

## Pattern and Toxicological Profile of Acute Organophosphorus Poisoning in Medicolegal Autopsy Cases: A Retrospective Study at a Tertiary Care Center

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### Abstract

**Background:** Organophosphorus (OP) compound poisoning remains one of the leading causes of suicidal and accidental deaths in developing countries, particularly in agrarian communities. Understanding the pattern and toxicological profile of fatal OP poisoning through medicolegal autopsy cases is essential for informing preventive strategies and improving clinical management.

**Methods:** This retrospective observational study was conducted at the Department of Forensic Medicine and Toxicology of Tertiary Care Hospital. A total of 186 medicolegal autopsy cases confirmed positive for organophosphorus compounds on chemical analysis were included. Demographic data, circumstances of poisoning, compound type, autopsy findings, and toxicological results were analyzed. Statistical analysis was performed using SPSS version 26.0, with chi-square tests and independent t-tests employed where appropriate. A p-value < 0.05 was considered statistically significant.

**Results:** The majority of victims were male (63.4%), aged 21–40 years (54.8%), and from rural backgrounds (71.5%). Suicidal intent accounted for 82.3% of cases. Chlorpyrifos (28.5%) and monocrotophos (22.0%) were the most frequently detected compounds. The mean serum cholinesterase level at admission was  $1,124.6 \pm 487.3$  IU/L. Pulmonary edema (87.1%), cerebral edema (62.4%), and congestion of abdominal viscera (78.0%) were the predominant autopsy findings. A statistically significant association was found between compound type and survival duration ( $p = 0.002$ ).

**Conclusion:** Fatal OP poisoning disproportionately affects young rural males with suicidal motivation. Highly toxic WHO Class I compounds are frequently implicated. Strengthened pesticide regulation, restricted accessibility, and community-level mental health interventions are imperative to reduce mortality.

**Keywords:** Organophosphorus poisoning; medicolegal autopsy; toxicological profile; forensic medicine; suicidal poisoning; pesticide mortality.

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### Introduction

Acute pesticide poisoning constitutes a major global public health emergency, with the World Health Organization estimating approximately 300,000 deaths annually, predominantly in low- and middle-income countries [1]. Among pesticides, organophosphorus (OP) compounds are the most commonly implicated agents in intentional self-harm and accidental poisoning deaths, particularly across South and Southeast Asia [2].

The widespread agricultural use of these compounds, coupled with their easy availability, low cost, and high toxicity, renders them a preferred agent for deliberate self-poisoning in

rural populations [3]. Organophosphorus compounds exert their toxic effects through irreversible inhibition of acetylcholinesterase, leading to accumulation of acetylcholine at synaptic junctions and neuromuscular junctions, resulting in a constellation of muscarinic, nicotinic, and central nervous system manifestations [4]. The clinical severity and outcome depend upon the specific compound ingested, the quantity consumed, the time elapsed before medical intervention, and the individual's metabolic capacity [5].

Medicolegal autopsy examination in cases of suspected OP poisoning serves a critical dual role: it establishes the cause and manner of death while also contributing valuable epidemiological data for public health surveillance [6]. Characteristic autopsy findings include pulmonary edema, visceral congestion, and a distinctive garlic-like odor emanating from the stomach contents [7]. Chemical analysis of biological specimens remains the gold standard for confirmatory diagnosis in forensic practice [8].

Several studies have documented the epidemiological patterns of OP poisoning across different geographical regions. Eddleston et al. highlighted the enormous burden of pesticide self-poisoning in rural Asia [9]. Srinivas Rao et al. reported that young adults from agricultural backgrounds constituted the most vulnerable demographic in India [10].

Despite these contributions, there remains a paucity of comprehensive studies correlating autopsy findings with toxicological profiles in fatal OP cases, particularly from tertiary care centers in central India [11].

Furthermore, evolving patterns of compound usage, driven by regulatory changes and market dynamics, necessitate periodic reassessment of the toxicological landscape [12].

The identification of specific compounds most frequently associated with fatalities can guide targeted regulatory interventions, such as bans or restrictions on the most lethal formulations [13].

The present study was therefore undertaken with the aim of analyzing the demographic patterns, autopsy findings, and toxicological profiles of fatal organophosphorus poisoning cases subjected to medicolegal autopsy at a tertiary care center over a five-year period, thereby contributing to the existing body of forensic toxicological literature and informing evidence-based preventive strategies.

## Materials and Methods

**Study Design and Setting:** This was a retrospective, record-based observational study conducted at the Department of Forensic Medicine and Toxicology of Tertiary Care Hospital in India.

**Study Population and Sample Size:** All medicolegal autopsy cases brought to the mortuary during the study period in which the cause of death was attributed to organophosphorus compound poisoning, confirmed by chemical analysis of viscera and body fluids at the Regional Forensic Science Laboratory (RFSL), were included.

A total of 186 cases fulfilled the inclusion criteria.

**Inclusion Criteria:** Cases were included if: (a) the autopsy was conducted at the study center during

the defined period; (b) the cause of death was consistent with OP poisoning based on clinical history, autopsy findings, and police documentation; and (c) the chemical analysis report from the RFSL confirmed the presence of organophosphorus compounds in biological specimens.

