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Professor (Additional)

Department of Forensic Medicine & Toxicology,

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Associate Editors

Dr Sadanand Bhise

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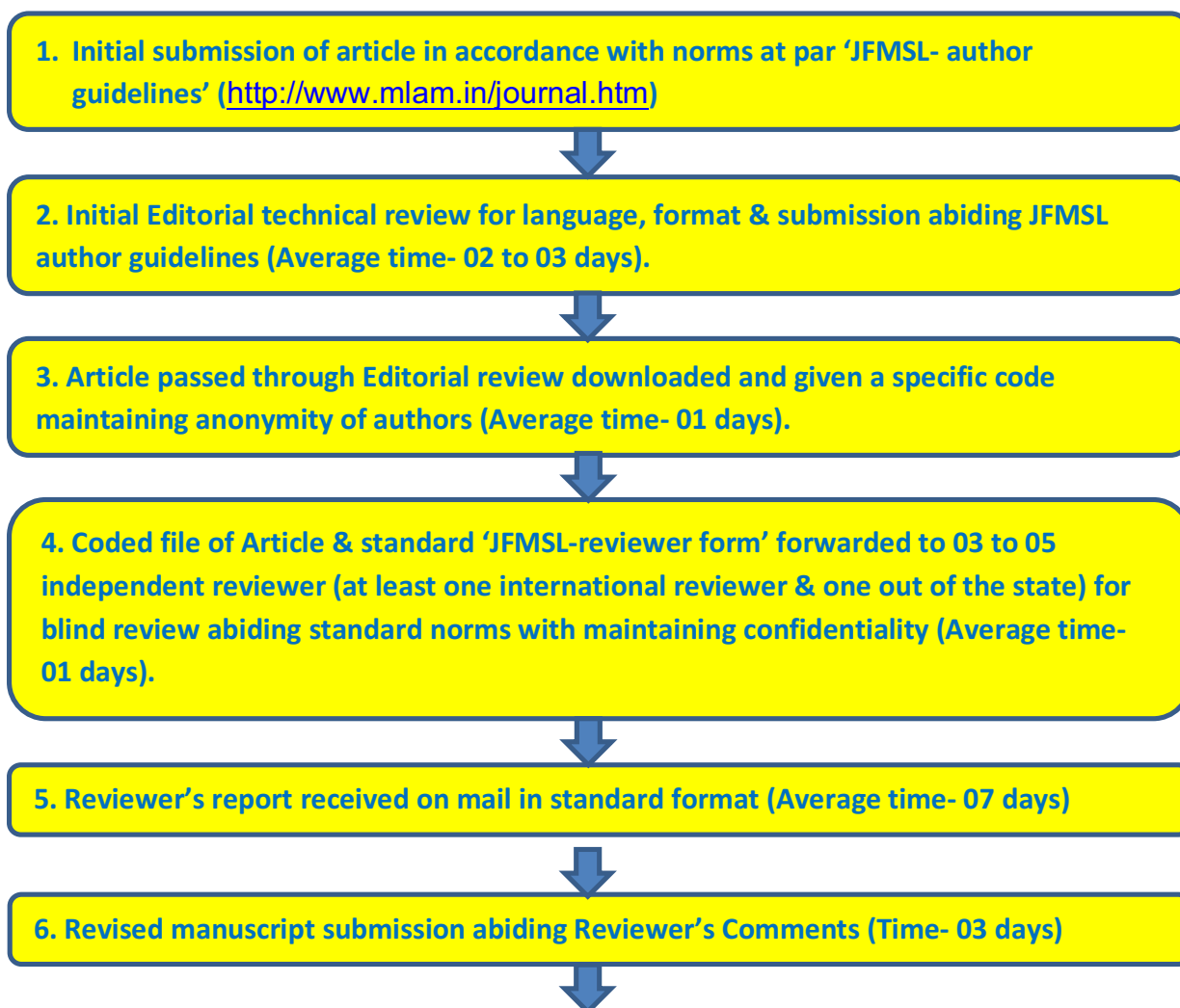
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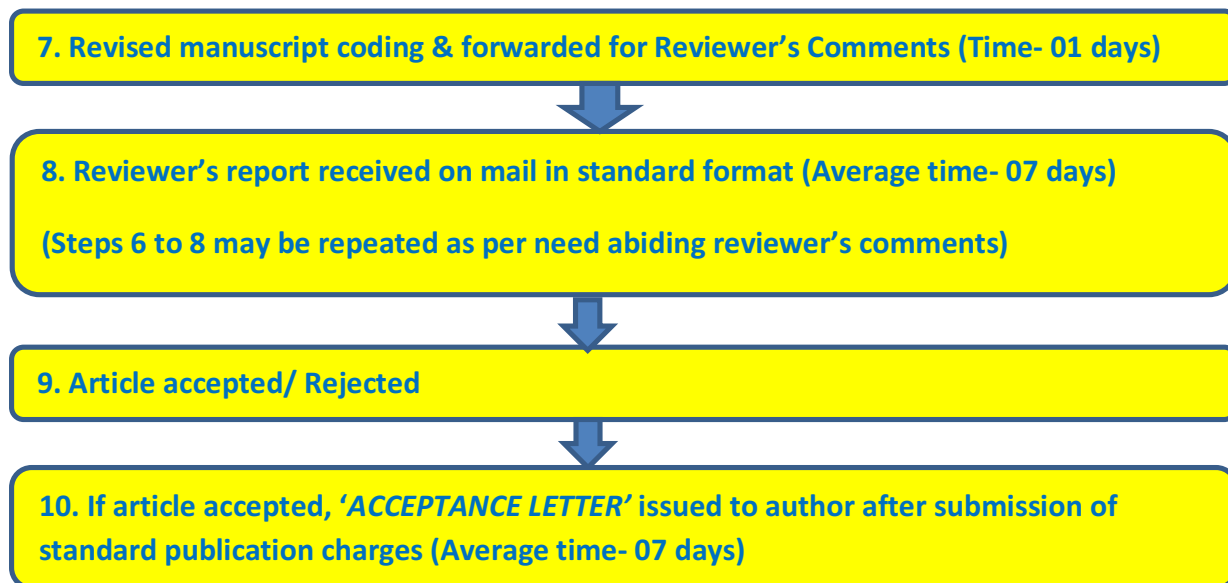
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#	First name and Last name	Affiliation	Country	Email
17	Dr Manish Shrigiriwar	Professor & Head, Department of Forensic Medicine & Toxicology, AIIMS, Nagpur, Maharashtra.	India	drmanishshrigiriwar@aiimsnagpur.edu.in
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39	Dr Pawan Sable	Professor (Additional), Department of Forensic Medicine & Toxicology, TNMC, Mumbai, Maharashtra.	India	25.pawan@gmail.com
40	Dr Ganesh Niturkar	Associate Professor, Department of Forensic Medicine & Toxicology, GMC, Aurangabad, Maharashtra.	India	niturkarg@gmail.com
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64	Dr Sandeep R Biraris	Orthopaedic Centre of the West 2122 East Highland Ave Ste 100 Phoenix, AZ 85016 USA	US	sandeepb143@yahoo.com
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66	Shashank S. Shettar	University of Oklahoma Health Sciences Center, Oklahoma City, Oklahoma, Country: USA.	US	ShashankShashank-Shettar@ouhsc.edu
67	Dr Abhishek Parashar	Lecturer, Department of Forensic Medicine, Maharajgunj Medical Campus, Institute of Medicine, Kathmandu, Nepal.	Nepal	drabhishekiparashar@gmail.com
68	Dr Vikrant Landge	Memorial Hospital, Sitwell, Oklahoma, USA.	US	vikrant.landge@gmail.com
69	Dr Geetanjali Pai	MD AAHIVS Memorial Hospital, Sitwell, Oklahoma, USA.	US	dr.paigg@gmail.com
70	Dr Ruta Bhargava	Hospitalist, Internal Medicine, Saint Banaras Medical Centre, Livingston NJ 07039, US.	US	drrutabendre@gmail.com
71	Dr Siddharth Virani	Shoulder & Elbow Surgery, East Kent Hospitals NHS Foundation Trust Pluto House, Ashford, Kent, UK.	UK	Siddharth.virani@nhs.net
72	Dr Rahul Tambade	ICU Gold Coast University Hospital, Australia.	Australia .	dr.rahultambade@gmail.com
73	Dr Anand B. Gaikwad	Consultant Radiologist, Southcoast Radiology, Australia.	Australia .	anandgaik01@gmail.com
74	Dr Arun M	Professor & Head, Department of Forensic Medicine & Toxicology, JSS Medical College, Mysuru, Karnataka – 570015.	India	arunmohanram@gmail.com
75	Dr T K Bose	Professor & Head, Department of Forensic Medicine & Toxicology, JIMSH, Budge Budge, Kolkata, India. 700137	India	drtapasbose@gmail.com
76	Dr O Gambhir Singh	Professor & Head, Department of Forensic Medicine, AIIMS Kalyani, West Bengal. 741245.	India	drgambhirsingh@gmail.com
77	Dr S K Dhattarwal	Professor, Department of Forensic Medicine & Toxicology, Postgraduate Institute of Medical Sciences, Rohtak, Haryana- 124001.	India	drskdhattarwal@gmail.com
78	Dr Uday Basu Roychowdhury	Professor & Head, Department of Forensic Medicine, Midnapore Medical College, West Bengal- 721101.	India	udayfsm@gmail.com
79	Dr T K Naidu	Professor & Head, Department of Forensic Medicine, Prathima Institute of Medical Sciences, Mukkrampura, Karimnagar, Telangana – 505001.	India	tekyamnaidu@gmail.com
80	Dr Prateek Rastogi	Professor & Head, Department of Forensic Medicine & Toxicology, Kasturba Medical College, Mangalore, Karnataka- 575001.	India	Prateek.rastogi@manipal.edu

#	First name and Last name	Affiliation	Country	Email
81	Dr Gautam Biswas	Professor & Head, Department of Forensic Medicine, Dayanand Medical College & Hospital, Ludhiyana, Punjab- 141001.	India	gautamdmc@rediffmail.com
82	Dr Mohammed Iliyas Sheikh	Professor & Head, Department of Forensic Medicine, SMIMER, Surat, Gujrat.	India	drmiliyas@gmail.com
83	Dr B Suresh Kumar Shetty	Professor, Department of Forensic Medicine & Toxicology, Kasturba Medical College, Mangalore, Karnataka- 575001.	India	Suresh.shetty@manipal.edu
84	Dr Harshwardhan Khartade	Assistant Professor, Department of Forensic Medicine & Toxicology, GMC Nagpur.	India	Harshwardhan.khartade@gmail.com
85	Dr Haneil L D'Souza	Associate Professor, Department of Forensic Medicine & Toxicology Kasturba Medical College, Mangalore, and District Medicolegal Consultant (Govt. of Karnataka), Karnataka- 575001.	India	hanihere@gmail.com
86	Dr Vikas Meshram	Associate Professor & Head, Department of Forensic Medicine & Toxicology, AIIMS Jodhpur, Rajashtan.	India	Drvpm26@gmail.com
87	Dr Kalpesh Zanzrukiya	Associate Professor & Head, Department of Forensic Medicine & Toxicology, SBKS MI & RC, Sumandeep Vidyapeeth, Vadodara, Gujrat.	India	Kalpeshzrk1987@gmail.com
88	Dr Raviraj KG	Associate Professor, Department of Forensic Medicine & Toxicology, St. Peter's Medical College, Hospital and Research Institute, Hosur, Tamil Nadu.	India	drkgraviraj@gmail.com
89	Dr Mohit Chauhan	Assistant Professor, Department of Forensic Medicine & Toxicology, Lady Hardlinge Medical College & Associated Hospitals (CHS & MHFW GOI), New Delhi.	India	Maahi474@gmail.com
90	Dr Senthil Kumaran	Assistant Professor & Head, Department of Forensic Medicine & Toxicology, AIIMS Mangalgiri, Andhra Pradesh.	India	Srsenthilkumaran84@gmail.com
91	Dr Rajiv Joshi	Professor, Department of Forensic Medicine, GGS Medical College, Faridkot, Punjab, India.	India	drrajivacme@gmail.com
92	Dr Ashutosh Potdar	Professor & Head, Department of Forensic Medicine, SSPM Medical College, Sindhudurg, Maharashtra, India.	India	drashpot@gmail.com
93	Dr Mallikarjun Ballur	Professor & Head, Forensic Medicine, KLE JGMM Medical College, Hubli, Karnataka, India.	India	drmallikarjunballur@gmail.com
94	Dr Swatoi Sonawane	Professor & Head, Forensic Medicine, Dr D Y Patil Medical College, Navi Mumbai, Maharashtra, India.	India	drswatifm@gmail.com
95	Dr Shweta Patel	Associate Professor, Forensic Medicine & Toxicology, GMERS Medical College, Panchmahal, Godhra, Gujrat, India.	India	drshwetafmt@gmail.com
96	Dr T Nataraja Moorthy	Professor of Forensic Sciences, Faculty of Health and Life Sciences, Managemnt and Science University, Sha Alam, Selangor, Malaysia.	Malaysia	natrajamoorthy@rediffmail.com

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Editorial

Need of Non-invasive Autopsy Centre as Adjuvant to Traditional Autopsy at Tertiary Care Institutions

Ravindra B Deokar^{a*}, Sachin S Patil^b, Sadanand S Bhise^c

^aProfessor (Additional), Department of Forensic Medicine & Toxicology, Lokmanya Tilak Municipal Medical college & LTMG Hospital, Sion, Mumbai-400022. Orcid Id: 0000-0003-1539-1035. ^bProfessor (Additional), Department of Forensic Medicine & Toxicology, Seth G S Medical college & KEM Hospital, Parel, Mumbai-400012. Orcid Id: 0009-0006-7420-1085. ^cDean, RCSM Government Medical College, Kolhapur, Maharashtra, India. Pin-416001. (M): +91-9503757487.

1. Introduction

Postmortem examination or Autopsy (or necropsy) is a specialized surgical procedure in which an expert examines the body of deceased carefully both internally and externally aiming to identify diseases, injuries and provide exact cause of death. It also facilitate to determine manner of death and appropriate documentation which will be useful to assist the legal investigations. The traditional autopsy involves complete external and internal examination of the deceased with preservation of necessary samples at autopsy and documenting all findings in the specific format abiding the experience and expertise of autopsy surgeons. Abiding the section 194 Bhartiya Nagrik Suraksha Sanhita (BNSS), 2023 a police inquest is done to do inquiry into the cause of death. Magistrate's Inquest done in certain cases (Death in custody, dowry deaths, etc.) abiding section 196 BNSS, 2023 and deceased forwarded for autopsy to on duty autopsy surgeon to concerned authorized postmortem centre as a standard practice, as off now.¹

Non-invasive autopsy is newer advanced development where the postmortem examination of the deceased done with use of high end machineries with technological advancement such as Computerized Tomography (CT) scan, three-dimensional (3-D) scans, Magnetic resonance

imaging (MRI) scan, Postmortem CT-Angiography, etc.^{2,3} In such autopsies the traditional cutting may avoided in certain cases. Implementing this may decrease the burden of cutting each and every deceased and the resources will be saved. Around 60-70 % of autopsy may be completed successfully using this advanced technique and only highly sensitive and homicide cases may be completed using traditional autopsy technique in addition to non-invasive autopsy, if such non-invasive autopsies permitted by State Government with appropriate Ordinance for its implementation.^{4,5}

2. Need of Non-invasive autopsy

There are thousands of autopsies done at various postmortem centres attached to tertiary care healthcare institutions. Out of these autopsies around 40 to 50 % autopsies are generally of natural deaths without any bodily surface injuries. 20 to 30 % deaths are associated with accidental, suicidal Injuries (Road traffic accidents, Railway accidents, burns, etc.) and 20-30% are sensitive cases including homicidal deaths.

With use of non-invasive autopsy technique using newer advanced machinery the body images can be taken and even three- dimensional virtual models can be created which are easy to detect abnormality and document such things by expert appropriately.

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*Corresponding author: Dr Ravindra B Deokar, Professor (Additional), Department of Forensic Medicine, Lokmanya Tilak Municipal Medical College & LTMG Hospital, Sion, Mumbai, Maharashtra, India- 400022. Email: ravideo803@gmail.com (M): +91-9423016325.

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It will have a great evidentiary value in court of law to establish the causal relationship of history, things happened and the positive findings. The cause of death can be given in many pathological diseases (natural deaths) and injury documentation can be done more efficiently and accurately in vehicular accident, railway accident cases, burn cases, etc.^{6,7}

Here, with use of non-invasive autopsies, we may curtail the complete postmortem in around 50-60 % cases and give cause of death and better documentation of evidentiary findings which may further required in court of law. Also, it will be useful in other cases for record of important evidences before sending the deceased for traditional medicolegal forensic autopsies by complete dissection (Invasive autopsies).

In many communities cutting of bodies is objectionable. Families are more willing to cause-of-death investigations, if it is done by non-invasive methods. It facilitates the justice with dignity as there is no unnecessary cutting of dead bodies.

3. Forensic and legal reasons for positive acceptance of non-invasive autopsies

- a. Natural deaths: Many pathological conditions are revealed better using CT scan, MRI and other advanced modalities as compared to gross naked eye examination.
- b. Injury/ Trauma cases: Non-invasive / virtual autopsies are gold standards for road traffic accidents, railway injuries, firearm, fall from height, burns cases.
- c. Mass disaster: in mass disaster cases the injury pattern is similar. Multiple cases can be handled and postmortem examination can be completed speedily with securing the necessary evidences appropriately.⁸
- d. Court acceptance: As it is easy to understand, it is well accepted in court of law.
- e. Infectious deaths: There is minimal risk to the autopsy surgeon and support staff in cases of highly communicable diseases like Tuberculosis, COVID, HIV, anthrax positive deceased.
- f. Decomposed or burned dead bodies: In spite of destruction of soft tissue, the bony injuries, fracture may be detected and appropriate cause of death may be given and manner of death may be predicted.
- g. Workload management: It can handle a huge workload in less time with a great workload at autopsy centre.

- h. Training and research: It can be used for training and further educational research purposes.

4. Key medicolegal issues: Administrative and Legal challenges

- a. The main key medicolegal issues are as follows
- b. Appropriate ordinance from state Government for its smooth implementation and acceptance as evidence in court of law.
- c. Standard algorithms are lacking.
- d. Training: Trained expert's availability through appropriate initial training workshops.
- e. With advancement and implementation of artificial intelligence (AI) in Healthcare appropriate standard operating procedures and ethical standard guidelines needed.⁹

5. Steps in implementation of Non-invasive autopsies

- a. The State Government need to bring appropriate legal reforms and bring an ordinance for policy change.
- b. Purchase of advanced technological equipment's and infrastructure facility development of the postmortem centre of the tertiary care institution is required.
- c. Appropriate standard ethical guidelines and standard operative protocols to be prepared through series of deliberations from committee/group of senior experts.
- d. Trained staff: Before implementing the system appropriate training is required to forensic and radiology experts.
- e. All dead body subjected to non-invasive autopsies and only in sensitive cases (homicidal, negligence, abuse cases, custodial deaths, etc.) further traditional autopsy can be performed.

6. The limitations

- a. Costly machineries: equipment cost is high.
- b. Trained staff required to handle the machinery and analyse the data.
- c. Vascular lesions, soft tissue injuries and histopathological changes are not always adequately captured through advanced imaging modalities.¹⁰
- d. It is a complementary tool rather than a replacement for traditional autopsy in all cases.

7. Conclusion:

Non-invasive autopsy is the transformative advancement in forensic medicine. It offers a non-invasive, accurate, and reproducible method of

evaluation of deceased with pathological diseases or trauma cases. Nowadays, imaging technologies are more accessible and affordable. It facilitates the integration of non-invasive autopsies into routine forensic analysis, alongside traditional autopsy to aid in administration of justice.

Starting a Non-invasive autopsies as a complimentary to the traditional autopsy at every tertiary care centre is need of hour. It holds great promise for enhancing diagnostic accuracy, improving legal documentation, and upholding ethical considerations.

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Original Research Article

Evaluation of Medical Certification of Cause of Death (MCCD) at Tertiary Healthcare Centre, Mumbai: A Retrospective Observational Study

B.G. Chikhalkar^a, Rahul Wagh^{b*}, Rupam Bhanarkar^c, Prashant Howal^d, Harshal Shingne^c

^aProfessor & Head, ^bAssistant Professor, ^cJunior Resident, Department of Forensic Medicine and Toxicology;

^dAssociate Professor, Department of Community Medicine, Grant Govt. Medical college & Sir JJ Hospital, Mumbai, Maharashtra, India.

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Death certificate,
Errors,
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Abstract

Background: Medical Certification of Cause of Death (MCCD) constitutes a critical medico-legal document and a primary source of mortality statistics. Deficiencies in certification practices diminish the interpretability and utility of death records. **Objective:** To evaluate the completeness and accuracy of MCCDs and identify common certification errors. **Materials & Methodology:** A retrospective observational study of 200 MCCDs selected using non-probability consecutive sampling from certificates registered between January and February 2025. Errors were classified using WHO and Registrar General of India guidelines. Data were analysed using descriptive statistical methods. **Result:** Inaccurate cause-of-death terminology was observed in 98% of certificates. Mechanism-only entries and symptom-based documentation were identified in 99% of cases. ICD-10 codes and time intervals were absent in all certificates. A statistically significant association was observed for Immediate Cause of Death ($p < 0.001$). **Conclusion:** Errors are common in the completion of death certificates issued by various physicians in Tertiary Healthcare Center, Mumbai. Educational interventions can improve the accuracy of reporting in death certificates.

1. Introduction

Mortality data are essential for monitoring health trends, shaping public health policy, and allocating healthcare resources.^{1,2} The Medical Certification of Cause of Death (MCCD), based on WHO and ICD-10 guidelines (Form No. 4/4A in India), offers a standardized approach to documenting causes of death.^{1,2} However, frequent documentation errors, such as

incomplete entries, diagnostic inaccuracies, illegibility, and inappropriate terminology, compromise the reliability of these data.^{3,4,5}

This study aims to evaluate the accuracy of MCCD forms and identify common errors, highlighting the urgent need to strengthen physicians' competence in proper death certification.^{6,7}

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***Corresponding author:** Dr. Rahul R. Wagh, Assistant Professor, Dept of Forensic Medicine & Toxicology, Grant Govt. Medical college & Sir JJ Hospital, Mumbai, Maharashtra, India. Email Id: waghr143@gmail.com

2. Materials And Methods:

During the study period (January 2025 to February 2025), a total of 348 Medical Certificates of Cause of Death (MCCDs) were registered at the Death Certification Department of the tertiary healthcare centre. The required sample size for the study was predefined as 200 MCCDs based on feasibility and study objectives. A non-random consecutive sampling method was adopted, wherein the first 200 eligible MCCDs received during the study period were included sequentially until the target sample size was achieved. No selection was made based on department, diagnosis, physician designation, or cause of death.

The remaining 148 MCCDs were not included solely because the predetermined sample size had already been reached, and not due to any systematic exclusion criteria. For alpha of 0.05 and 6% margin of error along with 73% prevalence of major errors according to previous literature we deemed that this non-random consecutive sample would be adequate. Including consecutive cases avoided selective inclusion and provided a pragmatic alternative to random sampling in record-based studies. The selected forms, completed in accordance with WHO guidelines, were evaluated using a pre-tested proforma containing a checklist of all variables included in the MCCD.⁸ Institutional Ethics Committee exemption was obtained prior to commencement of the study.

Operational Definitions:

- a. **Inaccurate Terminology:** use of non-etiological, ill-defined or non-specific terms in any part of the cause-of-death statement that prevent correct selection or coding of an aetiological underlying cause of death
- b. **Improper Mentioning:** any entry on the certificate that violates accepted rules of causal sequencing or specificity like: (a) reporting only unspecific causes on the lowest used line, (b) reporting two or more separate causal sequences on Part I, (c) incorrect causal sequence (temporal order reversed or biologically implausible), (d) placing mechanism/underlying/contributory
- c. **Errors in immediate cause:** any incorrect, missing, non-specific or mechanism-only entry recorded in the Immediate Cause of Death (ICOD / Part I line a) that results in (a) inability to identify the antecedent/underlying cause or (b) a category of error known to materially affect UCOD selection

- d. **Incorrect mentioning:** any error, omission, or internal inconsistency in the recorded data on the death certificate (including age, gender, date of death, date of certification, or interval inconsistencies) that conflicted with hospital records or rendered the certificate temporally inaccurate.

The errors were classified as major and minor errors (**Table 1**).

Table 1: Major and minor errors.

Error Type	Definition
Major Errors	Errors affecting validity of cause-of-death determination
1. Mechanism-only cause	Use of terminal events (e.g., cardiac arrest) without etiology
2. Incorrect causal sequence	Violation of WHO causal chain rules
3. Unrelated conditions	Independent diseases listed as causal
4. Missing underlying cause	Absence of etiologic disease/injury
Minor Errors	Errors affecting completeness but not fundamental validity
1. Missing time interval	Failure to record duration between onset and death
2. Abbreviations	Use of non-standard short forms
3. Overwriting	Corrections reducing document clarity
4. Incomplete demographics	Missing age, sex, etc.

Statistical Analysis:

Data were entered into Microsoft Excel (2024) and analyzed using Jamovi (Version 2.6). The analysis was primarily descriptive in nature. Documentation errors and certification deficiencies were categorized according to predefined criteria, and their frequencies and proportions were calculated. The audit-based retrospective design is given and minimal variability observed in several completeness indicators. Inferential statistical testing was not considered appropriate.

Findings were therefore interpreted using descriptive statistical methods to characterize the distribution and patterns of certification errors. The analytical approach focused on estimating error prevalence rather than evaluating inter-variable associations. It consistent with the audit-based retrospective design, inferential statistical testing was not emphasized. Errors were therefore interpreted using descriptive distribution analysis. The extremely high prevalence of Immediate Cause of Death deficiencies indicates systematic certification patterns.

3. Results:

A total of 200 Medical Certificates of Cause of Death (MCCDs) were evaluated (**Fig.1 & Table 2**). Core demographic variables were largely complete. The full name of the deceased was correctly documented in 199 (99.5%) certificates, while 1 (0.5%) certificate contained incomplete identification details. Date and time of death were recorded in 198 (99%) certificates, whereas 2 (1%) certificates lacked this information.

Figure 1: Department-wise Distribution of Medical Certificates of Cause of Death (n = 200).

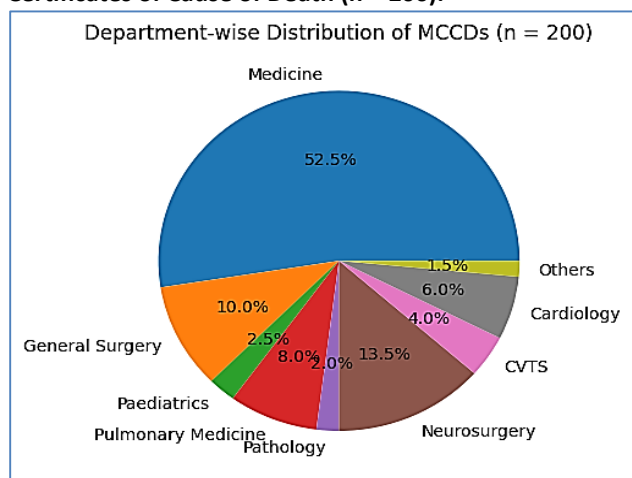
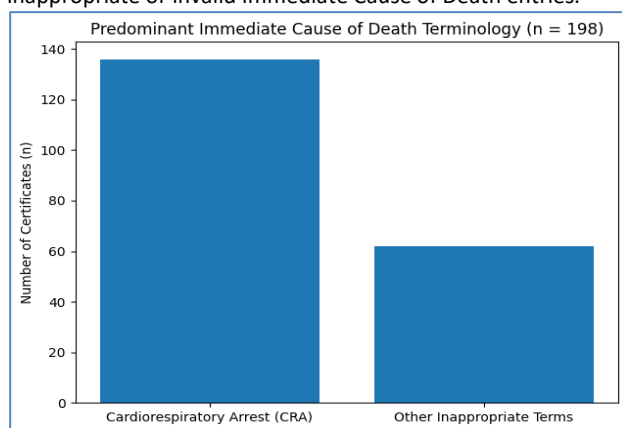


Figure 2: Distribution of Frequently Documented Inappropriate Immediate Cause of Death Terminology (n = 198). The denominator represents certificates demonstrating inappropriate or invalid Immediate Cause of Death entries.



Gender was correctly mentioned in 190 (95%) certificates and was missing or incorrectly recorded in 10 (5%) cases. None of the certificates documented the time interval between onset of illness and death (0%). ICD-10 codes were absent in all evaluated certificates (0%). Physician-related variables demonstrated high completeness. The treating physician's name was present in 192 (96%) certificates. Physician signatures were observed in 199 (99.5%) certificates, while 1 (0.5%) certificate

lacked a signature. The physician's registration number or official seal was present in 199 (99.5%) certificates (**Table 3**).

Table 2: Distribution of Cause-of-Death Certification Variables (n = 200).

Sr. No.	Cause-of-Death Variable	Observation	Frequency n (%)
1	Antecedent Cause	Mentioned	189 (94.5%)
		Not mentioned	11 (5.5%)
2	Other Significant Conditions	Mentioned	182 (91%)
		Not mentioned	18 (9%)
3	Manner of Death	Marked	173 (86.5%)
		Not marked	27 (13.5%)
4	Gender of Deceased	Correctly documented	190 (95%)
		Missing / incorrect entry	10 (5%)

Table 3: Distribution of Technical and Certification Variables (n = 200).

Sr. No.	Variable	Observation	Frequency n (%)
1	Pregnancy-related death (Females 15–49 yrs, n = 19)	Mentioned	15 (78.9%)
		Not mentioned	4 (21.1%)
2	Treating physician name	Mentioned	192 (96%)
		Not mentioned	8 (4%)
3	Physician signature	Present	199 (99.5%)
		Absent	1 (0.5%)
4	Registration number / seal	Present	199 (99.5%)
		Absent	1 (0.5%)
5	ICD-10 code	Mentioned	0 (0%)
		Not mentioned	200 (100%)
6	Overwriting / cancellations	Present	20 (10%)
		Absent	180 (90%)
7	Abbreviations used	Yes	6 (3%)
		No	194 (97%)
8	Time Interval (Onset to Death)	Mentioned	0 (0%)
		Not mentioned	200 (100%)

Table 4: Distribution of Documentation Deficiencies Across Certification Variables.

S. No.	Certification Variable	Deficiency Observed n (%)
1	Gender documentation errors	10 (5%)
2	Incomplete name documentation	1 (0.5%)
3	Missing Date & Time entry	2 (1%)
4	Missing treating physician name	8 (4%)
5	Missing physician signature	1 (0.5%)
6	Missing registration number / seal	1 (0.5%)
7	Overwriting / cancellations	20 (10%)
8	Abbreviations used	6 (3%)
9	Manner of death not specified	27 (13.5%)
10	Missing antecedent cause	11 (5.5%)
11	Missing underlying cause / OSC	18 (9%)
12	Immediate Cause of Death errors	198 (99%)

Abbreviations were identified in 6 (3%) certificates. Overwriting or cancellations were observed in 20 (10%) certificates. The manner of death was not specified in 27 (13.5%) certificates.

Deficiencies related to cause-of-death documentation were frequent. Immediate Cause of Death (ICOD) entries were found to be inappropriate or invalid in 198 (99%) certificates. Inaccurate or non-specific terminology was identified in 196 (98%) certificates ([fig. 2](#)). Antecedent causes were not documented in 11 (5.5%) certificates. Underlying causes or other significant conditions were absent in 18 (9%) certificates ([Table 4](#)). The majority of certificates were issued by the Medicine department (52.5%), followed by Neurosurgery (13.5%) and General Surgery (10%). Cardiorespiratory Arrest (CRA) was the most frequently documented Immediate Cause of Death terminology.

