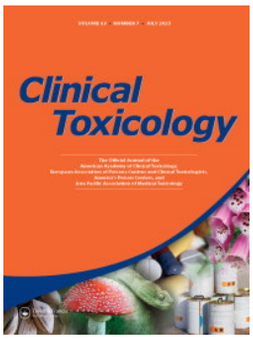

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CLINICAL RESEARCH

Neurological features of acute poisoning in paediatric patients presenting to the emergency department: a retrospective study

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ABSTRACT

Introduction: Early recognition of paediatric poisoning is crucial for timely intervention in emergency settings. This study aims to assess the epidemiological and clinical profiles of paediatric patients presenting with neurological features due to acute poisoning.

Methods: Data from children less than 18 years of age admitted to the emergency department of a tertiary paediatric hospital in Rome between 2017 and 2023 were retrospectively reviewed. Clinical variables associated with admission were reported and analysed across the entire study sample and stratified by age group. Logistic regression models were built to assess the association between clinical and/or laboratory signs and hospitalization in the whole study sample and stratified by age.

Results: A total of 276 children developed neurological features and were included in the study. The median age was 15.6 years (IQR: 14.0–16.7 years), with most patients being female. Ethanol was the single most frequently ingested xenobiotic (39.5%). The most commonly observed neurological feature was altered consciousness (74.3%). Most patients (56.9%) were graded as minor neurologically on the International Programme on Chemical Safety/European Association of Poison Centres and Clinical Toxicologists Poisoning Severity Score. Patients more than 10 years of age were significantly ($P = 0.017$) more frequently females (62.6%) and were significantly ($P = 0.001$) more likely to have a psychiatric co-morbidity (41.0%) than patients less than 10 years of age (4.1%). In patients more than 10 years of age, 55% of patients ingested a xenobiotic for recreational reasons, whereas none did in those less than 10 years of age ($P = 0.001$). The main predictor of hospitalization in patients more than 10 years of age was suicidal intent (odds ratio: 10.17; $P = 0.001$).

Discussion: While no specific neurological feature predicted hospitalization, ingestion of lithium, antipsychotics, and benzodiazepines increased the likelihood of admission. Female adolescents had higher rates of intentional poisoning, often linked to suicidal intent.

Conclusions: Altered consciousness is the most common neurological feature in paediatric poisoning but is not directly linked to hospitalisation. While neurological symptoms are important in assessment, factors such as suicidal intent, mode of emergency access, and age are stronger predictors of hospitalization and should be prioritized in the initial evaluation.

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Introduction

Poisoning is one of the leading causes of morbidity and mortality worldwide. Patients under 20 years of age accounted for 56.1% of approximately 2 million human exposures in the United States in 2021 [1]. Exposure to potentially toxic xenobiotics occurs mainly in the home environment and follows a bimodal pattern, primarily affecting two age groups: children under 5 years, typically due to unintentional ingestion, and adolescents, often as a result of intentional self-poisoning [1]. Although paediatric hospitalization and death rates are low, children can develop features and organ damage even from exposures to minimal doses due to their lower body weight and less developed metabolic pathways [2]. Most paediatric studies report that poisoned children are males under 5 years of age [3]; unintentional poisoning is reported as the most common cause of paediatric poisoning [4–6]. Lin et al. [7] studied 140 children with acute poisoning cared for in an emergency department; 18.6% were asymptomatic. Acute poisoning can affect the central nervous system, peripheral nervous system and the autonomic nervous system with multifaceted clinical manifestations, such as disturbance of consciousness, seizures, paralysis, alterations in pupillary motility, movement disorder, and behavioural alterations. Therapy is primarily supportive; decontamination may sometimes be appropriate to reduce xenobiotic absorption and antidotes are indicated for exposures to some xenobiotics [3,8,9].

The aim of this study was to review acutely poisoned paediatric patients presenting with neurological features to our hospital and to identify factors predicting hospitalization, with the goal of facilitating timely management in the future for potentially severe cases of poisoning.

Methods

A retrospective single-centre observational study was conducted at the emergency department of the tertiary care Bambino Gesù Children's Hospital in Rome, Italy in collaboration with the local paediatric poison control centre and the Postgraduate School of Paediatrics, Faculty of Medicine and Surgery, Sapienza University of Rome, Rome, Italy.

The study was conducted in accordance with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational research [10]. We included all patients under 18 years of age who presented to the paediatric emergency department with neurological features attributable to acute poisoning, as identified by toxicologists of the paediatric poison centre from 1 January 2017 through 31 May 2023. Patients presenting with xenobiotic exposure were initially assessed by an emergency paediatrician, and those exhibiting neurological features were further assessed by the on-duty consultant neurologist and a toxicologist from the paediatric poison centre. All patients were evaluated throughout their hospitalization by a neurologist and toxicologist. To ensure consistency, a single paediatric toxicologist systematically recorded all cases in the electronic database of the poison centre, which prospectively documents predefined, objective fields for all patients receiving toxicology consultations. Poisoned patients were identified by assessing the severity of their symptoms and analysing the type and dosage of the xenobiotic to which the child was exposed. Whenever possible, laboratory tests were performed to confirm exposure. In all cases of poisoning due to xenobiotics of misuse, a first-level screening was conducted. However, we were unable to detect other xenobiotics not identified by the basic screening, such as synthetic cannabinoids, cathinones, or other novel psychoactive xenobiotics. For these cases, a detailed medical history was obtained from the relatives to determine the type and dose of the xenobiotic(s) ingested. All admitted patients were monitored for the development of any signs or symptoms of poisoning during their hospital stay. Additionally, all patients, including those discharged from the emergency department, were followed up in an outpatient setting two weeks after discharge to assess their health status up to that point. We excluded patients exposed to carbon monoxide and envenomation.

