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Original quantitative research

Accidental substance-related acute toxicity deaths among youth in Canada: a descriptive analysis of a national chart review study of coroner and medical examiner data

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Part of our "Accidental overdose mortality" theme series.

Abstract

Introduction: Substance-related acute toxicity deaths (ATDs) are a public health crisis in Canada. Youth are often at higher risk for substance use due to social, environmental and structural factors. The objectives of this study were to understand the characteristics of youth (aged 12–24 years) dying of accidental acute toxicity in Canada and examine the substances contributing to and circumstances surrounding youth ATDs.

Methods: Data from a national chart review study of coroner and medical examiner data on ATDs that occurred in Canada between 2016 and 2017 were used to conduct descriptive analyses with proportions, mortality rates and proportionate mortality rates. Where possible, youth in the chart review study were compared with youth in the general population and youth who died of all causes, using census data.

Results: Of the 732 youth who died of accidental acute toxicity in 2016–2017, most (94%) were aged 18 to 24 years. Youth aged 20 to 24 who were unemployed, unhoused or living in collective housing were overrepresented among accidental ATDs. Many of the youth aged 12 to 24 who died of accidental acute toxicity had a documented history of substance use. Fentanyl, cocaine and methamphetamine were the most common substances contributing to death, and 38% of the deaths were witnessed or potentially witnessed.

Conclusion: The findings of this study point to the need for early prevention and harm reduction strategies and programs that address mental health, exposure to trauma, unemployment and housing instability to reduce the harms of substance use on Canadian youth.

Keywords: *substance use, drug overdose, opioid overdose, acute toxicity deaths, children, youth, young adults, Canada*

Highlights

- In 2016 and 2017, nearly half (46%) of all accidental deaths among youth 18 to 24 years of age were due to acute toxicity.
- Youth aged 20 to 24 who were unemployed, living in collective housing or unhoused were overrepresented among those who died of accidental acute toxicity.
- Almost one-third (30%) of youth 12 to 24 years of age who died of accidental acute toxicity had at least one documented potentially traumatic event during their life.
- Opioids (fentanyl, morphine, diacetylmorphine [heroin], carfentanil) and stimulants (cocaine, methamphetamine, amphetamine) of nonpharmaceutical origin were the most common contributors to accidental acute toxicity deaths among youth aged 12 to 24 years.
- Thirty-eight percent of the accidental acute toxicity deaths in youth were witnessed or potentially witnessed.

Introduction

Substance-related acute toxicity deaths (ATDs) are a public health crisis in Canada that have had a serious impact on youth. Between 2013 and 2017, there was a 53% increase in rates of opioid poisoning–related hospitalizations of youth aged 15 to 24.[1] In March 2022, pediatricians reported seeing a concerning number of children and youth with severe or life-threatening cases of opioid, stimulant or sedative use in the previous 24 months.[2] Youth face unique social, environmental and structural factors that contribute to substance use and can lead to poor overall health, mental health conditions and death.[3,4]

As the risk of ATD is often higher for youth with a history of substance use or substance use disorders, it is critical to explore the risk factors of substance use

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and substance use disorders in order to understand the risk of ATD.[5,6] Adolescents' risk factors for substance use and substance use disorders are unique to this age group due to the many changes that come with this transitional period of life.[5] Some risk factors include adverse childhood experiences (such as abuse, traumatic events, neglect and mental health conditions in family members),[3,4] mental health conditions,[7-9] history of correctional involvement[10] and family history of substance use.[3,4]

Analyses of death investigation data from Ontario and British Columbia and linkage of census and vital statistics data have revealed factors specifically associated with ATDs among Canadian youth.[6,11-12] These factors include neighbourhood-level income inequality,[11] living arrangements and housing instability, the absence of a bystander who could intervene, a mental health diagnosis[6,12] and receipt of current or previous child, youth or family services.[12]

Previous research has highlighted challenges in opioid-related services for youth, including gaps in the continuum of care, inaccessibility of services, stigma, lack of respect for youth autonomy and a lack of family supports.[13-16] Opioid agonist therapy prescription rates and residential treatment rates have been declining among Ontario youth since 2014, despite increasing opioid-related youth ATDs.[6] About half of the youth who died from opioid-related acute toxicity in Ontario had an opioid use disorder. Difficulties youth face in accessing treatment or harm reduction services that suit their needs and preferences limit their protection from an increasingly toxic and unpredictable illegal drug supply. Nonpharmaceutical fentanyl has been the primary contributor to youth ATDs in Ontario and British Columbia in recent years.[6,12] Youth who use substances intermittently may be at particular risk of opioid toxicity because they have less experience and lower opioid tolerance.[17]

Previous research has explored ATDs within provinces or cities or with a focus on subpopulations of youth, but only a few studies have examined ATDs among youth at a national level in Canada.[6,11-12,18-21] The purpose of this study was to address these knowledge gaps by examining ATDs among youth based on Canadian death investigation data from 2016 and 2017, and to set a baseline in the early years of the overdose crisis for comparison with future research. The objectives of this study were

(1) to report the minimum prevalence of risk factors for substance use and substance use disorders identified by previous research among youth who died of accidental acute toxicity in Canada in 2016 and 2017;

(2) to examine the most common substances contributing to ATDs among youth; and

(3) to describe the circumstances of ATDs among youth.