4. Discussion:

Accurate completion of the Medical Certificate of Cause of Death remains fundamental to medico-legal documentation and mortality surveillance frameworks. Certification deficiencies compromise the analytical validity of mortality data and may carry administrative or legal implications.^{1, 2, 10} The present study identified a predominant reliance on mechanism-based expressions within cause-of-death statements. Many certificates reflected terminal physiological events rather than etiologically meaningful disease conditions. According to established certification principles, such documentation restricts appropriate identification of the underlying cause of death and reduces the interpretative value of mortality records. Similar patterns of certification errors have been reported in previous audits conducted in different hospital settings, highlighting persistent systemic deficiencies in death certification practices.^{3, 5, 11, 12, 13}

Another notable finding was the absence of ICD-10 coding and temporal interval documentation in several certificates. Proper recording of these parameters forms an integral component of standardized death certification and is essential for accurate epidemiological analysis and mortality statistics. Failure to document these elements diminishes the statistical utility of death records and limits their contribution to national health information systems.^{10, 12}

In the present study, errors were most frequently observed in the Immediate Cause of Death section. This clustering of errors suggests a systematic pattern of documentation behavior rather than isolated inaccuracies. Such findings likely reflect limited familiarity with the principles of causal sequencing and underlying cause selection among

certifying physicians, a problem that has been reported in multiple institutional audits.^{4, 5, 6, 14, 15} Improving the quality of death certification requires a multifaceted approach involving structured training programs, periodic institutional audits, and adherence to standardized documentation protocols.^{16,17} Educational interventions have been shown to significantly enhance physicians' competence in completing death certificates.¹⁸⁻²⁰ Additionally, the implementation of electronic death certification systems incorporating mandatory validation checks may substantially reduce preventable documentation errors and improve the overall quality of mortality data.^{7, 21-23}

Limitations:

This study has certain limitations. The analysis was conducted using a predefined non-probability consecutive sample, which may limit the generalizability of the findings beyond the evaluated certificates. Although consecutive sampling minimized investigator-driven selection, the possibility of sampling bias cannot be entirely excluded.

The study was retrospective and relied exclusively on available records. Therefore, the observations were dependent on the accuracy and completeness of documented information. The evaluation focused on certification practices and documentation deficiencies rather than independent clinical verification of causes of death. Furthermore, the study was performed at a single tertiary care teaching hospital, and variations in certification practices across different institutions or healthcare settings may exist.

5. Conclusion:

Accurate death certification is an essential professional responsibility of medical practitioners. The present study demonstrates a high prevalence of certification deficiencies, particularly within cause-of-death documentation, including reliance on mechanism-based terminology and omission of critical certification elements.

Structured training initiatives, standardized certification protocols, and periodic forensic audits are necessary to improve the medico-legal reliability of MCCDs. Without corrective measures, persistent documentation errors may continue to compromise the validity and utility of mortality data systems.

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Original Research Article

Forensic Limnological Profile of Water Bodies in Marathwada Region of Maharashtra, India

Miriam Reji Puthenpurackal,^a Sandeep G. Sangle,^b Malla Bharadwaj Sai Satya Murthy^{c*}, Kattamreddy Ananth Rupesh^d

^aGovernment institute of forensic science, Chhatrapati Sambhajanagar, Maharashtra, India. ^bAssistant Professor, Forensic Biology, Serology and DNA fingerprinting, Government institute of forensic science, Chhatrapati Sambhajanagar, Maharashtra, India. ^cResearch Intern, GITAM school of sciences, Department of Chemistry, GITAM University, Visakhapatnam, Andhra Pradesh, India. ^dAssistant Professor of Forensic Medicine and Toxicology, Visakhapatnam, Andhra Medical College, India. Pin-530002.

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Abstract

Introduction: Drowning is one of the most common forms of unnatural death encountered in Forensic Medicine practice in India. Although considered obsolete by many practitioners, the diatom test still plays a role in linking the site of drowning with the recovered body to some extent. The availability of a diatom database for individual water bodies can expedite forensic investigations and assist in confirming the location of drowning incidents. This study aimed to analyze the diversity of diatoms from 14 water samples collected from the Marathwada region of Maharashtra by identifying diatoms at the genus level. **Methods:** Diatoms were extracted from the water samples using a standardized aqua regia method. Slides were prepared, mounted, and examined under a phase-contrast microscope. Classification was performed using the *Diatoms of North America* database. **Findings:** More than 50 different genera of diatoms were identified which included both common and unique diatoms. These findings provide valuable insights into the ecological characteristics of each water body and their distinctive flora. **Conclusion:** The data generated in this research will aid in drowning investigations in Marathwada region of Maharashtra and contribute to establishing a regional database on diatom diversity.

1. Introduction

Diatoms (Kingdom: *Protista*, Class: *Bacillariophyceae*) are unicellular, photosynthetic eukaryotic microalgae ¹⁻³ that are among the most prevalent and ecologically significant primary producers in aquatic ecosystems. They occur in marine, freshwater, terrestrial, and artificial or

man-made habitats.^{1,4} The diversity of diatoms is extensive, with current estimates indicating that approximately 100,000 to 200,000 species have been identified, exhibiting a wide range of sizes and morphological characteristics.² Their distinctive features, such as silica-based cell walls

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***Corresponding author:** Malla Bharadwaj Sai Satya Murthy, Research Intern, GITAM school of sciences, Department of Chemistry, GITAM university, Visakhapatnam, Andhra Pradesh, India. Email: satishmalla4153@gmail.com

or frustules, have intricate and species-specific designs.¹ Diatoms function as primary producers that convert sunlight into biomass, thereby sustaining aquatic food webs and contributing significantly to global carbon and silicon cycles, as well as influencing climate dynamics and nutrient cycling processes.¹⁻⁶

Drowning, a form of asphyxial death in which access of air to the lungs is prevented by the submersion of the body in water or another fluid medium. It accounts for approximately 320,000 deaths globally each year. The diatom test is based on the principle that, during drowning, water containing microscopic diatoms enters the lungs and may subsequently enter the bloodstream. If circulation is active at the time of submersion, these diatoms can be transported to distant organs such as the brain, kidneys, or bone marrow, where they can later be detected microscopically. The presence of diatoms in these internal organs supports a diagnosis of ante-mortem drowning. However, the reliability and diagnostic value of this test remain a subject of debate among forensic experts.⁵⁻¹²

The primary objective of the present study was to collect and analyze water samples from selected locations in the Marathwada region. The samples were processed, examined microscopically, and photographed to identify genus-level morphological characteristics of diatoms and to assess the diversity of diatom assemblages in each water body.

2. Methodology:

Study Area: The field locations for the study were chosen from the Marathwada region of Maharashtra, India. A total of 14 samples were collected from variety of diverse water bodies such as rivers, lakes, ponds, and dams. The geographical location of the field spots are as follows; 1. Aurangabad caves (Chhatrapati Sambhajinagar), 2. Bindusara Lake (Beed), 3. Hiranya Lake (Chhatrapati Sambhajinagar), 4. Jalna Ghanewadi Reservoir (Jalna), 5. Ladgao Lake (Chhatrapati Sambhajinagar), 6. Jayakwadi Dam (Chhatrapati Sambhajinagar), 7. Majalgaon Dam (Beed), 8. MIDC phase III pond (Jalna), 9. Salim Ali Lake (Chhatrapati Sambhajinagar), 10. Panasnala River (Shingnapur), 11. Siddheshwar Dam (Hingoli), 12. Terna Dam (Dharashiv), 13. Vilasnagar Ambad Well (Jalna), 14. Vishnupuri Dam (Nanded).

Sample collection: Water samples for the diatom study were collected primarily from riffle zones, where water flows over rocks or stones. Sampling from riffles provides optimal results, as continuous water movement minimizes chemical accumulation

and sedimentation, ensuring the collection of representative local biota.¹³ For still or deepwater bodies such as wells and ponds, samples were taken near the shore after gentle agitation to prevent the inclusion of organic debris or sediments.¹⁴

In all cases, samples were collected from depths of less than one meter, where sunlight penetration and substrate conditions best support diatom growth.¹³ Samples were collected in sterilized 250 ml screw cap glass bottles with tightly fitted caps and labeled with the location, date and time of collection, site coordinates, temperature, and humidity.

Sample Preparation: The agitated water samples were transferred to Falcon tubes and centrifuged using an Eppendorf Centrifuge 5810 R at 8000 rpm for 30 minutes.^{14, 15} The resulting pellet was subjected to acid digestion using the aqua regia method by adding equal volumes of HNO₃ and HCl to 2 mL of the sample under a fume hood. This process removed organic and unwanted materials from the sample. The digested mixture was then incubated at 30°C for 24 hours to facilitate complete digestion.^{5, 11, 14, 15, 17-19}

Slides were prepared by placing 40 µL of the digested sample on clean, labeled glass slides. A drop of DPX (Dibutyl Phthalate Polystyrene Xylene) mounting medium was added, and a coverslip was carefully placed on top. The slides were left undisturbed until completely dried. Observations were made under a phase-contrast microscope at 10×, 40×, and 100× magnifications. Images were captured using Mosaic 2.3 software with a GT 5.0 (5 MP) color microscope camera attached to the microscope. The captured images were labeled, saved, and compared with reference images from the *Diatoms of North America* database (diatoms.org) for genus-level identification. The above procedure is followed for all the collected samples to examine the diatoms morphologically under microscope.

This study was conducted at Forensic Biology Lab, Government Institute of Forensic Science, Aurangabad (GIFSA), Maharashtra, India. All the chemicals used in the study are quality grade. Proper safety precautions are taken to avoid any harm and the procedure is done in a clean work place to avoid contamination.

3. Results:

The results of the present study provide an overview of the diatom diversity observed in water samples collected from various locations in the Marathwada region of Maharashtra, India. Based on

morphological characterization, more than 50 diatom genera were identified across 14 water bodies. These findings highlight the ecological diversity of the sampled aquatic habitats. The observed genera and their distribution across sampling sites are summarized in **Figure 1**.

Figure 01: The observed genera and their distribution- 1-Afrocybella; 2-Amphora; 3-Aneumastus; 4-Aulacoseria; 5-Bacillaria; 6-Brebissonia; 7-Boreozonacola; 8-Cymbella; 9-Cyclotella; 10-Cyclostephanos; 11-Craticula; 12-Crenotia; 13-Cosmioneis; 14-Campylodiscus; 15-Diploneis; 16-Envekadea; 17-Encyonema; 18-Fragilariforma; 19-Gato ; 20-Grammatophora; 21-Hantzschia; 22-Homeocladia; 23-Iconella; 24-Lacustriella; 25-Mastoglia; 26-Navicula; 27-Navicymbula; 28-Neidiomorpha; 29-Nitzschia; 30-Nupela; 31-Nanofrustulum; 32-Oricymba; 33-Pinnularia; 34-Plagiotropis; 35-Rexlowea; 36-Stenopterobia; 37-Seminavis; 38-Stephanocylus; 39-Stauroneis; 40-Surirella; 41-Sellaphora; 42-Spicaticribra; 43-Tabularia; 44-Tetramphora; 45-Thalassionema; 46-Tryblionella; 47-Tibetiella; 48-Ulnaria; 49-62: Unidentified.

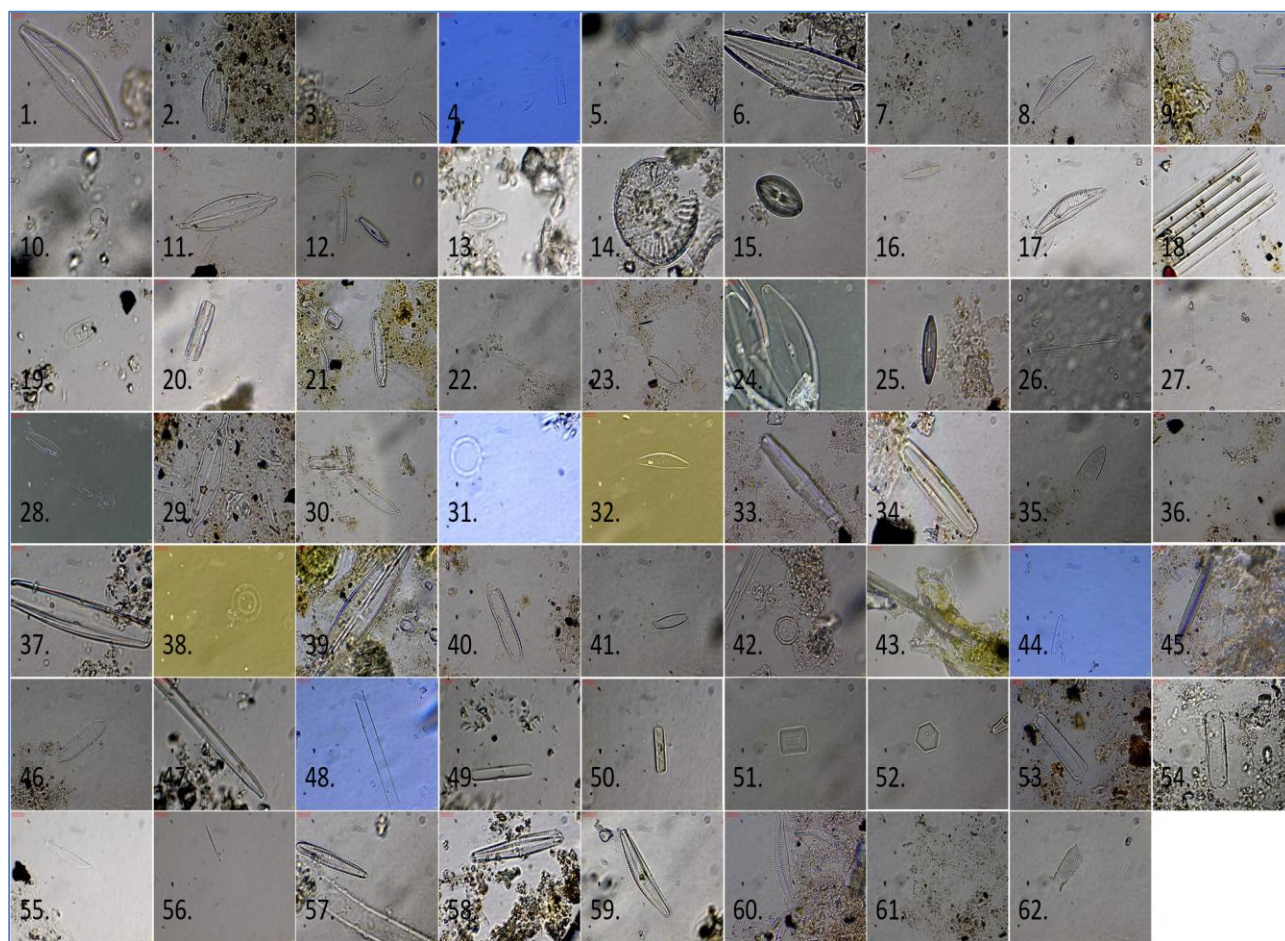


Table 1: Prevalence of Diatoms in Selected Water Bodies.

Sr. No.	Diatom	Water Samples														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	Afrocybella						+		+							2
2	Amphora												+			1
3	Aneumastus						+									1
4	Aulacoseria			+	+											2
5	Bacillaria													+		1
6	Brebissonia		+													1
7	Boreozonacola												+			1

8	Cymbella			+			+	+	+	+	+	+				7
9	Cyclotella	+		+	+	+			+	+			+		+	8
10	Cyclostephanos			+					+	+						3
11	Craticula					+			+							2
12	Crenotia	+		+												2
13	Cosmioneis	+														1
14	Campylodiscus												+			1
15	Diploneis						+		+						+	3
16	Diatomella								+							1
17	Envekadea	+														1
18	Encyonema	+		+	+		+						+			5
19	Fragilariforma	+				+										2
20	Gato	+														1
21	Grammatophora		+	+				+				+				4
22	Hantzschia					+			+							2
23	Homeocladia												+			1
24	Iconella					+										1
25	Lacustriella										+					1
26	Mastoglia											+				1
27	Navicula	+	+	+	+	+			+	+	+	+			+	10
28	Navicymbula											+				1
29	Neidiomorpha					+										1
30	Nitzschia	+		+		+	+		+	+	+			+	+	9
31	Nupela	+														1
32	Nanofrustulum									+						1
33	Oricymba				+											1
34	Pinnularia			+	+				+	+		+				5
35	Plagiotropis	+		+									+		+	4
36	Rexlowea		+													1
37	Stenopterobia		+			+										2
38	Seminavis			+	+		+		+			+				5
39	Stephanocylus		+		+										+	3
40	Stauroneis								+			+				2
41	Surirella					+			+					+		3
42	Sellaphora					+			+				+			3
43	Spicaticribra								+							1
44	Strelnikoviella								+							1
45	Tabularia	+														1
46	Tetramphora				+											1
47	Thalassionema											+				1
48	Tryblionella								+						+	2
49	Tibetiella	+			+								+			3
50	Ulnaria	+	+	+	+	+	+		+		+	+				9

51	Unidentified	2	0	2	0	1	0	0	1	0	2	5	1	1	0	15
		16	7	15	11	13	8	2	20	7	7	15	8	6	7	

Note: “+” symbol indicates the presence of particular diatom in the respective water bodies.

Morphological analysis revealed variation in the predominant diatom genera across the 14 water samples from the Marathwada region. *Encyonema* was the most abundant genus in samples 1, 3, 4, 6, and 12, while *Ulnaria* predominated in sample 5. *Cymbella* was dominant in samples 7 and 11. Sample 8 showed the highest frequency of *Pinnularia*, followed by *Cymbella*, and *Pinnularia* was also abundant in sample 9. In sample 10, *Navicula* and *Ulnaria* occurred with equal frequency. *Campylodiscus* was predominant in sample 13, and *Nitzschia* was dominant in sample 14.

Across all sites, the most frequently occurring genera were *Navicula*, followed by *Nitzschia*, *Ulnaria*, *Cyclotella*, *Cymbella*, *Encyonema*, *Pinnularia*, and *Seminavis*. Several genera were found to be unique to specific water bodies, including *Amphora* and *Boreozonacola* in Terna Dam; *Aneumastus* in Jayakwadi Dam; *Bacillaria*, *Campylodiscus*, and *Homeocladia* in Vilasnagar Well (Ambad); *Brebissonia* and *Rexlowea* in Bindusara Lake; *Cosmioneis*, *Envekadea*, *Gato*, *Nupela*, and *Tabularia* in Aurangabad Caves; *Diatomella*, *Spicaticribra*, and *Strelnikoviella* in the MIDC Pond; *Iconella* in Ladgaon Lake; *Lacustriella* in Panasnala River (Shingnapur); *Mastoglia*, *Navicymbula*, and *Thalassionema* in Siddheshwar Dam; *Nanonfrustulum* in Salim Ali Lake; and *Oricymba* and *Tetramphora* in the Jalna Ghanewadi Reservoir.

4. Discussion:

As shown in the **Table 1 and Figure 01**, a total of more than 50 identified genera of diatoms and 15 unidentified forms were recorded from 14 water samples collected across the Marathwada region, based on morphological analysis. Although 50 different genera of diatoms were identified using existing databases, several specimens remained unidentified due to the absence of an indigenous diatom database. While reference literature and international databases aided in the identification process, no comprehensive regional database currently exists for the Marathwada region or the state of Maharashtra. At a broader level, India also lacks an authentic and centralized database documenting algal diversity. The establishment of such a database would significantly enhance the accuracy of forensic investigations, particularly in

drowning cases. Similar observations have been reported by Pandey LK.²⁰

Seasonal variations can significantly influence diatom diversity and abundance, as changes in temperature, light availability, and nutrient concentration affect their growth dynamics. Periods of increased nutrient availability, such as during dry or mixing seasons, may promote higher diatom productivity and morphological variability.²¹ Previous studies, such as that by Dahiya P.⁵, have shown that physicochemical parameters and heavy metal concentrations significantly influence diatom diversity and growth. However, the present study did not include an analysis of environmental or nutrient factors affecting diatom population dynamics.

Recent studies suggest that the analysis of diatom presence, growth behavior, and succession patterns, when combined with modern techniques such as water elemental profiling and phytoplankton examination from dental samples, may enhance the understanding of post-mortem changes in aquatic environments. However, the application of these methods for post-mortem submersion interval (PMSI) estimation remains exploratory and has not yet been fully validated for routine forensic use.^{22, 23} Some studies show increase in the species diversity of diatoms on the decaying carcasses in particular time frames during the petrification in waterbodies, which can help in estimating the PMSI of the submerged dead body.²⁴ This is innovative field and more research will enhance the accuracy.^{25,26}

By comparison of diverse species of diatoms within the victim's body with those in the nearby water helps in determining the drowning site, as each water body has its distinct community of diatoms. Diversity in diatoms flora across micro-habitat such as benthic, floating, surfaces zones²⁷ should be considered during sampling to improve accuracy. Elemental and nutritional analysis of samples support understanding of diatom distribution. Further research on these factors can refine interpretation of diatoms prevalence and enhances the precision of forensic investigations.

5. Conclusion:

Forensic diatomology plays a vital role in drowning investigations by aiding in determining cause of death and site of drowning. Although considered a traditional method, it remains useful in

localizing the drowning site, particularly when a body is displaced from its original location. The detection of diatoms in vital organs supports the diagnosis of ante-mortem drowning. Additionally, diatom analysis can assist in post-mortem submersion interval (PMSI) estimation. Establishing limnological profiles of regional water bodies, including their seasonal variations, would further enhance the accuracy and efficiency of such forensic determinations.

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Original Research Article

Clinicopathological Features of Poisoning in Living and Deceased Individuals: An Observational Study

Ravindra S Honnungara^a, Dhivagar K^{b*}, Manoranjan B^c, Vidya M^d, Hemalatha K^e

^aProfessor & HOD, Department of Forensic Medicine & Toxicology, Jawaharlal Nehru Medical College, KAHER, Belagavi, Karnataka, India. ^bAssistant Professor, Department of Forensic Medicine & Toxicology, Tagore Medical College, Hospital, Chennai, Tamil Nadu, India. ^cAssistant Professor, Department of Forensic Medicine & Toxicology, SUT Academy of Medical Sciences, Thrissur, Kerala, India. ^dSenior Lecturer, Department of Oral Pathology, Tagore Dental College and Hospital, Chennai, India. ^eSenior Resident, Department of Radio-diagnosis, Sri Venkateshwara Medical College Hospital & Research Centre, Ariyur, Puducherry, India.

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Abstract

Introduction: Poisoning is a major cause of morbidity and mortality worldwide, particularly in low- and middle-income countries. Understanding the clinical and pathological profiles aids in timely diagnosis and effective management. **Objective:** To assess the clinicopathological features of poisoning in living and deceased individuals. **Materials and Methods:** A cross-sectional observational study was conducted over 18 months at KLE Hospital, Belagavi, involving 197 cases (163 living and 34 deceased). Data were collected using a structured proforma. Clinical features and laboratory parameters were analysed for living cases, and histopathological findings of brain, heart, liver, kidneys, and lungs were performed using haematoxylin and eosin staining for deceased cases. Quantitative data were analyzed using descriptive statistics and inferential tests (Chi-square, Fisher's exact test). Statistical significance was set at $p < 0.05$. **Results:** The mean age was 30.75 ± 15.62 years; 61% were males. The mortality rate was 17.3%, with 94% of deaths due to suicide. Paraquat accounted for 44% of fatal cases. Brain (82%) and heart (73.5%) were the most affected organs. Significant associations were observed between type of poison and clinical outcome ($p < 0.01$). **Conclusion:** Laboratory markers such as WBC and platelet counts can predict lethality. Autopsy findings revealed organ-specific damage particularly in paraquat and organophosphate ingestion. Early recognition of such parameters can reduce mortality.

1. Introduction

Poison is defined as any substance capable of causing harmful or fatal effects when introduced into the living body. According to the World Health Organization, poisoning contributes to nearly 0.3

million deaths annually, with most occurring in low- and middle-income countries.¹ In India, suicides account for a large share of poisoning cases, with the National Crime Records

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*Corresponding author: Dr Dhivagar K, Assistant Professor, Department of Forensic Medicine & Toxicology, Tagore Medical College, Hospital, Chennai, Tamil Nadu, India. Email- dhivagar.latha@gmail.com

Bureau reporting over 1.6 lakh deaths in 2021.² Common toxic agents include organophosphates, paraquat, rodenticides, and snake venom.³ Diagnosis in living patients depends on clinical findings, laboratory evaluation, and toxicological testing, while in deceased cases, histopathological examination provides crucial evidence.^{4,5} Major target organs include the liver, kidneys, lungs, and brain, as these are involved in metabolism and detoxification.⁶ This study aimed to evaluate the clinical, biochemical, and histopathological features of poisoning cases in living and deceased individuals in the Belagavi region.

2. Materials and Methods

Study Design and Setting: A cross-sectional observational study conducted at Jawaharlal Nehru Medical College and KLE Hospital, Belagavi, from January 2021 to June 2022.

Participants: A total of 197 cases were included (163 living and 34 deceased) using convenience sampling. Inclusion criteria included all poisoning cases within 24 hours of exposure. Exclusion criteria were food poisoning and cases brought dead without proper documentation.

Data Collection: Demographic, clinical, and laboratory data were collected from living patients. For deceased cases, tissue samples from brain, heart, lungs, liver, and kidneys were fixed in 10% buffered formalin, processed, sectioned at 5 μ m, and stained with hematoxylin and eosin. Statistical Analysis: Quantitative data were expressed as mean $\pm$ SD; qualitative data as frequencies and percentages. Associations were assessed using Associations were analyzed using Chi-square and Fisher's Exact tests. Statistical significance was set at $p < 0.05$.

Ethical Considerations: Informed consent was obtained from living participants. Ethical approval was granted by the Institutional Ethical Committee, Jawaharlal Nehru Medical College, KAHER (MDC/DOME/53). Convenience sampling was adopted due to the unpredictable and emergent nature of poisoning cases presenting to the hospital, ensuring inclusion of all eligible cases within the study duration.

3. Results

A total of 197 poisoning cases were analyzed, comprising 163 (82.7%) survivors and 34 (17.3%) deceased. The mean age was 30.75 ± 15.62 years, with most patients aged 21–40 years (53%), followed by those below 20 years (26%). Males accounted for 61% of cases, while 58% were unmarried. Among the deceased, 15% had a prior history of suicidal

attempts. **Table 1** shows that suicide was the leading cause of death (94%), while homicidal and accidental cases each accounted for 3%, indicating that most fatalities were due to intentional self-poisoning.

Table 1: Frequency distribution of intentional exposure of Deceased cases (n=34)

Intentional Accident/ Exposure	Deceased (%)
Suicide	32 (94)
Homicide	01 (03)
Accidental	01 (03)

Table 2: Frequency distribution of study participant's Place of ingestion.

Variable	Frequency (%)
Home	155 (79)
Farm	28 (14)
Hospital	05 (03)
Others	09 (05)

Table 3: Association of Place of Ingestion, clinical features, and compound ingested with poisoning

Variables	Survived (%) (n=163)	Deceased (%) (n=34)	Chi square (χ^2)	p-value
Place of Ingestion of poison				
Home	125 (77)	30 (88)	2.6	0.46
Farm	25 (15)	03 (09)		
Hospital	05 (03)	00 (00)		
Others	08 (05)	01 (03)		
Clinical features*				
Vomiting	46 (28)	13 (38)	34.96	<0.01**
Stomach pain	33 (20)	08 (24)		
Throat pain	14 (09)	10 (29)		
Breathlessness	00 (00)	08 (24)		
Drowsiness	09 (06)	09 (26)		
Defecation	04 (02)	03 (09)		
Others	28 (17)	03 (09)		
Type of Compound Ingested				
Paraquat	09 (05)	15 (44)	46.62	<0.01**
Organophosphorus	16 (10)	06 (18)		
Snake bite	38 (23)	00 (00)		
Unknown	40 (24)	06 (18)		
Component	60 (37)	07 (21)		
Others				

*Multiple responses ** $p < 0.05$, statistically significant

Table 2 shows that most poisonings occurred at home (79%), followed by farms (14%), indicating that domestic settings were the predominant site of ingestion. An association between the place of ingestion, clinical features, and type of compound with outcomes in poisoning cases was evaluated in **Table 3**. The place of ingestion had no significant impact on mortality ($p = 0.46$), whereas clinical features ($p < 0.01$) and compound type ($p < 0.01$) showed significant associations.

Haematological and biochemical parameters further supported these clinical observations. The mean haemoglobin level was 12.6 ± 2.5 g/dL, while

the mean platelet count was markedly lower in deceased cases ($0.71 \times 10^5/\mu\text{L}$). Elevated liver enzymes and serum creatinine values were also noted, indicating hepatic and renal involvement ($p < 0.05$).

Histopathological Findings: Microscopic examination of autopsy samples revealed characteristic multi-organ involvement. The brain showed vascular congestion, interstitial oedema, and focal neuronal necrosis, more prominent in paraquat-related deaths. The heart demonstrated myocardial fibre degeneration, interstitial haemorrhage, and mild lymphocytic infiltration in several cases. The lungs showed extensive alveolar congestion, oedema, and haemorrhage with occasional fibrin deposition. The liver exhibited centrilobular necrosis, fatty changes, and sinusoidal congestion, whereas the kidneys revealed tubular epithelial degeneration, glomerular congestion, and focal necrosis. These features were more severe in paraquat and organophosphorus poisoning.

4. Discussion

The predominance of young, unmarried males in this study is consistent with the psychosocial vulnerability patterns documented in Indian and South Asian populations, where occupational exposure and emotional stress play a significant role in self-poisoning incidents.⁷⁻⁹ Similar demographic trends have been documented across neighbouring countries. Studies from Bangladesh and Sri Lanka also report a predominance of male victims aged 20–40 years, reflecting shared sociocultural stressors, agricultural exposure, and easy access to toxic agents.¹⁰⁻¹² The current study revealed that paraquat and organophosphorus compounds were the most frequent fatal agents, responsible for 44% and 18% of deaths, respectively, whereas unknown compounds, snake bites, and household poisons predominated among survivors. Similar patterns of herbicide and pesticide-related toxicity have been documented across India.¹³⁻¹⁶

Laboratory abnormalities, such as elevated WBC and liver enzyme levels along with reduced platelet counts, reflect systemic toxicity and correlate strongly with fatal outcomes. These markers may serve as early prognostic indicators in triaging and clinical management, especially in resource-limited emergency settings.¹⁷⁻¹⁹ Histopathological evaluation of deceased cases demonstrated multi-organ involvement, predominantly affecting the brain (82%), heart (73.5%), lungs (65%), liver (50%), and

kidneys (15%). Cerebral congestion and hepatic changes observed in the present study correspond to previous autopsy-based findings.^{4,20,21} Recent advances with histopathological examinations facilitate to correlate the changes in tissue due to poisons. It provides insights into genetic susceptibility to environmental toxins and drugs.²²⁻²⁴

Histopathological findings confirmed that paraquat primarily affects pulmonary and cardiac tissues, while organophosphorus compounds show hepatic and renal involvement.^{5,17,25} Such correlations between laboratory and autopsy data highlight the importance of integrating clinical, biochemical, and morphological evaluation for early recognition of systemic toxicity and systemic toxicity and timely intervention.

Limitations: The study was limited by its single-centre scope and convenience sampling method. Some compounds lacked toxicological confirmation, which may have affected classification accuracy. Future multicentre studies with larger cohorts are recommended to validate these findings and develop region-specific clinical management protocols.

5. Conclusion

Laboratory parameters such as platelet and WBC counts are valuable in predicting severity and outcome in poisoning cases. Integrating clinical data with histopathological findings improves prognostic accuracy and guides management. Strengthened regulation of toxic agents, public awareness campaigns, and mental health support systems are vital to reduce suicidal poisonings. Multi-institutional studies should standardize clinicopathological correlations across diverse populations.

Ethical Clearance: IEC approval is taken from the Institutional Ethical committee.

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Original Research Article

Histopathological Alterations in Suprarenal Glands in Asphyxial Deaths: A Forensic Study

Raihan Uddin Ahmed^{a*}, Swaraj Phukon^b, Farheen A. Karim^c, Nabajit Barman^d

^aAssociate Professor, ^bAssistant Professor, Department of Forensic Medicine, Assam Medical College & Hospital, Dibrugarh, Assam, India. ^cAssociate Professor, Department of Anatomy, Jorhat Medical College & Hospital, Dibrugarh, Assam, India. ^dAssociate Professor, Department of Forensic Medicine, Gauhati Medical College & Hospital, Gauhati, Assam, India.

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Abstract

Introduction: Asphyxial deaths induce distinct histopathological changes in the suprarenal glands. Diagnosing hanging proves challenging when ligature marks are faint or absent. These glandular alterations assist in authenticating antemortem hanging, drowning, and other asphyxia mechanisms. This study examines detail histopathological changes of suprarenal glands in confirmed antemortem asphyxia cases. **Materials and Method:** The study utilized suprarenal glands which were obtained from the medico-legal autopsies of 55 cases of deaths due to asphyxia brought to the Mortuary of the Department of Forensic Medicine, Assam Medical College & Hospital, Dibrugarh, by the investigating authorities. The specimens were collected over a period of one year, from 1st January 2022 to 31st December 2022. **Results:** The microscopic examinations revealed that the suprarenal haemorrhage in 37 out of 55 (67.3%) asphyxia death cases. No haemorrhage was observed in the remaining 18 (32.7%) cases. **Discussions:** Roymedhi BC (1986-87) found definite histopathological changes in 44.29% of asphyxia deaths cases. The changes observed by Roymedhi BC were in the form of congestion and dilatation of blood vessels in the gland. The changes were both observed in the capsule and the substance of the glands. In some cases there was partial autolysis of the glands along with histopathological changes.