As this study was retrospective and descriptive, no power calculations were performed since no pre-specified hypothesis was tested. The study included all available data in the study period. The following data were reported for each patient: age; sex; type of emergency access (either through the emergency services or by referral); co-morbidities, including psychiatric co-morbidities; type of xenobiotic; ingestion of multiple xenobiotics; neurological signs and symptoms; type of ingestion, including the reason for ingestion; home exposure to xenobiotics; treatment; severity of overall and neurological poisoning according to the International Programme on Chemical Safety/European Association of Poison Centres and Clinical Toxicologists (IPCS/EAPCCT) Poisoning Severity Score [10,11]; hospitalization and length of stay. Co-morbidities were defined as any condition documented in the medical history that required treatment with medication or other therapeutic interventions. Psychiatric

co-morbidities were specifically identified when noted in the medical history or confirmed following consultation with a paediatric psychiatrist. The "other" xenobiotic category was created to group less frequently reported ingested xenobiotics, allowing for more systematic comparisons and improved readability. Continuous variables were reported as means and standard deviations when normally distributed and as medians and interquartile ranges when not normally distributed; categorical variables were reported as totals and relative percentages. Patients were grouped according to age and hospitalization, and a comparative analysis of the two groups was performed. Clinically and statistically significant variables from the bivariate analysis were adopted as independent factors associated with hospitalization in the corresponding multivariate models. Logistic regression models were created to assess the association between clinical and/or laboratory signs and hospitalization in the whole study sample and stratified by age. Hypothesis testing was performed based on the characteristics of the variables reported, and a *P* value of less than 0.05 was considered statistically significant. All statistical analyses were conducted using the open-source software R version 4.1.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

During the study period, a total of 9,660 contacts with the paediatric poison centre were recorded, including outpatient visits, individual telephone calls, telephone consultations from other hospitals, and in-hospital consultations conducted at the Bambino Gesù Children's Hospital. Of these, 2,433 patients were evaluated in the emergency department, and 865 were symptomatic. Among these symptomatic cases, 285 exhibited neurological features, and nine were excluded based on the eligibility criteria, resulting in a study sample of 276 patients.

Table 1 presents the characteristics of the study sample, stratified by hospitalization status. The median age of the patients was 15.6 years (IQR 14.0–16.7 years). An age histogram revealed a bimodal distribution, which was used for clustering in subsequent subgroup analysis (Figure 1). Female patients comprised the majority of the sample (59.1%). The most commonly observed neurological feature was altered consciousness (74.3%). Psychiatric co-morbidities (34.4%) were the most prevalent co-morbidity, observed in 34.4% of cases. Ethanol was the single most frequently ingested xenobiotic, accounting for 39.5% of cases. Recreational xenobiotic use was the most frequent motive of ingestion (45.3%), followed by suicidal intent (31.9%). Among the 79 patients hospitalized with suicidal intent, 54 (68.4%) were admitted explicitly for poisoning (data not shown). Based on the IPCS/EAPCCT Poisoning Severity Score, 36.6% of patients had mild poisoning, 55.1% moderate and 8.3% severe poisoning. Approximately, half of the patients (55.8%) were hospitalized for further management and treatment.

The comparison based on hospitalization revealed significant differences in sex, co-morbidities, type of xenobiotic, neurological symptomatology, mode and circumstances of exposure, and treatment administered. Most admitted patients had taken the xenobiotic with suicidal intent, while most who used a xenobiotic for recreational purposes were discharged from the emergency department. Table 2 presents the comparison based on the age cut-off of 10 years.

Older patients (aged >10 years) were more likely to be female and to have co-morbidities, particularly psychiatric ones. The characteristics of the study sample, analysed based on hospitalization status and a cut-off age of 10 years, are reported in Tables 3 and 4. In both age groups, patients admitted to the hospital were significantly more likely to have a higher IPCS/EAPCCT Poisoning Severity Score.

Among children under 10 years of age, an altered level of consciousness was significantly ($P = 0.016$) associated with hospitalization. For patients aged over 10 years of age, those admitted were more likely to be female ($P = 0.009$) and to have a co-morbidity, particularly a psychiatric co-morbidity ($P < 0.001$). The intake of multiple xenobiotics was strongly associated with admission. On the other hand, ethanol intake was significantly ($P < 0.001$) correlated with discharge.

The logistic regression models predicting the likelihood of hospitalization, built using clinically and statistically significant variables, are shown in Table 5. In the all-ages model and the model for patients aged ≥10 years, suicidal intent was identified as the primary factor associated with admission. For children under 10 years of age, altered consciousness was significantly associated with hospitalization. Interestingly, when patients with suicidal intent were excluded, no other variables were significantly associated with admission (data not shown). A simplified model incorporating only age and ethanol intake (including patients with suicidal intent but excluding suicidal intent as a predictor) showed that ethanol intake was significantly associated with discharge (OR 0.17; $P = 0.001$). The concordance between ethanol intake and suicidal intent, derived from a confusion matrix, was low (31.5%, Cohen's $K-48\%$; $P = 0.001$).

Table 1. Characteristics of the study sample and comparison according to hospitalization.

