpreted using the Cohen Kappa scale, as shown in Table 1. As indicated in Table 3, the calculated Kappa coefficient of 0.64024 falls within the range of 0.61 to 0.80, suggesting substantial agreement between the observers.

Table 3: ***Fleiss's kappa statistics for inter-observer reliability test. Observed Agreement (Po): 0.7511, Expected Agreement (Pe): 0.30815, Cohen's Kappa (K): 0.64024, indicating Substantial agreement.***

No. of Observers	No. of Trials	No. of Knuckle Crease Patterns classified	Kappa coefficient	Interpretation
3	1	90	0.6402	Substantial Agreement

Interobserver reliability analysis demonstrated substantial agreement among three observers, confirming the consistency of their classifications.

CONCLUSION

This study evaluates the reliability of knuckle crease patterns as a non-invasive and cost-effective biometric tool. Their potential applications may extend to forensic science, access control systems, and security domains, where dependable biometric identifiers are critical. In scenarios where traditional biometric traits may be affected by environmental conditions or physical alterations, knuckle crease patterns offer a promising alternative.

The objective was to validate a modified classification system through intra-observer and inter-observer evaluations, emphasizing its reliability for individual identification and forensic use.

The intra-observer analysis demonstrated near-perfect agreement, indicating that the method is highly repeatable when applied by a trained observer. Minor variations may have arisen due to the complexity of certain patterns, subjective interpretation, and external factors such as observer fatigue or time constraints.

While in the case of inter-observer analysis, "Substantial Agreement" was observed among the three observers. However, discrepancies in classification revealed challenges such as inconsistent crease identification, misinterpretation of anatomical terminology, and difficulty in classifying complex patterns. Notably, horizontal and semi-lunar patterns were often misclassified, and similar issues were observed with mixed and cross patterns.

In conclusion, although the proposed classification method for knuckle crease patterns shows strong potential for forensic identification; further refinement is needed to enhance its precision and reliability. Training observers to manually mark creases and standardizing the process could improve consistency. Alternatively, automating steps such as crease highlighting and central axis marking may help reduce human error and increase objectivity.

Future studies should focus on integrating minutiae features and expanding the classification system to establish a more comprehensive and structured approach. Validation using larger and more diverse datasets will strengthen its relevance for forensic identification and individualization in legal contexts. The development of standardized protocols will be essential for the broader adoption of knuckle crease pattern analysis within the field.

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A Study of Online and Offline Financial Frauds and Forensic Accounting Solutions




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ABSTRACT

Financial fraud, be it online or offline, represents a significant challenge to businesses, customers, and governments worldwide. The enormous increase in digital technologies, especially the rise in online fraud, has become a dominant issue, posing new complexities every day that require sophisticated responses. This paper presents an in-depth analysis of online and offline fraud, examining the evolving trends, their impacts on stakeholders, and potential strategies for mitigating these threats. The study also highlights the differences between online and offline fraud, investigates the technological and societal factors driving these trends, and proposes forensic accounting solutions for the mitigation of these financial frauds.

Keywords: *Forensic Accounting, Financial Frauds, Investigating, Mitigation, Technology*

INTRODUCTION

The Association of Certified Fraud Examiners (ACFE) defines fraud as any activity that depends on deceit to generate a profit. When there is a "knowing misrepresentation of the truth or concealment of a material fact to induce another to act to his or her detriment", fraud is considered a crime. (ACFE, 2025) In other terms, fraud is when a person or organization is cheated out of their money or property by lying. Although technology greatly contributes to making life easier for humans, some people use it unethically to obtain illicit gains. It can be both a blessing and a curse. The development of technology has led to a significant rise in cybercrime. Users of social networking sites have recently seen several distinct kinds of attacks. Technical assistance scams and Internal Revenue Service (IRS) impersonation scams are the most prevalent types of attacks employed by attackers to obtain financial benefits from unwitting victims. The increased global connectivity has given rise to many crimes. Cybercrimes are

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committed either via the internet, computers, or mobile phones, email, and other devices to steal personal information, cause financial losses, harm one's reputation, and violate one's right to privacy.

Online financial frauds include phishing, vishing, spoofing, credit card fraud, identity fraud, SIM cloning, etc.

Fraudulent activities have existed for centuries, but the methods by which they are perpetrated have evolved dramatically over time. While offline fraud traditionally involved face-to-face deception, physical forgery, or theft, the digital age has brought about an increase in online fraud activities, exploiting the anonymity, speed, and global reach of the internet. Financial fraud has taken a new turn since the time technological developments like Machine Learning (ML) & Artificial Intelligence (AI) have come into the market. With the aid of these technologies, fraudulent patterns can be automated, whether it is the creation of phishing emails, erroneous credit transactions, or other similar activities. Additionally, the usage of cryptocurrencies and blockchain technology has created new difficulties and chances for financial fraud, such as money laundering, cryptocurrency theft, and fraudulent Initial Coin Offers (ICOs) (Datta & Panda, 2020). These techniques are both a boon and a bane, depending on how they are utilized.

This research article aims to explore both types of fraud- offline and online by going through the latest trends, identifying and examining the economic and societal impacts, the importance of forensic accounting, and proposing mitigation strategies for various stakeholders.

REASONS BEHIND COMMITTING FRAUD

The Fraud Diamond Theory, given by Wolfe & Hermanson (Kwasi, 2018), briefly describes the causes and methods of organizational fraud and explains why deception is committed. Pressure, Opportunity, Rationalisation, and Capability are the four key components of the fraud diamond. Strong internal controls, a policy of zero tolerance, and a suitable code of ethics are also necessary to avoid fraud and to encourage personnel to act ethically. (Kenton, 2024)

DEFINITIONS AND TYPES OF FRAUD

This broad category of fraud encompasses numerous specific activities, which can be classified into two major categories: offline and online fraud.

1. **Offline Fraud:** Includes traditional forms of fraud, such as:
    - **Credit Card Fraud:** When someone uses a credit card to make purchases or cash withdrawals without the owner's consent.
    - **Cheque Fraud:** Forgery or alteration of checks, either by manipulating numbers or signatures.
    - **Identity Theft:** When someone exploits another person's personal information, such as their name, Social Security number, or credit card number, for financial gain or for the purpose of other illegal activity. (Faster Capital, 2024)
    - **Insurance Fraud:** Filing false claims by insurers to receive monetary benefits.
    - **Mortgage and Lending Fraud:** Target companies with high cash flow; fraudsters use false information to obtain a loan or line of credit.

- **Payroll fraud:** entails manipulating employee records, timecards, pay scales, or job categories in order to make illicit payments to current or non-existent employees.

2. **Online Fraud:** Refers to fraudulent activities that occur in the digital realm, including:
   - **Phishing and Spoofing:** Fraudsters impersonate respectable financial institutions or organizations by using technology to create compelling emails, webpages, or other communications.
   - **Online Shopping Scams:** Fraudulent e-commerce websites or fake listings.
   - **Account Takeovers:** Unauthorized access to online accounts using stolen credentials.
   - **Ransomware Attacks:** Malicious software that locks a user's data, demanding huge payments for release.
   - **Harmful Software:** Such as malware and ransomware, is used by fraudsters to access financial systems without authorization or encrypt sensitive data and demand ransom payments to decrypt it. Malware can be transmitted through malicious email attachments, hacked websites, or software flaws. Ransomware attacks have the potential to knock down financial institutions or hold sensitive consumer data hostage until the intended ransom is paid.
   - **UPI-fraud:** Unified Payment Interface, or UPI, is one of the most widely used payment methods in India. By doing this, we can make payments from any location in India just by linking our bank account to our cell phone. Fraudsters ask for OTP via calls or messages, send fake UPI links, etc., and defraud people.
   - **Deepfake Technology scam:** Artificial intelligence (AI) technology known as "deep fakes" employs deep learning to produce realistic-looking but fake movies and images. A recent incident in China involved a man who received a call from a buddy and was in desperate need of money to make a deposit in the bidding process. However, a fraudster actually employed deep fake technology to make a false claim.
   - **Digital Arrest:** A Scam wherein the fraudsters impersonate law enforcement officials online, either through emails or video calls, falsely accusing victims of crimes and further extorting money by threatening a digital arrest if they don't comply with their demands.

FACTORS CONTRIBUTING TO THE OCCURRENCE OF FINANCIAL FRAUDS

Creating effective preventive measures requires an understanding of the elements that influence the occurrence of financial scams. The present section seeks to examine a number of elements that are crucial in the facilitation of technology-based financial crimes in India. By looking at these elements, we can gain greater insight into the vulnerabilities and structural flaws that hackers take advantage of, which will help us develop ways to reduce risks and strengthen the security of the financial ecosystem (Jon Frost, 2021).

- **Vulnerabilities in Technology:** Technological factors associated with financial fraud, such as insufficient authentication methods, software issues, inadequate cybersecurity measures, and

the rapid evolution of attacking strategies, are leading to security breaches and posing a great risk to the banking systems as well. (Mehta, 2024)

- **Factors and Psychological Manipulation:** Financial fraudsters often exploit psychological tactics and human vulnerabilities to deceive others. Swindlers often manipulate their victims by appealing to their emotions, leveraging cognitive biases, and using persuasive techniques to convince individuals to share personal information or perpetrate fraud. Additionally, scammers also exploit the weaknesses in the detection systems by identifying human errors. (Nenad, Alan, Oladele, & Ann)
- **Organizational Faults:** Fraud in organizational settings includes a lack of internal controls, shaky risk management plans, a lack of staff awareness and training programmes, insufficient monitoring, and unethical behaviours. Insider threats and cooperation also play a role in the occurrence of financial fraud.
- **Challenges in Regulation and Law:** Politicians and regulators are important in preventing financial fraud. The effectiveness of regulations in addressing new fraud practices should be analyzed, along with an emphasis on collaboration of regulatory organizations and the need for uniform laws and regulations across different sectors. Also, there is a great challenge posed by international trade and the jurisdictional issues that hinder the efficient investigation and prosecution of financial fraud.

A complex interplay of technological deficiencies, human elements, organizational vulnerabilities, and regulatory challenges influences the prevalence of technology-driven financial fraud. Understanding these contributing factors is crucial for establishing a thorough and multifaceted approach to effectively identify and combat financial fraud. To mitigate the threats posed by financial fraud and safeguard the integrity of the country's financial system, governments, financial institutions, and individuals should implement targeted policies and safeguards to tackle these issues.

ROLE OF FORENSIC ACCOUNTING

Everyone knows that a forensic accountant is a bookkeeping bloodhound enthralled by the prospect of uncovering fraud and improper transactions within any organization. For auditing financial records, every company engages both internal and external auditors, who are on the lookout for conclusive evidence. The forensic accountant, on the other hand, seeks out substantial misstatements on purpose. When checking the books of accounts, forensic accountants use a more aggressive, skeptical approach, and they are less concerned with numerical precision than they are with revealing any chance of fraud. These people also appear to be on the lookout for benign documents, contents, and contradictions. (Singh & Gaur, 2025)

There are a few procedures that any forensic accountant must follow in the investigation process, in addition to the evidence retrieved from financial frauds, which include-

- Using reports and supporting documentation to communicate the results.
- Participating in court cases as a supporter.
- Contributing to the acquisition of records necessary to substantiate the claim.
- Examining the case's initial set of papers.

- Developing questions to be asked of the suspect concerning the financial documents obtained during the inquiry.
- Reviewing the opposing party's damages related to the report and conducting a thorough study of the situation.
- Assisting with negotiation and settlement discussions.
- Attending the other party's trial concerning the fraud that has taken place.
- Conducting a careful examination of all pieces of evidence found in the case and performing independent personal investigations.

TOOLS AND TECHNIQUES USED BY FORENSIC ACCOUNTANTS

Although investigations, suspect interviews, and financial data analysis are all a part of forensic accounting, they are not the only ones. The field is important and practical in addition to that feature. Due to the digitalization of everything in the present era, crimes are increasingly being committed online, where transaction data and other information can be recovered. Therefore, as part of their investigation process, forensic accountants may use particular investigative techniques in this scenario. A few essential tools and techniques are listed below-

- **Helix:** This internal utility can capture forensically reliable photos of many hard drive types. These can function in a variety of settings, including Mac, OSX, Windows, and Linux. Additionally, it may be used to boot any systems in a forensically sound environment. The helix method is another approach to using the Helix. It is used to acquire disc images that cannot be switched off or prolonged for longer periods.
- **ACL Desktop:** In essence, this is the audit command language, a tool used to read and analyse various types of data that are dispersed throughout the database. The key benefit of this program is that it gives us quick access to the transactional data of any firm, allowing us to study the full data set, identify any problem areas, and correct any mistakes or potential fraud. Another advantage of ACL is that it maintains data integrity by providing read-only access.
- **Ultra-block:** The hardware's major objective is to prevent digital forensic accounting from changing data. Since it is essential for forensic accounting to preserve the data's integrity when it is submitted in the court of law.
- **Advanced Hash Calculator:** Maintaining the integrity of the evidence in a court of law is the most crucial factor for a Forensic Accountant to take into account. Once the integrity is gone, it is worthless. As a result, the sophisticated hash calculator is crucial in this regard. CRC-32 Advanced, MD-2, MD-4, MD-5, etc, are supported.

There are also other traditional methods that Forensic Accountants use for investigations, including the following ones.

- **Benford's law:** In this mathematical test, the significance of variation between the two populations is determined using a parametric test known as the Z-test. This test simply identifies the areas of potential fraud, not any actual fraud. The fact that this test is unaffected by scale invariance and that it is extremely beneficial when there is no supporting documentation available to use as evidence of the legitimacy of any transaction are two of its main advantages. This law applies to dimensionless data, which means that their numerical values

depend on the unit- P(kx)=f(k)P, because if there is a universal probability distribution P(x), it must change with the scale (X).

- **Theory of Relative Size Factor:** This is done to identify any odd movements that must have resulted from fraud or actual errors. Simply put, this is determined by comparing the ratios of the numbers; if the second ratio is higher than the first, additional research is not necessary.
- **Computer-Assisted Auditing Tools:** These programs are used to aid auditors in more effectively carrying out audit procedures. These tools are used for a variety of purposes, including recalculating the calculations, running sampling programs, identifying discrepancies, and validating the specifics of transactions and balances.
- **Ratio Analysis:** Data analysis ratios, Financial ratios, and Utility ratios are just a few of the ratios that Forensic Accountants employ to determine any connection between normal and aberrant ratios, and are employed to look for probable fraud. Asset quality indices and gross margin indices are a few of the often-utilized ratios.
- **Data Mining Techniques:** These methods are employed to extract huge amounts of data for the study. This method is further divided into four sections:
  1. The discovery phase, in which the data pattern is found by analysing the trends and variations that result from them.
  2. Predictive Modelling, where the results are predicted based on the pattern that is observed.
  3. Determining whether items vary from the norms requires the application of deviation analysis.
  4. Link analysis is the stage where the particular pattern is found by employing graphical methods.

Other modern methodologies, developed by KPMG listed below, exist in addition to these general tools and processes:

- **Documentation Management:** The electronic evidence gathered during the investigation process can be preserved and presented in court using an e-discovery technology developed by KPMG.
- **Spot the Unusual:** This is a tactic in which transactions that took place over the holidays are specifically examined when investigating illegal financial transactions or the misappropriation of assets. In case of the frequent crimes like fraud and bribery, such transactions could be thought of as particularly strong evidence.
- **Verification (Know your Employee):** KPMG has made it a point to conduct a background check on each employee, including information on their address, education, previous job, physical and mental health, etc. To prevent fraud from happening within the company.
- **Fraud Risk Management:** KPMG takes a proactive approach to the prevention of fraud that could occur in any organization by offering training programs for risk assessment and awareness, vulnerability tools, data modelling, competitive risk management, and other things.

TRENDS IN FRAUD

The landscape of fraud has undergone significant changes due to various technological advancements and changes in consumer behaviour.

- The rise of online banking services, e-commerce facilities, and digital services has provided new opportunities for fraudsters to devise new methods of fraud. Particularly, the increasing use of mobile devices and e-wallets has introduced new channels for cybercrime. Data breaches, mostly resulting from inappropriate/ inadequate cybersecurity measures, have made personal information vulnerable to exploitation.
- Fraudsters are employing complex techniques to bypass the security systems, which include social engineering methods, deep fake technology, and advanced malware such as key loggers and spyware.
- The inception of cryptocurrencies has led to the emergence of new fraud techniques, like fake ICOs (Initial Coin Offerings), Ponzi schemes, and wallet thefts, etc. While cryptocurrencies are offering benefits, their pseudonymous nature makes them particularly susceptible to fraud.
- Despite a spike in online fraud, offline fraud has not disappeared. Instead, there has been an increase in hybrid fraud schemes that combine offline and online tactics, like using stolen credit card information obtained online to commit physical thefts or scams.

IMPACT OF FRAUD

Fraud has significant social and economic effects on individuals, businesses, and governments alike.

- **Financial Losses:** The Association of Certified Fraud Examiners (ACFE) estimates that each year, fraud losses worldwide amount to trillions of dollars. Direct costs are incurred by businesses, including the cost of putting fraud detection and prevention systems in place, legal fees, and monetary losses from fraudulent transactions. (ACFE, 2025)
- **Reputational Damage:** A business that experiences financial fraud may suffer a loss of clients' trust, which could result in lower sales and a lower value for its brand. The effects of online fraud can be particularly bad since compromised personal information can cause long-term damage to one's reputation.
- **Emotional and Psychological Repercussions:** Fraud Victims may often experience severe emotional distress, anxiety, loss of confidence, and long-term psychological effects. Identity theft and financial scams can cause long-term financial problems and disturb personal life.
- **Legal and Regulatory Consequences:** There is growing pressure on governments and regulatory agencies around the world to fight fraud. Businesses that fail to comply with set standards may face legal repercussions.

MITIGATION STRATEGIES

Fighting fraud requires a multipronged approach that includes consumer awareness, regulatory frameworks, technology, and human intervention. The following tactics are essential for preventing fraud in physical and online settings.

1. Tech-based Solutions

- **Advanced Encryption:** Robust encryption standards can help safeguard sensitive information during transactions and data transfers, preventing fraudsters from intercepting it.

- **Multi-Factor Authentication (MFA):** Requires multiple forms of identification before granting access to an account helps lower the possibility of unwanted/ unauthorized access. (Buzzclan, 2024)
- **Machine Learning (ML) & Artificial Intelligence (AI):** These technologies can be used to identify unusual patterns in transaction data and instantly indicate possible fraudulent activity.
- **Blockchain:** The inherent transparency and permanence of blockchain technology present exciting opportunities for combating fraud in sectors like digital payments and identity management.

2. Human-Driven Approaches

- **Training and Awareness:** Educating employees and consumers about fraud reporting and prevention techniques, and safe online practices, is important to preventing both online and offline fraud.
- **Internal Controls:** Organizations should implement strong internal controls to identify and avert fraud, including segregation of duties, conducting audits, and ensuring transparent financial operations.
- **Due Diligence:** The investigation of potential business partners/customers helps in uncovering red flags and associated risks before entering into a transaction or contract, thus helping mitigate the chances of falling prey to fraud.

3. Legal and Regulatory Measures

- **Stronger Cybersecurity Laws:** The government must reinforce laws and regulations pertaining to cybersecurity to ensure that businesses comply with rigorous data protection standards.
- **International Cooperation:** Given that fraud is becoming more international, law enforcement agencies, regulatory organizations, and private sector entities across borders need to work together to tackle fraud.

CONCLUSION

Based on the analysis, it is evident that factors such as organisational faults, human factors and psychological manipulation, vulnerabilities in technology, underuse of forensic accounting, and regulatory changes all contribute to the rise in fraud.

Further, a major issue is the lack of awareness about financial fraud among rural populations, who often become primary victims of technology-driven financial crimes. Equally important is the role of organisations and companies, where employees themselves may be involved in such frauds. Therefore, proper measures should be taken to prevent these activities. Internal controls must be strengthened by maintaining staff accountability and increasing vigilance, which will serve as an essential step towards, preventing technology-driven financial fraud. As the number of cases continues to rise, the government should also consider deputing more forensic accountants and experts in forensic accounting, whose expertise is highly valuable in courts of law and effective in tracing and resolving financial crimes. This indicates a growing demand for forensic accountants in the near future. Additionally, both the government and individuals should take steps to promote awareness through education programmes and public campaigns to prevent and mitigate fraud in the country, thereby supporting the Indian economy and contributing to national security.

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Development of Latent Fingerprints from Waste Materials: Cigarette Ash Powder

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ABSTRACT

A fingerprint can be defined as the patterns of ridges and valleys on the fingers, which are useful when identifying criminals. The basic chemical process is to dust the latent fingerprints, but the normal powders that are used are equally dangerous to people's health. Choosing the right fingerprint powder is key and should possess the following properties: the powder should not be toxic, the size of the particles should be very small, the color should contrast with the color of the latent fingerprint, and the powder should be stable. It is difficult indeed to create the perfect fingerprint powder that complies with these characteristics, and that is why there are many types of powders in existence these days. It is surprising that latent fingerprints, which are the most recurrent type of prints left behind at crime scenes, need to be enhanced in order to be detected. Recovery of latent prints is therefore considered one of the challenges in the field of forensic science, and there is a need to enhance it. Cigarette ash powder may also be used since it is readily available and relatively cheap when compared to commercially available powders. Local cigarette ash and foreign cigarette ash were used in the study as a fingerprint powder; both were effective in lifting fingerprints of both porous and non-porous objects. It emerged that the prints developed appropriately on both the glass slide and the lab platform, not on the rock and the Whatman filter paper. In other words, the time factor did not delay the process of developing latent fingerprints using the cigarette ash powder. In addition to the chemical analyses, it was further identified that the powder was fluorescent under ultraviolet radiation. In conclusion, cigarette ash powder can be used effectively to develop latent fingerprints more especially since it is easily available, and the powder provides better results. It can be of immense value in helping forensic investigators solve crimes that they are investigating. However, more investigation is required in order to establish the full characteristics of the powder, as well as its capability to be brought to the market as a new fingerprinting powder.

Keywords: *Fingerprint Powder, Cigarette Ash, Development, Crime Scene Investigation, Latent Fingerprints*

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INTRODUCTION

Fingerprints are unique ridges on the volar pads of the fingers that allow them to grip surfaces without slipping [1-2]. They provide permanent and valuable evidence in criminal investigations. Powder dusting is the standard method for revealing latent fingerprints, and it has been used since 1891[3]. This method is based on pressure deficit and the adhesion of powder particles to sweat deposits on the fingerprint remnant[4]. Other parameters that influence the efficacy of creating latent fingerprints include particle shape, fingerprint age, ambient circumstances, color contrast, and surface type [5].

The demand for alternative fingerprint powders stems from the health risks associated with traditional powders, such as heavy metal poisoning. Lead and mercury-based formulas have been phased out, and even ubiquitous powders such as cyanoacrylate fumes and carbon black powder have been connected to health concerns[6]. Skin problems and eye disorders are among the threats faced by law enforcement workers. A good fingerprint powder formulation should include tiny particles, strong color contrast, adequate flow ability, stability, a long shelf life, affordability, and the availability of common ingredients, in addition to being non-toxic. It shouldn't be as clunky as graphite powder.

Formulating a universal fingerprint powder that fits all of these characteristics is difficult; hence, several powders have been developed over time. Fingerprint experts believe that no single powder is appropriate for every situation, thus each fingerprint should be treated individually. The right fingerprint powder for a certain fingerprint requires careful consideration of a variety of parameters.

Based on the idea that every interaction leaves traces, latent fingerprints are the most common prints found at crime scenes. Enhancing latent fingerprints is required for them to be detected. Fingerprint patterns are created on the surfaces of the fingers and thumbs and are unique to each person. Fingerprint evidence is utilized extensively in the criminal justice system and can be used to identify individuals. For more than a century, fingerprint examination has been the foundation of forensic investigation.

The detection of latent fingerprints is a difficult aspect of forensic science. Crime scene investigators use a two-step procedure, first checking for visible or plastic prints and then blindly searching for latent prints. Latent print recovery is critical to scene reconstruction. In India, latent fingerprints are detected via chemical, physical, and instrumental approaches, with conventional powdering procedures being the most frequent. However, there is a need for new methods that are more efficient and have fewer constraints.

Why Cigarette ash powder?

As we all know, cigarette smokers are found everywhere around us, and according to the Global Adult Tobacco Survey India, 2016-17, nearly 267 million adults (15 years and above) in India (29% of all adults) are users of tobacco, making it easily available everywhere around us in form of waste material at almost zero or low cost.[7]

REVIEW OF LITERATURE

A new technique for producing hidden fingerprints with turmeric powder has been discovered. Commonly used in Indian cuisine, turmeric shows clear effects on nine different surfaces. Conventional fingerprint

identification approaches, including powder dusting and ninhydrin immersion, can be poisonous. The research investigates turmeric powder as a harmless option. The scientists discovered that besides on skin, turmeric could uncover fingerprints on many kinds of surfaces. They used powder dusting to remove excessive powder from a surface, and finely ground turmeric was applied. Chemical bonds formed with fingerprint oils made it effective on materials like aluminium, plastic, and paper. The writers recommend applying turmeric across different surfaces for improved visibility.[8]

Furthermore, investigated for fingerprint formation were other food powders, including cocoa and corn flour. They were discovered to be both non-toxic and efficacious on non-porous and porous surfaces. Since food powders provide less dangerous options, conventional fingerprint identification techniques usually rely on toxic chemicals. Though they did less well on substances like cardboard, different food powders left visible marks. This research shows that when traditional powders are not available, ordinary food powders may be used to substitute typical fingerprint dusting resources.[9]

Furthermore, research sought to produce good, activated carbon from banana peel for latent fingerprint detection. The banana peel was ground into fine particles, then checked for its adhesion to fingerprint residue together with sodium acetate and mineral oil. Certain levels of these compounds, particularly with 20% sodium acetate, increased fingerprint adherence, the results showed. It revealed that banana peel carbon could link well under ideal circumstances, exceeding certain commercial products in size and form.[10]

Powdering methods, which depend on the properties of the powder to stick to the oils left by fingerprints, were typically used to create latent prints. These methods' efficacy is affected by the surface chemistry and particle size, among others. The research stressed the need to use non-toxic and effective powders to create prints consistently, given the health dangers of certain conventional powders.[11]

Artificial food colors and gulal, a powder for festivals, were also tested by scientists on latent fingerprints derived from sweat and sebum. Testing on different surfaces revealed that these hues, particularly on standard paper and aluminium, might generate clear ridge patterns. The investigation revealed that these everyday materials can effectively compensate for costly powders typically used in fingerprint discovery.[12]

One other simple way was to show fingerprints with Multani Mitti (Fuller's earth), a nontoxic and readily available substance. This method has shown potential on numerous surfaces, consistent with normal fingerprinting based on the same core adhesion principle in powdering techniques.[13]

Research also under closer examination would involve using fingerprint development powder produced from waste marble slurry. By also addressing an environmental concern on marble waste disposal, this strategy effectively generates latent fingerprints on many kinds of surfaces.[14]

Particularly on challenging and multi-colored materials, a new approach using Robin® powder blue gave excellent fingerprint development results. This inexpensive home product adhered well to surfaces, gave easy lifting, and showed obvious fingerprint visibility.[15]

Also, under consideration was powdered rock phosphate for its ability to produce fingerprints on poly porous and permeable substrates; results were best among synthetic options. This research suggests that fingerprinting can be significantly effective using inexpensive, non-toxic compounds where traditional commercial powders are not located. Basically, ongoing research keeps turning up easy and already accessible methods for latent fingerprint development among food powders, fruit materials, and waste products, thus emphasizing simplicity and access in forensic processes. Since more eco-friendly options are gradually replacing arduous, damaging techniques, the numbers suggest a notable rise in practical applications linked to crime scene investigation.[16]

Particularly, silicon oxide nanoparticles (SiO2 NPs), the last two decades of nanoparticle use for latent fingerprint detection have captivated researchers. One significant finding in this field is a new study suggesting that, along with an excellent ruthenium complex, carboxyl-functionalized SiO2 NPs should be used. These functionalized nanoparticles were investigated in order to improve the sensitivity of detection. Lower amounts of these particles in a solution were demonstrated to increase detection precision. Furthermore, using higher temperatures and lower immersion times yielded better results than older techniques, therefore enhancing the efficacy of these identification marks for uncovering latent fingerprints. The forensic science sector values fingermark detection greatly because it aids in the resolution of crimes. Though tried methods are dependable, they sometimes do not work for every fingerprint mark, so new techniques are necessary to enhance crime resolution. Their luminescent properties, selective interaction with fingerprint residues, and high-resolution detection are among several advantages of nanoparticles. Given these characteristics, SiO2 NPs would be ideal for fingermark identification. Although earlier research demonstrated SiO2-based particles' flexibility, further comparative tests were needed. Although more fine-tuning is needed, recent studies pointed to possible SiO2 NPs application for latent fingerprint detection, hence equalizing their effectiveness with typical one-step cyanoacrylate fuming.[18]

Furthermore, a review was neutral alumina as a new and inexpensive option for fingerprint presentation. Non-poisonous and readily available, this stuff is a good alternative to costly store powders. Particularly since it could show thorough features of fingerprints using sophisticated imaging technology, the research tested alumina on sixteen different kinds of surfaces and confirmed its efficiency. This strategy sought to offer a reasonably priced and secure solution for fingerprint growth. Since forensic science began, traditional powder dusting techniques for fingerprint identification have been around, with several kinds of powders marketed. Neutral alumina was among several unconventional powders demonstrated to work. Alumina could generate high-contrast fingerprints on many surfaces, therefore offering a good candidate for replacement.[19]

In addition, the study looked into superglue fuming, ninhydrin, and eosin techniques for improving latent fingerprints on different materials. Super glue fuming was discovered to be effective on non-porous materials, producing excellent prints even days after. On porous surfaces, conversely, the ninhydrin technique is most effective as it interacts with sweat to create visible prints. The eosin technique made prints on flat surfaces more

visible, therefore stressing the need for surface type and age for results. All in all, these techniques add important information to forensic science.[20]

The research of fresh fingerprint powders centered on environmentally friendly, inexpensive possibilities. For latent fingerprint identification, researchers looked at several substances, including brick powder, gambir powder, and turmeric powder. Because of its non-toxic nature, gambir powder seemed to be a more environmentally friendly option and produced clear effects on several surfaces. Using brick powder proved effective in showing latent prints on dark and bright surfaces.[22]

Finally, research was done on Spirulina platensis powder as a non-toxic means of seeing fingerprints under near-infrared light, hence showing possibilities for application in different forensic situations. Furthermore, a fluorescent dust powder made from Zingiber Montanum was invented, showing the power to expose UV light fingerprints. New materials and techniques for fingerprint identification that satisfy the demands of forensic cases while being safe and easy to reach are continuously being sought.[25]

METHODOLOGY

Materials and apparatus:

Local Cigarette(Beedi) /Foreign Cigarette ash was collected from various smokers of different brands in a plastic box, mortar and pestle, Fingerprint Feather brush, latex gloves, VSC, UV-light Chamber, as well as four porous and non-porous study materials (Glass slide, Whatman Filter Paper, Rock, and Lab Platform).

Preparation of Cigarette Ash Powder:

About 30g of cigarette ash powder was ground to a fine powder with a mortar and pestle. The fine Cigarette Ash Powder was sealed in air-tight containers for later use.



Fig 1: *Mortar and Pestle*



Fig 2: *Plastic Box, Cigarette Ash Powder, Fingerprint Feather brush*

Preparation and Visualization of Fingerprint Samples:

The latent fingerprints in this study were collected and developed on several porous and non-porous surfaces, like glass, Whatman filter paper, rock, and tile with ash treatment. Powder dusting is utilized as the technique of latent fingerprint development in this study. This physical method depends on the capacity of the fine fingerprint powder particles to stick onto skin moisture and natural excretions, which appear on the skin pores in the form of ridge patterns.[23] The process must first identify which area is of interest, then dusts fingerprint powders over the suspected area,

with the powders adhering to the sweat oils and other dorsal components from the fingerprint. Therefore, trying to develop latent fingerprint samples in crime-related areas or suspected spots, a brush is employed to apply cigarette ashes-due to their finesse-in the affected places.[23]

RESULTS AND DISCUSSIONS

Consequently, this present research work sought to determine the viability of newly developed Cigarette ash Powder as a new form of fingerprint powder option. From the observation as highlighted from the experiment, it was quite clear that the finely ground cigarette ash powder was effective in the revelation of fingerprints on the porous and non-porous study materials, such as the glass slide, the Whatman filter paper, the rock, and the lab platform.

The Observations are as Follows:

- **Glass slide:** The fingerprints developed on the surface of the glass slide, and overall fingerprints could be easily developed. By natural appearance, each of the ridges can be observed and distinguished with much ease and comfort.
- **Whatman Filter Paper:** A visible print was discovered, although it was not clear in nature. The non-absorbent nature of the paper cover in this case meant that the particles could not cling to the surface due to its smoothness.
- **Rock:** The print was not developed.
- **Lab Platform:** The prints were sharp, but what could be termed as not crisp at all. A powdery substrate with no large lumps enabled the particles to adhere well and resulted in better visibility of the pattern.

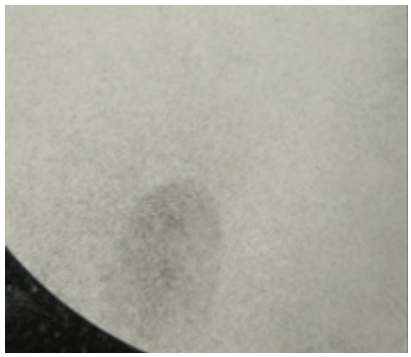


Fig 3: *Paper Surface*

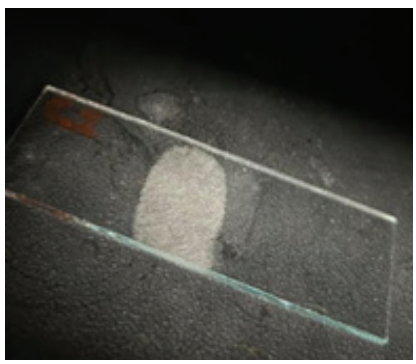


Fig 4: *Glass Slide Surface*

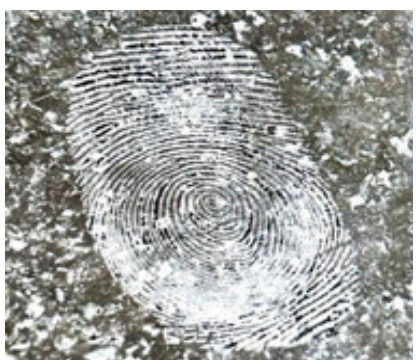


Fig 5: *Lab Platform Surface*

Effect of Time on Developing Latent Fingerprint from Cigarette Ash Powder:

The prints were taken from the donors at a single time, and various time-based developments were performed, i.e., instant development, development after 24 hours,

development after 48 hours, and development after 72 hours. After instantly developing the latent fingerprint, for the rest of the readings, prints were kept in an open atmosphere at approximately 35-40 degrees Celsius. The following results were obtained.



Fig 6: *Instant Development*



Fig 7: *Development after 24 Hours*



Fig 8: *Development after 48 Hours*

Fluorescence Analysis:

After the collection of cigarette ash in a plastic box, it was observed under UV-light in the UV-LIGHT Chamber, but no fluorescence was seen.