Methods

Ethics approval

This study was reviewed and approved by the Public Health Agency of Canada Research Ethics Board (REB 2018-027P), the University of Manitoba Health Research Ethics Board (HS22710) and Newfoundland and Labrador Health Research Ethics Board (20200153).

Data sources

This analysis uses data on 732 accidental ATDs of youth taken from a retrospective chart review study of coroner and medical examiner death investigations of ATDs in all Canadian provinces and territories that occurred between 1 January 2016 and 31 December 2017.[22] An ATD is defined as a death after an acute toxicity due to the direct effects of one or more drugs or alcohol.[23] Further details on the study protocol and the variables collected have been published elsewhere.[22] Using census data from 2016[24-27] and Canadian Vital Statistics - Death data from 2016 and 2017[28] permitted comparisons to the general population and the calculation of mortality rates.

Youth definition

In this study, youth are defined as individuals 12 to 24 years of age. To capture the differences among youth within this age range, this study stratifies youth into two categories: those between 12 and 17 years of age and those between 18 and 24 years of age. Each group has unique characteristics, and some variables are more age-dependent than others. Youth between 12 and 17 years of age are most likely students who live with parents or guardians, whereas youth aged 18 years and older may be legally permitted to use some substances and may no longer live with a parent or guardian and may have increased independence.

While youth aged 12 years and older are more likely to be actively using substances, children younger than 12 are more likely to experience accidental exposure to substances. Given the difference in the type of exposure (unintentional use is a different phenomenon from intentional use of substances) and the small number of ATDs in this age group, children under 12 were excluded from this study. Most of the analysis in this study includes youth aged between 12 and 24. However, to compare with the 2016 Census data, results for those aged 20 to 24 years are presented separately.

Variables of interest

The primary outcome variable in this analysis was ATDs. The chart review study dataset provided data on previously identified risk factors for substance use, substance use disorders and ATDs among youth. These include sociodemographic factors (i.e. age, sex, employment status, living arrangement) and social or medical history (i.e. history of incarceration, contact with health services in the preceding year, history of mental health conditions or symptoms, history of substance use, history of substance use disorder and potentially traumatic life events).

Contact with health services includes inpatient admission (hospital or other) and outpatient treatment (e.g. emergency medical services, emergency department, general practitioner or nurse practitioner).

Potentially traumatic events are used as the best comparable measure to adverse childhood events from the death investigation files. Potentially traumatic events include one-off events, series of events or circumstances that are physically or emotionally harmful or life threatening and could have lasting adverse effects on the person's mental, physical, social, emotional or spiritual well-being.[29] They might include a health problem of a family member or relative, intimate partner problems, other relationship problems (e.g. a family argument), job or school problems, financial problems, the recent death of a friend or family member, criminal or other

legal problems (e.g. custody dispute, civil suit), perpetrating or being a victim of interpersonal violence or a victim of child abuse, foster care experiences, experiencing sexual abuse, or experiencing physical abuse or assault.

These variables were collected from any available source in the death investigation file, which might include statements from family, friends or a primary health care provider, medical records, autopsy reports or police reports, for example. Therefore, some of the medical conditions reported may not necessarily have been medically diagnosed. Where available, residential postal codes were linked to Statistics Canada's Postal Code Conversion File Plus to obtain area-based neighbourhood income quintile after tax (QAATIPPE).[30]

In this paper, the substances contributing to death are reported by their origin (pharmaceutical or nonpharmaceutical) and whether the substance contributed to death alone or in combination with other substances.

Variables that indicate the circumstances of the acute toxicity events and death include the most likely mode of substance use, the presence of a witness, the actions taken by the witness during the first and subsequent encounters, the administration of naloxone for youth with symptoms of opioid toxicity, the place of the acute toxicity event and the place of death. We also examined whether the place of the acute toxicity event was indoors or outdoors, whether the person was found in or near a bed or in a vehicle and, in the case of youth who experienced the acute toxicity event inside their personal residence, whether they lived alone or with someone else.

Statistical methods

To calculate accidental acute toxicity mortality rates and proportionate mortality due to acute toxicity, we used population data from the 2016 Census and all-cause accidental death counts from the Canadian Vital Statistics - Deaths Database as denominators.[24,28] As a person's entire life history is not documented in coroner and medical examiner files and there is variation in what is collected across jurisdictions, there is likely additional history and information that was not captured. The results of this study should therefore be considered the minimum proportions of youth that had a given characteristic. Census data were used to compare proportions and calculate mortality rates for youth aged 20 to 24 by employment status and living arrangement.[25-27] For the remainder of the analyses, the minimum proportions of youth aged 12 to 24 who had a given characteristic were calculated. An UpSet plot was constructed using the ComplexUpSet package to identify the most common substances and substance combinations contributing to death, and their origin.[31]

All statistical analyses were performed using R statistical software version 4.1.1.[32] To protect privacy, cell sizes less than 10 were either suppressed or grouped into larger categories, all counts were randomly rounded to base 3 and proportions and mortality rates were based on rounded counts.[22]

Results

Burden of acute toxicity deaths among youth

Overall, there were 732 people aged 12 to 24 years who died of accidental acute toxicity, and most of these youth were between 18 and 24 years of age (94%; Table 1). Death due to accidental acute toxicity accounted for nearly half (46%) of all-cause accidental mortality among youth aged 18 to 24. Among youth aged 12 to 17 years, the contribution of acute toxicity to all-cause accidental deaths was higher among females (23%) than males (11%).

