ORIGINAL ARTICLE

Incidence, lethality, and sociodemographic characteristics of exogenous poisonings in children and adolescents in Brazil, 2013 – 2023: a descriptive ecological study

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Abstract

Objective: to describe the incidence and lethality of exogenous poisoning in children and adolescents in Brazil from 2013 to 2023.

Methods: this ecological study used data from DATASUS. Incidence rates, lethality rates, and proportions were calculated. Trend analyses were performed using the Joinpoint Regression Program.

Results: there were 535,321 exogenous poisoning cases in the period, with an increasing incidence rate in all regions. The South region had the highest rate for most of the period and the highest growth trend. Exogenous poisoning cases were more frequent in the 1–4 and 15–19 age groups, with a predominance of medications and suicide attempts. Of 2,000 deaths, most were due to drugs of abuse and medications; however, agricultural pesticides were the most lethal (2.1%). Medications, metals, pesticides used in public health, and drugs of abuse had the highest growth trends (APC ~ 12). Among the exposure circumstances, suicide attempts (APC = 16.1) and abuse (APC = 13.1) had the highest growth rates. Regarding lethality, the growth in violence/homicide stood out (APC = 79), alongside a decline in habitual use (APC = -34.3).

Conclusions: the observed epidemiological profile reinforces the need for improved adolescent mental health care, stricter medication and pesticide regulations, and investments in data quality to ensure effective prevention strategies for exogenous poisoning in Brazil.

Key words *Epidemiological surveillance, Poisoning, Pediatrics, Health information systems*

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Introduction

Compulsory notification of health-related incidents is a vital tool for ensuring the effective communication of events that pose a potential threat to public health. The Brazilian Ministry of Health relies on this data to implement effective public policies, preventive measures, and interventions to curb disease transmission. It also uses the data to respond promptly to public health emergencies and monitor epidemiological outbreaks.[1]

Exogenous poisoning (EP) is a mandatorily notifiable condition due to its potential for severe outcomes and the need for prompt medical intervention. Symptoms and severity are nonspecific, since many organs and systems can be affected depending on the substance involved, the dose, the amount absorbed, the duration of exposure, and the individual's health status.[1] Toxic agents are diverse and include a range of substances, such as chemicals, pharmaceutical drugs, illicit substances, heavy metals, pesticides, toxic gases, and poisons from animals and plants.[1]

The 2004 World Report on Child Injury Prevention highlighted over 340,000 fatalities related to EP, of which approximately 45,000 involved children and adolescents. This corresponds to a global mortality rate for poisoning of 1.8 per 100,000.[2] In high-income countries, this rate decreases to 0.5 per 100,000, whereas in low- and middle-income countries, the rate increases to 2.0 per 100,000. Poisoning is the 13th leading cause of death among individuals aged 15 to 19, and it is the 4th leading cause of hospitalization for accidents among children aged 0 to 14.[2]

In Brazil, the Notifiable Diseases Information System (SINAN) reported 177,766 cases of exogenous poisoning in 2022, with 32.6% of these cases occurring in children and adolescents. Among this group, medications were the most frequently involved toxic agent (63.8%), followed by household products (7.2%).[3]

Understanding the epidemiological profile of EP in children and adolescents is critical, given its preventable nature, high treatment costs, prolonged care, and the potential for severe clinical outcomes, including long-term effects and death. Furthermore, this understanding is vital for guiding the regulation of toxic substances, promoting the safe use of chemicals and pharmaceuticals, and implementing measures to reduce occupational exposure while strengthening environmental monitoring. Local and regional studies have described some elements of EP in their respective contexts. However, this is a national-level study that provides a comprehensive description of all toxic agents and exposure circumstances reported in the SINAN form, as well as lethality and trend analysis. Thus, the objective of this study is to describe the incidence and lethality of EP among children and adolescents in Brazil from 2013 to 2023.

Methods

This descriptive ecological study is based on data concerning EP in children and adolescents aged zero to 19 years, extracted in July 2024 from the Notifiable Diseases Information System (SINAN/DATASUS/SVS/MS) for the period from 2013 to 2023.[4] Population data were obtained from the Brazilian Institute of Geography and Statistics (IBGE), including demographic censuses and projections on the DATASUS TabNet platform.[4] The data were stratified by geographical region (Brazil and its North, Northeast, Central-West, Southeast, and South regions) and age group (under 1 year, 1–4 years, 5–9 years, 10–14 years, and 15–19 years). These age groups follow the classification adopted by the Notifiable Health Conditions Information System (SINAN) to reflect different life-cycle stages between childhood and adolescence, which are associated with distinct patterns of exposure, susceptibility, and severity of exogenous poisoning. Furthermore, they were categorized by year of notification, sex (female, male, unknown/missing), skin color/race (White, Black, Brown, Yellow, Indigenous, unknown/missing), toxic agent (medications, agricultural pesticides, domestic pesticides, public health pesticides, rodenticides, veterinary products, household products, cosmetics and personal hygiene products, chemical products, metals, illicit drugs, toxic plants, food and beverages, others, unknown/missing), exposure circumstances (habitual use, accidental, environmental exposure, therapeutic use, medical prescription, administration error, self-medication, abuse, food ingestion, suicide attempt, abortion attempt, violence/homicide, others, unknown/missing), confirmation criterion (clinical-laboratory, clinical-epidemiological, clinical, unknown/missing), and case outcome (recovery without sequelae, recovery with sequelae, death due to exogenous poisoning, death from other causes, loss to follow-up, unknown/missing).

Incidence rates, proportions, and lethality rates were calculated. Incidence rates were obtained by dividing the number of cases by the population corresponding to each stratum and study year, then multiplying the result by 100,000 inhabitants. Annual incidence rates were stratified by age group, geographic macro-region, and for Brazil as a whole, as well as by toxic agents and exposure circumstances. Age-specific incidence rates were calculated using the populations corresponding to the 0–4, 5–9, 10–14, 15–19 age groups and the total population aged 0–19 years in Brazil, as denominators for each study year. Incidence rates by geographic macro-region and for Brazil as a whole were calculated using the populations aged 0–19 years corresponding to each macro-region (North, Northeast, Central-West, Southeast, and South) and Brazil each year of the study. Incidence rates by toxic agents and exposure circumstances were calculated

using the Brazilian population aged 0–19 years as the denominator for each study year. Lethality was calculated by dividing the number of deaths by the number of cases and multiplying by 100. Data management and indicator calculations were performed using Microsoft Excel®.