	All patients (n = 276)	Discharged from the emergency department (n = 122)	Hospitalized (n = 154)	P value
Age (years), median [IQR]	15.6 [14.0–16.7]	15.7 [13.9–16.6]	15.6 [14.0–16.7]	0.771
Females, n (%)	163 (59.1)	63 (51.6)	100 (64.9)	0.035
Emergency access[a], n (%)	187 (67.8)	79 (64.8)	108 (70.1)	0.413
Co-morbidities, n (%)	114 (41.3)	32 (26.2)	82 (53.2)	<0.001
Psychiatric co-morbidity, n (%)	95 (34.4)	21 (17.2)	74 (48.1)	<0.001
Xenobiotics				
Ethanol, n (%)	109 (39.5)	71 (58.2)	38 (24.7)	<0.001
Benzodiazepines, n (%)	49 (17.8)	12 (9.8)	37 (24.0)	0.004
Cannabis, n (%)	43 (15.6)	21 (17.2)	22 (14.3)	0.618
Antipsychotics, n (%)	40 (14.5)	6 (4.9)	34 (22.1)	<0.001
Lithium, n (%)	14 (5.1)	0	14 (9.1)	0.002
Anticonvulsants, n (%)	12 (4.3)	1 (0.8)	11 (7.1)	0.024
Antidepressants, n (%)	11 (4.0)	3 (2.5)	8 (5.2)	0.399
Recreational xenobiotics, n (%)	11 (4.0)	3 (2.5)	8 (5.2)	0.399
Other xenobiotics[b], n (%)	44 (15.9)	17 (13.9)	27 (17.5)	0.519
Other than xenobiotic[c], n (%)	4 (1.4)	1 (0.8)	3 (1.9)	0.786
Unknown xenobiotic, n (%)	2	0	2	0.583
Association of xenobiotics, n (%)	64 (23.2)	16 (13.1)	48 (31.2)	0.001
Neurological signs and symptoms				
Altered consciousness, n (%)	205 (74.3)	91 (74.6)	114 (74.0)	1.000
Neuropsychiatric symptoms[d], n (%)	41 (14.9)	17 (13.9)	24 (15.6)	0.832
Vomiting, n (%)	26 (9.4)	15 (12.3)	11 (7.1)	0.212
Vertigo[e], n (%)	14 (5.1)	11 (9.0)	3 (1.9)	0.017
Tremors, n (%)	13 (4.7)	4 (3.3)	9 (5.8)	0.476
Ocular motility disorder[f], n (%)	11 (4.0)	6 (4.9)	5 (3.2)	0.693
Abnormal muscular tone[g], n (%)	10 (3.6)	2 (1.6)	8 (5.2)	0.213
Headache, n (%)	10 (3.6)	4 (3.3)	6 (3.9)	1.000
Dyskinesia/dystonia, n (%)	7 (2.5)	0	7 (4.5)	0.046
Seizures, n (%)	7 (2.5)	0	7 (4.5)	0.046
Dysarthria, n (%)	5 (1.8)	0	5 (3.2)	0.120
Muscular symptoms[h], n (%)	4 (1.4)	3 (2.5)	1 (0.6)	0.458
Ataxia, n (%)	3 (1.1)	1 (0.8)	2 (1.3)	1.000
Nystagmus, n (%)	3 (1.1)	0	3 (1.9)	0.334
Trismus, n (%)	2 (0.7)	0	2 (1.3)	0.583
Miscellaneous[i], n (%)	10 (3.6)	4 (3.3)	6 (3.9)	1.000
Type of ingestion				
Ingested, n (%)	260 (94.2)	111 (91.0)	149 (96.8)	0.042
Inhaled, n (%)	12 (4.3)	10 (8.2)	2 (1.3)	0.005
Mucosal exposure, n (%)	2 (0.7)	0	2 (1.3)	0.310
Not available, n (%)	1	0	1	0.558
Reason for exposure				
Recreational use	125 (45.3)	82 (67.2)	43 (27.9)	<0.001
Suicidal intent	88 (31.9)	9 (7.4)	79 (51.3)	<0.001
Unintentional	45 (16.3)	20 (16.4)	25 (16.2)	0.972
Incorrect use	10 (3.6)	5 (4.1)	5 (3.2)	0.234
Adverse reaction	6 (2.2)	5 (4.1)	1 (0.6)	0.055
Other[j]	2 (7.0)	1 (0.8)	1 (0.6)	0.495
Home exposure to xenobiotic, n (%)	199 (72.1)	75 (61.5)	124 (80.5)	0.001
Treatment				
Intravenous fluids, n (%)	151 (54.7)	69 (56.6)	82 (53.2)	0.669
Activated charcoal, n (%)	51 (18.5)	8 (6.6)	43 (27.9)	<0.001
Gastric lavage, n (%)	24 (8.7)	0	24 (15.6)	<0.001
Antidote administration, n (%)	11 (4.0)	0	11 (7.1)	0.007
Oesophagogastroduodenoscopy, n (%)	8 (2.9)	0	8 (5.2)	0.028
Poisoning Severity Score				
Minor, n (%)	101 (36.6)	83 (68.0)	18 (11.7)	<0.001
Moderate, n (%)	152 (55.1)	38 (31.1)	114 (74.0)	<0.001
Severe, n (%)	23 (8.3)	1 (0.8)	22 (14.3)	<0.001
Neurological score in Poisoning Severity Score				
Minor, n (%)	157 (56.9)	87 (71.3)	70 (45.5)	<0.001
Moderate, n (%)	110 (39.9)	35 (28.7)	75 (48.7)	0.001
Severe, n (%)	9 (3.3)	0	9 (5.8)	0.005
Hospitalization	154 (100)	0	154 (100)	<0.001
Paediatric ward, n (%)	133 (48.2)	0	133 (86.4)	<0.001
Paediatric intensive care unit, n (%)	21 (7.6)	0	21 (13.6)	<0.001
Length of hospitalisation (days), median [IQR]	1.0 [0–4]	0	3 [2–6]	<0.001

[a]By ambulance or transfer from other hospitals.
[b]Including anti-inflammatory xenobiotics (n = 9), bronchodilators (n = 5), paracetamol (n = 6), antihypertensives (n = 4), gastrointestinal xenobiotics (n = 4), nicotine (n = 4), antitussives (n = 2), melatonin (n = 2), xenobiotics to treat migraine (n = 3), aminopyridine (n = 1), antibiotics (n = 1), antihistamines (n = 1), antidysrhythmics (n = 1), benserazide (n = 1), eltrombopag (n = 1), and xenobiotics to treat thyroid disease (n = 1). Figures may not add up to the sum indicated in this Table, since some of the xenobiotics were taken in association with others.
[c]Foodborne botulism (n = 1), dye (n = 1), insecticide (n = 1), and mushrooms (n = 1).
[d]Presenting symptoms included psychomotor agitation, hallucinations, acute depression, arousal, and drug-induced psychosis. Among patients with neuropsychiatric symptoms (14.9%), 37% had a pre-existing psychiatric disorder: conduct disorder (n = 8), mood disorder (n = 4), depression (n = 1), eating disorder (n = 1), or schizophrenia spectrum disorder (n = 1), which may have contributed to their neuropsychiatric presentation.
[e]Objective vertigo.
[f]Mydriasis (n = 5), miosis (n = 4), and anisocoria (n = 2).
[g]Hypertonia (n = 9) and hypotonia (n = 1).
[h]Pain (n = 2), fasciculations (n = 1), and muscle cramps (n = 1).
[i]Asthenia (n = 4), diplopia (n = 2), paraesthesia (n = 2), and sphincter disorders (n = 2).
[j]Ingestion of mushrooms (n = 1) and lithium (n = 1).