Characteristics of youth who died of accidental acute toxicity

A subset of 567 youth between 20 and 24 years of age who died of accidental acute toxicity in 2016 or 2017 were compared

TABLE 1
Number of deaths, mortality rates and proportionate mortality rates for youth aged 12 to 24 years in Canada who died from accidental substance-related acute toxicity in 2016 and 2017

Measure	Youth aged 12–24 years	Youth aged 12–17 years	Female youth aged 12–17 years	Male youth aged 12–17 years	Youth aged 18–24 years	Female youth aged 18–24 years	Male youth aged 18–24 years
Number of acute toxicity deaths	732	42	24	18	690	183	507
Total population in 2016	5 418 470	2 339 370	1 139 935	1 199 430	3 079 100	1 505 960	1 573 145
Mortality rate due to accidental acute toxicity per 100 000 population	6.8	0.9	1.1	0.8	11.2	6.1	16.1
Total accidental deaths in 2016 and 2017	1 770	270	105	165	1 500	390	1 110
Proportionate accidental acute toxicity mortality rate in relation to all-cause accidental deaths[a]	41%	16%	23%	11%	46%	47%	46%

Data sources: National Chart Review Study of Substance-Related Acute Toxicity Deaths.[22] The denominator for each group's mortality rates is from the 2016 Census.[24] The all-cause mortality counts by demographic group used to calculate proportionate mortality rates were provided by Statistics Canada from the Canadian Vital Statistics - Death database.[28] All accidental deaths include *International Classification of Diseases 10th Revision* (ICD-10) codes: V01–V99, W00–W99, X00–X59, Y85 and Y86.

Notes: Counts from the National Chart Review Study of Substance-Related Acute Toxicity Deaths were randomly rounded to base 3, and proportions and rates are based on rounded counts. Deaths due solely to prescribed substances or alcohol were not available from British Columbia; therefore, acute toxicity deaths in this table may be underestimates.

[a] All-cause accidental death estimates are rounded using Statistics Canada's controlled rounding process for confidentiality purposes. The counts exclude the deaths of nonresidents of Canada. The cause of death is tabulated as the underlying cause of death. This is defined as (a) the disease or injury that initiated the train of events leading directly to death, or (b) the circumstances of the accident or violence that produced the fatal injury. This underlying cause is selected from a number of conditions listed on the death registration form.

to youth of the same age using 2016 Census data (Table 2). The employment status of youth who died of acute toxicity was most often unknown (49%), and the other employment status categories in Table 2 represent the minimum proportions of youth in that category. At least 23% of individuals who died were employed and at least 18% were unemployed. Given the number of unknowns, the employment rate among those who died of acute toxicity may be lower, equivalent or higher than the rate in the general population. However, unemployment was more prevalent among youth who died (at least 18% but perhaps higher) than among youth in the general population (11%). The mortality rate due to acute toxicity for youth who were unemployed was 20.4 per 100 000.

While most youth aged 20 to 24 lived in a private dwelling (70%), 4% lived in a collective dwelling and 9% were unhoused at the time of their death. Youth who were living in collective dwellings or unhoused were overrepresented among those who died of acute toxicity when compared to the general population. We did not calculate mortality rates for these two groups due to differences in the definitions used by the two data sources.

Table 3 presents the characteristics of the 732 youth aged 12 to 24 years who died of accidental acute toxicity in 2016 and 2017. Commonly documented mental health conditions or symptoms in this group included depressive disorder or depressive symptoms (22%), substance use disorder (excluding alcohol; 20%), anxiety disorder (16%) and suicidal ideation or suicide attempt (12%). Eighty-three percent of youth had a documented history of substance use, and more than

TABLE 2
Comparison of employment status and living arrangements for youth aged 20 to 24 years who died of accidental acute toxicity (2016 to 2017) and in the Canadian general population (2016)

Characteristic	Proportion of youth who died of accidental acute toxicity in 2016 or 2017, % (n)	Proportion of youth in the general Canadian population in 2016, % (n)	Rate of accidental deaths due to acute toxicity per 100 000 population, (95% CI)
Total youth aged 20 to 24 years	567	2 242 690	12.6 (11.6–13.7)
Employment status[a]			
Employed[b]	23 (132)	65 (1 466 900)	4.5 (3.7–5.3)
Unemployed[c]	18 (99)	11 (243 215)	20.4 (16.3–24.4)
Student (full-/part-time)	7 (39)	—	—
Social assistance program[d]	3 (18)	—	—
Illegal sources of income	3 (18)	—	—
Other income source	4 (21)	—	—
Unknown	49 (276)	<1 (21 015)[e]	—
Not in the labour force	—	23 (511 560)[f]	—
Living arrangement			
Private dwelling	70 (399)	99 (2 221 685)	9.0 (8.1–9.9)
Collective dwelling[g]	4 (24)	<1 (20 940)	Not calculated
Unhoused	9 (51)[h]	<1 (1 855)[i]	Not calculated
Other dwelling type	Suppressed	—	—
Unknown	15 (84)	—	—

Abbreviation: CI, confidence interval.