But after developing the latent fingerprint on a glass slide using cigarette ash powder, fluorescence was seen under UV-LIGHT in the UV-LIGHT chamber and in the VSC (Visual spectral comparator).

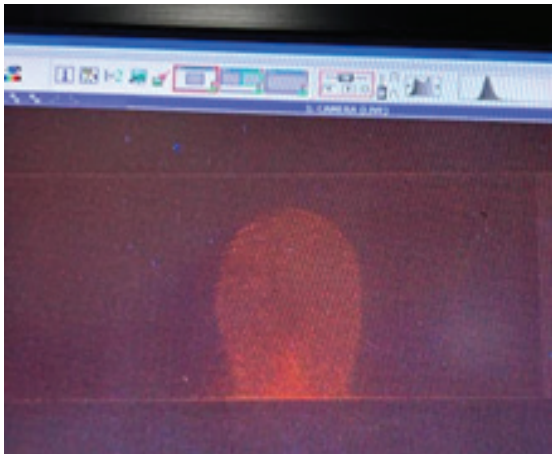


Fig 9: *Fluorescence seen in VSC*

CONCLUSION

It is concluded that the cigarette ash powder, which is used to develop latent Fingerprints, is easily available at a low cost and is found everywhere around us in the form of waste. The cigarette ash powder is very easy to use, providing better results on surfaces for developing latent Fingerprints.

In the context of understanding the Minor Project of Cigarette ash Powder, it is relevant to note that: The global availability of Cigarette ash is easy to find at any locality. One thing that comes out of this process is that nothing is priced at a higher price. This revelation, therefore, goes to show that the forensic experts sometimes do not arrive at the crime scene with latent fingerprint development powder, which is why Cigarette

ash powder can be used in the development of latent fingerprints and can be of paramount importance to solving a major crime scene. There are virtually different fingerprint powders in the market, which are chemically formulated, and it is expensive to make, while they have health-hazardous effects. This kind of cigarette ash powder proves useful in visualizing latent fingerprints at the scene of any crime.

Summarily, this waste material and cheap form of dusting with cigarette ash powder is in a position to reveal hidden fingerprints on both porous and non-porous surfaces. From this research, it was perceived that-result on glass slides gave the best result, followed by the result on the Lab platform, and then Whatman filter paper. Materials that are easily available and have been discarded as waste should be studied on many cross-sections and on many premises to test their usefulness as non-traditional fingerprinting powders. As a result, this field is very much untapped to researchers, as the question arises of how we can collect so much of cigarette ash conventionally and easily, for introducing powder in the market?

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Alternative Methods for Extraction of Blood From Different Surfaces For Species Origin Test

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ABSTRACT

At the crime scene, blood is a fundamental pool of information that will serve as access to understand what happened. It may manifest as pools or stain impressions, which could provide varying information. The proper collection and packaging of blood evidence are imperatives to ensure reliable results. At a crime scene, both human and animal blood can be found; however, testing such as the double diffusion test and the precipitin test would cause people to tell them apart. When the investigator arrives at a crime scene days after the events occurred, especially in open environments such as forests, outdoor blood can already be influenced by environmental factors like wind or moisture and variations in temperature. The blood can change from these natural conditions, complicating a clean test to determine where that blood comes from. The objective of this study is to determine how much effect these environmental factors have had on the discriminability by which species of origin can be assigned, given blood evidence.

Keywords: *Precipitin Test, Double Diffusion Test, Animal Blood, Human Blood, Comparison*

INTRODUCTION

Biological fluids are crucial pieces of evidence collected from crime scenes. Key fluids like blood, sweat, semen, and saliva are often found in cases of rape, murder, and sexual assault, with blood being the most common. Blood provides vital information about the suspect, such as personal identification, age, origin, sex, and DNA. After committing a crime, perpetrators often try to destroy evidence and clean the scene to avoid detection. However, these biological samples can still be recovered using chemical methods. Even if the culprit cleans surfaces with detergents, investigators can still detect the presence of blood.

At a crime scene, blood can be found in

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various forms, such as flakes, drops, pools, or splatters. In some cases, blood smears on surfaces may indicate that a body was moved. Evidence collection involves techniques like swabbing, scraping, and other methods. Proper packaging of biological samples is essential to prevent contamination and ensure accurate results. Sterilised equipment is typically used for collection, and samples are dried in the shade before being packed in paper bags. Biological evidence should never be stored in plastic, as this can lead to contamination. Improper handling of evidence can result in false outcomes.

Blood is one of the most critical forms of evidence, providing extensive information about criminal activities. It can be found at crime scenes in various forms, including pools, stains, and splatters. When properly collected and packaged, blood evidence can yield highly informative results. Both human and animal blood may be present at a scene, and distinguishing between them involves tests such as the double diffusion test and the precipitin test. In some cases, investigators arrive at the crime scene several days post-incident, especially in outdoor settings like forests, where environmental factors like wind, moisture, and temperature can impact the condition of the blood. This study is therefore conducted to assess how these natural conditions affect the determination of the species origin from blood evidence. This research paper will focus on alternative methods for extracting blood from different surfaces for species origin tests, aiding investigators in determining whether a substance is blood or not.

OBJECTIVES OF THE STUDY

To know the Influence of natural conditions in altering the origin test for blood.

To conduct an analysis of the Perception Test and Ouchterlony Test.

REVIEW OF LITERATURE

Abhishek Sharma, Swarthi Mahendra, and Shukla Jawaharlal Nehru from the CSIR Central Drug Research Institute in Lucknow conducted a study on the concept of dried blood spots (DBS), exploring its current state and future prospects in bioanalysis. Their research focused on the use of DBS sampling techniques, both quantitative and qualitative, within the context of bioanalysis. In this method, blood samples are allowed to dry before undergoing immunological or genomic detection. The study highlighted the efficiency of DBS in various applications, including pharmacokinetics, therapeutic drug monitoring, toxicokinetics, metabolism studies, and disease diagnosis. The dried blood spots were collected on cellulose filter paper, which serves as the medium for this sampling technique.

GS Rahman and Smith from the Pathological Laboratory at the University of Cambridge focused on the biological or precipitin test for blood, primarily from a medico-legal perspective. Similarly, F. Sanjar from the same laboratory examined the biological or precipitin test with a similar focus. Their study emphasised the greater medico-legal importance of human blood compared to that of other animals. While they noted that classifying blood from mammals, birds, and reptiles is relatively straightforward, distinguishing between different types of mammalian blood presents more challenges. In 1901, Nuttall was the first to explore the potential use of blood serum tests from a forensic perspective.

Uhlehut, Zienke, and Binodi were other

researchers who contributed to this area of study by experimenting with blood dried on various surfaces. Despite their efforts to eliminate errors, some inaccuracies occurred, which negatively impacted the outcomes of their research.

RESEARCH GAPS

- **Comparison of DBS and Traditional Methods in Forensics:** While Abhishek Sharma and colleagues explored the efficiency of DBS in bioanalysis, there is a gap in comparing the DBS technique with traditional methods used in forensic blood analysis, particularly in terms of sensitivity, specificity, and practical application in different forensic scenarios.
- **Forensic Application of DBS:** The study by Sharma et al. focused on bioanalysis but did not delve deeply into the potential application of DBS in forensic science, particularly in the context of crime scene investigations and legal proceedings, an area explored by GS Rahman and Smith with traditional blood tests. Investigating how DBS could be integrated or compared with existing forensic techniques represents a significant gap.
- **Impact of Environmental Conditions on DBS:** Previous research by Uhlehut, Zienke, and Binodi highlighted the challenges of analysing blood dried on various surfaces, particularly due to environmental factors. However, Sharma et al.'s study does not address how environmental conditions might affect the integrity of DBS samples, especially when used in outdoor crime scenes. This represents a potential area for further research.

  By going through this brief review of literature, I found a few gaps that I will try to fill in the present study.

METHODOLOGY

The aim & objective of the study is to know about the 'Alternative methods for extraction of blood from different surfaces for species origin test' to analyze the data. An exploratory and descriptive research design is adopted in the current study based on the primary data as well as the secondary sources. Exploring is nothing but trying to examine information obtained from the test-oriented procedures.

The field of the universe: The present study would be conducted in Thrissur, Kerala, India.

The samples: 5 Samples are collected from Human Blood, Goat Blood, Dog Blood, Fowl Blood, and Beef Blood for study.

Tools and methods of data collection

- ***Primary methods:*** - Data has been collected from Flesh Vendors and Veterinary Hospital, and Self Blood used to conduct the Perception Test and Ouchterlony Test. A test has been conducted in the Kerala Police Academy Mini Forensic Lab.
- ***Secondary methods: -***

  The secondary data being extensively used are as follows:

  i. Books, Journals, Articles, Periodicals, Publications.

  ii. Web Sources.
- **Limitation of the study:** For the present study, only 5 samples were collected.

GENERAL DISCUSSION

Blood and Its Relevance in Forensic Science

One of the most crucial biological clues commonly uncovered at crime scenes is blood. It is regarded as a crucial forensic tool because of the rich information it contains. The examination of various characteristics of

bloodstains can help to clarify the conditions in which some violent crimes were perpetrated. Such crucial information can assist in criminal investigations and crime resolution. In rare situations, it can also aid in the legal judgement of a criminal act, resulting in a more accurate and fitting penalty for the offender. It's crucial to figure out what happened when a violent crime involving blood was committed. Appropriate approaches from natural sciences, notably molecular biology methods, as well as mathematics, physics, and chemistry, are used to analyse various features of bloodstains. The evaluation of results and the collection of information are only possible with proper knowledge. A lot of important information can be gathered from examining the chemical components of a single drop of blood.

Bloodstains can provide significant information if they are investigated thoroughly. Depending on the surface on which the blood falls the shape of the splatter will also vary accordingly. A Forensic analyst should have knowledge regarding all these aspects for retrieving accurate results from a blood splatter. We need a specialised set of skills to be able to comprehend the results of a thorough bloodstain examination. Fundamentals of natural science, mathematics, biology, and physics are all essential, in addition to some real-world criminal investigation experience. Violent crimes leave a trail of blood. Keeping these factors in mind, prerequisites can be understood by a well-trained and experienced professional to analyze bloodstains at the crime scene with pinpoint accuracy and collect vital information. When this isn't immediately apparent, a comprehensive and committed examination of bloodstains might reveal vital details and aid in the investigation. Considering all of the assumptions, it is vital to note that this is a one-of-a-kind study. Only use this valuable tool if it is necessary to respond to specific inquiries about a specific incident of carnage event. As a result, this process should be used only as needed. Bloodstains of some kind can be found in every case. To determine whose blood it is, it should also rely on the results of DNA analysis.

Forensic Serology

The detection, identification, classification, and analysis of blood, sperm, saliva, urine, breast milk, vomit, faeces, perspiration, and other body fluids, as well as their relevance to a crime scene, is referred to as forensic serology. A forensic serologist can also undertake DNA and bloodstain pattern analysis. Serology testing starts with presumptive tests, which offer the analyst a hint that a specific physiological fluid is present but don't totally confirm it. The confirmatory tests come after the presumptive testing, and they confirm what the unknown chemical.

Properties of Blood

Blood is a connective tissue that consists of blood cells and plasma in a liquid state. Blood is a fluid having important biological, chemical, and physical qualities that must be considered while dealing with studying blood streaks at the crime scene. Blood is a viscous liquid. Blood cells and plasma make up the connective tissue. It is a bodily fluid, which makes up roughly 7% of the total body weight of a typical person, with a total of 4-5 litres in women and 5-6 litres in men.

Blood is primarily used to transport numerous chemicals across the body, as well as for defense against various types of threats. The ordinary human can withstand a sudden loss of nearly one-third of the total blood volume,

but any further loss may cause death. When bloodshed occurs during a criminal offense; due to its chemical and physical properties, the area often becomes covered in blood. The positioning and distribution of bloodstains are governed by mathematical and physical laws.

The pumping motion of the heart circulates blood through the body's arteries. In animals with lungs, arterial blood transports oxygen from inhaled air to the body's tissues, while venous blood carries carbon dioxide, a waste product of cellular metabolism, from the tissues to the lungs for expulsion. Circulation ensures that the composition of blood remains constant by transporting it through organs that regulate substance concentrations. Carbon dioxide is transferred from the tissues to the lungs, where it is exchanged for oxygen. Excess water and dissolved waste materials are filtered by the kidneys. After being absorbed through the gastrointestinal tract, nutrient molecules from food enter the bloodstream. The endocrine glands release hormones into the blood, which are transported to the tissues where they exert their effects. Many substances in the blood are recycled. For example, iron released during the breakdown of old red blood cells is transported by plasma to locations where new red cells are produced and reused. An effective regulatory mechanism maintains each component of blood within suitable concentration limits.

Blood absorbs oxygen from the air in the lungs and transports it to all the body's cells, while also removing waste carbon dioxide. After diffusing from the blood to the air, carbon dioxide is exhaled from the lungs.

Blood is vital to both the digestive and endocrine systems. The villi lining the small intestine contain capillaries that absorb digested nutrients into the bloodstream. These nutrients include glucose, amino acids, vitamins, minerals, and fatty acids. Blood also transports several hormones released by endocrine glands to target tissues and organs. Heat is absorbed and distributed throughout the body via blood, helping to maintain homeostasis by releasing or retaining heat. Blood vessels expand or constrict in response to external organisms such as bacteria, as well as internal hormonal or chemical changes. These processes regulate blood flow and heat distribution, bringing blood and heat closer to or away from the skin.

ABO Blood Group System

The ABO blood group system is used to indicate whether erythrocytes have one, both, or neither of the A and B antigens. It is the most important of the 38 various blood type (or group) classification systems now accepted in human blood transfusions. A mismatch in this, or any other serotype, can result in a potentially fatal adverse reaction after a transfusion or an undesired immunological response to an organ transplant (both of which are extremely rare in modern treatment). Anti-A and anti-B antibodies are usually IgM antibodies, which are formed in the first few years of life as a result of sensitisation to environmental elements like food, germs, and viruses. In 1901, Karl Landsteiner developed the ABO blood types, for which he received the Nobel Prize in Physiology or Medicine in 1930. ABO blood types are seen in other primates such as apes and Old-World monkeys. Jan Jansk, a Czech serologist, published the first blood type classification in a local magazine in 1907. He utilised the Roman numerals I, II, III, and IV in his writing (corresponding to modern O, A, B, and AB). Unbeknownst to Jansk, an American physician named William L. Moss developed a somewhat different categorisation system

based on the same numerical system, with his I, II, III, and IV corresponding to contemporary AB, A, B, and O. In medical practice, these two systems caused confusion and a risk of harm. Moss's system was accepted in the United Kingdom, France, and the United States, while Jansk's was favoured in most European countries and sections of the United States. In 1921, the American Association of Immunologists, the Society of American Bacteriologists, and the Association of American Immunologists merged to establish a unified body, but the classification conflict continued, especially where Moss's system had been in use. Landsteiner relocated to New York's Rockefeller Institute for Medical Research in 1927. As a member of a National Research Council committee on blood grouping, he proposed replacing Janský's and Moss's systems with the letters O, A, B, and AB. (There was also some uncertainty about Hirszfeld and von Dungern's choice of the numeral 0 for German null, because some used the letter O to represent "ohne", meaning without or zero; Landsteiner chose the latter.) The National Research Council accepted this classification, which became known as the National Research Council classification, the international classification, and most famously, the "new Landsteiner classification." The new system gradually gained acceptance, and by the early 1950s, it was widely used.

Over a century ago, when the ABO blood group was discovered, there was a lot of enthusiasm. Before that, all blood was considered to be the same, and the often-fatal implications of blood transfusions were unknown. Not only did our understanding of the ABO group improve the safety of blood transfusions, but scientists were also able to investigate one of the first human features to be demonstrated to be hereditary. The ABO blood type of a person was employed by lawyers in paternity cases, police in forensic science, and anthropologists in population studies.

The ABO blood group antigens are the most immunogenic of all the blood group antigens; hence, they remain very important in transfusion therapy. A clerical error in which an incompatible kind of ABO blood is transfused is the most prevalent cause of death from a blood transfusion. Because the frequencies of different ABO blood types fluctuate among different groups, suggesting that a particular blood type offered a selective advantage, the antigens of the ABO blood group appear to have been crucial throughout our evolution (e.g., resistance against an infectious disease).

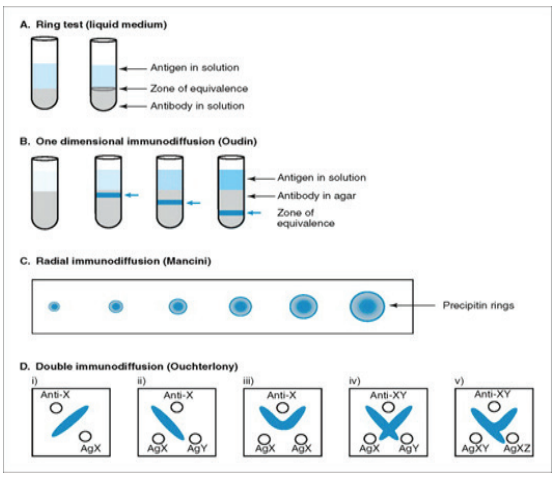
The physiological activities of ABO blood group antigens, despite their evident clinical importance, are unknown. People with the common blood type O do not express the antigens A or B, but they are otherwise healthy. A number of links have been found between specific ABO phenotypes and higher illness vulnerability. The ABO phenotype, for example, has been related to stomach ulcers (which are more common in some people) and gastric cancer (more common in group A individuals). Another finding is that people with blood type O had lower levels of the protein von Willebrand Factor (vWF), which is implicated in blood clotting.

Sr.no	Blood group	Antigen(s) present on the red blood cells	Antibodies present in the serum	Genotype(s)
1	A	A antigen	Anti-B	AA or AO
2	B	B antigen	Anti-A	BB or BO
3	AB	A antigen and B antigen	None	AB
4	O	None	Anti-A and Anti-B	OO

Analysis Of Blood Stains

Precipitin Test

Rudolf Kraus was the first to discover the precipitin test (1897). It was stated to be totally particular when it was originally reported. The antigen of the homologue causes a stronger reaction than any other. Nuttall (1904) compiled the available knowledge of precipitin reactivity in his classic, Blood Immunity and Blood Relationship. In all forensic science laboratories, the precipitin test is used to identify human blood or blood from other sources. Leave a drop of extracted blood in a precipitin tube, add one drop of serial antisera dilution to the same tube, and place it in the refrigerator overnight for 24 hours. Remove the tube and inspect it for a precipitin ring. A ring can be seen at the point where blood and antisera collide. Various techniques have been developed and are still used in these laboratories, but they all have flaws, such as:



Sources: Tak W. Mak, Mary E. Saunders, in The Immune Response, 2006, Exploiting Antigen–Antibody Interaction. https://www.google.com/search?q=precipitin+test&sxsrf=AOaemvKgYkaX3XKz8yGX1BOozjdmwHYeNw:1640007479691&source=lnms&tbm=isch&sa=X&ved=2ahUKEwiGuoX6v_L0AhXASWwGHWiTAvEQ_AUoAXoECAEQAw&biw=1536&bih=754&dpr=1.25#imgrc=ym6gFxj4YPITcM

(1) The time it takes to complete a large number of tests

(2) The danger of losing modest amounts of important extracts due to the time it takes to execute a large number of tests

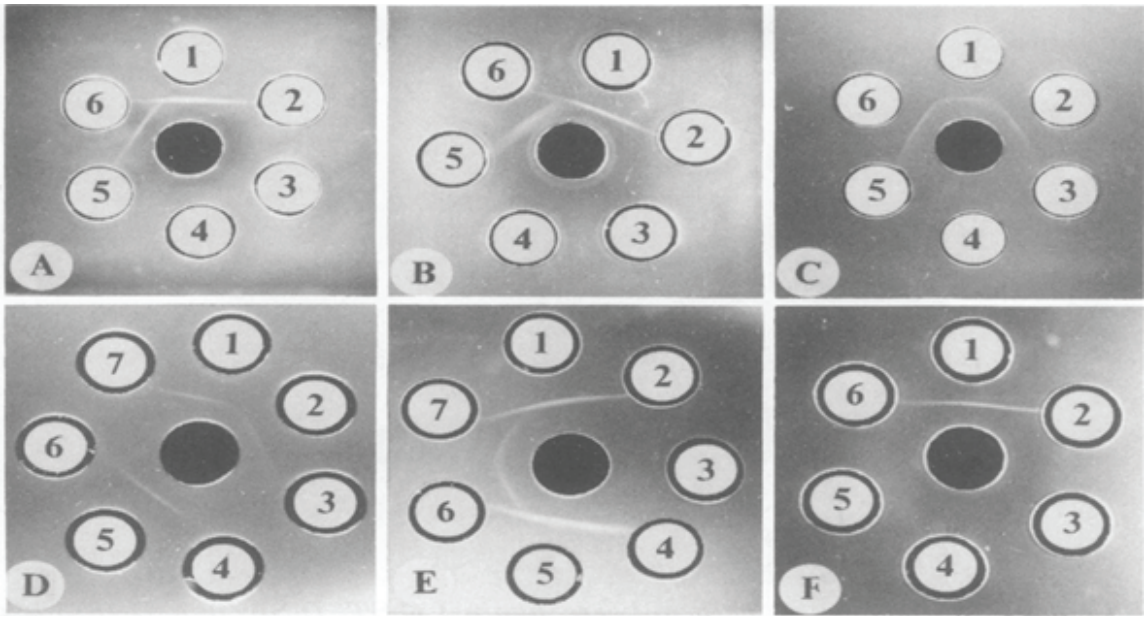
(3) The test's use of relatively high volumes of particular antisera and blood stain extract

(4) The manner in which the test is administered.

Outcherlony/ Double Diffusion Method

Ouchterlony double immunodiffusion (sometimes referred to as passive double immunodiffusion) is an immunological technique for detecting, identifying, and quantifying antibodies and antigens such as immunoglobulins and extractable nuclear antigens. Örjan Ouchterlony, a Swedish physician, devised the test in 1948, and the technique is named after him.

An agar or agarose gel is cut into a series of holes ("wells") using a gel plate. In one well, a sample extract of interest (for example, human cells extracted from tonsil tissue) is inserted, and the plate is permitted to expand for 48 hours while sera or purified antibodies are added in another well. During this time, both the antigens in the sample extract and the antibodies in the antibodies diffuse out of their respective wells. If any of the antibodies detect any of the antigens at the point where the two diffusion fronts meet, they will bind to the antigens and create an immunological complex. The immunological complex forms a thin white line (precipitin line) in the gel, which serves as a visible marker of antigen recognition.



Source:https://www.researchgate.net/figure/Ouchterlony-double-immunodiffusion-plate-showing-the-specificity-of-the-vitellogenin_fig1_23027042

Case Study

Blood spatter analysts, as played by Dexter Morgan on Showtime's Dexter, are modern-day heroes who solve cases that would otherwise go unsolved. It's vital to keep in mind, though, that blood spatter experts aren't perfect. While scientific, this field of forensics is subject to human interpretation, which can lead to debate within the criminal justice system. Some blood spatter analysis cases have resulted in the wrong person being charged or in the release of guilty offenders. There's no doubting that this relatively new sort of criminal forensics, which was initially used in a case in the 1950s and only became more formalized in the 1970s, has a lot of potential and is incredibly useful in discovering how a violent crime was committed. Even so, there have been situations where the blood spatter expert's report determined the entire outcome of a case.

Case Studies from Kerala

Scientific evidence in the Jisha rape and murder case has led to a guilty verdict. Following the horrible murder of Jisha, the accused Ameerul Islam, who departed Perumbavoor on the night of April 28, 2016, was wary of using his cellphone in order to avoid being monitored and apprehended by the police. Ameerul's involvement in the cold-blooded murder was confirmed by a scientific investigation based on DNA samples taken from the victim's nail clippings, saliva, and blood stains found in the victim's churidar, blood stains found on the door frame of Jisha's house, call detail records, and a statement given by a homemaker who was Jisha's neighbour. DNA samples retrieved from blood stains discovered on Ameerul's knife and chappals also matched Jisha's DNA.

In another case, police seized two additional swords, one with visible blood spots, allegedly

used in the twin killings of Youth Congress workers Kripesh and Sharathlal at Periya in Kerala. This development added a new twist to the case. A rusted sword and handle had already been discovered earlier in an abandoned well by the police. The deep cuts on the victims' bodies suggested that only a sharp-edged weapon could have caused such injuries, leading to allegations that the police were attempting to sabotage the investigation. However, the discovery of two more swords corroborated the earlier assumption that multiple swords were used to murder the victims. The swords were discarded by the assailants shortly after the incident, according to police. Blood traces were found on one of the recovered swords.

Test Analysis

Blood samples of animals like cattle, dogs, goats, and birds like chickens were collected from different sources like veterinary hospitals, butcher shops, farms, etc. Collected samples were properly labelled and packed in EDTA and cattle blood in a plastic bottle by adding common salt as a preservative in a refrigerator.

Then, different surfaces like tile pieces, glass, rust metal plate, and cotton cloth material were collected for smearing the blood samples. Took the surfaces as such from different places. Smeared the different blood samples of animals on selected surfaces with properly sterilised equipment and gloves. Added one drop of blood from each to the tile, glass, rust metal plate, and cotton cloth, respectively. They were then kept in a location with maximum exposure to natural conditions such as sunlight, moisture, and wind. The samples were later extracted from the different surfaces using various buffers, properly labeled, and preserved.

Precipitin Test

- Collected the blood samples of cattle, dog, goat, fowl and human
- Smeared it on different surfaces like tiles, rusted metal, glass, and cotton cloth
- Kept it for some days in place with maximum exposure to natural conditions like air, temperature, moisture, etc.
- Took the extract using different buffers like normal saline, distilled water, and Tris buffer
- Put the extract in different test tubes with 0.5 ml normal saline and distilled water
- Serial dilution was done using 2 drops of antiserum
- 10 dilutions were made using normal saline in order 1/2, 1/4, 1/8, 1/16, 1/32, 1/64, 1/128,1/256
- To an affine drop tube, one drop of blood from each extract and one drop from the serial dilution were added.
- Kept it in the fridge overnight

OBSERVATION

- No rings were found at the junction of extract and sera.

Double diffusion

- One square centimetre of 100 mg of dried blood or 100 mg of stained linen was soaked in 1 ml of distilled water overnight in clean tubes in the refrigerator.
- After centrifuging the extracts, the supernatants were transferred to clean tubes and kept in the refrigerator until testing.
- Immunodiffusion tests were performed on clean microscopic slides on which a 2 mm thick agar gel (1 percent agar in normal saline with 0.5 percent phenol

as a preservative) was poured and well patterns punched with a cork borer.

- A centre well was encircled by six equidistant periphery wells in this pattern. The slides were examined the next morning after being allowed to diffuse overnight at 8°C in moist chambers.
- They were dyed with amido black, separated in methanol-acetic acid, dried, and checked again before being kept.
- To ensure reproducibility, all experiments were repeated in duplicate or multiplicate.

Double diffusion experiments

In the first stage, the following preliminary double-diffusion experiments were set up:

- To assist the investigation of coalescence (identity) patterns of precipitin lines due to known human antigens, serial double dilutions 2X-512X of a known human serum were allowed to diffuse against equivalent dilutions of another known human serum placed in the center well.
- Antiserum put in the centre well was allowed to diffuse against serial double dilutions 2X-512X of a known rhesus monkey serum alternating with equivalent dilutions of another known rhesus monkey serum.
- To study the partial fusion with spur formation (partial identity) patterns of precipitin lines due to known human sera and known monkey antigens, serial double dilutions (2X-512X) of a known human serum alternating with similar dilutions of a known rhesus monkey serum were allowed to diffuse against the antiserum.
- Dilutions 100X of known human serum were placed in wells 1 and 4, similar approximate dilutions of human blood stain extract in wells 2 and 5, and similar dilutions of the questioned stain in wells 3 and 6. The central well in all the experiments contained the antiserum.

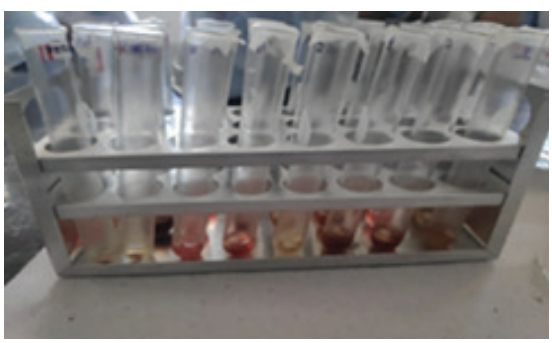
OBSERVATION

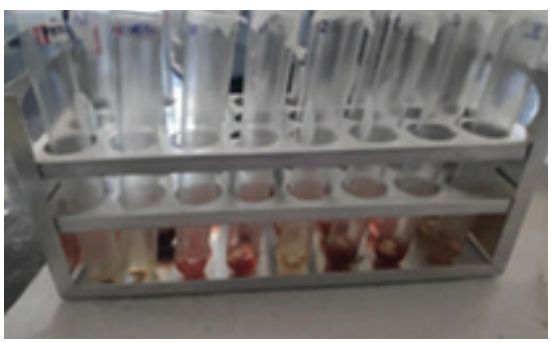
A hexagonal ring was found at the 4th dilution of chicken blood collected on day 4.

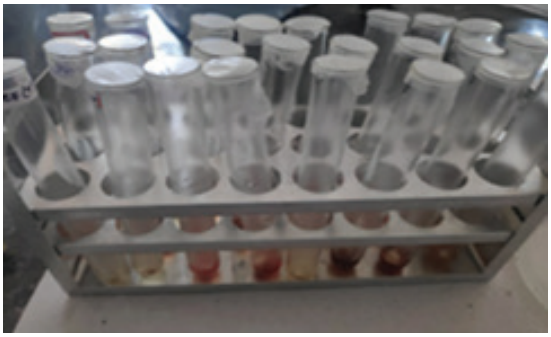
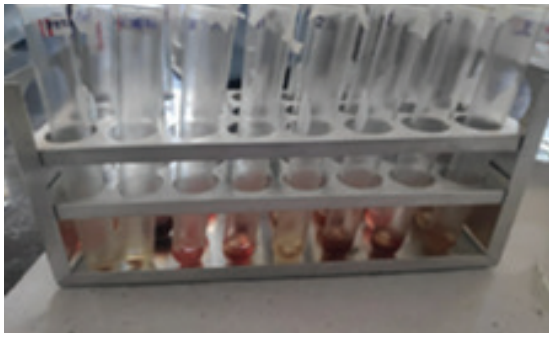
RESULT

Precipitin Test- No characteristic ring was formed at the junction of the sample and the antiserum

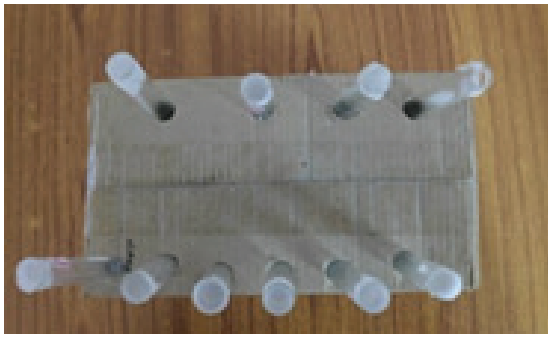
Double Diffusion Test- A hexagonal ring found at the 4th dilution of chicken blood collected on day 4





Blood samples of dogs, cattle, humans, fowl, and goat extracted from different surfaces



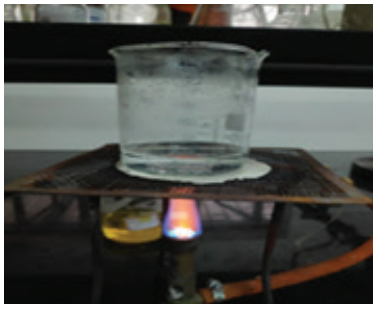
Serial dilution of the 10 concentration



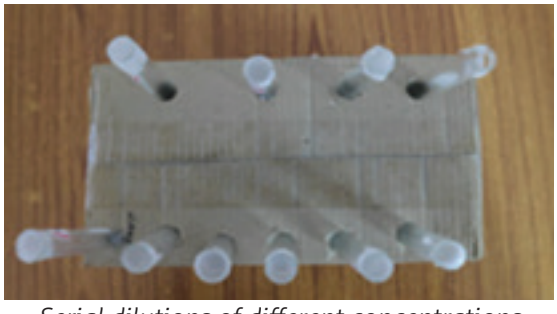
Sample and the antiserum in a microcentrifuge



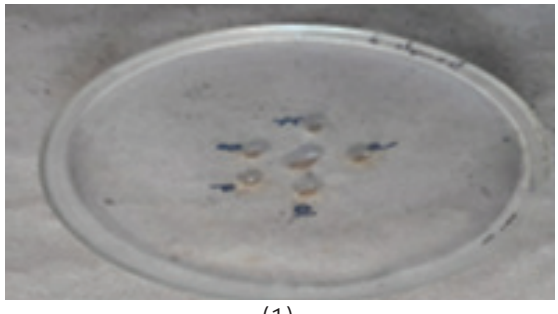
Blood sample for double diffusion test wells for the double diffusion test



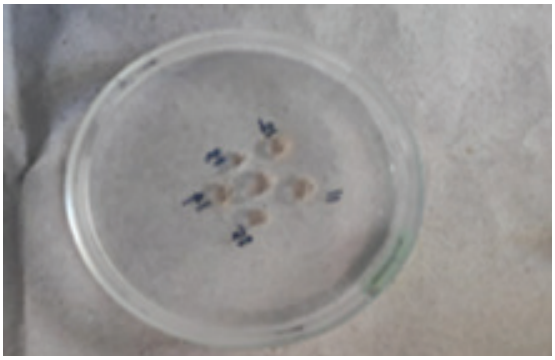
0.5 g of agarose in 500 ml of normal saline for making



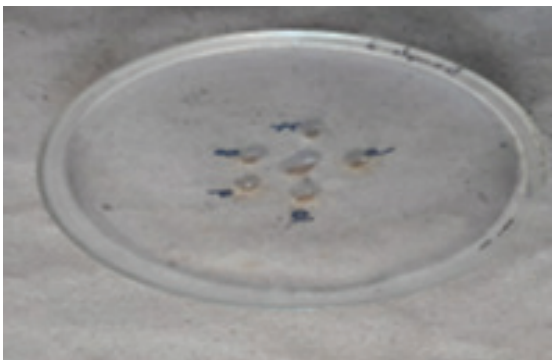
Serial dilutions of different concentrations



(1)



(2)



(3)



(4)

Images 1,2,3,4 are different wells for the double diffusion test.

DISCUSSION

The objective of the study was to determine whether there would be any kind of difficulties in finding the origin of the species of blood found at a crime scene. The blood samples were collected from different sources like beef, dog, cattle, goat, fowl and human. Blood was smeared over different surfaces like tile, cloth, rust metal and glass, and then kept under natural environmental conditions. On the 7th, 14th, 21st, and 28th alternate days, blood samples were extracted using normal saline, PBS buffer, Tris-HCl Hcl and distilled water. First, the precipitin test was conducted using these samples, and no reactions were observed. Next, the double diffusion test was conducted with these samples, and only one reaction occurred.

Through this study, it was found that the precipitin test did not give any reaction for samples collected after one month, and it is not a suitable test for determining species origin. Even though the double diffusion test did not give strong results, when compared with the precipitin test, it showed a single reaction, indicating that the double diffusion test was more sensitive than the precipitin test.

