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ORIGINAL ARTICLE

Sex Differences in Pediatric Poisonings by Age Group: a Toxicology Investigators' Consortium (ToxIC) Analysis (2010–2016)

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Abstract

Objective To review pediatric poisonings evaluated at the bedside by medical toxicologists and reported in the ToxIC registry, by sex and age group.

Methods Pediatric poisoning cases age ≤18 years, reported between January 2010 and December 2016, were reviewed. Descriptive statistics were used to describe study variables by age group and sex.

Results A total of 12,699 cases were analyzed. There were 7517 females and 5182 males. Those < 2 years old represented 12.5% of the study group ($n = 1584$), 17.2% were 2–6 years old ($n = 2178$), 8.6% were 7–12 years old ($n = 1097$), and 61.7% were 13–18 years old ($n = 7840$). The most common primary reasons for encounter were intentional pharmaceutical with 4900 females and 1836 males; intentional non-pharmaceutical with 952 females and 1213 males; unintentional pharmaceutical with 539 females and 644 males; and unintentional non-pharmaceutical with 435 females and 593 males. Overall, pharmaceuticals were the most commonly involved agents, including analgesics (20.9% of cases) and antidepressants (11% of cases): 27.8% of females and 10.7% of males were reportedly exposed to an analgesic.13.7% of females and 7.0% of males were reportedly exposed to an antidepressant. Among 1584 cases under 2 years, there were 747 females and 837 males; among 2178 cases aged 2–6 years, there were 954 females and 1224 males; among 1097 cases aged 7–12 years, there were 555 females and 542 males; and among 7840 cases aged 13–18 years, there were 5261 females and 2579 males. Death was reported in 0.7% of the cases: 20 females and 18 males. 6.1% of cases were managed with intubation: 421 females and 351 males.

Conclusions Sex-based characteristics of poisonings varied by age group among pediatric poisoning presentations reported to the ToxIC registry and further research is needed to determine implications for education and prevention efforts.

Keywords Pediatrics · Medical toxicology · Poisonings · Sex differences

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Introduction

Poisoning is a continued cause of morbidity and mortality in the pediatric population [1, 2]. Children younger than 20 represented close to 60% of all exposures reported to the National Poison Data System (NPDS) in 2017, and analgesics exposure was the most common cause of mortality due to poisoning in children < 5 years old [3]. The pediatric population is especially vulnerable to adverse drug reactions due to their unique physiological profile, such as their lower muscle mass and subsequently less gluconeogenic precursors, leading to increased risk of hypoglycemia [2, 4]. Even in low acuity cases, pediatric pharmaceutical ingestions lead to hospital admissions and cause significant healthcare cost burden [5, 6]. The rise in unintentional pediatric poisonings has been linked to increased adult prescription use, especially of opioid, medication for addiction treatment, attention deficit hyperactivity disorder (ADHD), cardiovascular, and sedative hypnotic agents [1, 6–9].

Understanding the epidemiology of pediatric poisonings is important to develop more targeted interventions. Underlying causes of increasing reports of adolescent suicide attempts, particularly involving analgesics, psychotropic medications, and ADHD medications, are not well understood, but may be correlated with adolescent risky behavior, increased information sharing, and self- medication practices [10–12].

Current literature shows sex-based differences in risk behaviors and mental health diagnoses among adolescents, which may be due to exploration of gender and societal norms during puberty [13]. Boys are more prone to substance use disorders and self-medication, while girls are more at risk for suicide attempts [12, 13]. Previous research on sex differences in pharmaceutical ingestions has demonstrated sex-based differences in drug metabolism, and that females experience more adverse drug reactions, which may be due to lesser representation in clinical trials and subsequent lack of sex-specific dosing regimens [14, 15]. Examining sex differences, by age group, in a pediatric population may reveal how sex and age interact to modulate risk factors, clinical features, and treatment of poisonings. In this study, we set out to evaluate sex-based characteristics by age group in cases of pediatric poisonings that were evaluated by a medical toxicologist and submitted to the ToxIC (Toxicology Investigator's Consortium) registry.

Patients and Methods

The ToxIC registry was established by the American College of Medical Toxicology in 2010 to create a central, de-identified database of patients seen by medical toxicologists in both inpatient and outpatient settings [16]. With over 50 participating facilities from the USA, Canada, Israel, and Saudi Arabia, the database captures more than 50,000 cases of toxicological exposures [16]. After consultation, medical toxicologists voluntarily complete forms, including information such as age and sex demographics, setting and reason for encounter (e.g., intentional and nonintentional exposures), toxicological agent, symptoms, and clinical interventions.

Cases of pediatric patients that were ≤ 18 years of age with known toxicological exposures from January 2010 through December 2016 were included in the study sample and analyzed. For consistency, standard categories for age and reason for encounter utilized in the ToxIC case submission system were also used in this study.

ToxIC defines "intentional pharmaceutical" as "intended use of approved medication for any purpose including self-harm, misuse/abuse, therapeutic use, or unknown." Subcategories of intentional pharmaceutical use are also defined as follows: "attempt at self-harm"; "misuse/abuse"; "therapeutic use"; and "unknown." "Attempt at self-harm" is further differentiated as either "suicide attempt," where there is "at least some intent to die," "no suicidal attempt," where there "no intent to die, behavior for other reason such as to relieve stress," or "suicidal intent unknown," where "intent to die is unknown and cannot be inferred." "Misuse/abuse" is defined as "no attempt at self-harm." When selecting "misuse/abuse" as reason for encounter, the toxicologist can then select one or more of the following subcategories: "use of a prescription medication without a valid prescription"; "taking any prescription medication in doses greater than prescribed"; "taking any over the counter medication in doses higher than labeled"; "taking excess doses or using another's medication for medical reasons (e.g., to treat a pain exacerbation)"; "taking a medication in an attempt to illicit a pleasurable sensation (e.g., to get "high")"; or "taking the medication in an attempt to avoid withdrawal." "Intentional non-pharmaceutical" as reason for exposure can also be similarly further defined, with one additional category: "drug concealment," defined as "conceal drug with intent to avoid law enforcement." Cases were excluded from the analysis if age or primary reason for encounter were missing, or if the toxicologist indicated that the consult was not related to a toxicological exposure. Demographic data of race, ethnicity, and pregnancy status were queried and reported as relative frequencies based on sex. Frequencies were categorized, and definitions used, based on the ToxIC Registry Data Sheet. Descriptive statistics (frequencies and percentages) were generated to summarize the reason for the encounter, exposure agent, route of administration, vital sign abnormalities, complications, and interventions performed by age group and by sex. When reporting descriptive statistics, any cases with "missing" or "N/A" were not included, but any cases with "unknown/uncertain" were still included. The study was presented to the lead author's Institutional Review Board; it was reviewed and assigned a determination of Not Human Research, given that the study

design involved analysis of an existing database housing de-identified data.

Results

From a total of 51,440 cases, 12,699 cases were analyzed (flow diagram, Fig. 1). There were 7517 females (59.2% of all cases) and 5182 males (40.8% of all cases). Those under 2 years old represented 12.5% of the study group ($n = 1584$): 17.2% were 2–6 years old ($n = 2178$), 8.6% were 7–12 years old ($n = 1097$), and 61.7% were 13–18 years old ($n = 7840$). Among 1584 cases under 2 years, there were 747 females (47.2% of cases < 2 years) and 837 males (52.8% of cases < 2 years). Among 2178 cases aged 2–6 years, there were 954 females (43.8% of cases 2–6 years) and 1224 males (56.2% of cases 2–6 years). Among 1097 cases aged 7–12 years, there were 555 females (50.6% of cases 7–12 years) and 542 males (49.4% of cases 7–12 years). Among 7840 cases aged 13–18 years, there were 5261 females (67.1% of cases 13–18 years) and 2579 males (32.9% of cases 13–18 years). For all ages taken together, the most common primary reason for a pediatric toxicology consult was for reported intentional pharmaceutical exposure (6736/12,699 or 53.0% of all cases), with females representing (4900/6736) 72.7% of those cases. The second most common primary reason for consult was intentional non-pharmaceutical (2165/12,699 or 17% of all cases) with males representing (1213/2165) 56.0% of those cases. Further demographics for all cases and by age group are described in Tables 1, 2, 3, 4, and 5.