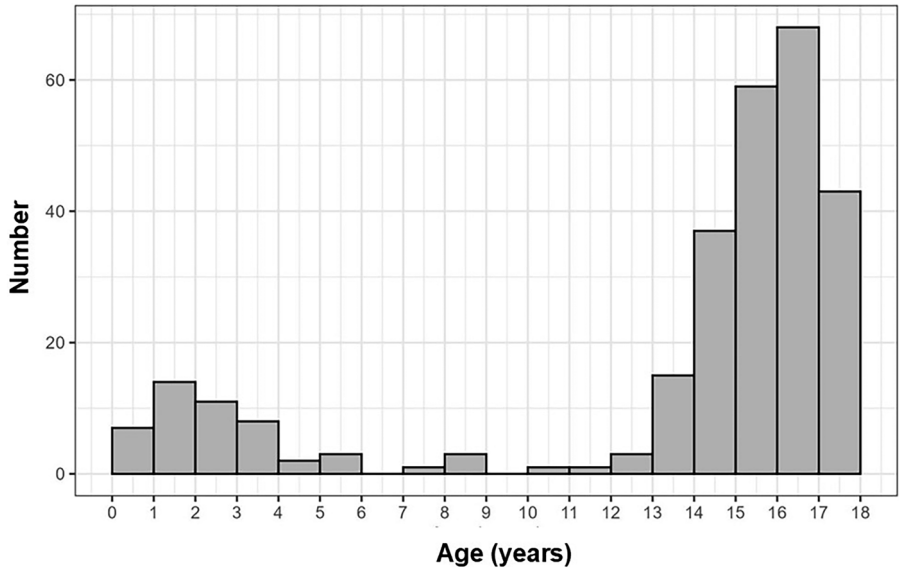

Figure 1. Age distribution of patients.

Discussion

Cases of gaseous xenobiotic inhalation, which are primarily associated with respiratory disorders and were widely reported by Lee et al. [3] and Lin et al. [7], were excluded from our analysis because of the neurological focus of our study. However, it is noteworthy that the rate of neurological presentations of poisoning increased from 15.1% to 55.2% when Lin et al. [7] compared children with ingestion of non-pharmaceutical and pharmaceutical xenobiotics, respectively. In our study, no neurological feature was significantly associated with admission, although vertigo was linked to discharge (OR: 0.05; P = 0.001). However, this result should be interpreted cautiously, given the small number of patients (n = 14) reporting this symptom. The intake of certain xenobiotics, such as lithium, antipsychotics and benzodiazepines, was also significantly associated with admission. This could be explained in the case of lithium, which has a narrow therapeutic range and carries a higher risk of toxicity. Loss of consciousness was the most prevalent neurological feature in our study, affecting 74.3% of patients. This observation aligns with the well-documented central nervous system depressant effects of several xenobiotics identified in our cohort. Ethanol, which accounted for 39.5% of ingestions, is known to produce dose-dependent sedation, stupor, and coma. Similarly, benzodiazepines (17.8% of cases) and antipsychotics (14.5% of cases) possess marked sedative and hypnotic properties that can precipitate loss of consciousness, particularly in overdose. In addition, lithium (5.1%) and anticonvulsants (4.3%) have a narrow therapeutic index, and their toxicity is frequently associated with clinically significant neurological depression. The high incidence of altered consciousness underscores the clinical importance of early recognition of these toxic exposures and the initiation of prompt supportive care to prevent further complications. In our study, consistent with previous reports [8,9], we observed a high utilization of gastric lavage and antidote administration in managing paediatric poisoning. Specifically, gastric lavage was performed in 24 patients (8.7% overall), with a higher rate among hospitalized patients (15.6%) compared to those discharged (0%). Antidotes were administered in 11 cases (4.0% overall; 7.1% among hospitalized patients). These findings underscore that, while these interventions are common treatment modalities for poisoning, their application can vary significantly depending on the type of ingested xenobiotic, local clinical expertise, and the absence of standardized treatment guidelines.

The age and sex distribution of our study sample aligns with current literature, showing that younger males and older females are more likely to present with neurological signs or symptoms of poisoning [1,2,12,13]. A lower median age was observed by Lee et al. [3] in 590 cases of paediatric poisoning cared for in an emergency department. In the study sample, children less than 5 years old were the most represented class (71.5%), with a slight male predominance (52.3%). A similar age distribution was found in other older studies, where unintentional poisoning was reported as the most common cause of paediatric poisoning [4–6]. However, it is important to note that these studies were conducted in geographically diverse regions, potentially affecting the generalisability of their results. Consistent with our findings, most children in this age group were males (52.3%). However,

Table 2. Comparison of patients according to age cut-off of 10 years.