Temporal data analysis used the joinpoint regression statistical model, implemented through the Joinpoint Regression Program version 5.2.0 (National Cancer Institute, USA).[5] The Annual Percent Change (APC) of incidence by macro-region, toxic agent, and exposure circumstance, as well as lethality by toxic agent and exposure circumstance, was estimated for the study period. The models were fitted using log-transformed rates, assuming Poisson variance and uncorrelated errors, with year as the independent variable. The maximum number of joinpoints was set to one, due to the number of time points available. For each analysis, the possible models generated by the program were compared, and the final model was defined based on the Weighted Bayesian Information Criterion (WBIC), the statistical significance of the APC (*p*-value), and visual inspection of the graphs, adopting the most parsimonious and epidemiologically interpretable model.

To enable joinpoint analysis, the recommended imputation method was applied by assigning the value 0.5 in instances where the original value was zero.[6] This occurred at least once in the following toxic agent categories: domestic pesticides, public health pesticides, veterinary products, cosmetics and personal hygiene products, metals, and toxic plants; and in the following exposure circumstances: environmental, therapeutic use, medical prescription, administration error, self-medication, food-beverage ingestion, abortion attempt, and others.

This observational study followed the recommendations of the STROBE Statement (Strengthening the Reporting of Observational Studies in Epidemiology) using a checklist and considering the items applicable to this study design.[7]

The data underlying each table and figure are provided as Supplementary Material to enhance transparency and facilitate reproducibility.

This study used a publicly available dataset that does not contain individually identifiable information; therefore, approval by a Research Ethics Committee was not required.

The study analysis plan was retrospectively registered in the Open Science Framework (OSF) to promote transparency and reproducibility (DOI: 10.17605/OSF.IO/PAZVR).

Results

Between 2013 and 2023, 535,321 notifications of EP in children and adolescents were reported in Brazil. A higher proportion was observed among females (61.1%) (Table 1). Most cases were confirmed through clinical criteria (64%) (data not shown), and the patients recovered mainly without sequelae (78.5%). A high proportion of missing or unreported data was noted for skin color/race (18%) and case outcome (18.3%) (Table 1).

Incidence of cases over the study period revealed notable increases across all age groups, with a temporary decline between 2020 and 2022. Until 2017, the 0–4-year age group exhibited the highest incidence, but this was overtaken by the 15–19 age group in 2018, reaching its peak in 2023 with 202.3 cases per 100,000 inhabitants. The lowest incidence was consistently observed in the 5–9 age group throughout the study period (Figure 1).

In the initial two years, the Central-West region presented the highest incidence, but from 2015 to 2023, the South surpassed these numbers, with the Southeast and Central-West regions alternating between second and third positions with similar incidences. Since 2021, the Midwest has consistently held the second-highest position. The North region had the lowest incidence across all years (Figure 1).

Medications were the most frequently reported toxic agent across all age groups. However, the second most frequently toxic agent differed across age groups, with household products being the most frequent among the 1–4 year age group and food and beverages in the 5–9 age group (Table 2). Accidental poisonings predominated in children, while suicide attempts were common among adolescents (Table 2).

Despite agricultural pesticides (2.1% in 8,753 cases) and substance abuse (1.8% in 32,091 cases) being the most lethal agents, medication poisoning occurred 33 times more frequently than agricultural pesticides (288,093 cases), albeit with a lethality rate of only 0.2%. Among medication cases, while lethality rates were relatively stable across age groups, the absolute number of cases sharply increased in the 15–19 age group, being 7 times higher than in the 5–9 age group and up to 10 times higher than in children under 1 year (Table 2).

Regarding exposure circumstances, the most lethal were substance abuse (1.5%) and violence/homicide (1%). In the 15–19 age group, substance abuse was the most lethal (1.8%). For ages 1–14, violence/homicide was the most lethal (0.9% for 1–4; 2% for 5–9; and 1.1% for 10–14). It is noteworthy that suicide attempts presented the highest number of cases among adolescents (44,877 for 10–14 years old and 142,023 for 15–19 years old) and deaths (151 and 622 deaths, respectively), making it the leading exposure circumstance related to EP (829 deaths) with the highest frequency of deaths over the period (Table 2).

The incidence of EP remained relatively stable during the early years of the study, followed by a significant increase

Table 1

General characteristics of children and adolescents reported to the Notifiable Diseases Information System due to exogenous poisoning in Brazil and by region, 2013 to 2023.

