



Reliability of Toxicological Analysis in Admitted Insecticide Poisoning Deaths: A Two-Year Retrospective Postmortem Study from Central India

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Abstract

Aims and objectives: To evaluate the reliability of forensic toxicological analysis reports in postmortem cases of admitted insecticide poisoning by correlating laboratory findings with clinical history, hospital records, police inquest, and autopsy observations.

Materials and methods: A retrospective postmortem-based study was conducted over two years (January 2023–December 2024) on medico-legal autopsies with a clinical diagnosis or history of insecticide ingestion and availability of Forensic Science Laboratory toxicological reports. Demographic variables, clinical parameters, duration of hospitalization, serum cholinesterase levels, autopsy findings, and toxicological results were analyzed. Categorical variables were compared using Chi-square or Fisher's exact test, continuous variables using the Kruskal–Wallis test, and binary logistic regression was performed to identify factors associated with toxicological positivity.

Results: A total of 57 eligible cases were included. Toxicological analysis was negative in 44 (77.2%) cases, positive for insecticides in 8 (14.0%), and positive for other toxic compounds in 5 (8.8%). Increasing age and shorter dispatch-to-FSL interval were significantly associated with toxicological positivity. Prolonged hospitalization was associated with reduced toxicological detectability, while solid viscera demonstrated higher positivity than blood specimens.

Conclusion: Toxicological analysis alone is insufficient to establish the cause of death in admitted insecticide poisoning cases. Medico-legal opinion should be based on integrated interpretation of clinical history, circumstantial evidence, autopsy findings, and toxicological analysis.

Keywords: Forensic toxicology; insecticide poisoning; postmortem examination; organophosphate poisoning; toxicological analysis; medico-legal opinion.

Introduction

Insecticide poisoning remains a major public health problem in developing countries, particularly in agrarian regions where easy accessibility and widespread use of toxic agrochemicals contribute to high morbidity and mortality. In India, insecticides—especially organophosphates, carbamates, and synthetic pyrethroids—are among the most frequently implicated agents in both suicidal and accidental poisoning cases. [1,2] Despite advances in clinical management, mortality continues to be substantial, making accurate diagnosis and cause-of-death certification crucial from both therapeutic and medico-legal perspectives. [3]

Toxicological analysis plays a pivotal role in confirming exposure, identifying the specific compound involved, and correlating clinical manifestations with laboratory findings. In admitted poisoning cases, biological samples such as blood, urine, gastric aspirate, and occasionally viscera are analysed to support clinical diagnosis and guide treatment decisions.[4] However, the interpretation of toxicological results in hospitalized patients poses unique challenges due to factors such as delayed sampling, prior gastric lavage, administration of antidotes, metabolism and elimination of the toxin, and degradation during storage and transport.[5]

Under BNSS Section 293, the toxicologist is confined to reporting analytical findings as scientific evidence and does not express an opinion on the cause of death; final interpretation is the responsibility of the forensic expert. At the Regional Forensic Science Laboratory (R.F.S.L.), insecticide poisons from tissues are extracted using anhydrous sodium sulphate and n-hexane, followed by cleanup with acetonitrile and hexane, pooling, and concentration. Blood samples are treated with sodium tungstate and sulfuric acid, filtered, extracted with n-hexane, dried over sodium sulphate, and cleaned. Preliminary screening includes specific colour tests for organophosphates, organochlorides, and carbamates. Confirmatory analysis is performed using thin-layer chromatography and high-performance liquid chromatography.[6]

In fatal cases following hospital admission, discrepancies are often observed between clinical diagnosis and postmortem toxicological findings. Negative or equivocal toxicology reports may occur despite strong clinical suspicion and documented exposure, raising concerns about the reliability and diagnostic value of toxicological analysis alone.[7] Such inconsistencies have significant implications for medico-legal opinions, insurance claims, and judicial outcomes, where laboratory confirmation is frequently regarded as definitive evidence.[8]