	<10 years (*n* = 49)	≥10 years (*n* = 227)	*P* value
Age (years), median [IQR]	2.26 [1.33–3.55]	15.93 [15.02–16.79]	<0.001
Females, *n* (%)	21 (42.9)	142 (62.6)	0.017
Emergency access[a], *n* (%)	16 (32.7)	171 (75.3)	<0.001
Co-morbidities, *n* (%)	5 (10.2)	109 (48.0)	<0.001
Psychiatric co-morbidity, *n* (%)	2 (4.1)	93 (41.0)	<0.001
Xenobiotics			
Ethanol, *n* (%)	0	109 (48.0)	<0.001
Benzodiazepines, *n* (%)	8 (16.3)	41 (18.1)	0.935
Cannabis, *n* (%)	11 (22.4)	32 (14.1)	0.213
Antipsychotics, *n* (%)	3 (6.1)	37 (16.3)	0.107
Lithium, *n* (%)	0	14 (6.2)	0.154
Anticonvulsants, *n* (%)	3 (6.1)	9 (4.0)	0.775
Antidepressants, *n* (%)	2 (4.1)	9 (4.0)	1.000
Recreational xenobiotics, *n* (%)	1 (2.0)	10 (4.4)	0.715
Other xenobiotics[b], *n* (%)	17 (34.7)	27 (11.9)	<0.001
Other than xenobiotic[c], *n* (%)	2 (4.1)	2 (0.9)	0.298
Unknown xenobiotic, *n* (%)	1	1	0.788
Association of xenobiotics, *n* (%)	3 (6.1)	61 (26.9)	0.003
Neurological signs and symptoms			
Altered consciousness, *n* (%)	31 (63.3)	174 (76.7)	0.078
Neuropsychiatric symptoms[d], *n* (%)	4 (8.2)	37 (16.3)	0.218
Vomiting, *n* (%)	1 (2.0)	25 (11.0)	0.093
Vertigo[e], *n* (%)	5 (10.2)	9 (4.0)	0.148
Tremors, *n* (%)	5 (10.2)	8 (3.5)	0.103
Ocular motility disorder[f], *n* (%)	4 (8.2)	7 (3.1)	0.213
Abnormal muscular tone[g], *n* (%)	6 (12.2)	4 (1.8)	0.002
Headache, *n* (%)	1 (2.0)	9 (4.0)	0.816
Dyskinesia/dystonia, *n* (%)	1 (2.0)	6 (2.6)	1.000
Seizures, *n* (%)	2 (4.1)	5 (2.2)	0.797
Dysarthria, *n* (%)	0	5 (2.2)	0.647
Muscular symptoms[h], *n* (%)	1 (2.0)	3 (1.3)	1.000
Ataxia, *n* (%)	2 (4.1)	1 (0.4)	0.142
Nystagmus, *n* (%)	0	3 (1.3)	0.960
Trismus, *n* (%)	1 (2.0)	1 (0.4)	0.788
Miscellaneous[i], *n* (%)	0	10 (4.4)	0.282
Type of ingestion			
Ingested, *n* (%)	46 (93.9)	214 (94.3)	0.255
Inhaled, *n* (%)	3 (6.1)	9 (4.0)	0.216
Mucosal exposure, *n* (%)	0	2 (0.9)	0.676
Not available, *n* (%)	0	1	0.822
Reason for exposure			
Recreational use, *n* (%)	0	125 (55.1)	<0.001
Suicidal intent, *n* (%)	0	88 (38.8)	<0.001
Unintentional, *n* (%)	40 (81.6)	5 (2.2)	<0.001
Incorrect use, *n* (%)	6 (12.2)	4 (1.8)	0.003
Adverse reaction, *n* (%)	3 (6.1)	3 (1.3)	0.061
Other[j], *n* (%)	0	2 (0.9)	0.676
Home exposure to xenobiotic, *n* (%)	42 (85.7)	157 (69.2)	0.030
Treatment			
Intravenous fluids, *n* (%)	18 (36.7)	133 (58.6)	0.009
Activated charcoal, *n* (%)	11 (22.4)	40 (17.6)	0.557
Gastric lavage, *n* (%)	2 (4.1)	22 (9.7)	0.325
Antidote administration, *n* (%)	0	11 (4.8)	0.242
Oesophagogastroduodenoscopy, *n* (%)	0	8 (3.5)	0.388
Poisoning Severity Score			
Minor, *n* (%)	23 (46.9)	78 (34.4)	0.097
Moderate, *n* (%)	21 (42.9)	131 (57.7)	0.058
Severe, *n* (%)	5 (10.2)	18 (7.9)	0.183
Neurological score in Poisoning Severity Score			
Minor, *n* (%)	26 (53.1)	131 (57.7)	0.551
Moderate, *n* (%)	20 (40.8)	90 (39.6)	0.880
Severe, *n* (%)	3 (6.1)	6 (2.6)	0.146
Hospitalization, *n* (%)	26 (53.1)	128 (56.4)	0.790
Paediatric ward, *n* (%)	21 (42.9)	112 (49.3)	0.410
Paediatric intensive care unit, *n* (%)	5 (10.2)	16 (7.0)	0.162
Length of hospitalization (days), median [IQR]	1 [0–2]	1 [0–4]	0.077

[a]By ambulance or transfer from other hospitals.
[b]Including anti-inflammatory xenobiotics (*n* = 9), bronchodilators (*n* = 5), paracetamol (*n* = 6), antihypertensives (*n* = 4), gastrointestinal xenobiotics (*n* = 4), nicotine (*n* = 4), antitussives (*n* = 2), melatonin (*n* = 2), xenobiotics to treat migraine (*n* = 3), aminopyridine (*n* = 1), antibiotics (*n* = 1), antihistamines (*n* = 1), antidysrhythmics (*n* = 1), benserazide (*n* = 1), eltrombopag (*n* = 1), and xenobiotics to treat thyroid disease (*n* = 1). Numbers may not add up to the sum indicated in this Table, since some of the xenobiotics were taken in association with others.
[c]Foodborne botulism (*n* = 1), dye (*n* = 1), insecticide (*n* = 1), and mushrooms (*n* = 1).
[d]Presenting symptoms included psychomotor agitation, hallucinations, acute depression, arousal, and drug-induced psychosis. Among patients with neuropsychiatric symptoms (14.9%), 37% had a pre-existing psychiatric disorder – conduct disorder (*n* = 8), mood disorder (*n* = 4), depression (*n* = 1), eating disorder (*n* = 1), or schizophrenia spectrum disorder (*n* = 1), which may have contributed to their neuropsychiatric presentation.
[e]Objective vertigo.
[f]Mydriasis (*n* = 5), miosis (*n* = 4), and anisocoria (*n* = 2).
[g]Hypertonia (*n* = 9) and hypotonia (*n* = 1).
[h]Pain (*n* = 2), fasciculations (*n* = 1), and muscle cramps (*n* = 1).
[i]Asthenia (*n* = 4), diplopia (*n* = 2), paraesthesia (*n* = 2), and sphincter disorders (*n* = 2).
[j]Ingestion of mushrooms (*n* = 1) and lithium (*n* = 1).

Table 3. Comparison of patients according to hospitalization (age <10 years).