1. Introduction

Asphyxial deaths, including suicidal hanging, impose severe stress on the suprarenal glands during the agonal death. This leads to characteristic gross and histopathological changes in the glands.¹ Histopathology examines the cytological and tissue-level alterations in the diseased states. In asphyxia deaths, these histopathological changes in the suprarenal glands² aid forensic investigations.

Hanging ranks as a leading suicide method globally, causing over one million deaths annually and ranking among the top 10 causes of death worldwide. In India, it is the second most common method after poisoning. Incidence of suicide is rising over the past 30 years, particularly among young adults due to easy access to ligature materials and ligature points.³

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***Corresponding author:** Dr Raihan Uddin Ahmed, Associate Professor, Department of Forensic Medicine, Assam Medical College & Hospital, Dibrugarh, Assam, India. Email: rahmedamc@gmail.com

It is sometimes employed as a secondary method after failed attempts of throat-cutting or ingestion of poison.^{4, 5}

Sometimes there may be faint ligature mark in the neck of the deceased due to hanging. In such cases positive findings in the suprarenal glands may be considered while deciding the cause of death. The histopathological findings of suprarenal gland will thus also provide a lead to the investigating authority. This study investigates histopathological changes in the suprarenal glands from antemortem asphyxia deaths.

Changes on Suprarenal Glands in Asphyxial Deaths:

J.M.B. Bloodworth (1965), while discussing the response of the adrenal cortex to the stimulation of stress i.e. mental agony, found that within 18 to 24 hours, there occurs rapid loss of lipid from outer cortex of the gland. If the person survives there will be redeposition of lipid within next few days and if the stress continues hyperplasia of the cortex occurs. If the body cannot overcome the mental agony or stress, the patient within first few hours dies with a normal sized, lipid depleted brown cortex. If the stress continues for two to three weeks, first redeposition of lipid followed by nodular hyperplasia and then secondary loss of lipid will occur, resulting in moribund condition of the patient (called as “stage of exhaustion of Sclye). This secondary loss of lipid will accompany the microscopic hemorrhages and focal cortical cell death resulting mottled appearance of cortex with irregular foci of residual yellow lipid. Throughout these changes due to stress, the medulla remains unchanged. The finding of exhaustion appears at any time after 10 days to two weeks.⁴

I. Nakasono *et al* (1983), in the study of “Strangulation and adrenocortical secretion”, found that there was increase in the level of 17-hydroxycorticosteroids (17-OHCS) from the adrenal gland just before death by ligature strangulation. This study was conducted on anaesthetized dogs. He also observed that the secretion of 17-hydroxycorticosteroids was markedly decreased in condition when strangulation was made by rope around neck

under resting of stressful condition. It will be remained at extremely low levels until death. In case of constriction of neck by a rope only for a short period and on removal of the rope, it was found that there was a marked increase in the adrenal secretion of 17- OHCS. He said that the decrease of 17- OHCS was probably due to a blockage of endogenous supply of adrenocorticotropin (ACTH) to the adrenal gland by constriction of neck.⁶

Dysregulation in the Hypothalamic-pituitary-adrenal (HPA) axis contributes substantially to depression and suicidal behaviour. Szigethy *et al* compared postmortem adrenal gland weight and morphology between suicide victims and nonpsychiatric sudden death controls. Suicides exhibited significantly greater combined left-right adrenal weight, driven by left adrenal enlargement due to cortical hypertrophy. Left-right adrenal weight asymmetry in suicides aligns with hypotheses of lateralized HPA axis dysfunction from higher control centers.⁷

Hypothalamic-pituitary-adrenal (HPA) axis dysfunction plays major role in depression and suicidal behaviour. In a study by Eva Szigethy *et al*, the weight and morphology of postmortem adrenal glands were compared between suicide victims and sudden death, nonpsychiatric controls. The mean adrenal weight of the combined left and right glands was significantly higher in the suicide group; this difference was accounted for specifically by increases in left adrenal weight of suicides compared with the control group. It was observed that the increase in weight of the adrenal gland was due to cortical hypertrophy. The finding of left-right adrenal weight asymmetry in suicides is consistent with the hypothesis of abnormal lateralized input from higher control centres of the HPA axis.⁷

B.C. Roymedhi has studied the effect of hanging on histopathology of suprarenal glands and cervical lymph nodes during the period from February 1986 to March 1987. Out of 70 cases of death due to hanging, 31 cases (44.29%) showed definite histopathological changes in suprarenal glands and in 51 (72.86%) cases there was histopathological changes in cervical lymph nodes.⁸

Lee et al. (1987) assessed hypoxia effects

(8% O₂ in N₂) on nor-epinephrine and epinephrine turnover in the heart, adrenal gland, submaxillary gland and stomach. The study reported that the effects of hypoxia on the activities of sympathoadrenal system differ in different organs, like there is increased activity in the heart and adrenal gland, decreased on the submaxillary gland and elicited no changes in the stomach.⁹

A study was done by Cheng WT *et al* (2008) in West China School of Preclinical and Forensic Medicine, Sichuan University to analyse the relationship between adrenal haemorrhage and the cause of death, age and gender. 82 cases of adrenal hemorrhage were statistically analysed. It was found that adrenal hemorrhage occurred mostly in cases of death which are sudden, or occurred from infection, trauma and asphyxia.¹⁰

2. Materials and Method

Population and sample collection: Suprarenal glands were obtained from medico-legal autopsies of 55 asphyxial death cases referred to the Mortuary of Department of Forensic Medicine, Assam Medical College & Hospital, Dibrugarh, by investigating authorities. The specimens were collected over a period of one year from 1st January 2022 to 31st December 2022.

Inclusion and Exclusion criteria

- Inclusion: Mechanical asphyxia deaths; drowning cases with asphyxia as the cause of death.
- Exclusion: Postmortem interval > 24 hours.

Data Collection and Autopsy Procedure: Epidemiological data (age, sex, religion, occupation, socioeconomic status, and circumstances of death) were extracted from the inquest reports, dead body challans, and through detail interviews with relatives, neighbours, eyewitnesses and police officials. A detail and thorough postmortem examinations were performed on all cases. Institutional ethics committee's approval was also obtained from the Assam Medical College & Hospital Institutional Ethics committee.

Microscopic and Histological Processing: Suprarenal glands were examined microscopically (intact and longitudinal sections) for congestion, haemorrhage, colour changes and other pathological conditions. The suprarenal

glands were collected in wide-mouthed labelled glass bottles (including tissue name, postmortem number, collection date and serial number) containing 10 % formalin solution and transferred from the mortuary to the laboratory for processing, staining and examination for histopathology under the microscope.

Data Analysis: Postmortem (gross and microscopic) findings were categorized, tabulated, graphically represented and statistically analysed using Microsoft excel.

3. Results

This study examined suprarenal glands from 55 medico-legal autopsies of asphyxia deaths (**Table 1**). **Table 2** showed that suprarenal hemorrhage occurred in 31/44 (70.5%) hanging deaths; the remaining 13/44(29.5%) exhibited no histopathological changes. It is also observed from the **Table 3** showed that 30 (96.78%) cases showed bilateral hemorrhage in the substances of suprarenal gland and one (3.22%) case showed unilateral hemorrhage in the substances of suprarenal gland. **Table 4** revealed suprarenal gland enlargement and congestion in 70.7 % hanging deaths and the remaining 29.5% showed no gross changes.

Table 1: Total number of deaths due to asphyxia (n=55)

Death due to Asphyxia	Number (n)
Hanging	44
Drowning	10
Strangulation	1

Table 2: Total number of Suprarenal Hemorrhage

Total number of hanging cases studied	Suprarenal Hemorrhage seen	Hemorrhage not seen
44	31	13

Table 3: Unilateral and bilateral hemorrhages

Total number of hanging cases studied	Suprarenal hemorrhage seen	Unilateral hemorrhage seen		Bilateral hemorrhage seen	
		n	%	n	%
44	31	1	3.22	30	96.78

Table 4: Changes in the Suprarenal glands

Gross changes in the glands	Number (n)	Percentage (%)
Glands enlarged and congested	31	70.45
Glands showing no gross changes	13	29.55
TOTAL	44	100.00

Plate 1: Hemorrhagic areas seen in the suprarenal gland in case of a death due to hanging

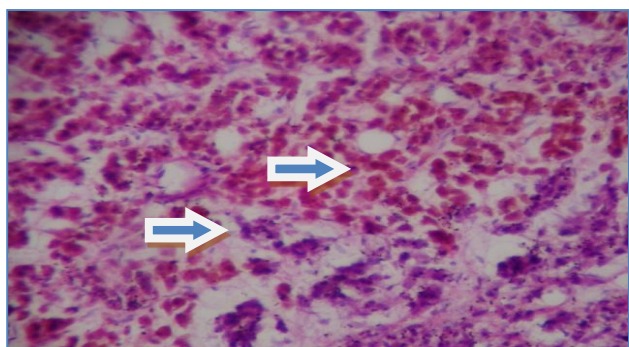


Table 5: Histopathological changes (microscopic hemorrhagic area) seen in death due to asphyxia (n=55)

Death due to asphyxia	Number (n)	Cases with suprarenal hemorrhage	
		n	%
Hanging	44	31	56.36
Drowning	10	5	9.09
Strangulation	1	1	1.80
TOTAL	55	37	67.27

One case of ligature strangulation was studied. The victim was a male of age 35 years. The suprarenal glands were found to be enlarged and congested, and petechial hemorrhage was found over the surface of the glands. The substance of both the glands showed a hemorrhagic area under microscope (**Plate 1**).

Table 5 represents the distribution of suprarenal hemorrhage among different types of asphyxia death. Out of the total number of 55 cases, hanging constituted 44 cases, out of which 31(56.36%) showed suprarenal hemorrhage on microscopic examination. Drowning accounted for 10 cases, with 5(9.09%) demonstrating suprarenal hemorrhage. A single case of strangulation was recorded, which also exhibited suprarenal hemorrhage (1.80%). Overall, suprarenal hemorrhage was observed in 37 cases (67.27%) of asphyxia deaths.

4. Discussion

It is seen from present study that in 70.45% cases of death due to hanging the suprarenal glands were enlarged and congested and 29.55% cases shows no gross changes in suprarenal glands. In these cases with enlarged and congested gland, hemorrhagic areas were found in substance of the gland. In all the cases the histopathological changes were bilateral except one case where unilateral histopathological changes were found.

There was also congestion and dilatation of capillaries of the glands. Roymedhi BC (1986-87) found definite histopathological changes in

44.29% of cases. The changes observed by Roymedhi BC were in the form of congestion and dilatation of blood vessels in the gland. The changes were both observed in the capsule and the substance of the glands. In some cases there was partial autolysis of the glands along with histopathological changes.^{8,9}

In the present study it was also observed that some of the individual cells undergo necrosis and dropout of tissue framework, sinusoids becomes dilated and congested, and small hemorrhages, in the extra glandular space seen.¹⁰ The colour of the cortex becomes mottled brown and red. Bloodworth JMB (1975) also found similar finding in the suprarenal glands.⁴ Innovative studies may facilitate further newer advancing knowledge in the field.^{11,12}

In deaths due to hanging out of 31 cases with microscopic hemorrhage in the substance of suprarenal glands, 25 (80.65%) cases showed hemorrhage only in the cortex, no cases showed hemorrhage only in the medulla and 6 (19.35%) cases showed hemorrhage in both cortex and medulla.¹³⁻¹⁶ In deaths due to drowning, out of 5 cases with microscopic hemorrhage in the substance of suprarenal glands, 4 (80%) cases showed hemorrhage only in the cortex, no cases showed hemorrhage only in the medulla and in one case (20%) hemorrhage was seen in both cortex and medulla.¹⁷⁻²⁰

5. Conclusion

The present study demonstrates that definite histopathological alterations occur in the suprarenal glands in substantial proportion of asphyxia deaths, with suprarenal hemorrhage observed in 62.27% of cases. Among the different types of asphyxia, all cases of hanging in this study were suicidal in nature. It is noteworthy that in certain instances of hanging, external signs such as ligature marks on the neck may be faint. In such circumstances, positive histopathological findings in the suprarenal glands may provide supportive evidence in determining the cause of death.

Furthermore, the observations suggest a possible association between mental stress or agony preceding death and its impact on the suprarenal glands, thereby offering additional supportive evidence alongside other autopsy

findings in the diagnosis of asphyxia deaths. Hanging emerged as the most common form of asphyxia death and remains a predominant method of suicide. The findings of this study may aid in correlating histopathological changes in the suprarenal glands with the gross features of hanging, thereby enhancing the accuracy of medico-legal importance.

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Conflict of interest: None to declare.

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Original Research Article

Criminological Insights into Medical Dispute Management: A Pilot Study from a Forensic and Criminological Perspective

Annisa A Muthahera*, Andi Muhammad Sofyan^b, Abd. Asis^b, Amir Ilyas^b, Muhammad Said Karim^b, Hijrah Adhyanti Mirzana^b, Lukman Setiawan^c, Edward Pandu Wiriansya^d, Ahmad Muchlis^e

^aMagister Program of Criminology, Postgraduate Program, Hasanuddin University and Department of Forensic Medicine and Medicolegal, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia, 90245.

^bDepartment of Criminal Law, Faculty of Law, Hasanuddin University, Makassar Indonesia, 90245. ^cDepartment of Management, Faculty of Economic and Business, University Bosowa Makassar City, 90231, Indonesia.

^dDirector, Ibnu Sina Hospital, Makassar City, 90231, Indonesia. ^eResearch and Community Service Institutions University Bosowa Makassar City, 90231, Indonesia.

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Key words

Medicolegal forensic analysis,
Medical disputes,
Criminology in healthcare,
Hospital legal responsibility.

Abstract

Background: Medical disputes in hospital settings represent complex socio-legal phenomena influenced by patient perceptions, institutional practices, and social control mechanisms, rather than purely clinical or legal issues. This study aims to analyze medical disputes at Hospital X Makassar from a criminological perspective and to examine the role of dispute management as a bridging mechanism between hospital legal responsibility and the application of Forensic and Medicolegal Medicine principles. **Methods:** This study employed a mixed-methods pilot design involving 35 patient complaint cases. Quantitative data were analyzed using exploratory regression models, while qualitative data were obtained through interviews and document reviews. **Results:** The regression model showed limited predictive power, with no significant overall model fit and a negative adjusted R-squared value. Qualitative findings revealed that most disputes were driven by communication gaps, perceived injustice, and information asymmetry rather than confirmed clinical negligence. **Discussion:** Criminological analysis indicates that conflict and labelling processes contribute to the escalation of disputes, whereas internal social control mechanisms play a role in preventing unnecessary criminalization of medical personnel. **Conclusion:** Medical disputes are predominantly non-clinical and should be managed through non-litigation approaches supported by Forensic and Medicolegal Medicine to ensure fair, objective, and sustainable dispute resolution.

1. Introduction

As a constitutional state, Indonesia requires healthcare services to meet both clinical and legal standards. Law No. 17/2023 reinforces hospitals'

legal responsibilities, including the obligation to protect healthcare workers. Legal disputes involving patients often arise from dissatisfaction,

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*Corresponding author: Annisa A Muthaher, Department of Forensic Medicine and Medicolegal, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia, 90245. Email: annisaanwar@unhas.ac.id

misunderstandings, or alleged negligence, each of which carries significant legal implications.^{1,2}

Forensic and medicolegal disciplines play a key role in evaluating such cases through medical record audits, *visum et repertum*, and the 4D framework (Duty, Deviation, Damage, Direct Cause).³ However, medicolegal analysis alone cannot fully explain the social factors that drive patient complaints against physicians.⁴ Criminological theories of labeling, conflict, and social control help clarify how communication gaps, institutional weaknesses, and emotional stress can escalate disputes into legal conflicts.^{5, 6, 7, 8, 9}

Despite existing regulations, many Indonesian hospitals still face challenges, including a limited number of forensic specialists, inconsistent documentation, and weak coordination with legal authorities.^{10, 11} Prior studies have often examined malpractice or legal protection separately, with little integration of medicolegal and criminological perspectives.^{12, 13}

RS X Makassar offers a relevant case owing to its role as a referral center that frequently handles medicolegal disputes. Issues such as inconsistent procedures and low legal awareness indicate gaps between regulations and practices.

This study aims to analyze medical disputes at RS X Hospital Makassar through a criminological lens within the framework of Forensic and Medicolegal Medicine, contributing to the development of fair, objective, and sustainable medical dispute resolution.

2. Methods

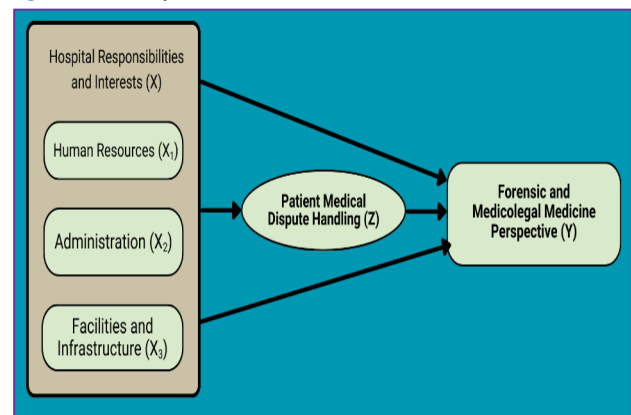
This study employed a mixed-methods approach^{14, 15}, integrating quantitative analysis through questionnaires with qualitative insights from in-depth interviews to comprehensively examine medical dispute handling at Hospital X in Makassar, a regional referral hospital with an active Medicolegal Clinic, conducted between February 2024 and October 2025 (Figure 1). The quantitative component analyzed the influence of hospital legal liability, patient legal case handling mechanisms, and the application of Forensic Medicine and Medicolegal principles, while the qualitative component explored legal, organizational, and criminological dimensions that could not be fully captured statistically. Data sources consisted of primary data from questionnaires and interviews, and secondary data including medical records, audit reports, medicolegal

documents, regulations, and scientific literature. Using purposive sampling, 35 patient respondents who had submitted complaints or medical disputes, along with key informants, were included.

Considering the limited sample size, this study was designed as a quantitative exploratory pilot study aimed at identifying preliminary patterns and contributing factors of medical disputes. Quantitative data were measured using a five-point Likert scale and analyzed through descriptive statistics and exploratory path analysis, supported by validity, reliability, and classical assumption tests to ensure robust and unbiased results, ultimately generating an initial conceptual model to guide future research with larger samples. The path analysis was applied in an exploratory manner to examine potential relationships among variables.

The Institutional Ethics Committee determined that this study was exempt from full ethical review because it involved anonymous survey data and posed minimal risk to participants.

Figure 1: Conceptual Framework



3. Results

Forms and Criminological Analysis of Patient Medical Disputes Based on Forensic and Medicolegal Theory Perspectives

The following data summarizes and analyzes the types of medical disputes reported by 35 respondents at Hospital X Makassar. The classification was developed by grouping recurring patterns of patient complaints and subsequently linking each form of dispute with relevant criminological explanations, including labeling theory, conflict theory, and social control theory.

Based on the table 1, most medical disputes (more than 50%) stem from operational service aspects, particularly waiting times, rather than

substantive medical negligence. Disputes that actually lead to allegations of medical negligence are very minimal, and after analysis using a Forensic Medicine and Medicolegal approach (4D: duty, deviation, damage, direct cause), no elements of negligence were found to be fully fulfilled. These findings confirm that the majority of medical disputes at Hospital X Makassar are service-related, influenced by miscommunication, patient expectations, and social dynamics, rather than pure clinical errors.

Table 1 also shows that most medical disputes stem not from crime or medical negligence but from social dynamics, conflicts of interest, and labeling processes in healthcare interactions. Conflict theory dominates system- and service-based disputes, whereas labeling theory explains the escalation of complaints due to perceptions and stigma against medical personnel or hospitals. Social control theory plays a crucial role in limiting the escalation of disputes through objective forensic and medicolegal mechanisms.

Research Instrument Testing

The questionnaire items were evaluated through validity and reliability testing using an initial distribution to 35 patients of Hospital X in Makassar who had submitted service complaints. All 25

statement attributes were valid at a 95% confidence level. The reliability test showed a Cronbach's α value above 0.60, indicating low measurement error and consistent results over repeated use.

Path Analysis.

Table 2 presents the results of the path analysis examining the direct and indirect relationships among hospital legal responsibility (X), forensic and medicolegal principles (Y), and the handling of patient medical disputes (Z) at Hospital X Makassar.

Note: Path a represents the effect of X on Y, Path b represents the effect of Y on Z, Path c represents the total effect of X on Z, and Path c' represents the direct effect of X on Z after controlling for Y. The mediation effect of Y is weak, indicating that forensic and medicolegal principles do not significantly mediate the relationship between hospital legal responsibility and the handling of medical disputes.

Overall, the path analysis indicates that hospital legal responsibility has a strong direct effect on the handling of medical disputes, while the mediating role of forensic and medicolegal principles is relatively weak, suggesting that dispute resolution is predominantly influenced by direct institutional and legal mechanisms rather than indirect medicolegal mediation.

Table 1: Forms and Criminological Analysis of Patient Medical Disputes Based on Forensic and Medicolegal Perspectives at Hospital X Makassar (n = 35)

No	Forms of Medical Disputes	Short Description	Hospital Interests and Responsibilities	Number of Cases	Percentage (%)	Relevant Criminological Analysis	Forensic and Medicolegal Perspectives
1	Long service waiting time	Complaints regarding long queues for registration, polyclinics, pharmacies, or doctor delays due to visits/emergencies, but not proven by 4D analysis	Administration (X ₂)	18	51,4	Conflict Theory Disputes arise from the imbalance of interests between patient needs for prompt service and limited hospital resources. Conflicts are triggered by patient expectations that do not align with the capacity of the service system.	Duty: Long waiting times do not indicate deviation, as hospitals follow standards, increase staff, and prioritize care amid high patient volumes. Damage: Generally, no direct medical harm is found, only subjective discomfort or dissatisfaction. Direct Causal Relationship: There is no direct causal link between waiting time and medical harm, thus negligence criteria are not met.
2	Miscommunication of medical/administrative information	Patients/families feel that they have not been explained, even though informed consent or an explanation has been given, but this has not been proven by 4D analysis.	HR (X ₁)	7	20,0	Labeling Theory: Patient misunderstandings can lead to medical personnel or hospitals being labeled as "non-transparent" or "negligent," even if procedures and informed consent have been followed. Negative labels arise from	Duty: Medical information was delivered per informed consent standards, with no deviation, despite the patient's limited subjective understanding Damage: The loss was non-medical and mild psychological, with no clinical impact. Direct Causal Relationship: No direct causal relationship was found, as no medical injury

						the patient's subjective interpretation.	resulted from the miscommunication.
3	Patient referral and discharge disputes	Refusal of referral, objection to being discharged/forced to go home (Hospital type B should be Hospital type A), but not proven by 4D analysis	Facilities and infrastructure (X ₃)	4	11,4	Conflict Theory & Social Control: Conflict arises from differences in medical and emotional perceptions between patients and families. Hospitals exercise social control through referral standards and clinical policies that patients may not always understand.	Duty: Physicians are required to make referrals and discharges according to medical indications and clinical standards. Deviation: There was no deviation, as referral/discharge decisions were in accordance with guidelines. Damage: There were no cases of objective health damage. Direct Causal Relationship: A causal relationship between the medical action and the loss was not proven forensically and medicolegally, therefore, the element of negligence was not met.
4	Administrative and financing disputes (BPJS/General)	Complaints related to BPJS status, non-covered costs, or changes in patient status, but not proven by 4D analysis	Administration (X ₂)	3	8,6	Conflict Theory: Disputes are fueled by the complex structure of the healthcare financing systems. Information imbalances and perceived administrative power give rise to conflicts between patients and institutions.	Duty: The hospital is obligated to carry out administration in accordance with the applicable regulations and financing systems. Deviation: No administrative errors occurred; miscommunication stemmed from limited understanding of BPJS rules, and application use did not constitute medicolegal violations. Damage: No physical or medical damage was found to the patient. Direct Causal Relationship: There was no direct causal relationship between the administrative issues and the patient's medical injury because no physical injury was found.
5	Perception of unprofessional /unfriendly service	Allegations of unfriendly or unprofessional behavior of officers without evidence of medical negligence, but not proven by 4D analysis	HR (X ₁)	2	5,7	Labeling Theory: Subjective assessments of an officer's behavior lead to negative labeling of an individual or institution, even when there is no apparent ethical or legal violation.	Duty: Healthcare workers have an ethical obligation to behave professionally. Deviation: A perceived unfriendly impression was observed, while no deviation from professional standards was observed because the medical and healthcare workers were providing emergency care to another patient. Damage: No medical harm was found. Direct Causal Relationship: There was no direct causal relationship between the healthcare worker's behavior and the patient's health impairment.
6	Alleged medical action/medical negligence	Initial complaints pointed to allegations of negligence, but were not proven by 4D analysis.	Facilities and infrastructure (X ₃)	1	2,9	Social Control Theory: Hospitals and Forensic Medicine and Medicolegal mechanisms serve as formal social control tools to objectively assess whether there are	Duty: Doctors have legal and professional obligations to adhere to medical standards of care. Deviation: There was no deviation from professional standards because it was only related to the hospital's application system experiencing a network outage,

						elements of medical negligence based on a 4D analysis.	which resulted in a patient's status changing from alive to dead. Damage: There was no actual damage or injury to the patient, only material loss due to the change in status, which can be addressed with system repairs. Direct Causal Relationship: There is no causal relationship between the medical action and the patient's loss because it is not directly related to the medical injury but only to the change in status in the system.
Total				35	100		

Source: Research Data, 2025.

Table 2: Path Analysis Results of the Mediation Model (n = 35).

Path	Relationship	Standardized Coefficient (β)	Test Statistic	p-value	Effect Type	Interpretation
Path a	Hospital Legal Responsibility (X) → Forensic and Medicolegal Principles (Y)	-0.112	F = 0.420	0.740	Direct	Not significant
Path b	Forensic and Medicolegal Principles (Y) → Handling of Medical Disputes (Z)	0.487	t = 3.215	0.003	Direct	Significant positive effect
Path c	Hospital Legal Responsibility (X) → Handling of Medical Disputes (Z)	0.652	F = 9.380	0.000	Direct	Significant effect
Path c'	Hospital Legal Responsibility (X) → Handling of Medical Disputes (Z) (controlling Y)	0.598	—	< 0.01	Direct (Adjusted)	Still significant
Indirect Effect	X → Y → Z	-0.054	—	—	Indirect	Weak mediation effect
Total Effect	X → Z (c + ab)	0.598	—	—	Total	Dominated by direct effect

4. Discussion

To further interpret the empirical findings, a criminological framework was applied to explain the underlying mechanisms of medical disputes.

Table 3: Criminological Interpretation of Medical Disputes Based on Forensic and Medicolegal Perspectives (n = 35).

Type of Medical Dispute	Frequency (%)	Key Characteristics	Criminological Interpretation
Waiting time complaints	51.4%	Service delay, high patient load	Conflict theory
Miscommunication	20%	Information gap, misunderstanding	Labeling theory
Referral disputes	11.4%	Disagreement on medical decisions	Conflict theory
Administrative issues	8.6%	BPJS, financing confusion	Social control theory
Service perception	5.7%	Attitude, communication tone	Labeling theory

Table 3 presents an integrated analysis linking the empirical forms of medical disputes with relevant criminological theories to explain their underlying dynamics. It demonstrates that most disputes arise from systemic, communication, and perceptual factors rather than actual medical negligence, with conflict, labeling, and social control theories providing the primary explanatory frameworks. This confirms that medical disputes are multidimensional phenomena that must be

interpreted beyond purely clinical or legal perspectives.

Overview of the Forms and Factors Causing Patient Medical Disputes at Hospital X in Makassar

Based on 35 respondents at Hospital X Makassar, medical disputes were multidimensional, shaped by service quality, communication, administration, structural limits, and psychosocial factors. The most frequent dispute involved long waiting times (51.4%), reflecting gaps between patient expectations and hospital constraints, rather than medical malpractice. Patients often do not fully understand this situation, which triggers negative perceptions of the hospital.¹⁶ The second most common form of dispute involved miscommunication of medical and administrative information, occurring in seven cases (20%). Although medico-legal verification showed that explanations and informed consent were generally provided according to procedure, limited health literacy, patients emotional conditions, and complex medical terminology contributed to misunderstandings. This indicates that many medical disputes stem from differences in interpretation rather than from breaches of professional standards.¹⁷

Disputes concerning patient referrals and discharge decisions were identified in four cases (11.4%). These disputes generally arose from conflicts between clinical judgments based on professional standards and the emotional expectations of patients' families, who in some instances perceived referral or discharge decisions as neglect despite their basis in medical indications, service efficiency, and patient safety considerations. This confirms that medical disputes are inseparable from the psychological and relational factors between medical personnel and patients.¹⁸ Administrative and financing-related disputes were identified in three cases (8.6%), primarily involving the BPJS Kesehatan system. These complaints included changes in membership status, costs not covered by insurance, and inconsistencies in administrative procedures, where the complexity of healthcare financing regulations often led patients to perceive the hospital as obstructing access to services. In this context, disputes arise as a consequence of complex structural systems, not from the individual errors of medical staff.¹⁹

Another form of dispute involved perceptions of unprofessional or unfriendly service, reported in two cases (5.7%). These disputes were largely subjective, without evidence of ethical or legal violations, and were mainly influenced by staff attitudes, communication style, and patients' expectations for empathy and personal attention. Factors such as healthcare worker fatigue and high service burden influence the dynamics of these interactions.^{20, 21}

Interestingly, among all analyzed dispute cases, only one case (2.9%) explicitly indicated alleged medical negligence.²² However, a forensic and medicolegal review using the 4D principle (duty, deviation, damage, and direct cause) showed that the case did not fully satisfy all elements required to establish medical negligence.²³ These findings underscore that most medical disputes do not automatically carry medicolegal implications, as disputes at early stages are predominantly administrative or social in nature, with forensic assessment becoming relevant only when there is a clear indication of deviation from professional standards.^{4, 18, 24, 25}

Relationships between Variables and Criminological Analysis of Patient Medical Disputes

1. Relationships Between Variables

The statistical results show that the simultaneous regression model assessing the influence of hospital interests and legal responsibility on patient medical disputes is not significant, with only the facilities and infrastructure variable demonstrating a significant partial effect, indicating that patients most clearly perceive legal responsibility through the adequacy of services provided. In contrast, human resources and administrative aspects did not show significant relationships, as they tend to be viewed by patients as standardized components of the system. Furthermore, medical disputes do not function significantly as an intervening variable between hospital legal responsibility and the application of forensic and medicolegal principles, largely due to differences in data characteristics, where subjective patient perceptions contrast with the objective evidence required in forensic–medicolegal analysis, reinforcing the conclusion that most medical disputes are administrative or social in nature and only gain medicolegal relevance when there is a clear indication of professional standard violations.

2. Criminological Analysis of the Dynamics of Medical Disputes from a Forensic and Medicolegal Perspective

The findings show that medical disputes are predominantly driven by systemic and perceptual factors rather than professional medical negligence. Most disputes involve long waiting times (51.4%) and miscommunication of medical or administrative information (20%), while allegations of medical negligence account for only 2.9% of cases. From a criminological perspective, this pattern aligns with conflict and labelling theories, where disputes arise from unequal expectations, limited resources, and subjective patient interpretations that may lead to negative labelling of healthcare workers. In line with Health Law No. 17 of 2023, such disputes should not be immediately framed as criminal acts, as the law emphasizes legal protection, proportional dispute resolution, and the prevention of unnecessary criminalization of medical practice through ethical and disciplinary mechanisms.²⁰

Government Regulation No. 28 of 2024 further reinforces the prioritization of non-litigation dispute resolution and the use of forensic and medicolegal analysis, particularly the 4D framework, as an

objective filter before legal escalation. Most cases fail to meet the elements of damage and direct causality required for medical negligence. The Professional Disciplinary Council functions as a formal social control mechanism, ensuring balance between patient protection and professional accountability. Overall, medical disputes should be addressed through preventive measures, effective communication, internal mediation, and proportional forensic-medicolegal evaluation, reflecting a rational and fair approach to managing conflicts in healthcare services.²³

Theoretical and Practical Implications and Strategic Recommendations

Theoretically, this study confirms that medical disputes constitute a multidimensional socio-legal phenomenon and cannot be reduced to purely technical medical issues. A clear distinction exists between disputes based on patient perceptions and medical negligence, which can only be determined objectively through Forensic Medicine and Medicolegal analysis.²⁵ From a normative perspective, dispute handling is grounded in Indonesia's health and legal framework, emphasizing hospitals' responsibility to protect both patients and healthcare workers through adequate human resources, administration, and facilities. Criminologically, medical disputes are best explained through conflict, labelling, social control, and strain theories, highlighting information gaps, power imbalances, and systemic pressures rather than negligence alone. The study recommends prioritizing non-litigation, science-based dispute resolution through internal hospital mechanisms and forensic-medicolegal evaluation, with restorative justice as an alternative when internal resolution fails, to ensure proportional, fair, and humane outcomes for all parties.