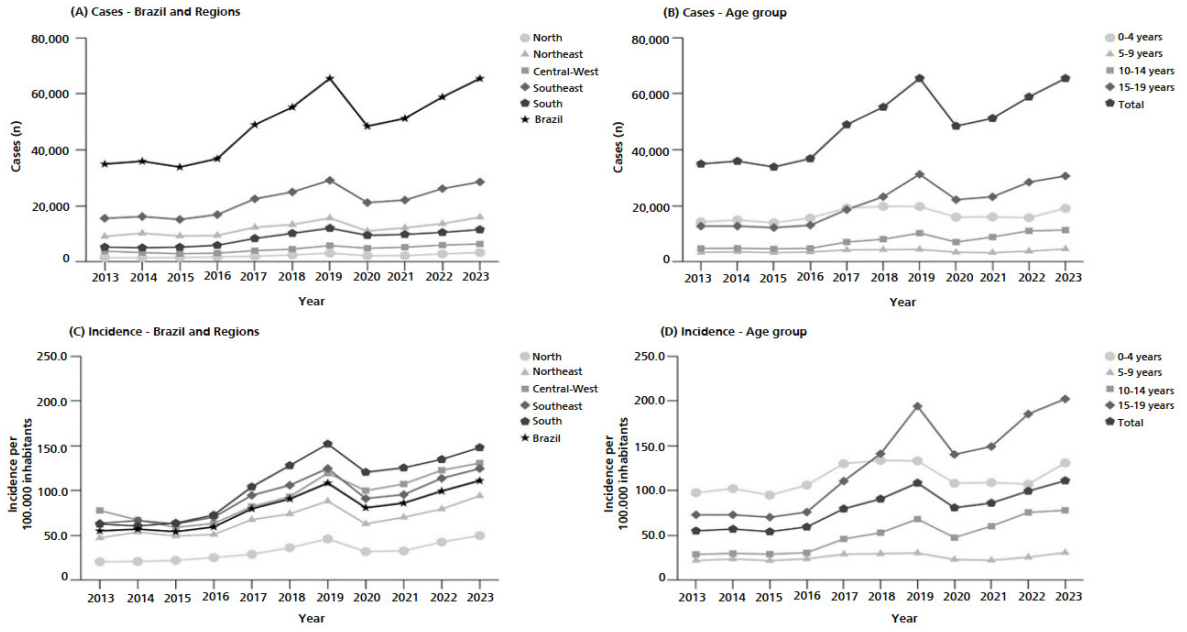
Characteristic	Brazil and Regions											
	North		Northeast		Central-West		Southeast		South		Brazil	
	n=23,663	%	n=131,586	%	n=49,399	%	n=237,868	%	n=92,805	%	n=535,321	%
Sex												
Female	13,771	58.2	77,232	58.7	30,119	61.0	147,947	62.2	58,127	62.6	327,196	61.1
Male	9,891	41.8	54,318	41.3	19,266	39.0	89,867	37.8	34,672	37.4	208,014	38.9
Unknown/Missing	1	0.0	36	0.0	14	0.0	54	0.0	6	0.0	111	0.0
Skin color/race												
Brown	17,811	75.3	82,835	63.0	21,818	44.2	75,201	31.6	11,128	12.0	208,793	39.0
White	2,501	10.6	12,495	9.5	11,250	22.8	105,280	44.3	72,141	77.7	203,667	38.1
Unknown/Missing	2,205	9.3	31,675	24.1	14,328	29.0	42,284	17.8	6,019	6.5	96,511	18.0
Black	508	2.2	3,541	2.7	1,358	2.8	13,239	5.6	2,615	2.8	21,261	4.0
Indigenous	468	2.0	456	0.4	246	0.5	659	0.3	401	0.4	2,230	0.4
Yellow	170	0.7	584	0.4	399	0.8	1,205	0.5	501	0.5	2,859	0.5
Age group (years)												
15–19	8,549	36.1	47,460	36.1	19,470	39.4	109,332	46.0	43,136	46.5	227,947	42.6
1–4	8,040	34.0	39,860	30.3	16,395	33.2	62,872	26.4	24,508	26.4	151,675	28.3
10–14	3,191	13.5	19,767	15.0	6,678	13.5	37,389	15.7	15,243	16.4	82,268	15.4
5–9	2,408	10.2	14,415	11.0	3,390	6.9	15,618	6.6	5,387	5.8	41,218	7.7
Under 1 year	1,475	6.2	10,084	7.7	3,466	7.0	12,657	5.3	4,531	4.9	32,213	6.0
Toxic agent												
Medication	9,049	38.2	63,171	48.0	25,446	51.5	133,566	56.2	56,861	61.3	288,093	53.8
Unknown/Missing	2,604	11.0	19,338	14.7	5,192	10.5	17,774	7.5	5,988	6.5	50,896	9.5
Household product	2,289	9.7	11,041	8.4	4,655	9.4	22,907	9.6	7,790	8.4	48,682	9.1
Drugs of abuse	912	3.9	4,464	3.4	2,243	4.5	19,611	8.2	4,861	5.2	32,091	6.0
Food and beverage	2,499	10.6	13,086	9.9	2,028	4.1	12,635	5.3	1,638	1.8	31,886	6.0
Rodenticide	1,127	4.8	3,936	3.0	2,369	4.8	6,748	2.8	3,186	3.4	17,366	3.2
Industrial chemical product	792	3.4	3,092	2.4	1,615	3.3	5,414	2.3	3,090	3.3	14,003	2.6
Other	956	4.0	3,331	2.5	1,087	2.2	6,224	2.6	2,350	2.5	13,948	2.6
Agricultural pesticide	926	3.9	2,601	2.0	865	1.8	2,394	1.0	1,967	2.1	8,753	1.6
Cosmetic and personal hygiene product	447	1.9	2,301	1.8	873	1.8	3,794	1.6	1,060	1.1	8,475	1.6
Domestic pesticide	733	3.1	1,969	1.5	1,051	2.1	2,472	1.0	1,501	1.6	7,726	1.4
Toxic plant	418	1.8	1,488	1.1	782	1.6	2,084	0.9	1,326	1.4	6,098	1.1
Veterinary product	486	2.1	1,305	1.0	891	1.8	1,673	0.7	922	1.0	5,277	1.0
Metal	229	1.0	297	0.2	248	0.5	353	0.2	207	0.2	1,334	0.3
Public health pesticide	196	0.8	166	0.1	54	0.1	219	0.1	58	0.1	693	0.1
Exposure circumstance												
Suicide attempt	6,330	26.8	36,072	27.4	17,855	36.1	92,165	38.8	41,425	44.6	193,847	36.2
Accidental	9,371	39.6	37,921	28.8	19,248	39.0	75,871	31.9	31,987	34.5	174,398	32.6
Unknown/Missing	2,045	8.6	21,412	16.3	3,661	7.4	13,856	5.8	2,930	3.2	43,904	8.2
Abuse	817	3.5	4,493	3.4	1,791	3.6	21,879	9.2	5,425	5.9	34,405	6.4
Food or beverage ingestion	1,719	7.3	9,454	7.2	1,809	3.7	7,708	3.2	1,041	1.1	21,731	4.1
Habitual use	1,133	4.8	5,996	4.6	1,543	3.1	7,849	3.3	2,168	2.3	18,689	3.5
Self-medication	612	2.6	4,580	3.5	996	2.0	7,382	3.1	2,956	3.2	16,526	3.1
Therapeutic use	191	0.8	5,668	4.3	429	0.9	2,702	1.1	848	0.9	9,838	1.8
Administration error	351	1.5	1,475	1.1	759	1.5	3,808	1.6	1,635	1.8	8,028	1.5
Other	299	1.3	1,568	1.2	743	1.5	2,212	0.9	1,109	1.2	5,931	1.1
Violence/Homicide	149	0.6	1,489	1.1	168	0.3	1,218	0.5	400	0.4	3,424	0.6