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Corroboration of Evidence in Cases of Theft Using Brain Electrical Oscillation Signature Profiling: A Simulation Study

K. Hemanth Sai Reddy*
Dr. Priyanka Kacker**





ABSTRACT

Theft is one of the most highly committed offenses throughout the world and though considered petty in nature; its impact can be disastrous for the victims and Law Enforcement Agencies investigating such offenses. In most such cases, it usually becomes difficult to trace the real perpetrator among likely suspects who were present around the scene of the crime when the incident occurred, therefore hindering the process of investigation and retrieval of the stolen item. At places with access control lists or CCTV surveillance at entry and exit points, identifying potential suspects becomes easier for the police, but pinpointing the real perpetrator often remains difficult due to insufficient evidence, leading to case closures. Therefore, the present study was designed with the goal of finding Experiential Knowledge of subjects' participation in theft through BEOS Profiling through a mock simulation study, which will serve as corroborative evidence hinting towards the subject's involvement in the act of theft. Dr. C. R. Mukundan created and evaluated the approach known as Brain Electrical Oscillations Profiling (BEOS), which is primarily used as a forensic tool for suspect deception identification. The test is intended to reveal if a subject has "Experiential Knowledge" about engaging in any activity by examining electrophysiological data collected from their scalp. The results of the study showed significant differences in the Experiential Knowledge (EK from here on) between the experimental and control group, and further, participants belonging to the experimental group had significantly higher EK, pointing towards their involvement in the simulation.

Keywords: *Theft, Corroborative Evidence, BEOS, Simulation, Forensic Psychology*

INTRODUCTION

Forensic Psychology

Forensic Psychology is a unique blend of forensic science, psychology, and law. Its application in the Indian criminal justice system has increased significantly over the last decade. With time, both the patterns of crime and the behaviour of criminals have evolved drastically. The advancement of

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technology, resources, and globalization now allows criminals to plan and execute crimes with greater precision. As a result, extracting evidence for investigation and conviction has become increasingly challenging for law enforcement agencies. In such scenarios, forensic psychology plays a crucial role, helping bridge the gap between evidence, behaviour, and justice.

Forensic psychology involves various investigative techniques such as Narco-analysis test, polygraph, brain electrical oscillation signature profiling and various methods as psychological autopsy and criminal profiling (Valli, 2020, p. 1477-1499). Though these technologies are a boon to the criminal investigation system, the reliability of evidence derived from these techniques is subject to scrutiny. The Indian Judiciary has been oscillating back and forth on the admissibility of evidence derived by forensic psychologists (Sahni & Bhadra, 2021).

Forensic psychological Investigative techniques like Polygraph, Narco-analysis and BEOS are helpful in indicating deception of individuals and aiding in further investigation. However, these techniques aren't accepted as conclusive evidence in the court as they are said to violate Article 20 (3) of the Indian Constitution (Valli, 2020, p. 1477-1499). As per the landmark judgement of Selvi & Ors vs State Of Karnataka & Anr on 5 May, 2010 and article 20(3) of Indian Constitution administration of Forensic psychological Investigative techniques violates the fundamental right against self-incrimination, however such tests can be administered with the prior consent of suspect and approval of court and the results of the test are only considered as corroborative or circumstantial evidence and aren't considered as conclusive proof to deliver judgement (Valli, 2020, p. 1477-1499). Therefore, based on the Selvi judgement in the ambit of Article 20 (3) of the Indian Constitution, it can be concluded that the value of forensic psychological evidence in India is corroborative in nature. (Selvi & Ors vs State of 1Karnataka , 2010)

Brain Electrical Oscillations Signature Profiling

Brain Electrical Oscillations Signature Profiling (BEOS) is an investigative tool developed by Prof. (Dr.) C.R. Mukundan in 2003 (Mukundan C R, 2007). The Brain Electrical Oscillation Signature (BEOS) is a computer-assisted technology that examines electrophysiological signals from the subject's scalp to detect the presence of "Experiential Knowledge" (EK), indicating potential involvement in a specific act. This technique is used for extracting a signature of electrical oscillations from the background electrical activity of the brain of a subject by presenting them with auditory cues relating to any act they have committed (Roy & Kacker, 2020). These auditory cues, referred to as probes, are designed to elicit "Experiential Knowledge" (EK) in a subject, potentially linked to an act they have committed (Mukundan, 2007). When exposed to the probe, the subject may become consciously aware of the associated experience or action if they were involved in it (Mukundan, 2007).

There is one difference between an innocent individual and one who perpetrates the crime, i.e, the perpetrator actually commits the crime and has knowledge of the crime in his memory as signatures, the same is absent in the memory of the innocent person. Therefore, BEOS scientifically detects the presence or absence of such specific information.

BEOS is used for eliciting electrophysiological responses of a person that can be used as

evidence to show the person's involvement and participation in the event. BEOS is a forensic psychological method that identifies the presence of specific information within the brain without requiring any surgical procedures or physical intrusion, making it a non-invasive technique.

Rationale & Objective

Theft is one of the most common and highly committed crimes throughout the world, and in most cases, it becomes almost impossible to find the real perpetrator among likely suspects who were present around the scene of the crime when the incident happened, hindering the process of investigation and retrieval of the item that has been stolen. In certain scenarios, such as places having a list of people entering or places having CCTV at entry and exit, it becomes easy for the police to filter out names of possible suspects, but finding the real perpetrator is always a tough task, and the lack of proper evidence leads to the disposal of cases. Therefore, the present study focuses on finding the real perpetrator among the possible suspects using experiential knowledge of theft through BEOS in a mock simulation study. The test is intended to reveal if a subject has "Experiential Knowledge" about engaging in any activity by examining electrophysiological data collected from their scalp.

METHODS & MATERIALS

Sample

Volunteers for the study were selected through purposive random sampling among the students at various universities in Gandhinagar, Gujarat. All the volunteers were well educated and were administered with Indian standardized version of GHQ 12, and acquired scores less than 12, indicating the absence of psychological morbidity. All the volunteers were cooperative, and they willingly agreed to participate in the study. The volunteers, though, who gave their consent for BEOS profiling, did not want to reveal their personal details in the study. The Age group was 20 – 30 years. The total sample size was 30, divided into an experimental and a control group with 15 volunteers in each group. People belonging to the experimental group were subjected to a simulation activity wherein they had to participate in a mock crime of theft, and the control group had to read about the same. Informed consent was taken from each volunteer.

Hypothesis

H1: There will be significant differences in the Experiential Knowledge between the Experimental & Control groups.

H2: Experiential Group will have higher Experiential Knowledge compared to the Control Group.

Procedure

The study aimed to determine whether Experiential Knowledge (EK) could be elicited from individuals who relocate or steal objects from areas under surveillance, allowing it to be corroborated with additional evidence. This investigation utilized the BEOS. In order to fulfil the objective of the study, a proper format was decided upon that involved sampling and subjecting the volunteers of the experimental group to a simulation activity wherein they had to go inside a designated room, search for a hidden object and take that object with them. Following the simulation activity, a standard set of probes was designed and administered to volunteers belonging to both experimental and control groups.

The research consisted of the following steps:

Phase I - Data Collection

The data was collected from university students in Gandhinagar, Gujarat. The age group was between 20 – 30 years. After taking consent from the volunteers, they were divided into an experimental and a control group, wherein the experimental comprising 15 participants, had to undergo a simulation activity. The simulation activity was designed in a way wherein the participant had to enter the BEOS lab of the National Forensic Sciences University and enter their personal details in the log sheet as an entry protocol, along with the date and time. Upon entry, he/she had to search for a new sealed smartphone case and steal it. The participant, while exiting the lab again, had to enter his/her exit time in the log sheet and then go out of the building along with the stolen smartphone. While the participants of the experimental group underwent this simulation, the participants of the control group, on the other hand, were given an auditory narration regarding the same.

Phase II – Designing of Probes

A standard set of probes was created in chronological order following the simulation activity, and was entered in a notepad in the VASP system, and event markers were attached to each probe. A total of 108 probes were created, including Neutral and Control probes, divided into 9 scenarios. These notepads were uploaded on the VASP, after which auditory probes were recorded and administered to participants based on gender. The recorded probes were subsequently transferred to the NSS system for presentation during the BEOS recording process.

Phase III – BEOS Recording

The volunteers were brought to the BEOS lab for recording at a time convenient to them. Upon arrival, the following instructions were provided: the participant was first asked to sit comfortably in the chair. Before the recording began, the room temperature was adjusted to ensure a comfortable environment. It was ensured that the temperature of the room was not hot, and it was ensured that the subject had removed his/her watch as well as other metal objects. The participant was asked to keep away from any electronic devices. Following this, a harness was attached around the participant's chest, and then an EEG head cap with 32 channels was placed on his/her head, attaching its grip to the harness. Saline gel was carefully applied to the electrodes using a syringe fitted with a blunt needle. Then the reference electrodes were attached to both the earlobes of the participant, following which the reference electrodes and the head cap were connected to the amplifier. Three baseline recordings were taken, namely SPU test, EC (eyes closed), and EO (eyes open), each lasting for 3 minutes. Following the baseline recordings, the BEOS recording began where the auditory probes were presented, during which the participant had to close his/her eyes. The volunteers were instructed not to sleep while BEOS recording, or else the probes would slow down or stop.

RESULTS AND DISCUSSION

The current research intended to expand and improve the scope of the corroboration of evidence in cases of theft using Forensic Psychological Investigative Technology: Brain Electrical Oscillation Signature Profiling through a mock simulation study. The

objective of the study was to find out whether the percentage of EK was higher in the group that had real experience in participating in the simulation activity (Experimental Group), compared to that of the group having secondary experience (Control group), which only read about the steps involved in the simulation activity. After the screening, simulation & BEOS recording of the participants, the results were computed using version 26 of IBM's SPSS (Statistical Package for Social Sciences), and the comparison graphs were made using MS Excel. The statistical analysis was done by finding the significant difference between the total number of EKs in the experimental and control groups through an Independent T-Test, as well as finding the significant difference in the EKs associated with relevant probes in the experimental and control groups. The names of all the volunteers were retained to ensure confidentiality.

Analysis of Significant Difference between EKs In the Experimental & Control Groups

Table 1: ***showing independent sample t-test results comparing EKs between Experimental & Control Group (below)***

Group	n	Mean	SD	t	Df	P (Sig.)
Experimental	15	28.13	5.125	5.163	28	.000
Control	15	14.47	8.879			

The analysis indicates that on a two-tailed t-test, the P value is .000, which is < 0.01, therefore showing a highly significant difference in the number of EKs between the Experimental & Control Groups. The Mean EK value of the Experimental group is 28.13, which is higher compared to the mean EK value of the control group.

Thus, based on the t-test, the H1 is accepted, stating that there will be a significant difference between Experiential Knowledge in the experimental & Control group.

Analysis of the Difference between Relevant EKs in Experimental & Control Groups

The participants belonging to both groups in this study were subjected to BEOS Profiling with 108 standard probes, and there was a significant difference in the Experiential Knowledge of participating in the act between the two groups. However, the main purpose of this study was to establish whether BEOS profiling and its report can be used as corroborative evidence or not. Therefore, among 108 Probes, 19 relevant probes pertaining to information about volunteers' entry into the lab, execution of the activity, and subjects' exit with the smartphone were separately analyzed to see whether there was a significant difference between the experimental and control groups. Below is the table showing a list of relevant probes and codes attached to them for analysis and representation:

Table 2: ***showing the list of relevant probes for analysis***

S.NO	Relevant Probe
1.	I opened the gate of the BEOS lab
2.	Entering details in the log Sheet
3.	Roaming around the lab
4.	searching for things
5.	There was a white box inside
6.	It was a new smartphone box
7.	Appo was written on the box
8.	I took that out
9.	I Opened the Box

S.NO	Relevant Probe
10.	There was a new smartphone inside
11.	The smartphone was sealed in the white case
12.	I took the Phone out
13.	I kept the phone inside my pocket
14.	I closed the smartphone box

S.NO	Relevant Probe
15.	I Wiped the Box with a Handkerchief
16.	I kept it back in the rack
17.	I rearranged everything as they were
18.	I entered the exit time in logbook
19.	I took the smartphone along with me

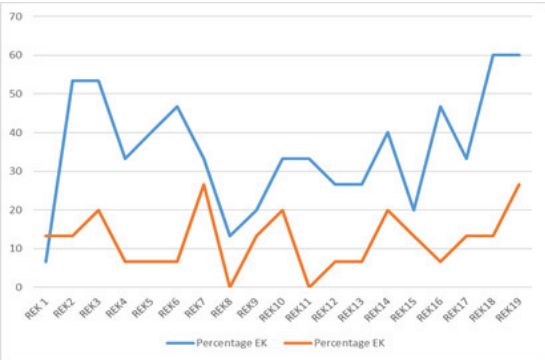
Table 3: ***showing the total number of Relevant EKs elicited by the number of volunteers in the Experimental & Control groups, with Percentage***

REK: Relevant Experiential Knowledge

Relevant EK	Experimental Group (N =15)	Percentage	Control Group (N = 15)	Percentage
REK1	1	6.6	2	13.3
REK2	8	53.3	2	13.3
REK3	8	53.3	3	20
REK4	5	33.3	1	6.6
REK5	6	40	1	6.6
REK6	7	46.6	1	6.6
REK7	5	33.3	4	26.6
REK8	2	13.3	0	0
REK9	3	20	2	13.3
REK10	5	33.3	3	20
REK11	5	33.3	0	0
REK12	4	26.6	1	6.6
REK13	4	26.6	1	6.6
REK14	6	40	3	20
REK15	3	20	2	13.3
REK16	7	46.6	1	6.6
REK17	5	33.3	2	13.3
REK18	9	60	2	13.3
REK19	9	60	4	26.6

The difference in the percentage of Relevant EK elicited from the volunteers of the experimental & control groups was plotted in a line graph to see the difference.

Graph 1: *The 'x' axis of the graph shows the plot is made between Percentage EK Vs Percentage EK.*



The above graph was generated by plotting the percentage of each relevant EK exhibited by the total volunteers in the experimental and control groups, which clearly demonstrated a significant difference between the two groups upon further analysis.

- In the relevant probe, 'entering details in the log sheet', which revealed the experiential knowledge of participants' entry into the lab (scene of Incidence), 53.3 % of participants belonging to the Experimental Group showed EK, whereas only 13 % of the participants belonging to the control group showed EK.
- In the relevant probe 'roaming around the lab', which revealed the experiential knowledge of participants' presence and activity in the lab (scene of Incidence), 53.3% of participants belonging to the Experimental Group showed EK, whereas only 20 % of the participants belonging to the control group showed EK.
- In the relevant probe, 'I took the phone out, which revealed the experiential knowledge of Participant finding a new smartphone and picking it up (displacing or stealing the object), 26.6 % of participants belonging to the Experimental Group showed EK, whereas only 6.6 % of the participants belonging to the control group showed EK.
- In the relevant probe, I kept the phone inside my pocket, which revealed the experiential knowledge of participants taking the smartphone (displacing or stealing the object). 26.6 % of participants belonging to the Experimental Group showed EK, whereas only 6.6 % of the participants belonging to the control group showed EK.
- In the relevant probe, I entered the exit time in the logbook, which revealed the experiential knowledge of participants' exit from the lab (exit from the scene of the incident after commission of the act). 60 % of participants belonging to the Experimental Group have shown EK, whereas only 13.3 % of the participants belonging to the control group showed EK.
- In the relevant probe, I took the smartphone with me, which revealed the experiential knowledge of the Participant taking the smartphone along with him outside the lab (taking the stolen object). 60 % of participants belonging to the Experimental Group showed EK, whereas only 26.6 % of the participants belonging to the control group showed EK.

The relatively moderate percentage of participants exhibiting positive Experiential Knowledge (EK) responses can be attributed to multiple factors. Firstly, the limited sample size of 30 participants reduced the statistical power of the study, thereby influencing the overall percentage of significant results. Secondly, since the present study was a simulated investigation rather than a real-life crime scenario, the participants were aware that the situation was artificial. This awareness likely diminished their emotional engagement

and autobiographical encoding of the simulated act, which are crucial for generating detectable experiential knowledge.

In real-life criminal acts, heightened emotional arousal and cognitive involvement tend to produce stronger and more persistent autobiographical memory traces, which could lead to higher EK detection rates. Additionally, variability in individual memory recall, the specificity and emotional salience of the auditory probes, and the potential delay between the simulated act and the testing session might have further influenced the findings.

Therefore, future studies with larger participant groups and more ecologically valid or emotionally intense simulations, such as acts involving aggression or vandalism, may yield higher percentages of significant EK responses.

CONCLUSION

The results indicate a significant difference in the number of Experiential Knowledge (EK) instances between the experimental and control groups. Participants in the experimental group who were involved in the act demonstrated a notably higher number of EKs compared to those in the control group.

It can be also interpreted from results that the participants from the experimental group showed higher percentage of EK's on the probes such as 'entering the details in the logbook', 'roaming in the lab', 'taking the smart phone', 'entering exit details in the logbook' and taking the smart phone outside lab which will have high corroborative evidentiary value. Therefore, the objective of this research can be considered fulfilled based on the significant differences in the EKs shown between the Experimental and Control groups and a higher percentage of relevant EKs in the experimental group, which shows the participants' involvement in the act, accepting the hypothesis of this study.

Previous empirical research supports the findings of the present study. For instance, Patel (2016) applied BEOS profiling in a simulated forensic setting and reported that participants who had actual experiential involvement in the act exhibited significantly higher Experiential Knowledge (EK) responses compared to control subjects. Similarly, Parmar and Mukundan (2017) demonstrated that auditory probes related to specific contextual memories—such as entry, exit, and object displacement—elicited stronger EK signatures in individuals who had performed the act, effectively distinguishing them from uninvolved participants. Furthermore, a review by Puranik, Joseph, Daundkar, and Garad (2009) summarized multiple forensic case applications of BEOS profiling across Indian forensic laboratories, emphasizing its increasing evidentiary credibility and acceptance in investigative contexts. Collectively, these findings reinforce that BEOS profiling is a reliable forensic psychological tool not only in simulated environments but also in real-world investigations.

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Transition of Conventional Drugs to New Psychotropic Substances (NPS) Abuse– Few Basic Concepts and Forensic Analytical Challenges from an Indian Perspective

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Rajvinder Singh*** **Adesh Kumar******
Surender Pal Singh, IPS***** **Priya Thakran********



ABSTRACT

Drug abuse is a widespread problem across all continents and nowadays has received more scientific attention than ever. Therefore, this general article aims to provide a forensic understanding of the pharmacology, pharmacokinetics, and underlying principles of drug abuse. Also, this article highlights the abuse of conventional and chemically synthesized drugs in the modern era. There is a discussion of the transition in the pattern of substance abuse from conventional drugs to New Psychotropic Substances like N-bomb, synthetic cathinone, tryptamine analogs, fentanyl analogs, etc., and the related difficulties in forensic analysis. This article can help the readers who want to brush up on their knowledge of NPS and associated implications from an analytical point of view. This article will benefit readers from multiple disciplines, like toxicology, clinical toxicology, and forensic toxicology.

Keywords: *NPS, Illicit Drug, Forensic Science, Designer Drugs*

INTRODUCTION

Forensic Psychology

A drug is a chemical substance that can be administered into the body through a variety of methods, and once entered into the body, it undergoes a series of changes that can generate a biological response to precisely alter the physiology and psychology of the abusers. Earlier, the drugs were occasionally

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utilized for medical purposes. Over time, drug abuse increased, driven by the growing illicit demand in the market. A rapid transition from the misuse of conventional drugs like opium, cocaine, cannabis, etc., to NPS and prescription medicines like benzodiazepines, opioids, etc. occurred in the market, attributable to various reasons discussed further in this article. Timely regulation of these substances has been done by the legislative and executive bodies of India, but this menace is still progressive (NCRB, 2021).

Consumption of the drugs in an appropriate, prescribed, or directed manner produces desirable results for the body's essential functioning. However, the consumption of drugs in more than the prescribed or directed quantity leads to overdose, rendering their misuse to such an extent that the functioning is coarsely impaired and even life is jeopardized. Overdose of a drug is also encountered in cases where the individual deliberately administers it with the purpose of "getting high" rendering its abuse. The impact of frequent overdoses results in diminished responsiveness of the postsynaptic neurons and inefficiency of presynaptic neurons to release neurotransmitters in the desired concentration. Drug abusers are prone to multiple risks like physical (impaired mobility, loss of reflexes, impeded psychomotor potential, amnesia, seizures, coma), mental (emotionally miserable, mood swings, bipolar disorder, anxiety, low self-esteem), health, socioeconomic, and in extreme cases, death is also reported.

The primary issue at hand pertains to the identification of NPS in the biological specimens due to complex and rapid biotransformation. Furthermore, a paucity of knowledge about the pharmacodynamics and pharmacokinetics studies of NPS presents another analytical challenge in determining the parent NPS and its subsequent metabolites. Pharmacokinetics is the quantitative study of the drug intake and the amount that is eliminated. The processing of the drug into a simpler form depends on the response of the body towards the substance, which in turn depends on factors including dose and frequency of the drug administered, its route of administration, the latency of onset, time, and duration of peak action. These factors cumulatively determine the amount of drug available at the target site, which in turn determines the intensity of the effect to be produced. What a body does to a drug fundamentally includes the following processes: Membrane transport followed by absorption, distribution, and excretion. The process is depicted in Figure 1. Forensically, the excretion of drugs through urine, feces, saliva, sweat, and milk is extremely relevant, as they contain the parent drug and its metabolites. Additionally, viscera samples collected during post-mortem examination are important because drugs bind to body tissues and can help determine the cause of death.

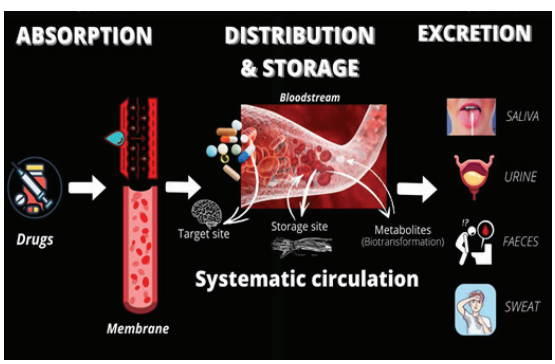


Figure 1: Diagrammatic description of the Pharmacokinetics of drugs

With reference to pharmacodynamics, a drug has varying responses. Methamphetamine acts as a substrate for dopamine transporter (DAT), blocking its function, thereby increasing the synaptic concentration of dopamine, serotonin, and norepinephrine, acting as a stimulant, while MDMA, structurally similar to methamphetamine, acts majorly on 5-HT neurons and imparts its hallucinogenic effect (Cunha-Oliveira et al., 2013). Conclusively, drugs of the same kind (derived from the same parent drug moiety with slight modification) may act on different receptors or the same to produce different effects. The fate of the drug inside the human body can also be determined by the factors, namely, administration (method of drug intake mentioned in Table 1), distribution (to what extent the drug is available throughout the body), metabolism (biotransformation of the parent drug inside the body), and elimination (removal of the drug from the body). Factors affecting all these processes are described in Table 2.

Different forms of drugs have varying responses to the processes depending upon their chemical nature, composition, and mode of administration. Furthermore, it is evident from Table 3 that concurrent administration of two drugs or more results in different interaction effects like additive (the effect added together), synergic (the effect is intensified in multiple), potentiating (the drug works only in concurrence with other drugs), and antagonistic (one drug nullifies the effect of other drugs). Table 4 describes the modes of drug abuse. A forensic drug analyst and toxicologist needs to be aware of all these significant factors to make proper decisions in NPS identification in different matrices.

Table 1: ***Some common routes for drug inoculation***

Route of Drug Administration	1. Local	Tropical (Skin, nasal mucosa, eyes, ear, anal canal, vagina etc)
		Arterial supply (Femoral or brachial artery)
		Deeper tissues (intra-articular injection)
	2. Systemic Circulation	Oral (Drug undergoes first pass metabolism)
		Sublingual (Stomach and Liver are bypassed, suitable for lipophilic drug)
		Inhalation Ex: Snorting, Sniffing. (Stomach and liver are bypassed, suitable for volatile liquids)
		Nasal, Snorting (Stomach and liver are bypassed)
		Parenteral (directly into blood) Ex: Intravenous, Intramuscular, Intradermal etc)

Table 2: ***Factors affecting the drug process in vivo***

Process	Some major factors that influence the process
Administration	Type and form of drug, the purpose of intake
Distribution	Size of drug molecule, solubility, lipophilicity, and ionization
Metabolism	Route of administration, dose, protein binding
Excretion	Protein binding, kidney function, and body fluids pH.

Table 3: ***Different interactions of concurrently administered drugs***

Interaction effect	Mathematical representation of the effect	Example of drug(s) administered in conjunction
Additive	1+1=2	Alcohol and depressants
Synergic	1x1+5	Narcotics and hypnotics/other opioids
Potentiating	0+1=2	Diazepam and alcohol
Antagonistic	1-1=0	Naltrexone and Naloxone

Table 4: ***Different modes of drug abuse***

Different modes of Drug abuse	Example
Injection	Heroine, speed, etc.
Smoked (vaporized)	Crack, speed, heroin, cocaine, cigarettes, marijuana, etc.
Sniffing	Cocaine, inhalants, and other volatile solvents, etc.
Swallowing or chewed	Pills, drugs as a solution example: cough syrup (Dextromethorphan), LSD, gamma hydroxybutyrate (GHB), Salvia, Rohypnol, etc.
Absorption	Nicotine patch, LSD pills, etc.

This article's subsequent sections address the following topics: 1) the idea of drug use, misuse, and abuse; 2) Classical drugs and their regulation in India; 3) The emergence of chemically synthesized drugs and the causes behind their abuse will be covered in detail, 4) the analytical difficulties, that forensic experts encounter while examining the questioned exhibits in forensic laboratories. For the construction of this article, the information is extracted from various databases like Scopus, Web of Science, and Google Scholar, and websites like Science Direct. Additionally, information available from the official websites of the United Nations Office on Drugs and Crime (UNODC), National Crime Record Bureau (NCRB), and United Nations Drug Enforcement Agency (UNDEA) was utilized for deducing inferences. This article will benefit readers from multiple disciplines, like toxicology, clinical toxicology, and forensic toxicology.

Drug use, abuse, and misuse, and the reasons behind the menace

Prescribed and over-the-counter (OTC) are the usable forms of drugs as medicines. Undeliberate intake of two or more drugs in conjunction without a doctor's consultation

can adversely impact the functioning of the body. However, adversity depends on the frequency and quantity of the dose. Deliberate use of drugs for unintended purposes amounts to misuse, whereas intake intended to get "high" amounts to abuse (NIDA and SIMSHA, 2020). Although the terms are used interchangeably, a significant difference lies scientifically. Data reported in Laha's work indicated that among total addicts in India, the maximum percentage of abusers belong to the age group 31-45 years, followed by 24-30 age group, then 18-23 years age group, 46 -60 years of age group, 12 -17 years age group and last age group includes people above 60 years of age (Laha, 2016). The most dreadful impact of drug abuse is on society, as youngsters who are considered conveyors of society get allured towards new trends and develop impaired consciousness, judgment, and lack of control under the drug influence, interpersonal relationships, and social problems, and also to fulfill their needs, commit crimes. According to the National Crime Record Bureau, drug offenses are progressive (NCRB, 2021). Nowadays, these drugs of abuse are ruling the illicit market, popularized with different slang that can be either connotative or denotative. Connotative (associative) terms are vague and implied, like street drugs, hard/soft drugs, club drugs, designer drugs, and club drugs. While denotative (operational) terms include precise terms like opiates, cannabinoids, etc. The general meaning of a few such terms is described in Table 5.

Table 5: ***A few important terms related to drug abuse***

Terms	Description	Example
Street drug	Terms that depict subcultural relations or different mixtures of drugs, manufactured clandestinely, violate the law, are abused for recreational objectives, and are highly dangerous.	Heroin (Brown sugar, Chitta)
Soft drug	Drugs are less dangerous than hard drugs and cause less dependence or immediate negative repercussions.	Nicotine, Cannabis (charas, ganja)
Hard drug	Potent drugs of more dangerous impact, immediate negative impact, and are highly susceptible to causing dependence.	Cocaine (Crack)
Club drug	Drugs (Party drugs) are predominantly abused in clubs, rave parties, or bars.	Rohypnol (roofies or date rape drug), Lysergic acid diethylamide (LSD), or Ketamine
Designer drug	The synthetic derivatives of the parent form of the drug exert effects similar to the parent drug.	Ecstasy, Diacetylmorphine, Amphetamine, etc

The menace of drug abuse has thrived for a long time and is supported by multiple factors like social environment (peer group and person's immediate surroundings), geographical (states close to the border are more prone to abuse due to illicit trafficking of drugs), interpersonal relationship (absistence of parental affection, dissolution of joint family living system), depriving cultural and moral values, economic conditions (lack of resources for sustainability, unemployment creates stressful lifestyle), and, biological (teenager due to hormonal change experience mood swings, a sense of sadness or isolation is a condition that favors substance abuse) can cumulatively make an individual vulnerable and susceptible to drug abuse.

Conventional/Classical Forms of Drug Abuse

Before embarking on the drug of abuse, the various classes of drugs of medical and scientific importance must be acknowledged. The components of different classes of drugs aid in the fabrication of Prescription and OTC medicines utilized for medical treatment. As per the NDPS Act of India, such drugs of medical or scientific importance are called Essential drugs (NDPS Act, 1985). Conventionally, based on chemical constituents, the drugs can be broadly classified as Opioids, Stimulants, Benzodiazepines, Hallucinogens, Barbiturates, and Cannabinoids. Among tons of drugs that are accessible in the market in both prescription and illegal strata, each one can be placed in any of the categories mentioned above. These categories can be further bifurcated into two categories, namely "Narcotic substance" and "Psychotropic substance", on the grounds of the effect they produce. Narcotics substances can be "any substance that makes the senses obtuse, such as alcohol, opium, belladonna, and morphine, that on binge consumption produce stupor, euphoria or coma, that cause addiction, dependence or habituation on unvarying intake and that can assist to relieve pain, induce drowsiness and cause sedation". While psychotropic substances can be "any substance as cocaine, barbiturates, benzo-diazepam that can affect the mind, behavior, and emotions of an individual and that can be used to treat the mental illness" (Weaver et al, 2015). NDPS Act defines narcotics as opium, leaf of the coca plant, cannabis (hemp), poppy straw, and all its manufactured goods (synthetic) (NDPS Act, 1985). However, the use of the terms Narcotics and Psychoactive overlap, but scientifically it's relevant to understand that all narcotic substances may not be psychotropic (as the former alters brain chemistry and is used for medical treatment), while on the contrary, all psychotropic substances may not be narcotics (the latter are sedative and analgesic, but the former is not). If the acts associated with legal drugs are not permitted by the law, it makes the substance illicit. The substance is used in an unusual manner that gives rise to an infringement of the legal system, causing its misuse or abuse.

Table 6: ***Explains the classes of conventional drugs with characteristic features.***

Class of Drug	Explanation	Example
Opioid	All synthetically manufactured products using natural products derived from the opium plant exert the same pharmacological function as that of opiates.	Heroine, fentanyl and its analogues, etc

Class of Drug		Explanation	Example
Stimulant		Class of drugs that can elevate the central nervous system and associated functions of the human body.	Amphetamine, Cocaine, methamphetamine, etc.
Benzodiazepam/ Tranquilizers/ Sedative/ Hypnotic/ Sporific drugs		Class of drugs that are used to treat mental disorders like insomnia, and anxiety and are sleep-inducing in nature.	Diazepam (Valium), Alprazolam (Xanax), Temazipam (Restoril), etc.
Hallucinogens	Class Hallucinogen	It causes only visual, auditory, and sensory hallucinations.	LSD, Psilocybin, Peyote, Dimethyltryptamine, etc.
	Dissociative Hallucinogen	Along with visual, auditory, and sensory hallucinations, a sense of detachment from your body is experienced.	Phencyclidine, Ketamine, Dextromethorphan, etc.
Barbiturate/ Depressants		Class of drug that depresses the central nervous system but is not used in the treatment of mental diseases due to high potency and small therapeutic range.	Seconal (secobarbital), Butisol Sodium (butabarbital), Amytal Sodium (amobarbital), Medaral (mephobarbital), etc.
Cannabinoids		Naturally occurring plant alkaloid present in Cannabis sativa that act on cannabinoids receptors and impart hallucinogenic effect.	Cannabigerols (CBG), Cannabinodiol (CBDL), Cannabidiol (CBD), Cannabichromenes (CBC), Tetrahydrocannabinol (THC), Cannabinol (CBN), etc.

REGULATION OF SUBSTANCES OF ABUSE

To counter the drug menace, a well-organized regulatory system is required. Therefore, every nation has its regulatory system for controlling these abused substances. Like the "U.S. Drug Enforcement Administration (DEA)" was established in the year 1973 to enforce the regulatory measures adopted for controlled substances through the Controlled Substances Act, 1970 (UNDEA, 2022). Similarly, in a country like Australia, the Controlled Substances Act, 1984 monitors illicit drug abuse/misuse (SA Health, 2022). In India "Narcotic Drugs and Psychotropic Substances Act (NDPS) Act", 1985 regulates drug substances. The Indian parliament implemented the NDPS Act on 14th November 1985 to regulate drug substances and to interdict their use, dispersion, transport, fabrication, and merchandising of the substance of abuse, specifically narcotic and psychotropic substances. One of the reasons behind the enactment of the NDPS Act was that the novel chemically modified substances weren't regulated under the three existing acts of earlier times, i.e., the Opium Act 1857, the Opium Act 1878, and the Dangerous Substance Act 1930. Finally, such substances were regulated under the list of Psychotropic Substances, clause (xxiii) of section 2 (NDPS Act, 1985). Even the precursor chemicals that have the potential to be rendered in the

clandestine manufacturing of NPS drugs were regulated.

Certain NPS were first synthesized decades ago; the phrase "new" does not always refer to fresh creations; rather, it refers to drugs that have recently entered the market and are novel to the scientific and legal bodies. UNODC defined "NPS as the "substances of abuse, either in a pure form or a preparation, that are not controlled by the 1961 Single Convention on Narcotic Drugs or the 1971 Convention on Psychotropic Substances but may pose a public health threat" (UNODC, 2021). According to the NDPS Act, 1985 Psychotropic Substances are "any substance, natural, or synthetic, or any natural material or any salt or preparations of such substances or material included in the list of psychotropic substances" (NDPS Act 1985). The NDPS Act has been amended many times for the effective regulation of psychotropic substances. Despite this, the Indian legislative bodies still lack scientific evidence about the substances abused to formulate laws to regulate their production and abuse (Sharma et al, 2017). The executive functions for the implementation of the regulatory provisions are performed by the Narcotics Control Bureau (NCB) in conjunction with other subordinate agencies and law enforcement agencies.