Study Limitation

One limitation of this study is the relatively small sample size, which restricts the generalizability of the statistical results. Therefore, the findings should be interpreted as preliminary insights into the dynamics of medical disputes in hospital settings. Future studies with larger and more diverse samples are necessary to validate the proposed model.

5. Conclusion

This study concludes that medical disputes at Hospital X in Makassar are predominantly non-clinical

in nature, mainly arising from miscommunication, prolonged waiting times, referral and discharge issues, financial administration, and perceptions of healthcare workers' attitudes and professionalism, which are driven by information gaps, limited patient understanding, emotional factors, and systemic service constraints. Criminological analysis indicates that these disputes are largely shaped by conflict theory, with labelling and social control theories also playing significant roles, demonstrating that disputes emerge not only from alleged medical negligence but also from relational imbalances and perceptions of injustice. The application of forensic and medico legal science through an early 4D analysis functions as an effective mitigation mechanism to identify cases with legal potential, enabling fair, proportional, and predominantly non-litigation dispute resolution while preventing the criminalization of medical personnel.

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Original Research Article

Accuracy Evaluation of 3D Palatal Rugae for Personal Identification in Monozygotic Twins: A Pilot Study

Riki Kristanto^{a*}, Icha Oktavia^b, Ni Luh Desy Ayu Susilahati^c, Desak Nyoman Ari Susanti^d

^aDepartment of Forensic Odontology; ^bBachelor of Dentistry; ^cDepartment of Periodontic; ^dDepartment of Dental Material; School of Dentistry, Faculty of Medicine, Udayana University, Indonesia.

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Abstract

Background: Rugoscopy serves as a vital alternative for personal identification when primary methods like fingerprints or DNA are unavailable. While 3D scanning offers digital advantages, its application for palatal rugae analysis in Indonesia remains limited. **Objective:** To evaluate the concordance between traditional study models and 3D scanning technology in identifying palatal rugae patterns among monozygotic twins. **Methods:** This cross-sectional analytic observational pilot study specifically focused on 10 pairs of monozygotic twins ($n = 20$). Palatal rugae were recorded using both physical study models and 3D scanning, then classified based on Thomas and Kotze's criteria (number, length, shape, and unification). Data were analyzed using paired t-tests for mean differences and Pearson's correlation to determine the strength of association between the two methods. **Results:** Descriptive analysis showed a consistent distribution of the dominant wavy pattern and divergent unification across both methods. Statistical analysis revealed no significant differences between study model and 3D scanning measurements for wavy ($p=0.100$) and divergent types ($p=0.083$). Furthermore, a strong positive correlation was observed between the two methods for both wavy ($r=0.888$, $p<0.001$) and divergent types ($r=1.000$, $p<0.001$). **Conclusion:** The 3D scanning method demonstrates high agreement with traditional study models, confirming its feasibility as a reliable digital tool for forensic identification. Despite being monozygotic twins, distinct variations in palatal rugae patterns were still identifiable, supporting the uniqueness of rugoscopy.

1. Introduction

Forensic identification is a critical component of medicolegal investigations, particularly in cases involving mass disasters, criminal acts, or decomposed remains. While DNA analysis, fingerprinting, and dental records are the primary methods of identification, their application

can be limited when bodies are severely burned, decomposed, or when antemortem records are unavailable.^{1,2,3} In such scenarios, alternative biometric markers that are resistant to post-mortem changes become essential for establishing identity.^{4,5}

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***Corresponding author:** Dr Riki Kristanto, Department of Forensic Odontology, School of Dentistry, Faculty of Medicine, Udayana University, Indonesia. Email- riki.kristanto@unud.ac.id

Rugoscopy, the study of palatal rugae, has emerged as a reliable alternative in forensic odontology. Palatal rugae are unique, stable, and protected by their anatomical position, making them highly resistant to high temperatures, chemical trauma, and decomposition.^{4,5,6} These patterns are so distinct that they remain individualistic even among monozygotic twins, despite their identical genotypes and phenotypes.^{8,9,10} While factors such as orthodontic treatment or thumb-sucking habits can influence minor changes, the core characteristics of the rugae remain a robust tool for personal identification.^{1,11}

Conventionally, rugoscopy is performed using plaster study models. However, these physical models have significant limitations, including their fragility, the risk of degradation over time, and the need for extensive physical storage space.^{12, 13} The transition to digital 3D scanning technology offers a transformative solution. 3D scanning allows for the conversion of physical impressions into high-resolution digital files that are easily stored, retrieved, and analysed.^{14,15} Recent studies, such as those by Simon et al. (2020) and Yilmaz et al. (2019), have demonstrated that 3D digital models provide the necessary efficiency and accuracy to distinguish individuals, including monozygotic twins, for forensic purposes.¹⁶⁻²¹

Despite these global technological advancements, forensic practice in Indonesia still predominantly relies on conventional study models.^{5, 22} There is a significant research gap regarding the accuracy and implementation of 3D digital rugoscopy within the Indonesian forensic context. Given the high demand for efficient and accurate identification methods in the region, evaluating digital alternatives is imperative.

This pilot study aims to evaluate the concordance of palatal rugae measurements between conventional study models and 3D scanning technology. By utilizing monozygotic twins—who represent the highest degree of phenotypic similarity—this research seeks to determine the accuracy and feasibility of 3D scanning as a digital approach for personal identification in forensic dentistry.^{10, 16}

2. Materials and Methods

Study Design and Ethical Approval

This analytic observational study employed a cross-sectional design to evaluate the concordance between conventional study models and digital 3D

scanning. The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Udayana University (No: 0002/UN14.2.2.VII.14/LT/2024). As this research serves as a pilot study to assess the feasibility of digital rugoscopy in a specific population, a sample size of 10 pairs of monozygotic twins ($n = 20$) was recruited. Quota sampling was utilized to ensure the inclusion of rare monozygotic twin pairs who met the stringent inclusion criteria within the study period.^{16,10}

Participant Selection

Participants were selected based on the following inclusion criteria: monozygotic twins aged 16–50 years with healthy oral conditions. Exclusion criteria included history of palatal clefts, active oral lesions (trauma, viral infections, or symptoms of sexually transmitted diseases), current orthodontic treatment, use of removable dentures, or recent tooth extractions that could alter the palatal architecture. Informed consent was obtained from all participants after a thorough explanation of the procedure.

Data Collection and Model Preparation

Clinical history and intraoral examinations were performed to ensure suitability. Maxillary impressions were taken using high-quality alginate (Hygident) and immediately poured with Type III dental stone (Formula Saint-Gobain Pro Dental) to minimize dimensional distortion.¹² To ensure stability during the digital acquisition, a standardized base was prepared for each stone model. Each model was coded with initials to maintain anonymity and stored in protective packaging to prevent physical damage.

3D Scanning and Digital Acquisition

The physical study models were converted into digital format using a high-precision laboratory 3D scanner (3Shape). The resulting digital files were exported in Standard Tessellation Language (.stl) format. All digital measurements and visualizations were performed using the 3Shape ScanIt Dental software (version 2.1.9.1).

Palatal Rugae Analysis and Measurement Units

Palatal rugae patterns were identified and classified according to the criteria established by Thomas and Kotze (**Figure 1**). The evaluation included:

- Rugae Number:** The total count of identifiable rugae on both sides of the palate.
- Rugae Length:** Categorized into primary (>5 mm), secondary (3–5 mm), and fragmentary (2–3 mm).

For statistical analysis, the cumulative length of each category was recorded in millimeters (mm).

3. **Shape and Unification:** Classified as curved, wavy, straight, or circular, and unification as convergent or divergent.

Measurement Reliability and Calibration

To minimize measurement bias and ensure high diagnostic accuracy, all procedures on both physical models (**Figure 2**) and 3D scans (**Figure 3**) were conducted by a single examiner who underwent a rigorous three-stage calibration process, with the entire measurement and classification process overseen and validated by two senior forensic odontology supervisors to ensure strict adherence to Thomas and Kotze's criteria. Intra-observer reliability was subsequently assessed by re-measuring 20% of the total samples after a two-week interval, where the calculated Intraclass Correlation Coefficient (ICC) exceeded 0.90, indicating excellent consistency and reliability of the measurements.

Statistical Analysis

Data were analyzed using SPSS software (version 26). Descriptive statistics were used to characterize the rugae patterns. The Shapiro–Wilk test confirmed the normal distribution of the data. To compare the mean values between the study models and 3D scans, a paired t-test was applied. The strength of the relationship between the two methods was evaluated using Pearson's correlation. Statistical significance was set at $p < 0.05$. For results where $p > 0.05$, it was interpreted as no statistically significant difference between the two methods, indicating high concordance.

3. Results

Characteristics of Palatal Rugae Patterns

The distribution of palatal rugae patterns among the 10 pairs of monozygotic twins was identified using both conventional study models and 3D digital scans. Descriptive analysis (**Table 1**) revealed that primary rugae (>5 mm) were the most prevalent across all samples. The wavy shape was the dominant pattern identified in both methods (Mean: Model = 9.18 mm; Scan = 8.93 mm), followed by the curved and straight types. Regarding unification, the divergent type was the most frequent pattern observed (Mean: Model = 13.41 mm; Scan = 13.56 mm). The low standard deviation values across both platforms suggest high data homogeneity, indicating that 3D scanning captures rugae morphology with a level of consistency comparable to traditional gypsum models.

Figure 1: Forms of Palatal Rugae According to the Thomas and Kotze Classification.

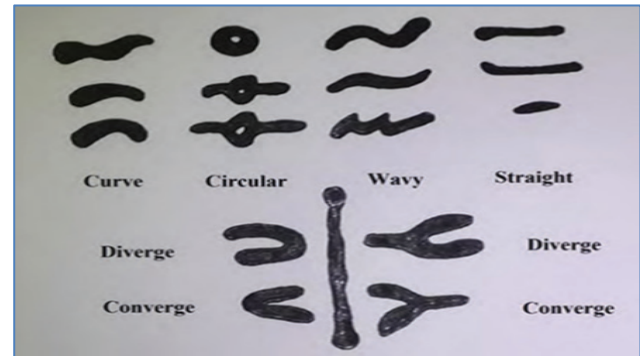


Figure 2: Study Model.

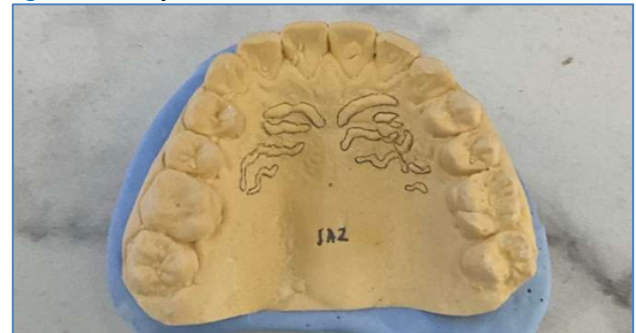
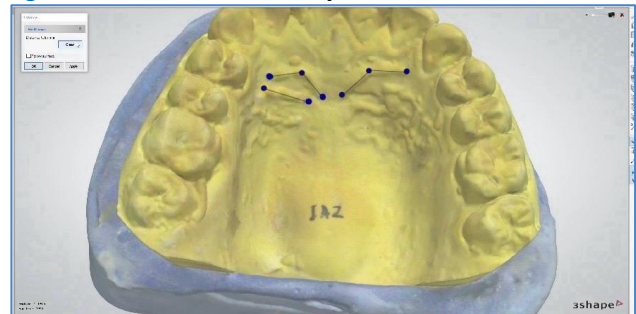


Figure 3: 3D Scan of the Study Model.



Methodological Concordance and Statistical Analysis

Data normality was confirmed via the Shapiro–Wilk test ($p > 0.05$), as detailed in **Table 2**, allowing for parametric comparative testing. To evaluate the agreement between the two measurement methods, a paired t-test was performed on the dominant patterns (Wavy and Divergent). The analysis revealed no statistically significant differences between the study models and 3D scans for the wavy type ($p = 0.100$, $p > 0.05$; that Wavy Model – Wavy 3D Scan) or the divergent type ($p = 0.083$, $p > 0.05$; Divergent Model – Divergent 3D Scan). These findings indicate that the digital 3D scanning method does not significantly deviate from the conventional gold standard in measuring rugae dimensions.

Correlation Analysis

The relationship between physical and digital measurements was assessed using Pearson's

correlation (**Table 3**). A strong and significant positive correlation was observed for the wavy pattern ($r=0.888$, $p<0.001$). For the divergent unification type, the analysis yielded a correlation coefficient of $r=1.000$ ($p<0.001$). While a perfect correlation is rare in biological studies, this result in our sample ($n=6$ for divergent type) reflects the high precision of the 3D software in replicating the linear unification patterns found on the physical models.

Table 1: Descriptive Statistics of Palatal Rugae Measurements in Study Models and 3D Scans

Rugae Type	N	95% CI		Mean	Std. Deviation
		Min.	Max.		
Wavy model	20	5.79	11.80	9.1845	1.30294
Wavy scan	20	5.47	11.80	8.9385	1.37081
Curved model	18	4.40	10.30	7.4522	1.66012
Curved scan	18	5.02	11.00	7.6367	1.71465
Circular model	5	7.84	15.37	10.1500	3.10924
Circular scan	5	8.63	15.69	10.4020	3.03535
Straight model	18	2.55	10.01	5.4033	2.00519
Straight scan	18	2.19	9.92	5.3428	2.04887
Divergent model	6	7.40	27.25	13.4133	7.18293
Divergent scan	6	7.53	27.43	13.5650	7.18433
Konvergent model	2	7.50	9.80	8.6500	1.62635
Konvergent scan	2	7.70	10.00	8.8500	1.62635

Table 2: Shapiro–Wilk Normality Test Results of Dominant Palatal Rugae Types in Study Models and 3D Scans

	Statistic	df	p-value
Wavy model	.958	20	.511 ^a
Wavy scan	.942	20	.267 ^a
Divergent model	.796	6	.054 ^a
Divergent scan	.796	6	.054 ^a

Note: a: normal distribution.

Table 3: Pearson Correlation Test Results of Palatal Rugae in Study Models and 3D Scans

		p-value	Correlation Coefficient
Wavy	Study Model	0.000 ^a	0.888
	3D Scan		
Divergent	Study Model	0.000 ^a	1.000
	3D Scan		

Note: a: significant correlation.

4. Discussion

The high concordance observed between conventional study models and 3D scanning in this pilot study underscores the reliability of digital rugoscopy as a robust forensic tool. The absence of statistically significant differences ($p>0.05$) between the two methods for both wavy and divergent patterns suggests that digital acquisition effectively preserves the morphological integrity of palatal rugae, making it a viable alternative to traditional physical casts. The uniqueness of palatal rugae, even among monozygotic twins, is rooted in complex embryological development. Although monozygotic

twins share identical genotypes, the formation of palatal rugae between the 12th and 14th weeks of intrauterine life is influenced by localized epigenetic factors and the dynamic environment of the fetal oral cavity. Factors such as the mechanical pressure from the developing tongue, the growth rate of the palate, and subsequent environmental influences—including thumb-sucking habits, orthodontic forces, or localized trauma—contribute to the distinct phenotypic expression of rugae patterns.^{1,3,11}

This biological individuality explains why the twins in this study exhibited distinguishable rugae variations despite their genetic identity, reinforcing rugoscopy's status as a "fingerprint" of the hard palate. The finding that palatal rugae can distinguish between monozygotic twins is consistent with the theory of epigenetic variation during prenatal development. While monozygotic twins share an identical genetic blueprint, the morphological development of the palate is a stochastic process influenced by the "micro-environment" of the amniotic sac. According to recent studies^{10,11}, even if the genetic signalling for palatal shelf elevation is identical, the physical space, tongue position, and localized pressure within the uterine environment differ for each twin. This results in subtle but permanent variations in the length, shape, and unification of the rugae.^{10,11}

Furthermore, the stability of these patterns post-birth adds to their forensic value. Unlike other physical traits that may converge in identical twins due to similar lifestyles, palatal rugae are protected by the buccal fat pads and the tongue, remaining unchanged by age or minor systemic physiological shifts. This study confirms that 3D scanning technology is sensitive enough to capture these minute "epigenetic signatures" that distinguish one twin from another, which is often impossible through DNA analysis alone in forensic settings.^{15,16} These anatomical nuances justify the use of rugoscopy as a definitive secondary identifier in specialized odontological cases.

Transitioning from physical study models to 3D scanning offers transformative advantages in forensic odontology. Traditional gypsum models are inherently fragile, prone to dimensional changes over time, and require significant physical storage space.^{12,13} In contrast, 3D scanning produces immutable .stl files that can be stored in cloud-based databases, encrypted for security, and transmitted instantly for global forensic consultation. In the Indonesian

context, where geographical barriers can delay the transport of physical evidence, a digital rugoscopy workflow could significantly expedite victim identification in mass disaster or criminal investigations, particularly when primary identifiers like fingerprints or DNA are compromised.^{4, 5} Our findings align with international studies that validate the precision of digital dental technology. The strong correlation ($r=0.888$ to 1.000) observed in this study mirrors the results of Yilmaz et al.¹⁷ and Taneva et al.,¹⁰ who found no significant differences between digital and manual measurements of dental arches and rugae. The "perfect" correlation ($r=1.000$) found in the divergent unification type, while statistically rare in larger biological datasets, likely reflects the high precision of the 3Shape software in replicating linear landmarks within our specific sample size ($n=6$). Furthermore, our results support the conclusions of Simon et al., who successfully distinguished monozygotic twins using intraoral scanners, highlighting that 3D technology captures minute morphological nuances that are essential for forensic differentiation.¹⁶ Despite the high accuracy reported, the implementation of digital rugoscopy in forensic practice faces hurdles.¹⁸⁻²⁰ The initial accuracy of the digital file remains heavily dependent on the quality of the primary impression.²¹⁻²³ While alginate is a cost-effective material with satisfactory accuracy, any procedural error during the impression-taking or gypsum-pouring stage will be duplicated in the 3D scan.²⁴ Additionally, the high cost of laboratory and intraoral scanners remains a primary barrier to widespread adoption in developing forensic facilities. There are other modalities for human identification such as brain fingerprinting.²⁵

Future research on palatal rugae in monozygotic twins is expected to involve a larger sample size to provide greater variation, thus offering a more comprehensive overview and enhancing the validity of the findings. Furthermore, future studies should use both study models and intraoral 3D scanning applied directly in the patient's oral cavity to advance and expand upon the present research.

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Case Series

Preliminary Thin Layer Chromatography Analysis of *Cerbera Odollam* in Oral Fluid

Ashwathi Vijayan^a, Reena Susan Philip^{b*}

^aResearch Scholar, ^bAssociate Professor & PhD Guide, Department of forensic science, JAIN (Deemed to be University), Bangalore, Karnataka, India, 560027.

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Abstract

The detection and recovery of toxic compounds is a critical aspect of **forensic toxicology**. This study investigates the use of Thin Layer Chromatography (TLC) for the detection of toxic compounds in the *Cerbera odollam* plant, known for its traditional use in various medicinal applications but also associated with potential poisoning incidents. We aimed to isolate and identify the phytochemicals in saliva, a vital matrix for assessing poisoning cases. Oral fluid samples were collected from 20 healthy individuals and prepared using appropriate extraction techniques, followed by **TLC analysis** with optimized solvent systems. This study underscores the importance of TLC as a rapid screening tool in toxicological assessments, offering valuable insights for further investigations into the safety and pharmacological properties of *Cerebra odollam*. The developed chromatograms were analyzed for specific retention factors (R_f values) ranging between 0.3-0.5, enabling the identification of compounds with potential toxicological significance. The results demonstrate that TLC is a valuable tool for the rapid screening of saliva in forensic toxicology. Our findings also highlights the potential of using **saliva** as a reliable biological matrix for the detection of poisons, paving the way for further research into its application in toxicological screenings.

1. Introduction

Human contact with potentially toxic plants, which may occur through abuse or by accident or attempted suicide, is frequent and sometimes results in clinically significant toxicity. Plants have evolved the strategy to produce bioactive natural products as a means of defense. Some plants produce toxins that can severely damage or kill a human.¹

Despite intensified efforts; intoxication by toxins is still significant threat to public health. In forensic toxicology, plant poison detection is

essential for solving criminal cases involving poisoning.² A diverse range of plants contain toxic compounds, including alkaloids, glycosides, and proteins, many of which can be lethal even in small amounts. Detecting and identifying these poisons in biological samples (blood, urine, tissues) is a critical aspect of forensic investigations.³

Forensic toxicology involves the detection, identification, and quantification of drugs, poisons, and other chemical substances in biological specimens to aid in legal investigations.⁴ Saliva has

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***Corresponding author:** Dr. Reena Susan Philip, Department of forensic science, JAIN (Deemed to be University), Bangalore, Karnataka, India. Pin-560027. Email: susanphilipr@gmail.com

emerged as an important biological matrix in forensic toxicology due to its unique advantages, ease of collection, and relevance in reflecting the presence of various substances in the human body. Saliva, a clear, slightly alkaline fluid secreted by salivary glands, plays a crucial role in oral health and digestion.⁵ Beyond its physiological functions, saliva serves as a valuable biological specimen in forensic science due to its ability to mirror the free (non-protein-bound) concentrations of substances present in blood plasma. One of the most significant advantages of using saliva is the non-invasive nature of its collection.⁶ Saliva primarily reflects recent substance use, with drugs being detectable for a shorter duration than in urine or hair. This correlation arises from passive diffusion, making saliva a suitable alternative to more invasive samples like blood and urine.⁷

Cerbera odollam, often called the "suicide tree," is infamous for its potent toxicity. Its seeds contain cerebrin, a cardiac glycoside that can cause fatal heart arrhythmias.⁸ In India, this tree's toxicity has historical, cultural, and forensic significance. The widespread presence of *Cerbera odollam* in coastal and tropical regions of the country has made it both accessible and frequently implicated in cases of poisoning, particularly suicides and homicides. The tree grows abundantly in the coastal states of Kerala, Tamil Nadu, and Karnataka, and is also found in other tropical regions. In Kerala, where it is colloquially known as "odollam," the plant is often planted as a natural fence due to its dense foliage and salt tolerance.⁹ However, its proximity to human settlements also increases the risk of its seeds being used for self-harm or harm toward others. India records a high incidence of poisoning cases, with *Cerbera odollam* playing a notable role in the southern states. Its availability, coupled with the lack of awareness about its toxicity, contributes to its frequent use in poisoning incidents. Homicidal use of the seeds has also been documented. The ease of concealing the seeds in food and the relatively delayed onset of symptoms make it an attractive option for malicious intent.¹⁰

Cases of poisoning are frequent in our country therefore toxicological analysis aims in identifying the toxic principles in the biological fluids. Thin Layer Chromatography (TLC) offers a fast, reliable, and cost-effective method for the detection and identification of plant-derived toxins. Saliva as a biological fluid is gaining popularity amongst researchers especially in

the field of forensic science. It is a complex biological fluid medium of choice for all forensic and criminal investigations because of its ease of collection and safety in handling. They reveal the presence of recent toxic alkaloids and free alkaloid concentration in the plasma. In this study, we have emphasized on the role of saliva in toxicological analysis of *Cerbera odollam* poisoning.¹¹

2. Materials and methods

Samples

Cerbera odollam fruits were collected from the Kottayam district in Kerala. The samples were shade-dried and stored in a dark, low-moisture environment.

Extraction of seed extract

A total of 12 g of ripe fruit was collected and extracted with one liter of boiling water, then left to cool to room temperature. The aqueous extract was combined with isobutyl alcohol to induce aqueous phase separation. The butanol phase was isolated by centrifugation at 3000 rpm for 30 minutes. The resulting extract was dried, dissolved in a small amount of methanol, and subjected to TLC analysis.¹²

Oral fluid sample preparation

Oral fluid was spiked with the seed extract and subjected to the same extraction procedures mentioned in the above. Twenty healthy saliva samples from the anonymous donors within the age group of 20-35 years with due approval of the institutional ethical committee. (Ethics clearance approval – PHD/EC/SC/F/008-AUG2022)

Chromatographic Isolation Techniques

Pre-prepared TLC plates were utilized for the analysis. The fruit extract and saliva samples were applied along the baseline of the plates using a fine capillary tubes, which were subsequently placed in a TLC chamber for development using various solvent systems. Five runs for each solvent system was done to obtain a standard mean.¹²

Solvent systems

Solvent system used in this study is mentioned in the below **table- 1**

Table 1: Various solvents were tested to optimize the separation process.

Mobile phase	Ratio
Butanol: Acetic Acid: Water	5:1:1
Dichloromethane: Ethylacetate	5:1
Chloroform: Methanol	9:1
Chloroform: Methanol: Water	9:0.5:1
Methanol: n-Hexane	8:2
Toluene : Ethyl Acetate : Formic Acid	5:4:1
Ethyl Acetate : Methanol : Water	10:2.5:1

Methanol : Ammonia	9:1
Ethyl Acetate : Methanol : Water	8:0.5:8
Toluene : Acetic Acid: Formic Acid	5:4:1
Butanol : Ammonia: Water	4:1:5
Chloroform : Acetone : Water	6:3:1

Visualization

The TLC plate was developed until three-quarters of its length, then removed and dried at room temperature. Visualization was performed using iodine vapors and UV-VIS chamber.

3. Results

Percentage of yield extracts

To evaluate the effectiveness of the extraction process and to demonstrate that the method can be consistently reproduced, the percentage yield of plant extract was determined by dividing the weight of the dried crude extract by the weight of the powdered plant material before extraction, and then expressing the result as a percentage. The percentage yield provides a quantitative measure of the effectiveness of the solvent used in the extraction process, and of the performance of the extraction itself. With respect to thin-layer chromatography (TLC), the percentage yield must be determined prior to the application of the extract onto the TLC plate in order to standardize the concentration of the extract (**Table 2,3**). This proper standardization of extracts will produce uniform spot intensity on the TLC plate, and improve the resolution of the phytochemical constituents, thereby allowing for valid qualitative comparisons of the chemical profiles of samples.

Table 2: Standardize the concentration of the extract on Thin Layer Chromatography (TLC).

Color of the extract	Yield of the extract (in gram)	Percentage yield (%w/w)
Pale yellowish	3	25%

Table 3: Experimental condition

Saturation time	15 min
Run time	10 min
Temperature	38 °C

In this study, spots obtained using different mobile phases were carefully recorded and mentioned in **table-3 & 4**, and their corresponding retention factor (Rf) values were calculated. This step was crucial in determining the efficiency of each solvent system in separating the target compounds. Multiple mobile phases were tested to optimize separation, with each solvent system tailored to the chemical nature of the compounds, such as glycosides, alkaloids, or phenolics.

The observation and documentation of distinct spots ensured that the compounds were effectively

separated, with clear differentiation between closely related substances. The use of visualizing agents like iodine vapor and UV-VIS fluorescence enhanced the clarity and detection of these spots, even for compounds with low concentrations. Several solvents were tested in order to optimize the extraction conditions: by adjusting the solvent ratio of **chloroform, methanol, and water** offered a unique balance of polarity and solubility making it highly effective in separating the compounds.

Recording the Rf values for each compound allowed for comparisons across different mobile phases, facilitating the selection of the most effective solvent system. The Rf value obtained ranges from 0.3-0.5.¹² This systematic approach ensured reproducibility and provided valuable data for the identification and characterization of the analytes.

Table 3: Results obtained for Cerebra Odollam extract

S. no	Mobile phase	Rf value (Mean value)	Observation
1	Butanol: Acetic Acid: Water	0	No movement of spots
2	Chloroform : Acetone : Water	0	
3	Butanol : Ammonia: Water	0	
4	Toluene : Ethyl Acetate : Formic Acid	0	
5	Dichloromethane: Ethylacetate	0	Spots migrated tailing
6	Chloroform: Methanol	0	
7	Toluene : Ethyl Acetate : Formic Acid	0	
8	Toluene : Acetic Acid: Formic Acid	0	
9	Methanol: n-Hexane	0	Spots moved along the solvent
10	Methanol : Ammonia	0	
11	Ethyl Acetate : Methanol : Water	0	
12	Chloroform: Methanol: Water	0.5	Spots migrated cleanly without any tailing

Table 4: Results obtained for oral fluid sample spiked with Cerebra Odollam

Sl no	Mobile phase	Rf value (Mean value)	Observation
1	Chloroform: Methanol: Water	0.5	Spots migrated cleanly without any tailing

4. Discussion

In the current study of *Cerebra odollam* (known as the suicide tree), the results are similar to those of previous research on the toxicology and phytochemistry of this plant, particularly in the chromatographic analysis of the cardiac glycoside cerberin. Furthermore, many investigators have utilized other preliminary analytical procedures, such as thin layer chromatography (TLC), in the

identification of toxins derived from plant sources and have indicated that when sophisticated instrumental methods are not available, they can be used as a screening technique for many types of toxins, including plant derived toxins. Similarly, in this study, the bioactive components isolated from the extracts of *C. odollam* were separated and produced unique Rf values which can be used as probable indicators of toxicity. Similar investigations have reported requiring TLC to identify cardiac glycosides present in plant materials, and while the ability of those studies to detect total cardiac glycoside concentrations using TLC may not have been extremely sensitive, they did indicate the utility of TLC as a means to conduct a preliminary toxicological screening.¹³ Additionally, the extraction efficiency and chromatographic behavior of the extracts from *C. odollam* were consistent with data previously reported regarding the influence of solvent polarity on the isolation of cerberin and other related components of a similar chemical structure.

Detecting plant-based toxin from a plant species, such as *Cerbera odollam*, in an individual's saliva creates important forensic implications, particularly because of the difficulty of identifying a plant-based poison postmortem. *Cerbera odollam*, as it undergoes rapid metabolism, contains the toxic chemical cerberin, which does not remain present in an individual's blood or tissues for long after death and therefore cannot be detected in those biological specimens. Saliva can provide a viable alternative specimen to conduct early detection of cerberin or its metabolites in postmortem testing by forensic investigators during cases of suspected suicide or homicide poisoning.^{14,15} These factors make saliva sampling advantageous when conducting field forensic testing and mass screening since saliva does not necessarily require a medically trained professional to obtain a sample. The interplay between toxicology and legal systems has become increasingly vital due to the rising complexity of environmental, pharmaceutical, and industrial challenges.¹⁶⁻¹⁹

There are multiple limitations associated with TLC when compared to advanced analytical methods such as HPLC and LCMS in regards to the ability to identify the toxins in *Cerbera odollam*.²⁰ The most significant disadvantage of TLC is that it has a low sensitivity, which makes the detection of cerberin at trace levels in biological specimens, such as saliva where the concentrations of the analytes are typically

very low, very difficult. Conversely, HPLC has higher resolution and sensitivity and provides much more accurate separation and quantitation of compounds. In addition to the higher resolution separation and sensitivity of HPLC versus TLC, LCMS provides further enhancement of the analytical capabilities by providing information regarding the molecular weight of the analytes and will provide some structural information about the analytes being analyzed. In addition, LCMS will provide a clear identification of the toxins being analyzed, even when they are in a complex matrix. Another disadvantage of TLC is that the detection methods used to identify the analyte include visual detection (i.e., UV light and/or chemical reagents) methods which may not be specific and can lead to a misinterpretation of the results. Another limitation of TLC is that the reproducibility of the TLC method is poor because factors including but not limited to plate quality, solvent composition and environmental conditions can influence Rf values. In contrast, the HPLC and LCMS are very reproducible and can be automated making them more appropriate for confirmatory analysis in a forensic laboratory.²¹

5. Conclusion

The developed TLC technique has demonstrated significant potential in effectively analyzing and identifying compounds in both raw plant samples and biological fluids such as oral fluid. This advancement represents a major step forward in simplifying the detection and analysis of bioactive compounds, including plant poisons, with applications in toxicology, pharmacology, and forensic investigations.

For biological fluids such as oral fluid, TLC offers a non-invasive and cost-effective method to detect the presence of plant toxins and other compounds. Oral fluid, being a readily accessible bio-fluid, can be an excellent medium for forensic and toxicological studies. The developed TLC technique has demonstrated its capability to separate and identify compounds present in saliva samples with minimal preprocessing. This is particularly significant in forensic investigations, where rapid and reliable detection of toxins can provide crucial evidence. The adaptability of TLC to analyze small volumes of oral fluid without extensive sample preparation enhances its practicality in resource-limited settings. The portability and low cost of TLC equipment further extend its applications to field studies and on-site analysis.