Data sources: National Chart Review Study of Substance-Related Acute Toxicity Deaths[22]; Statistics Canada, 2016 Census of Population, Statistics Canada Catalogue Nos. 98-316-X2016001,[24] 98-400-X2016198,[25] 98-400-X2016021[26] and 98-400-X2016018.[27]

Notes: This age range (20–24 y) was used in the table to align with the age range used in census data. "—" indicates that a comparable statistic was not available in census data or chart review study data. "Not calculated" indicates that a similar statistic was available in census data, but the variable definitions were too different to calculate a mortality rate. Counts from the National Chart Review Study of Substance-Related Acute Toxicity Deaths are randomly rounded to base 3, and percentages and rates are based on rounded counts.

[a] More than one selection may have been made for youth who died of acute toxicity, as the options were not mutually exclusive. Only one selection could be made in census data.

[b] Includes those who are employed full-time and part-time, and seasonal workers.

[c] The definition for unemployed used by the census may not be equivalent to the definitions used by the coroner and medical examiner offices.

[d] Includes disability support.

[e] Individuals aged 20 to 24 from the 2016 Census (98-316-X2016001) who are not accounted for in the labour force status statistics (98-400-X2016198).

[f] People who are not in the labour force include students, retired persons, unpaid family workers and others not looking for work.

[g] Includes supportive or transitional housing and health or correctional facility (mental health facility, substance use/addictions treatment facility, harm reduction residence, correctional facility or police custody). The chart review study did not include people living in shelters in this category, but they are included in the census count. The mortality rate for people who lived in collective dwellings was not calculated given the difference in definitions for the study and the census.

[h] Acute toxicity deaths data include people who are unsheltered, emergency sheltered, provisionally accommodated, at immediate risk of homelessness or hidden homelessness.

[i] 2016 Census data only include people in shelters. The mortality rate for people who were unhoused was not calculated given the difference in definitions for the study and the census.

TABLE 3
Characteristics of youth aged 12 to 24 years who died of accidental acute toxicity in Canada, 2016 or 2017

Characteristic	Proportion of youth who died of accidental acute toxicity (N = 732), % (n)
Documented mental health conditions or symptoms[a]	
Depressive disorder or depressive symptoms	22 (162)
Substance use disorder (excluding alcohol)	20 (147)
Anxiety disorder	16 (117)
Suicidal ideation/suicide attempt	12 (84)
Alcohol use disorder	5 (39)
Unknown	29 (210)
History of substance use (drugs and/or alcohol)	
Yes	83 (606)
Contact with health services in the year preceding death	
Yes	59 (432)
Potentially traumatic life events[b]	
Any potentially traumatic events in their lifetime	30 (219)
Criminal legal problem (e.g. arrest, jail, court)	14 (102)
Relationship problem not concerning intimate partner (e.g. family argument)	6 (45)
Any potentially traumatic events within 2 weeks of death	5 (36)
History of incarceration[c]	
Yes	6 (45)
Neighbourhood-level income quintile	
Q1 (lowest)	26 (192)
Q2 (medium-low)	16 (114)
Q3 (middle)	12 (90)
Q4 (medium-high)	12 (90)
Q5 (highest)	10 (72)
Unknown	24 (174)

Data source: National Chart Review Study of Substance-Related Acute Toxicity Deaths.[22]

Abbreviation: Q, quartile.

Notes: Counts from the National Chart Review Study of Substance-Related Acute Toxicity Deaths are randomly rounded to base 3, and percentages are based on rounded counts.

[a] More than one selection may have been made as the options were not mutually exclusive. Any mention of a mental health condition or symptom was abstracted but these may not all have been medically diagnosed.

[b] More than one type of potentially traumatic event could be documented for each person. Only the types of potentially traumatic events that occurred for more than 5% of youth that died are shown in this table.

[c] Information protected by the *Youth Criminal Justice Act*;[33] may be less available in coroner and medical examiner files.

half (59%) had contact with health care services in the year preceding their death. At least 30% of the youth had experienced a potentially traumatic event in their lifetime, the most common of these being a criminal legal problem (e.g. arrest, jail time, court hearing; 14%). About one in 20 (5%) experienced a potentially traumatic event in the two weeks before their death. Youth from the lowest neighbourhood income quintile were overrepresented among those who died. It is likely that many of the youths with unknown residential postal codes also belonged to lower income quintiles, because at least one-quarter of those with unknown postal codes were unhoused at the time of their death (data not shown).

Substances contributing to accidental ATDs

Fentanyl (56%), cocaine (30%), methamphetamine (18%) and ethanol (alcohol; 16%) were the most common substances identified as contributing to death among youth who died by accident (Table 4). Seven of the substances contributing to at least 5% of deaths were opioids (fentanyl, morphine, diacetylmorphine [heroin], carfentanil, methadone, oxycodone and hydromorphone); four were stimulants (cocaine, methamphetamine, amphetamine and MDMA); and the other two were alcohol and a benzodiazepine (alprazolam). The substances contributing to accidental deaths for youth were most often of nonpharmaceutical origin. Carfentanil, methadone, fentanyl, cocaine and ethanol (alcohol) contributed to deaths on their own (without the contribution of other substances) more often than other substances.

The substances and substance combinations that were the most common contributors to accidental deaths among youth 12 to 24 years of age were fentanyl alone (111 deaths, 15% of youth) and fentanyl and cocaine in combination (36 deaths, 5% of youth; Figure 1). Most of the top substances and combinations involved opioids and/or stimulants, and most were drugs of nonpharmaceutical origin.