EMERGENCE OF NPS DRUGS

NPS's rapid progression has challenged researchers, forensic chemists/toxicologists, the healthcare system, and policymakers. Historically, if we see that the term designer drugs was coined in the year 1980 for heroin-based designer drugs like fentanyl's analogs. 3, 4-methylenedioxymethamphetamine (MDMA), cathinone, tryptamines, 2,5-phenylamines, piperidine, 3,4-methylenedioxyamphetamine (MDA), spice, kratom, and several synthetic steroids are flooding the illicit drug market and are examples of designer substances. The term "designer" simply means the modification of the chemical structure of an existing drug to manufacture a new drug with similar and intensified recreational effects. "Psychoactive designer drugs" or the "legal highs" and new narcotic substances are the chemical substances synthesized by a chemist or a non-chemist in a self-designed laboratory, and they are capable of producing effects similar to psychoactive substances. The raw material used for making such drugs is readily available in the market. The science behind the formulation of such chemical compounds is derived from scientific literature that provides information about the chemical structure and the mechanism of action targeting specific receptors to produce psychotropic effects. These drugs are formulated by substituting the functional group or chemical constituent of the basic drug moiety in the clandestine labs.

This new emerging class of drugs is popular because this serves as a good alternative for controlled substances that are restricted in access, hence removing interdiction. These drugs are contained in very attractive packaging with tempting names that allure youngsters. The name "legal high" used for the commercialization of this product contributes to the perception that these drugs are safer and quality than traditional illicit drugs. Illicit digital marketing of these products made them readily accessible in the market. All these factors cumulatively contribute to the increased consumption of designer drugs that have adversely affected society. The heterogeneous variants of such drug products differ significantly in terms of concentration, chemical constituents, and content from each other and make them different from traditional illicit drugs. Along with this, rapid biotransformation offers an advantage by

making them non-identifiable in routine drug testing. It produced overlapping symptoms with the traditional drugs, making it difficult to characterize the potential for substance abuse (Weaver et al., 2015).

The youth, more precisely, the elite section of students or the medical students, are defenseless against these alluring substances, and the impacts are more deleterious as the new arrivals are more potent versions of existing drugs. With the emergence of these "legal highs", the ground scenario is perturbing, and due to an insufficient scientific database, India lacks to develop a legal system to restrict access to NPS (Patil et al., 2016). Data for drug abuse trends, especially for NPS, is limited, but large-scale data can be gathered from newspapers/social media to draw attention to the worrisome conditions of drug abuse in India.

CLASSIFICATION OF DESIGNER DRUGS

The UNODC has classified NPS into six categories, namely sedatives, dissociatives, hallucinogens, stimulants, synthetic cannabinoids, and opioids (Patil et al., 2016). Based on structural types, it can be classified into various types, namely AP-Type designer drug, 2,5-Phenethlamine (2C drugs) designer drugs, 2,5-Dimethoxy Amphetamine designer drugs, β-Keto Amphetamine designer drugs, Phencyclidine-derived designer drugs, Piperazine-designer drugs, Pyrrolidinopheone-derived designer drugs, fentanyl-derived designer drugs, Piperidine analogs, tryptamine-derived designer drugs, herbal drug Kratom, Synthetic cannabinoids (SC), designer steroids, and other miscellaneous. The characteristic feature of the following classes is described in Table 7.

Table 7: ***Different classes of drugs based on structural types.***

Class of drug	Characteristic Feature	Example
AP-Type Designer Drug	• Structural analogs for Amphetamine (AP) and Methamphetamine (MA) through the addition of N-alkyl substituents of varying sizes on the parent drug form. • The greater the size of the alkyl group, the less the potency.	3,4-methylenedioxyethylamphetamine (MDEA), N,N-dimethyl-3,4-methylenedioxyamphetamine (DMMDA),N-isopropyl-3,4-methylenedioxyamphetamine(N-isopropyl-MDA), N-propyl-3,4-methylenedioxyamphetamine (N-propyl-MDA), benzodioxolylbutanamine (BDB), N-methylbenzodioxolylbutaminamine (MBDB), etc.
2,5-Dimethoxy Amphetamine Designer Drugs	• Synthesized through the addition of a methyl group at the α position of the parent amphetamine structure. • Exhibit potent and long duration of action for hallucinogenic effects.	4-bromo2,5-dimethoxyamphetamine (DOB),2,5-dimethoxy-4-methyl-amphetamine (DOM), 4-iodo-2,5-dimethoxyamphetamine (DOI), 4-chloro-2,5-dimethoxyamphetamine (DOC), 2,4,5-trimethoxyamphetamine (TMA), 4-bromo-2,5-dimethoxymethamphetamine (MDOB).

Class of drug	Characteristic Feature	Example
β-Keto Amphetamine Designer Drugs	• Include cathinone analogues produced via extraction from the source Catha edulis or synthesized using precursor chemical α-bromopropiophenone. • Easy to prepare clandestinely.	cathinone, mephedrone (2-methylamino1-p-tolylpropane-1-one, ephedrone (methcathinone), 4-methylmethcathinone, bk-methylmethamphetamine (bk-MMA), ethylone (3,4methylenedioxyethylcathinone), butylone (2-methyl-amino1-(3,4-methylenedioxyphenyl) butan-1-one,bk-MBDB), bk-methylenedioxyethylamphetamine (bk-MDEA).
2,5-Phenethylamine Designer Drugs (2C drugs)	• The word 2C is derived from the chemical structure that possesses two carbon atoms separating the amine group from phenyl ring.	4-(2-fluoroethylthio)-2,5-dimethoxyphenethylamine (2C-T-21), 4-bromo-2,5-dimethoxyphenethylamine (2C–B), 4-methyl-2,5-dimethoxyphenethylamine (2C–D), 4-iodo-2,5-dimethoxyphenethylamine (2C–I), -chloro-2,5-dimethoxyphenethylamine (2C–C), 4-ethylthio-2,5-dimethoxyphenethylamine (2C-T-2), 4-ethyl-2,5-dimethoxyphenethylamine (2C–E), 4 4-(n)-propylthio-2,5-dimethoxyphenethylamine (2C-T-7)
Phencyclidine-Derived Designer Drugs	• Phencyclidine (1-(1-phenylcyclohexyl) piperidine, or PCP), developed in 1950, was never approved for human utilization due to its fatal effects, but all structurally derived analogues are illicitly abused and fall under this category.	N-(1-phenylcyclohexyl)propanamine (PCPPA), N-(1- phenylcyclohexyl)-2-methoxyethanamine (PCMEA), N-(1-phenylcyclohexyl)-3-methoxypropanamine (PCMPA), and N-(1-phenylcyclohexyl)-2-ethoxyethanamine (PCEEA)
Piperazine-Derived Designer Drug	• N-Benzylpiperazine (BZP) derived analogues are included in this class. • Mimic the effect of MDMA.	1-(3, 4-methylenedioxybenzyl)piperazine (MDBP), m-chlorophenylpiperazine (mCPP), trifluoromethylphenylpiperazine (TFMPP), fluorophenylpiperazine (FPP), and methoxyphenylpiperazine (MeOPP).
Pyrrolidinophenone -Derived Designer Drugs	• Pyrrolidinophenone derived analogues mimic the effect of amphetamine. • 3,4-Methylenedioxypyrovalerone (MDPV) is the methylenedioxy derivative of pyrovalerone.	α-pyrrolidinopropiophenone (PPP), 4-methoxy-α-pyrrolidinopropiophenone (MOPPP), 3,4-methylenedioxy-α-pyrrolidinopropiophenone (MDPPP), 4-methyl-α-pyrrolidinopropiophenone (MPPP), and 4-methylα-pyrrolidinohexanophenone (MPHP)

Class of drug	Characteristic Feature	Example
Fentanyl analogs	• Fentanyl is a synthetic opioid analgesic, and all its analogues fall under this category. • China white, all called α-methyfentanyl, was the most common designer drug abused illicitly.	para-fluorofentanyl, α-methylacetylfentanyl, 3-methylfentanyl etc.
Piperidine analogs	• Derivatives of piperidine, like MPP also called synthetic heroin or disaster designer drug by clinicians. • The toxic effects of MPP are due to the formation of by byproduct called MPTP.	1-methyl-4-phenyl-4-piperdyl propionate (MPP), 1-methyl-4-phenyl-1,2,5, 6-tetrahydropyridine (MPTP)
Tryptamine-Derived Designer Drugs	• Indoleethylamine, when substituted on eythlamide side chain and the indole ring, yields tryptamines that exert hallucinogenic effects.	N,N-Diisopropyl-5-methoxy-tryptamine (5-MeO-DIPT) also call "Foxy", 5-methoxy-N,N-dimethyltryptamine (5-MeO-DMT), N,N-dipropyltryptamine (DPT), N,N-diisopropyltryptamine (DIPT), a-methyltryptamine (AMT), a-ethyltryptamine (AET), N-isopropyl-5-methoxy-N-methyltryptamine (5-MeO-MIPT), N,N-diisopropyl-4-acetoxytryptamine (4-Acetoxy-DIPT) and 5-methyoxya-methyltryptamine (5-MeO-AMT).
Kratom	• An herbal drug retrieved from a plant native to Southeast Asian countries and Thailand containing alkaloids like mitragynine (MG) and Paynantheine (PAY). • Exhibit stimulant and euphoric effects. In addition to this, it relieves opiate withdrawal symptoms.	-

Class of drug	Characteristic Feature	Example
Synthetic cannabinoids	• Commonly known as "Spice," it is a synthetic analog of delta-9-tetrahydrocannabinol (THC), a principal alkaloid derived from the cannabis plant. • It is abused for recreational purposes as this acts on the CB1 receptor, contained in the central nervous system of the human body.	Tetrahydrocannabinols (9-THC, HU-210), naphthylmethylindenes (JWH176), naphthoylpyrroles (JWH-030), naphthoylindoles (e.g., JWH018, JWH-073, AM-2201), cyclohexylphenols (CP47,497), naphthylmethylindoles (JWH-185), phenylacetylindoles (JWH-250,RCS-4).
Designer steroids	• Mostly abused by athletes to enhance their performance.	Tetrahydrogestrinone (THG), Norbolethone, Desoxymethyltestosterone (madol)
Miscellaneous	• All designers' drugs not mentioned in the above categories that have a scarce amount of literature available about them fall in this class.	1, 4-butanediol, g-butyrolactone (GBL) and 1,4-butandiol.

Forensic science analytical limitations associated with the identification of designer drugs

Currently, the newly arrived designer drugs like LSD, ketamine, and mescaline are under the regulation of the NDPS Act, but to remove interdiction, new variants like N-bomb are available rapidly in the market as alternatives. This progressive emergence of novel-designed substances is a threat to national security and public health. The next section discusses challenges encountered in controlling NPS drugs:

- From an analytical point of view, due to the existence of a variety of chemical drugs and classes with unknown chemical compositions, multiple tests have to be conducted to determine the questioned drug that caused intoxication. The significant inefficiency of a few existing techniques for toxicologically screening biological samples to identify popular novel substances hitting the market is one of the major analytical challenges and a matter of forensic concern. These restrictions highlight the urgent need to improve analytical facilities in forensic toxicology laboratories and create rapid, flexible, yet highly targeted essays that can recognize novel compounds. Wagmann, L. and Maurer, H. H in 2018 have discussed a few bioanalytical developed for different classes of NPS identification. Such methods need to be revalidated by Indian laboratories before use, or new methodologies need to be devised.
- Forensic laboratories have certain limitations, such as the unavailability of resources and the high cost of expenses for developing analytical standard methods. By the time, forensic analyst develops any standard detection method,

the clandestine drug laboratories have probably moved to the synthesis of another novel substance of abuse.

- In addition, the dearth of Certified reference material (CRM) makes the identification of NPS substances a difficult task. This creates a challenge in the development and optimization of analytical methods, which are highly requisite to hold at the frontline, especially to combat the rapid surfacing of novel substances. Furthermore, if the substance's reference standard is unavailable in the Wiley Library and the National Institute of Standards and Technology (NIST), which are used in gas chromatography-mass spectrometry, it becomes more difficult to identify substance abuse. Therefore, the authors recommend using methods like Raman Spectroscopy and Nuclear Magnetic Resonance to determine the structure of the unidentified material.
- During toxicological analysis, a matrix effect is always possible while working with complicated biological samples. The selectivity of the sample pretreatment method has a notable impact on the matrix effect. The matrix effect impacts analytical sensitivity, specificity, accuracy, precision, and reproducibility of the analytical findings. Currently, such effective methodologies are lacking; hence, optimized sample pretreatment and extraction methodologies must be devised to generate non-erroneous scientific reports.
- Clinical toxicologists face challenges in curing drug-induced intoxication because the substance is non-identifiable in routine testing due to rapid biotransformation, so they treat the patient without knowing the exact specific drug. When forensic professionals conduct onsite and laboratory examination of drugs, they encounter analytical difficulties.
- These substances can be difficult to identify since they are found in minute concentrations in biological samples and can sometimes degrade rapidly. To optimize financial earnings, cutting agents and diluents are added to these samples to dilute the drug sample and increase its volume. These compounds hide the level of the principal drug, making it difficult to recognize in low concentrations.
- There is a dearth of information on the pharmacokinetics and pharmacodynamics of many NPS. This makes it more difficult to identify metabolites of the NPS and evaluate quantities to determine toxicity levels when quantitative data is available. The dynamic NPS market raises concerns regarding the chemical toxicity and metabolic profile of the synthesized substance.
- Lastly, using additional specialized analytical tools and expertise for NPS testing may be necessary, which could significantly increase the cost of analytical services. Like HighResNPS and NPS Data Hub databases, Indian forensic laboratories need to envision the establishment of such databases that provide all information on the drugs and their subsequent modification created. These comprehensive libraries are available to support and facilitate the screening of NPS and their bio-transformed products.

Current status of NPS: India vs other countries in brief

Until December 2021, NPS exhibiting effects similar to stimulants, synthetic cannabinoids, and hallucinogens were

reported, while recently, synthetic opioids and benzodiazepines are emerging trends globally (EMCDDA, 2019). The few NPS that have surfaced on the market in recent years are plant-derived substances like kratom, khat, and divinorum, tryptamines like a-methyltryptamine (AMT), piperazines like BZP, synthetic cathinones like 4-methylethcathinone (4-MEC) and a-pyrrolidinopentiophenone, synthetic cannabinoids like JWH-018 and APINACA, phenethylamines like 25H-NBOMe and 2C-E, aminoindanes like 5,6-methylenedioxy-2-aminoindane (MDAI) (UNODC EWA, 2021). As of March 18, 2022, the United States and Sweden reported a total NPS of 500, while Europe (including Poland, the United Kingdom, and Canada) reported 400 NPS, and Japan recorded more than 300 NPS. Russia, China, and Denmark have recorded more than 200 novel NPS compounds (UNODC EWA, 2021). Glancing at the Indian scenario, limited scientific information is available for NPS substances in the Indian market. According to UNODC reports, India is the biggest emerging exporter of precursors like Amphetamine like stimulants, N-acetylanthranilic acid, N-phenethyl-4-piperidone (NPP), and 2-bromo-4-chloropropiophenone and pharmaceutical chemical substances that are rendered in the manufacturing of NPS substances (UNODC, 2022). A recent study discerned novel NPS substances abused in India are synthetic cannabinoids (AB-CHIMNACA, AB-PINACA, JWH-018), phenylpiperzine (PNP I and PNP II), benzylpiperazine, synthetic cathinones (mephedrone, □-PVP), phenylethylamine (Mescaline), kappa opioid receptor agonist (Salvinorin A), Fentanyl analogs (Acetylfentanyl, Ocfentanyl, Carfentanyl), indole-based alkaloid (Mitragynine), synthetic opioid (MT-45, W-19, U-4700, AH-7921), and thienodiazepine (Etizolam) (NDDTC AIIMS, 2022). Decisively, the variation of NPS substances across continents exists which depends on the accessibility, availability, cost, and personal choices of the abusers.

CONCLUSION

Apart from classical drugs of abuse, the burning problem in society is the emergence of chemically modified substances (NPS) and polysubstance abuse. There is an urgent need for empirical research and evidence-based policy formulation. Research that maps the kinds of NPS and other non-classical substances, their availability, usage patterns, and reasons for use, as well as the harms connected with them, ought to be carried out in India. Prioritizing resources for a comprehensive examination that would assist in evaluating the rising trends of non-classical/homemade and other types of NPS in India should be a top priority for the government, academic institutes, and funding agencies. In addition, to obtain an additional understanding of the availability of NPS in India, traditional information sources like as surveys, forensic data, and hospital records should be used. Further information may be obtained by analyzing urban wastewater utilizing the "wastewater-based epidemiology" (WBE) method. Forensic toxicologists must envisage in-house libraries as the new substance is identified through routine drug testing. These multiple methods will surely help to improve public health on the continent by supporting the development of evidence-based harm reduction strategies. It is crucial to acknowledge that during regional and national studies, the researchers may face challenges attributable to its dynamic and complicated nature. Therefore, prioritizing human and other resources is necessary to mitigate these challenges as early as possible in an effective manner.

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Combating Human Trafficking: Challenges and Measures

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ABSTRACT

In contemporary world, Human trafficking is one of the most severe global human rights problems, involving a huge financial organized crime network. It has affected millions of people and continues to be a global challenge in its wider ramifications. In this context, India is seriously affected as a source, destination, and transit route. The aim of the paper is to understand the concept and its varied manifestations. The paper attempts to explore the human trafficking in its various forms, dynamics and institutional response. The paper covers a broad array of issues on Human Trafficking including the legal provisions, systemic challenges, strategies and the role of criminal justice system in countering the menace. Additionally, the paper includes some brief case studies which have been handled by the author and highlights the gravity of the problem along with lessons for the law enforcement.

Keywords: *Trafficking Dimensions, Anti-trafficking, Legal Provisions, Systemic challenges, Law enforcement*

BACKGROUND

Human trafficking represents one of the most heinous violations of human rights in the contemporary world, constituting the second-largest organized crime globally after drug trafficking and surpassing arms trafficking. According to the International Labour Organization (ILO, 2024) estimates, the trafficking industry generates approximately $236 billion annually, while other estimates place it as high as $498 billion per year.[1,2] This multifaceted crime affects millions worldwide, with the United Nations Global Report (2022) on Trafficking in Persons estimating approximately 50 million people living in modern-day slavery.[3] India has emerged as a critical hotspot for trafficking, functioning simultaneously as a sending, receiving, and transit nation, with particular vulnerability affecting women and children from economically disadvantaged backgrounds.

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2. https://www.gcffc.org/articles-and-publications/gcffc-estimates-proceeds-from-human-trafficking-at-usd-498-billion
3. https://www.un.org/en/delegate/50-million-people-modern-slavery-un-report

INTRODUCTION: UNDERSTANDING THE PROBLEM

Human trafficking is fundamentally defined as a crime wherein individuals are exploited for profit through various means of coercion and deception. The nature of trafficking transcends state jurisdictions operating across international boundaries and is associated with organized crime networks. It represents both a human rights violation and a complex criminal network requiring comprehensive approaches to combat effectively.

Definition and Scope

The United Nations Protocol to Prevent, Suppress and Punish Trafficking in Persons, Especially Women and Children (adopted in 2000)[4] provides a globally accepted definition.

Trafficking encompasses the recruitment, transportation, transfer, harboring, or receipt of persons through:

- Force or other forms of coercion
- Abduction
- Fraud or deception
- Abuse of power or position of vulnerability
- Giving or receiving payments or benefits to achieve consent
- All undertaken for the purpose of exploitation

This definition establishes that consent becomes irrelevant when any of these coercive mechanisms are involved.

FORMS OF TRAFFICKING

Movement Pattern

The types of movement patterns have been identified as follows:

I. **Domestic Trafficking**: This occurs within country borders and encompasses exploits migration patterns driven by rural-urban disparities in economic opportunity.

II. **External Trafficking**: Cross-border trafficking involving movement across regions and international borders in which the victims may be trafficked to other countries.

Purpose

The purposes for which individuals are trafficked are as follows:

I. **Sexual Exploitation**: Prostitution, sex tourism, and pornography production constitute the most visible form of trafficking, particularly affecting women and girls.

II. **Labor Exploitation**: Bonded labor, forced labor, domestic servitude, and cheap labor.

III. **Specialized Exploitation**: Organ transplantation, begging rackets, forced military service (child soldiers).

IV. **Crisis-Related Trafficking**: Disaster victims and refugees from armed conflict become particularly vulnerable populations for traffickers.

PUSH-PULL DYNAMICS

Human trafficking operates through a complex framework encompassing both 'push factors'

4. https://www.unodc.org/documents/treaties/Special/2000_Protocol_to_Prevent_2C_Suppress_and_Punish_Trafficking_in_Persons.pdf

and 'pull factors' that traffickers exploit to facilitate the operations.

Push Factors

I. **Economic Factors**: Poverty, Unemployment and underemployment, Lack of economic opportunities, promise of easy money.

II. **Educational and Social Factors**: Illiteracy and lack of formal education, social stigma and religious taboos, Child preference and gender inequality, etc.

III. **Familial and Personal Factors**: Runaways from abusive homes, Domestic violence and sexual abuse within families, substance abuse in family environments

IV. **Structural and Systemic Factors**: Weak law enforcement and judicial systems, Corruption within government institutions, Gender inequality and discrimination, and lack of access to quality education and healthcare.

Pull Factors

I. **Labor Demand**: Demand from organized crime networks for forced labor, Industries requiring cheap labor (agriculture, construction, domestic work), Lack of labor rights, etc.

II. **Sexual Demand**: Commercial sexual exploitation demand - Demand for younger and virginal victims, Preferences for specific physical characteristics ("white skin fetish," "blonde paradox"), Sex tourism markets.

III. **Demographic Factors**: Unfair sex ratios, Demand for women in marriage markets, Urbanization and demand for domestic workers.

INDIA: THE GLOBAL TRAFFICKING HOTSPOT

India's position in the global trafficking landscape is very significant. It experiences trafficking in all its dimensions: as a source country, destination country, and transit corridor.

Statistical Reality

According to India's National Crime Records Bureau (NCRB) data:

- **2020**: 1,714 cases registered with 4,709 identified victims (2,222 minors)
- **2021**: 2,189 cases registered with 6,533 identified victims (2,877 minors)
- **2022**: 2,250 cases registered with 6,036 victims (2,878 children).

The conviction rate remains low at 4.8% despite rising case registrations. The data reveals an upward trend with a 27.7% increase from 2020 to 2021.

Geographic Distribution

Certain regions within India demonstrate disproportionately high trafficking incidence. 'High supply zones' for sexual exploitation include Kolkata, Delhi, Karnataka, Andhra Pradesh, and Tamil Nadu, where approximately 23 lakh commercial sex workers operate, with 25% estimated to be minors.

Missing Children Crisis

47,000 children are reported missing annually, with 71.4% being minor girls (NCRB). The scale and pattern of disappearances suggest significant underreporting of trafficking cases,

as many missing children likely fall victim to trafficking networks.[5]

India's Role in Trafficking

- **Source Country**: India ranks among the world's primary trafficking sources, with women and children trafficked to Middle Eastern nations, Southeast Asian countries, and developed nations.
- **Destination Country**: India receives trafficked children from Bangladesh and Nepal, specifically for commercial sexual exploitation and forced labor.
- **Transit Country**: India serves as a passage point for trafficking networks routing victims across South and Southeast Asia.

INTERNATIONAL LEGAL FRAMEWORK AND INDIA'S COMPLIANCE

UN Protocol Definition and Implementation

The UN Protocol (2000) established the first globally accepted definition of human trafficking, distinguishing it from migrant smuggling and voluntary sex work. This framework emphasized that victim consent becomes immaterial once coercive mechanisms are employed.

India's Ranking

According to the 2025 Trafficking in Persons Report, India is classified as Tier-2, indicating that India's government does not fully comply with the Trafficking Victims Protection Act (TVPA) minimum standards but is making significant efforts to bring itself into compliance. This ranking reflects challenges despite several measures.[6]

3P Anti-Trafficking Policy Index

The index evaluates anti-trafficking efforts across three dimensions:

I. **Prosecuting**: Criminalizing traffickers and ensuring convictions

II. **Protecting**: Providing victim support and rehabilitation services

III. **Preventing**: Addressing root causes and preventing initial trafficking

India's performance on this index remains below optimal levels, particularly in conviction rates and victim protection mechanisms.

LEGAL FRAMEWORK IN INDIA

Constitutional Provisions

Article 23 of the Constitution of India explicitly prohibits Trafficking of human beings and forced labor. The other legislative measures are as follows:

- **Bonded Labour System (Abolition) Act 1976**: Criminalizes bonded labor and debt servitude, addressing one dimension of trafficking exploitation.
- **Child Labour (Prohibition and Regulation) Act 1986 (amended in 2016)**: Specifically addresses the exploitation of children through forced labor.
- **Juvenile Justice (Care and Protection of Children) Act 2015**: Provides protective mechanisms for child trafficking victims, establishing alternative judicial procedures for minors.
- **The Immoral Traffic (Prevention) Act (ITPA), 1956**

  The ITPA represented the primary anti-

5. https://theprint.in/india/more-than-47000-children-missing-in-india-71-are-girls-shows-ncrb-data/1880048/
6. https://www.state.gov/reports/2025-trafficking-in-persons-report/india/

trafficking legislation for decades, and criminalized: Keeping brothels or allowing premises for prostitution, living on prostitution earnings, procuring, or inducing persons for prostitution, Detention for prostitution purposes, and public solicitation for prostitution.

- **Criminal Law (Amendment) Act, 2013**

  A landmark legislative reform incorporating India's first legally defined trafficking offense. Section 370 of the Indian Penal Code was amended to define trafficking based on:

- **Acts:** Recruitment, transportation, harboring, transfer, or receipt
- **Methods:** Threats, force, coercion, abduction, fraud, deception, abuse of power, or inducement
- **Purpose:** Exploitation (physical, sexual, slavery, servitude, begging, organ removal)

Bharatiya Nyaya Sanhita (BNS), 2023

The New criminal laws introduced modernized anti-trafficking provisions:

- **Section 143 BNS** (corresponding to Section 370 IPC): Primary trafficking offense
- **Section 144 BNS** (corresponding to Section 370A IPC): Sexual exploitation of trafficked persons
- **Section 96 BNS** (corresponding to Section 366A IPC): Procuration of minors
- **Sections 98-99 BNS** (corresponding to Sections 372-373 IPC): Child sexual exploitation
- **Section 146 BNS** (corresponding to Section 374 IPC): Unlawful compulsory labor
- **Section 145 BNS** (corresponding to Section 371 IPC): Habitual trafficking

For trafficking of minors for sexual exploitation, Section 16 of the Protection of Children from Sexual Offences (POCSO) Act, 2012, additionally applies.

- The Information Technology Act, 2000, addresses trafficking with internet linkages:
  - » Section 67 (obscene materials)
  - » Sections 67A and 67B (sexual content involving children)

SYSTEMIC CHALLENGES IN COMBATING TRAFFICKING

I. Limitations of Law Enforcement

- **Organizational Challenges**: Collusion between law enforcement officials and trafficking networks, Border officials treating trafficking as a low priority, Immigration authorities lacking awareness and sensitivity, Insufficient coordination between law enforcement agencies, and Inadequate resource allocation to anti-trafficking units.
- **Investigative Limitations**: Lack of knowledge regarding transactions, methods, and locations, Insufficient intelligence databases on traffickers, pimps, and organized crime networks, Weak beat-level intelligence collection mechanisms, Limited technical, and forensic capabilities.
- **Victim-Related Challenges**: Victims rarely self-report due to fear of economic loss and social stigma, Language barriers, Absence of trauma-informed investigative procedures, and high rates of recidivism among rescued victims.

II. Judicial System Deficiencies

- **Conviction Rate Crisis**: - Overall conviction rate remains at 16% despite rising case numbers. Acquittals often result from inadequate prosecution, weak evidence presentation, or non-cooperation of victims.
- **Procedural Issues**: Excessive trial durations creating victim fatigue, Inadequate victim support systems during trial, Challenges in securing testimony from trafficked persons.

III. Systemic Failures in Victim Recovery

- **Lack of Rehabilitation Infrastructure**: Inadequate number of institutional facilities for safe custody, Poor conditions in existing government-run homes, Insufficient trained social workers and counsellors, Absence of gender-sensitive vocational training programs.
- **Repatriation Challenges**: Slow NGO-led repatriation processes, Insufficient inter-state coordination mechanisms, Inadequate documentation and tracking systems, Failure to prevent recidivism through proper rehabilitation.
- **Economic Vulnerabilities**: Lack of comprehensive rehabilitation packages, Insufficient job placement assistance post-recovery, Inadequate income-generation opportunities, and social ostracization preventing successful reintegration.

IV. Organizational and Administrative Gaps

- **Strategic Planning Deficits**: Absence of long-term, sustained anti-trafficking strategies, Lack of political will from regional governments, Insufficient area-specific anti-trafficking plans, and inadequate inter-departmental coordination.
- **Pitfalls in Multi-Agency Coordination**: Police and revenue departments operating in silos, Women and Child Development agencies insufficiently engaged, Labor department inadequately involved, Medical and health services lacking trafficking awareness, Panchayati Raj institutions underutilized for community prevention.

THE ROLE OF POLICE IN ANTI-TRAFFICKING OPERATIONS

I. Strategic Planning and Coordination

Police departments must develop area-specific anti-trafficking plans based on:

- Geographic vulnerability mapping, identifying source, transit, and destination zones
- Historical trafficking pattern analysis
- Identification of trafficking nexuses and organized crime connections
- Resource allocation for specialized anti-trafficking cells
- Establishing dedicated Anti-Trafficking Cells with specialized personnel ensures focused attention and institutional accountability for anti-trafficking efforts.

II. Intelligence Collection and Management

Effective intelligence management requires:

- Secure databases cataloging known and suspected brothel owners, pimps, and recruitment agents.

- Informant networks providing information on trafficking activities.
- Tracking systems for case registrations, investigation status, and conviction statistics.
- Analysis of organized crime structures and financial backers.
- Beat constable intelligence as a foundational information source

III. Community Engagement Strategies

- Formation of community vigilance groups at the grassroots level
- Involvement of diverse stakeholders (NGOs, medical practitioners, teachers, local leaders)
- Public awareness campaigns with prominent anti-trafficking signboards
- Education targeting vulnerable populations regarding trafficking dangers
- Stakeholder coordination meetings ensuring collective understanding of trafficking patterns

IV. Detection and Rescue Operations

- **Pre-Raid Planning**: Thorough collection and verification of intelligence through reliable personnel, Identification of premises and terrain assessment, Language barrier assessment and interpreter arrangement, Concurrence of senior officials and proper legal documentation, Identification of escape routes and deployment of adequately briefed personnel.
- **Rescue Execution**: Preferably conducted during daytime to maximize visibility, Plainclothes deployment for initial reconnaissance, Adequate personnel stationed at all exit points, Coordination with trained NGO personnel for victim support, Assessment of building structure for hidden rooms or underground tunnels, Mandatory involvement of Juvenile Welfare Officers when child rescue occurs.
- **Victim Handling During Rescue**: The victims must be handled in a sensitive as well as offensive operational approach, establish Confidence-building measures for hostile or traumatized victims, Empathetic understanding of victim conditions, Appropriate clothing provision post-rescue, and immediate access to medical facilities and specialized healthcare. The strategy must also include Mandatory involvement of child welfare committees for minor victims and Interpreter services for non-Hindi speaking victims for smooth communication.

V. Investigation and Case Registration

i) **FIR Registration**: Initiated on victim complaints, beginning from the point of abduction through rescue, applying multiple sections addressing the chain of offenses:

- Sections addressing sexual assault (Sections 64 and 65, BNS)
- Sections addressing abduction and confinement (126, 127, 137, 87, 61 BNS)
- Sections addressing criminal conspiracy (Section 61 BNS)

- Sections addressing criminal intimidation (Section 3, 351, BNS)
- Relevant ITPA sections

ii) Evidence Collection: -

- Independent witness testimony (NGO members, medical professionals, hotel, and transport staff)
- Circumstantial evidence linking transport, accommodation, and victim movement
- Medical evidence, including potential bone ossification tests for age verification
- Recording of Victim statements
- Identification and arrest of all individuals in the trafficking chain

iii) Chain of Custody: Maintaining proper documentation linking victim abduction points, transportation routes, destination locations, and perpetrator involvement.

VI. Victim Protection and Rehabilitation

i) Immediate Support:

- Declaration of safe custody institutions where trafficking victims can be housed
- Access to legal services explaining their rights and legal processes
- Medical and psychological counseling services to the Victim
- Restoration of self-confidence and psychological well-being

ii) Long-term Rehabilitation:

- Access to formal and non-formal education
- Gender-sensitive, market-driven vocational training programs
- Monitoring of rehabilitation progress to prevent recidivism
- Community involvement in reintegration processes
- Adequate staffing of institutions with trained social workers

PROSECUTION AND ROLE OF JUDICIARY

Public prosecutors bear critical responsibility for:

I. Case assessment and advancement: Application of correct legal provisions to police reports, verification of proper investigative procedures, expedited bail objections for trafficking defendants, and securing material evidence presentation in court.

II. Victim and Witness Support: Recording victim statements, Pre-trial counseling, preparing victims for court proceedings, Mock trial sessions, familiarizing victims with the courtroom environment, and ensuring provision for in-camera trials.

III. Search Warrant Facilitation: Obtaining search warrants and following proper procedures.

IV. Trial Advocacy: Prosecution during trial proceedings, objecting to inappropriate bail applications, enhancing punishment for habitual offenders, and Appellate advocacy in both acquittal and conviction appeals.

Judicial Considerations

- **In-Camera Trials**: Protecting victim privacy and dignity through closed courtroom procedures.

- **Speedy Trial Requirements**: Reducing trial duration to prevent victim fatigue and recidivism.
- **Sentencing Considerations**: Enhanced sentences for trafficking of minors and habitual offenders.

CASE STUDIES: TRAFFICKING IN INDIA

Case 1: Uzbek Belly Dancers Murder Case (2015)

Victims: Shakhnoza Shukurova (22) and Atazhanova Kupalbayevna (Naaz)

Background: Professional belly dancers from Uzbekistan who came to India. Shakhnoza arrived in 2008 for an embassy event and subsequently settled in Delhi. She met and befriended fellow Uzbek nationals, including Naaz.

Trafficking Nexus: Naaz's husband, Gagan (a taxi driver and pimp), controlled the trafficking network. Through coercion, including passport confiscation and threats of false criminal accusations, Gagan forced the women into prostitution.

Crime: In September 2015, Gagan murdered Shakhnoza when she demanded owed money (approximately 8 lakhs) to return to Uzbekistan. Fearing Naaz would report the murder to the police, Gagan murdered her in October 2015. The body was transported to Sonipat, Haryana, and burnt.

Key Lessons: - Transnational trafficking vulnerability of professional women from developing nations, Coercive control mechanisms (passport confiscation, threats), Perpetrator relationship to victims (intimate partner involvement in trafficking), International dimensions requiring cross-border investigation and cooperation

Case 2: Vasant Kunj - Falak and the Battered Baby (2012)

Victims: Meena (22, trafficking victim), Sana (3), Chand (5), Veera (16, trafficking victim)

Origin: Meena, a mother of three from Jhunjhnu, Rajasthan, was abandoned by her husband, who worked as a railway loader. After experiencing gang rape and family abandonment, she struggled for survival, supporting her children.

Recruitment: Meena received a missed call from Harish, initiating a honey trap. She agreed to marry him and traveled to Delhi with two of her children, leaving one daughter with a relative in Bihar.

Trafficking Dynamics: Upon arrival in Delhi, Harish abandoned Meena, who stayed with Laxmi. Despite continuous pressure to engage in prostitution, Meena resisted but ultimately had no economic resources. Unable to sustain herself and her children through legitimate employment, she became increasingly trapped.