In conclusion, the developed TLC technique has shown promising results in separating and identifying compounds in raw plant samples and biological fluids like saliva. Its cost-effectiveness, simplicity, and adaptability make it a powerful tool for research and diagnostic purposes. As further advancements in TLC technology emerge, its applications are expected to expand, offering even greater accuracy, sensitivity, and efficiency in chemical analysis.

Future research

Future advancements in TLC include incorporating advanced detection methods, such as fluorescence detection, to enhance sensitivity, and adopting automated systems to accelerate analysis. Moreover, combining TLC with hybrid techniques like HPLC and UHPLC offers more comprehensive analysis and improved identification of plant toxins.

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Systemic Review Article

Rehabilitation as a Medico-Legal Obligation: Evaluating India's Post-Rescue Response to Trafficking of Women and Girls

Sumedh Ganpat Sonavane^{a*}, Swati Rautela^b

^aPh.D. Scholar, Department of Law, University of Mumbai & Associate Professor, Department of Anatomy, Topiwala National Medical College, Mumbai. ^bProfessor & Ph.D. Guide, Department of Law, University of Mumbai, Maharashtra, India.

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Abstract

Background: Trafficking of women and girls for commercial sexual exploitation remains a serious human rights concern in India and across the Global South, as documented in international assessments such as those of the United Nations Office on Drugs and Crime. Post-rescue rehabilitation and reintegration are often treated as discretionary welfare measures rather than enforceable rights, despite judicial interpretation of Article 21 recognising dignity and rehabilitation as constitutional guarantees. **Aim:** To examine India's rescue and post-rescue framework for trafficked women and girls from a constitutional and forensic-legal perspective, focusing on institutional coordination, dignity, and reintegration outcomes. **Material and Methods:** A systematic doctrinal and qualitative review analysed constitutional provisions (Articles 21 and 23), the Immoral Traffic (Prevention) Act, 1956, key judicial decisions, and secondary data from National Crime Records Bureau reports and policy documents. **Results:** Findings reveal a rescue-centric approach with fragmented, under-resourced post-rescue mechanisms. **Conclusion:** Trafficking should be understood as a continuing medico-legal harm rather than an event concluded by rescue. Although constitutional and judicial frameworks recognise rehabilitation and dignity, post-rescue practices remain custodial. A forensic-legal approach emphasising trauma-informed care, documentation, and autonomy is essential to prevent secondary victimisation and ensure reintegration.

1. Introduction

In the context of trafficking and post-rescue care, medico-legal obligation denotes the State's duty to protect the physical and mental health, dignity, and autonomy of survivors under custodial conditions, in accordance with constitutional guarantees and principles of forensic care.

Trafficking of women and girls for commercial sexual exploitation constitutes a continuing medico-legal violation. From a forensic perspective, the harm associated with trafficking frequently extends beyond exploitation to include prolonged physical, psychological, and social injury,

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***Corresponding author:** Dr. Sumedh Ganpat Sonavane, Ph.D. Scholar in Law, Department of Law, University of Mumbai & Associate Professor, Department of Anatomy, Topiwala National Medical College, Mumbai, Maharashtra, India. Email: sumedh.sonavane@tnmcnair.edu.in ; Orcid ID: <https://orcid.org/0009-0007-2884-8141>

often aggravated by post-rescue institutional custody and inadequate rehabilitative care.^{1,2,3} In the Global South, including India, trafficking is sustained by structural vulnerabilities such as poverty, gender inequality, unsafe migration, and social marginalisation, underscoring its character as a systemic form of harm rather than an isolated offence.^{1,4}

The Indian constitutional framework recognises trafficking as a grave violation of fundamental rights, with Article 21 guaranteeing the right to life with dignity and personal liberty, and Article 23 explicitly prohibiting trafficking in human beings and forced labour.^{5,6} The Supreme Court of India has consistently held that these guarantees impose affirmative obligations on the State. In *Vishal Jeet v. Union of India*, the Supreme Court recognised trafficking as an organised social problem and directed the State to adopt preventive and rehabilitative measures beyond rescue, while in *Gaurav Jain v. Union of India*, the Court affirmed that trafficked women and children are entitled to dignity, humane treatment, and rehabilitation, rejecting punitive or moralistic approaches.^{7,8} Despite this jurisprudence, post-rescue practice in India and comparable Global South jurisdictions reveals persistent reliance on prolonged shelterisation, limited access to trauma-informed care, and weak reintegration pathways.^{4,9,10} From a forensic medicine standpoint, such conditions raise concerns of secondary victimisation, as protective custody, when prolonged or imposed without meaningful consent or periodic review, may become coercive in nature, restricting autonomy and reinforcing dependency rather than facilitating recovery.^{2,11}

Judicial acknowledgement of these harms is evident in *Budhadev Karmaskar v. State of West Bengal* and *Prajwala v. Union of India*, which exposed structural deficiencies in post-rescue governance and monitoring.^{12,13} Viewed through a forensic medicine and law lens, post-rescue governance constitutes a continuing phase of State-controlled intervention with direct implications for bodily autonomy, mental health, and legal agency. In this context, systematic documentation of psychological and physical harm is essential, as it enables recognition of trauma, informs appropriate care, and provides a medico-legal basis to assess whether custodial conditions support recovery or contribute to secondary harm.^{2,11,14} This study accordingly examines whether India's rescue and post-rescue framework meaningfully fulfils

constitutional, forensic, and human rights obligations owed to trafficked women and girls.

2. Research Methodology, Objectives, and Scope of the Study

This study adopts a doctrinal and qualitative methodology to examine India's legal and institutional response to trafficking of women and girls for commercial sexual exploitation, with particular emphasis on post-rescue rehabilitation and reintegration.^{4,5,6,15} Constitutional provisions, notably Articles 21 and 23 of the Constitution of India, the Immoral Traffic (Prevention) Act, 1956, and key judicial decisions are analysed to assess how State obligations relating to dignity, autonomy, and rehabilitation have been interpreted beyond rescue.^{4,6,7,15} Secondary data from the National Crime Records Bureau, government reports, and audit findings are examined to identify gaps between legal mandates and post-rescue implementation.^{16,17,18} The scope is confined to trafficking for commercial sexual exploitation affecting women and girls, with criminal processes considered only in so far as they impact survivor rights and rehabilitation outcomes.¹³ Secondary data were drawn from National Crime Records Bureau reports, government publications, and audit findings for the period 2019-2022. The study is guided by a constitutional and forensic-legal framework, focusing on how institutional practices address autonomy, mental health, and recovery in post-rescue contexts.

Limitation

The study relies on secondary data and legal analysis and does not include primary field-based evidence.

3. Institutional Framework for Rescue and Post-Rescue Interventions

India's response to trafficking operates through multiple institutions that engage with survivors at different stages, from rescue to rehabilitation. Although this framework appears comprehensive on paper, its effectiveness depends on how well these bodies coordinate their actions. In practice, weak linkages between institutions often result in fragmented care, where protection is prioritized but recovery and reintegration receive limited attention.

Table 1: Institutional framework for rescue and post-rescue interventions in India: a forensic-legal assessment^{2, 5, 6, 15,16,17}

Institution	Statutory / Functional Role	Stage of Intervention	Forensic-Legal Observations
Police / Anti-Human Trafficking Units	Identification, Rescue, Investigation	Identification; Rescue	Rescue-Led Approach; Limited Linkage with Rehabilitation Agencies; Trauma-Informed Practices Largely Absent
Judicial Magistrates	Production Orders, Protective Custody, Trial Oversight	Protection; Trial	Procedural Delays; Minimal Monitoring of Post-Rescue Rehabilitation Outcomes
District Magistrates	Supervision of Shelters; Administrative Oversight	Protection; Rehabilitation	Inconsistent Inspections; Prolonged Institutionalisation without Periodic Review
Child Welfare Committees	Care and Protection of Trafficked Children	Protection; Rehabilitation	Variable Decision Quality; Uneven Coordination with Police and Shelters
Shelter homes (ITPA / Swadhar / Ujjawala)	Custody, Counselling, Rehabilitation	Rehabilitation	Predominantly Custodial; Shortage of Trained Counsellors and Vocational Support
Prosecution Agencies	Prosecution of Trafficking Offences	Trial	High Attrition between Charge-Sheeting and Conviction

ITPA – Immoral Traffic (Prevention) Act, 1956.

Note: Anti-Human Trafficking Units are constituted under administrative guidelines issued by the Ministry of Home Affairs and implemented through state police frameworks. The forensic-legal observations presented in the table are derived from a synthesis of secondary literature, National Crime Records Bureau data, and government audit reports.

Table 1 indicates that India's anti-trafficking response is institutionally comprehensive on paper, with defined roles across stages from rescue to rehabilitation. In practice, however, these institutions often function in isolation. Police and Anti-Human Trafficking Units prioritise rescue and investigation, while the transition to rehabilitation remains weak and poorly coordinated. Judicial and administrative oversight largely focuses on custody and procedural compliance, with limited attention to recovery and reintegration outcomes. Shelter homes, though

intended as supportive spaces, frequently operate as custodial settings due to shortages of trained personnel and livelihood programmes. The significant drop between charge-sheeting and conviction further weakens accountability. From a forensic medicine and law perspective, these patterns suggest that post-rescue vulnerability arises not from absence of institutions, but from gaps in coordination, continuity of care, and implementation of survivor-centred rehabilitation.

4. Challenges Faced by Government Functionaries

Government functionaries involved in rescue and post-rescue interventions operate under significant structural and practical constraints. Many lack specialised training in trauma-informed and survivor-centred approaches, while shortages of counsellors, social workers, and rehabilitation resources limit their ability to provide meaningful post-rescue support. Fragmented coordination between departments further delays decision-making and continuity of care. As a result, even well-intentioned interventions may unintentionally prolong institutionalisation and deepen survivor vulnerability rather than facilitate recovery and reintegration.

Table 2: Operational constraints in post-rescue governance: selected national indicators ^{17,18,19,20}

Indicator	Year	Reported Figure	Forensic Significance
Anti-Human Trafficking Units Sanctioned	2019	696	Indicates Policy Intent
Anti-Human Trafficking Units Operational	2019	396	~43% Non-Functional, Weakening Rescue-Rehabilitation Linkage
Shelter Homes Without Counsellors	2015-16	~58%	Elevated Risk of Psychological Neglect
Shelter Homes Without Trained Social Workers	2015-16	~76%	Reinforces Custodial Rather than Rehabilitative Care
Unutilised Ujjawala Funds	2016-17	~32%	Reflects Governance Failure rather than Resource Scarcity

Indicator	Year	Reported Figure	Forensic Significance
Districts Without Trauma Counsellors	2018	~60%	Compromises Forensic Mental-Health Recovery

~ Approximately

Note: Data presented are derived from official sources including National Crime Records Bureau reports, Ministry of Home Affairs records, Comptroller and Auditor General audit findings, and Ministry of Women and Child Development reports. Figures represent nationally reported data and should be interpreted as aggregated estimates rather than uniform conditions across all states and districts. Percentages are approximate where indicated.

Table 2 highlights the operational constraints shaping post-rescue outcomes for trafficked women and girls in India. Although many Anti-Human Trafficking Units have been sanctioned, a substantial proportion remain non-functional, weakening the link between rescue and rehabilitation. Deficits in shelter homes, particularly the absence of counsellors and trained social workers, indicate limited psychological and social support, increasing the risk of secondary harm. The lack of trained counsellors also affects timely identification and medico-legal documentation of psychological trauma, which is essential for appropriate care and legal assessment. Under-utilisation of rehabilitation funds points to governance gaps rather than resource scarcity, while the absence of trauma counsellors in many districts further limits recovery pathways. From a forensic medicine and law perspective, these capacity gaps directly impact mental health outcomes, continuity of care, and the State's medico-legal responsibility towards survivors in post-rescue custody.

5. Empirical Evidence: National Crime Records Bureau Data and Ground Realities

Official data from the National Crime Records Bureau provide a quantitative picture of trafficking enforcement, but they also point to deeper gaps in survivor outcomes. While a significant number of cases are registered and victims identified each year, far fewer progress to timely trials or convictions. This disconnect suggests that rescue and case registration are not consistently followed by sustained investigation, accountability, or rehabilitative support. On the ground, these delays translate into prolonged uncertainty for survivors, limiting access to

justice and increasing the risk of renewed exploitation rather than meaningful recovery.

Table 3: Human trafficking cases and judicial outcomes in India (NCRB, 2019-2022)^{16,19,21}

Year	Cases Registered	Charge-Sheeted	Trials Completed	Convictions
2019	2,208	1,508	716	161
2021	2,189	1,645	201	32
2022	2,250	1,830	676	131

Note: Data are derived from National Crime Records Bureau (NCRB) reports. Data for 2020 are not included to maintain consistency in comparative analysis due to variations in reporting patterns during that period. Conviction figures represent cases in which final judgments were delivered during the reporting year and do not correspond directly to cases registered or victims rescued in the same year.

Table 3 presents the progression of human trafficking cases through the criminal justice system in India between 2019 and 2022. While cases registered and charge-sheeted remain relatively consistent, there is a marked drop at the stages of trial completion and conviction. This attrition reflects systemic challenges such as delays in investigation, evidentiary gaps, witness hostility, and withdrawal of survivors due to stigma, fear, or prolonged proceedings. From a forensic medicine and law perspective, these factors weaken accountability for traffickers and limit the protective and rehabilitative impact of legal intervention. The data indicate that without timely investigation, survivor-sensitive procedures, and judicial efficiency, rescue-centred responses risk leaving survivors without closure, justice, or meaningful support for long-term recovery.

6. Policy and Scheme Review: Rescue to Rehabilitation

India's post-rescue policy framework includes schemes intended to support rehabilitation and reintegration, signalling recognition that rescue alone is insufficient. In practice, however, these schemes are unevenly implemented, with gaps in funding utilisation, staffing, and service delivery. As a result, support often remains confined to institutional care, with limited pathways for education, livelihood, and community reintegration. For many survivors, this weak transition from rescue to rehabilitation turns welfare measures into temporary containment rather than tools for long-term recovery.

Table 4: Capacity and utilisation of post-rescue rehabilitation schemes in India^{17, 18, 22}

Scheme	Sanctioned Capacity / Allocation	Functional / Utilised	Forensic– Legal Implication
Ujjawala Scheme	₹50.33 Crore (2016–17)	₹34.21 Crore Utilised	Under-Utilisation Limits Post-Rescue Recovery
Swadhar Greh Homes	301 Sanctioned	246 Functional	Reduced Availability Prolongs Institutional Stay
Swadhar Beneficiaries	~7,000 Capacity	~4,600 Served	Access Gap Impacts Reintegration Outcomes
Shelter Vocational Facilities	124 Homes Assessed	~65% Absent	Limits Economic Independence Post-Rescue

~ Approximately

Note: “Sanctioned” refers to approved capacity or financial allocation, while “functional/utilised” indicates operational availability or actual beneficiaries served during the reporting period. Figures are based on Ministry of Women and Child Development reports and audit findings.

Table 4 highlights the gap between the availability of post-rescue rehabilitation schemes and their actual utilisation in India. Although substantial financial allocations and infrastructure have been sanctioned under schemes such as Ujjawala and Swadhar Greh, a significant proportion of resources remain under-used or non-functional. From a forensic-legal perspective, this under-utilisation results in prolonged institutional stays, limited access to counselling and vocational support, and reduced opportunities for social reintegration. Monitoring mechanisms under the Ministry of Women and Child Development, including periodic reporting and inspection frameworks, exist but are often unevenly implemented, limiting effective oversight and accountability. The absence of livelihood-oriented facilities within many shelters further constrains economic independence, increasing the risk of re-trafficking. The table thus indicates that deficiencies in rehabilitation outcomes arise not from lack of policy, but from gaps in implementation that weaken the State’s medico-legal obligation to support recovery, dignity, and autonomy.

7. Judicial Approach: Expanding the Jurisprudence of Dignity

Indian courts have played a crucial role in reframing trafficking responses through the language of dignity and rights. Judicial decisions have consistently clarified that rescue is only the first step and that rehabilitation and humane treatment are constitutional obligations of the State. By rejecting moralistic and punitive approaches, the courts have emphasised autonomy, choice, and protection from prolonged custody. This evolving jurisprudence reflects an effort to align legal responses with the lived realities of survivors and to ensure that protection restores dignity rather than restricts it.

Table 5: Judicial expansion of dignity and rehabilitation in trafficking jurisprudence in India ^{7, 8, 12, 23, 24}

Case	Year	Constitutional Provisions	Forensic Contribution
Vishal Jeet v. Union of India	1990	Arts. 21, 23	Recognised Rehabilitation as a State Obligation
Gaurav Jain v. Union of India	1997	Arts. 21, 14, 15, 23	Rejected Moralistic Treatment; Affirmed Dignity
Budhadev Karmaskar v. State of West Bengal	2011	Art. 21	Linked Dignity with Autonomy and Choice
Selected High Court Decisions	2015-2022	Art. 21; ITA	Restricted Prolonged Protective Custody

Table 5 traces the judiciary’s progressive recognition of dignity and rehabilitation as central components of India’s anti-trafficking response. Beginning with Vishal Jeet v. Union of India, the courts moved beyond viewing rescue as sufficient, instead identifying rehabilitation as a constitutional responsibility of the State. This shift was reinforced in Gaurav Jain v. Union of India, where moralistic and punitive approaches towards trafficked women were expressly rejected in favour of dignity and humane treatment. In Budhadev Karmaskar v. State of West Bengal, the Supreme Court further deepened this jurisprudence by linking dignity to autonomy and the right to choose rehabilitation pathways. Subsequent High Court decisions have operationalised these principles by restricting prolonged protective custody. From a forensic medicine and law perspective, this judicial evolution underscores that post-rescue confinement without meaningful rehabilitation may itself constitute harm, and that safeguarding dignity and autonomy is integral to the

State's medico-legal obligation towards trafficking survivors.

Building on the principles laid down in Vishal Jeet v. Union of India, Gaurav Jain v. Union of India, and Budhadev Karmaskar v. State of West Bengal, High Courts have increasingly applied a rights-based approach in bail and custody decisions. Courts have emphasised that protective custody must not become indefinite or coercive, and have ordered time-bound release, prioritised survivor consent, and encouraged community-based rehabilitation where appropriate. These decisions reflect a growing judicial effort to translate constitutional principles of dignity and autonomy into practical safeguards within post-rescue processes.

8. International Legal Framework and India's Obligations

International anti-trafficking instruments place clear obligations on States to prioritise victim recovery, dignity, and non-punishment alongside criminalisation of traffickers. While India has endorsed these frameworks, their principles are only partially reflected in post-rescue practice, which continues to rely heavily on scheme-based welfare and custodial protection. This gap between international commitments and domestic implementation means that survivors often lack enforceable rights to rehabilitation and autonomy. Bridging this divide is essential to ensure that post-rescue governance aligns with global human rights standards and genuinely supports recovery.

Table 6: International anti-trafficking obligations and Indian post-rescue practice: a forensic gap analysis^{15, 24,25,26,27}

Instrument	Core Obligation	Indian Position	Identified Gap
Palermo Protocol (Art. 6)	Recovery and Reintegration	Scheme-Based Welfare	No Enforceable Survivor Right
Palermo Protocol (Art. 6(5))	Non-Punishment	No Explicit Statutory Protection	Risk of Secondary Criminalisation
CEDAW (Art. 6)	Suppression of Trafficking	Criminalisation-Focused	Rehabilitation Weakly Enforced
ICCPR (Arts. 7, 9)	Liberty and Dignity	Protective Custody Under ITPA	Constitutional Tension

CEDAW – Convention on the Elimination of All Forms of Discrimination against Women; Art. – Article ICCPR – International Covenant on Civil and Political Rights; ITPA – Immoral Traffic (Prevention) Act, 1956.

Table 6 highlights the disconnect between India's international anti-trafficking commitments and post-rescue practices on the ground. While

instruments such as the Palermo Protocol, CEDAW, and the ICCPR emphasise recovery, non-punishment, dignity, and liberty of survivors, India's implementation largely relies on scheme-based welfare and custodial protection under domestic law. From a forensic medicine and law perspective, this gap has tangible consequences: survivors may move from exploitative control into prolonged institutional custody without enforceable rights to rehabilitation or autonomy. The absence of explicit statutory protection against criminalisation further increases the risk of secondary harm. The table thus illustrates how incomplete incorporation of international standards weakens medico-legal safeguards, reinforcing the need to align post-rescue governance with rights-based, survivor-centred obligations that prevent re-traumatisation and uphold dignity.

India is a signatory to the Protocol to Prevent, Suppress and Punish Trafficking in Persons and has ratified both the Convention on the Elimination of All Forms of Discrimination against Women and the International Covenant on Civil and Political Rights, thereby undertaking international obligations to prevent trafficking, protect survivors, and ensure dignity and rehabilitation. However, the extent to which these commitments are translated into enforceable post-rescue rights within domestic practice remains limited.

9. Discussion

For many women and girls who survive trafficking, rescue does not translate into immediate freedom. Instead, it often initiates a prolonged period of institutional control marked by restricted choice, delayed decision-making, and uncertainty. This pattern is not unique to India; across the Global South, rescue frequently replaces one form of coercion with another, as shelter-based systems prioritise safety while limiting autonomy and participation in post-rescue decisions.^{1,4,28} From a forensic medicine and law perspective, such prolonged custodial arrangements risk compounding psychological harm and secondary victimisation.²⁹⁻³¹ India's post-rescue practices reflect these broader trends. Although trafficking is expressly prohibited under Article 23 of the Constitution and the right to live with dignity under Article 21 has been firmly established through judicial interpretation, post-rescue implementation under the Immoral Traffic (Prevention) Act, 1956 often remains custodial in nature.^{5,15} Provisions relating to protective custody and rehabilitation under Sections 17, 17A, and 21 are

frequently applied through routine institutional placement, with limited attention to survivor consent, family linkages, or community-based alternatives. Courts have repeatedly cautioned that such practices risk converting protection into prolonged institutionalisation, thereby undermining dignity rather than restoring it.²³

Judicial jurisprudence has consistently clarified that rescue without rehabilitation is incomplete. In *Vishal Jeet v. Union of India* and *Gaurav Jain v. Union of India*, the Supreme Court rejected moralistic and punitive approaches and affirmed that dignity, humane treatment, and rehabilitation are integral to Article 21.^{6,8} However, everyday post-rescue governance often continues to treat survivors as passive recipients of protection rather than as rights-bearing individuals capable of shaping their own recovery. Empirical evidence reinforces this concern. Data published by the National Crime Records Bureau reveal that while a significant number of victims are identified annually, conviction rates remain low and trials are frequently delayed.^{16,19,21} Rescue is therefore seldom followed by accountability or sustained rehabilitative support, increasing vulnerability to re-trafficking. Judicial proceedings in *Budhadev Karmaskar v. State of West Bengal* and *Prajwala v. Union of India* further demonstrate that failures in post-rescue care are not merely administrative deficiencies but constitutional and medico-legal lapses affecting dignity and autonomy.^{12,13}

Comparative experiences from the Global South offer instructive insights. In Nepal and Bangladesh, protective custody has often substituted for rehabilitation, reinforcing stigma and dependency.^{1,4,28,32} South Africa, despite facing comparable socio-economic challenges, has shown partial progress through court supervised rehabilitation plans and community-linked reintegration, reducing reliance on long-term institutionalisation.^{1,4} These comparisons suggest that the principal challenge lies not in the absence of law, but in the translation of rescue into recovery. Across the Global South, emerging practices indicate that community-based rehabilitation models offer a more effective alternative to prolonged institutional care. In countries such as Nepal and Bangladesh, continued reliance on shelter-based systems has often reinforced dependency and stigma, whereas recent approaches in South Africa have emphasised community-linked reintegration, social support

networks, and survivor participation in decision-making. These models highlight the importance of shifting from custodial protection to community-based recovery, where access to livelihood, mental health support, and social inclusion are prioritised. For India, adopting such approaches could strengthen post-rescue outcomes by reducing institutionalisation and promoting autonomy, dignity, and sustainable reintegration.

For India, this analysis underscores the need to reorient post-rescue governance towards survivor-centred, trauma-informed, and accountable implementation of existing law. Aligning practice under the Immoral Traffic (Prevention) Act, 1956 with constitutional values and forensic standards is essential to ensure that rescue becomes the beginning of restoration and meaningful reintegration, rather than another phase of vulnerability under State control.

10. Conclusion

Trafficking for commercial sexual exploitation must be recognised as a continuing medico-legal harm that extends beyond rescue. Despite strong constitutional guarantees under Articles 21 and 23, post-rescue practices in India remain largely custodial, often undermining survivor dignity and autonomy. From a forensic and legal perspective, inadequate rehabilitation, lack of trauma-informed care, and weak institutional coordination constitute secondary harm and reflect systemic failures in fulfilling State obligations. A rights-based shift is essential where rehabilitation and reintegration are enforceable, institutionalisation is limited, and survivor agency is central. Only then can post-rescue governance truly uphold constitutional values and ensure meaningful, sustainable recovery for survivors.

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Review Article

Enhancing Vietnam's Criminal Law Responses to Increasingly Sophisticated Human Organ Trafficking Practices

Le Thi Thu Phan^{a*}, Hang Thu Mai^a

^aFaculty of law, Phenikaa University, Hanoi, Vietnam.

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Abstract

Introduction: Human organ trafficking has grown increasingly sophisticated, yet Vietnam's legal framework has not fully adapted to this evolving landscape. Aim: This study therefore aims to assess the effectiveness of Vietnam's current criminal-law provisions and to identify the gaps that emerge when these provisions are compared with international standards. **Methods:** Using a qualitative case-study design, the research integrates doctrinal legal analysis with a thematic comparison of global instruments, including UNODC guidance and the Council of Europe Convention. **Results:** The results reveal three central findings. First, Vietnam's Criminal Code lacks a standalone offence for organ-removal trafficking, creating definitional ambiguity that complicates prosecution. Second, the legal framework does not adequately address digital recruitment, medical-sector accountability, or cross-border cooperation – all of which are essential components highlighted in international models. Third, structural barriers such as limited investigative capacity, weak victim protections, and inconsistent interagency coordination further constrain enforcement in practice. **Conclusion:** Overall, these findings indicate that Vietnam must refine its statutory definitions, strengthen institutional mechanisms, and adopt victim-centered reforms to meet emerging global standards. The study concludes that aligning Vietnam's legal and operational systems with international best practices is crucial for addressing increasingly complex organ-trafficking networks.

1. Introduction

The global escalation of human organ trafficking has evolved into a highly organized, technologically sophisticated criminal enterprise, drawing increasing concern from researchers, policymakers, and international institutions.¹ Rather than constituting isolated incidents of illicit organ sales, contemporary trafficking in persons for organ removal (TIP for

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*Corresponding author: Le Thi Thu Phan, PhD. Faculty of law, Phenikaa University, Hanoi, Vietnam. E-mail: hang.maithu@phenikaa-uni.edu.vn

OR) increasingly operates through structured criminal networks that combine recruitment, financial brokerage, medical facilitation, and cross-border coordination. Despite being significantly underreported, trafficking in persons for organ removal (TIP for OR) is now understood to involve complex networks that operate across borders, exploit vulnerable groups, and rely heavily on digital tools to conceal their activities.²

International bodies such as the Inter-Agency Coordination Group against Trafficking in Persons³ and the Council of Europe⁴ have cautioned that the clandestine nature of this crime presents distinct doctrinal, investigative, and prosecutorial challenges, particularly in jurisdictions that lack precise legal definitions and specialized enforcement mechanisms. A growing body of scholarship has attempted to capture the organization and operational patterns of organ-trafficking networks. Existing studies demonstrate that offenders depend on transnational supply chains, falsified medical records, intermediary brokers, and encrypted digital communication, including platforms on the dark web.⁵ Comparative research in Europe⁶ and the Balkans⁷ further illustrates that weak statutory language, fragmented legal provisions, and inadequate victim-protection frameworks continue to obstruct effective enforcement.⁸ However, much of this literature remains primarily descriptive and has devoted limited attention to how domestic criminal-law provisions function in practice when applied to organ-removal cases. At the same time, global transplantation governance – though increasingly standardized – struggles to respond to the fluid boundaries between “trade,” “trafficking,” and “deceptive recruitment,” making legal classification and prosecution more difficult.⁹

Vietnam faces similar yet distinct challenges. Low organ-donation rates, socio-cultural beliefs surrounding post-mortem integrity, and persistent misconceptions about bodily wholeness contribute to an environment in which illicit exchanges may flourish.¹⁰ Although the 2015 Criminal Code¹¹ criminalizes human trafficking, its general provisions were not designed with the specific operational features of organ-removal trafficking in mind, such as digital recruitment channels, transnational brokerage, or medically orchestrated exploitation.¹² Moreover, investigative limitations and inconsistent interpretation of trafficking provisions have resulted in evidentiary gaps and, at times, wrongful

convictions.¹³ International frameworks – from the Council of Europe Convention⁴ to recent UN and U.S. policy guidance¹⁴ – offer valuable models for criminalization, reporting obligations, and victim-centered protections.¹⁴ Yet Vietnam has not fully aligned its laws with these standards.¹⁰ Existing domestic scholarship largely describes organ trafficking but seldom evaluates the shortcomings of Vietnam’s legal provisions or proposes targeted reforms.¹² This study addresses that gap by moving beyond descriptive comparison and offering a doctrinally focused assessment of how Vietnam’s trafficking provisions interact with contemporary organ-trafficking practices. Drawing on comparative international models, crime-script analyses, and doctrinal legal assessment methods,¹⁵ the study proposes a set of reforms tailored to Vietnam’s contemporary crime landscape. Its central contribution lies in illustrating how current trafficking practices – especially digital brokerage, cross-border coordination, and covert medical facilitation – interact with existing legal provisions. In doing so, the article offers an evidence-based framework to strengthen Vietnam’s criminal law, enhance enforcement capacity, and support alignment with global anti-trafficking standards. To guide this inquiry and clarify the scope of analysis, the study focuses on two central research questions that address both the effectiveness of Vietnam’s legal framework and its alignment with global standards as follows:

- a. How effective are Vietnam’s current laws against organ trafficking?
- b. What gaps appear when Vietnam’s laws are compared with international standards?

2. Methods

This study adopts a qualitative case-study design to examine how Vietnam’s current criminal-law provisions address the growing sophistication of human organ-trafficking practices. Vietnam was selected as a single-case study because it represents a transitional legal system confronting emerging organ-trafficking risks while increasingly engaging with international anti-trafficking norms, making it suitable for in-depth doctrinal analysis rather than statistical generalization. The primary aim is to analyze the effectiveness of existing statutory frameworks and identify gaps that hinder investigation, prosecution, and victim protection. To achieve this, the research integrates doctrinal legal analysis with thematic examination of international guidelines, judicial interpretations, and comparative

statutory models. Data were drawn from the 2015 Vietnam Criminal Code,¹¹ government circulars, selectively available court decisions, and official reports, alongside international instruments and scholarly literature. Legal sources were included where they directly addressed trafficking offences, exploitation, medical regulation, digital facilitation, or victim protection; materials lacking a clear nexus to these issues were excluded. These sources were selected because they collectively illustrate how legal norms operate in practice and how they diverge from emerging global standards. The material was coded thematically, enabling the identification of recurring legal limitations, structural inconsistencies, and enforcement challenges. Thematic coding was conducted through an iterative process, beginning with core analytical categories, such as offence definition, consent and exploitation, intermediary liability, digital recruitment, medical-sector accountability, and cross-border cooperation, which were refined as analysis progressed. Moreover, cross-jurisdictional comparisons with European and regional frameworks provided additional insight into the relative strengths and weaknesses of Vietnam's current approach. Comparative jurisdictions were selected based on functional relevance, particularly where legal frameworks offered detailed offence structures or enforcement mechanisms addressing trafficking for organ removal. Finally, the analysis followed an iterative process, allowing new themes to emerge as the data were examined. Methodological limitations are acknowledged: the study does not rely on a comprehensive empirical dataset of Vietnamese court judgments due to limited public accessibility, nor does it seek to quantify enforcement outcomes. This approach ensured that the findings reflect both the formal legal architecture and the practical realities of combating organ trafficking in Vietnam.