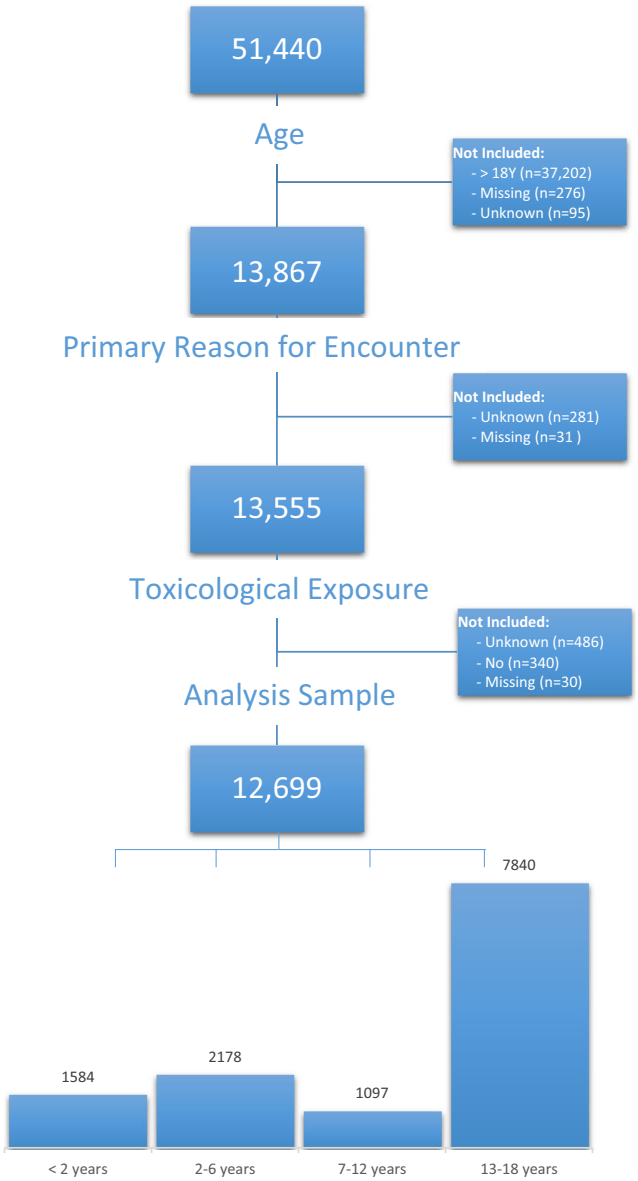

Fig. 1 Flow diagram for pediatric poisonings reported to the Toxicology Investigators' Consortium 2010–2016. Unknown data—indicated by medical toxicologist as "unknown"; Missing data—data not reported by the medical toxicologist

When analyzing all pediatric cases by sex, cases involving intentional pharmaceutical use as reason for the consult represented 65.2% of all female cases (4900/7517) and 35.4% of all male cases (1836/5182). Intentional use of non-pharmaceuticals (defined by the consortium as the "use of a substance other than an approved medications for any purpose") was found in 12.7% of all female cases (952/7517) and in 23.4% of all males cases (1213/5182). Unintentional use of pharmaceuticals and non-pharmaceuticals combined was found in 23.9% of all male cases (1237/5182) and 13.0% of all female cases (974/7517). Envenomations (snake, spider, scorpion, other) were reported in 7.7% of all male cases (399/5182) and 4.3% of all female cases (322/7157).

Detailed toxicological exposure data by age group and by sex are reported in Tables 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15.

When analyzing all pediatric cases by age group, among 1584 cases for patients with age less than 2 years (747 females and 837 males), the most common reported reason for consult was intentional non-pharmaceutical exposure (487/1584 or 30.7% of cases) with females representing (247/487) 50.7% of these cases. The most common agent involved among all reported exposures in this age group was cardiovascular medications (188/1522 or 12.4% of cases), with females representing (101/188) 53.7% of those cases.

Among 2178 cases for patients with age 2–6 years (954 females and 1224 males), the most common reported reason for consult was intentional non-pharmaceutical exposure (718/2178 or 33% of cases) with males representing (396/718) 55.2% of these cases. The most common agent involved among all reported exposures in this age group was cardiovascular medications (288/2091 or 13.8% of cases) with males representing (172/288) 59.7% of those cases.

Among 1097 cases for patients with age 7–12 years (555 females and 542 males), the most common reason for consult was intentional pharmaceutical (390/1097 or 35.6% of cases), with females representing (266/390) 68.2% of these cases.

Table 1 Demographics for pediatric poisonings reported to the Toxicology Investigators' Consortium 2010–2016

Variable	Total *N*	Entire sample *N* = 12,699 (%)	Female *N* = 7517 (%)	Male *N* = 5182 (%)
Age	12,699			
< 2 years		1584 (12.5)	747 (9.9)	837 (16.2)
2–6 years		2178 (17.2)	954 (12.7)	1224 (23.6)
7–12 years		1097 (8.6)	555 (7.4)	542 (10.5)
13–18 years		7840 (61.7)	5261 (70)	2579 (49.8)
Pregnancy status	7517			
Pregnant		40 (0.5)	40 (0.5)	-
Not pregnant		7477 (99.5)	7477 (99.5)	-
Race	8312			
American Indian/Alaska Native		73 (0.9)	34 (0.7)	39 (1.2)
Asian		151 (1.8)	92 (1.9)	59 (1.7)
Australian Aboriginal		0	0	0
Black/African		1058 (12.7)	578 (11.7)	480 (14.2)
Caucasian		4605 (55.4)	2759 (56)	1846 (54.5)
Native Hawaiian or Pacific Islander		12 (0.1)	5 (0.1)	7 (0.2)
Mixed		142 (1.7)	85 (1.7)	57 (1.7)
Other		441 (5.3)	242 (4.9)	199 (5.9)
Unknown/uncertain		1826 (22)	1129 (22.9)	697 (20.6)
Multiple races		4 (0.05)	3 (0.06)	1 (0.03)
Hispanic/Latino	5429			
Yes		763 (14.1)	472 (14)	291 (14.1)
No		3238 (59.6)	1992 (59.1)	1246 (60.5)
Unknown		1428 (26.3)	904 (26.8)	524 (25.4)

Mixed race indicates toxicologist selected "mixed race" in demographics data for the case

Multiple races indicate the toxicologist selected multiple race categories during data collection

Table 2 Demographics for pediatric cases < 2 years

Variable	Total *N*	Entire sample (*N* = 1584)	Female (*N* = 747)	Male (*N* = 837)
Race	980			
American Indian/Alaska Native		15 (1.5)	7 (1.5)	8 (1.6)
Asian		20 (2.0)	12 (2.6)	8 (1.6)
Australian Aboriginal		0	0	0
Black/African		152 (15.5)	72 (15.5)	80 (15.5)
Caucasian		486 (49.6)	229 (49.2)	257 (49.9)
Native Hawaiian or Pacific Islander		0	0	0
Mixed		24 (2.4)	12 (2.6)	12 (2.3)
Other		57 (5.8)	22 (4.7)	35 (6.8)
Unknown/uncertain		226 (23.1)	111 (23.9)	115 (22.3)
Multiple races		0	0	0
Hispanic/Latino	582			
Yes		92 (15.8)	41 (14.9)	51 (16.6)
No		322 (55.3)	157 (57.1)	165 (53.7)
Unknown		168 (28.9)	77 (28.0)	91 (29.6)

Mixed race indicates toxicologist selected "mixed race" in demographics data for the case

Multiple races indicate the toxicologist selected multiple race categories during data collection

Table 3 Demographics for pediatric cases 2–6 years

Variable	Total *N*	Entire sample (*N* = 2178)	Female (*N* = 954)	Male (*N* = 1224)
Race	1372			
American Indian/Alaska Native		9 (0.7)	3 (0.5)	6 (0.8)
Asian		26 (1.9)	14 (2.4)	12 (1.5)
Australian Aboriginal		0	0	0
Black/African		208 (15.2)	78 (13.2)	130 (16.7)
Caucasian		711 (51.8)	315 (53.2)	396 (50.8)
Native Hawaiian or Pacific Islander		1 (0.1)	1 (0.2)	0
Mixed		25 (1.8)	13 (2.2)	12 (1.5)
Other		82 (6.0)	35 (5.9)	47 (6.0)
Unknown/uncertain		309 (22.5)	133 (22.5)	176 (22.6)
Multiple races		1 (0.1)	0	1 (0.1)
Hispanic/Latino	781			
Yes		120 (15.4)	50 (15.2)	70 (15.5)
No		454 (58.1)	193 (58.5)	261 (57.9)
Unknown		207 (26.5)	87 (26.4)	120 (26.6)

Mixed race indicates toxicologist selected "mixed race" in demographics data for the case

Multiple races indicate the toxicologist selected multiple race categories during data collection

The most common pharmaceutical agent involved among all reported exposures in this age group was analgesics (97/1058 or 9.2% of cases) with females representing (85/97) 87.6% of those cases.