Therefore, evaluating the reliability of toxicological analysis in admitted insecticide poisoning deaths is essential. A critical appraisal of toxicological results in relation to clinical history, treatment received, survival period, and autopsy findings can provide a more holistic

understanding of poisoning-related deaths. The present study aims to assess the reliability of toxicological analysis in confirmed cases of insecticide poisoning deaths following hospital admission, emphasizing the need for integrated interpretation of clinical, analytical, and circumstantial evidence for accurate medico-legal conclusions.[9]

Materials And Methods

A retrospective postmortem-based study was conducted over a period of two years (January 2023–December 2024) in a tertiary care teaching hospital located in Central India. Medico-legal autopsy cases with a clinical diagnosis or history of insecticide ingestion and availability of Forensic Science Laboratory toxicological reports were screened. After applying the inclusion and exclusion criteria, **57 eligible cases** were included in the final analysis. Cases lacking hospital records or toxicological reports were excluded.

Data regarding demographic profile, clinical presentation (clinical history and medical signs), time interval between poison consumption and hospital admission, duration of hospitalization, serum cholinesterase levels, autopsy findings, interval between dispatch and receipt of viscera samples by the Regional Forensic Science Laboratory (R.F.S.L.), duration of toxicological analysis at R.F.S.L., and toxicological findings were collected from hospital records, postmortem reports, police inquest papers, and forensic laboratory reports.

Statistical analysis was performed using Microsoft Excel and appropriate statistical software. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test, as appropriate. Continuous variables were summarized as median (interquartile range) and compared using the Kruskal–Wallis test. Binary logistic regression analysis was performed to identify factors independently associated with positive toxicological analysis, and results were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). A p-value <0.05 was considered statistically significant. Institutional ethical clearance was obtained prior to commencement of the study.

Results

A total of 57 admitted insecticide poisoning deaths fulfilling the inclusion criteria were included in the analysis. Toxicological analysis was negative in 44 (77.2%) cases, while insecticide compounds were detected in 8 (14.0%) cases and other toxic compounds in 5 (8.8%) cases. The demographic characteristics, clinical presentation, laboratory findings, toxicological profile, and factors associated with toxicological positivity were compared among the three groups. The distribution of toxicological analysis results is presented in Table 1 and Figure 1.

Table 1. Distribution of toxicological analysis results (n = 57)

Toxicological analysis result	n	%
Negative	44	77.2
Positive for insecticide (Organophosphorus compounds)	8	14.0
Positive for other toxic compounds	5	8.8
Total	57	100

Figure 1. Distribution of toxicological analysis results among admitted insecticide poisoning deaths (n = 57). The pie chart illustrates the proportion of cases with negative toxico-

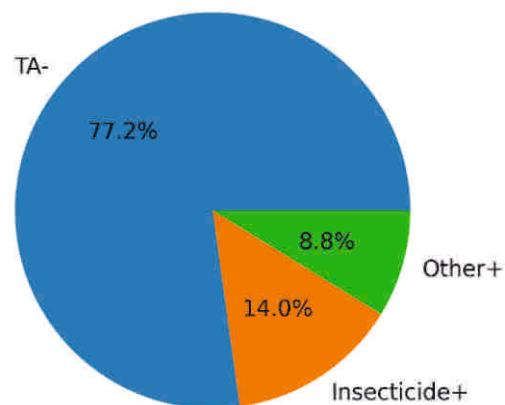


Figure 1. Distribution of toxicological analysis

logical analysis, insecticide-positive toxicological analysis, and toxicological positivity for compounds other than insecticides.

A total of 57 admitted insecticide poisoning deaths fulfilling the inclusion criteria were analyzed. Toxicological analysis was negative in 44 (77.2%) cases, while insecticide compounds were detected in 8 (14.0%) cases and other toxic compounds in 5 (8.8%) cases (Table 1, Figure 1). Thus, only about one-seventh of clinically suspected insecticide poisoning deaths demonstrated laboratory confirmation of insecticide poisoning, whereas toxicological analysis remained negative in more than three-fourths of the study population.

