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Routes of Marijuana Use — Behavioral Risk Factor Surveillance System, 22 U.S. States and Two Territories, 2022

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Abstract

Access to and use of cannabis in the United States has increased as new product types emerge in the marketplace, and as additional states legalize its use for medical and nonmedical purposes. To tailor education messages for preventing adverse health effects of cannabis use, understanding the routes of use of these products in the general population is important. The 2022 Behavioral Risk Factor Surveillance System included a newly revised optional marijuana module comprising questions on marijuana routes of use among adults aged ≥18 years who used marijuana during the past 30 days (current use). Twenty-two states and two territories administered the optional marijuana module in 2022. Weighted prevalences (with 95% CIs) of current and daily or near-daily marijuana use, as well as prevalence of each route of use, were reported overall and by demographic characteristics and, among women aged ≤49 years, by pregnancy status. Among the 15.3% of respondents who reported current marijuana use, smoking was the most frequent route (79.4%), followed by eating (41.6%), vaping (30.3%), and dabbing (inhaling heated concentrated cannabis) (14.6%). Vaping and dabbing were most prevalent among persons aged 18–24 years. Intervention measures intended for persons who smoke cannabis are important; however, understanding health outcomes associated with other routes of use might have substantial public benefit.

Introduction

As of June 2024, 38 states, three territories, and the District of Columbia (DC) have legalized cannabis* use for state-defined qualifying medical conditions, and 24 states, two territories, and DC have legalized nonmedical adult cannabis use (*1*). In recent decades, the perception of risk associated with cannabis use has decreased; cannabis products containing higher concentrations of tetrahydrocannabinol (THC), the psychoactive compound found in cannabis, have become more intoxicating, and routes of use (more commonly known as routes of administration) have evolved (*2*).

As the availability and types of cannabis products expand, less is known about how persons consume cannabis. Historically, cannabis has most often been smoked; however, additional routes of use are available, including oral ingestion, vaping, and more recently, dabbing (i.e., inhalation of highly concentrated THC-based oils often heated using a blowtorch) (*3*,*4*). Different routes of use might increase the risk for certain health effects; examples include an increased risk for lung injury associated with potential contaminants when vaping cannabis,† acute psychosis from dabbing highly concentrated

* Cannabis (e.g., marijuana, weed, pot, or bud) refers to the dried flowers, leaves, stems, and seeds of the cannabis plant and does not include hemp-based or cannabidiol-only products. Because the term marijuana is used in the Behavioral Risk Factor Surveillance System optional marijuana module, it is used in this report when referring to the survey results.

† https://archive.cdc.gov/#/details?url=https://www.cdc.gov/tobacco/basic_information/e-cigarettes/severe-lung-disease.html

INSIDE

205 Controlled Substance Prescribing Patterns Among Fatal Overdose Decedents with an Opioid, Stimulant, or Both Contributing to Death — Pennsylvania, 2017–2022

210 Notes from the Field: Recreational Nitrous Oxide Misuse — Michigan, 2019–2023

213 Notes from the Field: Suicidal Thoughts and Knowing Someone Who Died by Suicide Among Adults — United States, 2023

Continuing Education examination available at https://www.cdc.gov/mmwr/mmwr_continuingEducation.html

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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THC products, or overconsumption of cannabis when ingesting edibles (*4*).

Surveillance is important to better understand routes of cannabis use and frequency of use, especially given the rapid shifts in the cannabis marketplace. Limited information is available on the current prevalence of the most common routes of cannabis use. U.S. studies on routes of cannabis use might be outdated or include small sample sizes and are frequently single-state samples (*3*,*5*). This study analyzed data from the optional marijuana module administered in 22 U.S. states and two territories as part of the 2022 Behavioral Risk Factor Surveillance System (BRFSS) to measure the prevalence of routes of cannabis use among adults aged ≥18 years.

Methods

Data Source and Primary Measures

BRFSS is an annual, state-based landline and cellular telephone survey of health behaviors and conditions of noninstitutionalized adults aged ≥18 years in all 50 U.S. states, DC, and three territories.[§] The median combined response rate for BRFSS in 2022 was 45.1% for all states and territories, ranging from 22% to 58% in the jurisdictions included in this study[¶] (*6*).