Among 7840 cases for patients age 13–18 years (5261 females and 2579 males), the most common reason for consult was intentional pharmaceutical (6204/7840 or 79.1% of cases), with females representing (4570/6204) 73.7% of these

Table 4 Demographics for pediatric cases 7–12 years

Variable	Total *N*	Entire sample (*N* = 1097)	Female (*N* = 555)	Male (*N* = 542)
Pregnancy status	555			
Pregnant		2 (0.4)	2 (0.4)	-
Not pregnant		553 (99.6)	553 (99.6)	-
Race	738			
American Indian/Alaska Native		10 (1.4)	6 (1.6)	4 (1.1)
Asian		10 (1.4)	3 (0.8)	7 (1.9)
Australian Aboriginal		0	0	0
Black/African		100 (13.6)	49 (13.2)	51 (13.9)
Caucasian		427 (57.9)	223 (60.1)	204 (55.6)
Native Hawaiian or Pacific Islander		1 (0.1)	0	1 (0.3)
Mixed		15 (2.0)	8 (2.2)	7 (1.9)
Other		31 (4.2)	9 (2.4)	22 (6.0)
Unknown/uncertain		144 (19.5)	73 (19.7)	71 (19.3)
Multiple races		0	0	0
Hispanic/Latino	507			
Yes		61 (12.0)	33 (12.0)	28 (12.0)
No		327 (64.5)	176 (64.2)	151 (64.8)
Unknown		119 (23.5)	65 (23.7)	54 (23.2)

Mixed race indicates toxicologist selected "mixed race" in demographics data for the case

Multiple races indicate the toxicologist selected multiple race categories during data collection

Table 5 Demographics for pediatric cases 13–18 years

Variable	Total *N*	Entire sample (*N* = 7840)	Female (*N* = 5261)	Male (*N* = 2579)
Pregnancy status	5261			
Pregnant		35 (0.7)	35 (0.7)	-
Not pregnant		5226 (99.3)	5226 (99.3)	-
Race	5222			
American Indian/Alaska Native		39 (0.7)	18 (0.5)	21 (1.2)
Asian		95 (1.8)	63 (1.8)	32 (1.9)
Australian Aboriginal		0	0	0
Black/African		598 (11.5)	379 (10.8)	219 (12.7)
Caucasian		2981 (57.1)	1992 (56.9)	989 (57.4)
Native Hawaiian or Pacific Islander		10 (0.2)	4 (0.1)	6 (0.3)
Mixed		78 (1.5)	52 (1.5)	26 (1.5)
Other		271 (5.2)	176 (5.0)	95 (5.5)
Unknown/uncertain		1147 (22.0)	812 (23.2)	335 (19.4)
Multiple races		3 (0.1)	3 (0.1)	0
Hispanic/Latino	3559			
Yes		490 (13.8)	348 (14.0)	142 (13.3)
No		2135 (60.0)	1466 (58.9)	669 (62.5)
Unknown		934 (26.2)	675 (27.1)	259 (24.2)

Mixed race indicates toxicologist selected "mixed race" in demographics data for the case

Multiple races indicate the toxicologist selected multiple race categories during data collection

cases. The most common pharmaceutical agent involved among all reported exposures in this age group was analgesics (2248/7630 or 29.5% of cases) with females representing (1842/2248) 81.9% of those cases.

Among 38 reported cases that died during their hospital stay, 7 were < 2 years of age (3 females, 4 males), 3 were age 2–6 years (1 female, 2 males), and 28 were age 13–18 (16 females, 12 males). In the age < 2 years decedents, reasons for encounter were 4 unintentional pharmaceutical, 1 intentional pharmaceutical, 1 intentional non-pharmaceutical, and 1 for interpretation of toxicology laboratory data. Among decedents aged 2–6 years, reasons for encounter included 1 for withdrawal, 1 for environmental evaluation, and 1 for "more than one reason." Among deaths in the age group 13–18, 19 were seen for intentional pharmaceutical, 4 for intentional non-pharmaceutical, 2 for interpretation of toxicology laboratory data, 2 for environmental evaluation, and 1 for organ system dysfunction.

Discussion

Pediatric cases queried from the ToxIC registry from 2010 to 2016 showed that more than half of the encounters were patients aged 13–18 and intentional pharmaceutical was the most common reported exposure. These findings suggest that this age group may be at increased risk of self-harm attempts through toxicological ingestions. Existing studies have also shown a rapid increase in intentional poisonings among adolescents in recent years, with drug overdoses and poisonings identified as the sixth highest cause of death in pediatrics in 2016 [17, 18]. Our results once again point to an urgent need for public health initiatives that identify and reduce adolescent poisonings, with a particular focus on self-harm attempts.

Given the common availability of pharmaceutical agents in home environments, as well as that an estimated 19.8% of children and adolescents are prescribed at least one medication, [19] prevention interventions, such as safer medication storage, safer pharmaceutical packaging, prescribing precautions, and prevention education may be important to reducing morbidity [20]. Among patients aged 7–12 years, intentional pharmaceutical exposures were most common, further suggesting that efforts may be needed to ensure medications are stored more safely in the household. Analgesics were the most common pharmaceutical agent among reported exposures in both the 7–12- and 13–18-year age groups, consistent with studies that have shown that over the counter products like analgesics are more likely to be stored improperly, thus potentially increasing access [1]. Existing literature suggests that analgesics are the most likely agent used in suicidal intent [18, 21]. Interestingly, analgesics are also the most common self-medication agent used by adolescents, due to perceived safety and widespread availability [12]. Together, these findings suggest that caregivers and adolescents may benefit from medication education specifically directed to analgesics, their storage, and their appropriate use.

Table 6 Toxicological exposure information for pediatric poisonings reported to the Toxicology Investigators' Consortium 2010–2016

Variable	Total *N*	Entire sample *N* = 12,699 (%)	Female *N* = 7517 (%)	Male *N* = 5182 (%)
Primary reason for encounter	12,699			
Intentional pharmaceutical		6736 (53)	4900 (65.2)	1836 (35.4)
Intentional non-pharmaceutical		2165 (17)	952 (12.7)	1213 (23.4)
Unintentional pharmaceutical		1183 (9.3)	539 (7.2)	644 (12.4)
Unintentional non-pharmaceutical		1028 (8.1)	435 (5.8)	593 (11.4)
Malicious/criminal		18 (0.1)	6 (0.1)	12 (0.2)
ETOH abuse		44 (0.3)	18 (0.2)	26 (0.5)
Withdrawal—ETOH		3 (0.02)	3 (0.04)	0
Withdrawal—opioids		10 (0.1)	5 (0.1)	5 (0.1)
Withdrawal—sedative-hypnotics		10 (0.1)	0	10 (0.2)
Withdrawal—cocaine/amphetamines		1 (0.01)	1 (0.01)	0
Withdrawal—other		12 (0.1)	2 (0.03)	10 (0.2)
Envenomation—snake		414 (3.3)	162 (2.2)	252 (4.9)
Envenomation—spider		108 (0.9)	62 (0.8)	46 (0.9)
Envenomation—scorpion		29 (0.2)	18 (0.2)	11 (0.2)
Envenomation—other		170 (1.3)	80 (1.1)	90 (1.7)
Marine/fish poisoning		2 (0.02)	1 (0.01)	1 (0.02)
Organ system dysfunction		112 (0.9)	51 (0.7)	61 (1.2)
Interpretation of toxicology lab data		74 (0.6)	40 (0.5)	34 (0.7)
Occupational evaluation		6 (0.05)	2 (0.03)	4 (0.08)
Environmental evaluation		156 (1.2)	70 (0.9)	86 (1.7)
Unknown		0	0	0
Surveillance		0	0	0
Adverse drug reaction		195 (1.5)	80 (1.1)	115 (2.2)
Medication error		41 (0.3)	22 (0.3)	19 (0.4)
Other		5 (0.04)	0	5 (0.1)
More than one reason		177 (1.4)	68 (0.9)	109 (2.1)
Single or multiple exposure?	12,699			
Single exposure		9158 (72.1)	5172 (68.8)	3986 (76.9)
Multiple exposure		3541 (27.9)	2345 (31.2)	1196 (23.1)
Agent #1 class	12,301			
Alcohol ethanol		173 (1.4)	72 (1.0)	101 (2.0)
Alcohol toxic		100 (0.8)	42 (0.6)	58 (1.2)
Amphetamine-like hallucinogen		5 (0.04)	3 (0.04)	2 (0.04)
Analgesic		2570 (20.9)	2037 (27.8)	533 (10.7)
Anesthetic		30 (0.2)	14 (0.2)	16 (0.3)
Anticholinergic/antihistamine		839 (6.8)	536 (7.3)	303 (6.1)
Anticoagulant		17 (0.1)	10 (0.1)	7 (0.1)
Anticonvulsant		392 (3.2)	243 (3.3)	149 (3.0)
Antidepressant		1349 (11)	1001 (13.7)	348 (7.0)
Antimicrobials		80 (0.7)	44 (0.6)	36 (0.7)
Antipsychotic		699 (5.7)	389 (5.3)	310 (6.2)
Cardiovascular		806 (6.6)	426 (5.8)	380 (7.6)
Caustic		135 (1.1)	62 (0.8)	73 (1.5)
Chelator		1 (0.01)	0	1 (0.02)
Chemotherapeutic and immune		47 (0.4)	26 (0.4)	21 (0.4)
Cholinergic/parasympathomimetic		0	0	0
Cough and cold		245 (2)	96 (1.3)	149 (3)
Diabetic med		228 (1.9)	135 (1.8)	93 (1.9)

