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Twenty-year trends in ICU poisoning management with and without antidotes: experience from a tertiary hospital in Pakistan

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Abstract

***Background*:** Poisoning is a major global health challenge and often requires intensive care due to high morbidity and mortality. We evaluate epidemiological trends, clinical features, and outcomes of adults admitted to the ICU with toxic exposures or substance misuse over 20 years.
***Methods*:** We conducted a retrospective review at Aga Khan University Hospital, Karachi, including adults (≥18 years) admitted to the medical ICU between 2002 and 2022. Statistical analyses (Chi-square, Fisher's exact, Mann-Whitney U, and logistic regression) assessed associations and predictors of mortality.
***Results*:** Among 115 patients, most were young adults (18–30 years, 47%) and male (71.3%). Organophosphorus (OP) compounds were the most common (39.1%), followed by household bleach and paraquat (24.3%). Median ICU stay was 5 days, and hospital stay was 9 days. ICU mortality was 18.3%, with 81.7% surviving to discharge. Gastric lavage was performed in 23.5%, and antidotes in 65.2%, with slightly higher survival among recipients (66% vs. 61.9%). OP poisoning was linked to central nervous and cardiovascular complications, while methanol poisoning was strongly associated with acute kidney injury. Non-survivors had shorter ICU stays, more renal complications, higher vasopressor use (90.5%), and increased need for renal replacement therapy (52.4%). Logistic regression identified longer hospital stay (OR = 1.124, p = 0.044) and vasopressor use (OR = 0.029, 95% CI: 0.005–0.176) as significant mortality predictors.
***Conclusion*:** Poisoning-related ICU admissions mainly affected young males, with OP compounds and methanol as leading toxins. Methanol poisoning and vasopressor requirement were strongly associated with mortality. Early recognition and aggressive management are essential for improving outcomes.

Keywords: Antidotes, Intensive care units, Methanol, Organophosphates, Poisoning

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INTRODUCTION

Poisoning and substance abuse remain major global public health challenges, contributing substantially to morbidity and mortality worldwide [1]. In the United States, poisoning ranks among the leading causes of death [2]. A study conducted between 2010 and 2017 reported that individuals with substance use disorders lost an estimated 21.6 potential years of life, while those with co-existing mental health disorders lost approximately 23.2 years [3].

A wide range of substances, including alcohol, opioids, benzodiazepines, cocaine, and cannabis, are commonly misused [4]. Alcohol toxicity is a major contributor to unintentional injuries and hospital admissions [5]. Similarly, opioid overdose significantly increases the risk of death compared with the general population [6].

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The intensive care unit (ICU) frequently manages critically ill patients with acute poisoning, where rapid diagnosis and specialized interventions are essential [7]. The epidemiology, clinical manifestations, and outcomes of poisoning vary widely by region and are influenced by socioeconomic factors, healthcare access, and the availability of toxic agents [8, 9]. The reported ICU admission rates for poisoning differ considerably, reaching as high as 40% in some settings [10].

In Pakistan, data on the clinical profile and outcomes of poisoning-related ICU admissions remain limited [11]. This study aims to evaluate the epidemiological trends, clinical characteristics, and outcomes of adults admitted to the ICU with poisoning or substance misuse over a 20-year period. By identifying frequently encountered toxic agents, associated complications, and predictors of mortality, the study seeks to inform improved clinical management strategies and guide resource allocation, particularly in resource-constrained healthcare environments. Given that local patterns of poisoning, availability of specific toxins (e.g., agricultural pesticides vs. pharmaceuticals), and healthcare system factors differ from those reported internationally, context-specific data are essential for tailoring effective prevention and management strategies.

METHODS

This observational study was conducted in the Intensive Care Unit (ICU) of Aga Khan University Hospital, Karachi, Pakistan, and included all patients admitted to the medical ICU between 2002 and 2022.

Adult patients (≥ 18 years) admitted to the medical ICU with documented poisoning or substance abuse were eligible for inclusion. Patients with incomplete medical records were excluded. A case log was developed and patient files were retrieved from the hospital's Health Information Management System (HIMS), where clinical information is routinely documented using the latest version of the International Classification of Diseases (ICD). A structured data collection form was used to extract information on demographics, socioeconomic status, type of toxic exposure, clinical presentation, length of ICU stay, management strategies, and outcomes.