3. Results and discussion

Evaluating Vietnam's criminal-law responses to emerging patterns of human organ trafficking activities

Vietnam has taken notable steps to strengthen its legal framework on human trafficking, yet its response to organ-removal trafficking remains only partially aligned with the complexity of this evolving crime type. The findings of this study indicate that although the 2015 Criminal Code¹¹ provides a workable foundation, its effectiveness is constrained by both doctrinal ambiguity and institutional capacity limits. These challenges emerge most clearly in the

absence of a dedicated offence definition, the limited capacity to address digital and transnational operations, and the practical constraints facing investigators and prosecutors. To begin with, Vietnam's handling of organ trafficking is embedded in the general trafficking provisions of Articles 150, 151 and 154 of the 2015 Criminal Code.¹¹ These articles prohibit coercion, deception, or exploitation for various unlawful purposes, but they do not explicitly define trafficking for organ removal as a standalone offence. As a result, organ-removal cases must be subsumed under broader trafficking categories, requiring prosecutors to infer organ-specific exploitation from general statutory elements. In contrast, the Council of Europe Convention⁶ sets out a detailed structure that captures each stage of the illicit organ-removal process, including recruitment, medical involvement, transportation, and financial inducement.⁸ The UNODC toolkit similarly stresses that clear legal definitions are vital for harmonizing enforcement, guiding prosecutorial decisions, and enabling cross-border cooperation.² Without comparable statutory specificity, Vietnamese courts are afforded wide interpretive discretion, increasing variability across jurisdictions and weakening legal certainty.

This ambiguity also complicates victim identification. Many individuals who undergo organ removal do not initially perceive themselves as victims, especially when the transaction is framed as voluntary or financially necessary. Yet international guidance emphasizes that consent obtained through economic desperation, misinformation, or fraudulent medical representations still constitutes exploitation.¹⁶ Studies in Vietnam confirm that socio-economic vulnerabilities and cultural attitudes toward bodily integrity often obscure the exploitative nature of the act.¹⁷ In the absence of explicit statutory recognition of vulnerability-based exploitation or deceptive inducement, prosecutors may struggle to establish trafficking elements even where exploitation is substantively present. A second issue concerns the mismatch between Vietnam's legal provisions and the sophisticated digital methods increasingly used in organ trafficking. Global evidence demonstrates that trafficking networks rely on encrypted communication channels, anonymous social-media postings, and clandestine digital marketplaces to recruit and coordinate arrangements with potential donors.¹⁸ Several international bodies have encouraged States to incorporate digital-

recruitment and online-facilitation offences into their anti-trafficking frameworks.¹⁴ Although the 2015 Criminal Code¹¹ contains general cybercrime provisions, these are primarily designed to address data-related or financial harms rather than human exploitation. As a result, investigators may be unable to authenticate online evidence or pursue digital-trail investigations across borders, particularly when communication platforms or data servers are located abroad.

The medical sector presents another area of vulnerability. International transplantation-ethics literature consistently highlights the role of hospitals and clinicians in detecting forged documents, cross-checking donor relationships, and reporting suspicious transplantation patterns.¹⁶ Some jurisdictions impose mandatory reporting duties, backed by administrative or criminal liability for failure to act. Vietnam currently relies on professional guidance rather than statutory obligation, leaving potential gaps in oversight. This creates opportunities for traffickers to exploit administrative weaknesses by presenting falsified medical histories or using private clinics with limited regulatory scrutiny.¹³ Finally, the study identifies a series of enforcement challenges that weaken the practical application of the law. Investigators often lack specialized training in interpreting medical evidence, identifying forged documentation, or reconstructing complex trafficking chains. These constraints mirror patterns observed in other countries confronting intricate organ-removal schemes.¹⁹ Moreover, victims may be reluctant to cooperate due to stigma, fear of prosecution, or social pressure, which reduces opportunities for obtaining testimony. Cross-provincial coordination also remains inconsistent. Because organ-trafficking cases commonly span multiple locations, the absence of a specialized task force or centralized investigative framework leads to fragmented information-sharing and uneven case progression.¹⁰ Overall, these findings indicate that Vietnam possesses a functional legal baseline but lacks the statutory clarity, digital responsiveness, medical-sector accountability, and interregional coordination needed to confront increasingly sophisticated organ-trafficking operations.

Comparing Vietnam's legal framework with international standards on preventing organ-removal trafficking

A comparative examination of Vietnam's legal framework against international standards reveals

several areas where domestic provisions fall short of global best practices. These gaps affect not only doctrinal clarity but also the ability of enforcement agencies to identify victims, regulate medical actors, pursue digital evidence, and cooperate across borders.¹³ When viewed collectively, they underscore why Vietnam's current provisions struggle to keep pace with the dynamic structure of modern organ trafficking.²⁰ One of the clearest divergences lies in the absence of a standalone offence targeting trafficking for organ removal. International instruments – including the Council of Europe Convention and guidance from UNODC – emphasize the need for precise legal definitions to ensure consistency in prosecution and to reduce interpretive uncertainty.⁴ These frameworks articulate detailed offence elements: illicit removal, medical participation, recruitment, transportation, and financial arrangements. Comparative studies show that jurisdictions adopting these definitions achieve more consistent legal outcomes.⁷ While interpretive expansion of general trafficking provisions may be theoretically possible, reliance on broad clauses places excessive discretionary burdens on prosecutors and courts, increasing the risk of uneven application.¹² Closely related is the treatment of consent and exploitation. UNODC² and ICAT³ stress that consent acquired through poverty, manipulation, or misinformation does not negate exploitation. International crime-script analyses demonstrate that traffickers routinely exploit financial desperation, medical misinformation, and fabricated urgency to induce organ removal.²¹ While the 2015 Vietnam Criminal Code¹¹ recognizes coercion and deception generally, it does not explicitly identify the nuanced forms of inducement common in organ-removal trafficking. This omission allows exploitative schemes to be framed as “voluntary transactions,” a strategy that undermines prosecution and has been documented in multiple jurisdictions.⁹

A significant comparative gap also exists in relation to the medical sector. International standards increasingly require hospitals and transplant professionals to verify donor-recipient compatibility, scrutinize documentation, and report suspicious activities. The Council of Europe Convention even introduces liability for negligent failure to report.⁴ In contrast, Vietnam does not impose mandatory reporting duties or establish clear accountability mechanisms for medical actors. This

stands in tension with global transplantation-ethics recommendations highlighting the central role of clinicians in preventing illicit removals.²¹ Because traffickers frequently rely on complicit or inattentive medical intermediaries, this gap is particularly consequential.

Digital-crime responsiveness is another area where Vietnam's legal system diverges from international norms. Transnational trafficking networks increasingly rely on encrypted platforms, social-media outreach, and dark-web communication to recruit donors and coordinate their operations.⁵ International guidance encourages States to adopt digital-facilitation offences and streamlined digital-evidence procedures.¹⁴ Vietnam's legislation does criminalize certain online misconduct, but it does not explicitly connect digital-solicitation activities with organ-removal trafficking. Consequently, investigators may lack a clear statutory basis to pursue digital leads or request international data access. This challenge mirrors difficulties faced in other jurisdictions where cybercrime procedures have not fully integrated with trafficking frameworks.¹⁷

Victim protection also diverges from global expectations. International conventions stress non-criminalization, trauma-informed care, and long-term psychosocial support.⁴ Vietnam's current system does not provide explicit statutory guarantees shielding victims from prosecution for participating in illegal organ-selling arrangements. Research shows that fear of punishment, stigma, and familial pressures often discourage victims from reporting exploitation.¹⁰ Comparative jurisdictions that adopt clear non-punishment clauses report higher disclosure rates and more successful investigations.⁹ Finally, comparative analysis demonstrates notable shortcomings in cross-border cooperation. Organ trafficking operates across jurisdictions, involving international brokers, foreign clinics, and complex financial channels.¹⁸ Although Vietnam participates in regional anti-trafficking collaborations, its legal framework lacks specialized mechanisms for rapid information sharing, joint operations, or transplant-tourism detection. European reports similarly show that weak cross-border procedures can allow traffickers to exploit legal asymmetries.⁶ Without tailored cross-jurisdictional mechanisms, Vietnam remains vulnerable to transnational networks that can easily shift operations between countries. Thus, aligning domestic provisions with international best

practices would significantly improve detection, investigation, and victim protection.

Examining structural barriers and identifying reform priorities in Vietnam's anti-organ trafficking system

Beyond doctrinal gaps, Vietnam's response to organ-removal trafficking is constrained by deeper structural challenges that limit the practical enforcement of existing laws. These obstacles – operational, socio-cultural, and institutional – shape how cases are identified, investigated, and prosecuted.¹⁷ Understanding these structural barriers is essential because even well-crafted legislation cannot function effectively without adequate institutional capacity, cross-sectoral cooperation, and victim-centered protections. A first major barrier concerns the operational limitations faced by investigators.⁵ Organ trafficking is inherently difficult to detect, as illicit removals often occur in private clinics, informal medical facilities, or across national borders, leaving few visible indicators. International research shows that traffickers deliberately exploit these discreet environments to avoid detection.²⁰ Investigators in Vietnam, like those in many developing jurisdictions, often lack specialized training in analyzing medical documentation, detecting falsified patient histories, or interpreting transplant-related evidence. Comparative studies have similarly described how limited forensic capacity and inadequate medical-legal expertise undermine enforcement efforts.¹⁶

Compounding these challenges is the rapid evolution of digital platforms used for recruitment and communication. Trafficking networks increasingly rely on encrypted messaging, disposable online identities, and hidden digital marketplaces.²⁰ UNODC² and U.S. federal guidance¹⁴ highlight that digital tools have become indispensable components of contemporary organ-trafficking operations. However, Vietnamese investigators do not consistently have access to advanced digital-forensic tools or streamlined procedures for obtaining cross-border data.¹² In many cases, foreign platforms do not respond to domestic data requests, creating substantial evidentiary gaps. Without procedural integration between cybercrime enforcement and trafficking investigations, digital trails often remain unexplored. A second structural barrier arises from socio-cultural dynamics that shape victim behavior.¹⁹ Many victims do not initially recognize themselves as exploited, especially when the organ removal is connected to economic hardship, family obligations,

or misleading promises of medical safety. Cultural attitudes surrounding bodily integrity, honour, and community perception further discourage disclosure.¹⁰ International research similarly notes that victims may prefer silence to avoid stigma or legal consequences, especially when they are unsure whether their actions are themselves punishable.¹ Vietnam's legal framework does not include explicit non-criminalization protections for organ-trafficking victims, reinforcing the fear of prosecution. This lack of victim-centered safeguards undermines reporting and leaves law enforcement with limited firsthand information.

Victim assistance structures are also underdeveloped. International standards emphasize trauma-informed support, medical care, and psychological counseling as essential elements of anti-trafficking systems.⁴ Yet Vietnam lacks specialized services for individuals harmed by organ removal, leaving victims to navigate medical and emotional consequences without formal support. This contributes to under-reporting and limits the State's ability to gather valuable evidence. A third barrier concerns the fragmented nature of interagency coordination.⁹ Organ trafficking spans multiple domains: law enforcement, hospital administration, border control, and social services. However, Vietnam does not operate a dedicated multi-agency task force focused specifically on organ-removal crimes. This gap contrasts with international best practices advocating integrated investigative teams and mandatory communication protocols.^{16,21} Without structured coordination, cases progress in a piecemeal manner, with agencies operating in parallel rather than in partnership. For example, health authorities may detect anomalies in transplant documentation but lack clear channels to report concerns to law enforcement.

Cross-border coordination is similarly limited. Organ-trafficking networks frequently rely on international brokers and transplant facilities abroad.^{20,22,23} Yet Vietnam lacks specialized mutual-assistance agreements or rapid-response protocols tailored to organ trafficking. Comparative studies show that countries without such mechanisms struggle to trace victims or perpetrators across borders, leading to case attrition.⁶ Accordingly, reform priorities should extend beyond statutory amendment to include institutional strengthening, specialized training, and enhanced international cooperation. Vietnam would benefit from clarifying

statutory definitions to reduce interpretive uncertainty and align with global standards.¹³ Strengthening digital-forensics capacity, enhancing medical-sector accountability, and establishing mandatory reporting obligations are also essential. Equally important are victim-centered reforms, including confidential reporting channels and explicit non-punishment guarantees. Finally, developing a national multi-agency task force and enhancing cross-border cooperation would significantly improve Vietnam's ability to detect and dismantle sophisticated organ-trafficking networks.¹² Ultimately, addressing organ trafficking requires a holistic strategy that integrates legal refinement with institutional strengthening.^{24,25} By improving coordination, enhancing investigative capacity, and adopting victim-centered protections, Vietnam can build a more resilient and effective framework for combating organ-removal trafficking.

4. Conclusion

This study examined the adequacy of Vietnam's criminal-law framework in addressing the increasingly sophisticated nature of human organ trafficking. Although Vietnam has established a foundational set of provisions within the 2015 Criminal Code, the analysis shows that these provisions remain only partially responsive to the contemporary realities of organ-removal trafficking. Organ trafficking today operates through multilayered networks that use deception, digital recruitment, transnational brokerage, and, at times, complicit medical intermediaries.

Consequently, a legal framework grounded in broad human-trafficking clauses is insufficient to capture the full complexity of these activities. The findings indicate three central limitations. First, the absence of a standalone offence definition for organ-removal trafficking creates interpretive gaps that hinder consistent prosecution. Without explicit statutory elements, enforcement authorities must infer organ-specific exploitation from general trafficking provisions, increasing evidentiary burdens and judicial discretion. Second, the legal framework does not fully address the technological and cross-border features that now characterize organ trafficking.

The lack of tailored provisions on digital solicitation, medical-sector reporting obligations, and structured international cooperation leaves enforcement efforts fragmented and reactive rather than preventive. Third, the study highlights structural

barriers – such as limited investigative expertise, uneven institutional coordination, and insufficient victim protections – that further weaken practical implementation. So, these findings suggest that legal reform must be paired with institutional modernization.

Vietnam would benefit from clarifying statutory definitions, strengthening digital-forensic and medical-legal capacities, introducing mandatory hospital reporting mechanisms, and adopting explicit non-criminalization protections for victims of organ trafficking. Equally important is the development of integrated multi-agency investigative structures capable of coordinating across provinces and borders. Ultimately, enhancing Vietnam's response to organ trafficking requires a holistic approach that aligns legal clarity, institutional capability, and victim-centered protections.

By adopting reforms informed by international best practices and adapted to its domestic context, Vietnam can strengthen the effectiveness, coherence, and legitimacy of its efforts to combat this complex form of transnational exploitation.

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Review Article

Financial Autonomy in Vietnam's Public Health Facilities: Institutional Barriers under the 2023 Medical Examination and Treatment Law

Tuyen Quang Nguyen^a, Anh Hai Vu^{b*}

^aAssoc. Prof. Dr. Tuyen Quang Nguyen, Faculty of Economics Law, Hanoi Law University, Viet Nam. ^bBanking Academy of Vietnam.

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Abstract

Introduction: Vietnam has pursued financial autonomy in public health facilities as a core pillar of health-financing reform; however, the legislative shift introduced by the 2023 Law on Medical Examination and Treatment has generated both momentum and uncertainty. This study aims to examine the institutional barriers that shape the implementation of financial autonomy under the new law, with particular attention to the regulatory, governance, and operational dimensions affecting public hospitals. **Methods:** Employing a qualitative research design, the study applied Weimer and Vining's (2025) policy analysis framework to systematically analyse legal and policy documents issued before and after the enactment of the 2023 Law, together with secondary academic literature and policy reports. **Results:** The findings reveal persistent regulatory overlaps, pricing and procurement constraints, and limited managerial flexibility, which collectively undermine the intended effects of autonomy and inadvertently discourage innovation and investment in service quality. **Conclusion:** The study concludes that, while the 2023 Law provides an important legal foundation for strengthening autonomy, its effectiveness depends on clarifying sub-law regulations, harmonizing related legislation, and enhancing financial governance capacity. By offering a jurisdiction-specific institutional analysis, the study contributes contextual evidence to debates on hospital autonomy in transitional health systems.

1. Introduction

Vietnam's public healthcare system has historically been financed predominantly through State budget allocations, reflecting the country's

commitment to equitable access to essential health services. However, growing fiscal pressures, rising healthcare demand, and the need to

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***Corresponding author:** Dr Anh Hai Vu, Banking Academy of Vietnam, email: anhvh@hvn.edu.vn; <https://orcid.org/0009-0002-0822-4570>. Email: anhvh@hvn.edu.vn

modernize service delivery have prompted the government to gradually reduce budget dependency and enhance the autonomy of public hospitals. A major policy shift began with Decree No. 16/2015/NĐ-CP, later reinforced by Decree No. 60/2021/NĐ-CP,¹ both of which introduced a more flexible model of financial self-management for public service delivery units.² These measures signalled a transition toward a performance-oriented and efficiency-based management culture. The 2019 pilot of full financial autonomy at four central-level hospitals³ further demonstrated the government's intent to test a quasi-market model of hospital governance, granting significant discretion over revenue generation, expenditure, human resources, and investment decisions. Despite these ambitions, experience over the past few years has revealed uneven outcomes and multiple emerging challenges. While greater autonomy created opportunities for hospitals to diversify income, improve facilities, and attract skilled professionals,⁴ it also exposed systemic vulnerabilities. The COVID-19 pandemic, in particular, served as a stress test for the autonomy model. Hospitals confronted unprecedented operational pressures, including escalating treatment costs, shortages of medical supplies, and disruptions in procurement chains. The crisis highlighted rigidities in price-setting mechanisms, delayed approval processes, and compliance burdens that constrained hospitals' ability to respond swiftly and effectively.⁵ These weaknesses underscored that autonomy without regulatory coherence and adaptive governance can lead to operational inefficiencies, inequities, and financial risks. To analyse these dynamics, this study draws upon multiple theoretical foundations. Institutional Theory provides a useful lens to understand how formal rules – laws, decrees, circulars – and informal organisational practices intersect to shape behaviour and influence policy outcomes.⁶ It highlights that policy effectiveness depends not only on written regulations, but also on organisational culture, norms, capacity, and the degree of discretion exercised by hospital leaders. Public Choice Theory and New Public Management (NPM) further enrich the analysis by focusing on incentive structures, managerial autonomy, accountability frameworks, and the pursuit of efficiency in public service delivery.⁷ Together, these perspectives illuminate both the motivations and constraints that influence hospital decision-making when autonomy is expanded.⁸ Additionally, the

WHO/World Bank Health Financing Framework situates financial autonomy within core financing functions – revenue generation, pooling, and purchasing – linking it to universal health coverage (UHC) objectives of sustainability, equity, and access.⁹

Despite reform momentum, several critical problems persist. Fragmented and sometimes conflicting legal documents have created a layer of regulatory ambiguity. Intersections between the Law on Medical Examination and Treatment No. 15/2023/QH15,¹⁰ the Law on Prices No. 16/2023/QH15,¹¹ Decree No. 60/2021/NĐ-CP,¹ and guiding circulars have led to inconsistent implementation, particularly around pricing, service fee calculations, insurance reimbursement, investment, and procurement processes.¹¹ Many hospitals find themselves responsible for financial outcomes but still constrained by strict administrative controls, limited pricing authority, and slow approval procedures. Furthermore, existing scholarship on hospital financial autonomy has largely examined pre-2023 reforms, focusing on financial performance, accounting systems, or management capacity,¹² leaving limited qualitative evidence on new institutional barriers emerging since the 2023 Law took effect in January 2024.¹⁰ To address these gaps, this study offers the first qualitative institutional analysis centred specifically on the 2023 Law on Medical Examination and Treatment and its early implications for financial autonomy in Vietnam's public hospitals. This study does not seek to generate new empirical evidence at the hospital level, nor does it undertake cross-national comparison. Instead, it offers a qualitative, jurisdiction-specific institutional analysis of Vietnam's evolving legal framework for hospital financial autonomy following the enactment of the 2023 Law on Medical Examination and Treatment. It examines how regulatory misalignments, governance constraints, and policy-practice gaps shape autonomy outcomes. The study identifies unintended consequences for pricing, investment decisions, procurement, human-resource flexibility, and accountability. In doing so, it contributes timely evidence to ongoing policy debates and proposes refined pathways to align autonomy with UHC principles, efficiency targets, and sustainable health financing reform. Ultimately, the aim is to support a more coherent, equitable, and resilient model of hospital financial autonomy that strengthens Vietnam's health system rather than shifting financial burdens to health facilities or

patients. As such, this study aimed to answer the following questions:

- a. How do current regulatory and institutional frameworks affect the implementation of financial autonomy in public hospitals?
- b. What key barriers limit hospitals from achieving effective financial autonomy, and what policy adjustments are needed?

2. Methods

This study employed a qualitative exploratory design to investigate the institutional and policy factors influencing the implementation of financial autonomy in Vietnam's public hospitals under the Law on Medical Examination and Treatment No. 15/2023/QH15.¹⁰ The study did not seek to generate primary empirical data (e.g., interviews or case studies); rather, it focused on systematic analysis of legal and policy documents to examine institutional design and early implementation dynamics. A qualitative approach was deemed appropriate given the complexity of ongoing reforms and the need to capture contextual nuances, perceptions, and governance dynamics that quantitative methods alone cannot reveal. The research integrated policy and institutional analysis to examine how legal frameworks interact with management practices across the health sector. Data were collected from multiple sources to enhance credibility and depth. Primary materials included laws, decrees, circulars, and resolutions regulating hospital operations and financial autonomy, selected purposively based on their relevance to pricing, procurement, budgeting, investment, and human-resource governance, and covering both pre- and post-2023 reform periods. Secondary sources comprised peer-reviewed studies, policy briefs, and analytical reports from organizations such as the World Health Organization and the World Bank.⁹ To reduce selection bias, documents were cross-checked across official government portals and triangulated with independent policy analyses. To enrich this evidence base, expert commentary and grey literature from the Ministry of Health, Vietnam Social Security, and media policy discussions were reviewed, offering insights into stakeholder perspectives and implementation challenges. Analytical saturation was considered achieved when recurrent regulatory themes and institutional constraints consistently emerged across document types. The analysis followed Weimer and Vining's Policy Analysis Framework,¹³ which provides a structured approach

to policy evaluation by examining (1) problem diagnosis, (2) institutional constraints shaping policy implementation, (3) policy alternatives and design choices, and (4) expected versus unintended effects of policy reforms. These four dimensions were applied as a deductive coding structure to ensure analytical consistency and transparency. This framework was used to assess the coherence, efficiency, and feasibility of Vietnam's hospital financial autonomy reform.

3. Discussion

Institutional, regulatory, and legal constraints affecting the operationalisation of financial autonomy in vietnam's public hospitals

A persistent obstacle to achieving genuine financial autonomy in Vietnam's public hospitals lies within the country's complex regulatory and legal framework. Although the Law on Medical Examination and Treatment No. 15/2023/QH15¹⁰ was enacted to modernize service delivery and promote managerial independence, its practical impact remains limited by overlapping mandates, conflicting regulations, and vague implementation guidance.¹⁴ A central difficulty arises from the dispersion of authority among several ministries that jointly influence autonomy policy. The Ministry of Health, the Ministry of Finance, and the Ministry of Home Affairs each oversee aspects such as professional standards, budgeting, and staffing. Yet their regulations often lack coordination, leading to inconsistent or even contradictory instructions for hospitals.¹⁵ Consequently, decision-making on issues like pricing, personnel, and investment approval becomes cumbersome, reducing administrative flexibility and slowing reform progress. Pricing policy presents another significant barrier. Under the Law on Prices No. 16/2023/QH15,¹¹ hospitals are unable to set service fees that accurately reflect real costs – including labor, consumables, and equipment depreciation. Rather than reiterating broader governance concerns, this discussion isolates pricing as a regulatory mechanism that directly undermines cost recovery and reinvestment capacity. Rigid ceilings and lengthy approval processes have created a mismatch between actual expenditures and allowable prices.¹⁶ This misalignment has led to chronic funding shortfalls and hindered hospitals' capacity to reinvest in infrastructure or enhance service quality, especially among institutions with higher autonomy status. Furthermore, ambiguity in defining autonomy levels and revenue-retention

rules adds to the uncertainty. Although *Decree No. 60/2021/NĐ-CP*¹ specifies four autonomy tiers, the criteria and application remain inconsistently interpreted. Some hospitals exercise broad discretion in financial management, whereas others remain cautious due to audit and legal concerns. This uneven understanding has produced wide disparities in implementation across institutions of similar scale.¹⁷ Ultimately, these regulatory inconsistencies constrain hospitals' ability to innovate, plan strategically, and adapt to evolving healthcare demands – undermining the broader objectives of efficiency, sustainability, and quality improvement envisioned by recent reforms.

Structural constraints on procurement and investment decisions under the financial autonomy framework

Although Vietnam's autonomy reforms were designed to grant hospitals greater managerial discretion, public facilities still operate under tight structural constraints in procurement and investment. These limitations – rooted in rigid legal provisions, risk-averse administration, and fragmented oversight – continue to restrict hospitals' capacity to plan strategically and allocate resources effectively.¹⁸ One of the most persistent challenges lies in the complexity of public procurement rules. Despite the reform's intention to increase hospitals' authority to purchase equipment, supplies, and services, procurement remains governed by strict bidding procedures and multi-layered approvals aimed at preventing corruption.¹⁴ In reality, these safeguards often cause prolonged delays in acquiring essential medical equipment and consumables, particularly high-value items. The widespread use of the "lowest-price" criterion further compromises quality, leaving hospitals with substandard or short-lived technologies that lack adequate maintenance and after-sales support. This analysis avoids repeating regulatory fragmentation arguments and instead highlights procurement rules as an operational bottleneck. Similarly, investment planning faces similar bottlenecks.¹⁵ Although *Decree No. 60/2021/NĐ-CP*¹ allows hospitals to mobilize revenue for infrastructure or service upgrades, regulations on asset management and investment approval remain cumbersome and inconsistently applied. Proposals to build new facilities or upgrade diagnostic systems typically require sign-off from multiple authorities, including the Ministry of Health and the Ministry of Finance.¹⁶ This multi-agency approval process often

leads to bureaucratic inertia, limiting hospital leaders' ability to respond quickly to patient needs or market shifts. Public-private partnership (PPP) models could, in theory, offer a pathway to unlock new investment resources. Some pilot projects have shown promise in modernizing equipment and diversifying services.⁴ However, unclear legal responsibilities, weak risk-sharing frameworks, and inconsistent post-audit procedures have discouraged broader participation. Overall, these structural and procedural barriers reveal an enduring tension between autonomy and central control. While designed to ensure accountability, the current procurement and investment framework inadvertently constrains hospitals' capacity to innovate, plan long term, and deliver higher-quality care. Unless these obstacles are systematically addressed, the vision of genuine financial autonomy will remain out of reach.

Leadership, governance, and accountability challenges in the implementation of financial autonomy

Leadership capacity, governance design, and accountability mechanisms are central to how financial autonomy takes shape in Vietnam's public hospitals. Although recent reforms were intended to empower hospital leaders with greater decision-making authority, many institutions remain bound by entrenched bureaucratic norms that limit initiative and slow progress. The gap between formal autonomy and practical authority has resulted in uneven implementation and, in some cases, passive resistance to reform.¹⁷ A key weakness lies in leadership readiness and managerial competence. Historically, hospital directors have been appointed for their clinical expertise rather than for management or financial experience. As autonomy expands, these leaders are expected to assume roles similar to chief executives – defining strategic directions, managing staff, and ensuring fiscal sustainability. Nonetheless, limited exposure to contemporary hospital management practices and risk-based decision-making has left many unprepared for these responsibilities.^{12,19} This lack of capacity often translates into risk-averse behaviour, where compliance takes precedence over innovation to avoid administrative penalties. Governance structures further constrain decision-making. Despite policy reforms, most hospitals still operate under rigid hierarchies, with major decisions – such as pricing, investment, or staffing – requiring multiple layers of approval from internal committees and external

agencies.¹⁵ This process not only delays execution but also blurs accountability. In some cases, leadership boards lack sufficient authority over financial planning, leading to fragmented management and conflicting priorities. Such rigidity runs counter to the principles of New Public Management, which emphasise decentralisation and performance-based accountability.¹⁸ Moreover, heightened oversight from auditors and anti-corruption bodies has created a cautious managerial climate. While transparency is vital, excessive procedural scrutiny discourages bold decisions and reinforces defensive governance. The absence of clear performance metrics linking autonomy to outcomes further weakens accountability.¹² Fundamentally, without stronger leadership capacity, clearer governance mandates, and balanced accountability frameworks, financial autonomy risks remaining largely symbolic – granting responsibility without genuine power to innovate or improve healthcare delivery.

Strategic policy and practice implications to enhance the effectiveness of hospital financial autonomy

Enhancing the effectiveness of financial autonomy in Vietnam's public hospitals demands a coherent blend of policy, institutional, and operational reforms. These reforms must close regulatory gaps, ease governance constraints, and resolve implementation challenges, while maintaining a balance between autonomy and accountability. The overarching goal is to promote efficiency without eroding equity and to align delegated authority with institutional capacity. A foremost priority is harmonising the fragmented legal framework governing hospital autonomy. Greater alignment between the Law on Medical Examination and Treatment No. 15/2023/QH15,¹⁰ the Law on Prices No. 16/2023/QH15,¹¹ and Decree No. 60/2021/NĐ-CP¹ would eliminate overlapping provisions that currently create uncertainty for hospital leaders. Unified guidance on pricing, revenue retention, procurement, and investment approvals would provide a more predictable environment for strategic planning.^{2,20} Establishing cross-ministerial coordination bodies or joint circulars could further streamline oversight and enhance policy consistency. Operational reforms are equally critical. Revising procurement and investment rules to incorporate risk-based flexibility – granting higher autonomy to compliant, well-performing hospitals – would accelerate decision-making and innovation. Expanding transparent public-private partnership models, supported by clear risk-sharing and audit

frameworks, could unlock new funding sources for infrastructure and technology upgrades.⁷ Moreover, digital governance tools such as e-procurement platforms and open reporting systems would strengthen accountability while reducing bureaucratic delays. Leadership capacity must also be reinforced. Training programmes in strategic management, health economics, and risk governance would prepare hospital directors for the complex demands of autonomy.⁴ Linking performance evaluations to outcomes such as service quality, efficiency, and patient satisfaction would embed accountability and incentivise continuous improvement. Finally, equity safeguards remain essential.⁸ Equity considerations are retained but articulated concisely to avoid overlap with earlier policy discussions. Targeted subsidies, adjusted funding, and differential reimbursement mechanisms should protect vulnerable hospitals and patient groups. Collectively, these measures can transform financial autonomy from a procedural reform into a genuine driver of innovation, efficiency, and sustainability – while upholding the public service mission of Vietnam's healthcare system. Therefore, implementing these reforms is expected to strengthen the coherence and responsiveness of Vietnam's health-financing framework, enabling evidence-based policymaking, greater fiscal sustainability, and more equitable access to quality healthcare nationwide.

4. Conclusion

Vietnam's pursuit of financial autonomy in public hospitals marks a significant turning point in the country's health system reform trajectory. Designed to enhance efficiency, improve service quality, and reduce dependency on State budget allocations, autonomy offers a pathway for hospitals to take greater ownership of financial and managerial decisions. However, the extent to which these ambitions can be realised depends heavily on the ability of the system to minimise institutional frictions, address regulatory inconsistencies, and create an enabling environment that supports genuine decentralisation of authority.

The introduction of the Law on Medical Examination and Treatment No. 15/2023/QH15 represents an important legislative milestone that lays the groundwork for a more modern, accountable, and performance-oriented public health sector. Nevertheless, early evidence indicates that structural, legal, and governance barriers continue to

constrain effective implementation. Fragmented policies, inflexible pricing regulations, procurement challenges, limited investment autonomy, and risk-averse leadership cultures have constrained the intended benefits of the reform. Without targeted adjustments, autonomy risks remaining largely symbolic—transferring responsibility to hospitals without sufficient authority or flexibility.

Looking ahead, strategic policy refinements are essential to ensure that autonomy drives the outcomes it is intended to deliver. Priority actions include harmonising legal frameworks, strengthening managerial and leadership capacity, and recalibrating accountability mechanisms toward performance-based models that protect equity while incentivising efficiency and quality. If supported by coherent policy, capable leadership, and balanced oversight, financial autonomy has the potential to contribute meaningfully to a more efficient, high-quality, and sustainable public healthcare system in Vietnam.

This study also has some limitations. It does not include primary empirical data from hospitals or policymakers, as the focus is on institutional design rather than implementation outcomes, and the analysis is jurisdiction-specific. These limitations reflect deliberate analytical choices rather than methodological gaps. By concentrating on Vietnam's legal and regulatory architecture at a critical reform juncture, the study offers timely insights into how hospital autonomy reforms are shaped by institutional coherence, governance capacity, and regulatory layering.

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Review Article

Ethical and Legal Conflicts in HIV Status Disclosure: An Indian Perspective

Sachin S Patil^{a*}, Ravindra B Deokar^b, Rajesh C Dere^c

^aProfessor (Additional), Department of Forensic Medicine and Toxicology, Seth GS Medical College and KEM hospital, Mumbai. ^bProfessor (Additional), Department of Forensic Medicine and Toxicology, LT Municipal Medical College and LTMG hospital, Mumbai. ^cProfessor and Head, Department of Forensic Medicine and Toxicology, TN Medical College and BYL Nair hospital, Mumbai, Maharashtra, India.