The Battered Baby (Falak): During police intervention, an injured baby was discovered. Subsequent investigation revealed the baby belonged to another victim, a 22-year-old woman from Bihar who had been gang-raped and abandoned with three children, one of whom was severely beaten.

Investigation Complexity: - Multi-state investigation spanning Delhi, Bihar, Haryana, Rajasthan, and Maharashtra by a team of 45 police officers, Multiple perpetrators,

including Laxmi, Raju, Pratima, and Saroj, in the trafficking chain. Questions regarding the culpability of individuals at different points in the chain.

Investigative Aids: - Cell phone and data analysis, Trained police officials using innovative methods, Bank and ATM tracking, Media pressure on perpetrators, Victim-centric investigative approach, Inter-state coordination mechanisms

Critical Issues Raised: - Should Meena, as a trafficking victim herself, face criminal charges? - What was the culpability of the "new duped husband"? - What role did the bangle seller and others in the chain play? How should victims-turned-perpetrators be treated within the legal framework?

Key Lessons: Trafficking victims may simultaneously commit offenses under coercion and desperation. Victim-centered investigations require empathetic understanding, interstate coordination demands sophisticated communication and investigation protocols, and the complexity of trafficking chains implicates multiple actors with varying degrees of culpability.

Case 3: Asha's Mass Suicide - Systemic Failure (2012-2013)

Victims: A family of five (Asha, 14½ years old—the primary victim)

Timeline and Events:

- **May 15, 2012**: Asha was allegedly kidnapped and raped by a villager in District Hissar, Haryana
- **Same day**: FIR No. 95/2012 registered under Sections 363/366/376/506 IPC; accused arrested
- **May 18, 2012**: Asha was recovered by the police
- **May 23, 2012**: Victim statement recorded under Section 164
- **June 9, 2012**: Asha again goes missing; reported to the police
- **June 12, 2012**: Police filed DD No. 13 (missing report) instead of FIR
- **February 22, 2013**: DD No. 13 converted to FIR No. 54/13 under Section 346 IPC (about 8 months later)
- **April 22, 2013**: Family commits mass suicide while under police interrogation pressure

Systemic Failures:

- **Investigative Failures**: Non-registration of FIR on Asha's second disappearance, Section 363 (kidnapping) not explored despite minor status, Delayed FIR conversion (8 months), and inadequate protection of the trafficking victim
- **Prosecutorial Failure**: Inadequate age verification evidence, non-availability of the prosecutrix used as sole ground for acquittal, Violation of Supreme Court precedent (State of Karnataka v. Mahabaleshwar Gourya Naik) that non-availability of the victim cannot be the sole ground for acquittal when other evidence exists
- **Judicial Failure**: Acquittal of accused Rohtash based on prosecutorial inadequacy, no state appeal against the acquittal, failure to apply established Supreme Court jurisprudence.
- **Custodial Pressure**: Fast Track Court

repeatedly summoned Asha's father, Police interrogation under pressure demanding the victim's whereabouts, Humiliation of a family member, causing psychological trauma.

- **Outcomes**: Asha's mother, two younger siblings, poisoned themselves - Asha's father, traumatized and jailed under Section 309 IPC (attempt to suicide), died in police custody in June 2014 - Family member (Asha) remains missing or deceased.
- **Critical Issues**: Multiple jeopardy doctrine violation through repeated interrogation, Insensitive police and judicial procedures toward traumatized families, Failure of victim protection mechanisms, Systemic institutional failures compounding trafficking trauma.
- **Key Lessons**: - Proper victim protection is mandatory after initial recovery, Harassment of victim families compounds trauma and may drive further victimization, Procedural safeguards must prevent re-victimization, Systemic failures at multiple institutional levels (police, prosecution, judiciary) create cascading negative outcomes.

COMBATING TRAFFICKING: COMPREHENSIVE STRATEGIES

Intelligence-Led Policing

Effective anti-trafficking policing requires:

1. **Source and Suspect Identification**
   - Background study of the area and people
   - Identification of stakeholders involved in organized crime
   - SWOT analysis of collected intelligence
   - Vulnerability mapping through Panchayati Raj Institutions
2. **Information Analysis**
   - Categorization of clients and complainants
   - Identification of important role players
   - Intelligence corroboration through reliable staff
   - Assessment of terrain and topography facilitating trafficking
3. **Operational Preparedness**
   - Selection of a sensitive, competent, dedicated team
   - Adequate representation of women officers
   - Team members with specialized raid and rescue expertise
   - Regular legal knowledge updates

Prevention Strategies

- **Vulnerability Reduction**
  - Targeting source and transit areas through community-based prevention
  - Poverty alleviation and income-generation programs
  - Education and skill development initiatives
  - Women's empowerment and economic independence programs
- **Demand Reduction**
  - Public awareness campaigns regarding trafficking consequences
  - Educational programs addressing demand drivers
  - Regulation of sex industries and commercial exploitation

- Monitoring and interdiction of organ trafficking markets

- **Victim-Centered Prevention**
  - Community awareness regarding trafficking dangers
  - Identification and protection of vulnerable populations
  - School-based awareness programs
  - Confidence-building in law enforcement agencies

Institutional Strengthening

- **Police Capacity Building:**
  - Specialized anti-human trafficking units (AHTUs) with trained personnel
  - Comprehensive training on trafficking dynamics and investigation techniques
  - Strengthened intelligence collection and analysis capabilities
  - Technology integration (video conferencing, digital forensics, databases)
- **Judicial Efficiency**
  - Constitution of special courts for trafficking cases in all states
  - Enhanced prosecution capacity and training
  - Victim-friendly courtroom modifications
  - Timely trial completion to prevent victim fatigue
- **Inter-Agency Coordination**
  - Clear specification of inter-state and inter-departmental roles
  - Regular coordination meetings between stakeholders
  - Unified data collection and sharing mechanisms
  - Integrated victim support systems

Repatriation, Rehabilitation, and Reintegration (3R) Framework: This framework focuses on the approach of Repatriation, Rehabilitation, and Reintegration in a coordinated manner.

- **Repatriation**

  This approach involves the following steps:
  - Standard Operating Procedures (SOPs) replacing slow NGO-led processes
  - Rapid victim identification and documentation
  - Safe transport to home states
  - Liaison with source-state authorities for reception and support
- **Rehabilitation**

  This approach involves the following steps:
  - Individual assessment of short-term and long-term victim needs
  - Expansion and upgrading of existing institutional infrastructure
  - Provision of legal, medical, and psychological services
  - Mental health support addressing trauma, depression, and anxiety
  - Restoration of self-confidence and psychological resilience
- **Reintegration**

  This approach involves the following steps:
  - Formal and non-formal education access
  - Gender-sensitive, market-driven vocational training

- Job placement assistance and employment linkages
- Community involvement ensuring social acceptance
- Ongoing monitoring preventing recidivism
- Microfinance and income-generation opportunities

MEDIA AND PUBLIC COMMUNICATION

Ethical Guidelines for Trafficking Case Reporting

- **Victim Protection**:
  - Name changes for women and children in all reports
  - Prohibition on photography of trafficking victims
  - Avoidance of detailed descriptions enabling identification
  - Confidentiality regarding victim locations and shelter information
- **Media Briefing Protocols:**
  - Press conferences held away from actual operation venues
  - Communication of arrest information and perpetrator backgrounds
  - Avoidance of raking up new controversies
  - Serious approach, maintaining investigative integrity, limited disclosure using "guarded comments" when appropriate
  - Non-obligation to comment on sensitive details

CONCLUSION

Human trafficking remains one of the most pervasive and egregious human rights violations. The intersection of poverty, gender inequality, weak institutions, and organized crime further aggravates the conditions in which trafficking flourishes.

Addressing trafficking requires comprehensive, multidisciplinary approaches transcending traditional law enforcement frameworks. The **3P Strategy**- Prosecute, Protect, Prevent must be integrated with victim-centred approaches in prioritizing restoration of human dignity and rights.

Critical gaps persist across the criminal justice system, from inadequate investigation and low conviction rates to insufficient victim rehabilitation and reintegration. Police require enhanced capacity, training, and resources. Prosecution must be vigorous and competent, and the Judiciary must prioritize speedy trials with victim protection mechanisms. Most importantly, institutional culture must fundamentally shift toward victim protection and dignified treatment.

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Beyond OTP and Passwords: Strengthening Digital Security Against the Threats of Malicious RATs, Deepfakes, and Cryptocurrencies




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ABSTRACT

Cyber criminals no longer need OTPs and Passwords and can enter into anybody's phone or database. Remote Access Trojans, Android Package Kits (APKs), are widely used to invade devices and unwittingly get permissions. Digital arrests, Voice cloning, investment frauds using WhatsApp and Telegram channels, impersonation through Facebook, Sextortion through matrimony websites, and dating apps for sextortion are all used for financial frauds. Using AI-enabled deepfakes to create images, voices, and content, investment frauds are on the rise. AI is both a boon and a bane. AI can create viruses, malicious apps, JavaScript, and whatnot. With mere anonymity using fake ID, social media accounts, mule bank accounts, the victim's money is almost untraceable, with many layers involving cryptocurrencies, which is a challenge for investigation.

This paper examines the ongoing threat posed by these scams, the effectiveness of current fraud prevention mechanisms, and the role of government initiatives like the Sanchar Saathi portal, CEIR (Central Equipment Identity Register), TAFCOP (Telecom Analytics for Fraud Management and Consumer Protection), I4C, MeiTy, RBI, etc. It also explores challenges faced by citizens in reporting fraud and the importance of technology in combating financial crimes.

Keywords: *Digital Arrest Scam, IVR Systems, Fraud Prevention, Cybercrime, Sanchar Saathi Portal, CEIR, TAFCOP, Mule Accounts, RATs, APKs, Cybersecurity, Consumer Protection*

INTRODUCTION

Every day, nearly 7000 cyber complaints are made in the national Cyber helpline number 1930. When the public is made aware of one type of fraud, the fraudsters come up with a new type. The technology they use scares people that hardly any individual is left out. Traditional crimes are outnumbered by cyber

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crimes. These days, transborder linkages to crimes like Investment frauds emanating from Myanmar, Laos, Thailand, and "Digital Arrest" scams have become a pervasive threat, with fraudsters increasingly exploiting technology to deceive and defraud individuals. These scams often involve impersonation of law enforcement officers or government officials, and the use of sophisticated methods such as Interactive Voice Response (IVR) systems, malicious APKs, and Remote Access Trojans (RATs). As the digital landscape evolves, it is critical to understand the tactics employed by fraudsters and the responses from law enforcement and governmental organizations.

In India, initiatives like the Sanchar Saathi portal, Central Equipment Identity Register (CEIR), and Telecom Analytics for Fraud Management and Consumer Protection (TAFCOP), efforts from I4C, AI mule hunter of RBI, Kavach app of C-DAC, ASTR software of DoT, and so on, are aimed at combating frauds. However, challenges remain, since the fraudsters came up with a novel way and used unique technology; usage as a Sandbox of phone calls makes investigation difficult. Further, fraudsters use fake ID cards, Aadhar cards, PAN cards, Photos, fake social media accounts Pseudonyms to make them mere anonymity. National Help Line number 1930 is widely used, but complexity in solving cybercrimes and a lack of advanced databases to track and monitor criminal activities. Money is siphoned off with mule accounts, cryptocurrencies, and money laundering and transborder cybercrimes like Digital arrest, Investment frauds, etc., are a challenge and need coordination not only amongst states but internationally as well. Some banks are finding new methods to find mule accounts. Thanks to the pressure from the central government and RBI, and other regulatory agencies.

RESEARCH METHODOLOGY

This paper adopts a qualitative research methodology based on secondary data analysis. The research is primarily based on reports, case studies, government portals, and existing literature on digital fraud and cybersecurity measures in India. The analysis focuses on the effectiveness of government platforms like Chakshu, Sanchar Saathi, and TAFCOP, as well as the Central Equipment Identity Register (CEIR), which are designed to protect consumers from telecom fraud. Case studies involving the loss of significant amounts of money due to malicious software, including RATs and APKs, are reviewed to understand the evolving nature of scams.

Additionally, the research methodology includes a review of common issues faced by users while reporting fraud and suspicious activities through official channels. The study also discusses the latest trends in Cybercrimes and identifies gaps in the current system, and suggests improvements based on these findings.

BACKGROUND

"Digital Arrest" may seem straightforward to address because the impersonators typically wear uniforms and pose as law enforcement officers, but law enforcement agencies continue to face significant challenges. These include the absence of a centralized, advanced database for recording and updating criminal records. Even after the Prime Minister highlighted this in his Man Ki Baat, the criminals continue to fool the victims.

Central Equipment Identity Register (CEIR), which is a centralized database for tracking mobile equipment identifiers like IMEI numbers (for GSM networks) and MEID numbers (for CDMA networks). Developed by the Department of Telecommunications. CEIR aims to reduce the prevalence of counterfeit mobile phones and curb mobile theft. A similar centralized approach to tracking criminals could be crucial in enhancing fraud prevention efforts and improving overall public safety. For more details on CEIR and other services, visit the Sanchar Saathi Portal 0

REPORT SUSPECTED OF FRAUDULENT COMMUNICATION

Chakshu provides a platform for citizens to report suspicious communications designed to defraud telecom service users. These can include cybercrimes, financial fraud, impersonation, or other forms of misuse conducted via calls, SMS, or WhatsApp.

Examples of such fraudulent communications include:

- Messages related to bank accounts, payment wallets, SIM cards, gas connections, electricity connections, KYC updates, deactivation, or expiry.
- Impersonation of government officials, relatives, or other entities.
- Sextortion-related communications.

REPORT UNSOLICITED COMMERCIAL COMMUNICATION (UCC) / SPAM

Chakshu also allows citizens to report UCC or spam received via voice calls or SMS that violate the recipient's given consent or registered preferences. UCC and spam are regulated under the Telecom Commercial Communication Customer Preference Regulation (TCCCPR), 2018, by the Telecom Regulatory Authority of India (TRAI). It is advisable that Complaints be made at the earliest, either by calling 1930 or in the portal within 3 days of receiving such messages. They will be investigated by telecom service providers, which may result in action against the sender. Reports filed after 3 days are treated as information, which may not immediately lead to action but will help identify and monitor spammers proactively.

TAFCOP SERVICES

Know the Number of Connections Issued in Your Name:

The Sanchar Saathi portal by the Department of Telecommunications provides TAFCOP (Telecom Analytics for Fraud Management and Consumer Protection) services to subscribers across India. By logging in with their mobile number, users can easily check the number of telecom connections issued in their name. To access this, users need to:

1. Enter their mobile number.
2. Fill in the captcha.
3. Verify using the OTP received on their mobile.

If any unauthorized or unnecessary connections are identified, users can report them through the platform.

Know Your Wireline Internet Service Provider (KYI):

The KYI (Know Your ISP) module allows citizens to find details of wireline internet service providers across India. By entering a PIN

code, address, or ISP name, users can verify the presence of ISPs in any region, helping them make informed decisions about internet connectivity.

RICWIN MODULE

The RICWIN (Report Incoming Calls with Indian Numbers) module helps citizens report incoming international calls that appear to originate from local Indian numbers (e.g., +91-xxxxxxxxxx). These calls are often linked to illegal telecom setups that cause financial losses to the government and pose a threat to national security. By reporting such calls, citizens contribute to uncovering and dismantling such operations. Sandboxing of calls is the latest technique used by Cambodia, Myanmar, Laos, and Thailand-based fraudsters in investment frauds to make the calls appear from India, although made outside the country.

However, users have been facing several issues when trying to report incoming international calls with Indian numbers (RICWIN) through official channels like the Sanchar Saathi portal and the NCRP (National Cybercrime Reporting Portal). Reported issues include:

1. **Error Messages:** Users are facing the 502 Bad Gateway error when trying to submit complaints via the Sanchar Saathi portal. This technical issue can often be due to server overload, configuration problems, or maintenance activities.
2. **Submission Issues on NCRP Portal:** Users experience difficulties in uploading complaints on the NCRP portal, often requiring multiple attempts before successfully submitting a report. The complexity of the required details may contribute to this problem, making the complaint process cumbersome. This can be reported on 1963/1800110420

The Startup India Initiative and Digital Communication Innovation Square (DCIS)

The Government of India launched the **Startup India** initiative to foster a thriving startup culture and create an inclusive ecosystem for innovation and entrepreneurship across the country. This initiative aims to support the growth of startups by offering various incentives and simplifying regulations, thereby encouraging a new wave of innovation.

Additionally, the Digital Communication Innovation Square (DCIS) has been set up to enhance the ecosystem for research, design, development, and testing of new technologies. DCIS also focuses on intellectual property rights (IPR) creation, pilot projects, and manufacturing. The goal is to cover the entire value chain and position India as a global leader in telecommunication equipment production and digital communication services.

High Information Load: The extensive information requested during complaint submissions can be overwhelming. Daily, around 7000 cyber complaints are registered, with 1920. A more efficient system with the option to submit basic, essential details may help streamline the process and save time.

3. **Ineffective Customer Support:** When calling the helplines, 1920 or 1963, or 1800110420, some users report that the customer service representatives seem to lack sufficient training or attention to detail. The representatives may ask only

whether international calls were received, without gathering comprehensive information for proper investigation. This lack of thoroughness might be attributed to the hiring of temporary or contractual workers who are not fully engaged in the process. However, the good thing is that when the call is made to 1930 no need to authenticate the victim, and a ticket or token is sent to the victim's WhatsApp, and that may be used as an acknowledgement. However, in the NCRP portal, one needs to be patient in filling in all the details and uploading the documents, like the transaction receipt, screenshots. It is better that every citizen should make a mock complaint registration in the National Cyber Crime reporting portal, not submitting it finally. This helps in filing a complaint when they are victim of financial fraud.

SUGGESTED IMPROVEMENTS

- Simplify the complaint process, allowing users to provide basic details first, with the option to submit additional information as necessary.
- Address the technical issues with the portals to ensure smoother submission of complaints. Many a time, even after calling many times, the complaint cannot be lodged since all the representatives are busy, or the call will be cut off. Further, in waiting for calls, if it is kept in loudspeaker mode when the representatives start speaking, it gets disconnected.
- Enhance training and accountability for support staff to ensure they handle reports more effectively and take the necessary details for follow-up.

MALICIOUS APKS AND RATS:

In a classic case in Haryana, the son of a wealthy businessman downloaded a malicious gaming app as directed by a fraudster who happens to be a social media friend, to which the boy was rewarded some Rubles(Russian Currency) to play the games. Many times, many apps were downloaded and uninstalled, which led to a loss of money from the father's account. Here, the fraudsters put Remote Access Trojans on the father's phone to steal the money, and when the investigators verified the mobile, they found nothing suspicious at first glance. But when it went deep inside the malicious software, once downloaded came into the fore. Fraudsters are finding new methods to steal funds without requiring OTPs and passwords.

Another scam begins with a message that appears to be from a bank. Upon clicking the link in the message, the victim's account is accessed, and money is withdrawn without any OTP being required. Recently, this method has led to over Rs 40 lakh being stolen from individuals in the Bengaluru Rural district alone. Not to mention that there a SMS related to the cut down of electricity, recharge of mobiles, and offering government schemes. RATs and APKs are malicious software that allow cybercriminals to remotely control a victim's device without their knowledge.

Fraudsters often create counterfeit apps that mimic the logos of legitimate nationalized or private banks. These malicious app links are then shared via WhatsApp or text messages, or through social media platforms. Once the victim installs the app on their phone, the fraudsters can easily access their financial information and steal money. This represents a more sophisticated type of phishing, bypassing

traditional security measures and accessing sensitive information without authorization. Initially, such tactics were used to steal large sums from major corporations.

CASE STUDY 1

On May 21, the Deputy Superintendent of Police (Dy. SP) from Hassan's sub-division fell victim to a similar scam, losing Rs 15.98 lakh. He had installed a nationalized bank's app after receiving a link via text message. The link contained a malicious APK or RAT file. Investigations revealed that, shortly after the theft, the stolen money was transferred to multiple mule accounts. It was further discovered that the perpetrators had used 900 SIM cards linked to the same IMEI number.

What is a mule bank account?

A mule account is a bank account that criminals exploit for illegal purposes, such as laundering illicit funds. These accounts are typically obtained from their legitimate owners, who are often individuals from lower-income backgrounds or those with limited technical knowledge.

The term "money mule" refers to the unsuspecting victims whose bank accounts are used by criminals to funnel stolen or illegal money. When such cases are reported, the money mule becomes the focus of law enforcement investigations, as their accounts are implicated, while the actual perpetrators often remain untraceable.

MuleHunter.ai

The Reserve Bank Innovation Hub (RBIH), a subsidiary of the Reserve Bank of India, has developed an AI/ML-powered system called **MuleHunter.ai** to tackle the growing issue of mule accounts involved in financial fraud. These accounts are often used by criminals to launder money from cybercrimes. MuleHunter.ai analyzes data from banks to better identify patterns of fraudulent activity, enabling more efficient detection of mule bank accounts. A pilot program conducted with two major public sector banks has shown promising results in combating this type of financial crime.

Advantages

- **Detection of Mule Accounts:** The system focuses on identifying and tracking mule accounts, which are often used for facilitating fraudulent transactions. By analyzing transaction behaviors, it can flag accounts involved in transferring illicitly obtained funds.
- **Real-time Monitoring:** It provides the ability to monitor transactions in real-time, enabling banks and financial institutions to detect and respond to suspicious activities quickly. This proactive approach helps prevent further fraudulent transactions.
- **Advanced Data Analytics:** Utilizing advanced data analytics and machine learning algorithms, the system processes large volumes of transaction data. This helps in identifying trends and patterns linked to fraudulent activities, enabling the early detection of potential scams.
- **Collaboration Across Institutions:** The system fosters collaboration between banks, payment service providers, and law enforcement agencies. Sharing information about identified mule accounts helps create a more robust defense against digital fraud.

- **Regulatory Compliance:** It assists financial institutions in meeting regulatory standards related to anti-money laundering (AML) and combating the financing of terrorism (CFT), contributing to the overall integrity and security of the financial system.

Recent NEWS Article: Delhi High Court Encourages States, UTs, and Intermediaries to Join I4C's SAHYOG Portal to Tackle Cybercrime: The Delhi High Court recently addressed important concerns regarding data requests from IT intermediaries, issues raised by Law Enforcement Agencies (LEAs), and the status of the SAHYOG portal. Currently, only 16 states and 9 IT intermediaries have joined the portal, which is designed to facilitate smoother data access for investigations. The court also reviewed the progress made by Delhi Police in developing a handbook for standard operating procedures (SOPs).

On December 11, 2024, the Delhi High Court discussed the challenges faced by LEAs in relation to IT intermediaries, assessed the role of the Indian Cyber Crime Coordination Centre (I4C), and evaluated the implementation of the SAHYOG portal, an initiative launched by the Ministry of Home Affairs (MHA) to enhance data accessibility for criminal investigations.

GRIEVANCES RAISED BY LEAs

The court acknowledged several significant challenges faced by Law Enforcement Agencies (LEAs) when attempting to obtain timely responses from IT intermediaries. The key issues highlighted include:

1. FIR Requirement: IT intermediaries demand First Information Reports (FIRs) for data disclosure, even for preventive actions, causing unnecessary delays.
2. VPN Use: Many cybercrimes utilize proxy servers or VPNs, which require requests to go through the lengthy Mutual Legal Assistance Treaty (MLAT) process.
3. Delayed Responses: IT intermediaries often take 15 to 30 days to respond to data requests, even in emergencies.
4. Complicated Portals: Different intermediaries operate separate portals with complicated procedures, making the data request process more cumbersome.
5. Absence of Grievance Officers: Many foreign intermediaries do not have designated grievance officers in India, leading to communication barriers.
6. Incomplete Logs: Only the last logged-in IP address is provided, limiting the effectiveness of investigations.

ROLE OF I4C

The Indian Cyber Crime Coordination Centre (I4C), operating under the Ministry of Home Affairs (MHA), has been designated as the central agency for handling cybercrime complaints and coordinating with intermediaries. The SAHYOG portal has been launched, with all designated officers from states and Union Territories (UTs) onboard. This will focus on the removal of illegal content, with future updates set to include lawful data requests. In the recent past Cyber Fraud Mitigation Centre (CFMC) has been added to I4C. Threat Analytical Unit (TAU) identifies the various advanced threats that are floating in the current cyberspace.

SAHYOG Portal, Adoption and Challenges: The SAHYOG portal, designed as a centralized

platform to manage data requests and content takedowns.

Almost all states and UTs have been integrated into the system and adhere to Section 79(3)(b) of the IT Act, 2000. Nine intermediaries, including Google, Meta, Amazon, and Telegram, have signed up for the portal, but platforms like X (formerly Twitter) and LinkedIn are being integrated with the portal. The phased rollout aims to improve transparency and efficiency, though full integration remains a work in progress.

AI Scams: Voice Cloning and Deepfake Threats

Deepfake Case Study: Deepfake technology, which manipulates audio and video to create convincing but fraudulent content, has been increasingly used for scams and criminal activities.

In July 2022, Kerala experienced its first deepfake fraud case. A 73-year-old man, Radhakrishnan, became the victim of a sophisticated scam that led to a loss of ₹40,000. Radhakrishnan received a WhatsApp call from someone who seemed to be his former colleague, Venu Kumar. The caller, utilizing deepfake technology, was able to replicate Venu Kumar's voice and appearance with remarkable accuracy. The caller requested a loan of ₹40,000, claiming an urgent need for the money. Trusting that it was his colleague, Radhakrishnan transferred the money without suspicion. In these cases, it was necessary to call back the fraudster to find their authenticity. Sometimes, even a small information, such as receiving the money not require scanning the QR code but only payment to others. The salary is deposited from the office without our notice.

Investigation Process: The scammer used advanced AI technology to create the deepfake. The fraudster had gathered personal details about Radhakrishnan, including his relationship with Venu Kumar, through social media. The police traced the stolen money to an account in Maharashtra. Subsequently, the Kerala police have issued a public warning about the risks of deepfake scams, advising individuals to remain cautious when receiving unexpected calls or messages.

One can witness a lot of AI-generated investment offers from Finance Minister Nirmala Sitharam, Infosys chairman, Nandan Nilkeni, stating that if you invest 21,000 or so, then you will get lakhs and crores of rupees subsequently, and the Narendra Modi government wants to end poverty in this regard. One can always see that there is a difference between the videos of these personalities and AI videos. The Skin touch, the way they talk, the movements, and the naturalness of the talk are always different, and of course, nowadays more sophisticated way of Deep fakes, voice cloning, and images has come. But one must copy the domain name or the video link and check on various platforms on the internet to check its authenticity. The KAVACH app, developed by C-DAC, will assist in finding which apps are malicious on our phones.

VOICE CLONING SCAMS

Case Study: In Yamuna Vihar, Delhi, cybercriminals used voice cloning technology to deceive Lakshmi Chand Chawla, a senior citizen, and steal 50,000 rupees. Chawla received a WhatsApp message claiming that his cousin's son had been kidnapped. To make the scam more convincing, the criminals used

AI to clone the child's voice, which could be heard begging for help. Overcome with panic, Chawla sent 50,000 rupees via Paytm. He only realized the child was safe after contacting his cousin. While digital financial transactions, such as UPI, are being widely adopted across India, many people with basic digital literacy still struggle with understanding online security. With the rise of cybercrime, scams, and fraud, there has been little prosecution of these criminals, and justice for victims remains rare. The growth of AI-powered crimes poses even greater risks, with fraud techniques rapidly evolving and creating new challenges. Scammers collect personal information, such as contact details and names, to make fraudulent calls appear credible. They employ social engineering techniques, manipulating the emotions of the victim's family members to heighten the sense of urgency.

Once a voice sample is captured, it's difficult to prevent scammers from using it. They can obtain voice data from various sources, including wrong-number calls, social media platforms like Instagram or YouTube, and even TV broadcasts. This also introduces a "liar's dividend" effect: as these scams become more widespread, people may start doubting legitimate distress calls, wasting valuable time verifying authenticity instead of offering help.

A significant case occurred in Hong Kong last year when scammers used a deepfake video to impersonate a company's CFO, leading to a financial loss exceeding $25 million (about ₹212 crore). Anyone could now fall victim to AI-enabled deception. As AI continues to blur the lines between reality and fabrication, the consequences of fraud become increasingly severe.

Additionally, the Digital Personal Data Protection Act of 2022 focuses on protecting personal data collected both online and offline. It limits the use of such data to lawful, consensual purposes. In the event of a data breach, individuals can demand corrections or deletions, and those responsible for mishandling data may face harsh penalties. The Act also establishes a Data Protection Board to handle consumer complaints regarding data misuse, which could encompass the unauthorized use and distribution of deepfake technology.

CRYPTOCURRENCY FRAUD

Cryptocurrency fraud is increasingly prevalent, especially among criminals operating on the dark web or hidden networks. Fraudsters have fake SIM cards, Fake identities like Aadhar, and use Mule accounts to siphon off the fraud amount. Either the amount is withdrawn through ATM's that too outside the country or parked in cryptocurrencies. Legal businesses typically do not engage in transactions using Bitcoins, so any request for payment or business dealings involving Bitcoin should be considered suspicious and avoided. Many investment fraudsters pose as if they are experts in Crypto investments and guarantee unbelievable returns. So those involved in buying or selling Bitcoin and other cryptocurrencies need to exercise caution, as fraudsters often attempt to deceive individuals with fake identities and fraudulent transactions on various platforms.

The Reserve Bank of India (RBI) has not granted authorization to any company or entity to handle virtual currencies. Cryptocurrencies are the only digital assets in India. The victim should always give the Bitcoin address

involved, the amount of Bitcoin that is part of the transaction, and the address from which the Bitcoin was sent or received.

Cryptocurrency Case Study: The Enforcement Directorate (ED) recently arrested two chartered accountants and a cryptocurrency trader in connection with a cyber fraud case involving ₹640 crore. The funds were illicitly acquired through activities such as betting, gambling, part-time job scams, and phishing. These funds were then channeled through over 5,000 mule accounts in India and transferred to "PYYPL," a payment platform based in the United Arab Emirates.

The arrests followed searches conducted across 13 locations. The raids resulted in the seizure of various items, including documents, cheque books, ATM cards, PAN cards, digital signatures, trust wallet recovery phrases, ₹47 lakh in cash, and cryptocurrency worth ₹1.36 crore.

The ED has attached properties and cryptocurrencies worth ₹70 crore as part of the investigation. The agency is probing the role of the accused in operating mule accounts and the use of these accounts for illicit transactions linked to the transfer of funds to the UAE. The case serves as a reminder of the rising threat posed by cryptocurrency scams and the ongoing efforts of authorities to track and dismantle fraudulent networks.

The Government of India came up with the tax regulations for Crypto investments, i.e., 1% overall TDS on the amount invested in Crypto and 30 % tax on the profits made, with no set-off and set on. Now, one must follow the KYC norms to invest in Crypto. Wazir -Ex was in a legal tangle since the investments made through it were not clear whether they were the proceeds of a cyber fraud. The fraudsters now choose a method where they take a house for rent and make rent agreements. Using this, they change their Aadhar address and subsequently open some bank accounts and obtain an ID. Although it appears genuine, they routed the fraud amount through these accounts, and one night, they emptied the accounts and ran away. Now the UADIA will give only the current address of the particular Aadhar number and not the earlier ones. So, the investigators could not determine where the criminals originated.

In social media also fake accounts are also opened using websites like https://temp-mail.org/for temporary emails, and https://receive-smss.com/sms for virtual mobile numbers of any country. AI-enabled near-perfect photos can be gotten from https://this-person-does-not-exist.com/en.

LIMITATIONS

1. **Data Privacy Concerns:** While MuleHunter.ai enhances the detection of mule accounts, it relies on large-scale data analytics, which could raise privacy concerns for individuals whose financial data is being analyzed. There may be challenges in ensuring compliance with privacy regulations while gathering and processing sensitive transaction data.
2. **False Positives and Overburdening Law Enforcement:** While AI-powered systems like MuleHunter.ai provide real-time monitoring, the possibility of false positives could overwhelm law enforcement agencies. They may be inundated with non-fraudulent cases, which could dilute

focus and lead to inefficient investigations.

3. **Technological Barriers for Law Enforcement Agencies (LEAs):** As highlighted by the Delhi High Court, LEAs often face issues such as delayed responses from IT intermediaries, the complexity of multiple portals, and the requirement of FIRs for data disclosure. Although the ISP/ISP guidelines 2021 have been framed but still more coordination is required. These barriers hinder the timely and effective use of AI-driven systems in addressing cybercrime.
4. **Deepfake and Voice Cloning Vulnerabilities:** Although advancements in technology like deepfake and voice cloning offer new ways to detect fraud, they also open new avenues for scams. The emergence of AI-based fraudulent activities such as voice cloning scams shows that while technology can offer solutions, it simultaneously creates new challenges, such as difficulties in verifying the authenticity of calls.

RECOMMENDATIONS

1. **Enhancing Data Privacy Protocols:** Financial institutions and AI-powered systems like MuleHunter.ai should implement stringent data privacy protocols to ensure that sensitive financial information is safeguarded. Compliance with privacy regulations like the Digital Personal Data Protection Act of 2022 should be prioritized to mitigate the risks of data misuse.
2. **Expanding the SAHYOG Portal's Adoption:** To make the SAHYOG portal a success, greater collaboration is needed between states, Union Territories, and IT intermediaries. The MHA should work to expedite the onboarding process and address technical barriers so that law enforcement agencies have real-time access to the necessary data for more efficient investigations.
3. **Training for Law Enforcement Agencies:** Law Enforcement officers should receive ongoing training to keep pace with emerging technologies and AI-based tools. This will ensure that they can use AI tools effectively without being overwhelmed by false positives, thus improving the overall efficiency of investigations. In all the Cyber Crime Police stations, there should be a proper way to appoint the Station House officers, either with a technical background or having experience in investigating Cyber Crimes.
4. **Public Awareness on AI Threats:** Everyone needs to be made aware of AI threats. Interestingly, AI is used to commit Cyber Crimes and many digital payment frauds, and huge data analysis is done using AI tools.
5. **Strengthening Legal Frameworks for Cryptocurrency Transactions:** The lack of a clear legal framework for cryptocurrency transactions is a significant concern. The Reserve Bank of India and other relevant authorities should work toward creating regulations that govern cryptocurrency activities. This would ensure that platforms operating in the cryptocurrency space are more transparent and accountable.

To file a cybercrime report, one can visit the National Cybercrime Reporting Portal (NCRP) at https://cybercrime.gov.in. The portal has two sections: one for reporting crimes

related to women and children (which can be done anonymously) and another for general cybercrimes. One can also report via the helpline on 1930, which connects you to State Cyber Crime Coordination Centres, where authorized personnel can assist in freezing or blocking fraudulent transactions in a bank account.

CONCLUSION

When the phone is connected to the rest of the world, it means it is compromised in one way or another. Now everyone is a victim of cyber fraud, with only one difference that some knew that they were a victim, and others did not know. It is astonishing how the fraudsters came up with new types to commit cyber fraud. Earlier, it was OTP's, Passwords, Impersonation, social media, Phishing links, Deep fakes, Voice cloning, AI-enabled crimes, Investment frauds, Digital arrest, and so on, like a new type of car emerges in the market. Cyber criminals are always steps ahead of the Victims. They obtain SIM cards fraudulently, open fictitious bank accounts, get fake Aadhaar cards, PAN cards, and the fraudulently obtained amount is routed to cryptocurrencies, which is near unanimity.