Table 2. Clinical complaints according to toxicological analysis result

Complaint on admission	TA Negative (n=44)	Insecticide Positive (n=8)	Other Positive (n=5)	p value
History of pesticide/insecticide ingestion	31 (70.5%)	4 (50.0%)	3 (60.0%)	0.501
Vomiting	12 (27.3%)	1 (12.5%)	0	0.293
Chronic alcohol use/intoxication	12 (27.3%)	2 (25.0%)	1 (20.0%)	0.937
Breathlessness/abdominal pain/drowsiness	6 (13.6%)	0	0	0.371

Clinical complaints at presentation are summarized in Table 2. A history of pesticide or insecticide ingestion was the most frequent presenting complaint across all three groups, occurring in 70.5% of toxicology-negative, 50.0% of insecticide-positive, and 60.0% of other toxicology-positive cases. Vomiting and chronic

alcohol use were the next most common complaints, whereas breathlessness, abdominal pain, and drowsiness were observed only among toxicology-negative cases. None of the presenting complaints differed significantly among the three groups (all $p > 0.05$).

Table 3. Clinical examination findings according to toxicological analysis result

Clinical finding	TA Negative (n=44)	Insecticide Positive (n=8)	Other Positive (n=5)	p value
Hypertension	11 (25.0%)	1 (12.5%)	1 (20.0%)	0.732
Tachycardia	10 (22.7%)	1 (12.5%)	0	0.414
Hypoxemia	9 (20.5%)	0	0	0.206
Prediabetic RBS4	(9.1%)	0	1 (20.0%)	0.458
Diabetic RBS	3 (6.8%)	0	0	0.626
Bradycardia	2 (4.5%)	0	0	0.736
Hypotension	2 (4.5%)	0	0	0.736

The distribution of clinical examination findings is presented in Table 3. Hypertension and tachycardia were the most frequently documented signs, predominantly among toxicology-negative cases. Hypoxemia was observed exclusively in toxicology-negative patients, while prediabetic random blood sugar levels were recorded in both

toxicology-negative and other toxicology-positive groups. Bradycardia, hypotension, and diabetic random blood sugar levels were infrequent findings. No clinical sign demonstrated a statistically significant association with toxicological analysis outcome (all $p > 0.05$).

Table 4 : Continuous variables according to toxicological analysis result

Variable	TA Negative (n=44)	Insecticide Positive (n=8)	Other Positive (n=5)	p value
Age (years)	37.0 (27.0–45.0)	58.5 (52.8–63.8)	49.5 (45.5–62.0)	0.0003
Time from ingestion to hospital admission (hours)	3.5 (2.0–5.0)	4.0 (1.5–6.4)	5.5 (3.8–7.0)	0.531
Duration of hospitalization (hours)	42.0 (11.3–93.0)	3.0 (0.8–7.3)	5.0 (2.5–28.3)	0.001
First serum cholinesterase level (U/L)	1896 (824–4603)	1291 (850–1732)	3936 (2186–5762)	0.270
Dispatch/receipt to FSL interval (days)	165.5 (143.5–182.5)	119.5 (107.0–151.0)	143.0 (128.5–195.5)	0.046
FSL toxicological analysis duration (days)	23.5 (14.5–38.5)	28.5 (15.0–35.5)	37.0 (14.5–50.5)	0.801

*Kruskal-Wallis test.