Data were analyzed using IBM SPSS version 27. Quantitative variables were summarized as means with standard deviations or medians with interquartile ranges (IQR), depending on distribution. Categorical variables were reported as frequencies and percentages. Descriptive statistics were used to characterize patient demographics, poisoning type, and clinical management. Chi-square and Fisher's exact tests were applied to evaluate associations between poisoning type and antidote administration, organ involvement, and organ failure. The Mann-Whitney U test was used to assess group differences for non-normally distributed variables. To identify independent predictors of ICU mortality, we performed a binary logistic regression analysis. Variables were initially screened using univariate analysis, and those with a p-value < 0.10 were considered eligible for inclusion in the multivariable model. Clinically important variables identified, such as vasopressor use, renal failure, and type of poisoning, were also included irrespective of their univariate significance. The final model was constructed using a backward stepwise elimination approach while checking for multicollinearity and ensuring clinical plausibility. Odds ratios (ORs) with 95% confidence intervals (CI) were reported. As this was an observational study, the OR for hospital stay reflects the association rather than causation; therefore, the finding of OR >1 indicates that patients who ultimately died tended to have prolonged overall hospital stays rather than implying that longer stays increased mortality risk.

RESULTS

A total of 115 patients with acute poisoning were included in the analysis. Nearly half (47%) were young adults aged 18–30 years, with a progressive decline in older age groups; only 0.9% of cases occurred among patients aged 70–82 years (Table 1). Males were disproportionately affected (71.3%), and most patients belonged to middle–socioeconomic status households (71.3%), followed by high (17.4%) and low socioeconomic groups (7%). The median ICU stay was 5 days (IQR: 4–8), and the median total hospital stay was 9 days (IQR: 6–14.75). In 46.1% of cases, the time from toxic exposure to hospital presentation was unknown. Cardiac arrest occurred in 23.5% of patients during hospitalization, with most events (13%) occurring in the ICU. Overall mortality was 18.3% (21 patients), while 81.7% (94 patients) survived to discharge. Tracheostomies were performed in 13.9% of cases (16 patients) (Table 1).

Organophosphorus (OP) compounds were the most frequently identified toxins, accounting for 39.1% of all cases, followed by bleach, paraquat, and rodenticide ingestions (24.3%). A detailed distribution is presented in Figure 1.

Figure 2 shows the trend of poisoning-related ICU admissions over 20 years, with a peak in 2014 (15 patients) followed by a gradual decline.

Gastric lavage was performed in 23.5% of patients (27/115). Mechanical ventilation was required in nearly all cases (99.1%, 114 patients), most commonly due to depressed mental status, with a Glasgow Coma Scale (GCS) < 8 recorded in 61.3% (71 patients). Vasopressors were used in 33.9% of cases (39 patients), predominantly norepinephrine (27%, 31 patients), followed by dopamine (3.5%, 4 patients). Renal replacement therapy was required in 16.5% of patients, including intermittent hemodialysis (9.6%) and continuous renal replacement therapy (7%). Antidotes were administered to 65.2% of patients (75/115). Among survivors (n = 94), 66% had received antidotes, compared with 61.9% in non-survivors (p = 0.92). The most

Table 1. Demographic characteristics and clinical outcomes of the patients

Variable	N = 115	Percentage (%)
Age (years)		
18-30	54	47%
31-43	30	26.1%
44-56	19	16.5%
57-69	9	7.8%
70-82	1	0.9%
Gender		
Male	82	71.3%
Female	33	28.7%
Socioeconomic status		
Low Class	8	7%
Middle Class	82	71.3%
High Class	20	17.4%
Length of stay		
In ICU (days) Median with IQR	5	4 – 8
In hospital (days) Median with IQR	9	6 – 14.75
Time-lapse between ingestion and presentation		
Not known	53	46.1%
0-10 hours	38	33%
>10-24 hours	6	5.2%
>24 hours	18	15.7%
Cardiac arrest in hospital		
Yes	27	23.5%
No	88	76.52%
Place of cardiac arrest		
ER	9	7.8%
ICU	15	13%
SCU	2	1.7%
Ward	1	0.9%
Hospital Outcome		
Survived	90	78.26%
Expired	25	21.73%
ICU outcome		
Expired	21	18.3%
Shifted out	94	81.73%
Tracheostomy	16	13.91%

Abbreviations: ICU: intensive care units; IQR: interquartile range; ER: emergency room; SCU: special care units

commonly administered antidote was the combination of atropine and pralidoxime (24.3%, 28 patients).

