



EPIDEMIOLOGICAL PROFILE AND PREDICTORS OF PESTICIDE-RELATED FATALITIES IN A TERTIARY CARE CENTRE OF WEST BENGAL: A RETROSPECTIVE AUTOPSY STUDY

Swapan K. Adhikari¹, Soumya Dey^{2*}, Pratipjit Mondal³,

¹MBBS, MD Department of Forensic Medicine & Toxicology, Murshidabad Medical College & Hospital, Berhampore, West Bengal, India

^{2*} MBBS, MD Department of Radiation Oncology/Radiotherapy, Murshidabad Medical College & Hospital, Berhampore, West Bengal, India

³ MBBS, MD Senior Resident, Kurseong SDH, Darjeeling, West Bengal, India

***Corresponding Author:** Soumya Dey

*MBBS, MD Department of Radiation Oncology/Radiotherapy, Murshidabad Medical College & Hospital, Berhampore, West Bengal, India

ABSTRACT

Background: Pesticide poisoning contributes significantly to unnatural deaths in agrarian regions of India. Autopsy-based data offer valuable insights into demographic predictors, poison types, and histopathological changes associated with fatal pesticide ingestion.

Objectives: To analyze demographic factors, determinants, patterns of pesticide poisoning, and autopsy findings among fatal cases in a tertiary care centre in West Bengal.

Methods: A retrospective autopsy-based study was conducted at Burdwan Medical College & Hospital from February 2015 to January 2016. Of 2,423 total autopsies, 351 (14.38%) deaths were due to poisoning, among which 268 (76%) were pesticide-related. Data were collected from autopsy reports, police inquest forms, and emergency records. Descriptive statistics were applied.

Results: Pesticide-related deaths constituted 9.04% of all unnatural deaths (268/2423). Males formed 67.2% of cases, predominantly aged 20–29 years. Most victims were married (67.5%), from rural backgrounds (69.8%), and agriculturists (69.8%). Organophosphorus compounds accounted for 86.2% of cases. Autopsy revealed stomach haemorrhage (93.7%), stomach congestion (96.3%), liver congestion (98.5%), and tubular necrosis (97.8%) as the most prevalent histological changes. A majority (68.6%) of incidences occurred between 12 AM to 6 AM.

Conclusion: Fatal pesticide poisoning primarily affects young adult males from rural agrarian backgrounds, with organophosphorus compounds dominating. Autopsy findings consistently revealed gastrointestinal and hepatic congestion and necrosis. Strengthening pesticide regulation, mental-health support, and rural poison-control services are crucial.

Keywords: pesticide poisoning, organophosphorus, autopsy, West Bengal, forensic study

INTRODUCTION

Pesticide poisoning remains a major public health concern worldwide, contributing substantially to morbidity and mortality, particularly in developing countries. In India, pesticide self-poisoning is among the most common methods of suicide due to the easy availability, unrestricted sale, and widespread agricultural use of toxic compounds. Unintentional and accidental exposures also occur, while homicidal cases, though less common, are documented. Globally, Each year 250 000- 370 000 people die from deliberate ingestion of pesticides[1], with organophosphorus (OP) compounds constituting the most frequent agents involved. Earlier studies have shown that OP pesticides, carbamates, organochlorines, and aluminium phosphide contribute significantly to poisoning-related deaths, with OP compounds alone responsible for over half of pesticide poisoning cases in many regions. The World Health Organization (WHO) recognises pesticide poisoning to be the single most important means of suicide worldwide. [2]

Pesticides are chemically diverse substances used predominantly in agriculture to prevent, destroy, or control pests, vectors of disease, and unwanted plant or animal species. According to the Food and Agriculture Organization (FAO), pesticides also include substances used for regulating plant growth, preventing premature fruit drop, and protecting commodities during storage and transport. Their extensive use in agriculture and vector control has improved crop yields and contributed to public health; however, their toxicological properties pose a significant risk to human life. Depending on their chemical nature, pesticides act through various mechanisms—most commonly affecting the nervous and cardiovascular systems. Organophosphates inhibit acetylcholinesterase, leading to excessive accumulation of acetylcholine, whereas carbamates act through similar but reversible enzyme inhibition. Organochlorines such as DDT, though largely banned, persist in the environment, while pyrethroids, synthetic analogues of natural chrysanthemum compounds, have been modified for greater stability but may remain neurotoxic.