Table 6 (continued)

Variable	Total *N*	Entire sample *N* = 12,699 (%)	Female *N* = 7517 (%)	Male *N* = 5182 (%)
Endocrine		38 (0.3)	26 (0.4)	12 (0.2)
Envenomation		690 (5.6)	302 (4.1)	388 (7.8)
Foreign objects		10 (0.1)	5 (0.1)	5 (0.1)
Fungicide		0	0	0
Gases/vapors/irritants/dust		157 (1.3)	76 (1)	81 (1.6)
GI		37 (0.3)	16 (0.2)	21 (0.4)
Herbals/dietary supps/vitamins		133 (1.1)	75 (1)	58 (1.2)
Herbicide		3 (0.02)	2 (0.03)	1 (0.02)
Household		272 (2.2)	119 (1.6)	153 (3.1)
Hydrocarbon		154 (1.3)	50 (0.7)	104 (2.1)
Insecticide		41 (0.3)	20 (0.3)	21 (0.4)
Lithium		122 (1)	77 (1.1)	45 (0.9)
Marine toxin		1 (0.01)	1 (0.01)	0
Metals		236 (1.9)	118 (1.6)	118 (2.4)
Opioid		565 (4.6)	291 (4)	274 (5.5)
Other non-pharmaceutical		31 (0.3)	10 (0.1)	21 (0.4)
Other pharmaceutical		37 (0.3)	25 (0.3)	12 (0.2)
Parkinson's med		7 (0.1)	5 (0.07)	2 (0.04)
Photosensitizing agents		3 (0.02)	3 (0.04)	0
Plants and fungi		94 (0.8)	39 (0.5)	55 (1.1)
Psychoactive		485 (3.9)	164 (2.2)	321 (6.4)
Pulmonary		15 (0.1)	11 (0.2)	4 (0.1)
Rodenticide		31 (0.3)	11 (0.2)	20 (0.4)
Sed-hypnotic/muscle relaxant		681 (5.5)	389 (5.3)	292 (5.9)
Sympathomimetic		601 (4.9)	276 (3.8)	325 (6.5)
WMD/NBC/riot		1 (0.01)	0	1 (0.02)
Unknown agent		140 (1.1)	71 (1)	69 (1.4)
Route of administration	7677			
Oral		6626 (86.3)	4253 (90)	2373 (80.4)
Inhalation		238 (3.1)	75 (1.6)	163 (5.5)
Parenteral		195 (2.5)	91 (1.9)	104 (3.5)
Intranasal		25 (0.3)	15 (0.3)	10 (0.3)
Dermal		216 (2.8)	98 (2.1)	118 (4)
Unknown		284 (3.7)	159 (3.4)	125 (4.2)
Rectal		2 (0.03)	1 (0.02)	1 (0.03)
Other		91 (1.2)	34 (0.7)	57 (1.9)
Type of exposure	9234			
Acute		8071 (87.4)	4986 (88.4)	3085 (85.9)
Chronic		337 (3.6)	153 (2.7)	184 (5.1)
Acute-on-chronic		674 (7.3)	426 (7.6)	248 (6.9)
Unknown		152 (1.6)	76 (1.3)	76 (2.1)

In both under 2-year and the 2–6-year age groups, cardiovascular medications were most commonly implicated in reported exposures. Prior studies of children presenting to emergency departments with poisoning by medications have implicated cardiovascular medications as a common reported exposure [1, 7]. Prior ToxIC registry analyses of pediatric exposures have also implicated cardiovascular medications as a common reported etiology of toxicity [22]. While NPDS studies most commonly report analgesics as the most common agent involved in pediatric poisonings [3], cases reported to ToxIC registry are potentially higher acuity cases seen by a toxicologist, and thus, medications with potential

Table 7 Toxicological exposure information for pediatric cases < 2 years

Variable	Total *N*	Entire sample (*N* = 1584)	Female (*N* = 747)	Male (*N* = 837)
Primary reason for encounter	1584			
Intentional pharmaceutical		43 (2.7)	25 (3.3)	18 (2.2)
Intentional non-pharmaceutical		487 (30.7)	247 (33.1)	240 (28.7)
Unintentional pharmaceutical		411 (25.9)	192 (25.7)	219 (26.2)
Unintentional non-pharmaceutical		462 (29.2)	194 (26.0)	268 (32.0)
Malicious/criminal		14 (0.9)	5 (0.7)	9 (1.1)
ETOH abuse		0	0	0
Withdrawal—ETOH		1 (0.1)	1 (0.1)	0
Withdrawal—opioids		2 (0.1)	2 (0.3)	0
Withdrawal—sedative-hypnotics		1 (0.1)	0	1 (0.1)
Withdrawal—cocaine/amphetamines		0	0	0
Withdrawal—other		1 (0.1)	0	1 (0.1)
Envenomation—snake		23 (1.5)	7 (0.9)	16 (1.9)
Envenomation—spider		8 (0.5)	4 (0.5)	4 (0.5)
Envenomation—scorpion		12 (0.8)	10 (1.3)	2 (0.2)
Envenomation—other		21 (1.3)	8 (1.1)	13 (1.6)
Marine/fish poisoning		1 (0.1)	1 (0.1)	0
Organ system dysfunction		18 (1.1)	7 (0.9)	11 (1.3)
Interpretation of toxicology lab data		28 (1.8)	19 (2.5)	9 (1.1)
Occupational evaluation		0	0	0
Environmental evaluation		21 (1.3)	11 (1.5)	10 (1.2)
Unknown		0	0	0
Surveillance		0	0	0
Adverse drug reaction		8 (0.5)	3 (0.4)	5 (0.6)
Medication error		8 (0.5)	5 (0.7)	3 (0.4)
Other		0	0	0
More than one reason		14 (0.9)	6 (0.8)	8 (1)
Single or multiple exposure?	1584			
Single exposure		1357 (85.7)	615 (82.3)	742 (88.6)
Multiple exposure		227 (14.3)	132 (17.7)	95 (11.4)
Agent #1 class	1522			
Alcohol ethanol		14 (0.9)	7 (1.0)	7 (0.9)
Alcohol toxic		33 (2.2)	11 (1.5)	22 (2.7)
Amphetamine-like hallucinogen		0	0	0
Analgesic		88 (5.8)	40 (5.6)	48 (6.0)
Anesthetic		8 (0.5)	2 (0.3)	6 (0.7)
Anticholinergic/antihistamine		34 (2.2)	19 (2.7)	15 (1.9)
Anticoagulant		4 (0.3)	2 (0.3)	2 (0.2)
Anticonvulsant		29 (1.9)	13 (1.8)	16 (2.0)
Antidepressant		53 (3.5)	28 (3.9)	25 (3.1)
Antimicrobials		16 (1.1)	6 (0.8)	10 (1.2)
Antipsychotic		52 (3.4)	24 (3.4)	28 (3.5)
Cardiovascular		188 (12.4)	101 (14.1)	87 (10.8)
Caustic		55 (3.6)	24 (3.4)	31 (3.8)
Chelator		0	0	0
Chemotherapeutic and immune		5 (0.3)	1 (0.1)	4 (0.5)
Cholinergic/parasympathomimetic		0	0	0
Cough and cold		8 (0.5)	4 (0.6)	4 (0.5)
Diabetic med		75 (4.9)	40 (5.6)	35 (4.3)

Table 7 (continued)