Antidote administration was most consistent among patients with OP poisoning and snake envenomation, with all 45 OP cases and all 5 snake bite cases receiving specific antidotes (table 2). In contrast, antidote use for other toxic exposures, such as benzodiazepines and methanol, was more variable.

OP poisoning was most strongly associated with central nervous system (CNS) complications (44.4%), followed by methanol (20%) and other agents (20%). OP compounds also accounted for the highest cardiovascular involvement (34.4%), followed by methanol (25%). Methanol poisoning demonstrated the greatest renal involvement (63.2%). Statistically significant associations were observed between OP poisoning and CNS ($p = 0.005$) and cardiovascular complications ($p = 0.001$), and between methanol poisoning and renal dysfunction ($p < 0.001$). No significant associations were detected between poisoning type and gastrointestinal or respiratory involvement.

A higher proportion of survivors had OP poisoning (45.7%) compared with non-survivors (9.5%), whereas non-survivors showed a greater prevalence of methanol toxicity (42.9%) and snake envenomation (14.3%). No deaths occurred among patients with beta-blocker, calcium channel blocker, or opioid toxicity. Both survivors and non-survivors had notable proportions of patients with other toxic exposures (e.g., bleach, paraquat, rodenticides), though the prevalence was slightly higher among non-survivors (33.3% vs. 22.3%). Non-survivors had a

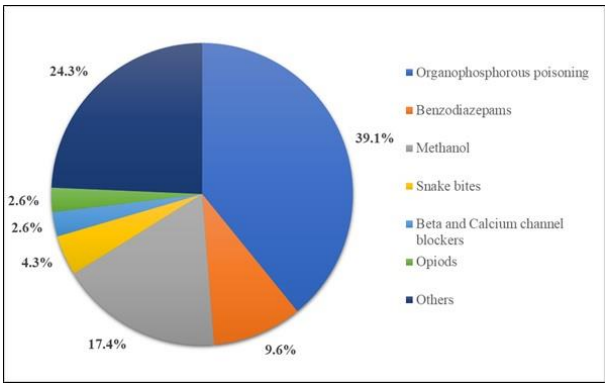

Figure 1. Distribution of poisoning types among patients requiring ICU admission

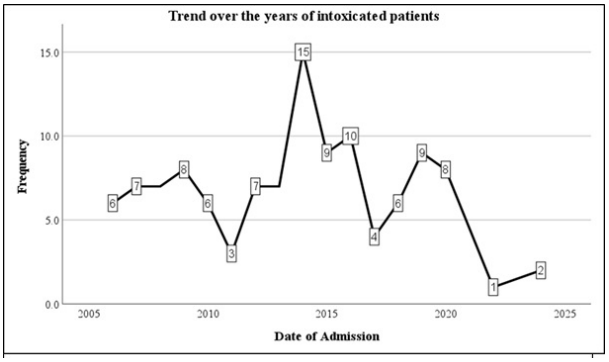

Figure 2. Twenty-year trend in ICU admissions for acute poisoning

Table 2. Type of poisoning with antidote administration

Type of Poisoning	Antidote Status		
	Not Given (n: 40)	Given (n: 75)	Total (N: 115)
Organophosphate	0	45 (100%)	45
Benzodiazepines	10 (90.9%)	1 (9.1%)	11
Methanol	5 (25%)	15 (75%)	20
Snake bites	0	5 (100%)	5
Beta and Calcium channel blockers	1 (33.3%)	2 (66.7%)	3
Opioids	1 (33.3%)	2 (66.7%)	3
Others	23 (82.2%)	5 (17.9%)	28

significantly shorter median ICU stay (4 days; $p = 0.027$) and hospital stay ($p < 0.001$), a higher rate of renal failure (40%; $p < 0.001$), greater need for renal replacement therapy (52.4%; $p < 0.001$), and more frequent vasopressor use (90.5%; $p < 0.001$).

Binary logistic regression identified hospital length of stay and vasopressor use as significant independent predictors of mortality. Longer hospital stay was associated with increased mortality (OR = 1.124, $p = 0.044$). Vasopressor requirement was associated with a markedly lower likelihood of survival (OR = 0.029; 95% CI: 0.005–0.176) (Table 3).