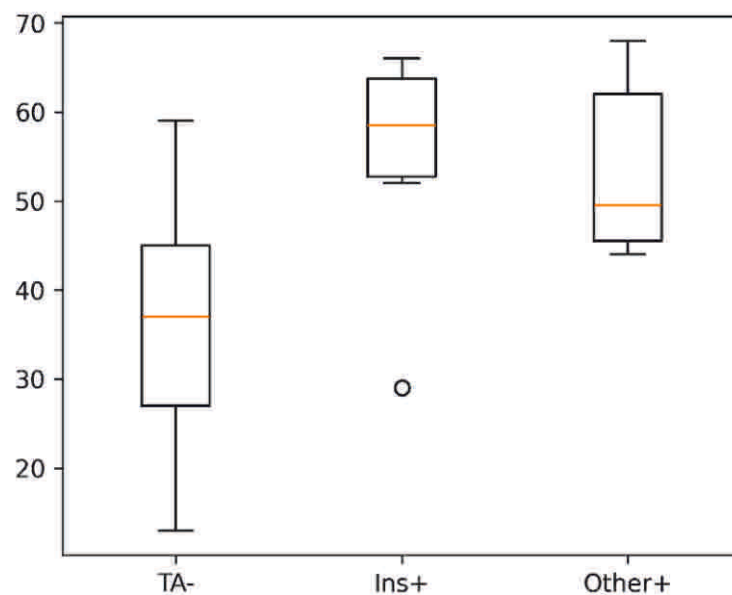


Figure 2 : Age distribution according to toxicological analysis result.

Box-and-whisker plot demonstrating the age distribution among cases with negative toxicological analysis, insecticide-positive toxicological analysis, and positivity for other toxic compounds.

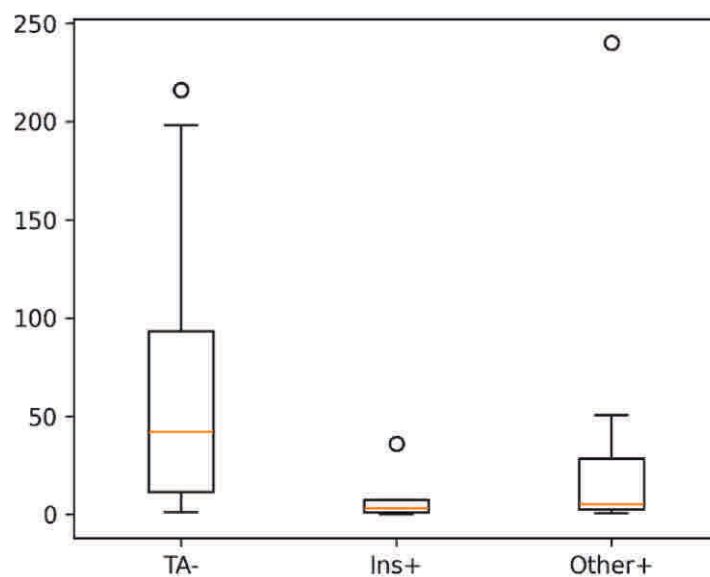


Figure 3 : Duration of hospitalization according to toxicological analysis result.

Box-and-whisker plot showing the duration of hospitalization before death among cases with negative toxicological analysis, insecticide-positive toxicological analysis, and positivity for other toxic compounds.

Continuous variables according to toxicological analysis result are shown in Table 4, while the distributions of age and duration of hospitalization are illustrated in Figures 2 and 3, respectively. Age differed significantly among the three groups ($p=0.0003$), with insecticide-positive cases having the highest median age.

Duration of hospitalization also showed a significant difference ($p=0.001$), with toxicology-negative cases demonstrating substantially longer hospital stay than insecticide-positive and other toxicology-positive cases. The interval between dispatch and receipt of viscera at the Regional Forensic Science Laboratory was likewise significantly different among groups ($p=0.046$). In contrast, the time from poison ingestion to hospital admission, serum cholinesterase level, and duration of toxicological analysis did not differ significantly between the groups (all $p>0.05$).