Environmental exposure	598	2.5	1,064	0.8	268	0.5	722	0.3	689	0.7	3,341	0.6
Abortion attempt	39	0.2	198	0.2	87	0.2	313	0.1	137	0.2	774	0.1
Inadequate medical prescription	9	0.0	196	0.2	42	0.1	183	0.1	55	0.1	485	0.1
Case classification												
Confirmed poisoning	14,118	59.7	74,203	56.4	30,155	61.0	145,414	61.1	59,694	64.3	323,584	60.5
Exposure only	5,403	22.8	25,116	19.1	11,175	22.6	54,751	23.0	24,042	25.9	120,487	22.5
Unknown/Missing	2,656	11.2	21,836	16.6	6,616	13.4	28,124	11.8	6,216	6.7	65,448	12.2
Adverse reaction	1,192	5.0	8,211	6.2	891	1.8	6,210	2.6	2,136	2.3	18,640	3.5
Other diagnosis	254	1.1	2,056	1.6	514	1.0	3,212	1.4	658	0.7	6,694	1.3
Withdrawal syndrome	40	0.2	164	0.1	48	0.1	157	0.1	59	0.1	468	0.1
Confirmation criteria												
Clinical	13,962	59.0	79,679	60.6	35,428	71.7	154,225	64.8	59,146	63.7	342,440	64.0
Clinical-epidemiological	5,963	25.2	28,968	22.0	8,054	16.3	51,972	21.9	22,848	24.6	117,805	22.0
Unknown/Missing	2,721	11.5	19,836	15.1	4,659	9.4	24,292	10.2	6,653	7.2	58,161	10.9
Laboratory	1,017	4.3	3,103	2.4	1,258	2.6	7,379	3.1	4,158	4.5	16,915	3.2
Case outcome												
Recovery without sequelae	17,751	75.0	98,306	74.7	37,460	75.8	185,924	78.2	80,672	86.9	420,113	78.5
Unknown/Missing	4,745	20.1	29,175	22.2	10,444	21.1	43,998	18.5	9,543	10.3	97,905	18.3
Loss to follow-up	737	3.1	2,154	1.6	821	1.7	4,291	1.8	1,058	1.1	9,061	1.7
Recovery with sequelae	314	1.3	1,401	1.1	498	1.0	2,484	1.0	1,180	1.3	5,877	1.1
Death due to exogenous poisoning	96	0.4	476	0.4	143	0.3	985	0.4	300	0.3	2,000	0.4
Death due to other cause	20	0.1	74	0.1	33	0.1	186	0.1	52	0.1	365	0.1

Source: Ministry of Health. Notifiable Diseases Information System (SINAN/DATASUS/SVS/MS).

Figure 1

Temporal distribution of cases and incidence rate per 100,000 inhabitants of exogenous poisoning in children and adolescents, by geographic regions of Brazil and age groups, Brazil, 2013–2023.



Source: Ministry of Health. Notifiable Diseases Information System (SINAN/DATASUS/SVS/MS).

In Figures (B) and (D), the age groups "under 1 year" and "1–4 years" were combined to correspond to the 0–4-year age group, according to the standard population stratification provided by the Brazilian Institute of Geography and Statistics (IBGE), used for incidence rate calculations. To ensure comparability and improve data visualization, the number of cases was also aggregated using the same categorization.

from 2016 onward. The highest number of cases occurred in 2019, with the Southeast region reporting the most cases (29,114; 44.4%). A decline in notifications in 2020 interrupted the previously observed growth trend; however, the number of cases rose again in subsequent years (Figure 1).

The annual percent change (APC) for Brazil and all macro-regions demonstrated an increasing trend from 2013 to 2023, with the greatest increase in the South region (APC = 9.5) and the smallest in the Northeast region (APC=6.3) (Figure 2).

Statistically significant incidence increases were observed for certain toxic agent categories and exposure circumstances. The largest increases were seen for public health pesticides (APC= 12.3), medications (APC= 12), metals (APC= 12), drugs of abuse (APC= 11.8, up to 2019), and toxic plants (APC= 8.2, up to 2018). The

Table 2

Number of cases, deaths, and lethality rate of exogenous poisoning among children and adolescents, by toxic agent, exposure circumstance, and age group, Brazil, 2013-2023.

Type of toxic agent	Age group					Total
	Under 1 year	01–04 years	05–09 years	10–14 years	15–19 years	
Medication						
Cases (n)	13,876	59,488	19,661	53,059	142,009	288,093
Deaths (n)	35	65	18	102	322	542
Lethality (%)	0.3	0.1	0.1	0.2	0.2	0.2
Agricultural pesticide						
Cases (n)	597	1,871	635	1,107	4,543	8,753
Deaths (n)	16	11	6	28	124	185
Lethality (%)	2.7	0.6	0.9	2.5	2.7	2.1
Domestic pesticide						
Cases (n)	614	4,128	745	615	1,624	7,726
Deaths (n)	1	7	0	5	11	24
Lethality (%)	0.2	0.2	0.0	0.8	0.7	0.3
Public health pesticide						
Cases (n)	50	186	109	169	179	693
Deaths (n)	1	0	0	0	1	2
Lethality (%)	2.0	0.0	0.0	0.0	0.6	0.3
Rodenticide						
Cases (n)	1,282	6,891	817	1,487	6,889	17,366
Deaths (n)	7	15	7	20	88	137
Lethality (%)	0.5	0.2	0.9	1.3	1.3	0.8
Veterinary product						
Cases (n)	291	2,994	397	406	1,189	5,277
Deaths (n)	1	9	2	3	8	23
Lethality (%)	0.3	0.3	0.5	0.7	0.7	0.4
Household product						
Cases (n)	3,228	33,183	3,407	2,738	6,126	48,682
Deaths (n)	5	23	4	4	22	58
Lethality (%)	0.2	0.1	0.1	0.1	0.4	0.1
Cosmetic and personal hygiene product						
Cases (n)	1,1	4,875	660	615	1,225	8,475
Deaths (n)	1	2	5	3	2	13
Lethality (%)	0.1	0.0	0.8	0.5	0.2	0.2
Industrial chemical product						
Cases (n)	929	8,002	1,034	919	3,119	14,003
Deaths (n)	6	23	0	5	21	55
Lethality (%)	0.6	0.3	0.0	0.5	0.7	0.4
Metal						
Cases (n)	87	564	243	157	283	1,334
Deaths (n)	1	1	1	0	3	6
Lethality (%)	1.1	0.2	0.4	0.0	1.1	0.4

Drugs of abuse						
Cases (n)	1,836	789	319	4,509	24,638	32,091
Deaths (n)	18	3	1	31	525	578
Lethality (%)	1.0	0.4	0.3	0.7	2.1	1.8
Toxic plant						
Cases (n)	410	3,117	1,32	529	722	6,098
Deaths (n)	0	5	5	0	2	12
Lethality (%)	0.0	0.2	0.4	0.0	0.3	0.2
Food and beverage						
Cases (n)	2,357	5,824	5,508	6,436	11,761	31,886
Deaths (n)	6	4	6	8	14	38
Lethality (%)	0.3	0.1	0.1	0.1	0.1	0.1
Other						
Cases (n)	1,214	5,436	1,499	1,652	4,147	13,948
Deaths (n)	10	20	10	10	128	178
Lethality (%)	0.8	0.4	0.7	0.6	3.1	1.3
Unknown/Missing						
Cases (n)	4,342	14,327	4,864	7,87	19,493	50,896
Deaths (n)	12	17	12	22	86	149
Lethality (%)	0.3	0.1	0.2	0.3	0.4	0.3