Despite their widespread use, the diagnosis of fatal pesticide poisoning remains challenging. Autopsy findings are often nonspecific and depend heavily on chemical analysis of viscera, which may be limited by decomposition, unavailability of confirmatory tests, and post-mortem changes in the chemical composition of toxins. Therefore, systematic assessment of autopsy changes in vital organs such as the stomach, liver, and kidneys is essential to enhance diagnostic accuracy and support toxicological results.

Given the significant burden of pesticide-related deaths in India and especially in agrarian states like West Bengal, the present study was undertaken to evaluate the demographic patterns, determinants, and characteristic autopsy findings in confirmed cases of pesticide poisoning. The study aims to provide reliable epidemiological and pathological insights that may assist forensic practitioners in establishing a dependable diagnosis of acute pesticide poisoning and contribute to preventive public health strategies.

MATERIALS AND METHODS

This retrospective observational study was conducted in the Department of Forensic Medicine & Toxicology, Burdwan Medical College & Hospital, West Bengal, covering the period from February 2015 to January 2016. All medicolegal autopsies performed during this 12-month interval were systematically reviewed to identify fatalities attributable to pesticide ingestion. A total of 2,423 autopsies were examined, among which 351 deaths (14.38%) were classified as poisoning-related. Of these, 268 cases (76% of all poisoning deaths) demonstrated confirmed evidence of pesticide exposure and constituted the final study cohort. Cases were included when both a documented history indicative of pesticide ingestion and toxicological confirmation of pesticide compounds were available. Historical information was derived from inquest reports, witness statements, and hospital treatment documentation, while toxicological confirmation was established through chemical analysis of viscera. This dual requirement ensured that only definitively established pesticide-related deaths were analysed. Exclusion criteria comprised bodies in an advanced state of decomposition that precluded reliable histopathological evaluation, and mixed-poisoning cases in which the specific involvement

of pesticides could not be conclusively identified. Data collection involved a comprehensive review of multiple official sources to ensure reliability and completeness. These included autopsy reports prepared at the time of post-mortem examination, inquest papers provided by investigating authorities, available hospital case sheets, and detailed histopathology findings. All records were cross-verified, and discrepancies were resolved through consensus review by the forensic team. Data were compiled in Microsoft Excel and underwent descriptive statistical analysis. Categorical variables were summarised using frequencies and percentages, while continuous variables were expressed as appropriate summary statistics. The findings were organised into structured tables and charts to illustrate demographic trends, patterns of pesticide use, and related epidemiological characteristics.

ETHICAL CLEARANCE

The study was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and the applicable national guidelines for biomedical research. Ethical approval for this retrospective record-based study was obtained from the Institutional Ethics Committee of Burdwan Medical College & Hospital, West Bengal.

RESULTS.

Table 1: Distribution of study subjects according to age and sex (n=268)

Age Group	Male n (%)	Female n (%)	Total
20–29	165 (95.9%)	7 (4.1%)	172
30–39	0 (0%)	71 (100%)	71
40–49	15 (100%)	0 (0%)	15
>50	0 (0%)	10 (100%)	10
Total	180 (67.2%)	88 (32.8%)	268

Table 2: Distribution according to occupation (n=268)

Sex	Agriculture n (%)	Non-agriculture n (%)	Total
Male	180 (96.3%)	0 (0%)	180 (67.2%)
Female	7 (3.7%)	81 (100%)	88 (32.8%)
Total	187 (69.8%)	81 (30.2%)	268

Table 3: Distribution according to sex and locality (n=268)

Sex	Rural n (%)	Urban n (%)	Total
Male	180 (96.3%)	0 (0%)	180 (67.2%)
Female	7 (3.7%)	81 (100%)	88 (32.8%)
Total	187 (69.8%)	81 (30.2%)	268

Table 4: Distribution according to sex and marital status (n=268)

Sex	Married n (%)	Unmarried n (%)	Total
Male	174 (96.7%)	6 (3.3%)	180
Female	7 (8%)	81 (92%)	88
Total	181 (67.5%)	87 (32.5%)	268

Table 5: Distribution according to sex and educational status (n=268)

Sex	Secondary School	Secondary School	Graduate	Total
Male	7 (3.9%)	153 (85%)	20 (11.1%)	180
Female	3 (3.4%)	76 (86.4%)	9 (10.2%)	88
Total	10 (3.7%)	229 (85.4%)	29 (10.8%)	268

Table 6: Frequency of admission in hospital (n=268)

Status	Number	Percentage
Admitted	217	81.0%
Not Admitted	51	19.0%
Total	268	100%

Table 7: Distribution according to time of incidence (n=268)