	Discharged from the emergency department (n = 122)	Hospitalized (n = 26)	P value
Age (years), median [IQR]	2.45 [1.29–3.71]	2.15 [1.45–3.36]	0.841
Females, n (%)	11 (47.8)	10 (38.5)	0.710
Emergency access[a], n (%)	3 (13.0)	13 (50.0)	0.014
Co-morbidities, n (%)	1 (4.3)	4 (15.4)	0.423
Psychiatric co-morbidity, n (%)	0	2 (7.7)	0.526
Xenobiotics			
Ethanol, n (%)	0	0	–
Benzodiazepines, n (%)	5 (21.7)	3 (11.5)	0.564
Cannabis, n (%)	2 (8.7)	9 (34.6)	0.068
Antipsychotics, n (%)	0	3 (11.5)	0.278
Lithium, n (%)	0	0	–
Anticonvulsants, n (%)	0	3 (11.5)	0.278
Antidepressants, n (%)	2 (8.7)	0	0.417
Recreational xenobiotics, n (%)	0	1 (3.8)	1.000
Other xenobiotics[b], n (%)	13 (56.5)	4 (15.4)	0.007
Other than xenobiotic[c], n (%)	0	2 (7.7)	0.526
Unknown xenobiotic, n (%)	0	1	1.000
Association of xenobiotics, n (%)	2 (8.7)	1 (3.8)	0.913
Neurological signs and symptoms			
Altered consciousness, n (%)	10 (43.5)	21 (80.8)	0.016
Neuropsychiatric symptoms[d], n (%)	2 (8.7)	2 (7.7)	1.000
Vomiting, n (%)	1 (4.3)	0	0.951
Vertigo[e], n (%)	5 (21.7)	0	0.042
Tremors, n (%)	3 (13.0)	2 (7.7)	0.885
Ocular motility disorder[f], n (%)	4 (17.4)	0	0.090
Abnormal muscular tone[g], n (%)	1 (4.3)	5 (19.2)	0.250
Headache, n (%)	1 (4.3)	0	0.951
Dyskinesia/dystonia, n (%)	0	1 (3.8)	1.000
Seizures, n (%)	0	2 (7.7)	0.526
Dysarthria, n (%)	0	0	–
Muscular symptoms[h], n (%)	1 (4.3)	0	0.951
Ataxia, n (%)	1 (4.3)	1 (3.8)	1.000
Nystagmus, n (%)	0	0	–
Trismus, n (%)	0	1 (3.8)	1.000
Miscellaneous[i], n (%)	0	0	–
Type of ingestion			
Ingested, n (%)	20 (87.0)	26 (100)	0.096
Inhaled, n (%)	3 (13.0)	0	0.096
Reason for exposure			
Recreational use, n (%)	0	0	–
Suicidal intent, n (%)	0	0	–
Unintentional, n (%)	17 (73.9)	23 (88.5)	0.128
Incorrect use, n (%)	3 (13.0)	3 (11.5)	0.329
Adverse reaction, n (%)	3 (13.0)	0	0.096
Other[j], n (%)	0	0	–
Home exposure to xenobiotic, n (%)	22 (95.7)	20 (76.9)	0.144
Treatment			
Intravenous fluids, n (%)	4 (17.4)	14 (53.8)	0.019
Activated charcoal, n (%)	4 (17.4)	7 (26.9)	0.649
Gastric lavage, n (%)	0	2 (7.7)	0.526
Antidote administration, n (%)	0	0	–
Oesophagogastroduodenoscopy, n (%)	0	0	–
Poisoning Severity Score			
Minor, n (%)	19 (82.6)	4 (15.4)	<0.001
Moderate, n (%)	4 (17.4)	17 (65.4)	0.001
Severe, n (%)	0	5 (19.2)	0.034
Neurological score in Poisoning Severity Score			
Minor, n (%)	20 (87.0)	6 (23.1)	<0.001
Moderate, n (%)	3 (13.0)	17 (65.4)	<0.001
Severe, n (%)	0	3 (11.5)	0.141
Hospitalization, n (%)	0	26 (100)	
Paediatric ward, n (%)	0	21 (80.8)	<0.001
Paediatric intensive care unit, n (%)	0	5 (19.2)	0.034
Length of hospitalization (days), median [IQR]	0 [0–0.5]	2.00 [1.00–2.75]	<0.001

[a]By ambulance or transfer from other hospitals.
[b]Including anti-inflammatory xenobiotics (n = 9), bronchodilators (n = 5), paracetamol (n = 6), antihypertensives (n = 4), gastrointestinal xenobiotics (n = 4), nicotine (n = 4), antitussives (n = 2), melatonin (n = 2), xenobiotics to treat migraine (n = 3), aminopyridine (n = 1), antibiotics (n = 1), antihistamines (n = 1), antidysrhythmics (n = 1), benserazide (n = 1), eltrombopag (n = 1), and xenobiotics for treating thyroid disease (n = 1). Numbers may not add up to the sum indicated in this Table, since some of the xenobiotics were taken in association with others.
[c]Foodborne botulism (n = 1), dye (n = 1), insecticide (n = 1), and mushrooms (n = 1).
[d]Presenting symptoms included psychomotor agitation, hallucinations, acute depression, arousal, and drug-induced psychosis. Among patients with neuropsychiatric symptoms (14.9%), 37% had a pre-existing psychiatric disorder – conduct disorder (n = 8), mood disorder (n = 4), depression (n = 1), eating disorder (n = 1), or schizophrenia spectrum disorder (n = 1), which may have contributed to their neuropsychiatric presentation.
[e]Objective vertigo.
[f]Mydriasis (n = 5), miosis (n = 4), and anisocoria (n = 2).
[g]Hypertonia (n = 9) and hypotonia (n = 1).
[h]Pain (n = 2), fasciculations (n = 1), and muscle cramps (n = 1).
[i]Asthenia (n = 4), diplopia (n = 2), paraesthesia (n = 2), and sphincter disorders (n = 2).

Table 4. Comparison of patients according to hospitalization (age ≥10 years).