Type of exposure circumstance	Age group					Total
	Under 1 year	1–4 years	5–9 years	10–14 years	15–19 years	
Habitual use						
Cases (n)	1,708	2,762	1,933	2,792	9,494	18,689
Deaths (n)	7	2	3	4	54	70
Lethality (%)	0.4	0.1	0.2	0.1	0.6	0.4
Accidental						
Cases (n)	12,217	122,448	22,432	7,817	9,484	174,398
Deaths (n)	19	155	36	17	104	331
Lethality (%)	0.2	0.1	0.2	0.2	1.1	0.2
Environmental exposure						
Cases (n)	334	874	537	624	972	3,341
Deaths (n)	2	2	0	0	1	5
Lethality (%)	0.6	0.2	0.0	0.0	0.1	0.1
Therapeutic use						
Cases (n)	1,874	2,819	1,865	1,517	1,763	9,838
Deaths (n)	0	8	0	1	4	13
Lethality (%)	0.0	0.3	0.0	0.1	0.2	0.1
Inadequate medical prescription						
Cases (n)	87	141	87	59	111	485
Deaths (n)	0	1	0	0	0	1
Lethality (%)	0.0	0.7	0.0	0.0	0.0	0.2
Administration error						
Cases (n)	1,719	2,42	1,698	1,045	1,146	8,028
Deaths (n)	5	2	2	0	2	11
Lethality (%)	0.3	0.1	0.1	0.0	0.2	0.1
Self-medication						
Cases (n)	831	1,36	1,43	4,419	8,486	16,526
Deaths (n)	2	4	1	3	6	16
Lethality (%)	0.2	0.3	0.1	0.3	0.1	0.1

Abuse						
Cases (n)	1,680	288	312	5,46	26,665	34,405
Deaths (n)	17	0	2	33	469	521
Lethality (%)	0.1	0.0	0.6	0.6	1.8	1.5
Food or beverage ingestion						
Cases (n)	1,625	4,782	4,373	4,591	6,36	21,731
Deaths (n)	2	7	10	8	9	36
Lethality (%)	0.1	0.1	0.2	0.2	0.1	0.2
Suicide attempt						
Cases (n)	5,581	577	789	44,877	142,023	193,847
Deaths (n)	50	2	4	151	622	829
Lethality (%)	0.9	0.3	0.5	0.3	0.4	0.4
Abortion attempt						
Cases (n)	28	6	4	131	605	774
Deaths (n)	1	0	0	0	3	4
Lethality (%)	3.6	0.0	0.0	0.0	0.5	0.5
Violence/Homicide						
Cases (n)	245	907	306	562	1,404	3,424
Deaths (n)	4	8	6	6	10	34
Lethality (%)	1.6	0.9	2.0	1.1	0.7	1.0
Other						
Cases (n)	461	1,548	748	1,09	2,084	5,931
Deaths (n)	1	2	2	3	12	20
Lethality (%)	0.2	0.1	0.3	0.3	0.6	0.3
Unknown/Missing						
Cases (n)	3,823	10,743	4,704	7,284	17,35	43,904
Deaths (n)	10	12	11	15	61	109
Lethality (%)	0.3	0.1	0.2	0.2	0.4	0.2
Total						
Cases (n)	32,213	151,675	41,218	82,268	227,947	535,321
Deaths (n)	120	205	77	241	1,357	2,000
Lethality (%)	0.4	0.1	0.2	0.3	0.6	0.4

Source: Ministry of Health. Notifiable Diseases Information System (SINAN/DATASUS/SVS/MS).

Note: Records under "suicide attempt" and "attempted abortion" in the "exposure circumstance" variable for age groups 0–9 years should be interpreted with caution, as they are largely biologically implausible and likely reflect database recording errors (e.g., misentries in age, birth date, or classification). Due to the inability to verify these inconsistencies, they were retained in the dataset but should not be considered valid.

exposure circumstances with the highest APC were suicide attempts (16.1), substance abuse (13.1, up to 2018), self-medication (12.1), and violence/homicide (9). Therapeutic use was the only exposure circumstance that showed a decline after 2018 (APC= -11.4) (Table 3).

Regarding lethality, a decreasing trend was observed for "other" toxic agents (APC= -17.4), for agricultural pesticides after 2021, and for domestic pesticides (APC= -28.1 and -8.4, respectively). Toxic plant-related lethality increased until 2017 and then declined (APC= 46.3; -25.3) (Table 3).

For lethality by exposure circumstance, a decrease was seen for: habitual use (APC= -34.3, from 2020 onward), administration error (APC= -16.9), accidental poisoning (APC= -15.6), substance abuse (APC= -14.6, from 2015), and suicide attempts (APC= -10). Attempted abortion showed an initial decline followed by an increase (APC= -21.2; after 2017 = 14.7). Violence/homicide lethality increased after 2021 (APC= 79.1), as did other circumstances (APC= 7) (Table 3). All of these trends must be interpreted with caution, as, for certain categories, these pronounced relative increases likely reflect marked trends driven by a small absolute number of annual events.

Discussion

This study reveals a significant increase in cases of EP among children and adolescents in all Brazilian macro-regions over the analyzed period. Notifications, which remained relatively stable between 2013 and 2016, began to show an upward trend afterward, which was interrupted in 2020, reflecting the COVID-19 pandemic's impact on the healthcare system and social behavior, leading to underreporting.[8,9] According to the study by Sallas *et al.*,[9] there was a change in the profile of the main compulsorily