**Exclusion Criteria:** Cases were excluded if: (a) chemical analysis reports were unavailable or inconclusive; (b) mixed poisoning with non-OP agents was detected; (c) decomposed bodies precluded meaningful autopsy interpretation; or (d) records were incomplete with missing critical variables.

**Data Collection:** Data were extracted from autopsy reports, inquest documents, hospital clinical records (where available), and chemical analysis reports. A structured proforma was used to systematically record: demographic variables (age, sex, residence, occupation, marital status); circumstances of poisoning (manner, route, alleged compound, time of ingestion, survival duration); clinical parameters (serum cholinesterase levels, treatment received); gross autopsy findings (organ-specific observations); and toxicological results (compound identified, specimen analyzed).

**Statistical Analysis:** Data were entered into Microsoft Excel 2019 and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as frequencies, percentages, and mean  $\pm$  standard deviation (SD). The chi-square test was used for comparing categorical variables between groups, and the independent samples t-test was used for continuous variables. A p-value of less than 0.05 was considered statistically significant.

## Results

A total of 186 confirmed fatal OP poisoning cases were analyzed. The mean age of victims was  $33.7 \pm 12.4$  years (range: 14–72 years). Males constituted 118 cases (63.4%) and female's 68 cases (36.6%), yielding a male-to-female ratio of 1.74:1. The largest proportion of victims belonged to the 21–30 years age group (32.3%), followed by the 31–40 years group (22.5%). Rural residents accounted for 133 cases (71.5%), and 109 victims (58.6%) were engaged in agricultural occupations. Regarding marital status, 138 cases (74.2%) were married. Suicidal poisoning was the predominant manner of death (153 cases, 82.3%), followed by accidental poisoning (28 cases, 15.0%) and homicidal poisoning (5 cases, 2.7%). The oral route was the mode of ingestion in all cases. The mean survival duration after ingestion was  $14.8 \pm 18.6$  hours. A total of 64 cases (34.4%) died within 6 hours of ingestion, while 42 cases (22.6%) survived beyond 24 hours.

**Table 1: Demographic and Circumstantial Profile of Fatal OP Poisoning Cases (N = 186)**

Variable	Category	n (%)
<b>Sex</b>	Male	118 (63.4)
	Female	68 (36.6)
<b>Age group (years)</b>	≤20	28 (15.1)
	21–30	60 (32.3)
	31–40	42 (22.5)
	41–50	31 (16.7)
	>50	25 (13.4)
<b>Residence</b>	Rural	133 (71.5)
	Urban	53 (28.5)
<b>Occupation</b>	Agriculture	109 (58.6)
	Laborer	32 (17.2)
	Homemaker	24 (12.9)
	Student	14 (7.5)
	Other	7 (3.8)
<b>Manner of death</b>	Suicidal	153 (82.3)
	Accidental	28 (15.0)
	Homicidal	5 (2.7)
<b>Survival duration</b>	<6 hours	64 (34.4)
	6–24 hours	80 (43.0)
	>24 hours	42 (22.6)

The toxicological analysis revealed chlorpyrifos as the most frequently identified compound in 53 cases (28.5%), followed by monocrotophos in 41 cases (22.0%), methyl parathion in 29 cases (15.6%), malathion in 24 cases (12.9%), phorate in 18 cases (9.7%), and others in 21 cases (11.3%). Among these, WHO Class I (extremely or highly hazardous) compounds accounted for 96 cases (51.6%). The mean serum cholinesterase level at

hospital admission (available in 142 cases) was  $1,124.6 \pm 487.3$  IU/L, significantly lower in the WHO Class I group compared to Class II/III ( $872.3 \pm 391.5$  vs.  $1,398.4 \pm 412.8$  IU/L;  $p < 0.001$ ).

There was a statistically significant association between WHO toxicity class and survival duration ( $p = 0.002$ ), with Class I compounds associated with shorter survival times.

**Table 2: Toxicological Profile and Compound Distribution (N = 186)**

OP Compound	WHO Class	n (%)	Mean Survival (hours)	Mean Serum ChE (IU/L)
Chlorpyrifos	II	53 (28.5)	$18.2 \pm 16.4$	$1,287.5 \pm 438.2$
Monocrotophos	I	41 (22.0)	$8.6 \pm 9.3$	$814.6 \pm 362.4$
Methyl parathion	I	29 (15.6)	$7.4 \pm 7.8$	$756.3 \pm 298.7$
Malathion	III	24 (12.9)	$24.7 \pm 21.5$	$1,542.8 \pm 401.6$
Phorate	I	18 (9.7)	$6.2 \pm 5.1$	$692.4 \pm 274.3$
Others	Variable	21 (11.3)	$16.9 \pm 19.2$	$1,318.7 \pm 467.5$

Autopsy examination revealed consistent pathological findings across cases. Pulmonary edema was the most common finding, observed in 162 cases (87.1%), and followed by congestion of abdominal viscera in 145 cases (78.0%) and cerebral edema in 116 cases (62.4%). A characteristic garlic-like odor from the stomach contents was documented in 134 cases (72.0%). Subendocardial hemorrhages were noted in 47 cases (25.3%).