In 2022, a total of 22 U.S. states and two territories[**] included a revised (2022) optional marijuana module that asked about current marijuana use and routes of use.[††] This was the first optional marijuana module administered since 2016 that permitted selection of multiple routes of use. In the revised 2022 module, respondents who reported past 30-day use were also asked to indicate all routes of marijuana use and primary route of use during the previous 30 days (during 2017–2021, the marijuana modules only permitted selection of one primary route of use).

Current marijuana use was defined as any reported use during the past 30 days, and daily or near-daily use (daily use) was defined as reported use ≥20 times during the past 30 days. Current and daily marijuana use and routes of use were measured by age group (18–24, 25–34, 35–44, 45–54, 55–64, and ≥65 years), sex (female or male), race and ethnicity (non-Hispanic American Indian or Alaska Native [AI/AN], non-Hispanic Asian, non-Hispanic Black or African American, non-Hispanic Native Hawaiian or Pacific Islander [NH/PI], non-Hispanic White; Hispanic or Latino [Hispanic], and non-Hispanic multiracial persons), highest level of education attained (less than high school, high school diploma or general

§ https://www.cdc.gov/brfss/

¶ https://www.cdc.gov/brfss/annual_data/2022/pdf/Overview_2022-508.pdf

** Connecticut, Delaware, Hawaii, Illinois, Indiana, Kansas, Maine, Maryland, Massachusetts, Michigan, Mississippi, Montana, Nebraska, Nevada, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, Virginia, Wisconsin, Wyoming, Guam, and the U.S. Virgin Islands.

†† https://www.cdc.gov/brfss/questionnaires/modules/category2022.htm

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educational development certificate, some college, or college degree), and pregnancy status[§§] (pregnant or not pregnant).

Statistical Analysis

Prevalence and 95% CIs of current and daily marijuana use and routes of use were reported overall and by age group, sex, race and ethnicity, education level, and pregnancy status. Rao-Scott chi-square tests were used to identify differences across sociodemographic characteristics, with p-values <0.05 considered statistically significant. Sample weights and design variables were used to account for the complex survey design.[¶¶] Analyses were conducted using R (version 4.3.2, R Foundation). This activity was reviewed by CDC, deemed not research, and was conducted consistent with applicable federal law and CDC policy.[***]

Results

The study population comprised 138,625 respondents, including 14,044 (15.3%) who reported current marijuana use, and 6,848 (7.9%) who reported daily use (Table 1). Both current and daily marijuana use were most prevalent among adults aged 18–24 years (25.9% and 13.4%, respectively), males (18.0% and 9.5%, respectively), non-Hispanic multiracial adults (24.7% and 14.0%, respectively), AI/AN adults (20.7% and 14.0%, respectively), those with a high school diploma or less (17.2%–17.4% and 10.1%–12.1%, respectively), and women who were not pregnant (19.5% and 10.1%, respectively).

Among adults who reported current cannabis use, smoking was the most prevalent route of use (79.4%), followed by eating (41.6%), vaping (30.3%), and dabbing (14.6%) (Table 2). Vaping and dabbing were most prevalent among adults aged 18–24 years (44.7% and 28.4%, respectively) and among NH/PI adults (51.7% and 42,9%, respectively). Dabbing was also more prevalent among AI/AN adults (29.3%), and adults with less than a high school diploma (23.0%). A majority of respondents reported smoking as their primary route of use (62.4%; 95% CI = 60.2%–64.6%), followed by vaping (16.8%; 95% CI = 15.1%–18.6%) and eating (14.2%; 95% CI = 12.8%–15.8%).

Approximately one half of adults who currently use cannabis reported two or more routes of use (46.7%; 95% CI = 45.1%–48.3%). Among adults who reported current cannabis use and two or more routes of use, the most prevalent combinations were smoking and eating (55.2%; 95% CI = 52.7%–57.6%) and smoking and vaping (54.5%; 95% CI = 52.1%–56.9%) (Figure).

Summary

What is already known about this topic?

Cannabis policies, availability, products, and use patterns in the United States have changed during the last several years. Historically, smoking has been the most common route of cannabis use; however, other routes of use are increasing.

What is added by this report?

In 2022, 15.3% of adults reported current cannabis use, approximately 80% of whom reported smoking. Eating, vaping, and dabbing (inhaling heated concentrated cannabis) were also common, and approximately one half of respondents reported multiple routes of use. Vaping and dabbing were most prevalent among adults aged 18–24 years.