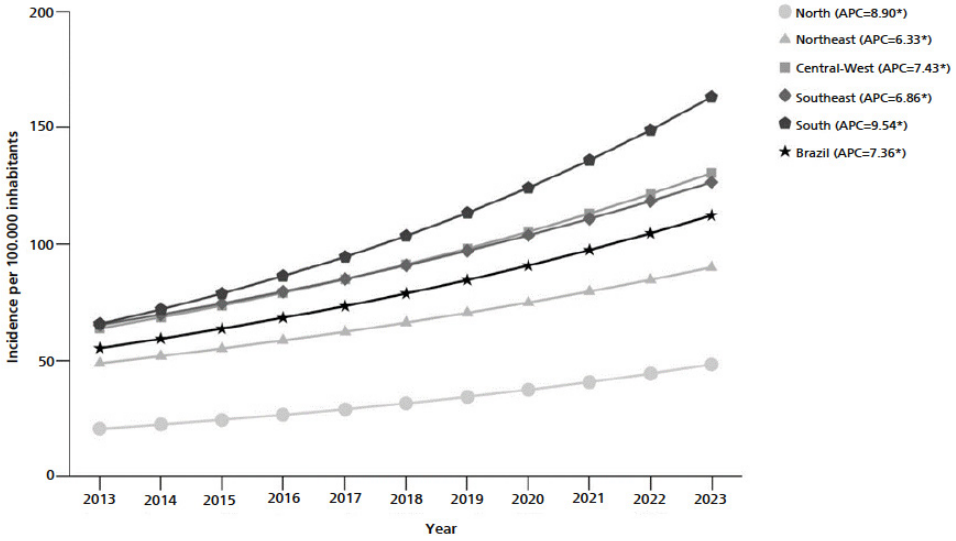
notifiable diseases, with a decrease in cases observed in the first year of the pandemic, particularly those reported through the Brazilian National Hospital Epidemiological Surveillance Network (RENAVEH). This decline has been discussed as potentially associated with the consequences and repercussions of the COVID-19 pandemic, including the prioritization of COVID-19 cases, the exhaustion of human and material health resources, the implementation of social distancing measures, underreporting of cases, and issues related to data recording.[9]

However, cases began to rise again in the following years, surpassing the levels observed at the beginning of the series. This upward trend in multiple age groups is corroborated by studies in different Brazilian states, indicating an alarming national pattern.[10-13] Given its mandatory notification status, the increase in reported exogenous poisoning cases over time may partially reflect improvements in surveillance and reporting processes rather than a true increase in incidence. The expansion of coverage, sensitivity, and overall quality of health information systems may also have reduced underreporting and improved case ascertainment during the study period.[1]

Since 2015, the South region has shown the highest incidence rates. It was also notable for its 2.4-fold increase in incidence during the study period and the highest Annual Percent Change (APC=9.5). Even though the Southeast region consistently presented the

Figure 2

Incidence rate and annual percentage changes (APC) of exogenous poisoning in children and adolescents by region, Brazil, 2013-2023.



Source: Ministry of Health. Notifiable Diseases Information System (SINAN/DATASUS/SVS/MS).

Note: APC values marked with * are statistically significant (p<0.05).

Table 3

Annual percentage changes (APC) and JoinPoint Regression estimates of incidence and lethality rates of exogenous poisoning in children and adolescents, by toxic agent and exposure circumstances, Brazil, 2013-2023.

Toxic agent	APC Incidence	95%CI[1]	*p*	Period (year)	APC Lethality	95%CI[1]	*p*	Period (year)
Medication	12.0*	8.2; 17.0	<0.001	2013-2023	-1.9	-4.6; 1.6	0.312	2013–2023
Unknown/Missing	4.8*	1.3; 9.0	0.013	2013-2023	-4.2	-14.3; 7.0	0.366	2013–2023
Household product	4.4*	2.2; 6.7	<0.001	2013-2023	-2.4	-10.9; 7.1	0.523	2013–2023
Drugs of abuse	11.8*	4.8; 80.7	0.021	2013-2019	-9.0	-23.1; 4.5	0.165	2013–2023
	-9.7	-41.1; 1.1	0.074	2019-2023	–	–	–	–
Food and beverage	-3.5	-8.6; 1.3	0.127	2013-2023	-9.1	-22.2; 0.7	0.064	2013–2023
Rodenticide	-1.2	-3.9; 1.5	0.360	2013-2023	-4.5	-11.7; 2.8	0.189	2013–2023
Industrial chemical product	0.01	-3.2; 3.2	0.981	2013-2023	-1.0	-15.1; 13.7	0.771	2013–2023
Other	4.7	-2.4; 13.2	0.157	2013-2023	-17.4*	-31.6; -9.6	< 0.001	2013–2023
Agricultural pesticide	-3.0	-7.7; 1.8	0.178	2013-2023	-1.3	-4.5; 10.2	0.724	2013–2021
	–	–	–	–	-28.1*	-42.3; -6.9	0.002	2021–2023
Cosmetic and personal hygiene product	6.1*	2.0; 10.8	0.004	2013-2023	8.1	-9.3; 33.5	0.245	2013–2023

Domestic pesticide	3.4	-0.7; 7.9	0.091	2013-2023	-8.4*	-17.8; -0.0	0.049	2013–2023
Toxic plant	8.2*	4.3; 23.7	0.001	2013-2019	46.3*	15.3; 578.3	0.003	2013–2017
	-2.2	-11.7; 1.5	0.288	2019-2023	-25.3*	-52.8; -15.8	0.002	2017–2023
Veterinary product	6.6*	2.1; 26.1	0.020	2013-2018	1.4	-11.6; 16.9	0.808	2013–2023
	-3.2	-16.3; 1.0	0.137	2018-2023	–	–	–	–
Metal	12*	3.8; 23.6	0.006	2013-2023	-12.8*	-24.8; -0.1	0.048	2013–2023
Public health pesticide	12.3*	1.5; 28.5	0.031	2013-2023	-6.3	-18.1; 7.4	0.314	2013–2023
Exposure circumstance	**APC Incidence**	**95%CI[1]**	***p***	**Period (year)**	**APC Lethality**	**95%CI[1]**	***p***	**Period (year)**
Suicide attempt	16.1*	10.4; 22.2	<0.001	2013-2023	-10.0*	-12.0; -7.7	< 0.001	2013–2023
Accidental	3.2	-0.3; 7.1	0.068	2013-2023	-15.6*	-24.7; -5.5	0.001	2013–2023
Unknown/Missing	0.1	-5.0; 5.3	0.982	2013-2023	-4.2	-12.9; 4.1	0.278	2013–2023
Abuse	13.1*	3.6; 87.4	0.036	2013-2018	51.1	-7.8; 191.9	0.137	2013–2015
	-6.2	-38.8; 2.3	0.108	2018-2023	-14.6*	-58.1; -7.9	0.027	2015–2023
Food or beverage ingestion	-3.2	-8.3; 1.6	0.158	2013-2023	-7.4	-21.9; 3.0	0.133	2013–2023
Habitual use	5.7*	2.9; 9.1	<0.001	2013-2023	3.6	-25.8; 44.5	0.392	2013–2020
	–	–	–	–	-34.3*	-73.3; -0.3	0.047	2020–2023
Self-medication	12.1*	8.6; 16.8	<0.001	2013-2023	-8.7	-19.5; 5.2	0.207	2013–2023
Therapeutic use	9.6	-0.8; 72.0	0.062	2013-2018	2.0	-9.7; 14.9	0.773	2013–2023
	-11.4*	-41.0; -1.7	0.038	2018-2023	–	–	–	–
Administration error	6.1	-2.2; 15.9	0.124	2013-2023	-16.9*	-31.9; -1.4	0.036	2013–2023
Other	7.0	-0.3; 15.8	0.061	2013-2023	7.0*	2.2; 14.1	0.004	2013–2023
Violence/Homicide	9.0*	2.0; 16.5	0.010	2013-2023	-9.1	-27.9; 14.5	0.186	2013–2021
	–	–	–	–	79.1*	3.5; 194.2	0.024	2021–2023
Environmental exposure	-1.2	-9.9; 7.9	0.724	2013-2023	-2.1	-12.5; 10.7	0.704	2013–2023
Abortion attempt	5.0*	0.7; 10.0	0.030	2013-2023	-21.2*	-50.3; -3.8	0.015	2013–2017
	–	–	–	–	14.7*	3.3; 62.6	0.016	2017–2023
Inadequate medical prescription	0.1	-10.8; 11.5	0.999	2013-2023	4.4	-4.7; 14.8	0.243	2013–2023