Variable	Total *N*	Entire sample (*N* = 1584)	Female (*N* = 747)	Male (*N* = 837)
Endocrine		6 (0.4)	4 (0.6)	2 (0.2)
Envenomation		59 (3.9)	25 (3.5)	34 (4.2)
Foreign objects		6 (0.4)	4 (0.6)	2 (0.2)
Fungicide		0	0	0
Gases/vapors/irritants/dust		14 (0.9)	6 (0.8)	8 (1.0)
GI		13 (0.9)	4 (0.6)	9 (1.1)
Herbals/dietary supps/vitamins		25 (1.6)	11 (1.5)	14 (1.7)
Herbicide		1 (0.1)	1 (0.1)	0
Household		134 (8.8)	56 (7.8)	78 (9.7)
Hydrocarbon		77 (5.1)	29 (4.1)	48 (6.0)
Insecticide		15 (1)	8 (1.1)	7 (0.9)
Lithium		1 (0.1)	0	1 (0.1)
Marine toxin		0	0	0
Metals		47 (3.1)	23 (3.2)	24 (3.0)
Opioid		147 (9.7)	79 (11.0)	68 (8.4)
Other non-pharmaceutical		14 (0.9)	3 (0.4)	11 (1.4)
Other pharmaceutical		10 (0.7)	5 (0.7)	5 (0.6)
Parkinson's med		2 (0.1)	1 (0.1)	1 (0.1)
Photosensitizing agents		0	0	0
Plants and fungi		18 (1.2)	14 (2.0)	4 (0.5)
Psychoactive		42 (2.8)	21 (2.9)	21 (2.6)
Pulmonary		3 (0.2)	1 (0.1)	2 (0.2)
Rodenticide		20 (1.3)	6 (0.8)	14 (1.7)
Sed-hypnotic/muscle relaxant		73 (4.8)	31 (4.3)	42 (5.2)
Sympathomimetic		112 (7.4)	49 (6.8)	63 (7.8)
WMD/NBC/riot		0	0	0
Unknown agent		21 (1.4)	13 (1.8)	8 (1.0)
Route of administration	887			
Oral		747 (84.2)	341 (83.0)	406 (85.3)
Inhalation		15 (1.7)	10 (2.4)	5 (1.1)
Parenteral		25 (2.8)	11 (2.7)	14 (2.9)
Intranasal		1 (0.1)	0	1 (0.2)
Dermal		22 (2.5)	9 (2.2)	13 (2.7)
Unknown		57 (6.4)	30 (7.3)	27 (5.7)
Rectal		1 (0.1)	1 (0.2)	0
Other		19 (2.1)	9 (2.2)	10 (2.1)
Type of exposure	1119			
Acute		1033 (92.3)	489 (93.7)	544 (91.1)
Chronic		41 (3.7)	18 (3.4)	23 (3.9)
Acute-on-chronic		14 (1.3)	4 (0.8)	10 (1.7)
Unknown		31 (2.8)	11 (2.1)	20 (3.4)

to cause more severe toxicity may be more commonly reported in ToxIC-based research.

Our results describe characteristics in toxicological consultations by sex. Our study case numbers by sex among patients with unintentional pharmaceutical and non-pharmaceutical exposures aged 2–6 years appear to align with the most recent NPDS data, which reported increased risk of pediatric exploratory ingestions among males [23], and prior studies that show that toddler males were more prone to accidental ingestions [24]. While the reasons are unclear, males may express more exploratory behavior that puts them at risk for encountering improperly stored pharmaceuticals. Our study finding that

Table 8 Toxicological exposure information for pediatric cases 2–6 years

Variable	Total *N*	Entire sample (*N* = 2178)	Female (*N* = 954)	Male (*N* = 1224)
Primary reason for encounter	2178			
Intentional pharmaceutical		99 (4.5)	39 (4.1)	60 (4.9)
Intentional non-pharmaceutical		718 (33.0)	322 (33.8)	396 (32.4)
Unintentional pharmaceutical		604 (27.7)	276 (28.9)	328 (26.8)
Unintentional non-pharmaceutical		404 (18.5)	166 (17.4)	238 (19.4)
Malicious/criminal		3 (0.1)	0	3 (0.2)
ETOH abuse		2 (0.1)	1 (0.1)	1 (0.1)
Withdrawal—ETOH		0	0	0
Withdrawal—opioids		0	0	0
Withdrawal—sedative-hypnotics		0	0	0
Withdrawal—cocaine/amphetamines		0	0	0
Withdrawal—other		3 (0.1)	1 (0.1)	2 (0.2)
Envenomation—snake		106 (4.9)	47 (4.9)	59 (4.8)
Envenomation—spider		23 (1.1)	10 (1.0)	13 (1.1)
Envenomation—scorpion		11 (0.5)	5 (0.5)	6 (0.5)
Envenomation—other		53 (2.4)	24 (2.5)	29 (2.4)
Marine/fish poisoning		0	0	0
Organ system dysfunction		17 (0.8)	8 (0.8)	9 (0.7)
Interpretation of toxicology lab data		18 (0.8)	6 (0.6)	12 (1.0)
Occupational evaluation		0	0	0
Environmental evaluation		47 (2.2)	20 (2.1)	27 (2.2)
Unknown		0	0	0
Surveillance		0	0	0
Adverse drug reaction		35 (1.6)	16 (1.7)	19 (1.6)
Medication error		9 (0.4)	5 (0.5)	4 (0.3)
Other		1 (0.05)	0	1 (0.1)
More than one reason		25 (1.1)	8 (0.8)	17 (1.4)
Single or multiple exposure?	2178			
Single exposure		1864 (85.6)	812 (85.1)	1052 (85.9)
Multiple exposure		314 (14.4)	142 (14.9)	172 (14.1)
Agent #1 class	2091			
Alcohol ethanol		12 (0.6)	7 (0.8)	5 (0.4)
Alcohol toxic		23 (1.1)	10 (1.1)	13 (1.1)
Amphetamine-like hallucinogen		0	0	0
Analgesic		137 (6.6)	70 (7.6)	67 (5.7)
Anesthetic		7 (0.3)	5 (0.5)	2 (0.2)
Anticholinergic/antihistamine		103 (4.9)	41 (4.5)	62 (5.3)
Anticoagulant		5 (0.2)	0	5 (0.4)
Anticonvulsant		53 (2.5)	24 (2.6)	29 (2.5)
Antidepressant		103 (4.9)	44 (4.8)	59 (5.0)
Antimicrobials		14 (0.7)	7 (0.8)	7 (0.6)
Antipsychotic		104 (5.0)	53 (5.8)	51 (4.4)
Cardiovascular		288 (13.8)	116 (12.6)	172 (14.7)
Caustic		42 (2.0)	18 (2.0)	24 (2.1)
Chelator		0	0	0
Chemotherapeutic and immune		20 (1.0)	10 (1.1)	10 (0.9)
Cholinergic/parasympathomimetic		0	0	0
Cough and cold		34 (1.6)	18 (2.0)	16 (1.4)
Diabetic med		82 (3.9)	43 (4.7)	39 (3.3)

Table 8 (continued)

Variable	Total *N*	Entire sample (*N* = 2178)	Female (*N* = 954)	Male (*N* = 1224)
Endocrine		18 (0.9)	12 (1.3)	6 (0.5)
Envenomation		185 (8.8)	78 (8.5)	107 (9.1)
Foreign objects		2 (0.1)	0	2 (0.2)
Fungicide		0	0	0
Gases/vapors/irritants/dust		36 (1.7)	15 (1.6)	21 (1.8)
GI		10 (0.5)	3 (0.3)	7 (0.6)
Herbals/dietary supps/vitamins		35 (1.7)	16 (1.7)	19 (1.6)
Herbicide		1 (0.05)	1 (0.1)	0
Household		80 (3.8)	27 (2.9)	53 (4.5)
Hydrocarbon		55 (2.6)	18 (2.0)	37 (3.2)
Insecticide		7 (0.3)	3 (0.3)	4 (0.3)
Lithium		2 (0.1)	0	2 (0.2)
Marine toxin		0	0	0
Metals		103 (4.9)	43 (4.7)	60 (5.1)
Opioid		125 (6.0)	59 (6.4)	66 (5.6)
Other non-pharmaceutical		12 (0.6)	7 (0.8)	5 (0.4)
Other pharmaceutical		11 (0.5)	6 (0.7)	5 (0.4)
Parkinson's med		3 (0.1)	2 (0.2)	1 (0.1)
Photosensitizing agents		0	0	0
Plants and fungi		27 (1.3)	9 (0.1)	18 (1.5)
Psychoactive		67 (3.2)	29 (3.1)	38 (3.2)
Pulmonary		5 (0.2)	3 (0.3)	2 (0.2)
Rodenticide		10 (0.5)	5 (0.5)	5 (0.4)
Sed-hypnotic/muscle relaxant		147 (7.0)	72 (7.8)	75 (6.4)
Sympathomimetic		91 (4.4)	33 (3.6)	58 (5.0)
WMD/NBC/riot		0	0	0
Unknown agent		32 (1.5)	14 (1.5)	18 (1.5)
Route of administration	1218			
Oral		1028 (84.4)	452 (84.8)	576 (84.1)
Inhalation		30 (2.5)	9 (1.7)	21 (3.1)
Parenteral		30 (2.5)	15 (2.8)	15 (2.2)
Intranasal		0	0	0
Dermal		62 (5.1)	30 (5.6)	32 (4.7)
Unknown		52 (4.3)	23 (4.3)	29 (4.2)
Rectal		0	0	0
Other		16 (1.3)	4 (0.8)	12 (1.8)
Type of exposure	1494			
Acute		1339 (89.6)	584 (89.8)	755 (89.5)
Chronic		77 (5.2)	31 (4.8)	46 (5.5)
Acute-on-chronic		48 (3.2)	21 (3.2)	27 (3.2)
Unknown		30 (2.0)	14 (2.2)	16 (1.9)

envenomations were reported in 7.7% of all male cases and 4.3% of all female cases is consistent with studies that show males are more at risk for snakebites than females [25].