**Table 3: Gross Autopsy Findings in Fatal OP Poisoning Cases (N = 186)**

Autopsy Finding	n (%)
Pulmonary edema and congestion	162 (87.1)
Congestion of liver, spleen, and kidneys	145 (78.0)
Garlic-like odor from stomach contents	134 (72.0)
Cerebral edema and congestion	116 (62.4)
Frothy fluid in trachea and bronchi	108 (58.1)
Congested and edematous gastric mucosa	97 (52.2)
Petechial hemorrhages on visceral surfaces	63 (33.9)
Subendocardial hemorrhages	47 (25.3)
Fatty changes in liver	34 (18.3)
Cyanosis of nail beds and lips	89 (47.8)

## Discussion

The present study provides a comprehensive analysis of the patterns and toxicological characteristics of fatal organophosphorus poisoning in a central Indian setting. The findings corroborate existing literature while elucidating region-specific nuances of considerable forensic and public health relevance.

The predominance of male victims (63.4%) in the current study is consistent with observations by Jesslin et al., who reported a male preponderance in pesticide poisoning deaths across South India [14]. This gender disparity is attributable to greater occupational exposure among males in the agricultural sector, coupled with impulsive access to pesticides during emotional distress [15]. The peak incidence in the 21–40 years age group (54.8%) mirrors findings by Banerjee et al., who identified young adults as the most vulnerable cohort, likely reflecting the combined pressures of financial burden, agricultural debt, and interpersonal conflicts [16].

The overwhelming suicidal intent (82.3%) documented in our study aligns with the observations of Gunnell et al., who estimated that deliberate self-poisoning with pesticides accounts for approximately one-third of all suicides worldwide [17]. The rural predominance (71.5%) further supports the well-established association between pesticide accessibility and rural suicidal behavior, as demonstrated in the landmark Sri Lankan studies by Eddleston and colleagues [9]. Notably, the restriction of WHO Class I pesticides in Sri Lanka led to a significant decline in suicide rates without adversely affecting agricultural productivity [18], offering a compelling policy model for India.

The toxicological findings of our study are particularly noteworthy. Chlorpyrifos emerged as the most commonly detected compound (28.5%), reflecting its continued widespread availability in the Indian market despite regulatory concerns [19]. However, the highest fatality rates and shortest survival durations were associated with WHO Class I compounds—monocrotophos, methyl parathion, and phorate—which collectively accounted for 51.6% of deaths.

This finding is concordant with the study by Roberts et al., who demonstrated a clear relationship between pesticide toxicity classification and case fatality rates [20]. The significantly lower mean serum cholinesterase levels in the WHO Class I group ( $p < 0.001$ ) reflect the greater degree of enzyme inhibition achieved by these highly potent compounds, consistent with prior pharmacokinetic analyses [21].

The autopsy findings in the present study are characteristic of OP poisoning and are well-documented in forensic literature. Pulmonary edema, observed in 87.1% of cases, represents the terminal pathological event resulting from excessive bronchial secretions, bronchospasm, and respiratory failure [22]. Cerebral edema (62.4%) reflects the central nervous system toxicity of OP compounds, while diffuse visceral congestion indicates the systemic hemodynamic collapse that accompanies severe cholinergic crisis [23]. The garlic-like odor from stomach contents, documented in 72.0% of cases, remains a highly valuable diagnostic clue at autopsy, particularly in cases where the history is ambiguous [24].

The significant association between compound toxicity class and survival duration ( $p = 0.002$ ) carries critical implications for emergency management. Cases involving WHO Class I compounds presented with rapid deterioration and death, often before effective medical intervention could be rendered, underscoring the need for pre-hospital care strengthening in rural areas [25]. Additionally, the intermediate syndrome and organophosphate-induced delayed neuropathy were not specifically evaluated in this retrospective analysis, representing a limitation that future prospective studies should address.

The limitations of this study include its retrospective design, reliance on secondary data sources, and potential selection bias inherent in a single-center study. Chemical analysis reports, while confirmatory, did not provide quantitative estimation of compound levels in all cases. Furthermore, psychological autopsy data regarding precipitating factors for suicidal cases were not systematically available.

## Conclusion

This five-year retrospective study of 186 fatal organophosphorus poisoning cases reveals that young, married, rural males engaged in agriculture constitute the most vulnerable population. Suicidal intent is the predominant manner of death, and WHO Class I compounds—particularly Class I compounds—monocrotophos, methyl parathion, and phorate—are associated with the shortest survival durations and most severe cholinesterase depression. Pulmonary edema, visceral congestion, and cerebral edema are the hallmark autopsy findings. These data strongly support the implementation of stringent regulatory measures including the banning of highly hazardous pesticides, promotion of safer alternatives, gatekeeper training in rural communities, and establishment of poison information centers. Community-based mental health interventions targeting at-risk populations are imperative to reduce the burden of suicidal poisoning deaths. Periodic medicolegal

surveillance studies are essential to track evolving trends and evaluate the impact of policy interventions.

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