Source: Ministry of Health. Notifiable Diseases Information System (SINAN/DATASUS/SVS/MS).

Note: 95%CI[1] = 95% Confidence Interval. A single time interval indicates that no joinpoint was identified. The presence of two time intervals indicates one joinpoint, corresponding to the year in which the temporal trend changed. APC values marked with * are statistically significant ($p<0.05$).

highest absolute number of notifications due to its higher population density and concentration of healthcare centers, other regions exhibited higher incidence rates.

Globally, the study by Ferrari *et al.*,[14] based on the Global Burden of Disease (GBD) 2021 estimates, provides an overview of the global burden of 371 diseases and injuries organized within a hierarchical cause framework. Within this system, injuries constitute one of the primary cause groups and encompass various categories, including poisoning, transport injuries, falls, drowning, burns, self-harm, and interpersonal violence.[14]

The study demonstrated that the injury burden varies across the life course, decreasing after the neonatal period, specifically in infants under 1 year of age, and during childhood, particularly in the 5–9 age group, before progressively increasing in subsequent age groups, including adolescence, encompassing significantly the 15–19 age groups.[14]

In the United States, among children under the age of 5, the most frequently involved substances were household cleaning substances (10%), cosmetics/personal care products (9.2%), and analgesics (8.9%).[15] In Chile, the Toxicological Information Center of the Pontifical Catholic University of Chile (CITUC) reported 8,861 cases (77.6%) classified under accidental exposure which was the most frequent circumstance among children under 12 years of age.[16]

In Brazil, the incidence of EP among children aged ≤9 years was 50.49 cases per 100,000 inhabitants, with household products being the second most frequent toxic agent and accidental exposure the main circumstance in this group.[17] Children's cognitive and behavioral development may help explain the high number of cases in this age group, as children tend to crawl and explore their surroundings, often putting objects into their mouths, thereby increasing the risk of oral and dermal exposure.[16,18,19] Our findings reveal age-related differences in poisoning profiles. In children, poisoning events were predominantly accidental and occurred mainly in the home environment.

Medications were the most frequently involved toxic agents across all age groups and regions in our study. This

aligns with existing literature indicating that medications account for nearly half of childhood poisonings.[17] Pediatric medications with flavored formulations and colorful packaging may be particularly attractive to children. In addition to medications, household products and toxic plants are also common causes of accidental poisoning in young children.[17] All three agents, along with cosmetics and personal hygiene products, showed statistically significant upward trends in our analysis, further emphasizing the importance of the domestic accidental context.

Regarding toxic plants, between 1999 and 2017, the National System of Toxic-Pharmacological Information (SINITOX) registered 28,691 cases of exogenous poisoning caused by toxic plants. Based on annual counts provided by the system and stratified by toxic agent and age group, individuals aged 0–19 years accounted for more than half of the cases in this category, particularly among children aged 1–4 and 5–9 years.[20] Campos *et al*.[21] described native and exotic toxic plant species widely cultivated throughout Brazil for ornamental, landscaping, and medicinal purposes, as well as some used for consumption. In this context, Aguiar and Veiga Júnior[22] highlighted the presence of ornamental plants in Brazilian households, including species containing toxic compounds capable of causing EP through contact or ingestion. The widespread distribution of these species, combined with a lack of awareness regarding their toxicity, may increase the likelihood of accidental exposure, particularly among children.[22]

In contrast, adolescents aged 15 to 19, who accounted for 42.6% of cases in our study, presented a higher prevalence of intentional poisonings, with suicide attempts as the leading exposure circumstance. Medications remained the most common toxic agent among adolescents and were frequently used in suicide attempts.[23,24] Illicit drug use, which also showed a significant upward trend, was the second most common toxic agent and is often associated with recreational use or self-medication.[19]

In Brazil, several studies point to an increase in suicide attempts and drug abuse among adolescents.[19,25,26] Alves *et al*.[26] analyzed national data for individuals aged 10 and older and observed that self-harm behaviors are more frequent among females and those aged 10–19, while suicide is more common among adult and elderly men. However, trend analyses between 2011 and 2022 revealed a substantial rise in suicide and self-harming behaviors among adolescents, identifying them as the fastest-growing group in the country (APC= 6.1 and 28.8, respectively).

In our study, suicide attempt was the most frequently reported exposure circumstance (193,847 cases) and also exhibited the highest trend of increase (APC= 16.1). While substance abuse and violence/homicide had the highest lethality rates, with substantial variation across age groups, suicide attempts accounted for the highest absolute number of deaths (829) in our analyses. It is also important to note that, besides medications, pesticides played a significant role in poisonings related to suicide.[27]

These findings underscore adolescent mental health as a public health priority, which is closely tied to the country's broader social and economic development. Identifying inequities in this context and engaging youth in policymaking processes are essential steps toward improving care for this population.[28]

Between 2007 and 2017, medications were responsible for the largest number of potential years of life lost due to EP in Brazil, accounting for 23.4% of years lost, equivalent to 74,131 years.[24] From 2005 to 2018, 731 children under the age of five died in the United States due to poisoning-related causes. In those cases, opioids were the most frequently involved agents.[29] Although medications were the most common toxic agent and were responsible for roughly one-quarter of all deaths (542 out of 2,000), both our findings and the broader literature suggest that agricultural pesticides and illicit drugs are more lethal.[28] This contrast highlights the greater potential for severe outcomes when exposure involves these agents.