Our study findings that female cases represented 59.2% of all cases, 67.1% of all cases in the age 13–18 years category, and 73.7% of intentional pharmaceutical exposures among cases aged 13–18 years align with previous studies that found that adolescent females were more likely than adolescent males to attempt suicide through self-poisonings [11, 26]. Sex has been acknowledged as a moderator of adolescent suicidal behavior, with females more likely to overdose, while males are more likely to use firearms [27]. While the reasons are unclear,

Table 9 Toxicological exposure information for pediatric cases 7–12 years

Variable	Total *N*	Entire sample (*N* = 1097)	Female (*N* = 555)	Male (*N* = 542)
Primary reason for encounter	1097			
Intentional pharmaceutical		390 (35.6)	266 (47.9)	124 (22.9)
Intentional non-pharmaceutical		112 (10.2)	47 (8.5)	65 (12.0)
Unintentional pharmaceutical		95 (8.7)	31 (5.6)	64 (11.8)
Unintentional non-pharmaceutical		84 (7.7)	31 (5.6)	53 (9.8)
Malicious/criminal		1 (0.1)	1 (0.2)	0
ETOH abuse		2 (0.2)	0	2 (0.4)
Withdrawal—ETOH		0	0	0
Withdrawal—opioids		0	0	0
Withdrawal—sedative-hypnotics		1 (0.1)	0	1 (0.2)
Withdrawal—cocaine/amphetamines		1 (0.1)	1 (0.2)	0
Withdrawal—other		2 (0.2)	0	2 (0.4)
Envenomation—snake		153 (13.9)	64 (11.5)	89 (16.4)
Envenomation—spider		38 (3.5)	24 (4.3)	14 (2.6)
Envenomation—scorpion		3 (0.3)	1 (0.2)	2 (0.4)
Envenomation—other		46 (4.2)	25 (4.5)	21 (3.9)
Marine/fish poisoning		0	0	0
Organ system dysfunction		22 (2.0)	10 (1.8)	12 (2.2)
Interpretation of toxicology lab data		10 (0.9)	2 (0.4)	8 (1.5)
Occupational evaluation		0	0	0
Environmental evaluation		38 (3.5)	15 (2.7)	23 (4.2)
Unknown		0	0	0
Surveillance		0	0	0
Adverse drug reaction		67 (6.1)	24 (4.3)	43 (7.9)
Medication error		15 (1.4)	7 (1.3)	8 (1.5)
Other		1 (0.1)	0	1 (0.2)
More than one reason		16 (1.5)	6 (1.1)	10 (1.8)
Single or multiple exposure?	1097			
Single exposure		902 (82.2)	438 (78.9)	464 (85.6)
Multiple exposure		195 (17.8)	117 (21.1)	78 (14.4)
Agent #1 class	1058			
Alcohol ethanol		5 (0.5)	2 (0.4)	3 (0.6)
Alcohol toxic		5 (0.5)	2 (0.4)	3 (0.6)
Amphetamine-like hallucinogen		0	0	0
Analgesic		97 (9.2)	85 (15.7)	12 (2.3)
Anesthetic		8 (0.8)	3 (0.6)	5 (1.0)
Anticholinergic/antihistamine		64 (6.0)	39 (7.2)	25 (4.8)
Anticoagulant		1 (0.1)	1 (0.2)	0
Anticonvulsant		42 (4.0)	19 (3.5)	23 (4.5)
Antidepressant		85 (8.0)	60 (11.1)	25 (4.8)
Antimicrobials		13 (1.2)	7 (1.3)	6 (1.2)
Antipsychotic		59 (5.6)	21 (3.9)	38 (7.4)
Cardiovascular		65 (6.1)	25 (4.6)	40 (7.8)
Caustic		5 (0.5)	1 (0.2)	4 (0.8)
Chelator		1 (0.1)	0	1 (0.2)
Chemotherapeutic and immune		6 (0.6)	3 (0.6)	3 (0.6)
Cholinergic/parasympathomimetic		0	0	0
Cough and cold		10 (0.9)	3 (0.6)	7 (1.4)
Diabetic med		16 (1.5)	11 (2.0)	5 (1.0)

Table 9 (continued)

Variable	Total *N*	Entire sample (*N* = 1097)	Female (*N* = 555)	Male (*N* = 542)
Endocrine		3 (0.3)	1 (0.2)	2 (0.4)
Envenomation		233 (22.0)	111 (20.5)	122 (23.6)
Foreign objects		0	0	0
Fungicide		0	0	0
Gases/vapors/irritants/dust		46 (4.3)	20 (3.7)	26 (5.0)
GI		1 (0.1)	1 (0.2)	0
Herbals/dietary supps/vitamins		14 (1.3)	7 (1.3)	7 (1.4)
Herbicide		1 (0.1)	0	1 (0.2)
Household		13 (1.2)	6 (1.1)	7 (1.4)
Hydrocarbon		6 (0.6)	0	6 (1.2)
Insecticide		11 (1.0)	3 (0.6)	8 (1.6)
Lithium		16 (1.5)	8 (1.5)	8 (1.6)
Marine toxin		1 (0.1)	1 (0.2)	0
Metals		27 (2.6)	8 (1.5)	19 (3.7)
Opioid		19 (1.8)	6 (1.1)	13 (2.5)
Other non-pharmaceutical		1 (0.1)	0	1 (0.2)
Other pharmaceutical		3 (0.3)	3 (0.6)	0
Parkinson's med		0	0	0
Photosensitizing agents		3 (0.3)	3 (0.6)	0
Plants and fungi		19 (1.8)	10 (1.8)	9 (1.7)
Psychoactive		40 (3.8)	10 (1.8)	30 (5.8)
Pulmonary		0	0	0
Rodenticide		0	0	0
Sed-hypnotic/muscle relaxant		56 (5.3)	35 (6.5)	21 (4.1)
Sympathomimetic		51 (4.8)	21 (3.9)	30 (5.8)
WMD/NBC/riot		0	0	0
Unknown agent		12 (1.1)	6 (1.1)	6 (1.2)
Route of administration	647			
Oral		438 (67.7)	251 (73.2)	187 (61.5)
Inhalation		38 (5.9)	16 (4.7)	22 (7.2)
Parenteral		56 (8.7)	25 (7.3)	31 (10.2)
Intranasal		0	0	0
Dermal		66 (10.2)	27 (7.9)	39 (12.8)
Unknown		26 (4.0)	15 (4.4)	11 (3.6)
Rectal		0	0	0
Other		23 (3.6)	9 (2.6)	14 (4.6)
Type of exposure	781			
Acute		619 (79.3)	346 (82.6)	273 (75.4)
Chronic		71 (9.1)	31 (7.4)	40 (11.0)
Acute-on-chronic		67 (8.6)	35 (8.4)	32 (8.8)
Unknown		24 (3.1)	7 (1.7)	17 (4.7)

it may be due to exploration of social norms and gender roles during adolescence. Females are more likely to be body-conscious and consider the state of their body after suicide completion, while males are more familiar with using firearms [27].