Circumstances of accidental acute toxicity event and death

During the acute toxicity event that led to death, the mode of substance use by youth aged 12 to 24 was most often unknown; however, similar proportions of youth were likely using substances orally (15%), through nasal insufflation (snorting; 14%), smoking (13%) or injection (11%; Table 5).

For 38% (279) of youth, the acute toxicity event was witnessed or potentially witnessed (the person was still alive when found, or it was unclear) (Table 5). In these situations, witnesses called 911 58% of the time and attempted resuscitation 32% of the time. No action was taken by potential witnesses for one in four acute toxicity events (25%). When no action was taken at the first encounter, the potential witnesses believed the individual was sleeping 61% of the time. Other reasons the potential witness might not have taken action at the first encounter included not recognizing a medical emergency or lack of access to a phone, for example.

During subsequent encounters, potential witnesses called 911 in 91% of cases and attempted resuscitation in 35% of cases.

TABLE 4
Origin of the most common substances contributing to accidental acute toxicity deaths among youth 12 to 24 years of age in Canada, 2016 to 2017

Most common substances contributing to death	Deaths where substance contributed (N = 732), n (%)	When substance contributed to death, the origin of the substance,[a] n (%)			When substance contributed to death, the contribution of other substances, n (%)	
		Nonpharmaceutical	Pharmaceutical	Unknown	None	Multiple substances contributed
Fentanyl	408 (56)	213 (52)	Suppressed	189 (46)[b]	111 (27)	297 (73)
Cocaine	216 (30)	208 (100)	NA	NA	24 (11)	189 (88)
Methamphetamine	132 (18)	125 (100)	NA	NA	Suppressed	126 (96)
Ethanol (alcohol)	117 (16)	NA	NA	NA	12 (10)	102 (87)
Morphine	96 (13)	21 (22)	0 (0)	78 (81)	Suppressed	90 (94)
Amphetamine	84 (12)	15 (18)	Suppressed	68 (81)	Suppressed	81 (96)
Diacetylmorphine (heroin)	75 (10)	75 (100)	NA	NA	Suppressed	72 (96)
Alprazolam	72 (10)	NA	72 (100)	NA	Suppressed	69 (96)
Carfentanil	63 (9)	51 (100)	NA	NA	24 (38)	39 (62)
Methadone	48 (7)	NA	45 (100)	NA	15 (31)	33 (69)
Oxycodone	39 (5)	NA	39 (100)	NA	0 (0)	39 (100)
Hydromorphone	36 (5)	NA	36 (100)	NA	Suppressed	30 (83)
MDMA	36 (5)	36 (100)	NA	NA	Suppressed	27 (75)
For all deaths	732 (100)	534 (73)	213 (29)	84 (12)	480 (66)	237 (32)

Data source: National Chart Review Study of Substance-Related Acute Toxicity Deaths.[22]

Abbreviation: NA, not applicable.

Notes: More than one substance can be identified as a contributor to death in a single ATD. Some of the substances in this table are active metabolites of other substances. For example, morphine is a metabolite of heroin and amphetamine is a metabolite of methamphetamine. Their presence in toxicology might indicate that they were consumed, or a parent substance was consumed. Counts from the National Chart Review Study of Substance-Related Acute Toxicity Deaths are randomly rounded to base 3, and percentages are based on rounded counts.

[a] A substance can have more than one origin. Some substances have only one origin and the other is not applicable (NA).

[b] In most cases where fentanyl is listed as being of unknown origin, it is due to data being unavailable from British Columbia. As pharmaceutical fentanyl is not widely available, nearly all fentanyl of unknown origin is likely to have been nonpharmaceutical.

When individuals showed symptoms of opioid toxicity (such as snoring or gurgling, difficulty breathing, pinpoint pupils, being unconscious or unresponsive, or blue lips, fingernails or face), naloxone was given at least 34% of the time.

The most common place of acute toxicity event was in a personal residence setting (60%) followed by the home of another person (15%). A minority of acute toxicity events occurred outside (6%) or inside a vehicle (4%). Almost one-third of those who died were found in or near a bed (31%). Most youth died where the acute toxicity event occurred (70%), while 23% died in a hospital.