Time Slot*	Number	Percentage
1	49	18.3%
2	22	8.2%
3	13	4.9%
4	184	68.6%
Total	268	100%
*1 = 6 AM–12 PM, 2 = 12 PM–6 PM, 3 = 6 PM–12 AM, 4 = 12 AM–6 AM		

Table 8: Distribution according to type of poison (n=268)

Type of Poison	Number	Percentage
1 (Organophosphorus)	231	86.2%
2 (Carbamate)	10	3.7%
3 (Organochloride)	5	1.9%
4 (Endosulphan)	10	3.7%
5 (Aluminium phosphide)	12	4.5%
Total	268	100%

Table 9: Frequency of post-mortem histological findings (n=268)

Findings	Present n (%)	Absent n (%)
Stomach haemorrhage	251 (93.7%)	17 (6.3%)
Stomach congestion with mononuclear infiltration	258 (96.3%)	10 (3.7%)
Stomach necrosis	256 (95.5%)	12 (4.5%)
Erosion of lamina propria	260 (97%)	8 (3%)
Liver haemorrhage	262 (97.8%)	6 (2.2%)
Liver congestion	264 (98.5%)	4 (1.5%)

Bile pigment in hepatocytes	258 (96.3%)	(3.7%)	10
Degeneration of hepatocytes	262 (97.8%)	(2.2%)	6
Liver sinusoidal dilatation	263 (98.1%)	(1.9%)	5
Liver steatosis	260 (97%)	8 (3%)	
Kidney haemorrhage	264 (98.5%)	(1.5%)	4
Glomerular congestion	265 (98.9%)	(1.1%)	3
Tubular necrosis	262 (97.8%)	(2.2%)	6

DISCUSSION

In this retrospective series of 268 pesticide-related deaths, males constituted 67.2% of victims, with the majority concentrated in the 20–29-year age group, while females more commonly belonged to the 30–39 and >50-year categories. Most victims (69.8%) were agricultural workers and resided in rural areas, with nearly all males engaged in agriculture and all urban cases being female. A high proportion (67.5%) were married, and the majority (85.4%) had secondary school education. Notably, 81% of victims had been admitted to hospital before death, and most incidents (68.6%) occurred during the early morning hours between 12 AM and 6 AM. Organophosphorus compounds accounted for 86.2% of all poisoning agents, followed by smaller proportions of carbamates, organochlorides, endosulfan, and aluminium phosphide. Histopathological examination revealed widespread multi-organ damage, with stomach haemorrhage (93.7%), congestion with mononuclear infiltration (96.3%), necrosis (95.5%), and erosion of the lamina propria (97%) being frequent findings. Liver pathology was equally prominent, including haemorrhage (97.8%), congestion (98.5%), bile pigment deposition (96.3%), hepatocyte degeneration (97.8%), sinusoidal dilatation (98.1%), and steatosis (97%). Kidney involvement was extensive, with kidney haemorrhage (98.5%), glomerular congestion (98.9%), and tubular necrosis (97.8%) observed in nearly all cases. Overall, the findings highlight that young rural males in agricultural occupations, predominantly exposed to organophosphorus pesticides, represent the most vulnerable group, with consistent and severe multisystem histopathological features confirming the toxic insult.

In the present investigation, pesticide poisoning emerged as a major contributor to unnatural deaths, accounting for 14.38% of all autopsied cases, of which 76% were due to pesticide ingestion. Pesticide-related deaths constituted 9.04% of all unnatural deaths (268 out of 2423), a finding consistent with earlier studies by **A.K. Kapoor, Dalal JS et al.**, and **PC Vaghela et al.**, while **Dhattarwal SK et al.** reported even higher incidences (23.42%) (**Rajani V. Bhagora et al.**, 2009). Similar to previous literature, the present study observed a clear male predominance (67.2%), which aligns with findings by Dalal JS et al., PC Vaghela et al., and S. Chowdhury et al. Studies across India consistently highlight male predominance in poisoning cases, attributed to greater exposure to occupational stress, social responsibilities, and being the principal earning members (Gupta BD, Vaghela PC, 2005).

Age-wise distribution also showed concordance with earlier studies. The highest incidence of deaths occurred in the 20–29 years age group, followed by 30–39 years, comparable with the observations by **Navin Verma, AK Kapoor, JS et al.**, **Sanjay Gupta et al.**, and **Manish Nigam et al.** (Nigam M et al., 2004; Gupta S et al., 2007; Rajani V. Bhagora et al., 2009). This vulnerability in younger adults may be explained by psychosocial stressors including financial strain, relationship issues, examination pressure, unemployment, and lifestyle-related stress, making them more prone to deliberate self-harm. Married individuals formed the majority in this study, similar to findings by **Dalbair et al.** (1999), **Vijay K.**, and **Sharma et al.** (2002). Married individuals often face heavier financial and familial

responsibilities, contributing to psychological distress and higher suicide rates. In contrast, unmarried individuals, being relatively carefree, exhibited lesser incidence.