Previous literature has shown that substance dependence is twice as common in adult and adolescent males as females [28]. Our study findings that males represented 60.4% of intentional non-pharmaceutical exposures and 57.5% of ethanol abuse cases among those aged 13–18 years are consistent with

Table 10 Toxicological exposure jnformation for pediatric cases 13–18 years

Variable	Total *N*	Entire sample (*N* = 7840)	Female (*N* = 5261)	Male (*N* = 2579)
Primary reason for encounter	7840			
Intentional pharmaceutical		6204 (79.1)	4570 (86.9)	1634 (63.4)
Intentional non-pharmaceutical		848 (10.8)	336 (6.4)	512 (19.9)
Unintentional pharmaceutical		73 (0.9)	40 (0.8)	33 (1.3)
Unintentional non-pharmaceutical		78 (1.0)	44 (0.8)	34 (1.3)
Malicious/criminal		0	0	0
ETOH abuse		40 (0.5)	17 (0.3)	23 (0.9)
Withdrawal—ETOH		2 (0.03)	2 (0.04)	0
Withdrawal—opioids		8 (0.1)	3 (0.1)	5 (0.2)
Withdrawal—sedative-hypnotics		8 (0.1)	0	8 (0.3)
Withdrawal—cocaine/amphetamines		0	0	0
Withdrawal—other		6 (0.1)	1 (0.02)	5 (0.2)
Envenomation—snake		132 (1.7)	44 (0.8)	88 (3.4)
Envenomation—spider		39 (0.5)	24 (0.5)	15 (0.6)
Envenomation—scorpion		3 (0.04)	2 (0.04)	1 (0.04)
Envenomation—other		50 (0.6)	23 (0.4)	27 (1.0)
Marine/fish poisoning		1 (0.01)	0	1 (0.04)
Organ system dysfunction		55 (0.7)	26 (0.5)	29 (1.1)
Interpretation of toxicology lab data		18 (0.2)	13 (0.2)	5 (0.2)
Occupational evaluation		6 (0.1)	2 (0.04)	4 (0.2)
Environmental evaluation		50 (0.6)	24 (0.5)	26 (1.0)
Unknown		0	0	0
Surveillance		0	0	0
Adverse drug reaction		85 (1.1)	37 (0.7)	48 (1.9)
Medication error		9 (0.1)	5 (0.1)	4 (0.2)
Other		3 (0.04)	0	3 (0.1)
More than one reason		122 (1.6)	48 (0.9)	74 (2.9)
Single or multiple exposure?	7840			
Single exposure		5035 (64.2)	3307 (62.9)	1728 (67.0)
Multiple exposure		2805 (35.8)	1954 (37.1)	851 (33.0)
Agent #1 class	7630			
Alcohol ethanol		142 (1.9)	56 (1.1)	86 (3.5)
Alcohol toxic		39 (0.5)	19 (0.4)	20 (0.8)
Amphetamine-like hallucinogen		5 (0.1)	3 (0.1)	2 (0.1)
Analgesic		2248 (29.5)	1842 (35.8)	406 (16.3)
Anesthetic		7 (0.1)	4 (0.1)	3 (0.1)
Anticholinergic/antihistamine		638 (8.4)	437 (8.5)	201 (8.1)
Anticoagulant		7 (0.1)	7 (0.1)	0
Anticonvulsant		268 (3.5)	187 (3.6)	81 (3.3)
Antidepressant		1108 (14.5)	869 (16.9)	239 (9.6)
Antimicrobials		37 (0.5)	24 (0.5)	13 (0.5)
Antipsychotic		484 (6.3)	291 (5.7)	193 (7.7)
Cardiovascular		265 (3.5)	184 (3.6)	81 (3.3)
Caustic		33 (0.4)	19 (0.4)	14 (0.6)
Chelator		0	0	0
Chemotherapeutic and immune		16 (0.2)	12 (0.2)	4 (0.2)
Cholinergic/parasympathomimetic		0	0	0
Cough and cold		193 (2.5)	71 (1.4)	122 (4.9)
Diabetic med		55 (0.7)	41 (0.8)	14 (0.6)

Table 10 (continued)

Variable	Total *N*	Entire sample (*N* = 7840)	Female (*N* = 5261)	Male (*N* = 2579)
Endocrine		11 (0.1)	9 (0.2)	2 (0.1)
Envenomation		213 (2.8)	88 (1.7)	125 (5.0)
Foreign objects		2 (0.03)	1 (0.02)	1 (0.04)
Fungicide		0	0	0
Gases/vapors/irritants/dust		61 (0.8)	35 (0.7)	26 (1.0)
GI		13 (0.2)	8 (0.2)	5 (0.2)
Herbals/dietary supps/vitamins		59 (0.8)	41 (0.8)	18 (0.7)
Herbicide		0	0	0
Household		45 (0.6)	30 (0.6)	15 (0.6)
Hydrocarbon		16 (0.2)	3 (0.1)	13 (0.5)
Insecticide		8 (0.1)	6 (0.1)	2 (0.1)
Lithium		103 (1.3)	69 (1.3)	34 (1.4)
Marine toxin		0	0	0
Metals		59 (0.8)	44 (0.9)	15 (0.6)
Opioid		274 (3.6)	147 (2.9)	127 (5.1)
Other non-pharmaceutical		4 (0.1)	0	4 (0.2)
Other pharmaceutical		13 (0.2)	11 (0.2)	2 (0.1)
Parkinson's med		2 (0.03)	2 (0.04)	0
Photosensitizing agents		0	0	0
Plants and fungi		30 (0.4)	6 (0.1)	24 (1.0)
Psychoactive		336 (4.4)	104 (2.0)	232 (9.3)
Pulmonary		7 (0.1)	7 (0.1)	0
Rodenticide		1 (0.01)	0	1 (0.04)
Sed-hypnotic/muscle relaxant		405 (5.3)	251 (4.9)	154 (6.2)
Sympathomimetic		347 (4.5)	173 (3.4)	174 (7.0)
WMD/NBC/riot		1 (0.01)	0	1 (0.04)
Unknown agent		75 (1.0)	38 (0.7)	37 (1.5)
Route of administration	4925			
Oral		4413 (89.6)	3209 (93.3)	1204 (81.0)
Inhalation		155 (3.1)	40 (1.2)	115 (7.7)
Parenteral		84 (1.7)	40 (1.2)	44 (3.0)
Intranasal		24 (0.5)	15 (0.4)	9 (0.6)
Dermal		66 (1.3)	32 (0.9)	34 (2.3)
Unknown		149 (3.0)	91 (2.6)	58 (3.9)
Rectal		1 (0.02)	0	1 (0.1)
Other		33 (0.7)	12 (0.3)	21 (1.4)
Type of exposure	5840			
Acute		5080 (87.0)	3567 (88.1)	1513 (84.5)
Chronic		148 (2.5)	73 (1.8)	75 (4.2)
Acute-on-chronic		545 (9.3)	366 (9.0)	179 (10.0)
Unknown		67 (1.1)	44 (1.1)	23 (1.3)

this literature. This may be due to gender norms that influence adolescent males to use substances in social bonding and to treat pain autonomously through self-medication [13]. In both males and females, substance dependence is associated with depression, trauma, and suicide risk [28]. Our results point to the need for further research focused on sex-specific initiatives that target adolescents in substance use prevention.

The most common clinical complication in the pediatric patients included in the ToxIC registry was tachycardia (63.1% were female), and bradycardia (56.4% male). Further research outside of a limited dataset, such as the

Table 11 Complications among pediatric poisonings reported to the Toxicology Investigators' Consortium 2010–2016

Variable	Total *N*	Entire sample *N* = 12,699 (%)	Female *N* = 7517 (%)	Male *N* = 5182 (%)
Major vital sign abnormalities	4569			
Hypotension		213 (4.7)	139 (5.1)	74 (4)
Hypertension		142 (3.1)	70 (2.6)	72 (3.9)
Bradycardia		326 (7.1)	142 (5.2)	184 (9.9)
Tachycardia		1202 (26.3)	759 (27.9)	443 (23.9)
Tachypnea		0	0	0
Bradypnea		106 (2.3)	56 (2.1)	50 (2.7)
Hyperthermia		31 (0.7)	17 (0.6)	14 (0.8)
Hypothermia		0	0	0
None		2234 (48.9)	1374 (50.6)	860 (46.4)
Multiple symptoms		315 (6.9)	160 (5.9)	155 (8.4)
Death	5769			
Yes		38 (0.7)	20 (0.6)	18 (0.8)
No		5731 (99.3)	3547 (99.4)	2184 (99.2)
Life support withdrawn	38			
Yes		33 (86.8)	17 (85)	16 (88.9)
No		3 (7.9)	2 (10)	1 (5.6)
Unknown		2 (5.3)	1 (5)	1 (5.6)
CPR	12,699			
Yes		31 (0.2)	15 (0.2)	16 (0.3)
No		12,668 (99.8)	7502 (99.8)	5166 (99.7)
ECMO	12,699			
Yes		21 (0.2)	13 (0.2)	8 (0.2)
No		12,678 (99.8)	7504 (99.8)	5174 (99.8)
Intubation/ventilation	12,699			
Yes		772 (6.1)	421 (5.6)	351 (6.8)
No		11,927 (93.9)	7096 (94.4)	4831 (93.2)

ToxIC registry, would be needed to determine if there are statistically significant sex-specific differences in cardiotoxicity following pediatric poisonings that may mirror known sex differences in adult cardiotoxicity related to