Discussion

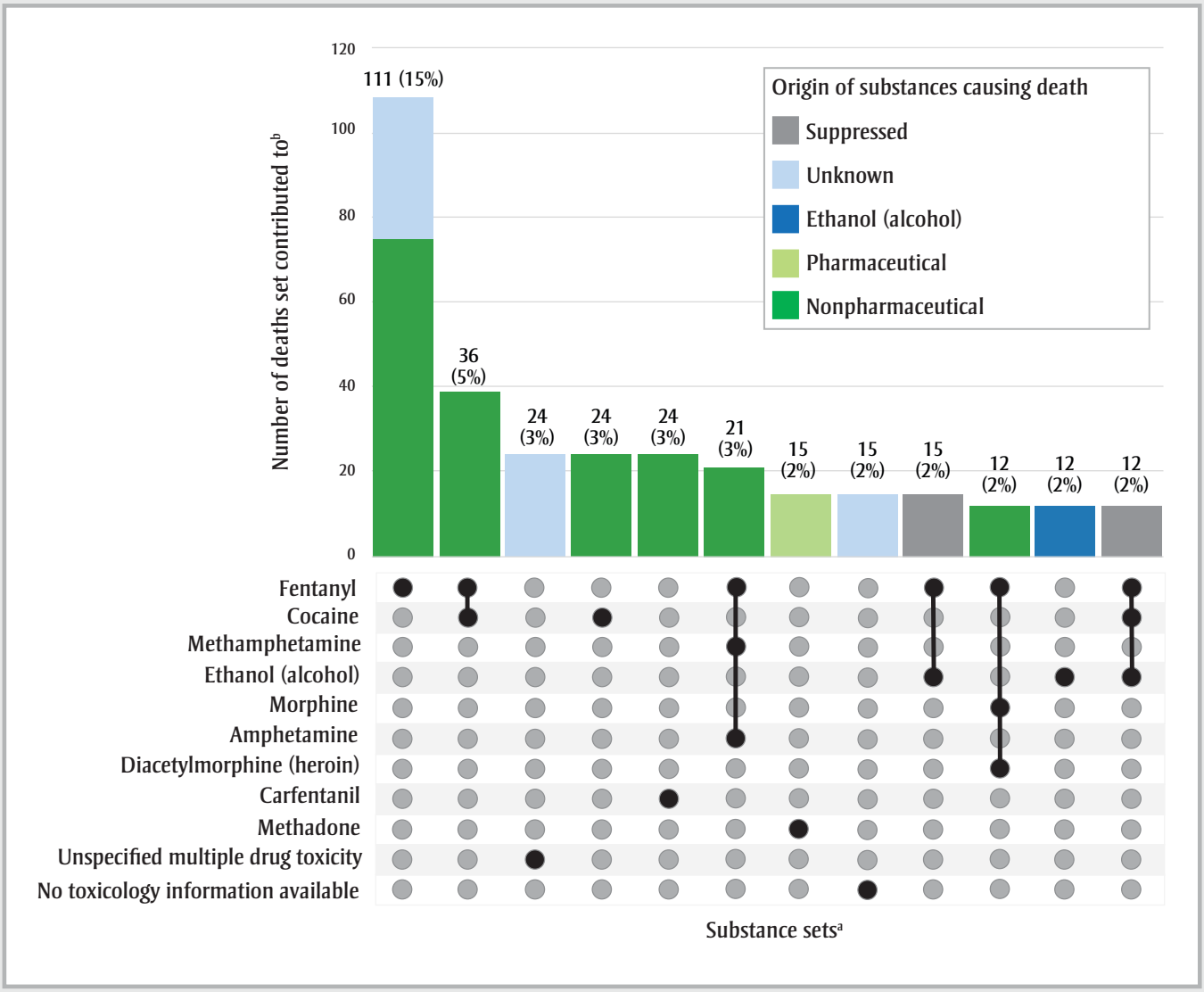
The findings of this study highlight the minimum prevalence of factors among accidental youth ATDs that previous researchers have identified as important for youth substance use, substance use disorders, and ATDs. Most youth who died of acute toxicity had a history of substance use (83%), and 20% had a documented history of a substance use disorder. Mental health conditions or symptoms such as depressive disorder or depressive symptoms, anxiety disorder and suicidal ideation or suicide attempts were commonly documented among youth who died of acute toxicity.

Previous research has pointed to the relationship between mental illness, history of substance use and substance use disorders;[5-6,12] this study's findings further illuminate the need for early prevention, treatment and harm reduction for substance use and accessible mental health care and supports for youth to prevent ATDs. More than half of youth had contact with health services in the year preceding their death, suggesting a potential opportunity for intervention. Ensuring that substance use services for youth are appropriately tailored to the unique needs of this population is important. Improved and targeted supports for youth, including during transitions to early adulthood, could reduce harms in this population.

Additionally, about one-third of youth who died of accidental acute toxicity experienced at least one potentially traumatic event in their lifetime. This finding aligns with existing literature on the role that trauma plays in substance use disorders.[34] However, different types of traumatic events may impact individuals differently, and may or may not always be related to substance use. Death investigations do not deliberately set out to collect potentially traumatic events that occurred earlier in life; therefore, the number of youth who had been exposed to traumatic events is likely higher than was documented in this study. In British Columbia, 73% of youth aged 18 and younger who died of an unregulated drug-related acute toxicity were in receipt of child, youth or family services.[12]

The results of this study also suggest potential opportunities for targeted upstream

FIGURE 1
UpSet plot of the most frequent substances and substance combinations contributing to accidental deaths for youth 12 to 24 years of age in Canada, 2016 to 2017



Data source: National Chart Review Study of Substance-Related Acute Toxicity Deaths.[22]

Notes:

(a) The grid of substance sets displays specific substances and combinations of substances contributing to death in columns. Substances are represented by black dots and combinations are joined by a black line. "Unspecified multiple drug toxicity" refers to cases in which multiple substances contributed to death but the specific substances were not identified. "No toxicology information" means that nothing is known about specific substances contributing to death or their number.

(b) The vertical bar chart shows the number of deaths for which a specific substance or substance combination described in the grid below contributed to death. The percentage of deaths due to the set is also shown above the bars. The bars are coloured to show the origin of the substances. As pharmaceutical fentanyl is not widely available, nearly all fentanyl of unknown origin is likely to be nonpharmaceutical.