What are the implications for public health practice?

Continued surveillance of routes of cannabis use and use patterns might be helpful to understanding health outcomes in the evolving cannabis marketplace.

Discussion

In this analysis of the BRFSS optional marijuana module, 15.3% of adults reported current marijuana use. Among adults aged 18–24 and 25–34 years, approximately one in four reported current marijuana use, and approximately one in eight reported daily use. Current marijuana use was lower among pregnant women than among those who were not pregnant, similar to findings from other national studies (*7*). Approximately four in five adults with current cannabis use reported smoking; other routes of use, including eating, vaping, and dabbing, were also common. Approximately one half of adults with current cannabis use reported multiple routes of use.

Compared with 2016 BRFSS data in 12 states, the prevalences of eating and vaping marijuana were each higher in 2022, as was the prevalence of reporting multiple routes of use (*3*). These differences might reflect a shift in use patterns and might also reflect the larger sample and inclusion of different states in this analysis. Monitoring these changes is important because each route of use is associated with unique health risks. For example, the wider availability of edibles has been associated with increased accidental pediatric ingestion (*2*).

Vaping and dabbing were most common among young adults aged 18–24 years. Trends in both of these routes of use have increased among adolescents and young adults (*2*,*8*). This shift in routes of use among younger persons could lead to exposure to higher concentrations of THC at an age when brain development is still occurring, and thus increase the

§§ Only asked of women aged ≤49 years.

¶¶ https://www.cdc.gov/brfss/annual_data/2022/pdf/Complex-Sampling-Weights-and-Preparing-Module-Data-for-Analysis-2022-508.pdf

*** 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

TABLE 1. Prevalence of current* and daily or near-daily† marijuana§ use, overall and across sociodemographic characteristics — Behavioral Risk Factor Surveillance System, 22 U.S. states and two territories,¶ 2022

		Current marijuana use*			Daily or near-daily marijuana use†		
Characteristic	**Total no.**	**No.**	**Weighted % (95% CI)**	**p-value****	**No.**	**Weighted % (95% CI)**	**p-value****
Overall	**138,625**	**14,044**	**15.3 (14.9–15.7)**	—	**6,848**	**7.9 (7.6–8.2)**	—
Age group, yrs							
18–24	**8,063**	1,626	25.9 (24.1–27.9)	<0.001	1,801	13.4 (11.9–15.0)	<0.001
25–34	**13,968**	2,579	24.2 (22.7–25.6)		2,873	13.0 (11.9–14.1)	
35–44	**17,881**	2,635	19.2 (18.1–20.4)		3,230	10.6 (9.7–11.6)	
45–54	**20,393**	2,089	12.9 (12.0–13.9)		3,625	6.6 (6.0–7.4)	
55–64	**26,107**	2,490	11.3 (10.5–12.2)		4,164	5.5 (5.0–6.2)	
≥65	**52,213**	2,625	6.2 (5.7–6.7)		7,339	2.6 (2.3–2.9)	
Sex							
Female	**73,892**	6,047	12.8 (12.2–13.4)	<0.001	2,824	6.4 (6.0–6.9)	<0.001
Male	**64,733**	7,997	18.0 (17.3–18.7)		4,024	9.5 (8.9–10.0)	
Race and ethnicity**							
AI/AN	**2,092**	331	20.7 (17.3–24.7)	<0.001	207	14.0 (11.0–17.5)	<0.001
Asian	**5,282**	240	5.9 (4.7–7.4)		86	1.7 (1.2–2.6)	
Black or African American	**11,245**	1,117	19.0 (17.3–20.8)		597	10.4 (9.2–11.8)	
NH/PI	**1,732**	211	17.1 (11.7–24.4)		89	6.5 (4.2–10.0)	
White	**103,965**	10,427	15.0 (14.5–15.5)		4,964	7.6 (7.2–7.9)	
Hispanic or Latino	**10,414**	1,099	13.4 (12.2–14.7)		568	7.1 (6.2–8.1)	
Multiracial	**3,895**	619	24.7 (21.5–28.2)		337	14.0 (11.5–16.9)	
Education							
Less than HS	**7,516**	844	17.4 (15.6–19.4)	<0.001	525	12.1 (10.5–13.9)	<0.001
HS diploma or GED	**35,221**	4,001	17.2 (16.3–18.1)		2,266	10.1 (9.4–10.8)	
Some college	**38,245**	4,320	16.9 (16.0–17.7)		2,207	8.5 (7.9–9.2)	
College degree	**57,031**	4,862	11.5 (11.0–12.1)		1,840	4.1 (3.8–4.4)	
Pregnancy status††							
Pregnant	**706**	43	6.6 (4.2–10.3)	<0.001	21	4.2 (2.3–7.6)	0.003
Not pregnant	**23,254**	3,431	19.5 (18.5–20.6)		1,646	10.1 (9.3–11.0)	