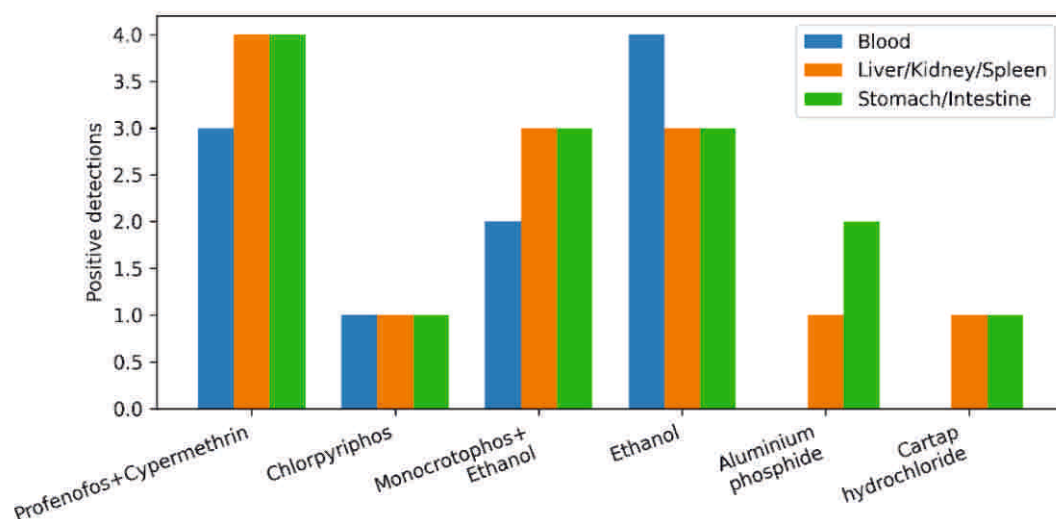


Figure 4 : Distribution of toxic compounds detected in blood and viscera specimens among toxicology-positive cases.

Table 5 : Toxic compounds detected among toxicology-positive cases (n = 13)

Toxic compound detected	Blood positive	Solid viscera positive	Total positive cases
Profenofos + Cypermethrin	3	4	4
Monocrotophos + Ethanol	2	3	3
Ethanol	4	3	3
Aluminium phosphide	0	1	2
Cartap hydrochloride	0	1	1
Chlorpyrifos	1	1	1

Clustered horizontal bar chart showing the frequency of individual toxic compounds detected in blood, liver/kidney/spleen, and stomach/intestinal specimens among cases with positive toxicological analysis.

The spectrum of toxic compounds detected among the 13 toxicology-positive cases is presented in Table 5 and Figure 4. The most frequently detected compounds were the combination of profenofos with cypermethrin (4 cases), followed by monocrotophos with ethanol and ethanol alone (3 cases each). Aluminium phosphide was detected in two cases, whereas chlorpyrifos and cartap hydrochloride were identified in one case each. Overall, solid viscera yielded a greater number of positive detections than blood specimens, supporting the higher diagnostic utility of viscera for postmortem toxicological confirmation.

Factors associated with positive toxicological analysis are summarized in Table 6. Binary logistic regression demonstrated that increasing age was independently associated with higher odds of obtaining a positive toxicological analysis (OR 1.135, 95% CI 1.052–1.225; $p=0.001$). A longer interval between dispatch and receipt of samples at the Regional Forensic Science Laboratory was associated with reduced odds of toxicological positivity (OR 0.861, 95% CI 0.745–0.996; $p=0.044$). Duration of hospitalization, time from poison ingestion to hospital admission, serum cholinesterase level, and duration of toxicological analysis were not significantly associated with toxicological positivity (all $p>0.05$).

Overall, toxicological positivity was significantly associated with increasing age and a shorter interval between receipt and processing of specimens by the Regional Forensic Science Laboratory, whereas prolonged hospitalization was associated with a higher proportion of negative toxicological findings. Clinical complaints, examination findings, serum cholinesterase levels, time from poison ingestion to hospital admission, and duration of toxicological analysis did not differ significantly between the groups. These findings indicate that toxicological analysis should be interpreted in conjunction with clinical history, hospital records, and autopsy findings rather than as an isolated determinant of insecticide poisoning deaths.