Digital fraud, particularly scams involving impersonation and technological exploitation, has seen a rapid increase in India. While the government has implemented several initiatives, such as the Sanchar Saathi portal, CEIR, and TAFCOP, citizens still face significant barriers when reporting fraud. Addressing these challenges, particularly the complexity of reporting processes and the technical issues faced by users, is critical in ensuring more effective fraud detection and prevention.

Furthermore, as cybercriminals continue to innovate and exploit new technologies like RATs and APKs, it is essential for both consumers and law enforcement agencies to remain vigilant. Proactive measures like the development of AI-powered tools such as MuleHunter.ai could provide a much-needed edge in tackling financial fraud, while simplifying reporting mechanisms and improving consumer support services will enhance user experience and trust in digital fraud prevention systems. But the ultimate solution is awareness and being cautious; otherwise, negligence pays its penalty.

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3D & Drone-Based Crime Scene Management System (3DD-CSMS): A Concept Paper

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ABSTRACT

Effective crime scene documentation is critical for investigations and judicial processes. Traditional methods such as 2D photography and manual sketches often fail to capture spatial complexities, compromising the integrity of evidence. The 3D & Drone-Based Crime Scene Management System (3DD-CSMS) integrates advanced technologies like LiDAR-enabled cameras, drones, and virtual reality (VR) to create detailed, non-intrusive, and interactive crime scene reconstructions. This paper provides a theoretical grounding for 3DD-CSMS, outlining its components, applications, and limitations, while exploring the integration of Artificial Intelligence (AI) and the Internet of Things (IoT) for automated scene reconstruction.

Keywords: *3D Crime Scene Reconstruction, LiDAR, Virtual Reality (VR), Augmented Reality (AR), VR in Forensics, Extended Reality (XR), Internet of Things (IoT), 3DD-CSMS, 3D Modelling Methods, Image Processing, Keyframe extraction, Time-of-flight (ToF) camera, 3D point cloud, Novel view synthesis, etc.*

INTRODUCTION

Crime scene management has traditionally relied on manual documentation techniques, including photographs, hand-drawn sketches, and physical measurements. While these methods have served their purpose historically, they are inherently limited in capturing the spatial and temporal nuances of a crime scene. With advancements in technology, Extended Reality (XR)—a collective term for Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR)—has emerged as a promising tool in modern forensic investigations. The application of these technologies by the LEAs is helpful in making a digital twin of a crime scene, which can give them better investigative and supervisory experiences.

The concept of 3DD-CSMS is rooted in spatial cognition theories, which emphasize the role of spatial understanding in reconstructing events. According to the Cognitive Load Theory (Sweller, 1988), immersive environments

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such as those created by VR reduce cognitive overload by presenting information in an intuitive, visual format. This facilitates better comprehension of complex spatial relationships, making 3DD-CSMS particularly effective for crime scene analysis. Crime scene is a silent witness, but 3D makes it speak (Erkan Bostanci, 2015) - is a powerful statement emphasizing how 3D technology brings clarity and voice to the otherwise mute details of a crime scene.

A basic introduction to the technologies that are being used in the 3DD-CSMS is mentioned below:

- Virtual Reality (VR) is a computer-generated simulation that immerses users in interactive, three-dimensional environments, allowing them to experience and interact with artificial worlds as if they were real. The first VR experience emerged in 1962, aiming to engage all five senses. While current technology primarily stimulates sight and sound, there have also been advancements in haptic feedback technology to simulate the sense of touch. Future developments may incorporate additional senses to enhance the immersive experience.
- Augmented Reality (AR) is a technology that blends the real world with digital elements, enhancing the user's perception of their surroundings. AR overlays virtual objects, information, or visuals onto the real-world environment in real time, typically through devices like smartphones, tablets, or AR glasses. AR is distinct from Virtual Reality (VR), which creates a fully immersive digital environment, and from Mixed Reality (MR), which allows digital and real-world objects to interact as explained below.
- Mixed Reality (MR) is a technology that merges the real world and virtual environments, allowing physical and digital objects to coexist and interact in real time. Unlike Augmented Reality (AR), which simply overlays digital elements onto the real world, MR creates a more integrated experience where digital and physical components can influence and respond to one another. It represents a significant step toward more immersive and interactive digital experiences, blending the best aspects of AR and VR.
- Extended Reality (XR) is an umbrella term encompassing all immersive technologies that combine the real and virtual worlds to varying degrees. It includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR). Paul Milgram and Fumio Kishino introduced the reality-virtuality continuum in 1994. This continuum is a scale that ranges from a completely real environment to a completely virtual environment. XR represents the entire spectrum of digital and physical interaction, from fully real to fully virtual environments. With advancements in 5G, AI, and wearable devices, XR is expected to become more seamless and accessible. Its applications are expanding into industries like real estate, tourism, defense, and urban planning, making XR a key component of the next digital revolution.
- 3D Point Cloud Data is a collection of data points in a three-dimensional space, typically generated by sensors like LiDAR (Light Detection and Ranging), photogrammetry, or structured light scanning. Each point in a point cloud represents a precise location in 3D space and can often include additional attributes such as color, intensity, or time. Each point

is defined by its X, Y, and Z coordinates, which provides a detailed representation of the geometry of a scene or object. It can capture millions or even billions of points, while offering fine details.

- Novel View Synthesis (NVS) is a computer vision and graphics technique that generates images or renderings of a scene from new viewpoints based on a limited set of input images or data. This process involves understanding the scene's 3D geometry, texture, and lighting, and then creating a realistic representation of how it would look from an unseen perspective. It typically requires multiple images of a scene captured from different viewpoints or 3D data such as point clouds or depth maps. These inputs help infer the spatial structure and appearance of the scene.
- Photogrammetry is the science and technology of extracting precise measurements and 3D information from photographs. It involves capturing overlapping images of an object, structure, or landscape from different angles and using software to stitch them together into a 3D model. Photogrammetry gives a basic overview of the scene but lacks depth information.
- Time-of-Flight (ToF) camera is a 3D imaging device that measures the distance between the camera and objects in its field of view by calculating the time it takes for light to travel to the object and return to the sensor. This method provides depth information for every pixel in the captured scene, enabling precise 3D mapping. The camera emits light, typically infrared (IR), in the form of pulses or continuous waves toward the scene. The light reflects off objects in the scene and returns to the camera. The camera measures the time delay (or phase shift) between the emitted and reflected light to calculate the distance and generates a depth map by determining the distance for each pixel, resulting in a 3D representation of the scene. Since this camera works on IR, it can be used in low-light conditions as well. (Silvio Giancola, 2017)
- LiDAR (Light Detection and Ranging) is a remote sensing technology that uses laser light to measure distances and map the physical characteristics of objects and environments with high precision, and works as a high-tech measuring tape, which can help in eliminating human measuring error. It works by emitting laser pulses, measuring the time it takes for the pulses to bounce back after hitting a surface, and calculating the distance based on the speed of light. LiDAR is faster and more accurate than Photogrammetry; for example, even scratches can be identified through it. But it has some disadvantages also. Firstly, reflective things like mirrors, polished metals, windows, glossy magazine covers, etc., can cause distortions in a 3D model whose details might not be captured. Secondly, dark materials, which can absorb a lot of infrared light might give a less detailed description of those objects in 3D models.
- 3D scene reconstruction using Neural Radiance Fields (NeRFs) is a cutting-edge technique in computer vision and graphics that uses neural networks to generate highly detailed, photo-realistic 3D representations of a scene from 2D images. NeRFs excel at capturing intricate visual details, including reflections, refractions, and subtle lighting effects. It takes as input a set of 2D images of a scene, along with information about the camera positions and angles (camera poses).

1. COMPONENTS OF 3DD-CSMS AND HOW IT WORKS

The 3D & Drone-Based Crime Scene Management System (3DD-CSMS) includes both hardware and software components. The hardware comprises 3D cameras, 360° cameras, drones, VR headsets, and AI glasses, while the software consists of a crime-number-wise directory that organizes 3D models and drone footage for efficient retrieval and analysis. This directory is also referred to as 3DD-CSMS and serves as a centralized repository for all recorded data. This combination of hardware and software ensures comprehensive crime scene management, enabling LEAs to document, organize, and analyze crime scenes effectively.

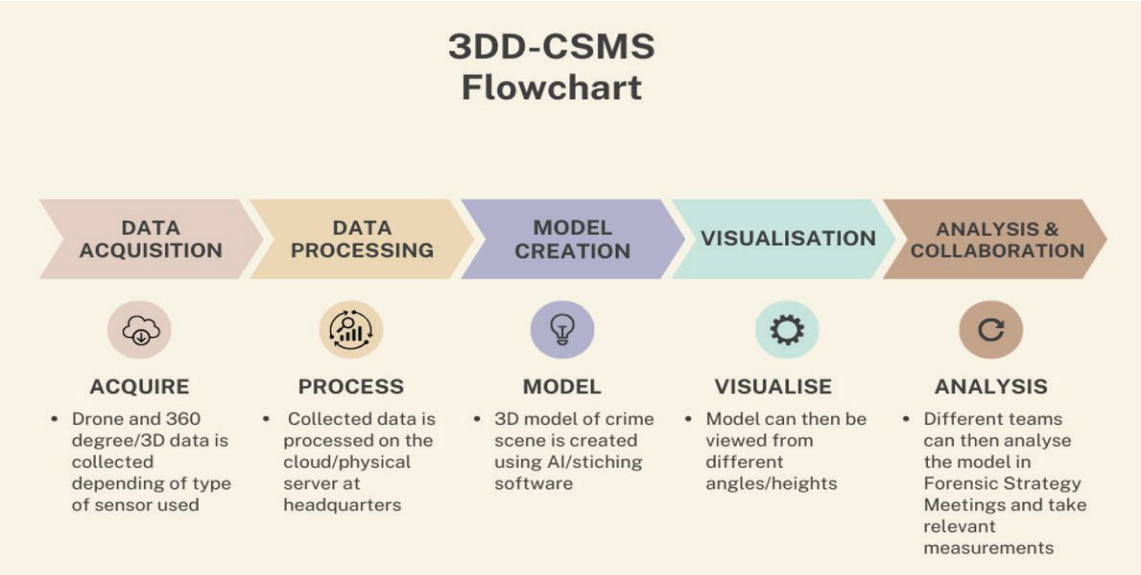


Figure 1: *Flowchart of 3DD-CSMS for crime scene 3D data management and analysis*



Figure 2



Figure 3

Figure 2 &3: *Web application Layout of 3DD-CSMS*

A short description of the hardware components is as follows: -

1.1 Drones in 3DD-CSMS

Drones play a pivotal role in capturing crime scenes from diverse angles and elevations. In 3DD-CSMS, we can use either Camera Drones or FPV (First Person View) Drones:

- **Camera Drones:** Equipped with high-resolution cameras and stabilizers, these drones provide wide-area views essential for mapping large crime scenes or hazardous areas. Examples include DJI Mavic 3, Autel Evo Lite, and Parrot Anafi.
- **FPV Drones:** Offer immersive, real-time visuals, enabling investigators to maneuver drones dynamically for precise documentation. These drones are highly agile and suitable for navigating complex or cluttered crime scenes. Examples include DJI FPV, BetaFPV, and iFlight Nazgul5.



Figure 4: *Shows an operator using FPV Drone to capture a drone shot of a crime scene*

Difference between Camera Drone and FPV Drone

- **Camera Drones:** Prioritize smooth, high-quality imaging and ease of use for photographers and filmmakers.
- **FPV Drones:** Focus on speed, agility, and an immersive flying experience, appealing to racers and drone enthusiasts.

1.2 LiDAR and 3D Cameras

3D cameras are indispensable for creating accurate, spatially detailed reconstructions of crime scenes.

- **LiDAR Technology:** LiDAR cameras use laser pulses to measure distances and generate 3D point clouds, offering unparalleled accuracy in documenting spatial relationships. Examples include Faro Focus 3D, Leica BLK360, Matterport Pro3, and Trimble X7.
- **360° Cameras:** Capture panoramic views but lack the depth perception necessary for forensic analysis. While 3D cameras are preferable due to their ability to generate accurate measurements, limited budgets at the local level may compel law enforcement agencies (LEAs) to use smartphone-based 360° cameras as a cost-effective alternative. Examples include Insta360 ONE X2, GoPro MAX, and Ricoh Theta Z1. These cameras, though less precise, still provide valuable visual documentation of the crime scene.

Difference between 360-degree Camera and 3D Camera

1. **360-degree Camera:** Best for providing an all-encompassing, panoramic perspective, but it does not include depth.
2. **3D Camera:** Best for adding realism through depth perception, making objects appear tangible and spatially accurate. This is crucial for the measurement aspect of 3D Crime Scene.

Feature	360-degree Camera	3D Camera
Definition	A 360-degree image or video allows the viewer to look around in all directions (up, down, left, right) from a single point of view.	A 3D image or video provides depth perception, allowing the viewer to perceive the dimensions (length, width, and depth) of objects in a scene.
View	Surround view from a fixed perspective; the viewer feels like they are "inside" the scene but can't move around within it.	Stereoscopic depth creates a sense of spatial realism; viewers feel objects are closer or farther away in the scene.
Interaction	The viewer can rotate the view in all directions but cannot move forward/backward or interact with objects.	The viewer perceives depth and can often interact with or move within the scene (in immersive VR setups).
Equipment	Requires a 360-degree camera for capture and a compatible device (e.g., VR headset, smartphone) for viewing.	Requires a stereoscopic camera or LiDAR for capture and VR/AR devices or 3D displays for viewing.
Usage	Primarily for immersive panoramic views, such as virtual tours, live events, and documentaries.	Used for immersive environments where depth perception is critical, such as VR gaming, simulations, and 3D modeling.
Example	Virtual tour of a museum where the viewer can look around but remains in one spot.	A VR simulation where the viewer can perceive the depth of objects, like walking through a virtual forest.

Feature	360-degree Camera	3D Camera
File Format	360-degree images/videos are often in equirectangular format (e.g., .mp4, .jpg) and are wrapped for immersive viewing.	3D content is often in stereoscopic formats or 3D model files (e.g., .fbx, .obj, or .stl).
Realism	Provides a realistic surround view but lacks the sense of depth.	Creates a more immersive experience by adding depth perception.



Figure 5: *Shows the process of capturing the crime scene with 3D camera from different Angles and heights*

1.3 VR Headsets in 3DD-CSMS

VR headsets are critical for immersive crime scene analysis, enabling investigators to virtually explore and analyze reconstructed environments. Different types of VR headsets serve various levels of law enforcement:

1. **Tethered VR:** Requires a powerful, high-throughput computer connected by cable to a head-mounted display. This setup provides the most immersive experience and is suitable for use at the headquarters level.
2. **Standalone VR:** A mid-range option with an in-built processor, allowing for portability and ease of use. This can be utilized at the DCP/SP level for field operations.
3. **Smartphone VR:** The most affordable option, using a smartphone as the display. While less immersive, it is suitable for use at the Circle/Thana level.

Examples of VR Headsets for 3DD-CSMS:

JioDive: Smartphone-based Virtual Reality Headset.

Meta (formerly Oculus) Quest: Virtual and Augmented Reality Headset.

HTC VIVE: Mixed Reality Headset.

Microsoft HoloLens: Mixed Reality Headset.

Apple Vision Pro: Extended Reality Headset.

2. CASE STUDIES: APPLYING 3DD-CSMS IN CRIME SCENE INVESTIGATIONS

2.1 Murder Crime Scene

A homicide investigation demonstrates the practical application of 3DD-CSMS:

- Aerial Documentation: Drones map the crime scene, highlighting potential entry and exit routes.
- Ground-Level Reconstruction: LiDAR cameras preserve details such as blood spatter patterns and weapon placement, creating a high-resolution 3D model.
- Immersive Analysis: Investigators use VR headsets to simulate the sequence of events, enabling collaborative hypothesis testing among forensic experts and legal teams.

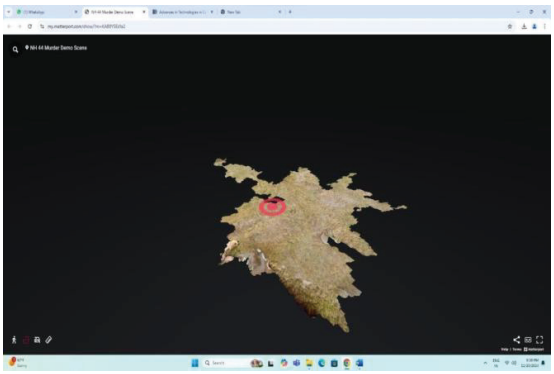


Figure 6: *Shows the field view of Murder Demo Crime Scene as captured by 3D Camera*



Figure 7: *Shows the view captured by 3D camera with Measurements*

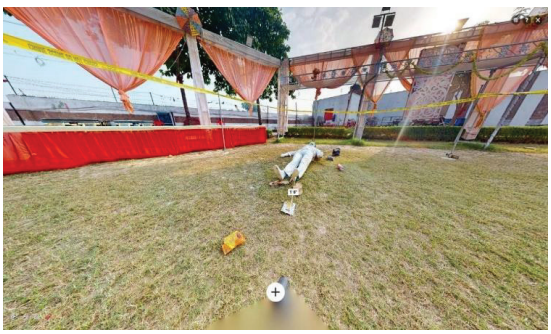


Figure 8: *Shows the view captured from different angle by 3D came*

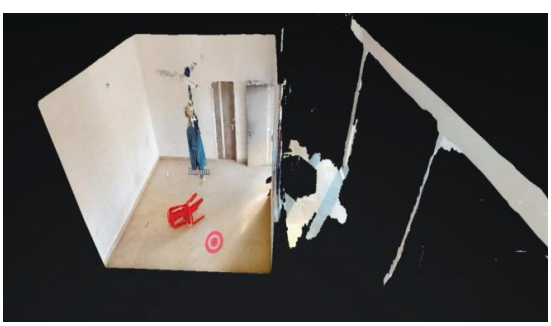


Figure 9: *Shows the view captured by 3D camera from a different angle with different height.*

2.2 Suicide Crime Scene

A suicide investigation demonstrates another practical application of 3DD-CSMS:

- Interior Mapping: LiDAR technology captures the position of the body, nearby objects, and environmental factors such as light and angles.
- Evidence Preservation: Digital reconstructions allow investigators to revisit the scene virtually, preserving spatial relationships for court presentations



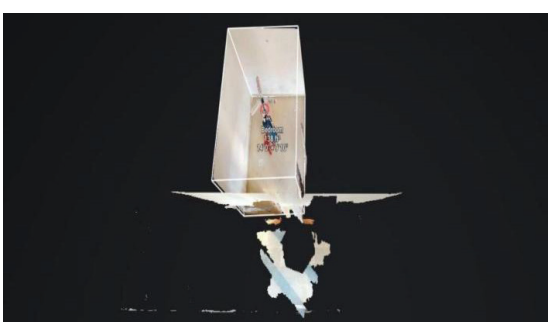


Figure 10 & 11: *Shows the field view captured by 3D camera*

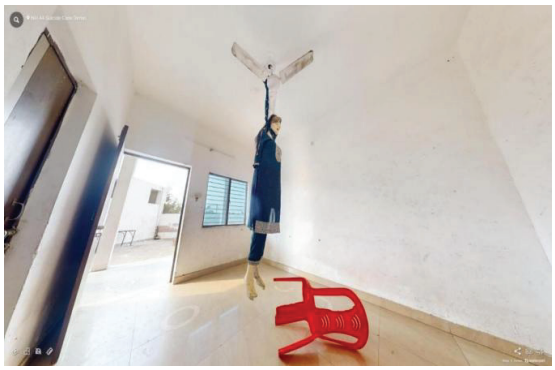


Figure 12: *Shows the indoor view of the crime scene as captured by 3D camera*



Figure 13: *Shows the indoor view of the crime scene as captured by 3D camera from a different angle*



Figure 14: *Shows the indoor view of the crime scene as captured by 3D camera from a different height*



Figure 15: *Shows the indoor view of the crime scene as captured by 3D camera from a different height*



Figure 16: *Shows the indoor view of the crime scene as captured by 3D camera with measurements.different height*

3. ADVANTAGES AND LIMITATIONS OF 3DD-CSMS

3.1 Advantages

- ***Enhanced Accuracy:*** First responders and field units might miss minute details on the crime scene, which can later be found out by investigating, as well as supervisory officers, while they revisit the crime scene in a 3D model. VR helps in picking up details otherwise missed in 2D renditions. It is like a high-tech magnifying glass that helps us see things in a better way.

- ***Improved Safety and Non-Intrusive Evidence Collection:*** Drones and remote technologies allow access to hazardous areas, reducing risks for investigators. It reduces the need for physical interaction with the crime scene, minimizing contamination risks.
- ***Immersive Analysis:*** VR provides a dynamic platform for visualizing and testing hypotheses about crime scene events. It provides a deeper understanding of the crime scene layout. Investigators would encounter fewer uncertainties, doubts, or limitations in their analysis once they can visualize the subject or data using a virtual reality (VR) model.
- ***Long-Term Preservation:*** Digital reconstructions ensure that evidence remains intact for future analysis, even after physical alterations to the crime scene. VR is like a time machine. It can simulate past events with a high level of detail, allowing users to step into historical moments or revisit scenes that no longer exist.
- ***Scene Reconstruction:*** By integrating AI-powered tools, it can automatically recreate crime scenes, providing insights into possible sequences of events.
- ***Multi-Stakeholder Access:*** Investigators, forensic experts, and legal professionals can collaborate effectively by accessing shared 3D models, and it is possible to work with experts remotely on a crime scene (Erkan Bostanci, 2015).
- ***Reduced Time on Scene:*** Automated data collection through drones and IoT devices speeds up the documentation process. In potential law and order situations, we can immediately scan the crime scene, and evidence would not be lost.
- ***Courtroom Impact:*** 3D and VR reconstructions provide a more tangible and understandable depiction of the crime scene for judges.
- ***Adaptable to Various Scenarios:*** The system can document crime scenes ranging from small indoor environments to large outdoor areas.
- ***Reuse of Data:*** Captured data can be revisited for future investigations, training, or case reviews without requiring repeated site visits.
- ***Integration of Advanced Technologies like AI for Pattern Recognition:*** AI can identify patterns in evidence, such as shoe prints, trajectories, or suspect movements.

3.2 Limitations

- ***High Costs:*** The technology involves significant investment in equipment and training.
- ***Environmental Constraints:*** Drones and cameras may face operational challenges in adverse weather conditions or densely populated areas.
- ***Data Protection:*** Cloud storage of crime scene data requires robust security measures to prevent unauthorized access, as 3D models have detailed information about people, places, and objects. So, data needs to be handled responsibly so that people's privacy is protected. One solution for this could be on-device processing, which would be like a mini forensic lab in your pocket.
- ***Equipment Failure:*** Malfunctions in drones, LiDAR cameras, or VR systems could result in incomplete or inaccurate reconstructions.
- ***Data Overload:*** High-resolution 3D imaging generates large amounts of data,

potentially overwhelming storage and processing capacities.

- ***Misuse of Technology and Manipulation:*** Advanced imaging and AI capabilities could potentially be misused for unauthorized surveillance, creation of fake evidence, biased reconstructions, and manipulation of how user sees events, for example, deepfakes for 3D is possible (M. A. Maneli and O. E. Isafiade, 2022). Although we can tackle such deepfakes by embedding digital fingerprints or watermarks into original images used to create 3D models. This can be an effective solution to maintain authenticity and detect tampering.
- ***Training Requirements and SOP:*** Personnel need specialized training to operate and interpret data from the system, increasing both time and cost. Researchers, developers, and policy makers all must come on board to devise an industry standard and SOP.
- ***Chain of Custody:*** Managing the digital evidence while maintaining a proper chain of custody can be challenging, especially if we are using 3rd party servers to store and process 3D point cloud data and models. In this regard, Blockchain technology can be used to create a tamper-proof record of the data, which will solve the chain of custody issue.
- ***Standardization Issue:*** If one police agency uses one type of 3D laser scanner and another one uses another one, then especially with fast changing technology, there are cost issues related to buying new hardware and software and training on that as well as issues related to sharing data among these different agencies if they are working on the case jointly (M. Esposito, 2023). For example, two districts, district and ATS, ATS and STF, etc.
- ***Hash Value Verification:*** To safeguard against potential tampering of 3D models on servers or during remote collaboration, hash value verification can be employed. By generating and comparing hash values, any unauthorized modifications can be detected. This approach, as successfully implemented in the e-Sakshya App, ensures the integrity and authenticity of digital evidence, providing a robust defense against hacking and data manipulation.
- ***Low light conditions:*** LiDARs have limitations in low light conditions, so in those cases, Time of flight cameras can be used since they use IR (Infrared Radiation).
- ***Digital invasion of privacy:*** The creation of 3D models of people and their surroundings without their consent, particularly for sensitive uses like generating virtual avatars of eyewitnesses or bystanders at a crime scene, raises serious concerns about digital privacy, ethics, and legality. One solution could be blurring out humans using AI (Benedict Q., 2022).
- ***3DD-CSMS*** shouldn't be used near military bases since the enemy might use it in interests adverse to the country (Benedict Q., 2022).
- ***Motion sickness*** might be experienced by some investigators while using VR headsets (M. A. Maneli and O. E. Isafiade, 2022).

4. WAY FORWARD: AI AND IOT IN CRIME SCENE RECONSTRUCTION AND TRAINING

The future of 3DD-CSMS lies in the integration of AI and IoT technologies and relevant training:

- ***Training of Field Units in VR/AR:*** Proper training of Field Unit personnel and new recruits in a virtual crime lab is required.

- ***AI for Automated Analysis:*** Machine learning algorithms can analyze 3D data to identify patterns, simulate events, and generate actionable insights.
  1. Interactive AI-enabled Drone and 3D models can help investigators to recreate the crime scene and sequence of events, and even modify it by moving things around, checking alibi, running simulations, and collaborating with experts remotely.
  2. Forensic Command Centre can be developed in districts (Erkan Bostanci, 2015).
  3. A rewind button for Accidents can be made using AI: Recreating accidents, digitally recreating the whole crash scene, analysing everything that happened from every single angle, speed of vehicle, angles of impact, and simulations of different scenarios about how the accident might have happened.
  4. Human-AI Partnership: AI algorithms can analyse complex 3D datasets, recognise objects, clean up noise in the data, and reconstruct the scene on their own.
- **IoT for Real-Time Monitoring:** IoT-enabled devices can stream live 3D reconstructions to command centers, facilitating real-time decision-making by supervisory officers. Additionally, IoT can incorporate advanced sensors capable of detecting microscopic evidence, such as tiny DNA fragments or trace materials, which traditional methods might overlook. These cutting-edge sensors are designed to analyze minuscule evidence with precision, significantly enhancing forensic investigations and evidence collection.

Therefore, AI-enabled systems can enhance predictive modeling for crime scene analysis. By integrating historical data, AI can generate probable scenarios, aiding investigators in solving complex cases. IoT devices equipped with environmental sensors can further enrich crime scene data, capturing variables such as temperature, humidity, and sound.

CONCLUSION

The 3D & Drone-Based Crime Scene Management System represents a significant leap in forensic investigation capabilities. By integrating LiDAR, Drones, and XR technologies, 3DD- CSMS addresses the limitations of traditional methods, ensuring accurate, immersive, and collaborative crime scene analysis. A picture is worth a thousand words, but with VR, it's like a million words! While challenges such as cost and data security remain, the continued evolution of AI and IoT promises to make this technology more accessible and effective for law enforcement agencies worldwide. We should always remember that technology is just a tool; the human element is still needed and is of paramount importance. Drone Shots and 3D models are just pieces of the puzzle, but the onus of solving that puzzle lies on human investigators only. Technology can only tell us the "what" and "how; but the "why" still needs to be figured out by humans only.

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A Systematic Review of Workplace Issues Faced by Women Traffic Police Personnel




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P.G Sunanda Bhagavathy**

ABSTRACT

Women's roles in law enforcement have been steadily increasing, albeit slowly. Though the total number of women in law enforcement has increased, there are numerous challenges, such as lack of women in leadership and cutting-edge positions, their marginal role in overall law enforcement, gender-specific issues, lack of infrastructure, and dealing with stereotyping by male colleagues. Especially in the instances of traffic policewomen, in which they have prolonged duty hours in the field and don't have the privilege to avail basic amenities while in need. This review would help to elucidate the issues faced by women police personnel. The number of studies reviewed was 30 using the PRISMA guidelines. All of the studies included in this review showed that there are various unattended issues faced by women traffic police personnel in our country. Various stressors are faced by Traffic policewomen that lead to less satisfaction and work motivation, which in fact leads to a very low work-related quality of life. From the existing literature, it has been observed that very few studies have been conducted in this field using the PRISMA and SLR techniques, and no studies focusing on women traffic police officers.

Keywords: *Traffic police, Workplace, Stressors, Environment, Well-being, Equality*

INTRODUCTION

Traffic police have existed for nearly three eras, where road traffic started to boom in the eighteenth century. In response, the Lord Mayor of London appointed three men in 1722 to ensure that traffic stayed well. They were most likely the world's first traffic cops. In terms of work, traffic officers and their responsibilities include both authoritative interventions and equal justice. They are full-service cops, but their work is usually limited to a specific location and field duties, such as patrolling public roads and traffic infractions. A traffic cop's primary duties include traffic control, enforcement, and escorting dignitaries. (Kaur R., 2013)

The history of traffic police in India dates to the early 20th century, when the first traffic

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constable was appointed in Mumbai in 1929. However, it was not until 1942 that the duties of traffic control were formalised and separate traffic battalions were established. Over the years, the traffic police have expanded to cover the entire country and now play a crucial role in maintaining road safety and traffic flow.

It is observed that even though there's an increase in the number of women in law enforcement, they face numerous challenges. Especially in the case of women traffic police officers who work long shifts and do not have the luxury of receiving basic necessities when they are in need. Their typical day consists of long hours spent in the field, often without access to water, food, or a restroom. And for female traffic officers who are pregnant or menstruating, such days can be depressing. ("Women in Police Face Privacy, Sanitation Issues at Work: Survey," 2016)

Modern police officers have a multifaceted role that includes citizen welfare, social and community policing. Apart from physical competency, all of these roles necessitate a strong mind. Although women cops do their jobs with total effort, and the number of women in law enforcement has increased, the challenges still exist. Problems such as a lack of women in leadership, their marginal role in overall law enforcement, gender-specific issues, a lack of infrastructure, and dealing with stereotyping by male colleagues are some of the specific challenges. As such, various workplace challenges hinder the work of traffic policewomen, which would be listed in the following lines.

As mentioned earlier, this study aims to review and explore the workplace challenges faced by the traffic policewomen. The present study uses the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to carry out a systematic literature review (SLR) and assess the existing literature on traffic police officers to answer the following research questions (RQs):

a) What are the common workplace challenges confronted by women traffic police officers?
b) Do the challenges faced by the women traffic officers hinder their quality of life?

As very few studies have been carried out on the workplace issues of traffic police officers, and no studies on women traffic police officers. This study would be an essential review study that would fill the literature gap, which would be beneficial for further studies and research work. The current study is instituted to focus on the three areas:

1. General well-being
2. Workplace environment
3. Job stress

METHODOLOGY

A review of multiple publications was conducted related to workplace challenges faced mainly by police officers, as papers on issues faced by the traffic police sector, especially women officers, were not available. Henceforth, as traffic police are a section of law enforcement, and hence, problems faced are the same, papers related to them were collected and analysed. The study was conducted according to the PRISMA checklist. The Sources of data collection were Scopus journals, Google Scholar and Inflibnet, and Police journals. Reviews were conducted to investigate and know the workplace challenges faced by traffic policewomen, with three parameters taken into account, which are workplace environment, general well-

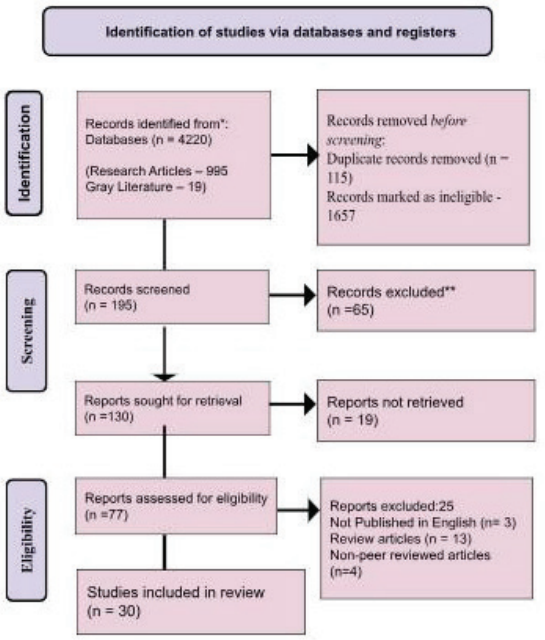
being, and job stress. A total of 30 studies were reviewed and analysed.

The inclusion criteria were all publications that referred to traffic police officers, regardless of age and gender; the exclusion criteria were studies that collected data from populations other than this specific population. Data or articles written in languages other than English were not considered. After the initial screening of articles, a few studies did not clearly meet the criteria; therefore, not included. Some studies were discarded because the full text of the studies was not available. Eligible full texts that met all criteria and protocols were selected and checked for consistency and used in the review.

Grey literature was also included to avert publication bias and improve understanding of the subject matter. There was no primary data collected. All secondary data research protocols and ethics have been followed, and there is no ethical risk to consider.

PRISMA Diagram

Figure 1. PRISMA Flow Diagram



S. N.	Author/ Year of publication	Country	Title	Focus of study	Methodology	Findings
1	Mathur, Pragya 1993	India	Stress in Police Personnel: A preliminary Survey.	To identify the stressors that cause stress among the police personnel.	Survey method Sample n= 118	Stressors identified among Indian police personnel include inadequate equipment, fear of serious injury, working conditions, anti-terrorist operations, a lack of recognition, being killed on duty, work overload, shooting someone in the line of duty, a confrontation with the public, a lack of job satisfaction, and a police hierarchy.

S. N.	Author/ Year of publication	Country	Title	Focus of study	Methodology	Findings
2	Simon and Sharon, 1998	England	Policing women police: Uniform patrol, promotion, and representation in the CID	The aim of the study was to identify the gender differences and factors that lead to gender differences among law enforcers.	Survey method Sample n = 563	They believed that structural, gender inequalities, and professional cultural processes were important factors to consider in addressing gaps in men's and women's work experiences. It was discovered in female officers' apparent acceptance and reinforcement of views associated with the police occupational culture.
3	Melchor and Frank, 2004	Philippine	Policewomen and Their Problems: The Philippine Context	To understand and know about the challenges faced by female officers.	Survey method Sample n= 33	The paper outlined the challenges that policewomen face in adapting to a predominantly male-dominated organisation. According to the data, female officers face gender-related issues.
4	Naparajit Mukherjee, 2005	India	Dealing with Job-Oriented Frustration and Dissatisfaction in Police Service	This paper points out that one of the major psychological issues that can arise in the workplace is frustration.	Review paper	The findings of the paper were that performance suffers as a result of frustration, and the best output from human resources is not available. The author also discusses various methods for dealing with frustration.
5	McCarty, Garland, and Zhao, 2007	U.S. A	Occupational stress and burnout between male and female police officers: Are there any gender differences?	Aimed at exploring to see if male and female police officers experience different levels of occupational stress and burnout.	Questionnaire Sample n = 1100	The findings indicated that female officers face additional stressors in the police organisation as a result of various discriminations, harassment, and duty schedule conflicts with families.