Abbreviations: AI/AN = American Indian or Alaska Native; GED = general educational development certificate; HS = high school; NH/PI = Native Hawaiian or Pacific Islander.
* Current use is defined as any use during the past 30 days.
† Daily or near-daily use is defined as use ≥20 times during the past 30 days.
§ The term marijuana, rather than cannabis, is used when referring to survey findings to align with the Behavioral Risk Factor Surveillance System optional marijuana module. In this report, both terms refer to the dried flowers, leaves, stems, and seeds of the cannabis plant and do not include hemp-based or cannabidiol-only products. All table comparison p-values are based on Rao-Scott chi-square tests.
¶ Reflects noninstitutionalized adults (aged ≥18 years) in Connecticut, Delaware, Hawaii, Illinois, Indiana, Kansas, Maine, Maryland, Massachusetts, Michigan, Mississippi, Montana, Nebraska, Nevada, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, Virginia, Wisconsin, Wyoming, Guam, and the U.S. Virgin Islands.
** Persons of Hispanic or Latino (Hispanic) origin might be of any race but are categorized as Hispanic; all racial groups are non-Hispanic.
†† Pregnancy status only asked of women aged ≤49 years.

risk for cannabis use disorder, injuries, or acute psychosis (*2*). In addition, those who consume cannabis through vaping can also be exposed to potentially harmful contaminants or adulterants, as was the case during the 2019 e-cigarette, or vaping, product use–associated lung injury outbreak that was strongly linked with vitamin E acetate, an additive in some THC-containing vapes (*9*). Dabbing also often requires the use of a blowtorch, which might increase the risk for burn injuries (*4*). AI/AN and NH/PI adults also reported the highest prevalences of dabbing (42.9% and 29.3%, respectively). Therefore, increased efforts to decrease dabbing among these two populations might decrease the risk for the associated potential adverse health effects.

Limitations

The findings in this report are subject to at least three limitations. First, the BRFSS optional marijuana module was not administered in all jurisdictions; therefore, this study sample is not representative of the entire U.S. adult population. Second, data are self-reported, which might lead to underestimation of prevalence estimates if respondents were influenced by social desirability. Finally, questions about routes of use had not been consistently asked across previous BRFSS survey years or asked consistently across the same jurisdictions every survey year. Therefore, it is not possible to examine trends in routes of use, and comparisons of results to those obtained in previous years might reflect changes in sampling rather than only changes in prevalence.

TABLE 2. Prevalence of routes of marijuana use among persons who reported current marijuana use,*,† overall and across sociodemographic characteristics — Behavioral Risk Factor Surveillance System, 22 U.S. states and two territories,§ 2022