Morphine and amphetamine are active metabolites of diacetylmorphine (heroin) and methamphetamine, respectively, and might be present in toxicology results because the parent substance was consumed (diacetylmorphine [heroin] or methamphetamine). Counts are randomly rounded to base 3. Sets contributing to fewer than 10 deaths were excluded from the plot. The substances in the UpSet plot differ from the substances most commonly contributing to death (Table 2) because exclusive combinations are prioritized over total number of deaths. For example, although alprazolam contributed to 10% of deaths, it does not appear in the UpSet plot because it was involved in a variety of combinations contributing to fewer than 10 deaths each.

interventions. Male youth aged 18 to 24 accounted for the highest proportion of youth ATDs. Unemployed youth had a very high mortality rate due to acute toxicity, though it is unknown if all people described as unemployed in their coroner or medical examiner file met the Statistics Canada definition. Youth who lived in collective housing or were unhoused were overrepresented among those who died of acute toxicity. The Statistics Canada definition of collective housing includes more institution types than that used by the chart review study, yet the minimum proportion of youth who died of accidental acute toxicity and lived in collective housing was higher than that of the general population of youth (4% and <1%, respectively). The Statistics Canada definition of being unhoused counted only those who were staying in a shelter, while the chart review study definition also included youth unsheltered on the street or temporarily staying with family or

TABLE 5
Circumstances of death for accidental acute toxicity events and deaths among youth 12 to 24 years of age in Canada, 2016 to 2017

Circumstances of death	Proportion, % (n)
Mode of substance use,[a] N = 732	
Likely oral	15 (108)
Likely nasal insufflation or intranasal (snorting)	14 (102)
Likely smoking	13 (96)
Likely injection	11 (78)
Other or unknown[b]	57 (420)
Witnesses, N = 732	
No, individual deceased when found and no evidence event was witnessed	22 (162)
Unclear, unconscious or unresponsive when found	21 (150)
Yes, individual alive when found and showing symptoms of acute toxicity	12 (90)
Unclear, individual thought to be asleep	6 (42)
Unknown	39 (288)
Action taken when potential witness was at scene,[c] N = 279	
Called 911	58 (162)
Attempted resuscitation[d]	32 (90)
No action taken	25 (69)
Other	23 (63)
When potential witness did not take action at first encounter, N = 69	
Witness thought they were sleeping	61 (42)
On subsequent encounter, called 911	91 (63)
On subsequent encounter, attempted resuscitation[d]	35 (24)
On subsequent encounter, took some other action[e]	17 (12)
Naloxone given to individuals showing symptoms of opioid toxicity,[f] N = 255	
Yes	34 (87)
No	25 (63)
Unknown	41 (105)
Location of acute toxicity event, N = 732	
Indoor setting	93 (684)
Personal residence	60 (441)
Home of another person	15 (108)
Hotel or motel	3 (21)
Public building	2 (15)
Substance use/addictions treatment facility	2 (12)
Other (all other indoor settings)	5 (36)
Outdoor setting	6 (45)
Outdoor public place	5 (33)
Other (all other outdoor settings)	2 (12)
Unknown setting	8 (57)
Living situation of those who had the acute toxicity event inside their personal residence, N = 441	
Living with parents	20 (90)
Living with friends or roommates	9 (39)
Living alone	7 (30)
Living with partner (not common law or unknown if common law)	3 (12)

Continued on the following page

friends. Nevertheless, it is very concerning that nearly 1 in 10 youth who died of accidental acute toxicity were documented as unhoused—a situation that should be rare.

Developing prevention and harm reduction programs specifically for youth who are unemployed, living in collective housing or unhoused would reach a large proportion of youth at risk for ATD. These findings also highlight a need for improved service integration for this population, so that other social supports such as housing and employment that are often interrelated are easily accessible alongside mental health and substance use services.

The substances most commonly contributing to youth ATDs were opioids and stimulants of nonpharmaceutical origin. In Canada, illegal fentanyl was first recognized in 2011, and by 2016, opioids were among the top 10 controlled substances most detected by Canada's Drug Analysis Service (DAS).[35] Additionally, over half of the heroin samples tested by DAS between 2012 and 2017 contained fentanyl.[35] As youth may not have been aware of these changes in the drug supply, increasing awareness of the presence of fentanyl in other substances could potentially reduce accidental ATDs.[4,36] People who have been using opioids for a long time develop a tolerance, requiring greater amounts over time to achieve the same effects.[17] Those who have just started using substances or who have had a break in substance use—situations in which many youth may find themselves—cannot tolerate greater amounts, and highly toxic opioids such as fentanyl present a greater risk.

Evidence-based prevention and treatment for opioid toxicity such as naloxone access, opioid agonist treatment and supervised consumption sites are key.[37] Drug-checking services that are accessible to youth may allow them to test that the substances they purchase on the street are not contaminated with dangerous drugs.[37] Additionally, services that offer prescribed medications as an alternative to illegal drugs may give youth access to a safer supply while connecting them with health and social services.[38]

Another important method to reduce the risk of an ATD is to not use substances alone.[17] Only 38% of accidental acute toxicity events leading to death among youth

TABLE 5 (continued)
Circumstances of death for accidental acute toxicity events and deaths among youth 12 to 24 years of age in Canada, 2016 to 2017

Circumstances of death	Proportion, % (n)
Living with family (spouse, common law partner or children)	3 (12)
Other	4 (18)
Unknown	53 (234)
Specific setting of acute toxicity event, N = 732	
In or near bed	31 (228)
Vehicle	4 (27)
Location of death, N = 732	
Same as place of acute toxicity event	70 (513)
Hospital	23 (168)
Other	7 (51)

Data source: National Chart Review Study of Substance-Related Acute Toxicity Deaths.[22]

Notes: Counts from the National Chart Review Study of Substance-Related Acute Toxicity Deaths are randomly rounded to base 3, and percentages are based on rounded counts.