S. N.	Author/ Year of publication	Country	Title	Focus of study	Methodology	Findings
6	Punam Sahgal 2007	India	Gender Discrimination: Beliefs and Experiences: A Comparative Perspective of Women and Men in Delhi Police	The paper focused on Gender based discrimination in Delhi police.	In-depth interviews Sample n = 478	The results suggest that gender-based work behaviour differences are perceived to be predominant. These findings have significant implications for developing relevant human resource policies in police departments to deal with the changing demographics and for building a gender-inclusive organisation.
7	Anupam Kulshreshtha, 2008	India	"Mainstreaming of Women in Police"	The paper focused on the entry of women into the police and the challenges faced by them.	Review paper	This paper explained that there was no clear strategy or consistency in recruitment, training, work distribution, promotion, posting welfare, and so on. According to the study, female police officers face infrastructure issues such as long shifts, a lack of crèches, and toilet issues, which lead to health issues.
8	Dr. Guruprasad 2008	India	A profile of Junior Ranks of Karnataka Police Survey of Their Attitudes, Behaviour, Mental Makeup and Stress Levels. Bengaluru. Engendering Policing"	To assess attitudes, behaviour, mental makeup, and stress levels among police officers of Bengaluru.	Survey Method Sample n = 205	The survey discovered reasons for dissatisfaction were 'lack of time for rest,' 'harassment by superiors,' 'inadequate leave,' 'public disrespect,' and 'lack of remuneration.'

S. N.	Author/ Year of publication	Country	Title	Focus of study	Methodology	Findings
9	Abdul Jassim Mohammad 2009	U.A. E	Determinants of job satisfaction among Dubai police employees	To check and understand the job satisfaction among the Dubai police	Mixed method: In-depth interview, Focus group Questionnaire Sample n= 1017	Factors related to job satisfaction are mainly divided into two: Personal factors and environmental factors. This paper concluded that the work environment is a better predictor of job satisfaction than individual demographic variables and that personal factors are of little value to understanding job satisfaction.
10	Marilda Lipp 2009	Spain	Stress and Quality of Life of Senior Brazilian Police Officers	To explore the stress factor and the quality of life among Brazilian officers	Questionnaire survey Sample n= 418	Findings indicated that females were found to be more stressed than males. Women officers were reported having more significant stressors related to family than men. Stress indicators such as somatization and poor health were reported by female officers.
11	Noblet et al. 2009	Australia	Job stress in the law enforcement sector: Comparing the linear, non-linear, and interaction effects of working conditions	Addressed a stress gap in law enforcement agencies working in high-risk situations.	Survey Sample n = 2085	According to the findings, police work is one of the most stressful occupations, and there are organisational conditions that must be addressed for the well-being of police officers performing high-risk duties.
12	Padma S. and Sudhir Reddy 2013	India	Effects of Stress on Work-Life Balance – A Study on Female Police Personnel	The role of family support in balancing the personnel and work life of women police in Andhra Pradesh Police Department was researched.	Survey Sample n = 651	The results revealed that there was a positive correlation between stress and work-life balance, and stress was the predictor of work-life balance.

S. N.	Author/ Year of publication	Country	Title	Focus of study	Methodology	Findings
13	R. Kaur et al. 2013	India	A psychological study of stress, personality, and coping in police personnel	To investigate the relationship between personality traits and coping methods, and psychological stress in police officers.	Questionnaire Sample n= 150	They concluded that personality traits and coping strategies play an important independent and interactive role in the development of high psychological stress in police officers, putting them at risk of developing psychiatric disorders.
14	Joseph & Nagaraja Murthy 2014	India	Stress in Police Officers	The focus of the study was stress among police officers	Unstructured interview method Sample n= 118	The primary causes of stress among police officers, according to the study's findings, were political pressure, a lack of time for family, a negative public image, and a low salary. It was also discovered that police officers experience significantly more stress.
15	Rajan R Patil et al. 2014	India	Global review of studies on the Traffic police with special focus on environmental health effects	The objective of the paper review was to investigate the impact of occupational health hazards on the health of traffic police officers.	Review paper	According to the findings of this paper, occupational hazards can cause a variety of health problems as well as a high level of stress in one's life.
16	Adnan Jamil et al. 2015	Pakistan	General problems faced by women police	The focus of the study was the general issues faced by police officers.	Participant observation and in-depth interview Sample n= 40	According to the researchers, police officers faced a variety of social, personal, and psychological issues due to a variety of factors, including insufficient transportation and infrastructure. Discriminatory behaviour was also evident.

S. N.	Author/ Year of publication	Country	Title	Focus of study	Methodology	Findings
17	Roxanne Chen 2015	Canada	Women in policing: In relation to female police officers' level of motivation toward the career, level of stress, and attitude of misconduct.	The focus of the study was to know workplace issues faced by women police.	Survey method	As studied, because of psychological differences between both genders, gender stereotypes, and workplace culture, women experience higher levels of stress. Female police officers, according to the study's findings, have the same starting motivations as male police officers, but their motivation fades over time. Furthermore, it was argued that, while female police officers committed less misconduct, they tend to blend into the environment after some time on the job.
18	Shanmuga-vadivu and Sethurama-subbia h 2018	India	Occupational stress and work-life balance among married women police	Attempted to determine the level of work-life balance among married female police officers	Structured survey questionnaire Sample n= 226	Age, income, number of children, and total number of working hours per day are all significant predictors of work-life balance among married police officers.
19	Laksheeta and Rufus 2020	India	Sexual Victimisation of Women Police and Its Deleterious Impact on the Victims: A Thematic View	Aimed at understanding the nature of work and the workplace environment, as well as the problems faced by women police officers in Jaipur	Thematic analysis Descriptive research	It was concluded that female officers faced workplace issues in the form of sexual harassment and discriminatory behavior.
20	Dr. Maheshwari S. Kachapur 2017	India	Workplace Problems of Women Police Constables	Emphasised workplace issues of female police constables in Karnataka's north-eastern range	Interview method Sample n= 205	According to the study, policing as a job includes a variety of jobs such as law enforcement, service, escorting, and clerical work. Women constables carry out tasks that have been delegated to them.

S. N.	Author/ Year of publication	Country	Title	Focus of study	Methodology	Findings
						However, they believe that their responsibilities are restricted to more traditional and limited roles.
21	G Ragesh et al. 2017	India	Occupational stress among police personnel in India	The purpose of this study was to see if occupational stress and related physical and mental health issues are adequately addressed in	Questionnaire Sample n= 406	The findings indicate that Indian police officers are highly stressed and that immediate government intervention to address occupational stress is required.
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26	Deepti Gangwar and Dr. UV Kiran 2017	India	Quality of life among traffic police	The study's goal was to look into the connection between traffic officers' psychological well-being and their overall quality of life.	Questionnaire Sample n= 148	According to the findings, an increase in psychological well-being leads to an increase in personnel quality of life.
27	Sridher S. et al 2017	India	Health status of traffic police personnel in Chennai city	evaluated the health of traffic police officers in Chennai.	Cross-sectional study Sample n= 139	The findings of this paper were that each traffic officer in the study had one or more health issues, and one factor was the work environment.
28	Sayanti Kar 2024	India	A Study on the Impact of Air Pollution on the Health Status of Traffic Police Personnel in Kolkata, India	This study investigated health challenges faced by traffic police personnel due to prolonged exposure to air pollutants prevalent in traffic-congested areas.	Secondary data from 2019-2023 Questionnaire Sample n= 100	The results of this study established a strong positive correlation between air pollution and a range of health issues experienced by the exposed group.

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32	Rifi Hamdani Sitohang et al. 2023	Indonesia	Factors and Impact of Work-life balance of police officers: A literature Review	This study is a literature review of previous research investigating the determinants and impacts of work-life balance for police officers.	Review paper	A number of key factors were found that influence the achievement of work-life balance of police officers and the impact it has. This research looks at trends in the study of work-life balance in police officers so that it can provide a conceptual framework for future research and practical suggestions for police institutions.

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RESULT ANALYSIS

The studies (n= 30) in the provided list offer a comprehensive examination of workplace issues faced by traffic policewomen across the world. Due to a lack of literature, studies from all over the world were collected and analysed as per the PRISMA guidelines. Literature giving emphasis on workplace issues encountered by policewomen from the United States, United Kingdom, Spain, Australia, Philippines, Indonesia, and India was included.

Research studies on workplace issues confronted by traffic policewomen is limited. This diverse compilation of studies explores various workplace issues faced among traffic policewomen.

The selected papers were grouped based on three main themes to enable a precise analysis, specifically on the workplace's issues:

1. General wellbeing
2. Workplace environment
3. Job stress

General well-being

In this review, nine papers were identified as studies that focused on and highlighted the overall well-being of police officers, as papers on traffic police, especially women, were not available.

General problems faced by policewomen were discussed, which outlined the police women face in adapting to male-dominated organisations where they face gender related discrimination and lack of mental support, which in turn disrupts their overall wellbeing.

Women police officers face infrastructure issues such as long shifts, a lack of crèches, and toilet issues, which lead to health issues, which can be physical and psychological issues, this in turn leads to disruption in work-life balance. It studied workplace issues encountered by women police officers because of psychological differences between both genders, gender stereotypes, and workplace culture, with women experiencing higher levels of stress.

Few studies implied towards factors and impact of work-life balance of police officers, quality of life among traffic police where the focus was to know psychological well-being and overall quality of life among the officers.

It is concluded that there is a significant relationship between stress management with stress faced by the women police personnel. The work environment timings weren't flexible for the women's time. Work-life balance issues were present.

Workplace Environment

About 10 studies from the above table discuss the workplace environment that causes a lot of physical and psychological ramifications.

Some studies find that the increased workplace incivility experienced by policewomen exacerbates emotional exhaustion and may prompt them to consider leaving their organisation. These studies discussed the health status and the physical determinants of long-term health effects of traffic police officers and the lack of basic amenities for women. Workplace problems confronted by women police officers were explored, which are more restricted to traditional and limited roles, even though they are able to carry out every task delegated. Studies deploying structural, gender inequalities, and professional cultural processes studied important factors to consider in addressing gaps in men's and women's work experiences.

Job satisfaction among police, irrespective of gender, concludes that environment is a better predictor of job satisfaction than individual demographic variables and that personal factors are of little value to understanding job satisfaction. Another study conducted a thematic study on the various types of victimisation, especially sexual victimisation and its impacts faced by women police officers, which is less reported and focused.

Lack of basic facilities such as toilets, restrooms, dining areas, and so on in the workplace can cause a lot more physical discomfort and mental stress and strain, in addition to leading to various physical constraints such as UTIs and other illnesses, particularly among pregnant women. Female cops go without water for long periods of time to avoid urination. Long exposure to torrential climatic conditions and the recipient of pollutants causes various physical illnesses and leads to long-term health deterioration, not only physical but also mental illnesses.

Job Stress

In this review paper, eleven papers related to Job stress overlooked by women traffic officers were reviewed.

Common stressors among the police officers were also identified, which were inadequate equipment, fear of serious injury, working conditions, anti-terrorist operations, a lack of recognition, being killed on duty, work overload, shooting someone in the line of duty, a confrontation with the public, a lack of job satisfaction, and a police hierarchy.

The primary causes of stress among police officers were identified, and it was concluded that political pressure, a lack of time for family, a negative public image, and a low salary. It was also discovered that police officers experience significantly more stress.

One of the studies focused on studying the effect of the added stress of the COVID-19 pandemic and population lockdown on the sleep/wake 24 h rhythm of traffic police. The survey identified discontinuation of sleep,

shift of mid-sleep time, increase in depression, plus stress and anxiety among traffic police personnel that affected their chronobiological milieu.

Overall, all the papers reviewed about the occupational stress and frustration that lead to disturbances in work-life balance of women police officers, closely focusing on women traffic police officers, as they have more field-oriented work-life.

IMPLICATIONS OF THE RESEARCH

This systematic literature review would help in understanding the workplace challenges overlooked by women traffic police officers. Focusing on the workplace conditions, general well-being, and job stress. These factors overall lead to a broader understanding of the work-related quality of life.

The paper can also be a contribution to existing knowledge about the challenges encountered by traffic police officers, which can pave the way for researchers to conduct more studies related to issues faced by women traffic police officers. The review study will contribute to understanding the traffic police officer's life, in addition, provide literature focusing on challenges faced by the women traffic police officers, which is less analysed rather than thought over and studied. The review paper can also support the research evaluations and studies conducted in the future that measure any frameworks for this specific population.

Research related to women was less, especially of this specific branch of police. This study is one of the first kinds done on workplace issues faced by traffic policewomen, with a few parameters taken into brief.

This study can be an insight for researchers to invest in interventions that can help and support the work-life balance of women traffic police. In addition, this paper brings almost all studies done on traffic police officials together and makes it easier to access and use them for further approaches and academic purposes. It highlights the main factors that affect the work-related quality of life of traffic policewomen.

CONCLUSION

The police department is a vast department and so-so-called essential service, with a lot of women being recruited into various positions. The traffic police wing is one such department where a lot of hassles are faced from jobs as well as the environment, which in turn leads to physiological and psychological stress and strain. These issues turn out to affect the quality of life and lack of motivation to complete a work, which in turn can lead to women not taking up job opportunities such as serving the nation and community. Traffic police officers are the ones who control the public and the wheels they are in, so that everything runs at a smooth pace so as does the transportation system. In addition, it is a solace to observe that women traffic police officers are increasing in number, though they are obviously undergoing a lot of physical and mental challenges. Amidst all the stress from

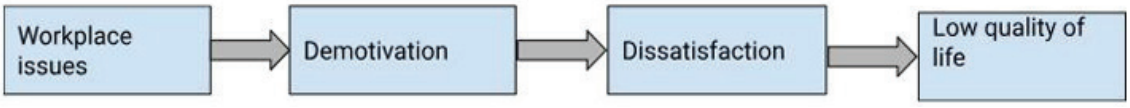


Figure 2. *Flowchart of what workplace complexities can lead to.*

home and work, they manage to do their work diligently. Hence, the well-being of the Traffic Police, especially women officers, is of primary importance. Therefore, as policymakers and researchers, it should be our prerogative to ensure their problems are inquired into, resolved, and interventions developed, whereby we would pave the way to uphold the traffic rules.

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Crowd Management in Mega Religious Events: A Case Study of Navratri at Kalkaji Temple, New Delhi



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ABSTRACT

This paper examines the strategic crowd management practices implemented during the 2025 Navratri festival at Kalkaji Temple, New Delhi, a prominent religious site attracting over one lakh devotees daily. Anchored in anticipatory governance, multi-agency coordination, and technological innovation, strategic interventions ensured an incident-free event, addressing challenges like unregulated crowd flow and inadequate infrastructure. The study outlines core crowd management principles, recent trends, use of smart technology, actions taken, outcomes, lessons learned, and future recommendations, offering a replicable model for managing high-density religious gatherings.

Keywords: *Crowd Management, Religious Festivals, Kalkaji Temple, Public Safety, Smart Technology, Stakeholder Coordination*

INTRODUCTION

India's religious festivals, characterized by massive gatherings, pose significant challenges to urban infrastructure and public safety. The Navratri festival at Kalkaji Temple, a revered Hindu site in Southeast Delhi, exemplifies these complexities, with continuous footfall exceeding 100,000 devotees daily over nine days. Past incidents, including two fatalities in 2024 due to electrocution, underscored the need for robust strategies for crowd management. This paper explains the 2025 Chaitra Navratri crowd management framework, highlighting its integration of spatial planning, smart technology, and inter-agency collaboration to achieve a safe and spiritually fulfilling experience.

Core Crowd Management Principles

Effective crowd management of large events rests on several fundamental principles, based on international best practices and adapted to local conditions/contexts:

1. **Anticipatory Governance:** Proactive risk assessment and scenario planning identify potential hazards, such as crowd surges or choke points, enabling pre-emptive solutions (NDMA, 2022).
2. **Unidirectional Flow:** Segregated entry and exit routes minimize cross-movement

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and congestion, hence reducing stampede risks (Jalaja & Biradar, 2024).

3. **Multi-Agency Coordination:** Seamless collaboration among police, civic bodies, and emergency services ensures rapid response and unified command (Kasthala et al., 2019).
4. **Crowd Deceleration:** Strategic spatial designs, like zig-zag barricades, regulate density and slow movement to prevent surges (Ardh Kumbh Mela, n.d.).
5. **Information Dissemination:** Clear communication via signage, announcements, and digital platforms fosters compliance and reduces anxiety (Vizor & Ramota, 2024).
6. **Technology Integration:** Real-time monitoring tools, such as CCTV analytics and RFID tracking, enhance situational awareness and operational efficiency (Nishinari et al., 2024).

RECENT TRENDS IN CROWD MANAGEMENT

Modern crowd management techniques reflect the convergence of technological advancement alongside behavioural sciences as well as inclusive planning strategies for handling mass gatherings. Smart surveillance systems, leveraging AI-driven CCTV and facial recognition, enable real-time monitoring of crowd density and detection of potential threats, enhancing situational awareness (Thesis et al., 2024). Digital access control mechanisms employing QR codes and RFID tags optimize security measures by simplifying entry management and mitigating unauthorised access while improving both operational efficiency and safety (Jalaja & Biradar, 2024). Pre-event planning becomes more effective through crowd simulation software that generates models of crowd traffic flow while forecasting probable congestion zones (Kasthala et al., 2019). Crowd psychology-based behavioural analysis helps create interventions that enhance audience compliance and reduce panic through behaviour modification (Vizor & Ramota, 2024). Finally, inclusive planning prioritizes accessibility, incorporating facilities for disabled attendees to ensure equitable and safe experiences for all participants (Ardh Kumbh Mela, n.d.). The modern direction in crowd management integrates data analytics with human-centred approaches to achieve safety goals and scalable solutions.

CASE STUDY: NAVRATRI 2025 AT KALKAJI TEMPLE

1. Context and Challenges

Situated in a densely populated urban enclave of Southeast Delhi, Kalkaji Temple encounters significant logistical and safety challenges during the Navratri festival, driven by an influx of over 100,000 devotees daily and constrained infrastructure. The temple operates nonstop 24x7, leading to dense crowds during increased surge periods. The temple's limited space for darshan inside the sanctum sanctorum, combined with limited accessible entry points, causes a bottleneck effect that restricts crowd movement and crowd flow. Ritual practices, such as diya lighting, tying of sacred threads, and prasad offerings within the sanctum, further contribute to congestion, slowing devotee movement, and intensifying pressure on the temple's core areas. Civic infrastructure shortfalls, including inadequate lighting, sanitation, and water facilities, undermine devotee comfort and enhance health risks. Additionally, the temple being located on

the outer ring road and in the vicinity of Nehru Place market and the famous tourist place Lotus Temple, there is an issue of regulating the high volume of vehicular movement, parking that disrupts traffic flow, and hinders emergency access, posing significant safety concerns. The tragic fatalities in 2024, attributed to electrocution, underscored the critical need for a comprehensive and proactive crowd management strategy to address these multifaceted challenges.

2. Strategic Interventions for Effective Crowd Management

The 2025 Navratri crowd management plan at Kalkaji temple is an action research case study of multifactorial best practice through spatial organization, use of smart technology, stakeholder synergy, meticulous pre-event and day-of-event planning, and robust supervision. These measures emphasized convergence of both the traditional and modern approaches to crowd management to ensure safety, operational efficiency, and an overall positive experience for devotees.

The following points outline what was done as best practices, demonstrating their critical role in achieving an incident-free event. The interventions prioritized safety, efficiency, and devotee experience, leveraging both traditional crowd control techniques and modern technological advancements to ensure seamless operations.

2.1. **Spatial Reconfiguration and Circulation Planning:** To alleviate congestion, four distinct entry and exit points were set up, including opening a new access route near NSIC Okhla Metro Station, aimed at decentralizing crowd inflow. The implementation of color-coded gates significantly improved navigational clarity, while zig-zag barricades and interim queue cut-off points (stop and go) effectively regulated crowd density and decelerated movement. Ritual activities, such as the lighting of diyas and the tying of sacred threads, were strategically relocated to peripheral zones. This relocation preserved the sanctum's capacity for darshan and minimized bottlenecks.

2.2. **Technological Integration:** Advanced surveillance systems were pivotal in this context. AI-enabled CCTV with headcount analytics provided real-time monitoring of crowd density, triggering alerts for high-risk zones. The use of QR-code-based VIP passes curtailed misuse, ensuring equitable access. Additionally, a WhatsApp group for stakeholders facilitated rapid incident reporting and response coordination.

2.3. **Advance Planning and Close Supervision:** Working closely with the Temple Management Committee helped in tackling potential challenges, fixing the issues faced during the last arrangement, seeking their support, and utilizing resources effectively. Joint surveys were conducted by BSES, traffic police, temple authorities, and the contractor to assess infrastructure needs like barricading, mojo barriers,

channelisers, CCTV coverage, lighting, and electrical safety. A new entry route was introduced near NSIC Okhla Metro Station to decongest and improve crowd circulation. Close supervision by senior officers, real-time CCTV monitoring, and whistle protocols during the event ensured a swift response to crowd movements and strict adherence to the plan.

2.4. **Devotee Facilitation Measures:** To enhance comfort and reduce anxiety, temporary amenities included toilets, water stations, desert coolers, and organized shoe stands. Regular public announcements and LED screens broadcasting live darshan kept devotees informed and engaged. Clear signage for facilities and exits improved accessibility, fostering a calm and orderly environment.

2.5. **Civic Infrastructure Enhancements:** A collaborative survey conducted with BSES identified deficiencies in illumination, leading to the installation of temporary lighting in inadequately lit areas. Electrical safety audits were performed to mitigate risks of fire and electrocution. In collaboration with the Municipal Corporation of Delhi (MCD), a no-hawker zone was enforced, and sanitation was maintained, ensuring a clean and safe environment.

2.6. **Seamless Multi-Stakeholder Communication and Coordination:** Effective crowd management was contingent upon seamless communication among diverse stakeholders, including the Delhi Police, the Temple Management Committee, civic bodies (MCD, PWD), BSES, fire services, and medical teams. A 24/7 multi-agency control room functioned as the operational hub, centralizing real-time decision-making and incident response. A dedicated WhatsApp group facilitated rapid information sharing, enabling stakeholders to address emerging issues, such as crowd surges or logistical bottlenecks, with agility. Pre-event coordination meetings with the Temple Management Committee ensured alignment on circulation plans, infrastructure upgrades, and safety protocols, fostering a unified approach that integrated religious, administrative, and public safety objectives.

2.7. **Detailed Deployment Plan with Intensive Staff Briefing:** A meticulously crafted deployment plan underpinned operational success, with sector-specific roles assigned to police officers, home guards, private security personnel, and temple sevadars. Each team was allocated clear area-wise (sectors) responsibilities to regulate crowd flow, manage queues, and ensure compliance with safety protocols. Intensive pre-event briefings equipped personnel with detailed operational guidelines, crowd psychology insights, and emergency response procedures, enhancing their preparedness

for dynamic scenarios. Training emphasized de-escalation techniques and effective communication with devotees, ensuring a calm and orderly environment throughout the nine-day festival.

2.8. **Safety and Contingency Planning:** A 24x7 multi-agency control room, centralized coordination among police, fire services, medical teams, and civic bodies. Fire tenders, ambulances, medical kiosks, and stretchers were strategically stationed. A mock drill on March 26, 2025, tested inter-agency readiness.

2.9. **Traffic and Perimeter Management:** A vehicle-free zone, dedicated pedestrian channeliser, and pathways around the temple ensured pedestrian safety, with designated parking lots connected to public transit. Additional traffic personnel managed diversions, and recovery vans cleared unauthorized vehicles, maintaining emergency access.

OUTCOMES OF THE INTERVENTIONS

The strategic interventions implemented during Navratri 2025 yielded measurable and transformative outcomes, demonstrating the efficacy of a coordinated, technology-driven approach. These results not only addressed the immediate safety concerns but also enhanced the overall spiritual and logistical experience for devotees, setting a benchmark for future mass gathering event management.

1. **Incident-Free Festival:** Not even a minor disruption was reported, a significant improvement over the 2024 incidents, reflecting robust risk mitigation and preparedness.
2. **Reduced Waiting Times:** The queues for darshan moved 30-40% faster than in previous years, thanks to optimized flow management and the relocation of rituals, which directly enhanced devotee satisfaction.
3. **Enhanced Accessibility and Comfort:** Feedback surveys indicated better access to amenities, clearer navigation, and a more comfortable environment, attributed to improved civic infrastructure and communication systems.
4. **Operational Efficiency:** The multi-agency control room and real-time communication via WhatsApp facilitated quick problem-solving, reducing operational delays.
5. **Scalable Best Practices:** The successful deployment of QR-code systems, analytical, and FRS-based CCTV surveillance validated their potential for wider use in managing high-density events.

LESSONS LEARNT

The 2025 Navratri event at Kalkaji Temple offered valuable insights into crowd management, providing practical lessons for law enforcement, policymakers, event planners, and researchers. These insights highlight the necessity of combining design, technology, and human factors to ensure safe and efficient large gatherings.

1. **Spatial Design as a Control Mechanism:** Implementing zig-zag barricades and peripheral ritual zones effectively controlled crowd density and movement, emphasizing the significance of physical infrastructure in influencing behaviour.

2. **Technology as a Force Multiplier:** AI-powered CCTV and QR code access systems minimized the need for manual supervision, allowing for precise monitoring and quick response, thereby improving operational scalability.
3. **Communication and Crowd Psychology:** Timely advisories, LED queue displays for darshan, and pre-recorded public announcements encouraged compliance and reduced anxiety, illustrating the psychological benefits of clear information dissemination.
4. **Community Engagement:** Temple sevadars and volunteers were instrumental in managing queues, fostering trust, and easing enforcement through community-led initiatives.
5. **Personnel Welfare:** Providing hydration, food & refreshment, rest breaks, and morale-boosting measures for staff ensured consistent performance, highlighting the importance of the human element in operational success.

FUTURE RECOMMENDATIONS

Building on the achievements of the 2025 Navratri framework, a forward-thinking agenda is proposed to institutionalize and expand these practices for future religious and public events. These recommendations aim to improve preparedness, utilize technology, and promote inclusive planning to ensure sustainable crowd management.

1. **Standard Operating Procedures (SOPs):** Develop and institutionalize comprehensive SOPs for religious gatherings, codifying best practices for replication across India.
2. **Advanced Technological Integration:** Expand the use of RFID tracking and crowd simulation software to enable real-time monitoring and predictive planning, enhancing proactive risk management.
3. **Behavioural Expertise:** Incorporate crowd psychologists and behavioural analysts in planning phases to design interventions that align with attendee psychology and reduce panic risks.
4. **Permanent Infrastructure Upgrades:** Invest in fixed entry/exit routes, additional civic amenities, and robust electrical systems to address recurring festival demands.
5. **Capacity-Building Programs:** Implement certified training modules for volunteers, police, and civic personnel, focusing on crowd psychology, emergency response, and communication skills.
6. **Structured Feedback Mechanisms:** Establish digital platforms and surveys to capture post-event feedback, enabling continuous improvement and stakeholder engagement.

CONCLUSION

The 2025 Navratri at Kalkaji Temple illustrates the effectiveness of anticipatory, technology-driven, and collaborative crowd management. By addressing spatial, logistical, and safety challenges, the framework ensured a safe and spiritually enriching experience for devotees. This case study provides a blueprint for managing high-density mass gathering, highlighting the synergy of technology innovation, community engagement, and disciplined execution.

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Retrospective Application of Victim Compensation in India

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ABSTRACT

In recent years, India has made significant strides in recognizing and upholding the rights of victims of crime. Victim compensation, a relatively modern concept in Indian jurisprudence, aims to provide financial assistance and rehabilitation to victims of grave offenses. However, a critical question has emerged: Can compensation schemes apply retrospectively, benefiting victims of crimes that occurred before such provisions were enacted or enforced? This article explores the retrospective application of victim compensation laws in India, the challenges involved, judicial interpretations, and the implications for justice.

Keywords: *Victim Compensation, Section 357A of CrPC, Section 396 of BNSS*

INTRODUCTION

The concept of victim compensation in India began taking shape with the introduction of Section 357A in the Code of Criminal Procedure (CrPC), through the 2008 amendment.[1] This provision required the state and central governments to formulate victim compensation schemes. As a result, each state now has its own compensation scheme to provide financial aid to victims of serious crimes, including acid attacks, rape, and custodial violence. Victim compensation in India aims to address the economic losses and psychological trauma caused by offenses, particularly in cases where the offender is unable to pay damages or remains unidentified.

However, many victims who seek compensation have survived crimes that occurred before the victim compensation scheme was established, leading to their denial of compensation. These deserving victims are often turned away due to the lack of clarity surrounding Section 357A of the CrPC, which creates ambiguity regarding eligibility for compensation claims based on the timing of the offenses.

RESEARCH METHODOLOGY

This article employs a doctrinal-analytical research methodology, focusing on the study and interpretation of primary legal sources. Key sources include statutory provisions such as Section 357A of the CrPC, the newly introduced Section 396 of the Bharatiya Nyaya Sanhita (BNSS), and relevant judicial pronouncements from the Supreme

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1 Code of Criminal Procedure (Amendment) Act, 2008 (Act No. 5 OF 2009), sec.357A

Court and High Courts pertaining to victim compensation. The research undertakes a critical examination of judicial interpretations regarding the retrospective application of victim compensation, analyzing the challenges involved, discernible trends in court rulings, and their broader implications. Patterns in rulings, implementation challenges, and insights from case studies are further examined to assess the practical effectiveness of compensation schemes in upholding the welfare, dignity, and rights of victims, thereby aligning legal analysis with the broader objective of achieving comprehensive and restorative justice.

CONCEPTUALISING THE TERM 'VICTIM'

The term *victim* occupies a central place in the discourse on compensation. Under Section 2(wa) of the Code of Criminal Procedure, 1973, a victim is defined as any person who has suffered loss or injury caused by an act or omission for which the accused has been charged, and this includes the guardian or legal heir of a victim who is deceased. This statutory definition reflects a shift in Indian criminal jurisprudence from an offender-centric model to one that acknowledges the rights and needs of those who suffer harm. At the international level, the United Nations Declaration of Basic Principles of Justice for Victims of Crime and Abuse of Power (1985) adopts a broader understanding by including those who suffer physical or mental harm, emotional suffering, economic loss, or impairment of fundamental rights. Together, these definitions underline that a victim is not merely a passive sufferer of crime but a rights-bearing individual entitled to protection, redress, and rehabilitation.

EVOLUTION OF VICTIM COMPENSATION IN INDIA

Victim Compensation Schemes in India are rooted in Section 357A of the Code of Criminal Procedure. This provision ensures that victims of crime receive financial assistance, regardless of the outcome of criminal proceedings. It does not impose additional criminal liability on the accused but enforces the State's obligation to deliver social justice, as mandated under Article 38 of the Constitution of India.[2]

The right to receive compensation is intrinsic to Article 21 of the Constitution, which guarantees the Right to Life.[3] This right encompasses the right to live with dignity, meaning that a person should not have to surrender their dignity simply because they have become a victim of a crime. Even if the accused is acquitted, it does not mean the crime did not occur, nor does it diminish the victim's need for support. Compensation remains essential to address the physical, emotional, and financial impact of the crime.

The uncertainty of legal proceedings often leaves victims vulnerable. Acquittals, though not uncommon, only indicate that the accused's guilt could not be established beyond reasonable doubt. They do not negate the fact that a crime took place. In such instances, it becomes the State's responsibility to provide financial and rehabilitative support to victims. This is particularly crucial for individuals from economically disadvantaged backgrounds, who may lack the resources to cope with the aftermath of severe crimes.

Victims of grievous offenses, such as acid attacks, require sustained medical care and rehabilitation. Their recovery involves complex

2. The Constitution of India, Art.38.
3. The Constitution of India, Art.21.

reconstructive surgeries, psychological counselling, and continuous social support to help them reintegrate into society. These processes demand time and significant financial resources, which are often beyond the reach of the victims or their families. The emotional trauma, coupled with the financial burden, can overwhelm survivors, making State intervention indispensable.

Section 357A of the CrPC empowers the government to implement schemes to assist such victims. Section 357B of the CrPC further mandates that compensation from the State under Section 357A is in addition to any fines imposed on offenders under specific sections of the Indian Penal Code, such as Section 326A for acid attacks and Section 376D for gang rape.[4] This ensures that victims are not solely dependent on criminal proceedings for financial relief.

These compensation schemes reflect the State's commitment to social justice by acknowledging the need to support victims through their recovery journey. The assistance provided is not limited to financial aid but also includes medical, psychological, and social rehabilitation. Through these measures, the State fulfills its duty to protect citizens and ensures that victims are not abandoned to bear the consequences of criminal acts alone. This framework not only upholds the dignity of survivors but also empowers them to rebuild their lives with hope and resilience.

A BRIEF OVERVIEW OF SECTION 357A

Section 357A of the Code of Criminal Procedure was introduced through an amendment in 2009, marking a significant shift in India's approach to victim compensation. It obligates every State government, in coordination with the Central Government, to prepare a scheme for providing funds for compensation to victims or their dependents who have suffered loss or injury as a result of a crime and who, due to the inadequacy of the legal framework, are unable to access proper restitution. This compensation is intended to cover medical expenses, rehabilitation, and even psychological support for victims, especially in cases of heinous crimes like acid attacks, rape, and other serious offenses.

A unique feature of this provision is that compensation under Section 357A can be awarded irrespective of whether the offender is convicted, acquitted, or if the crime remains unsolved. The courts, in consultation with the District Legal Services Authority (DLSA) or the State Legal Services Authority (SLSA), can recommend compensation based on the gravity of the crime and the economic condition of the victim.

Section 357 of the Code of Criminal Procedure, which pertains to the order to pay compensation, has been incorporated into Section 395 of the Bharatiya Nyaya Sanhita (BNSS)[5]. Additionally, Section 357A of the CrPC, which addresses victim compensation schemes, has been incorporated into Section 396 of the BNSS[6]. It is important to note that there are no changes in the provisions of these sections.

ROLE OF DLSA AND SLSA IN DISBURSEMENT OF VICTIM COMPENSATION

The disbursement of victim compensation in India under Section 357A of the Code of

4. The Criminal Law (Amendment) Act, 2013. (Act 13 of 2013).
5. The Bharatiya Nyaya Sanhita, 2023 (Act 45 of 2023), Sec.395
6. The Bharatiya Nyaya Sanhita, 2023 (Act 45 of 2023), Sec.396

Criminal Procedure, 1973, and the NALSA Compensation Scheme for Women Victims/ Survivors of Sexual Assault/Other Crimes, 2018, is primarily carried out through the State Legal Services Authorities (SLSAs) and the District Legal Services Authorities (DLSAs). These authorities ensure that compensation reaches victims promptly and effectively.

1. State Legal Services Authority (SLSA)

a. Monitors implementation by DLSAs and issues directions for uniformity and fairness.

b. Maintains and administers the Victim Compensation Fund at the state level.

c. Ensures proper budget allocation, fund utilization, and compliance reporting to NALSA.

d. The Secretary of the SLSA may, suo moto, or after preliminary verification, provide interim relief to victims at any time following the commission of the offense.

e. Victims can appeal against a DLSA order before the SLSA.