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Abstract

Introduction: Human Immunodeficiency Virus (HIV) infection presents complex ethical and legal challenges beyond clinical management, particularly regarding disclosure of an individual's HIV-positive status to spouses and intimate partners. In India, these dilemmas are intensified by persistent social stigma, gender inequality and the medico-legal consequences associated with HIV/AIDS. The discussion is grounded in core ethical principles—autonomy, confidentiality, beneficence, non-maleficence, and justice—and their practical application in forensic and clinical settings. **Methods:** The review integrates ethical analysis, legal interpretation, and public health perspectives relevant to forensic and medico-legal practice. **Discussion:** The legal framework governing disclosure is analyzed with reference to the Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (Prevention and Control) Act, 2017, which permits limited disclosure to spouses under defined circumstances while prioritizing patient confidentiality and safeguarding individuals, particularly women, from violence, abandonment, and discrimination. The paper highlights real-world ethical dilemmas faced by practitioners when patients refuse disclosure, the gendered implications of disclosure decisions and the potential impact on marital relationships and public health. **Conclusion:** From a forensic and medico-legal standpoint, the article underscores the importance of structured counselling, adherence to statutory guidelines, and institutional protocols to guide ethically defensible decision-making. The article concludes that a balanced, ethically sensitive, and legally informed approach is essential to protect individual rights while ensuring partner safety and public health within the Indian context.

1. Introduction

Human Immunodeficiency Virus (HIV) globally and in India, despite advances in diagnosis, continues to be a significant public health concern treatment, and prevention strategies. Although

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***Corresponding author:** Dr Sachin Sudarshan Patil, Professor (Addl), Department of Forensic Medicine and Toxicology, Seth GS Medical College and KEM hospital, Mumbai. Email id: sspfmt7@gmail.com

antiretroviral therapy has transformed HIV infection into a chronic manageable condition, HIV/AIDS continues to generate complex ethical, legal, and medico-legal challenges that extend beyond clinical management.^{1, 2} One of the most contentious issues in this domain is the disclosure of an individual's HIV-positive status to spouses and intimate partners, particularly within the institution of marriage, where issues of consent, trust, and legal responsibility intersect.³ From an ethical and forensic standpoint, disclosure of HIV status raises competing duties owed by healthcare professionals. The obligation to maintain patient confidentiality and respect autonomy is a foundational principle of medical ethics and is reinforced by ethical guidelines and constitutional protections of privacy in India.^{4,5} At the same time, the principles of beneficence and non-maleficence impose a duty to prevent foreseeable harm, including the transmission of HIV to an unsuspecting spouse.^{4,5} Failure to disclose may expose partners to significant health risks, while involuntary disclosure may result in adverse consequences such as stigma, discrimination, marital breakdown, and social exclusion.^{6,7}

In the Indian socio-legal context, these ethical conflicts are further compounded by persistent stigma, limited awareness, and entrenched gender inequalities. Studies and policy reports have consistently demonstrated that women living with HIV face disproportionate risks of domestic violence, abandonment, and economic deprivation following disclosure.^{6,7,8} These realities necessitate a cautious and legally informed approach to disclosure, particularly where disclosure may place an individual at risk of physical or social harm. Recognizing these competing interests, India has adopted a rights-based legal framework through the enactment of the Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (Prevention and Control) Act, 2017.³ The Act establishes confidentiality as the default legal position while permitting limited disclosure to spouses under narrowly defined circumstances, subject to counselling and risk assessment. It further incorporates specific safeguards for women where disclosure may result in violence or abandonment and imposes a statutory duty on persons living with HIV to take reasonable precautions to prevent transmission.^{3,9} With increasing litigation, forensic evaluations, and medico-legal scrutiny relating to alleged nondisclosure, marital disputes, and HIV

transmission, healthcare and forensic professionals are frequently required to provide expert opinions within this legal framework. A clear understanding of the ethical principles, statutory provisions, and practical implications governing HIV status disclosure is therefore essential. This article critically examines the ethical and legal conflicts surrounding HIV status disclosure in India, with particular emphasis on forensic and medico-legal responsibilities, and proposes ethically defensible and legally compliant approaches for managing disclosure within spousal relationships.

2. Materials and Methods

Study Design

This article was conducted as a systematic narrative review focusing on ethical and legal conflicts related to disclosure of HIV status to spouses and intimate partners in the Indian context. The review integrates ethical analysis, legal interpretation, and public health perspectives relevant to forensic and medico-legal practice.

Data Sources

A comprehensive literature search was performed using electronic databases including PubMed/MEDLINE, Google Scholar, Scopus, and IndMED. In addition, official documents and legal texts were retrieved from authoritative sources such as the Government of India, National AIDS Control Organisation (NACO), World Health Organization (WHO), UNAIDS, and the Indian Council of Medical Research (ICMR).

Search Strategy

The search was conducted using combinations of the following keywords and Medical Subject Headings (MeSH): HIV disclosure, confidentiality, spousal notification, medical ethics, forensic medicine, medico-legal responsibility, HIV/AIDS Act 2017, public health law, and India. Boolean operators ("AND", "OR") were applied to upgrade the search. Articles published in English up to December 2024 were considered.

Inclusion and Exclusion Criteria

Studies and documents were included if they:

- Addressed ethical, legal, or medico-legal aspects of HIV status disclosure
- Were relevant to the Indian context or comparable socio-legal settings
- Included guidelines, legislation, policy documents, or peer-reviewed articles

Exclusion criteria included:

- Purely clinical studies without ethical or legal discussion
- Opinion pieces lacking scholarly or legal basis
- Non-English publications and duplicate records

Data Extraction and Analysis

Relevant information was extracted independently by the authors, focusing on ethical principles, legal provisions, judicial interpretations, public health implications, and practical challenges faced by healthcare professionals. Data were thematically analyzed and synthesized under predefined domains: ethical principles, legal framework, gender considerations, clinical and forensic dilemmas, and public health impact.

The Ethical Principles

The ethical tension in HIV disclosure revolves around four core principles:

a. Autonomy and Confidentiality

Patients have a fundamental right to privacy and confidentiality regarding their health information. This is rooted in ethical medical practice and recognized by legal frameworks and constitutional protections in India (e.g., the right to privacy under Articles 19 and 21). Breach of confidentiality without consent is generally unethical.^{4, 5, 9}

b. Beneficence and Non-maleficence

Healthcare professionals have a duty to protect patient welfare (beneficence) and to avoid causing harm (non-maleficence). Not informing a spouse at risk of contracting HIV may result in avoidable harm, while involuntary disclosure can lead to social stigma, violence, abandonment, or even divorces.^{4, 5, 6}

c. Justice

Fairness and protection for both partners are vital. Ethical justice demands that neither partner be disadvantaged—especially in contexts where gender dynamics traditionally place women at greater risk of violence and abandonment.^{4, 8, 10-13}

3. Legal Framework in India

India's HIV and AIDS (Prevention and Control) Act, 2017 specifically addresses disclosure of HIV status to partners. Key provisions include:

- Section 8 (Confidentiality Rule): No healthcare provider may disclose a person's HIV status to their partner, except under specific conditions.
- Section 9 (Partner Notification): Providers may inform a spouse only when:
 1. They believe the partner is at significant risk of transmission,
 2. The HIV-positive person has been counselled to disclose,
 3. The provider believes the patient will not inform their partner, and
 4. The patient has been informed of the provider's intention to disclose.
- 5. In-Person & Post-Counselling: The disclosure must be done in person and followed by immediate counselling for the partner.
- Exception for Women: When disclosure may put a woman at risk of violence, abandonment, or harmful consequences, providers must not inform the partner.¹⁴

Additionally, the Act places a duty on persons with HIV to take reasonable precautions—including informing partners before sexual contact—to prevent transmission.^{3, 15}

Indian courts have consistently recognized that confidentiality of HIV status, though fundamental, is not absolute and must be balanced against competing rights and public interest considerations. In the landmark decision of *Mr. X v. Hospital Z*, the Supreme Court held that disclosure of an individual's HIV-positive status to a prospective spouse could be justified where there existed a real and foreseeable risk of transmission, thereby prioritizing the partner's right to life and health over strict medical confidentiality. The Court emphasized that the right to privacy is subject to reasonable restrictions when non-disclosure poses a serious threat to another individual's fundamental rights. At the same time, subsequent judicial pronouncements by High Courts have reinforced that arbitrary or unnecessary disclosure of HIV status constitutes a violation of dignity and privacy under Article 21 of the Constitution, attracting constitutional liability and, in appropriate cases, compensation.

These judicial trends align with the Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (Prevention and Control) Act, 2017, which codifies confidentiality as the default legal rule while permitting limited partner notification under narrowly defined conditions, subject to counselling, risk assessment, and safeguards against harm—particularly for women.¹⁶ In case of *M. Vijaya v. Singareni Collieries* (2001): The Andhra Pradesh High Court held that while a person has a right to privacy, the employer's duty to ensure the health of other employees and the public interest can occasionally override it, but only in specific, high-risk contexts.¹⁷ In case *Lucy R. D'Souza v. State of Goa* (1990): which is one of the earliest cases. The Bombay High Court upheld the isolation of an HIV-positive

person under the Goa Public Health Act, prioritizing public safety over individual liberty—a stance that would likely be viewed differently today under the 2017 Act.¹⁸ This case challenged mandatory testing. The court held that individual rights could be restricted for the "collective interest of the community." The petitioner challenged Section 13 of the Goa, Daman and Diu Public Health Act, 1985, which authorized the government to isolate/quarantine any person found to be HIV-positive. The Petitioner's Argument: It was argued that such power was "draconian," violated the right to liberty (Article 21), and led to social ostracization without a scientific basis for the necessity of isolation. The Court's View: The Bombay High Court (Panaji Bench) upheld the validity of the law. In a recent [Case of Chhattisgarh High Court – HIV Privacy Breach Case \(2025\)](#), the Chhattisgarh High Court directed the State Government to pay compensation after a government hospital publicly displayed a notice revealing a mother's HIV-positive status near her newborn. The court described this act as "inhuman, unethical, and a violation of privacy under Article 21 of the Constitution."¹⁹

These legal obligations illustrate the dual ethical aim: upholding confidentiality while safeguarding partners from harm. Indian criminal law also provides a forensic framework for addressing HIV nondisclosure through Sections 269 and 270 of the Indian Penal Code (IPC), which criminalize negligent and malignant acts likely to spread infection of a disease dangerous to life. Section 269 IPC applies where an individual, through negligence, exposes another person to the risk of infection, while Section 270 IPC addresses deliberate or reckless conduct with knowledge of potential transmission. Although Indian courts have not conclusively criminalized mere nondisclosure of HIV status per se, forensic and medico-legal interpretation suggests that intentional concealment of HIV-positive status in a marital or sexual relationship, coupled with unprotected exposure, may attract criminal liability under these provisions if mens rea or gross negligence is established.²⁰

The Evolution of Legal stance for HIV status disclosure

The legal stance in *Lucy R. D'Souza* is largely considered outdated by modern human rights standards and subsequent legislation. The shift in Indian law can be visualized through the changing priorities of the court:

During 1980s - 1990s, primary focus was on public safety where mandatory testing and isolation were seen as valid "reasonable restrictions" on liberty. During 2000s – 2017, primary focus shifted to privacy and rights where Courts began recognizing that stigmatization and "civil death" are worse than the disease itself. During 2017 – Present, primary focus was on Autonomy & Consent, where The HIV Act (2017) expressly prohibits mandatory testing and isolation, making the *Lucy D'Souza* approach illegal today.¹⁸

4. Discussion

Ethical Dilemma in Practice

The real-world ethical dilemma surfaces when these principles conflict:

a. When Patients Refuse to Disclose

If an HIV-positive patient refuses to inform their spouse, healthcare providers face a moral and legal conundrum. Should they maintain strict confidentiality or prioritize the spouse's right to know? In many settings, counsellors feel constrained by legal protections for confidentiality, yet frustrated by inability to protect unaware spouses.^{5, 6}

b. Gendered Implications

Indian society still often places women in vulnerable positions within marriage. The 2017 Act's special safeguard for women highlights the ethical necessity to protect women from potential violence or abandonment that may result from disclosure.^{6, 7, 8}

c. Stigma and Social Consequences

Disclosing HIV status—even with consent—can have devastating social consequences, including discrimination from family and community, forced separation, or divorce. Several Indian news reports describe marital discord after disclosure or concealed HIV status leading to disputes.^{7, 15}

5. Societal and Public Health Considerations

a. Public Health vs. Individual Rights

From a public health perspective, nondisclosure may allow ongoing transmission within couples. Conversely, involuntary disclosure may deter people from seeking testing or treatment due to fear of stigma. This illustrates the delicate ethical balance between individual rights and community health needs.^{1, 5, 15}

b. Stigma and Awareness

HIV/AIDS remains stigmatized in many parts of India. Efforts to reduce stigma through

education, accessible care, and open dialogues are essential to create an environment where disclosure is less dangerous and more supportive for patients and their partners.^{7,8}

6. Ethical and Practical Recommendations

Based on existing legal and ethical frameworks, the following approaches help navigate this dilemma:

a. Strengthen Counselling and Support

Counsellors play a crucial role. Comprehensive, empathetic counselling can encourage voluntary disclosure, helping partners understand risk reduction and treatment.

b. Clear Institutional Protocols

Healthcare institutions should establish explicit protocols aligned with the 2017 Act to guide practitioners on when and how to disclose status to partners ethically and legally. Proper training of handling as well as proper documentation of such records should be provided to concerned doctors.

c. Address Gender-Based Violence

Because of the potential for violence after disclosure, additional safeguards, protective services, and legal support should be provided, particularly for women.

d. Community Awareness Campaigns

Reducing stigma at the community level encourages earlier testing, responsible disclosure, and mutual support among spouses—key to both ethical conduct and public health.^{1,3,9,10,21}

The National HIV Counselling and Testing Guidelines 2024 emphasize:

- **Index Testing:** A voluntary process where providers offer HCTS (HIV Counselling and Testing Services) to the partners and biological children of PLHIV.
- **Integration of Care:** Disclosure is permitted between healthcare providers *only* if it is necessary for the immediate care or treatment of the patient.
- **Pseudonymity in Courts:** Under Section 34 of the 2017 Act, Legal proceedings involving HIV status must be conducted *in camera* (privately) and allow the use of pseudonyms (e.g., "Mr. X") to prevent public disclosure.^{22,23}

Institutional Responsibilities

Under the NACO Data Protection Guidelines, every establishment (hospitals, labs, or offices) that keeps records of "protected persons" (HIV-positive individuals) must:

- Appoint a Complaints Officer to handle grievances regarding privacy breaches.
- Ensure that HIV status is not recorded on general medical files accessible to non-essential staff.
- Use coded identifiers (UIDs) instead of names on samples and public registers.²⁴

Key takeaway Messages

- **Informed Consent:** Testing or disclosure without informed consent is a violation of the law.
- **Right to Health vs. Privacy:** If a conflict arises between "Right to Privacy" and "Right to Life" (of a partner), the Right to Life usually prevails, but only following the strict protocols of the 2017 Act.

7. Conclusion

The ethical dilemma of HIV status notification to a spouse in India is multifaceted and deeply sensitive. While confidentiality and respect for autonomy are fundamental, the partner's health and well-being cannot be ignored. The Indian legal framework—through the HIV/AIDS Act, 2017—attempts to mediate this dilemma by setting clear conditions for when disclosure is permitted and by protecting vulnerable individuals from harm.

Effective resolution demands:

- ethical sensitivity,
- robust counselling,
- informed legal practice,
- and societal efforts to reduce stigma.

Only with a balanced approach that respects both individual rights and the health and safety of partners can this dilemma be navigated responsibly in the Indian context.

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Review Article

Forensic Justice for Sexual Assault Survivors: A Critical Analysis of Rape Kit Implementation in India

Bharti Nair Khan^{a*}

^aAssistant Professor (SS), UPES, Knowledge Acres Kandoli, Dehradun 248007, Uttarakhand, India.

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Abstract

Introduction: Rape kits, or Sexual Assault Evidence Collection Kits (SAECKs), are critical forensic tools used in the investigation and prosecution of sexual assault. Despite their proven importance, India faces numerous implementation challenges due to infrastructure deficits, lack of training, and policy gaps. **Methods:** This study adopted a qualitative and descriptive research methodology to assess the application, availability, and effectiveness of Sexual Assault Evidence Collection Kits (SAECKs) in India. Data collection involved a review of secondary sources, including government guidelines, legal provisions, and research publications such as the Ministry of Health and Family Welfare (2014), CEHAT (2018), UNFPA, and National Crime Records Bureau (2023). **Discussion:** Findings indicate systemic barriers in infrastructure, training, and survivor-sensitive care. Comparative analysis with international standards highlights India's need for legally binding mandates on SAECK use, nationwide Sexual Assault Nurse Examiner (SANE) programs, and technological solutions for evidence tracking. **Conclusion:** Strengthening rape kit implementation through statutory backing, infrastructure expansion, and survivor-centric protocols is essential to improving conviction rates and ensuring justice for survivors of sexual violence in India.

1. Introduction

In India, rape kits, also known as Sexual Assault Evidence Collection Kits (SAECKs), are increasingly being recognized as indispensable forensic tools in the investigation and prosecution of sexual offences.

Globally, the use of rape kits has significantly improved the quality of evidence presented in courts, enhancing conviction rates and reinforcing survivors' testimonies with objective, scientific proof such as DNA, semen, saliva, blood, and skin

particles. However, in the Indian context, the implementation of rape kits remains inconsistent, underutilized, and poorly regulated.

Following the brutal 2012 Nirbhaya case, India witnessed a wave of legal reforms, including the Criminal Law (Amendment) Act, 2013, which expanded the definition of sexual offences and mandated prompt medical examination of survivors. In 2014, the Ministry of Health and Family Welfare (MoHFW) issued medico-legal

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*Corresponding author: Bharti Nair Khan, Assistant Professor (SS), UPES, Knowledge Acres Kandoli, Dehradun 248007, Uttarakhand, India. E-mail: bhartinair.khan@ddn.upes.ac.in

guidelines emphasizing the use of SAECKs for comprehensive and respectful treatment of survivors. Yet, the lack of legal codification of these guidelines and limited awareness among law enforcement and healthcare personnel have hindered effective implementation.¹

Infrastructure and human resources pose additional challenges. A 2018 study by CEHAT (Centre for Enquiry into Health and Allied Themes) found that only 20% of hospitals in Maharashtra followed proper forensic protocols, and fewer than 10% had trained staff or access to rape kits. Furthermore, India's Forensic Science Laboratories (FSLs) are overburdened and lack the capacity to process samples efficiently, contributing to extensive delays and case backlogs. For instance, in Delhi alone, over 16,000 DNA cases were pending in 2021, undermining the timely delivery of justice.²

Thus, while rape kits hold the potential to transform India's response to sexual violence, their effectiveness is currently curtailed by systemic inefficiencies, training gaps, and lack of accountability mechanisms. Urgent reforms are needed to integrate SAECKs within a survivor-centric, rights-based legal and medical framework.

2. Rape Kit

A rape kit also known as a Sexual Assault Forensic Evidence (SAFE) kit, Sexual Assault Evidence Collection Kits (SAECKs) in India is a collection of items used by medical professionals to gather and preserve physical evidence following an alleged sexual assault.³

Key Components of a Rape Kit:

One of its primary components includes swabs and envelopes, which are used to collect bodily fluids such as semen, saliva, and blood from the survivor's body or clothing. These samples are vital for DNA analysis and play a crucial role in establishing physical contact or identifying the perpetrator. The kit further contains documentation forms, which allow the medical examiner to record a detailed account of the survivor's statement, obtain informed consent for the examination, and note clinical observations and injuries. In instances where drug-facilitated sexual assault is suspected, blood and urine collection kits are essential to test for intoxicating substances that may impair memory or consent. Some advanced kits may also include tools for photographic evidence, enabling the medical professional to document visible injuries, always ensuring this is done with the survivor's explicit consent to protect dignity and privacy. Lastly, chain of custody forms is a critical legal

component of the kit, as they record each person who handles the evidence, ensuring its admissibility in court by maintaining its integrity from collection to laboratory analysis.⁴

The Evidentiary Value of Rape Kits

Studies globally confirm that rape kits enhance the legal credibility of the survivor's testimony. When kits are used and analyzed, prosecution rates improve. The presence of DNA evidence often shifts a case from circumstantial to corroborated, allowing for stronger prosecutorial decisions.⁵ Absence of DNA or physical trauma should not invalidate a survivor's testimony, especially in cases where the victim delayed reporting or the assault did not involve penetrative contact.⁶

National Standards and Statutory Provisions

Free and Immediate Medical Treatment for Survivors: Section 473 of Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS) mandates that every hospital, whether public or private, shall immediately provide first-aid or medical treatment, free of cost, to victims of sexual offences and must inform the police.

Medical Examination of Rape Survivors: Section 184 of the BNSS lays down a statutory framework for conducting the medico-legal examination of a survivor in cases of rape or attempted rape. It emphasizes time-sensitive, consent-based, and scientifically valid processes, reinforcing the evidentiary foundation for prosecuting sexual offences while upholding the survivor's dignity and bodily autonomy.

Legal Accountability: Section 203 of Bharatiya Nyaya Sanhita, 2023 (BNS) prescribes punishment up to one year imprisonment and/or fine for people in charge of hospitals who contravene the provisions of section 473 BNSS.

Consent and Voluntariness: Section 35 of the Bharatiya Sakshya Adhinyam, 2023 (BSA), explicitly reinforces the need for consent and voluntariness when recording evidence, particularly in cases involving survivors of sexual violence. This section upholds that any statement, confession, or forensic evidence such as bodily samples or physical examinations must be obtained without coercion, intimidation, or inducement. The provision is crucial in cases of sexual assault where survivors are often in a vulnerable and traumatized state.

Medico-Legal Guidelines for Sexual Assault Survivors in India: In 2014, the Ministry of Health and Family Welfare (MoHFW), Government of India, released the "Guidelines and Protocols: Medico-Legal

Care for Survivors/Victims of Sexual Violence". This landmark document was developed in response to increasing concerns about the insensitive and inconsistent medico-legal practices surrounding sexual assault cases in India. It aimed to standardize the care of survivors and ensure the ethical, scientific, and legally sound collection of forensic evidence using Sexual Assault Evidence Collection Kits (SAECKs).⁷

3. Results

The analysis of secondary sources and legal documents reveals significant discrepancies between policy frameworks and ground-level implementation of Sexual Assault Evidence Collection Kits (SAECKs) in India.

Inconsistent Implementation of National Guidelines:

Despite the 2014 Ministry of Health and Family Welfare guidelines mandating the standardized use of SAECKs in all cases of sexual violence, actual implementation across states remains inconsistent. Some states, such as Maharashtra and Delhi, have adopted structured medico-legal protocols, while others continue to rely on outdated or informal practices.⁸

Shortage and Uneven Distribution of SAECKs:

Several hospitals, especially in rural or under-resourced districts, reported a lack of rape kits or received them sporadically. A 2018 CEHAT study revealed that many district hospitals in Maharashtra lacked access to functioning SAECKs, limiting proper forensic documentation.

Low Forensic Utilization Rates: Even when kits are available, forensic evidence is often underutilized. Healthcare providers frequently lack proper training to administer SAECKs in a trauma-informed manner. As a result, critical evidence is lost or improperly preserved.

Legal Accountability Measures Remain Underused:

Section 203 of the Bharatiya Nyaya Sanhita (BNS), 2023, prescribes penalties for hospital administrators who fail to comply with forensic obligations under section 473 BNSS. However, there are limited cases of enforcement, indicating a gap between legislative intent and operational practice.

Informed Consent and Survivor Rights: While section 35 of the Bharatiya Sakshya Adhinyam (BSA) underscores the importance of consent and voluntariness, many survivors report being examined without adequate explanation or choice. Documentation standards are also poorly followed,

often lacking comprehensive medical history or psychological assessment.⁹

Low Conviction Rates Correlate with Poor Evidence

Collection: According to the National Crime Records Bureau (NCRB), 31,516 rape cases were registered in India in 2022, but only 27.2% ended in conviction. Experts attribute part of this gap to deficient forensic collection and evidence handling during the early stages of investigation.

Limited Training and Awareness: There is a significant lack of regular training programs for doctors, forensic staff, and police officers involved in sexual assault investigations. The absence of trauma-informed, rights-based approaches contributes to further trauma for survivors and weakens the evidentiary chain.

4. Discussion

The present study set out to evaluate the implementation and effectiveness of SAECKs in India, examining whether forensic evidence collection in sexual assault cases is adequately standardized, survivor-centered, and legally enforced.

Uneven Implementation across States: The study confirmed that despite national guidelines introduced in 2014 by the Ministry of Health and Family Welfare emphasizing standardized medico-legal care and SAECK usage, implementation varies widely. States such as Delhi and Maharashtra have integrated these kits more systematically into healthcare protocols, while others lag behind due to administrative inefficiencies and lack of training. These findings align with prior studies (CEHAT, 2018; UNFPA, 2020), which found that regional disparities in medico-legal practices stem from inconsistent political will, funding, and infrastructure.

Forensic Practices and Low Conviction Rates: The correlation between poor forensic procedures and low conviction rates is evident in the data from the National Crime Records Bureau (2023), where only 27.2% of registered rape cases in 2022 led to convictions. Inadequate evidence handling, delays in collection, and lack of proper preservation protocols result in compromised prosecutions. This pattern is consistent with prior literature indicating that evidence collected within the first 72 hours post-assault significantly influences legal outcomes.¹⁰

Ground-Level Enforcement: The Bharatiya Nyaya Sanhita (2023), specifically sections 203 and 473, has introduced accountability mechanisms to ensure hospitals comply with forensic obligations. However, as our results show, there is little evidence of

enforcement. No significant case law or penalties have been documented against institutions that fail to use SAECKs, suggesting that the law's deterrent potential is not being realized.

Moreover, section 184 of the Bharatiya Nagarik Suraksha Sanhita (BNSS) and section 164A of the CrPC emphasize timely medical examination and consent-based procedures. Yet survivor testimonies and NGO reports continue to highlight violations, including non-consensual exams and re-traumatization. This disconnect between statutory law and practice reflects systemic deficiencies in training and accountability.

Comparison with International Standards: Compared to global practices, such as the U.S. Violence Against Women Act 1994 (VAWA), which mandates free and timely forensic exams irrespective of police reporting, India's approach appears underdeveloped in terms of both survivor rights and evidentiary rigor. The lack of a uniform national protocol backed by enforceable compliance mechanisms places Indian survivors at a disadvantage in the justice process.

Survivors' Experience and Psychosocial Gaps: The findings also reinforce that medical response to sexual violence in India is still largely procedural, with insufficient emphasis on psychosocial support, informed consent, and trauma-informed care. Prior studies¹¹ have emphasized that the lack of empathetic care not only deters survivors from reporting but also affects their willingness to undergo critical forensic procedures, leading to compromised evidence chains.

Enhancing the Quality of Response of the Health Care System to Sexual Violence (ICMR-DHR Study Report, 2022): This comprehensive study examines the preparedness of India's public healthcare system in responding to survivors of sexual violence. It evaluates infrastructure, human resources, and healthcare providers' knowledge of the Ministry of Health and Family Welfare's 2014 guidelines. The report highlights significant gaps in training, awareness, and infrastructure, emphasizing the need for standardized protocols and capacity building.¹²

Recommendations and Reforms for Effective Implementation of Rape Kits in India: For rape kits to become a robust instrument in ensuring justice for survivors of sexual assault, India must implement comprehensive reforms across legal, infrastructural, procedural, and social dimensions. These reforms must move beyond guidelines to become enforceable

mandates, supported by training, funding, and accountability mechanisms.

Legal Mandate for Rape Kit Use: The first step toward uniform and mandatory use of Sexual Assault Evidence Collection Kits (SAECKs) is to enact statutory backing. This can be achieved through an amendment to the Bharatiya Nagarik Suraksha Sanhita, 2023 (BNSS), inserting a specific provision that mandates the use of SAECKs in all registered cases of sexual assault. Such a provision should codify the existing Ministry of Health and Family Welfare (MoHFW) 2014 guidelines, making them binding on all medical institutions both public and private.

Standardized Training and Certification Programs: To ensure the sensitive and skilled use of rape kits, India must implement a national certification program for medical professionals. The introduction of Sexual Assault Nurse Examiner (SANE) training, under the regulatory oversight of the Indian Nursing Council, would professionalize the process. Certified SANEs should be made mandatory in all tertiary care hospitals and One Stop Centres (OSCs).¹³

Infrastructure and Technology Expansion: Lack of infrastructure remains a critical bottleneck in the effective use of rape kits. All state Forensic Science Laboratories (FSLs) should be equipped with dedicated DNA analysis units to reduce the current backlog of sexual assault cases. Every rape kit must be equipped with a unique barcode to ensure traceability, and a centralized digital platform.¹³ National Sexual Assault Evidence Management System (NSAEMS) should be created to log kit issuance, collection, testing status, and evidence chain of custody. This will significantly improve transparency, inter-agency coordination, and judicial efficiency.

Monitoring, Evaluation, and Accountability: Regular monitoring and public auditing are essential to measure the effectiveness of rape kit usage. The National Crime Records Bureau (NCRB), in coordination with State Forensic Boards, should be mandated to publish annual reports on rape kit usage, delays in testing, conviction outcomes, and gaps in infrastructure or training. Additionally, third-party or judicial oversight committees can be established to independently review compliance and recommend improvements. This will create a culture of accountability and promote data-driven reforms.

Survivor-Centric and Rights-Based Protocols: Survivor dignity must be at the heart of every forensic protocol. Informed consent should be obtained at

every stage examination, evidence collection, testing, and legal proceedings. Survivors must have access to female medical professionals trained in trauma-informed care, ensuring the process does not inflict further psychological harm. Post-examination support such as access to mental health professionals, shelter, legal aid, and rehabilitation must be integrated into the protocol to promote holistic recovery and empowerment.¹⁴⁻¹⁶

Financial Support and Public Awareness: The central government must significantly increase the allocation from the Nirbhaya Fund for the procurement of SAECKs, training of healthcare and law enforcement personnel, development of forensic labs, and digital infrastructure.¹⁷⁻¹⁹ Additionally, mass awareness campaigns should be launched to educate the public about the availability and importance of rape kits, debunk myths around sexual violence, and encourage reporting. These campaigns should be survivor-led, intersectional, and tailored to local languages and contexts.²⁰

5. Conclusion

The study critically examined the deployment, utility, and legal relevance of Sexual Assault Evidence Collection Kits (SAECKs) within India's criminal justice and healthcare systems. Despite policy advancements and growing recognition of the forensic and legal value of SAECKs, their implementation remains fragmented, inconsistent, and under-enforced.

The findings confirm that although guidelines issued by the Ministry of Health and Family Welfare (2014) and legal mandates such as sections 203 and 473 of the Bharatiya Nyaya Sanhita (BNS, 2023) and section 184 of the BNSS promote the timely collection and admissibility of forensic evidence, real-world application is hindered by gaps in infrastructure, training, survivor-centered care, and procedural accountability. While SAECKs have the potential to significantly improve conviction rates in sexual offence cases, as seen in global contexts, their impact in India is currently muted by systemic deficiencies.

Further, the low conviction rate of 27.2% in rape cases as reported by the National Crime Records Bureau (2023) underscores the urgent need for comprehensive reform in forensic response protocols. Survivors often face re-traumatization, lack of informed consent, and inadequate psychosocial support factors that ultimately diminish the evidentiary and therapeutic value of SAECK-based interventions.

Thus, the study concludes that SAECKs are not merely forensic tools but indicators of a system's commitment to justice, sensitivity, and scientific rigor. Their effective use depends on synchronized efforts from healthcare professionals, law enforcement agencies, forensic laboratories, legal bodies, and survivor support services.