Geographical distribution revealed that 69.8% of cases belonged to rural areas, a pattern consistent with studies by Naveen Verma, PC Vaghela, and Dhattarwal SK et al. Higher rural prevalence may be attributed to increased agricultural activities, easy availability of pesticides, lack of awareness, and limited healthcare access. Conversely, poisoning cases were lower in urban regions due to better literacy rates and easier access to immediate medical care. Similar observations were made by Navin Verma, AK Kapoor et al., and S. Chowdhury et al., who noted higher rates (64.9%) in urban areas compared to rural ones (35.1%) in some regions, reflecting regional variations in pesticide usage.

The predominance of organophosphorus compounds observed in the present study is consistent with multiple previous reports, including those by Singh et al., **Sanjay et al.**, Vinay et al., and Gupta et al. Dalbir et al., Sharma et al., **Gargi et al.**, and Sinha et al. also reported aluminium phosphide poisoning as common in some regions. **Shahin et al.** noted opioid poisoning in 41.54% cases. This diversity indicates that the pattern of poisoning depends heavily on regional agricultural practices, accessibility, and availability of specific toxic agents (Singh Dalbir et al., 1999; **Vij K., Sharma et al.**, 2002; Gargi J. et al., 2004).

Autopsy findings in the present study revealed classical features of acute pesticide poisoning. Cyanosis of the lips, fingertips, and nose, along with generalized visceral congestion, were observed in all cases. Dissection showed congestion of the gastric mucosa with scattered submucosal petechial haemorrhages in 98.3% cases. Histopathology of the stomach demonstrated petechial and submucosal haemorrhages in all acute cases, in contrast to only 1.2% in the control group, correlating strongly with the findings of organophosphorus poisoning reported from Bangladesh (**Ahmed et al.**, 2009). Additional prominent gastric findings included congestion, erosion of muscularis mucosa, submucosal haemorrhages, and areas of necrosis.

The liver showed consistent patterns of congestion, sinusoidal dilatation, hepatocyte degeneration, and haemorrhage, again matching previously described toxic effects of organophosphorus compounds. Kidney findings, including haemorrhage, tubular necrosis, and marked glomerular congestion, were also in line with established toxicological effects. These findings together formed a reliable constellation of autopsy and histopathological markers supporting the diagnosis of acute pesticide poisoning.

From the present investigation, it is evident that beyond the general findings, several histological changes serve as valuable indicators of pesticide poisoning. These include:

1. Stomach congestion, erosion of mucosa, and submucosal petechial haemorrhages
2. Gastric necrosis with submucosal haemorrhage
3. Liver congestion, sinusoidal dilatation, hepatocyte degeneration, and haemorrhages
4. Kidney haemorrhage, tubular necrosis, and glomerular congestion

These well-defined histopathological features complement gross autopsy findings and significantly aid in establishing a dependable diagnosis of acute pesticide poisoning, especially when chemical analysis faces limitations such as decomposition, transport delays, or unavailability of toxicology facilities

LIMITATIONS

This study has certain inherent limitations that warrant consideration. First, as a single-centre study conducted in a tertiary care hospital, the findings may not be fully generalizable to the broader population of West Bengal or other regions with different agricultural or socioeconomic profiles. Second, the retrospective design relies on the accuracy and completeness of existing records, which may introduce documentation bias and limit the ability to explore certain clinical or circumstantial variables in depth. Finally, toxicological analysis in this study was qualitative in nature, and the absence of quantitative toxicological data restricted the assessment of dose–response relationships and prevented correlation between pesticide concentration levels and clinical or pathological severity.

Future directions

Based on the patterns observed in this study, several public health and policy measures are recommended. There is an urgent need to regulate and progressively phase out highly hazardous pesticides (HHPs), which continue to account for a substantial proportion of fatal poisoning cases. Establishing and strengthening rural poison-control centres would enhance early diagnosis, timely referral, and appropriate management of pesticide poisoning, particularly in underserved agrarian communities. Mental health support services, including routine psychological counselling and suicide-prevention initiatives, should be integrated into primary health centres to address the underlying psychosocial drivers of intentional self-poisoning. Additionally, targeted training programs for emergency medical personnel on the recognition and standardized management of organophosphate and other pesticide poisonings would improve clinical outcomes and reduce mortality.