	Discharged from the emergency department (n = 99)	Hospitalized (n = 128)	P value
Age (years), median [IQR]	16.01 [15.26–16.74]	15.88 [14.97–16.86]	0.972
Females, n (%)	52 (52.5)	90 (70.3)	0.009
Emergency access[a], n (%)	76 (76.8)	95 (74.2)	0.774
Co-morbidities, n (%)	31 (31.3)	78 (60.9)	<0.001
Psychiatric co-morbidity, n (%)	21 (21.2)	72 (56.2)	<0.001
Xenobiotics			
Ethanol, n (%)	71 (71.7)	38 (29.7)	<0.001
Benzodiazepines, n (%)	7 (7.1)	34 (26.6)	<0.001
Cannabis, n (%)	19 (19.2)	13 (10.2)	0.081
Antipsychotics, n (%)	6 (6.1)	31 (24.2)	<0.001
Lithium, n (%)	0	14 (10.9)	0.002
Anticonvulsants, n (%)	1 (1.0)	8 (6.2)	0.096
Antidepressants, n (%)	1 (1.0)	8 (6.2)	0.096
Recreational xenobiotics, n (%)	3 (3.0)	7 (5.5)	0.574
Other xenobiotics[b], n (%)	4 (4.0)	23 (18.0)	0.003
Other than xenobiotic[c], n (%)	1 (1.0)	1 (0.8)	1.000
Unknown xenobiotic, n (%)	0	1	1.000
Association of xenobiotics, n (%)	14 (14.1)	47 (36.7)	<0.001
Neurological signs and symptoms			
Altered consciousness, n (%)	81 (81.8)	93 (72.7)	0.144
Neuropsychiatric symptoms[d], n (%)	15 (15.2)	22 (17.2)	0.818
Vomiting, n (%)	14 (14.1)	11 (8.6)	0.267
Vertigo[e], n (%)	6 (6.1)	3 (2.3)	0.280
Tremors, n (%)	1 (1.0)	7 (5.5)	0.149
Ocular motility disorder[f], n (%)	2 (2.0)	5 (3.9)	0.669
Abnormal muscular tone[g], n (%)	1 (1.0)	3 (2.3)	0.804
Headache, n (%)	3 (3.0)	6 (4.7)	0.771
Dyskinesia/dystonia, n (%)	0	6 (4.7)	0.077
Seizures, n (%)	0	5 (3.9)	0.125
Dysarthria, n (%)	0	5 (3.9)	0.125
Muscular symptoms[h], n (%)	2 (2.0)	1 (0.8)	0.822
Ataxia, n (%)	0	1 (0.8)	1.000
Nystagmus, n (%)	0	3 (2.3)	0.343
Trismus, n (%)	0	1 (0.8)	1.000
Miscellaneous[i], n (%)	4 (4.0)	6 (4.7)	1.000
Type of ingestion			
Ingested, n (%)	91 (91.9)	123 (96.1)	0.179
Inhaled, n (%)	7 (7.1)	2 (1.6)	0.032
Mucosal exposure, n (%)	0	2 (1.6)	0.317
Not available, n (%)	1 (1.0)	0	0.436
Reason for exposure			
Recreational use, n (%)	82 (82.8)	43 (33.6)	<0.001
Suicidal intent, n (%)	9 (9.1)	79 (61.7)	<0.001
Unintentional, n (%)	3 (3.0)	2 (1.6)	0.265
Incorrect use, n (%)	2 (2.0)	2 (1.6)	0.366
Adverse reaction, n (%)	2 (2.0)	1 (0.8)	0.323
Other[j], n (%)	1 (1.0)	1 (0.8)	0.494
Home exposure to xenobiotic, n (%)	53 (53.5)	104 (81.2)	<0.001
Treatment			
Intravenous fluids, n (%)	65 (65.7)	68 (53.1)	0.078
Activated charcoal, n (%)	4 (4.0)	36 (28.1)	<0.001
Gastric lavage, n (%)	0	22 (17.2)	<0.001
Antidote administration, n (%)	0	11 (8.6)	0.007
Oesophagogastroduodenoscopy, n (%)	0	8 (6.2)	0.030
Poisoning Severity Score			
Minor, n (%)	64 (64.6)	14 (10.9)	<0.001
Moderate, n (%)	34 (34.3)	97 (75.8)	<0.001
Severe, n (%)	1 (1.0)	17 (13.3)	0.001
Neurological score in Poisoning Severity Score			
Minor, n (%)	67 (67.7)	64 (50.0)	0.008
Moderate, n (%)	32 (32.3)	58 (45.3)	0.047
Severe, n (%)	0	6 (4.7)	0.031
Hospitalization, n (%)	0		
Paediatric ward, n (%)	0	112 (87.5)	<0.001
Paediatric intensive care unit, n (%)	0	16 (12.5)	<0.001
Length of hospitalization (days), median [IQR]	0	4 [2–7]	<0.001

[a]By ambulance or transfer from other hospitals.
[b]Including anti-inflammatory xenobiotics (n = 9), bronchodilators (n = 5), paracetamol (n = 6), antihypertensives (n = 4), gastrointestinal xenobiotics (n = 4), nicotine (n = 4), antitussives (n = 2), melatonin (n = 2), xenobiotics to treat migraine (n = 3), aminopyridine (n = 1), antibiotics (n = 1), antihistamines (n = 1), antidysrhythmics (n = 1), benserazide (n = 1), eltrombopag (n = 1), and xenobiotics to treat thyroid disease (n = 1). Numbers may not add up to the sum indicated in this table, since some of the xenobiotics were given in association with others.
[c]Foodborne botulism (n = 1), dye (n = 1), insecticide (n = 1), and mushrooms (n = 1).
[d]Presenting symptoms included psychomotor agitation, hallucinations, acute depression, arousal, and drug-induced psychosis. Among patients with neuropsychiatric symptoms (14.9%), 37% had a pre-existing psychiatric disorder – conduct disorder (n = 8), mood disorder (n = 4), depression (n = 1), eating disorder (n = 1), or schizophrenia spectrum disorder (n = 1), which may have contributed to their neuropsychiatric presentation.
[e]Objective vertigo.
[f]Mydriasis (n = 5), miosis (n = 4), and anisocoria (n = 2).
[g]Hypertonia (n = 9) and hypotonia (n = 1).
[h]Pain (n = 2), fasciculations (n = 1), and muscle cramps (n = 1).
[i]Asthenia (n = 4), diplopia (n = 2), paraesthesia (n = 2), and sphincter disorders (n = 2).
[j]Ingestion of mushrooms (n = 1) and lithium (n = 1).

Table 5. Logistic regression models (outcome: admission).