2. District Legal Services Authority (DLSA)

a. Receives applications for compensation directly from victims, dependents, or via police/court referral.

b. Conducts a preliminary inquiry, verifying FIRs, medical reports, and the extent of injury/loss.

c. Recommends the quantum of compensation based on case circumstances within the framework of the scheme.

d. Disburses interim relief immediately in urgent cases of medical care or rehabilitation, followed by final compensation.

e. Coordinates with hospitals, counselling centres, and rehabilitation agencies to ensure compensation translates into real support.

THE SIGNIFICANCE OF *NIPUN SAXENA V. UNION OF INDIA* (2018) IN VICTIM COMPENSATION

The Supreme Court's judgment in Nipun Saxena v. Union of India (2018) marked a watershed moment in strengthening the rights of victims of sexual offences and acid attacks. While the primary issue before the Court was the protection of the identity and privacy of victims, the Court went further to recognize that justice cannot be meaningful unless victims are adequately rehabilitated. In this context, the Court directed the National Legal Services Authority (NALSA) to frame a uniform set of model rules for victim compensation under Section 357A of the Code of Criminal Procedure.

Pursuant to this direction, NALSA introduced the "Compensation Scheme for Women Victims/ Survivors of Sexual Assault/Other Crimes, 2018", which has since served as the guiding framework for all States and Union Territories. The scheme standardized compensation across the country, prescribing minimum and maximum amounts for offences such as rape, gang rape, and acid attacks. For instance, acid attack survivors with disfigurement of the face are entitled to compensation between ₹7 to 8 lakhs, while rape survivors are entitled to a minimum of ₹4 lakh.

The importance of Nipun Saxena lies not only in its reinforcement of victim privacy but also in its recognition that compensation must be realistic, uniform, and adequate for rehabilitation. The judgment ensured that

compensation moved beyond tokenism, providing a structured basis for medical treatment, psychological counselling, and livelihood support. In doing so, the Court linked the idea of victim dignity with tangible state responsibility, embedding compensation as an integral part of restorative justice in India.

INTERPRETING THE LIMITATION PERIOD FOR VICTIM COMPENSATION

In the legal system, limitation periods serve as deadlines within which a person must exercise their legal rights. These periods are crucial for ensuring that legal claims are pursued diligently and that courts are not burdened with stale claims. However, while limitation periods are well-established in various domains of law, the CrPC does not explicitly mention a limitation period for claims under Section 357A. This ambiguity has led to different interpretations by courts and authorities regarding when and how a victim can approach the legal services authorities for compensation.

LEGAL IMPLICATIONS AND CHALLENGES OF THE RETROSPECTIVE APPLICATION OF COMPENSATION

Retrospective application of victim compensation raises key legal issues, including interpretation of statutes, judicial discretion, and adherence to constitutional rights under Articles 14 and 21.

There is often confusion surrounding the disbursement of victim compensation in cases where the crime or incident occurred prior to the implementation of the victim compensation scheme. This uncertainty arises from differing interpretations of whether victims can claim compensation for events that took place before the establishment of the scheme, leading to potential inconsistencies in the application of justice.

The core issue lies in the legal framework that governs victim compensation. Authorities may argue that such a move could strain public resources and create challenges in implementing the scheme effectively. Some argue that compensation should be available to all victims, regardless of when the crime occurred, as a matter of justice and equity, further believing that victims should not be penalized or denied support based on the timing of the crime in relation to the introduction of the compensation scheme.

Legal ambiguity, strict state-specific limitations, administrative delays, and inadequate awareness further complicate retrospective compensation. Most states do not permit compensation for crimes that occurred before the scheme's enactment, often denying such claims unless the High Court or Supreme Court intervenes. Even in cases where judicial intervention allows retrospective relief, victims frequently face bureaucratic delays, and many remain unaware of their entitlement.

JUDICIAL PRECEDENTS ON RETROSPECTIVE COMPENSATION

In the absence of a prescribed limitation period, judicial discretion plays a critical role in determining whether an application for compensation under Section 357A is allowed after a significant delay. Courts have generally adopted a liberal approach, recognizing that many victims, especially those from marginalized backgrounds, may face difficulties in accessing the legal system promptly. Issues such as trauma, medical

treatment, lack of awareness, and economic hardships often prevent victims from applying for compensation within a reasonable time.

1. Aarti Thakur vs. State of Maharashtra[7]

The Bombay High Court's Division Bench issued a significant order addressing the implementation of the Manodhairya Scheme for victim compensation. The court examined the government's decision to restrict the scheme's applicability to women victims of rape, sexual assault, and acid attacks occurring after a specific cut-off date.

The Manodhairya Scheme was introduced by the Maharashtra government in response to the Supreme Court's directives in Laxmi vs Union of India & Ors[8], which emphasized the need for adequate compensation and rehabilitation for acid attack survivors and other victims of grievous crimes. However, the Bombay High Court raised concerns about the scheme's cut-off date, which excluded victims whose suffering predated the specified period. The court observed that in the Laxmi case (Supra), the incident had occurred well before the scheme was framed. This, according to the court, revealed the irrationality of imposing a retrospective cut-off that would deprive victims like Laxmi and others from receiving much-needed support.

The court expressed the view that restricting benefits based on the date of the crime was arbitrary and contrary to the purpose of the scheme, which aimed to provide relief to all victims, regardless of when the crime occurred. The High Court stressed that the need for rehabilitation and financial aid does not diminish simply because the incident took place earlier. By excluding victims of earlier crimes, the policy was at odds with the Supreme Court's directions, which were intended to promote fairness and ensure adequate relief for all victims.

This decision underscored the importance of inclusive and equitable victim compensation schemes. Government initiatives must align with judicial principles of fairness and non-discrimination, ensuring that no victim is left out based on arbitrary timeframes. The court emphasized that the Manodhairya Scheme must fulfill its intended purpose of social justice by offering timely aid and rehabilitation to all deserving victims, past and present.

2. Piyali Dutta vs State of West Bengal and Others.[9]

The Hon'ble High Court of Calcutta emphasized in its observation that Section 357A of the Criminal Procedure Code (CrPC) is a progressive and beneficial piece of legislation intended to provide compensation and support to victims of crime. The court clarified that the provision was introduced to ensure that crime victims, regardless of when the offense occurred, are entitled to financial relief to aid their recovery and rehabilitation.

A key point the court stressed is that Section 357A acts as a time-neutral provision, meaning that it does not differentiate between incidents that happened before

7. Civil Writ Petition. No.4267 of 2014 in the High Court of Judicature of Bombay.
8. (2014) 4 SCC 427
9. (2017 Cr.LJ 4041)

or after the introduction of the section. As such, a victim of a crime that occurred before the section was enacted is equally entitled to benefit from it, just as much as someone whose victimization took place after the section came into effect.

This interpretation by the Calcutta High Court demonstrates a victim-centric approach, highlighting that the justice system must prioritize the rights and needs of victims, regardless of procedural technicalities or the timing of the offense. The absence of a statutory time limit reflects the understanding that the harm suffered by victims often has long-term consequences, requiring sustained financial support for medical treatment, rehabilitation, or psychological recovery, even if the crime occurred years earlier.

By holding that Section 357A is not constrained by temporal limitations, the court ensures that justice is not denied due to bureaucratic formalities or outdated legal frameworks. It serves as a reminder that the law intends to provide meaningful relief to all victims, acknowledging the ongoing impacts of crime and the importance of compensation in restoring dignity and security to those affected.

3. Gulnaz Khan vs State of Uttarakhand and Others.[10]

The Hon'ble High Court of Uttarakhand, in its order dated 16th December 2022, held that although the acid attack incident occurred on 29th November 2014, the cause of action continued well beyond that date. The court recognized that the impact of the acid attack was not limited to the day of the incident but persisted over several years, as the victim required multiple reconstructive surgeries for her face, ear, and other body parts, alongside extensive medical procedures and treatments.

The court emphasized that since the victim's recovery journey was ongoing as of 2nd October 2018, the compensation scheme applicable in 2018 could be invoked to provide relief. This approach acknowledged the long-lasting nature of acid attack injuries and the recurring medical expenses that victims often face. Accordingly, the court awarded the victim an amount of ₹35,00,000 (Thirty-Five Lakhs) as compensation.

This decision reflects the court's progressive stance in considering the prolonged suffering and continuous medical needs of acid attack survivors. It highlights the judiciary's awareness that compensation frameworks must account for both immediate and future challenges, including surgeries, rehabilitation, and psychological care, ensuring that victims receive adequate and timely support over the course of their recovery.

4. Kavita Nityanand Shetty vs. State of Maharashtra[11]

In this case, Kavita Nityanand Shetty sought compensation under the Manodhairya Scheme for burn injuries inflicted by her husband as she was attacked with a boiling corrosive substance, causing severe burns (70-80%) on her face and body.

The State of Maharashtra argued that her case was not eligible for benefits under the Manodhairya Scheme, as the attack took

10. Writ Petition (MS) No.26 of 2019 Before the Hon'ble High Court of Uttarakhand.

11. Writ Petition (ST.) No. 6115 of 2021 Before the Hon'ble High Court of Judicature at Bombay.

place before the scheme's implementation. However, the Bombay High Court found the state's stance problematic, emphasizing that such technical cut-off dates should not deprive deserving victims of essential compensation. The court stressed that victims of violent assaults requiring rehabilitation should be treated equally, whether the incident involved acid or other corrosive substances.

Considering the statutory mandates under Section 357A of the CrPC and relevant schemes, the court directed the State to compensate the petitioner with ₹10,00,000, of which 75% would be placed in a fixed deposit and 25% given to her for immediate needs. The court also instructed the District Legal Services Authority to provide legal assistance, to ensure free medical treatment, and to ensure all rehabilitative measures are made available to the petitioner.

5. District Collector, Alappuzha v. District Legal Services Authority (DLSA) & Others[12]

The Kerala High Court considered the question of whether Section 357A(4) of the Code of Criminal Procedure (Cr.P.C.), which allows victims to claim compensation, could be applied to crimes that occurred before the provision's enactment on December 31, 2009.

In this case, respondents, legal heirs of a deceased individual named Sivadas, sought compensation after he died in an accident in 2008. The accused was unidentified, and the case did not proceed to trial. In 2013, the respondents applied for compensation from the State under Section 357A(4) Cr.P.C. After an inquiry, the District Legal Services Authority (DLSA) ordered the State to pay Rs. 3,03,000 in compensation.

The State, represented by the District Collector, argued against this order, asserting that Section 357A(4) could not apply retrospectively to events predating its 2009 enactment.

They contended that doing so would be against statutory norms and would impose an unfair financial burden on the government.

The respondents argued that Section 357A(4) was a remedial and beneficial provision, intended to support crime victims. They contended it should apply retroactively to provide justice to victims regardless of when the crime occurred.

Justice Bechu Kurian Thomas observed that Section 357A was introduced as a welfare measure to ensure crime victims' rehabilitation and was remedial in nature. He emphasized that remedial laws, even if substantive, can have a "prospective benefit" based on past facts without violating principles against retrospectivity. Therefore, Section 357A(4) could be applied to past incidents without making the provision retrospectively enforceable.

The court held that Section 357A(4) Cr.P.C. allows victims to claim compensation for crimes occurring before its enactment, giving victims a prospective right to seek redress based on past events. The writ petition was dismissed, upholding the compensation order, and it was emphasized that beneficial legislation should be interpreted to support the welfare of victims, not deny it.

12. Writ Petition Civil No. 7250 of 2014 Before the Hon'ble High Court of Kerala.

CONCLUSION

The retrospective application of victim compensation schemes in India reflects an evolving justice system that prioritizes the welfare and dignity of victims. It is not merely a policy choice but a constitutional, moral, and practical imperative, ensuring that justice is not denied based on the timing of the crime. The effectiveness of victim compensation as a restorative justice tool is significantly diminished if it arbitrarily excludes past victims. A forward-looking justice system must paradoxically look backward to ensure comprehensive justice and healing for all victims of crime. The timely intervention by the courts through judicial dicta has played a pivotal role in bridging legislative gaps, enabling many victims to receive the compensation they need, regardless of when the offense occurred.

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Ergonomical and Occupational Health Problems amongst Police Personnel: A Review of Health Implications



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ABSTRACT

The role of police personnel is inherently psychologically taxing, as it necessitates the enforcement of law, order, and justice. The nature of their duties is linked to various occupational health issues, both physical and mental. Prolonged exposure to outdoor conditions can lead to heat stress, respiratory issues, musculoskeletal disorders, metabolic disturbances, and cardiovascular concerns. Additionally, extended working hours during unconventional times contribute to psychological stress, depression, and other related challenges. This review aims to investigate the work-related health risks encountered by police personnel worldwide due to the demands of their profession. The findings indicate that police personnel exhibit reduced lung function, heightened hearing loss, increased musculoskeletal issues, and other physiological and psychological stressors when compared to civilians. Factors such as age, length of exposure, and work environment significantly influence these outcomes. This study provides valuable insights for administrators and researchers to address the practical challenges faced in this profession.

Keywords: *Police Job, Occupational Stress, Occupational stressors, Physiological Problems, Social problems*

INTRODUCTION

The ultimate goal of law and justice extends beyond crime prevention to maintaining critical societal parameters such as safety, security, and overall well-being. The evolution of the police system runs parallel to the development of the state (Sharma et al., 2018). In a welfare state, policing is expected to be both citizen-friendly and service-oriented (Kumar et al., 2017).

However, the role of police personnel is highly demanding and stressful. Officers face significant physiological (e.g., prolonged standing, poor posture), physical (e.g., harsh environmental conditions, inadequate logistics), and psychological (e.g., irregular working hours, anxiety, depression) stressors. In some cases, even basic necessities such as access to healthy food, drinking water, and

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proper sanitation are inadequate (Korde et al., 2017).

Occupational stressors are among the key determinants of health. Understanding their impact on police personnel is crucial for assessing workplace hazards and their effects on overall well-being. This review aims to define and conduct a precise risk assessment to identify potential solutions that can alleviate occupational health challenges and make policing a less stressful profession.

METHODOLOGY

This review is based on a comprehensive literature survey using PubMed, Scopus, DOAJ, ScienceDirect, and peer-reviewed journals published between 1989 and 2018. The search included keywords such as "police and occupational diseases," "occupational hazards in police work," "occupational health and safety," "police work-related injuries," and "stress and workplace injuries in law enforcement."

From the databases searched, 160 research papers were identified. Among these, 92 full-text studies were directly related to occupational health issues among police personnel and were included in this review.

- **Health predicaments due to occupational exposure**

  Risks of occupational problems in traffic cops were compared to those of civilians. As per their working requirement, they have to perform their duties in a completely open environment, which exposes them to different types of stressors, like vehicular emissions of fumes, heat exposure, noisy and polluted environment. They also face a huge amount of mental stress because of controlling a large amount of traffic volume. Standing for a long time in a static position or riding a bike for a very long time leads to musculoskeletal problems. Physical and mental health manifestations get accentuated with increased duration of service (Satapathy et al., 2009). Exposure to a high volume of vehicular noise for a long time can cause hearing impairment as well as an increase in mental stress. Exposure to microwave radiation of responding devices, such as walkie-talkies, results in severe damage to tissues, which in turn may lead to cancer (Lotz et al., 1995).

- **Studies on Pulmonary Health**

  Air pollutants and traffic fumes are major causes that affect the respiratory health of traffic cops. Vehicular exhaust contains a variety of pollutants, which include carbon monoxide (CO), Carbon-di-oxide (CO2), Sulphur-dioxide (SO2), nitrogen dioxide (NO2), and major determinants as particulate matter 2.5 (PM2.5), Particulate matter 10 (PM10), ozone etc. which causes respiratory problems and other severe diseases including cancer (Anderson et al., 2004). Polyaromatic hydrocarbons like benzene and toluene are carcinogenic as well as genotoxic(Suglia et al., 2008).

  The majority of studies on abnormal pulmonary function among traffic police were performed in different areas of India as well as in other countries. Pulmonary function tests were performed by Vitalograph or a digital spirometer. It is found that traffic police constables belong to a higher risk group of the population who are likely to develop respiratory dysfunctions (Thippanna et al., 1999). Some studies found significant variation in Peak Expiratory Flow Rate (PEFR), Forced Expiratory Volume in 1stsec (FEV1), and Forced Vital Capacity (FVC) of the traffic

police against the controlled group of population (Singh et al., 2009). Similar studies, but with improved methods, were performed, where no consistent trend of decreased pulmonary function was found in them (Ingle et al., 2005; Bluhm et al., 2004).

Research on smoking and non-smoking traffic cops revealed reduced Forced Expiratory Volume in 1st sec (FEV1) and other prominent respiratory symptoms. They also found a significant difference in FEV1 data, after the exclusion of smokers, with the non-smoking subjects who were exposed as compared to those who were not (Ingle et al., 2005; Pal et al., 2010). Pulmonary Function Test is a significant way to detect respiratory abnormalities. Decrease in VC, FEV1, PEF, MVV, FEF-25, and PIF may be due to exposure to vehicular pollution for several hours in a day for many years, resulting in decreased Functional Capacity of the lungs. Chronic smoking worsens the condition (Sayyad et al., 2013; Srestha et al., 2015; Maddur et al., 2016).

Case studies performed to investigate the impact of vehicular emissions for long-term exposure have revealed increased levels of pro-inflammatory cytokines and chemokines in plasma, cytological changes suggesting inflammation in airways, altered immunity, and moreover increase in oxidative damage and increased chromosomal breakage and DNA damage. Chronic exposure to vehicular pollution reduces lung function, increases blood pressure, suppresses immunity, and enhances the risk of developing lung cancer(Cattaneo et al., 2010; Saenghirunvattana et al., 1995; Ray et al., 2010).

Among various air pollutants, PM 2.5 and 10 are found to be associated with decreased conditions of respiratory and cardiovascular health of traffic police, leading to death (Kumar et al., 2010; Samet et al., 2000).

- **Study on Musculoskeletal Problems**

  Musculoskeletal symptoms (MSS) are defined as any trouble (ache, pain, or discomfort) in nine topographic regions of the body (Paudel et al., 2018). The work-related musculoskeletal disorders (WRMSDs) describe a wide range of inflammatory and degenerative disease conditions that result in pain and functional impairment affecting the neck, shoulders, elbows, wrists, and hands (Phadke et al., 2015).

  Traffic police personnel are one of the most vulnerable groups with respect to physical and physiological conditions, and the risk factors they deal with lead to WRMSS, like age, working hours, work experience in the field (years), etc., leading them to sickness, absenteeism, and ultimately a reduction in productivity. (Phadke et al., 2015).

  Pain has a mechanical origin and occurs when the joint between two bones has been placed in a position that overstretches the surrounding soft tissues. This is true for mechanical low back pain in any joints of the body, including the spine (McKenzie, 1995). Riding bikes and driving cars involve prolonged sitting. Sitting in a fixed posture and vibration can cause musculoskeletal trouble (Gyi & Porter, 1998).

  The results of some studies reveal that the most common musculoskeletal symptoms among local police officers are cervico-brachial pain, low back pain, and sciatica (Centemeri et al., 2005). Among work-

related musculoskeletal disorders, low back pain was found mostly in the common body region (Rufai et al., 2019; Heliovaara et al., 1989).

Different studies on musculoskeletal health problems of Traffic Police Personnel are being summarized in the table below, which shows the effects of posture-related problems among them:

Table 1: ***Musculoskeletal problems in Police Personnel***

S. N.	Source	Year	Area of Study	Study participants	Study variables	Study outcomes
1	Phadke et al.	2015	Navi Mumbai, India	270 traffic police	i. Work-related musculoskeletal problems	Back pain was found to be the most common symptom. Chronic pain in the lower back 38%, upper back 36%, reason to cause activity loss due to pain in the lower back 16%, upper back 15% and neck 14%
2	Phadke et al.	2014	Navi Mumbai, India	Traffic policemen	i. Assessment of obesity ii. Assessment of lumbar curvature angle with Flexi curve	Most police officers were found to be overweight; the most common obesity is android type. Most have high fat percentage and altered lumbar curvature.
3	Diyana et al.	2017	Malaysia	Traffic police force	i. Vibration exposure ii. Work-related exposure	Police riders have a high incidence of WMSDs, which, in combination with exposure to vibrations, prolonged sitting, and static posture, increase their susceptibility to WMSD.
4	Cho et al.	2014	Korea	353 police officers, who visited the National Police Hospital from March 2013 to May 2013	i. Musculoskeletal symptoms	The shoulder had a 4.87 times higher risk in police lieutenants than in corporals, 1.78 times higher risk in people with chronic diseases than those without chronic diseases. The arm/elbow had a 2.37 times higher risk in people who exercised than those who did not exercise, and a 1.78 times higher risk in people with a chronic disease than without chronic diseases.

- **Study on Metabolic and Cardiovascular Disorders**

  NCEP (National Cholesterol Education Program) defined the metabolic syndrome as having 3 or more of the following 5 cardiovascular risk factors: 1) central obesity, 2) elevated triglycerides, 3) diminished high-density lipoprotein (HDL) cholesterol, 4) systemic hypertension, and 5) elevated fasting glucose(Mottillo et al. 2010). Analysis of different studies indicates that there is a lack of sufficient information in support of it, in respect of which it can be declared as a syndrome (Kahn et al., 2005). Work stress leads to headaches, heart attacks, and high blood pressure in police officers. Chronic exposure to critical incidents such as high responsibility, heavy workload, contact with criminals, and irregular duty hours may adversely affect sleep quality and health. Metabolic syndrome diagnosis performed by researchers shows a correlation between blood pressure and triglycerides. It was also found that due to enormous stress and high-pressure pressure police personnel do not take a healthy diet and exercise regularly, as a result of which the BMI of the police population is found to be significantly higher (Saha et al., 2010).

  Metabolic Syndrome is a cluster of anthropological and biochemical abnormalities that predispose individuals to coronary disease(Grundy et al. 2004). Policing is a hectic job, but being an essential service, it needs to be provided without interruption. As a result, police personnel need to work continuously, creating shift and night work schedules (Brum et al., 2015& Saha et al., 2008).

  Recent findings of the effects of changes in shifts suggest that such schedules may affect glucose tolerance and induce obesity and systemic arterial hypertension (Karlsson et al., 2001; Bacquer D et al., 2009). The study performed in the US shows that employment as a law enforcement officer is associated with increased cardiovascular disease morbidity, and this relationship persists with several conventional risk factors (Franke, 1998).

  Physiological fitness is an important factor related to stress. Obesity and mental exertion create a significant effect on stress factors as well as increased cardiovascular stress (Saha, 2015). Researchers found a significant correlation between increased cardiovascular risk factors and increased stress in police officers (Saha et al., 2010). As the work is very stressful in nature, it requires extreme skill besides muscular force and strength, thus requiring more cardiac efficiency (Durlov& Sahu, 2015).

Different studies on metabolic and cardiovascular health problems of Traffic Police Personnel are summarized in the table below.

Table 2: ***Summary of Assessed studies on metabolic and Cardiovascular disorders and their effects on Police Personnel***

S. N.	Source	Year	Area of Study	Study participants	Study variables	Study outcomes
1	Thyyil et al.	2012	Calicut, Kerala	960 police personnel	i). Dietary history ii). Personal habits and addiction iii). Blood pressure iv). Anthropometric parameters v). Morbidity history	5.8% found hypertensive 48% in pre-hypertensive stage 41.4% in hypertensive range 75.2% have abnormal lipid profiles 13.7% have high blood glucose
2	Saha.	2016	West Bengal	159 male police officers and 21 female officers	i). Demographics and occupational characteristics ii). Physical health status iii). Different stress levels	Stress perceived in police officers who have been in service for 11 to 20 years.
3	Biggam et al.	2007	Scotland	699 police officers	i). Symptoms of anxiety ii). Somatic complaint iii). Severe depression iv). Social dysfunction	Police officers perceiving stress due to staff shortages, inadequate resources, time pressures, lack of communication and work overload
4	Esposito et al.	2012	Globally	Patients with metabolic syndrome	i). Metabolic syndrome ii). Cancer risk	Metabolic syndromes are associated with increased risk of common cancers; for some cancers, the risk differs between sexes, populations, and definitions of metabolic syndrome

- **Study on Occupational Stress:**

  Occupational stress is a mismatch between the role to be played and the performance; the outcome of which is the source of various stressors (Gorsy et al., 2017). Stress is associated with various work stressors, like physical, physiological, heat, and other stressors, which are mentioned previously, such as cardiovascular and metabolic. Heat and humidity not only affect human physiology but also reduce work productivity, which

in turn condenses the world's economic productivity and particularly affects the developing countries lying in the tropical climate zone(Sett & Sahu, 2014).

The impact of stress on the mental and physical health of police personnel is not adequately addressed by the concerned authorities, scientists, and health professionals in India. Operational stress is associated with doing the job, and organizational stress is associated with the organizational culture within which the job is performed by both male and female police officers (McCreary et al., 2006).

Policing is a profession riddled with severe stress, and the failure of police personnel to deal with high-pressure situations affects their work performance (Chapman, 2009). In India, a survey concludes that work overload is the second-highest job-related stressor. Findings on the stress scale response study have been corroborated by the findings of the qualitative analysis, where 90% of inspectors work for long duty hours with a high level of accountability (Singh et al., 2015).

- **Studies on Change in the shift**

  Shift work has its own demands that set it apart from jobs with traditional working hours. Shift work has its benefits as well as problems. Changing of shift is one of the powerful stressors, which affects not only physiological aspects but also creates some psychological problems in them(Saha et al., 2012). Police personnel, most of the time, have a prolonged duty period. Also, they have to perform day and night duties in shifts(Saha et al., 2014).

  There is some evidence that shift work leads to numerous adverse health outcomes, including risk factors for cardiovascular disease, metabolic syndrome, diabetes, specific types of cancer, fatigue, on-duty injury, and autoimmune hypothyroidism (Fekedulegn et al., 2017).

- **Psychological Stress Problems**

  Physiological function and health conditions of human beings are impaired by different stressors, which affect their work capacity and productivity. The stress associated with police work is quite inimitable and has many negative consequences. Stressors are being manifested in forms of depression, fatigue, inability to concentrate, irritability, anxiety, regression, arousal, and impulsive behavior (Nathawat, 2016). The role of policemen involves many challenges, such as encounters, immediate decision making, and so on, so it is defined as a high-stress occupation (Band &Manule, 1987). Some preliminary observations had been made, but not collectively on stress factors. Studies have been performed on Emotional Intelligence (EI) competencies on stress, which showed positive correlations (Gardner, 2005; Spector & Goh, 2001). Some researchers did not find any significant correlation between hardiness and stress (Bartone, 1984). Physical threat/force, exposure to danger, facing the unknown, and immediate decision making are the potential psychological stressors (Biggam et al., 1997). Researchers found that most salient stressors are organizational factors (Coman &evans, 1991) and some of them selected direct sources of stressors are being 'second-guessed' in fieldwork, punishment for 'minor' infractions, lack of reward for a job well done, fear of being 'scold' and lack of support from higher authorities (Amaranto et al., 2003). In India, socio-psychological studies and surveys on "police stress" have been largely focused on experiences

of job stress, job satisfaction, and the impact of geographic and cultural variation on occupational stress among police personnel (Joseph et al., 2014). An increased level of mental stress arises due to occupational requirements, resulting in increased risk of cardiovascular as well as respiratory, and psychological diseases (Saha et al., 2014; Saha et al., 2016).

There were some conflicting results brought forward by a number of researches. Some of them couldn't find any indication of more prevalent self-reported mental health disturbances in police officers than normal people (Valden et al., 2013), whereas some other studies offered conceptual ideas on empirical associations between stressful workplace exposures & their impact on mental and physical health problems in police officers (Violanti et al., 2017).

Different studies on different psychological health problems of Traffic Police Personnel are being summarized in the table below: -

Table 3: ***Summary of Assessed studies on Psychological stress of Police Personnel***

S N.	Source	Year	Area of Study	Study participants	Study variables	Study outcomes
1	McCreary et al.	2006	Canada	Police officers	Stress	Developed and validated 2 types of questionnaires, Operational and Organizational (PSQ-Op) & (PSQ-Org)
2	Collins & Gibbs	2003	United Kingdom	1206 Police officers	Home and work-related stressors	Found some organizational issues as stressors, lack of concentration, and communication
3	Kaur et al.	2013	Vizianagram town, Andhra Pradesh, India	150 Police personnel	Psychological stress, personality traits, and coping methods	Personality traits and coping methods have been found significant independent and interactive role in the development of psychological stress
4	Bano et al.	2011	Aligarh, Uttar Pradesh, India	65 policemen	i). Socio-demographic details ii). Working condition iii). Non-cooperation iv). Political pressure	i). Political pressure, lack of time for family, negative public image and low salary are the primary causes of stress. ii). Age, education level, work experience have significant association with increasing stress.

S N.	Source	Year	Area of Study	Study participants	Study variables	Study outcomes
					v). Lack of time for family vi). Lack of Govt. Support vii). Torture of senior officers viii). Irregular and long working hours etc.	iii). Regular organizing training program, yoga and counseling were suggested.

CONCLUSION:

Traffic police personnel face significant physical, physiological, and psychological health risks due to their demanding job. Prolonged exposure to vehicular pollution increases their risk of respiratory diseases and potential genetic alterations. Standing for long hours and repetitive movements contribute to musculoskeletal disorders, particularly in the back, neck, and shoulders, worsened by obesity and constant bike vibrations. Irregular eating habits lead to digestive and metabolic issues, while occupational stressors—such as long duty hours, lack of resources, and erratic shifts—disrupt their biological clock, increasing the risk of cardiovascular diseases. Psychological stress from political pressure, negative public perception, and work-life imbalance further impacts their overall well-being. Despite numerous studies highlighting these issues, effective preventive measures and policy interventions remain insufficient, necessitating further research and systemic reforms.

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INNOVATIONS IN POLICING

GUJARAT POLICE INDUCTS HIGH-TECH UNDERWATER ROVs FOR CRIME AND RESCUE OPERATIONS

The Gujarat Police have significantly enhanced their underwater search and surveillance capabilities with the induction of innovative Deep Tracker Remotely Operated Vehicles (ROVs). These portable machines can dive up to 200 metres and lift weights of up to 100 kg, enabling efficient evidence recovery and maritime operations. Equipped with



ultra-high-definition 4K cameras, powerful 2000-lumen lights, and advanced multi-beam SONAR systems, the ROVs provide crystal-clear visuals and precise navigation even in murky waters. Each unit also features a 360-degree grabber arm for retrieving heavy objects. These systems are designed for underwater evidence recovery, surveillance, crime scene documentation, and post-crime videography. Their operational value was demonstrated during rescue operations following the Gamira Bridge accident near Padra in Vadodara district, where a trained police team successfully located submerged vehicles and retrieved key evidence using the Deep Tracker.

ODISHA POLICE: ENHANCING COUNTER-TERRORISM OPERATIONS WITH SURVEILLANCE BALL CAMERAS

Odisha Police has introduced throwable surveillance ball cameras to strengthen counter-terrorism and anti-Maoist operations. These innovative devices provide real-time 360° views of hazardous or confined areas, allowing officers to assess threats remotely and minimize risks to personnel. Equipped with two-way communication, they also enable interaction with hostages during rescue missions, enhancing situational awareness and response efficiency. In addition, the force plans to procure thermal night sights for sniper rifles to support operations in dense forests and hilly terrains, ensuring better visibility in low-light conditions. Together, these technological upgrades mark a major step toward modernizing Odisha Police's tactical and surveillance capabilities.

ODISHA POLICE USES DATA ANALYTICS TO REDUCE ROAD FATALITIES IN MINING DISTRICTS

To address rising road accidents in Odisha's most accident-prone mining districts (Sundargarh and Keonjhar), the police launched a pilot project integrating data analytics with targeted enforcement and rapid response. Using the Integrated Road Accident Database (iRAD), three years of data were analyzed to identify patterns by time, location,



and cause. Hotspots such as sharp turns, lateral entries, and weekly markets were found especially vulnerable due to overspeeding, pedestrian movement, and drunken driving. Enforcement was accordingly strengthened, highway patrolling intensified, patrol vehicles stationed at hotspots, and market-day traffic closely managed. As a result, fatalities fell sharply: Rourkela recorded 17 deaths in July 2024 versus 12 in July 2025; Sundargarh, 18 to 9; and Keonjhar, 21 to 8.

UTTAR PRADESH POLICE: MISSION SHAKTI EMPOWERS WOMEN THROUGH AI-DRIVEN LEGAL ACCESS

Under the state's Mission Shakti initiative, Uttar Pradesh Police has launched NyaySanhita.in, an AI-powered platform designed to simplify access to justice and enhance legal awareness, particularly among women. The tool enables users to describe incidents in Hindi or English and instantly identifies relevant legal sections with explanations and links to the updated criminal codes- Bharatiya Nyaya Sanhita, Bharatiya Nagarik Suraksha Sanhita, and Bharatiya Sakshya Adhiniyam. By integrating artificial intelligence with legal processes, this innovation strengthens citizens' understanding of their rights, minimizes procedural errors, and supports both police and legal professionals in ensuring faster and more transparent justice delivery.

GEO-TAGGING OF CRIMINALS LAUNCHED IN NAGPUR TO ENHANCE SURVEILLANCE

In a major step towards tech-driven policing, Nagpur Police have geo-tagged over 1,500 known offenders and their residences, complete with latitude, longitude, and timestamp details, to enable real-time monitoring of their movements. The initiative leverages the Smart E-Beat System app, allowing beat marshals to record live presence of criminals through geotagged images and timestamps. Data collected through the app will soon be integrated with the Simba App and citywide CCTV networks for seamless tracking. Currently operational in North Nagpur's Zone V, the system aims to cover 5,000 offenders under daily watch by 1,903 beat marshals. According to senior police officers, the initiative enhances accountability and acts as a deterrent by keeping repeat offenders under continuous scrutiny.

PUNE POLICE INTRODUCES WEB-BASED BREATH ANALYSERS FOR REAL-TIME DRUNK DRIVING ENFORCEMENT

The Pune City Traffic Police have introduced web-based breath analyser machines to strengthen enforcement against drunk driving. These internet-connected devices enable senior officers to supervise field operations in real time from a central control room, ensuring transparency and accountability. When a driver is tested, the machine automatically transmits the result; positive or negative, to the control room, where it is recorded for action. If a positive reading is detected, a digital receipt is generated, and enforcement action follows immediately. This connectivity



also allows officers to operate the machines anywhere in the city under live supervision. Senior officers can monitor each field operation, review actions taken, and seek explanations if enforcement lapses occur. According to the Additional Commissioner, the system enhances operational efficiency, deters negligence, and ensures consistent action against offenders through transparent, technology-driven monitoring.

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Note for Contributors

The Indian Police Journal (IPJ) is the oldest Police Journal of the country, being published since 1954. A flagship Journal of the Bureau of Police Research and Development (BPR&D), MHA, it is published on a half yearly basis.

The IPJ is peer reviewed and features various matters and subjects relating to policing, internal security, police reforms, good practices and allied subjects. Over the years it has evolved as an academic journal of the Indian Police, providing critical inputs to stakeholders. It is circulated through hard copy and is also available on the BPR&D website https://bprd.nic.in/

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Interested author/s may note that the following criteria are mandatory for papers/articles–

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- The topic should be related to police and security subjects, as outlined above.
- The paper/article should be original and should not have been published anywhere else previously.
- A brief about the author/s and passport photo/s of the author/s should also be submitted.
- The paper/article can be submitted via email to:
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