[a] More than one mode of use may have been selected, so the combined count does not equal the total number of ATDs in youth. There can be uncertainty about the mode of drug use; therefore, these are described as the mode of use most likely based on evidence available in the death investigation file.

[b] Includes unknown or other modes of use (e.g. transdermal patches); these categories have been collapsed because of small cell sizes.

[c] The denominator for "action taken" proportion calculations is the number of ATDs in which the person was still alive (or if it was unclear if they were still alive) when found. More than one action may have been taken by each potential witness; these actions are not mutually exclusive.

[d] Includes CPR, rescue breathing, stimulation, giving epinephrine, giving oxygen and other resuscitative activities.

[e] Includes calling someone else, other, and no action taken.

[f] The denominator for "Naloxone given to individuals showing symptoms of opioid toxicity" proportion calculations is the number of ATDs for which opioid toxicity symptoms (such as snoring, difficulty breathing, loss of balance, confusion, or if the individual was asleep) were observed.

were witnessed or potentially witnessed by someone who could call for help or give aid. Among the youth whose fatal acute toxicity event occurred in their personal residence, 20% lived with their parents, 9% lived with friends or roommates and only 7% were living alone. For many of those who died, someone might have been nearby while they used substances, but stigma may have prevented the youth from telling others about their substance use and having someone who could support them in the event of an emergency.[39]

The ability of the bystander to recognize and respond to an acute toxicity event is also important. About one in three youth were found in or near a bed, and when bystander actions were delayed, it was most often due to a belief that the person was asleep or sleeping off substance use. These findings suggest a need for increasing awareness of the signs of acute toxicity and how it may be confused with sleep so that bystanders can better recognize the medical emergency.

Other reasons bystanders might not act immediately could be the absence of a phone to call 911 or not having naloxone on hand, for example. Improving access to naloxone and the means of calling emergency health services would increase bystanders' ability to act more rapidly.

Targeted public education and awareness efforts on the toxicity of the drug supply and recognizing and responding to an overdose, as well as to reduce stigma around substance use in this population remain important. It is also relevant to note that the study period reflects the early stages of the overdose crisis before communications and messaging efforts were widely increased.

Some of the youth in this study were above the legal threshold for majority, and some were below; there are big differences in how laws, policies and practices are applied to these two groups.[36] While minors are often grouped together in these analyses due to small counts, interventions for youth under the age of 18 must consider the roles of parents and guardians and children's rights.

Strengths and limitations

This study provides an important baseline to examine ATDs among Canadian youth on the national level near the beginning of the overdose crisis. Coroner and medical examiner data provide details on the circumstances of death, such as the location of death and the presence of witnesses, and are often more comprehensive than other mortality data sources.

However, it is important to note that death investigations are not methodologically designed to collect all variables of interest to our study, and some variables may be more likely to have missing data than others. Information protected by the *Youth Criminal Justice Act*,[33] such as history of incarceration, may have been less available in the death investigation files for youth. Based on the numbers reported by British Columbia,[12] death investigation files provide limited documentation of child, youth or family services received by youth who died. Therefore, as information is missing for many of our variables of interest, the findings in this analysis only represent the minimum proportions of youth characteristics, and the mortality rates and proportions presented are likely underestimated.

Both the drug supply and environmental stressors have changed since the study period in 2016 and 2017, particularly during the years of the COVID-19 pandemic. Some of the findings may no longer be as relevant to youth today, as the substances contributing to death and the harm reduction practices adopted by youth may have changed since 2017. There has been conflicting evidence on whether substance use among youth decreased or increased during the COVID-19 pandemic; changes in the patterns of substance use may be due to other factors.[40-43]

Based on an Ontario comparison of youth aged 15 to 24 who died of opioid-related acute toxicity during the pre-pandemic period versus the pandemic period, we might expect to see an increase in the proportion of deaths to which nonpharmaceutical fentanyl or benzodiazepines contributed, fewer deaths outdoors and an increase in substance use via inhalation or smoking in recent years across Canada after our study period.[6] However, as the

pace of change and context of the overdose crisis varies across provinces and territories, it is difficult to extrapolate from one province to the national level.

Nevertheless, despite the older study period, this study identified concerning upstream factors that were highly prevalent among youth who died of acute toxicity and can serve as a baseline for future studies.

Conclusion

This study provides an important baseline near the beginning of the overdose crisis for examining ATDs among Canadian youth on the national level, and will support future work investigating how the crisis has evolved over time. Understanding the characteristics of youth who died of accidental acute toxicity, the substances contributing to their deaths and the circumstances of death can inform harm reduction and social programs and policies to better meet the needs of youth and prevent further acute toxicity deaths. Additionally, these findings highlight the need to implement early prevention interventions that address mental health, exposure to trauma, unemployment and homelessness to reduce the harms of substance use on Canadian youth.

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Conflicts of interest

None.

Authors' contributions and statement

YSC, AV, KM, FK: Conceptualization.

YSC, AV: Analysis.

YSC: Writing—original draft.

YSC, AV, KM, FK: Writing—review & editing.

YSC, AV: Project administration.

AV: Supervision.

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