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Review Article

Leveraging AI for Clinical and Toxicological Profiling of New Psychoactive Substances

Veenakirthika Seetharaman^a, Rajkumar Krishnan Vasanthi^b, Kumaraswamy Dabburu^c, Ramanya Gayathri Muraliram^d, Lubna Khondker^e, Shanthi Balasubramanian^f, Pichandy Muthuprasanna^g, Abhijit Dutta^{h*}

^aProfessor, Faculty of Physiotherapy, Dr. M.G.R Educational and Research Institute, Deemed to be University, Chennai, Tamil Nadu, India, 600095, Orcid ID- 0000-0003-3790-9579, ^bFaculty of Health and Life Sciences, INTI International University, Nilai, Negeri Sembilan, Malaysia, 71800, Orcid ID- 0000-0001-6866-8224, ^cProfessor of Pharmacology, University: Bridgetown International University, Barbados, USA, BB14022, Orcid ID- 0009-0004-7226-0538, ^dAssistant Professor, School of Law, SASTRA Deemed to be University, Thanjavur, Tamil Nadu, India, 613401, Orcid ID- 0000-0001-5748-9570, ^eAssociate Professor, Dept of Dermatology and Venereology, Bangladesh Medical University(BMU), Dhaka, Bangladesh, Orcid ID-0000-0002-7186-3749, ^fProfessor and HOD, Dept of Biochemistry, Sree Balaji medical college and hospital, Tamil Nadu, India, 600044, Orcid ID- 0000-0002-7435-5985, ^gProfessor, Department of Pharmaceutical Biotechnology, Surya School of Pharmacy, Vikiravandi, Villupuram Dt. Tamil Nadu, India, 605652, Orcid ID- 0000-0001-5907-6649, ^hDean and Professor, Royal School of Medical and Allied Sciences, The Assam Royal Global University, Betkuchi, Guwahati, Assam, India, 781035, Orcid ID- 0000-0002-0055-6696.

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QSAR.

Abstract

Background: Artificial intelligence (AI) is an important tool for dealing with the growing problem of new psychoactive substances (NPSs). AI can predict how chemicals will behave, create new psychoactive frameworks, and assist forensic labs in identifying drugs that have not been recognized but can be detected by advanced machine learning (ML), deep neural networks, and generative algorithms. Generative models such as Dark-NPS and STNGS have demonstrated efficacy in producing libraries of potential NPS analogs, thereby enhancing proactive detection and management. **Objective:** To explore AI's role in predicting, detecting, and regulating new psychoactive substances while ensuring ethical and legal compliance. **Discussion:** AI-driven quantitative structure-activity relationship (QSAR) modeling and predictive analytics facilitate the evaluation of pharmacological efficacy, toxicity, and metabolic stability, thereby supporting drug research and regulatory decision-making. Policymakers in the EU and the US are realizing that there needs to be a flexible law for AI-generated drugs that affect the mind. **Conclusion:** To ensure AI is used correctly in the NPS domain, we need a multidisciplinary approach that includes data science, toxicology, chemistry, and legal frameworks. This helps us find a balance between innovation and public safety.

1. Introduction

Psychoactive substances are chemical compounds that act on the central nervous system to perception observation, mood, cognition, or behavior. NPS are newly emerging compounds

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***Corresponding author:** Dr. Abhijit Dutta, Dean and Professor, Royal School of Medical and Allied Sciences, The Assam Royal Global University, Betkuchi, Guwahati, Assam, India. E-mail: duttapapa2025@gmail.com

designed to produce similar effects to controlled drugs while often evading regulatory classification. AI has rapidly become an important tool for solving the NPS problem. QSAR algorithms and deep learning (DL) can explore large biological spaces to identify candidates with a strong interest in therapeutic goals or a high level of harmfulness before synthesis.¹ NPS are a heterogeneous collection of compounds often marketed as "legal" substitutes for traditional controlled narcotics, including heroin, cocaine, amphetamines, and benzodiazepines. The word may be seen as rather misleading, since several chemicals have subsequently been included in the roster of scheduled drugs at both national and international levels. The "legality" of these substances remains a primary appeal for users. Although several drugs are now regulated, some remain unscheduled, undiscovered, and unidentified. The primary motivations for using NPS are the asserted attributes of "safety" and "natural origin" by the provider, both of which have contributed to a remarkable surge in the appeal of NPS, despite being marketed as "safe" or labeled "not for human consumption," these chemicals pose significant health hazards, requiring a comprehensive understanding of their pharmacokinetic and pharmacodynamic characteristics for effective prevention. NPSs are also referred to as upscale drugs or exploration compounds. More than 850 NPSs were being watched in Europe, and about two NPSs were sent out every week. Globally, more than 1,200 NPSs were recorded.²

These chemicals come in many different types, and most of them have not been through safety tests. Many NPSs were linked to major health problems and even death, which was a threat to public health. Regulatory authorities have struggled to keep up with the NPS problem. The use of AI in the domain of innovative psychoactive drugs is a classic double-edged sword. AI provides robust answers to methodical and forensic experiments: it may expedite drug discovery effectively, assist forensic laboratories in outpacing traffickers, and deliver insights into the extensive biochemical landscape of psychoactive that were formerly unattainable for humans.³ AI models do not get biased, so they can constantly look for strange patterns in data streams like mass spectra and social media signals. In medical chemistry, this could be beneficial (for instance, finding new pain relievers with less potential for addiction). In illegal drug markets, it could get around current rules by

bringing in drugs that do not fit into traditional structural categories. When legislators find out about new chemicals, they often make them illegal.⁴ The present review aims to critically examine AI applications in the prediction, detection, and regulation of NPS, with emphasis on analytical toxicology, forensic identification, regulatory challenges and future research directions.

2. Discussion

AI Generative Models

Generative models are designed to create new molecular structures by analyzing how existing substances behave and using that information to predict the behavior of new substances. The Dark-NPS methodology is a new way to look at NPSs.⁵ By sampling this model, researchers developed a substantial collection of probable NPS like structures, referred to as structural "priors," which might aid in identifying unknown designer drugs. The Smart Technology-Enabled Novel Generation Systems (STNGS) framework, devised by Liu and co-authors⁶, represents an AI-driven system for NPS prediction and evaluation. This framework provides a scaffold-based molecular generator, equipped with a multifaceted recording system to evaluate the generated compounds.

As a replacement for employing unfocused generation techniques, STNGS emphasizes established core scaffolds typical in natural products. It utilizes a transformer-based neural network, which includes a T-scaffold encoder-decoder and a Mol-GPT module, to produce analogs based on these scaffolds. Current AI models for molecular generation and prediction employ varied architectures, each with distinct advantages. Graph neural networks (GNNs) represent molecules as graphs containing atoms and bonds, allowing direct learning of structural relationships and chemical topology. These models are particularly effective for forecasting molecular properties and receptor interactions. In contrast, SMILES-based transformer models treat molecular structures as sequential strings and apply natural language processing techniques to generate novel compounds or predict chemical properties.⁷ While SMILES-based methods enable efficient large-scale generation, they may produce syntactically valid but chemically impractical molecules. Hybrid approaches combining graph-based representations with sequence-based learning have also been explored to improve analytical accuracy and chemical validity. Generative models are subjective to biases in training

datasets, which may limit chemical diversity and lead to over-representation of known structural classes. The dual-use nature of such technologies also raises concerns regarding the potential generation of harmful or toxic compounds without adequate safeguards.

AI-Based QSAR Modeling

QSAR is a computational method widely used in pharmacology, leveraging arithmetical and ML models to forecast biological actions based on chemical structure descriptors. QSAR modeling relies on the removal of molecular descriptors that numerically represent chemical structure and physicochemical properties. Common descriptor categories include constitutional descriptors (molecular weight, atom counts), topological descriptors (connectivity indices), electronic descriptors (charge distribution, polarizability), and physicochemical properties such as lipophilicity and hydrogen bonding capacity.⁸ More progressive approaches incorporate 3D structural descriptors, pharmacophore features, and molecular fingerprints. The choice of descriptors suggestively influences model performance and interpretability, and inappropriate descriptor selection may lead to dismissal, model variability, or reduced predictive accuracy. Similarly, Floresta⁹ and co-authors introduced a multi QSAR modeling method aimed specifically at predicting μ -opioid receptor (μ -OR) binding similarities for newly synthesized fentanyl analogs. AI algorithms are being employed to predict additional attributes essential for NPSs. ML techniques are being harnessed to forecast the metabolic stability and toxicity of novel analogs, a critical aspect given that some NPSs can function as prodrugs or generate harmful metabolites.¹⁰ AI predictive models can forecast chromatographic retaining times or mass spectrometry fragmentation arrangements, enhancing analytical detection capabilities. Workflow of QSAR-Based Prediction is NPSs shown in [figure 01](#). Virtual docking, paired with ML scoring, is also pragmatic for forecasting which new psychoactive analogs are likely to stimulate the serotonin 5-HT_{2A} receptor, a determinant in distinguishing genuine psychedelic compounds from potentially therapeutic or inert analogs.¹¹

Despite the capable predictive performance of QSAR models, several limitations must be considered. QSAR models are highly dependent on the quality and diversity of training datasets and limited chemical space coverage may restrict their applicability to NPS

with uncommon structures. Excessive model fitting remains a major concern, particularly when models are trained on small datasets or large numbers of molecular descriptors. Internal validation alone may overrate predictive performance and external validation using independent datasets is critical to ensure generalizability. The applicability domain of QSAR models must be clearly defined, as estimates outside this domain may lead to unpredictable estimates of biological activity or toxicity.

AI-Based Automated NPS Synthesis

AI is significantly advancing the development of NPSs through the creation of AI-driven retrosynthetic planning tools. These tools can propose synthetic pathways for new chemicals, potentially optimizing the laboratory synthesis of NPS analogs. Innovations in computerized synthesis might lead to the rapid production of AI-designed psychotropic substances for further evaluation.¹² This capability allows for feasible synthesis designs to be identified within minutes when integrated into an AI-generated NPS framework. These same AI techniques can be beneficial for reputable laboratories, enabling them to swiftly produce reference materials for new NPSs, which is critical for analytical and toxicological assessments. The revolution in NPS creation and preliminary assessment, driven by AI methodologies ranging from DL generative models to predictive QSAR and property models, transforms the landscape. Instead of reacting to the emergence of new drugs, scientists and regulators can proactively investigate potential NPSs that may be created. AI technology can build virtual libraries of analogs and predict their potency or hazard levels, thus assisting in the prioritization of properties for synthesis, preparation, and observation of the most concerning applicants.

AI-Based Mass Spectrophotometry for NPS

The exploration of NPSs presents significant challenges, particularly due to the lack of available reference spectra for newly discovered compounds. Innovative advancements in AI and ML have developed as powerful tools for overcoming these challenges. The progress of DL models that can directly forecast mass spectrometry/mass spectrometry (MS/MS) spectra of organic compounds based on their structures.¹³ The authors also compiled an extensive database containing approximately 8.8 million potential NPS structures, informed by the "Dark-NPS" library and additional combinatorial inventories, each linked to its

anticipated spectra. Methodologies like Competitive Fragmentation Modeling (CFM) have demonstrated effectiveness in predicting fragmentation pathways and their intensities.¹⁴

Figure 01: Workflow of QSAR-Based Prediction in NPSs

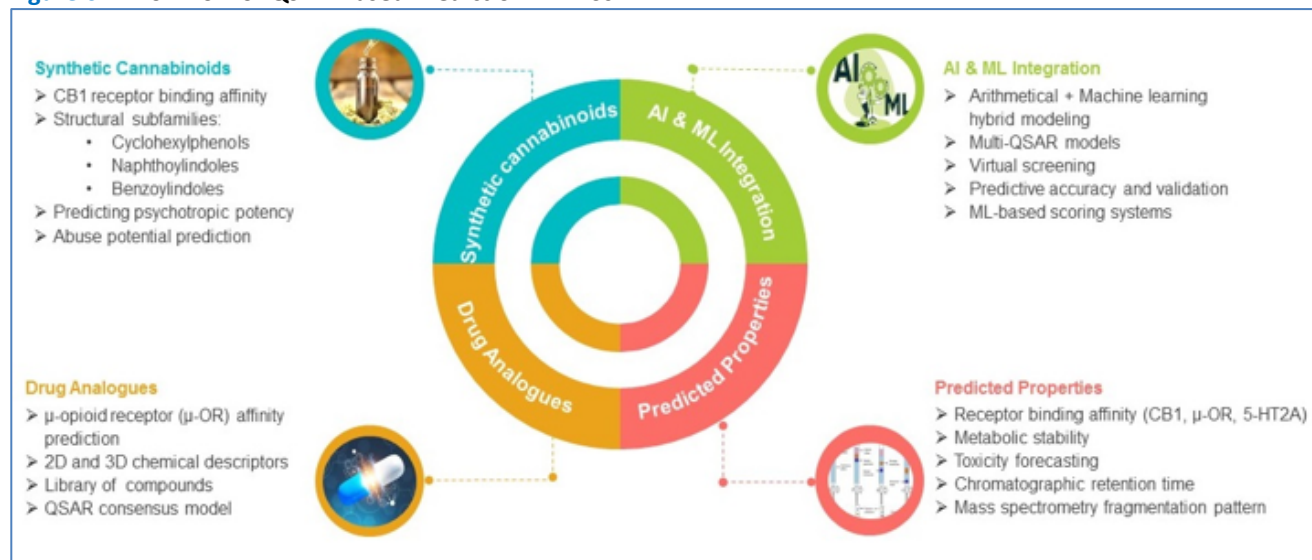
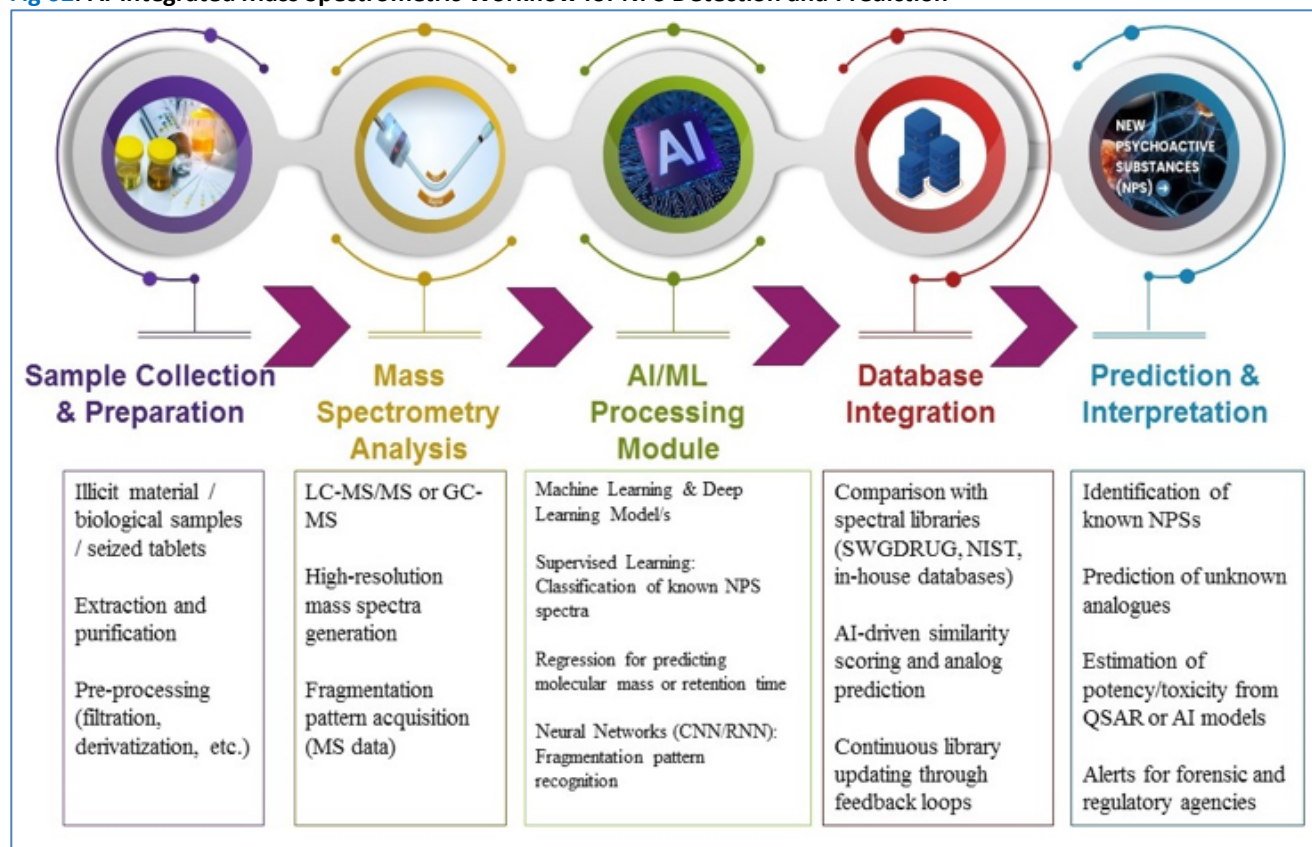


Fig 02: AI-Integrated Mass Spectrometric Workflow for NPS Detection and Prediction



AI further aids in spectral matching, wherein unidentified spectra are aligned against databases of known spectra to ascertain potential matches. In practical applications, Tian¹⁵ and co-authors have combined Shifted-Excitation Raman Difference Spectroscopy (SERDS) with ML to facilitate rapid on-

site identification of NPSs. By employing SERDS to curate fluorescence-free Raman spectra of samples and subsequently applying support vector machines (SVMs), their enhanced SVM model has achieved over 97% accuracy in classifying unknown substances into distinct drug families, such as fentanyl analogs,

amphetamine-type stimulants, or synthetic cannabinoids.¹⁶ AI-Integrated Mass Spectrometric Workflow for NPS Detection and Prediction, shown in [figure 2](#). This integrated computational-analytical framework supports forensic chemists and regulatory authorities in rapidly identifying emerging NPSs, estimating toxicity or abuse potential, and guiding effective law enforcement responses. AI-assisted mass spectrometry has significantly improved NPS detection; several analytical trials remain. Predictive models may produce false positive or false negative identifications, mainly when analyzing structurally novel compounds outside the model's training distribution. Indecision quantification is often limited in current operations, which may affect the certainty in forensic interpretation. Performance depends heavily on the quality of spectral databases and reference libraries and incomplete datasets may reduce identification accuracy. These limitations highlight the need for standardized validation procedures and cautious interpretation of AI-assisted results in forensic settings.

Explainable AI and Model Interpretability in NPS Research

The application of AI in forensic and governing contexts requires model transparency. Explainable AI (XAI) techniques aim to clarify how predictive models generate outputs, thereby increasing trust and supporting decision-making in legal and clinical environments. Methods such as feature importance analysis, SHAP (Shapley Additive Explanations), and attention-based conception enable identification of structural features responsible for expected biological activity or toxicity. In QSAR modeling, transparency allows researchers to identify key molecular descriptors influencing receptor binding or pharmacological effects. Model transparency is particularly important for forensic toxicology, where AI-generated forecasts may influence regulatory classification or legal evidence. Lack of transparency in "black-box" models remains a significant challenge and future research should order interpretable architectures and standardized explanation methods to ensure responsibility and regulatory acceptance.¹⁷

Governance and Legal Perspectives On AI-Driven Psychoactive Compound Development

The convergence of AI, NPSs, and drug policy introduces complex legal and supervisory challenges, particularly within the European Union (EU) and the United States (USA). In the EU, the management of NPSs is coordinated through an initial cautionary

system functioned by the European Monitoring Center for Drugs and Drug Addiction. At present, no law exists to prohibit the public dissemination of procreative models that may be used to produce NPSs or other hazardous substances. In the USA, the regulatory landscape for NPSs is primarily governed by the **Controlled Substances Act** and the **Controlled Substances Analog Enforcement Act of 1986**¹⁸, which empowers authorities to classify substances that are "substantially similar" to existing controlled drugs. Both areas are gradually strengthening their rules to find a balance between rapid regulatory responses and the risks associated with faster AI-driven drug synthesis.

a. AI Regulatory Frameworks for High-Risk Systems

The rising use of AI in drug discovery and forensic analysis has prompted the development of regulatory frameworks addressing high-risk AI applications. The European Union has introduced the EU AI Act, which categorizes AI tools used in forensic toxicology or drug prediction may fall within this high-risk classification, requiring transparency, human oversight and rigorous concert evaluation.¹⁹ Such frameworks highlight data quality, accountability, and traceability of AI decisions, which are particularly relevant for AI-assisted identification or prediction of NPS. Traditional drug control policies primarily rely on structure-based scheduling, where substances are regulated based on structural similarity to known controlled drugs.²⁰ AI-assisted prediction of receptor required and pharmacodynamic effects may support such effect-based regulation by enabling early identification of harmful compounds. A hybrid regulatory strategy combining structural and functional evaluation may therefore provide more effective control of emerging AI-generated psychoactive substances.

b. Liability and Responsibility in AI-Generated Molecules

The use of AI systems capable of generating novel psychoactive compounds raises multiple questions regarding legal liability. Responsibility may extend to developers of AI algorithms, providers of training datasets, or users who apply predictive tools for illegal purposes. The absence of clear legal frameworks creates uncertainty regarding accountability when AI-generated molecular designs contribute to public health risks or illegal drug production. Starting liability standards for AI-assisted drug design remains a significant policy challenge and requires clear guidelines defining originator

responsibility, user responsibility and institutional oversight.

c. Regulation of Predictive Modeling and Dual-Use Concerns

AI-based predictive modeling of psychoactive compounds presents a dual-use problem, as the same technologies that assist forensic laboratories and public health authorities may also enable the design of illegal substances. This raises policy questions regarding whether access to predictive models, generative algorithms, or chemical libraries should be restricted.²¹ While open scientific research promotes innovation and public safety alertness, unrestricted distribution of models capable of generating highly important compounds may increase the risk of misuse. Balancing scientific openness with security deliberations remains a key challenge for regulators and research institutions.

1. 3. Regulatory Challenges and Ethical Considerations

AI applications in the calculation and generation of NPS raise concerns related to dual-use research, where technologies planned for beneficial purposes may also be misused. Governance frameworks for dual-use research emphasize risk mitigation, institutional error and responsible distribution of sensitive findings. International policy discussions highlight the need for ethical review mechanisms, organized data sharing and observation of high-risk research outputs. Several risk qualification approaches have been proposed to reduce potential misuse of AI systems capable of predicting or generating psychoactive compounds. Monitoring usage patterns, incorporating safety filters to prevent the generation of risky compounds, and establishing institutional review procedures for high-risk research may further decrease misuse. Such safeguards can help balance scientific openness with public health and security considerations. AI algorithms may generate dangerous or unstable chemicals if not meticulously regulated, and insufficient or inconsistent data often constrain the predicted accuracy for NPSs.²²⁻²⁴

Responsible organization of AI in forensic and pharmaceutical research requires adherence to principles of transparency, accountability, equality. International enterprises, including guidelines proposed by the OECD and regulatory efforts within the European Union, emphasize reliable AI systems that ensure data integrity, model dependability and explainability. In forensic toxicology, responsible AI implementation is particularly important because

predictive outputs may influence clinical decisions, regulatory classification, or legal proceedings. Creating standardized governance frameworks and ethical guidelines will be essential to ensure safe and accountable use of AI technologies in the study of NPS.

4. Prospective Outlook

Advancements in generative AI within the field of NPS are increasingly directed toward the creation of models capable of designing unique molecular scaffolds with targeted psychoactive effects. Future investigations are anticipated to integrate multi-parametric optimization, assessing not only psychoactive potency but also toxicity, metabolic stability, and other pharmacokinetic parameters to generate comprehensive “risk” or “danger” scores.²⁵ Such outputs could significantly aid both drug developers and regulatory authorities in evaluating potential threats. At the same time, policymakers might push for the use of predictive modeling platforms to predict when new NPS will appear and help with proactive control strategies. Because NPS proliferation happens across borders, effective implementation will depend on countries working together and sharing data. It is also very important to consider the ethical issues that arise when using AI in this field.²⁶⁻²⁸ To stop abuse and allow responsible innovation, there needs to be oversight similar to high-risk biological research.

5. Limitations of AI in NPS Research

Despite rapid advancements, AI-based approaches for NPS prediction and detection face several limits. Model performance is strongly reliant on data quality, dataset representativeness and validation policies. Many studies report high predictive accuracy without adequate external validation or reproducibility evaluation. Algorithmic bias, uncertainty in predictions and lack of standardized evaluation metrics may affect forensic dependability. Transparency of DL models remains limited, which poses challenges for legal and regulatory acceptance of AI-generated evidence. Addressing these limitations requires improved data sharing, standardized benchmarking procedures and transparent validation frameworks. Consistent QSAR model development requires rigorous validation procedures to ensure analytical performance. Common approaches include k-fold cross-validation, leave-one-out validation and external validation using independent datasets.²⁹ Cross-validation helps evaluate a model and detect overfitting, while

external validation provides stronger evidence of predictive dependability for novel compounds. The limited availability of diverse NPS datasets often constrains healthy validation, which may affect model reproducibility and applicability in forensic practice.

2. 6. Conclusion

AI is renovating the field of NPS through advancements in the design, estimation, and identification of new chemical compounds. Mass spectrometry, predominantly in ML, improves the speed and accuracy of NPS identification, addressing substantial challenges in forensic science. The growth of AI necessitates a reevaluation of regulatory strategies, as prevailing policies in the EU and the USA need to adapt to the evolving landscape of illegal drugs.

Future efforts must emphasize emerging specialized AI models for NPS, refining data sharing, and fostering interdisciplinary association to validate AI predictions. Policymakers, scientists, and ethicists must engage in ongoing dialogue to ensure that advancing laws reflect current scientific empathy and uphold principles of ethical and accountable AI use. There is a perilous need for training practitioners in forensic labs to interpret AI outputs precisely.

Finally, while AI delivers powerful tools to address the complexities of the designer drug market, cautious oversight is vital to stabilize its benefits against potential risks, ensuring we stay ahead in combating substance abuse. Future work should arrange interpretable AI models and standardized validation frameworks to support forensic and regulatory adoption.

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Short Communication

Effective media communication by a Forensic Medicine (Medico-legal) Expert

Ravi Rautji^a, Niraj Dingre^b

^aProfessor & Head, ^bProfessor, FMT, Bharti Vidyapeeth (DU) Medical College, Pune, Maharashtra, India.

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Abstract

Clear and responsible interaction with the media is an essential duty of forensic medicine professionals involved in medico-legal work. While providing factual and scientifically supported information, experts must ensure confidentiality, follow ethical principles, and avoid expressing personal opinions or conclusions beyond established forensic evidence. Using simple and precise language helps the public understand complex medico-legal issues. Strict confidentiality must be maintained to protect victims, suspects, and sensitive details of ongoing investigations. Effective coordination with law enforcement agencies and judicial authorities is necessary to ensure that information released to the public is accurate, consistent, and does not interfere with legal proceedings or spread misinformation. Media interactions should be well prepared and, when necessary, conducted after consultation with legal advisors. All communication must remain objective, evidence-based, unbiased, and free from exaggeration or sensational presentation. This paper presents practical guidelines for media engagement by forensic professionals, drawing upon national standards such as the NMC Code of Ethics, ICMR Ethical Guidelines, and Press Council of India norms, as well as international frameworks including WHO communication principles and the AAFS Code of Ethics. These guidelines aim to preserve the integrity of investigations and strengthen public confidence in forensic science and the justice system.

1. Introduction

In the current media environment, medico-legal professionals are often asked to share expert views on legal cases, ethical issues, and public health matters. Forensic medicine specialists play an important role in supporting the justice system by providing accurate and scientifically reliable information.¹

Communication with the media requires careful attention to factual correctness, confidentiality, and professional ethics. Incorrect

or sensational reporting can create misunderstanding and mislead the public.² Therefore, forensic experts must develop appropriate communication skills to ensure responsible information sharing and to maintain professional credibility. Media coverage can influence public opinion, ongoing investigations, and court decisions. For this reason, medico-legal professionals should communicate in a clear, objective, and professional manner.³

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This article offers practical guidance for medico-legal experts on interacting with the media during medico-legal cases. The recommendations promote ethical and legally appropriate communication while safeguarding the integrity of investigations and fairness of legal processes. The guidelines are based on Indian regulations, such as the NMC Code of Ethics, ICMR Ethical Guidelines, and Press Council of India standards, as well as international frameworks including WHO communication principles and the AAFS Code of Ethics.⁴⁻⁹

2. Material and Methods

This study used a qualitative synthesis approach, reviewing literature, guidelines, and case examples on medico-legal media interactions. Sources included: guidelines from Indian bodies (NMC, ICMR, Press Council of India); international organizations (WHO, AAFS); peer-reviewed articles on forensic ethics and media; historical media reports on medico-legal cases; and expert opinions from forensic, legal, and media professionals.

Analysis involved thematic comparison of best practices, pitfalls, and policy frameworks, leading to evidence-based recommendations. No primary data collection (e.g., interviews) was conducted; synthesis focused on existing sources for guideline development.

3. Results and Observations

Analysis of literature and guidelines revealed common pitfalls in forensic experts' media interactions, observed across cases and reports:

1. Lack of preparation leading to misquotes or confusion.
2. Over-interpretation or speculation beyond evidence.
3. Premature disclosure interfering with investigations.
4. Breaches of confidentiality violating privacy laws/ethics.
5. Use of jargon confusing the public.
6. Pressure from media/deadlines causing rushed statements.
7. Conflicting public opinions eroding trust.
8. Speculation on motives/circumstances beyond evidence.
9. Ignoring potential legal consequences (e.g., inconsistencies with court testimony).

These align with observed risks in media reporting of medico-legal cases, per Press Council of India norms and forensic ethics literature.^{6,10,11}

4. Discussion

Forensic experts should communicate with the media in ways that follow both national (Indian) and international rules to promote ethical and careful practices. In India, the National Medical Commission (NMC) Code of Ethics⁴ limits public comments that might look like advertising or attracting patients. Experts can share general information on public health issues, but they must avoid writing or speaking about diseases or treatments in ways that promote themselves. Keeping patient information private is a top priority.

Table no. 1: Comparison of Main Rules on Media Communication by Medico-legal and Healthcare Experts.

Aspect	National (India) Rules	International Rules	Key Observations and Suggestions
Confidentiality	Very strict (NMC, ICMR); no sharing of personal details publicly.	Strong focus on privacy (WHO, AAFS).	Always make this the first priority; work with relevant authorities.
What Can Be Said	Stick to verified facts and public health topics; no guesses (NMC, Press Council).	Base statements only on solid evidence; no false claims (AAFS).	Talk only about what is confirmed; do not offer legal judgments.
Preparation and Coordination	Match statements to ongoing investigations; get legal input if needed (Press Council).	Use preparation and official ways to share (WHO).	Check with legal or public relations teams; keep language neutral.
Effects on the Public	Avoid harming court cases or using dramatic styles (Press Council).	Build trust through accuracy (WHO).	Fix wrong reports when possible; add clear context.

The Indian Council of Medical Research (ICMR) Ethical Guidelines stress responsible behavior, protecting privacy, and sharing information accurately without misleading anyone.⁵ The Press Council of India guidelines warn against reporting on crimes in ways that could harm ongoing investigations, such as by including details that suggest someone is guilty or by using sensational language.⁶ The Bharatiya Sakshya Adhiniyam, 2023, mainly deals with what evidence (including expert views) can be used in court. It highlights the need for caution in any public comments that might influence legal cases.¹²

Internationally, the World Health Organization (WHO) principles for communication focus on being open, quick, and trustworthy, especially in public health matters. These ideas apply to forensic experts when sharing findings.⁷ The American Academy of Forensic Sciences (AAFS) Code of Ethics forbids members from making public statements that seem to speak for the organization

without permission and from misrepresenting facts or data.⁹

These rules show strong agreement on using only evidence-based facts while protecting privacy. Past problems show that not following these can spread false information and damage public trust. Experts should follow them closely, and linking them to real examples of mistakes can help improve understanding. Better combining of policies and more training for forensic experts would be useful. **Table no. 1** gives the comparison of Main Rules on Media Communication by Medico-legal and Healthcare Experts.

Guidelines for Medico-legal Experts in Media Interactions

1. Speak only to confirmed, evidence-based findings; avoid speculation on motives/legal conclusions.
2. Protect confidentiality per NMC/ICMR guidelines; no victim/suspect details.
3. Use simple, jargon-free language for public clarity.
4. Coordinate with authorities to avoid interfering with proceedings.
5. Review statements with legal advisors.
6. Maintain neutral, professional tone; avoid sensationalism.
7. Defer to official spokespersons in high-profile cases.
8. Provide context to prevent misinterpretation.
9. Explain forensic evidence limits (e.g., DNA identifies but not causation).
10. Correct misreporting via official channels.

5. Conclusion

Forensic medicine experts should communicate with the media carefully, objectively, and ethically. They must rely only on verified information, protect confidentiality, and follow established professional guidelines issued by bodies such as the NMC, ICMR, Press Council, WHO, and AAFS. This approach helps maintain the integrity of the justice system, protects the credibility of experts, and builds public trust. Clear and responsible communication can also reduce misinformation in high-profile cases, improve public understanding of forensic science, and strengthen cooperation between legal and medical fields. Future studies should assess how well these guidelines are applied using surveys or case-based analyses. There is also a need to develop training programs tailored to the Indian context. Including media ethics in forensic

education may help prevent ethical risks in professional practice.

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