DISCUSSION

This study examined the clinical characteristics, prognostic indicators, and outcomes of patients with acute poisoning requiring ICU admission in a low- and middle-income country (LMIC) setting. The findings demonstrate a high burden of poisoning among young adults (47% aged 18–30 years) and males (71.3%), with most patients belonging to middle-socioeconomic households. OP compounds were the most common toxic agents (39.1%), followed by other substances, including household chemicals and agricultural toxicants. Antidotes were administered to 65.2% of patients, whereas only 23.5% underwent gastric lavage, primarily due to delayed presentation. Non-survivors (18.3%) had significantly higher rates of methanol poisoning, renal failure, and vasopressor use, factors strongly associated with mortality. Logistic regression confirmed hospital stay duration and vasopressor use as independent predictors of poor outcomes.

A key observation in this study is the disproportionate impact of poisoning on young adults, consistent with multiple studies from LMICs [12]. Studies from Pakistan and India have attributed this pattern to risk-taking tendencies, occupational exposure to toxic agents, and accidental ingestion due to inadequate storage or labeling of hazardous substances [12]. The predominance of males in our cohort also mirrors regional data, often linked to the male-dominated agricultural workforce and occupational hazards [13]. Conversely, studies from Iran report differing trends, with methadone- and benzodiazepine-related poisonings more evenly distributed between genders, largely due to intentional overdoses associated with psychosocial stressors and self-harm [14]. This difference is primarily attributed to intentional poisoning with hypnotics and sedatives, often associated with suicidal intent [15, 16]. These variations highlight the influence of cultural, socioeconomic, and behavioral factors on poisoning epidemiology.

Pesticides, particularly organophosphates were the leading toxic agents in this study (39.1%), reflecting their wide availability and use in agriculture. Similar findings have been reported across South Asia, where pesticide poisoning remains a major cause of morbidity and mortality [17]. The easy availability and often unregulated use of pesticides further heighten the risk of poisoning incidents [18]. In addition to OP compounds, methanol emerged as a significant toxicant in our cohort, contributing disproportionately to mortality. A study from Rawalpindi also reported high rates of OP poisoning but identified aluminum phosphide as a predominant agent, suggesting regional variations in toxic exposures [12, 19]. Such differences show the need for localized surveillance and region-specific prevention strategies.

While OP poisoning is known to carry a significant mortality risk, our study observed comparatively better survival among these patients [20]. This may reflect timely recognition of cholinergic symptoms and prompt initiation of antidotal therapy, namely atropine and pralidoxime, administered in nearly one-quarter of cases in our study.

One of the key findings of our study was the survival rate, with 81.73% of patients successfully discharged from the ICU. Although the majority required invasive ventilation due to altered consciousness and intermediate syndrome, timely and targeted interventions played a crucial role in improving outcomes. Managing toxicity in a critical care setting demands swift assessment and intervention by clinicians to optimize treatment strategies.

In developing countries, tools such as the Poisoning Severity Score (PSS), Simplified Acute Physiology Score (SAPS) II, and APACHE score are commonly used to classify disease severity [21]. In our study, we relied on the initial clinical presentation to aid physicians in rapidly identifying high-risk patients, predicting unfavorable outcomes, and prioritizing ICU admissions. Similar findings were reported by [22], who utilized the A, B, and C principles of emergency management to stratify disease severity effectively.

Effective decontamination, including gastric lavage and activated charcoal administration, is most beneficial when performed within one hour of poisoning [23]. However, in our study, only 23.5% of patients received this timely intervention. This low rate was primarily due to delays in

Table 3. Logistic regression showing association to mortality

Variables	Bivariate analysis			Multivariate regression	
	Non- survivors (N: 21)	Survivors (N: 94)	P value	Odds ratio, 95% CI (lower limit – upper limit	p-value
Organophosphate	2 (9.5%)	43 (45.7%)	0.034[a]		0.830
Benzodiazepines	0	11 (11.7%)	0.020[a]		0.158
Methanol	9 (42.9%)	11 (11.7%)	0.999[a]		IS
Snake bites	3 (14.3%)	2 (2.1%)	0.152[a]		IS
Beta and Calcium channel blockers	0	3 (3.2%)	0.137[a]		IS
Opioids	0	3 (3.2%)	0.999[a]		IS
Others	7 (33.3%)	21 (22.3%)	0.999[a]		IS
Length of stay in ICU (days)	4 (1 – 7)	6 (4 – 8)	0.027◦		0.222
Length of stay hospital (days)	4 (1 – 7)	8 (7 – 15)	<0.001◦	1.124 (1.003 – 1.259)	0.044
CNS involvement	16 (76.2%)	74 (78.7%)	0.775		IS
CVS involvement	18 (85.7%)	46 (48.9%)	0.002		0.625
Renal failure	8 (40%)	5 (5.6%)	<0.001*		0.276
Renal replacement therapy done	11 (52.4%)	9 (9.7%)	<0.001*		IS
Vasopressors/inotropes	19 (90.5%)	20 (22%)	<0.001	0.029 (0.005 – 0.176)	<0.001