The temporal analysis of lethality due to agricultural pesticides in our study showed a decreasing trend over the last two years (APC = -28.1). Nevertheless, it is essential to acknowledge the broader consequences of chronic exposure to pesticides, including highly toxic ones, which affect multiple systems such as the cardiovascular, nervous, reproductive, endocrine, and immune systems, as well as the gastrointestinal tract, liver, and kidneys, while increasing cancer risks, including childhood cancers. Children are especially vulnerable to these effects.[30] According to the Epidemiological Bulletin on pesticide-related poisonings in Brazil (2013–2022), the highest incidence occurred in 2018 and 2019. The South region consistently reported the highest incidence of poisoning from both agricultural and household-use pesticides between 2017 and 2022.[31] Notably, in 2018, Brazil was ranked among the world's top five pesticide-consuming countries, with 49% of its pesticide sales classified as highly hazardous, much higher than the average in European countries, which maintain stricter regulations under European Union laws.[32] The high lethality from pesticide poisonings points to systemic issues beyond individual behavior, demanding stricter regulatory and enforcement measures.

The Brazilian Ministry of Health's recommendations to reduce pesticide-related poisonings include improving notification systems, strengthening health surveillance, and promoting intersectoral collaboration between the

health, environment, labor, and agriculture sectors.[33] Some progress has already been made, such as the development of a new regulatory framework to clarify pesticide toxicological classification.[34]

Although we observed significant upward trends in the incidence of various toxic agents and exposure circumstances over the years, it is important to note the decline in lethality for most of them. This may suggest improvements in healthcare services, increased access to poison control centers, more effective treatment protocols, or awareness campaigns that have led to faster case management. On the other hand, the sharp increase in lethality related to violence/homicide after 2021 (APC= 79.1) is a concern and warrants further research to better understand the phenomenon, taking into account the agents involved, contextual factors, and changes in reporting patterns.

The evolution of cases reveals a public health and potentially socioeconomic impact that goes beyond the 2,000 recorded deaths among 535,321 reported cases. The occurrence of sequelae in 5,877 individuals highlights the burden that exogenous poisonings place on the health of children and adolescents, with consequences for quality of life and the potential need for long-term care. Therefore, discussions about the impact of poisonings should extend beyond mortality to include morbidity and long-term implications for individuals and the healthcare system. Additionally, it is worth noting that the lack of data on case outcomes (categorized as unknown, missing, or lost to follow-up) affected approximately 20% of records, making it difficult to fully assess the impact of poisonings.

The 18% incompleteness in the race/skin color field, despite the requirement established by Ordinance MS/GM No. 344/2017,[35] represents a significant limitation. Although leaving this field blank does not prevent the notification from being entered into the system, it is essential for an adequate epidemiological characterization of cases. This limitation compromises equity analyses and may obscure racial disparities in EP profiles, access to health services, and clinical outcomes.

From the perspective of critical social epidemiology, the absence of this information is not neutral: it statistically renders racial groups invisible, hinders the identification of differentiated risk patterns, and weakens the development of equitable public policies. In the context of EP, this gap may conceal inequalities related to toxic agents, exposure circumstances, housing conditions, working conditions, and timely access to care. Therefore, improving the quality and completeness of SINAN notification form data entry, combined with ongoing training of health professionals, is essential to strengthen epidemiological surveillance and support actions aimed at reducing racial health inequities.[35,36]

Some limitations are inherent to using secondary data, including incomplete information and underreporting, despite EP being a notifiable condition. Additional challenges involve the difficulty faced by healthcare teams in determining whether a poisoning was intentional or accidental.

It is important to note that, in the analyzed dataset, some categories of the "exposure circumstance" variable, such as "suicide attempt" and "abortion attempt," include cases recorded in biologically implausible age groups. Specifically, there were 5,581 reported suicide attempts in the under-1 age group, 577 in the 1–4 age group, and 789 in the 5–9 age group, as well as 28 reported abortion attempts in the infants under one year of age group, 6 in the 1–4 age group, and 4 in the 5–9 age group. These records suggest potential inconsistencies in the SINAN database, likely reflecting errors in the recording of age or date of birth. However, due to the inability to verify these inconsistencies, such cases were retained in the dataset. An alternative explanation is intentional poisoning by third parties. Despite these limitations, these inconsistencies do not preclude the use of this database, as it remains the only available source for obtaining information on EP in Brazil.

Furthermore, the ecological design adopted does not allow for causal inferences at the individual level, and the observed temporal trends should be interpreted with caution, as improvements in surveillance sensitivity and reporting processes throughout the study period may have contributed to the increase in recorded cases, rather than necessarily reflecting a true rise in incidence. This underscores the need for complementary epidemiological studies to achieve a more comprehensive understanding of the investigated phenomenon. Despite these limitations, the study offers a national overview of exogenous poisonings in children and adolescents, with a focus on lethality, a crucial aspect given the preventable nature of this condition, its high cost, and the severity of its outcomes.

This study provides a relevant basis for understanding EP in children and adolescents in Brazil by describing national incidence, lethality, and temporal trends. Public health policies should promote educational campaigns targeting parents and caregivers, emphasizing safe storage practices for medications, household products, and toxic plants. Improving mental health services for adolescents is essential. Furthermore, stronger regulations are needed regarding medication packaging, proper disposal, and pesticide use. Finally, it is crucial to enhance data quality in SINAN, particularly in fields marked as "unknown" or left blank, while supporting ongoing professional training and investing in technologies that enhance data integration. These efforts will strengthen epidemiological surveillance and help develop more effective and context-sensitive strategies for prevention and management.

Author's contribution

Siqueira DT: conceptualization, data curation, formal analysis, writing – original draft.

Espíndola AS: formal analysis, writing – original draft.

Silva TV: writing – original draft.

Reis KP: data curation, writing – original draft.

Salim TR: writing – original draft.

Vinagre F: supervision, writing – original draft, writing – review and editing.

Carneiro LBV: conceptualization, supervision, writing – original draft, writing – review and editing.

All authors approved the final version of the article and declare no conflict of interest.

Data availability

All datasets supporting the results of this study are included in the article.

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