	All ages[a]		
	Odds ratio	95% confidence intervals	*P* value
Age (years)	0.95	0.89–1.02	0.159
Sex (male)	0.88	0.49–1.59	0.678
Psychiatric comorbidity (yes)	1.16	0.50–2.70	0.722
Ethanol (yes)	1.52	0.67–3.46	0.314
Benzodiazepines (yes)	0.70	0.29–1.68	0.424
Antipsychotics (yes)	0.79	0.29–2.19	0.657
Anticonvulsants (yes)	1.68	0.54–5.22	0.367
Association of xenobiotics (yes)	5.52	0.52–58.14	0.154
Home exposure to xenobiotic (yes)	0.844	0.42–1.71	0.637
Vertigo (yes)	0.05	0.01–0.33	0.001
Suicidal intent (yes)	12.31	3.75–40.35	<0.001
Age <10 years[b]			
Sex (male)	0.84	0.22–3.28	0.806
Emergency access (yes)	8.39	1.65–42.58	0.010
Altered consciousness (yes)	6.94	1.55–31.080	0.011
Age ≥10 years[c]			
Sex (male)	0.76	0.39–1.46	0.413
Psychiatric comorbidity (yes)	0.89	0.36–2.15	0.789
Ethanol (yes)	0.72	0.30–1.73	0.461
Benzodiazepines (yes)	0.84	0.25–2.80	0.775
Antipsychotics (yes)	1.12	0.34–3.71	0.850
Association of xenobiotics (yes)	1.80	0.78–4.17	0.171
Home exposure to xenobiotic (yes)	1.20	0.60–2.57	0.642
Suicide (yes)	10.81	3.41–34.25	<0.001

[a]Lithium, dyskinesia/dystonia, and seizures were not included in the model due to complete separation.
[b]Vertigo was not included in the model due to complete separation.
[c]Lithium was not included in the model due to complete separation.

many other studies also describe female adolescents as the most involved in intentional xenobiotic poisoning [14–18]. Lin et al. [7,19] published two paediatric studies on this topic: one reporting poisoning by any xenobiotic [7] and another focusing only on pharmaceutical xenobiotics as the cause of poisoning [19]. A comparison between the two studies revealed an increase in both the median age (from 9.0 to 11.3 years) and the female-to-male ratio (from 0.97 to 1.23), favouring female adolescents. The authors also noted a higher risk of suicidal attempts in this subgroup. Similarly, Soave et al. [9] compared 436 children with intentional or unintentional ingestion of xenobiotics and found that males were more represented in the unintentional ingestion group. In our study, most patients ingested pharmaceutical xenobiotics (97.5%) primarily through ingestion (94.2%) at home (72.1%), consistent with most cited reports. Home exposure to the xenobiotic was more common in patients less than 10 years of age. In line with this, patients who were exposed to the xenobiotic at home were more likely to be hospitalized as they were younger and at a higher risk of poisoning [2]. Lin et al. [7] also noted greater exposure to pesticides and chemical xenobiotics in their sample, attributed to the rural settings of their study. In contrast, our study was conducted in a tertiary hospital serving a large urban area. The primary cause of poisoning in children less than 10 years of age was unintentional ingestion, which is a well-documented finding, although not typically associated with a higher likelihood of hospitalization [1,3]. The ingestion of "other" xenobiotics in younger patients hints at their unintentional intake. Some of these xenobiotics were nonsteroidal anti-inflammatory drugs, antihistamines, cardiovascular drugs, triptans, metoclopramide and melatonin, which are commonly used by adults or elders and might have been ingested because they were left within reach of children. Conversely, in patients aged 10 years or older, the primary reason for hospitalization was suicidal intent, necessitating a thorough evaluation of the underlying psychiatric condition. Ethanol was responsible for most exposures in this age group and typically required only brief observation rather than hospitalization [20–22]. Ethanol exposure has a low concordance with suicidal intent; suicidal attempts primarily involve ingestion of pharmaceutical xenobiotics [17,18,20–22].

The high rate of suicidal attempts in our cohort – all verified by trained paediatric psychiatrists – may be explained by two key factors. First, individuals attempting suicide are more likely to ingest higher doses of xenobiotics, increasing the likelihood of pronounced neurological features and thus their inclusion in our cohort. Second, the study period includes the COVID-19 pandemic, a time marked by heightened psychiatric distress and a documented rise in psychiatric co-morbidities, which may have contributed to the increased incidence of suicidal attempts [23,24].

This study has limitations due to its retrospective design and small sample size. Moreover, patients were evaluated by different neurologists without an assessment of inter-rater reliability, which could potentially introduce variability in the clinical evaluations. These aspects reduce the generalizability of our results. Additionally, some patients had pre-existing neuropsychiatric conditions that may have contributed to poisoning, particularly in cases of suicidal intent, and which could have influenced the severity of their features. All patients included in our database presented with neurological features attributable to poisoning, as evaluated by experienced paediatric toxicologists. However, we found that among patients hospitalized with suicidal intent, 68.4% were admitted explicitly for

poisoning. For the remaining cases, although their symptoms were indicative of poisoning, we could not definitively ascertain whether their admission was primarily due to suicidal intent, poisoning, or a combination of both.

Finally, the focus on the neurological presentation of acute paediatric poisoning has limited comparisons with other studies and the generalizability of our findings.

Conclusions

Altered consciousness is the most commonly reported feature of paediatric poisoning, though it is not directly linked to hospitalization. No single neurological feature can reliably guide the management of poisoning cases, making a case-by-case evaluation essential. However, non-neurological factors such as suicidal intent, mode of emergency access, and age play a crucial role in hospitalization decisions. This study highlights that suicidal intent and admission via emergency services are the strongest predictors of hospitalization, while ethanol ingestion is more frequently associated with discharge.

Author contributions

Marco Roversi, Marco Marano, Francesca Cautilli and Umberto Raucci contributed to the conception and design of the study. Giacomo Garone, Sebastian Cristaldi, Mara Pisani, and Alessandra Salvatori organised the database. Marco Roversi performed the statistical analysis. Marco Roversi, Marco Marano, Francesca Cautilli and Umberto Raucci wrote the first draft of the manuscript. Giacomo Garone, Sebastian Cristaldi, Mara Pisani, and Alessandra Salvatori wrote sections of the manuscript. Corrado Cecchetti, Alberto Spalice, Massimiliano Raponi, and Alberto Villani made substantial revisions. All authors contributed to the manuscript revision and approved the submitted version.

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Data availability statement

Research data will be made available upon reasonable request.

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