Table 12 Complications for pediatric cases < 2 years

Variable	Total *N*	Entire Sample (*N* = 1584)	Female (*N* = 747)	Male (*N* = 837)
Major vital sign abnormalities	469			
Hypotension		20 (4.3)	9 (4.1)	11 (4.5)
Hypertension		21 (4.5)	7 (3.2)	14 (5.7)
Bradycardia		28 (6.0)	16 (7.2)	12 (4.9)
Tachycardia		129 (27.5)	60 (27.0)	69 (27.9)
Tachypnea		0	0	0
Bradypnea		25 (5.3)	8 (3.6)	17 (6.9)
Hyperthermia		4 (0.9)	3 (1.4)	1 (0.4)
Hypothermia		0	0	0
None		208 (44.3)	102 (45.9)	106 (42.9)
Multiple symptoms		34 (7.2)	17 (7.7)	17 (6.9)
Death	648			
Yes		7 (1.1)	3 (1.0)	4 (1.2)
No		641 (98.9)	299 (99.0)	342 (98.8)
Life support withdrawn	7			
Yes		7 (100.0)	3 (100.0)	4 (100.0)
No		0	0	0
Unknown		0	0	0
CPR	1584			
Yes		3 (0.2)	2 (0.3)	1 (0.1)
No		1581 (99.8)	745 (99.7)	836 (99.9)
ECMO	1584			
Yes		2 (0.1)	1 (0.1)	1 (0.1)
No		1582 (99.9)	746 (99.9)	836 (99.9)
Intubation/ventilation	1584			
Yes		77 (4.9)	38 (5.1)	39 (4.7)
No		1507 (95.1)	709 (94.9)	798 (95.3)

Table 13 Complications for pediatric cases 2–6 years

Variable	Total *N*	Entire sample (*N* = 2178)	Female (*N* = 954)	Male (*N* = 1224)
Major vital sign abnormalities	630			
Hypotension		30 (4.8)	11 (4.1)	19 (5.2)
Hypertension		15 (2.4)	10 (3.7)	5 (1.4)
Bradycardia		71 (11.3)	19 (7.1)	52 (14.3)
Tachycardia		118 (18.7)	51 (19.1)	67 (18.5)
Tachypnea		0	0	0
Bradypnea		30 (4.8)	16 (6.0)	14 (3.9)
Hyperthermia		6 (1.0)	3 (1.1)	3 (0.8)
Hypothermia		0	0	0
None		310 (49.2)	134 (50.2)	176 (48.5)
Multiple symptoms		50 (7.9)	23 (8.6)	27 (7.4)
Death	868			
Yes		3 (0.3)	1 (0.3)	2 (0.4)
No		865 (99.7)	372 (99.7)	493 (99.6)
Life support withdrawn	3			
Yes		3 (100.0)	1 (100.0)	2 (100.0)
No		0	0	0
Unknown		0	0	0
CPR	2178			
Yes		2 (0.1)	1 (0.1)	1 (0.1)
No		2176 (99.9)	953 (99.9)	1223 (99.9)
ECMO	2178			
Yes		2 (0.1)	1 (0.1)	1 (0.1)
No		2176 (99.9)	953 (99.9)	1223 (99.9)
Intubation/ventilation	2178			
Yes		99 (4.5)	42 (4.4)	57 (4.7)
No		2079 (95.5)	912 (95.6)	1167 (95.3)

medications, such as antipsychotics and antidepressants [29].

There are several limitations to this study. Given voluntary reporting, cases seen by a toxicologist at institutions

Table 14 Complications for pediatric cases 7–12 years

Variable	Total *N*	Entire sample (*N* = 1097)	Female (*N* = 555)	Male (*N* = 542)
Major vital sign abnormalities	419			
Hypotension		10 (2.4)	5 (2.3)	5 (2.5)
Hypertension		6 (1.4)	2 (0.9)	4 (2.0)
Bradycardia		34 (8.1)	9 (4.1)	25 (12.4)
Tachycardia		83 (19.8)	59 (27.2)	24 (11.9)
Tachypnea		0	0	0
Bradypnea		3 (0.7)	2 (0.9)	1 (0.5)
Hyperthermia		3 (0.7)	2 (0.9)	1 (0.5)
Hypothermia		0	0	0
None		256 (61.1)	131 (60.4)	125 (61.9)
Multiple symptoms		24 (5.7)	7 (3.2)	17 (8.4)
Death	510			
Yes		0 (0)	0 (0)	0 (0)
No		510 (100.0)	269 (100.0)	241 (100.0)
Life support withdrawn	-			
Yes		-	-	-
No		-	-	-
Unknown		-	-	-
CPR	1097			
Yes		0	0 (0)	0 (0)
No		1097 (100.0)	555 (100.0)	542 (100.0)
ECMO	1097			
Yes		0	0 (0)	0 (0)
No		1097 (100.0)	555 (100.0)	542 (100.0)
Intubation/ventilation	1097			
Yes		47 (4.3)	24 (4.3)	23 (4.2)
No		1050 (95.7)	531 (95.7)	519 (95.8)

Table 15 Complications for pediatric cases 13–18 years

Variable	Total *N*	Entire sample (*N* = 7840)	Female (*N* = 5261)	Male (*N* = 2579)
Major vital sign abnormalities	3051			
Hypotension		153 (5.0)	114 (5.7)	39 (3.8)
Hypertension		100 (3.3)	51 (2.5)	49 (4.7)
Bradycardia		193 (6.3)	98 (4.9)	95 (9.1)
Tachycardia		872 (28.6)	589 (29.3)	283 (27.2)
Tachypnea		0	0	0
Bradypnea		48 (1.6)	30 (1.5)	18 (1.7)
Hyperthermia		18 (0.6)	9 (0.4)	9 (0.9)
Hypothermia		0	0	0
None		1460 (47.9)	1007 (50.1)	453 (43.6)
Multiple symptoms		207 (6.8)	113 (5.6)	94 (9.0)
Death	3743			
Yes		28 (0.7)	16 (0.6)	12 (1.1)
No		3715 (99.3)	2607 (99.4)	1108 (98.9)
Life support withdrawn	28			
Yes		23 (82.1)	13 (81.3)	10 (83.3)
No		3 (10.7)	2 (12.5)	1 (8.3)
Unknown		2 (7.1)	1 (6.3)	1 (8.3)
CPR	7840			
Yes		26 (0.3)	12 (0.2)	14 (0.5)
No		7814 (99.7)	5249 (99.8)	2565 (99.5)
ECMO	7840			
Yes		17 (0.2)	11 (0.2)	6 (0.2)
No		7823 (99.8)	5250 (99.8)	2573 (99.8)
Intubation/ventilation	7840			
Yes		549 (7.0)	317 (6.0)	232 (9.0)
No		7291 (93.0)	4944 (94.0)	2347 (91.0)

participating in the ToxIC registry may go unreported; thus, this data may not represent all bedside toxicology consults performed at ToxIC sites. Further, some toxicological cases presenting to any participating institution may not be evaluated at the bedside by a medical toxicologist, and thus may not be included in the registry. There may have been less severe exposures, or even fatalities at reporting institutions that may have been treated without consultation by a toxicologist. The number of sites participating in the ToxIC registry varies by year, thus making year-to-year comparisons unfeasible within this dataset. Case descriptors selected by the medical toxicologist submitting case information may not be interpreted similarly by all participating toxicologists, thus resulting in confounding of data. For example, when indicating "intentional" as reason for a pediatric exploratory exposure, the registry does not clearly define if the substance was defined as such due to self-administration, or due to administration with specific intent. The nature of voluntary reporting of all case variables, including race, ethnicity, reason for exposure, and presenting signs and symptoms, may result in under-reporting or inaccurate reporting of such findings. We excluded cases where age or reason for the encounter was missing, thus potentially introducing bias into the analysis. Sensitivity analysis around the possibilities for missing data was not performed; thus, it is not possible to estimate potential bias. Further, the ToxIC registry does not capture all toxicology consults seen across the USA, as not all institutions with a toxicology service participate in the ToxIC registry. Thus, this registry is not the appropriate data source to determine the nature or urgency of poisoning prevention strategies. The authors acknowledge that more comprehensive morbidity and mortality data, along with economic analyses, would be needed to define necessary public health interventions related to pediatric poisoning. Data collection was limited to female and male sex. Following the completion of this study, ToxIC has begun to collect data on transgender patients. Thus, a limitation of this study is that transgender data was not collected during the study time period. Confirmatory testing is

not typically reported within the ToxIC registry; thus, identification of the agents involved in reported exposures is often provided based on the best judgement of the bedside toxicologist. Lastly, some cases were missing data for specific variables, and therefore, the sample size for those variables was reduced.

Conclusions

We report characteristics of pediatric poisonings reported to the ToxIC registry by age and sex categories. Raw data appeared consistent with the limited existing literature around age- and sex-based risk factors for poisoning presentations. Our findings may provide the groundwork for hypothesis generation around sex- and age-based outcomes, education, and prevention efforts for poisonings among children.

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Compliance with Ethical Standards

Conflicts of Interest None.

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