a: logistic regression test
*Fischer's Exact test
◦Mann-Whitney test
p-value taken significantly at ≤0.05
IS: insignificant

presentation, influenced by factors such as limited pre-hospital care, accessibility barriers, and insufficient public awareness. Establishing a poison control center with telephone consultation services could significantly enhance timely interventions in such critical situations. Systematic reviews on activated charcoal for gastrointestinal decontamination indicate that prompt medical intervention significantly improves survival outcomes [24].

Our study identified methanol poisoning, complicated by severe renal dysfunction, as a leading cause of mortality (42.9% of non-survivors), particularly in our tertiary care setting. The consumption of adulterated alcohol, leading to severe metabolic acidosis and kidney failure, is the primary driver of this trend [25]. Global reports further emphasize the high fatality rates associated with methanol poisoning, emphasizing the urgent need for stricter regulation of alcoholic beverages [26]. Notably, we observed a strong association between renal failure and mortality ($p < 0.001$), aligning with previous studies and reinforcing the nephrotoxic effects of methanol and the critical role of early hemodialysis in improving outcomes.

Compared to other toxic exposures, benzodiazepine overdoses may be less severe or even have a protective effect, as evidenced by the absence of benzodiazepine poisoning among non-survivors in our study. This finding contrasts with research from high-income countries, where benzodiazepine overdoses—especially when combined with opioids or alcohol—significantly contribute to poisoning-related mortality [27]. This disparity may be attributed to regional differences in substance use patterns, healthcare access, and variations in poisoning management strategies.

This study has several important limitations. First, it was conducted at a single tertiary-care center, which may limit the external validity of the findings, particularly for regions with different healthcare infrastructures or toxic exposure patterns. Second, the retrospective design relies on previously recorded clinical data and is therefore susceptible to incomplete, missing, or inaccurately documented information, including details on toxin type, quantity ingested, and timing of presentation. Third, confirmation of specific toxic agents was constrained by limited diagnostic resources, increasing the risk of misclassification. Finally, these methodological constraints restrict the study's generalizability, and the results should be interpreted with appropriate caution.

Overall, our findings highlight the importance of timely antidote administration, early hospital presentation, and intensive supportive care in improving outcomes for poisoning-related ICU admissions. The relatively favorable prognosis in OP poisoning shows the benefits of prompt treatment, whereas the high mortality associated with methanol toxicity calls for urgent public health action.

Addressing poisoning in LMICs requires a comprehensive, multi-tiered approach. National poison

registries and prospective surveillance systems could greatly enhance data quality, facilitate early detection of emerging trends, and inform policy decisions. Public awareness campaigns, community education programs, and training for healthcare providers are essential to improving early recognition and timely intervention. Implementing these strategies can strengthen poisoning prevention and management efforts, ultimately reducing morbidity and mortality in LMIC settings.

CONCLUSION

This study highlights the substantial burden of poisoning-related ICU admissions, with organophosphorus compounds most common and younger males disproportionately affected. Mortality was linked to methanol poisoning, renal failure, and vasopressor need. Early antidote use and timely critical care are vital. Strengthening poisoning management through national registries, surveillance systems, and targeted education is crucial. Future research should include prospective, multicenter studies for generalizable data and qualitative studies to explore psychosocial drivers of intentional self-poisoning to guide prevention strategies.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Review Committee of Aga Khan University Hospital, Karachi (ERC No.: 2024-9767-28194). Due to its retrospective design using anonymized medical records, the requirement for informed consent was waived. Patient confidentiality was strictly maintained by de-identifying all data and restricting access to the research team. The authors confirm adherence to all ethical standards, including avoidance of plagiarism, data fabrication, falsification, and duplicate publication.

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