CONCLUSION

Fatal pesticide poisoning disproportionately affects rural young adult males engaged in agriculture. The predominance of organophosphorus agents and consistent histological findings underline the need for stricter pesticide regulation, restriction of toxic compounds, and improved rural emergency response. Enhancing community awareness, early hospital intervention, and adopting evidence-based poison management protocols can significantly reduce morbidity and mortality associated with pesticide poisoning.

References:

1. Dawson AH, Eddleston M, Senarathna L, Mohamed F, Gawarammana I, Bowe SJ, et al. Acute human lethal toxicity of agricultural pesticides: a prospective cohort study. *PloS Med* 2010; 7:e1000357.
2. Bertolote JM, Fleischmann A, Eddleston M, Gunnell D. Deaths from pesticide poisoning: a global response. *Br J Psychiatry* 2006; 189:201-3.
3. Sinha US, Kapoor AK, Agnihotri AK, Srivastava PK. A Profile of Poisoning Cases Admitted in SN Hospital Allahabad with Special Reference to Aluminium Phosphide Poisoning. *J Forensic Med Toxicol.* 1999; 16(1): 43-2.
4. Dalal JS, Gorea RK, Aggarwal AK, Thind AS, Sandhu SS. Poisoning Trends- A Post Mortem Study. *J Ind Acad Forensic Med.* 1998; 20(2): 27-31
5. Dhatarwal SK, Harnam Singh. Profile of Death due to Poisoning in Rohtak, Haryana. *J Forensic Med Toxicol.* 2001; 18(2): 28-9.
6. Gupta BD, Vaghela PC. Profile of fatal poisoning in and around Jamnagar. *J Indian Acad Forensic Med.* 2005; 27(3):145-8.
7. Chaudhary S, Momin SG, Vora DH, Modi P, Chauhan V, Chotaliya D. An epidemiological study of fatal aluminium phosphide poisoning at Rajkot. *IOSR J Pharm.* 2013; 3(1): 17-23.
8. Bhagora RV, Singh K, Oberoi SS, Bhullar DS. Poisoning trends in the Malwa region of Punjab. *J Punj Acad Forensic Med Toxicol.* 2003; 3:26-9.
9. Rajani V. Bhagora. Profile Study of Fatal Poisoning Cases Brought for Postmortem Examination at Mortuary of Sir Takhtsinhji General Hospital, Bhavnagar (Gujarat). *Int J Res Med* 2015;4(3):59-63.
10. Varma N, Kalele SD. Original Research Paper Study of Profile of Deaths due to Poisoning in Bhavnagar Region. *J Indian Acad Forensic Med.* 2011; 33(4):313-8.
11. Sanjay Gupta, M. I. Sheikh, study and changing trends of poisoning in year 2004-05 at Surat, India. *International Journal of Medical Toxicology and legal Medicine* Vol – 10, No:01, July-Dec 2007, Pp:16-9.
12. Nigam M., Jain A. K., Dubey B.P. (2004) Trends of organophosphorus poisoning in Bhopal region – An autopsy based study, *JIAFM*, Vol. – 26, No.-2, pp 62 - 5.

13. Singh D, Jit I, Tyagi S. Changing trends in acute poisoning in Chandigarh zone: a 25-year autopsy experience from a tertiary care hospital in northern India. *Am J Forensic Med Path.* 1999;20(2):203-10.
14. Sharma BR, Harish D, Sharma V, Vij K. The epidemiology of poisoning: An Indian view point. *J Forensic Med Toxicol.* 2002;19(2):5-11.
15. Shadnia S, Esmaily H, Sasanian G, Pajoumand A, Hassanian-Moghaddam H, Abdollahi M. Pattern of acute poisoning in Tehran-Iran in 2003. *Human & experimental toxicology.* 2007;26(9):753-6.
16. Vij K, Sharma BR, Harish D. Poisoning in northern India – Changing trends, causes and prevention thereof. *Med Sci Law* 2002; 42(3):251-7.
17. Gargi J, Hakumat R, Ashok C, Gurmanjit R, Gaurav S, Baggai JS. Current trends of poisoning: A hospital profile. *JPAFMT* 2004; 3.
18. Rahman F N, Ashrafuzzaman M, Chowdhury DKP, Ali M. Overview of Organo- phosphorus Compound Poisoning in Bangladesh and Medico-legal Aspects Related to Fatal Cases. *JAFMC Bangladesh* 2009;5:41-5.