Discussion

The present study demonstrated that toxicological analysis confirmed insecticide poisoning in only 14.0% of clinically suspected admitted poisoning deaths, whereas 77.2% yielded negative toxicological reports despite supportive clinical history and autopsy findings. These observations are consistent with Drummer et al.[7], who reported that negative postmortem toxicological findings do not necessarily exclude poisoning because analytes may fall below detectable concentrations due to metabolism, redistribution, and postmortem changes. Similarly, Baselt et al.[4] emphasized that therapeutic interventions and prolonged survival substantially influence postmortem toxicological detectability.

Table 6 : Factors associated with positive toxicological analysis

Variable	Odds ratio	95% CI	p value
Age, per year	1.135	1.052–1.225	0.001
Duration of hospitalization, per hour	0.987	0.971–1.003	0.112
Time to hospital admission, per hour	1.029	0.918–1.154	0.621
Dispatch to FSL, per day	0.861	0.745–0.996	0.044
FSL analysis duration, per day	0.998	0.966–1.031	0.909
Serum cholinesterase, per 1000 U/L	0.888	0.617–1.277	0.522

Age was significantly associated with toxicological positivity, with older individuals demonstrating greater laboratory confirmation than younger patients. Although few studies have specifically evaluated age-related toxicological detectability, Goswami et al.[10] observed that acute poisoning predominantly affects younger adults in India, highlighting the importance of demographic factors in poisoning epidemiology. The lower toxicological positivity among younger individuals in the present study may reflect faster metabolism and elimination of insecticides.

Duration of hospitalization was also significantly associated with toxicological findings, with toxicology-negative cases surviving considerably longer before death. This finding supports the observations of Kintz et al.[5], who described reduced postmortem analyte concentrations following prolonged survival, medical treatment, and biological degradation. Likewise, Eddleston et al.[1] reported that atropine therapy, gastric lavage, and supportive management alter toxicokinetics, thereby reducing recoverable insecticide concentrations.

The interval between receipt of viscera and laboratory processing showed a significant association with toxicological positivity. Jaiswal and Millo et al.[6] emphasized that proper specimen preservation and standardized laboratory protocols are essential for maintaining analytical sensitivity. The present findings suggest that adequate analytical processing time may improve the probability of obtaining true-positive toxicological results by permitting comprehensive extraction, purification, and confirmatory testing, thereby reducing the likelihood of analytical failure. This should not be interpreted as support for unnecessary administrative or procedural delays in laboratory workflow; rather, it highlights the importance of sufficient scientific processing while minimizing avoidable delays in transport and sample handling. In contrast, serum cholinesterase levels and time from poison ingestion to hospital admission were not significantly associated with toxicological positivity. Similar observations were reported by Sd et al.[12], who found that

clinical severity and outcome depend on multiple factors rather than admission delay alone.

Finally, solid viscera demonstrated greater diagnostic yield than blood specimens, corroborating the observations of Baselt et al.[4] that liver, kidney, spleen, stomach, and intestinal contents retain toxic compounds longer than blood after prolonged hospitalization. Overall, the findings support the recommendations of Saukko and Knight[8] and DiMaio et al.[9] that medico-legal opinion should be based on integrated interpretation of clinical history, autopsy findings, and toxicological evidence rather than toxicological analysis alone.

Conclusion

Toxicological analysis alone is insufficient to determine cause of death in admitted insecticide poisoning cases. Prolonged survival and medical treatment markedly reduce detectability of insecticides. Holistic medico-legal evaluation is essential for accurate opinion.

Limitations of Study

The retrospective nature of the study and absence of quantitative statistical analysis at this stage are limitations.

Ethical Clearance

Ethical approval and informed consent statements: This study was approved by the Institutional Ethics Committee (approval no. GMCG/Pharmac/IEC/185/2026) on March 09, 2026.

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