	Route of marijuana use									
	Smoking		Eating		Vaping		Dabbing¶		Other	
Characteristic	Weighted % (95% CI)	p-value	Weighted % (95% CI)	p-value	Weighted % (95% CI)	p-value	Weighted % (95% CI)	p-value	Weighted % (95% CI)	p-value
Overall	**79.4 (78.2–80.5)**	—	**41.6 (40.1–43.2)**	—	**30.3 (28.8–31.9)**	—	**14.6 (13.5–15.8)**	—	**6.0 (5.3–6.9)**	—
Age group, yrs										
18–24	86.1 (83.2–88.5)	<0.001	36.5 (32.7–40.5)	<0.001	44.7 (40.6–48.9)	<0.001	28.4 (24.7–32.4)	<0.001	6.2 (4.3–8.5)	0.887
25–34	81.7 (78.9–84.1)		42.2 (38.9–45.6)		36.6 (33.4–40.0)		16.8 (14.6–19.3)		6.3 (4.6–8.5)	
35–44	77.0 (74.2–79.6)		48.3 (44.9–51.7)		30.9 (27.7–34.3)		13.4 (11.0–16.1)		5.2 (3.8–6.9)	
45–54	76.0 (72.7–79.0)		46.4 (42.7–50.3)		23.4 (20.4–26.6)		11.2 (9.0–13.9)		6.6 (5.1–8.3)	
55–64	79.8 (76.9–82.4)		34.6 (31.2–38.1)		16.4 (13.7–19.4)		4.6 (3.3–6.5)		6.2 (4.3–8.5)	
≥65	69.0 (65.3–72.5)		39.1 (35.4–43.0)		11.9 (9.8–14.4)		1.6 (1.0–2.5)		6.0 (4.6–7.8)	
Sex										
Female	74.2 (72.2–76.1)	<0.001	46.4 (43.9–48.8)	<0.001	29.3 (27.0–31.7)	0.24	10.9 (9.4–12.7)	<0.001	6.4 (5.4–7.6)	0.375
Male	83.3 (81.8–84.7)		38.0 (36.0–40.0)		31.1 (29.2–33.1)		17.4 (15.8–19.2)		5.8 (4.7–6.9)	
Race and ethnicity**										
AI/AN	87.2 (77.4–93.2)	<0.001	34.8 (26.7–44.0)	<0.001	36.8 (27.8–46.8)	<0.001	29.3 (21.0–39.2)	<0.001	8.5 (3.9–15.8)	0.033
Asian	72.9 (61.0–82.3)		31.5 (22.2–42.4)		39.0 (28.1–51.2)		15.9 (8.3–28.5)		4.6 (0.9–13.0)	
Black or African American	89.6 (86.5–92.0)		30.9 (26.3–35.9)		19.8 (15.9–24.4)		8.0 (5.6–11.2)		4.8 (2.5–8.2)	
NH/PI	78.5 (44.2–94.4)		34.6 (19.8–53.2)		51.7 (32.3–70.6)		42.9 (23.4–65.0)		5.8 (0.7–19.9)	
White	76.5 (75.0–77.9)		44.7 (43.0–46.5)		31.2 (29.4–32.9)		14.6 (13.2–16.0)		5.5 (4.8–6.3)	
Hispanic or Latino	84.5 (81.0–87.5)		39.4 (32.0–47.2)		33.2 (28.6–38.2)		18.9 (15.0–23.5)		9.0 (6.1–12.6)	
Multiracial	79.5 (72.2–85.3)		40.2 (35.3–45.3)		34.6 (27.3–42.8)		16.2 (11.2–22.8)		10.3 (6.0–16.1)	
Education										
Less than HS	92.1 (88.9–94.4)	<0.001	28.3 (23.3–33.9)	<0.001	28.8 (23.7–34.5)	0.055	23.0 (18.1–28.8)	<0.001	6.1 (3.9–9)	0.82
HS diploma or GED	86.0 (84.0–87.7)		33.9 (31.3–36.6)		32.2 (29.5–35.1)		20.2 (17.9–22.7)		6.6 (5.1–8.3)	
Some college	80.8 (78.6–82.9)		40.9 (38.1–43.6)		31.6 (29.0–34.4)		12.5 (10.9–14.4)		5.7 (4.5–7.2)	
College degree	62.7 (60.2–65.2)		59.0 (65.5–61.5)		26.8 (24.6–29.1)		6.5 (5.4–8.0)		5.9 (4.7–7.2)	
Pregnancy status††										
Pregnant	72.0 (46.2–88.5)	0.65	36.0 (17.6–59.6)	0.38	23.4 (9.1–48.2)	0.34	12.2 (4.5–29.0)	0.82	7.5 (1.3–33.3)	0.85
Not pregnant	76.8 (74.3–79.1)		46.5 (43.4–49.5)		34.5 (31.6–37.5)		13.6 (11.6–15.9)		6.3 (5.1–7.8)	

Abbreviations: AI/AN = American Indian or Alaska Native; GED = general educational development certificate; HS = high school; NH/PI = Native Hawaiian or Pacific Islander.

* The term marijuana, rather than cannabis, is used when referring to survey findings to align with the Behavioral Risk Factor Surveillance System optional marijuana module. In this report, both terms refer to the dried flowers, leaves, stems, and seeds of the cannabis plant and do not include hemp-based or cannabidiol-only products. All table comparison p-values are based on Rao-Scott chi-square tests.

† Current use is defined as any use during the past 30 days.

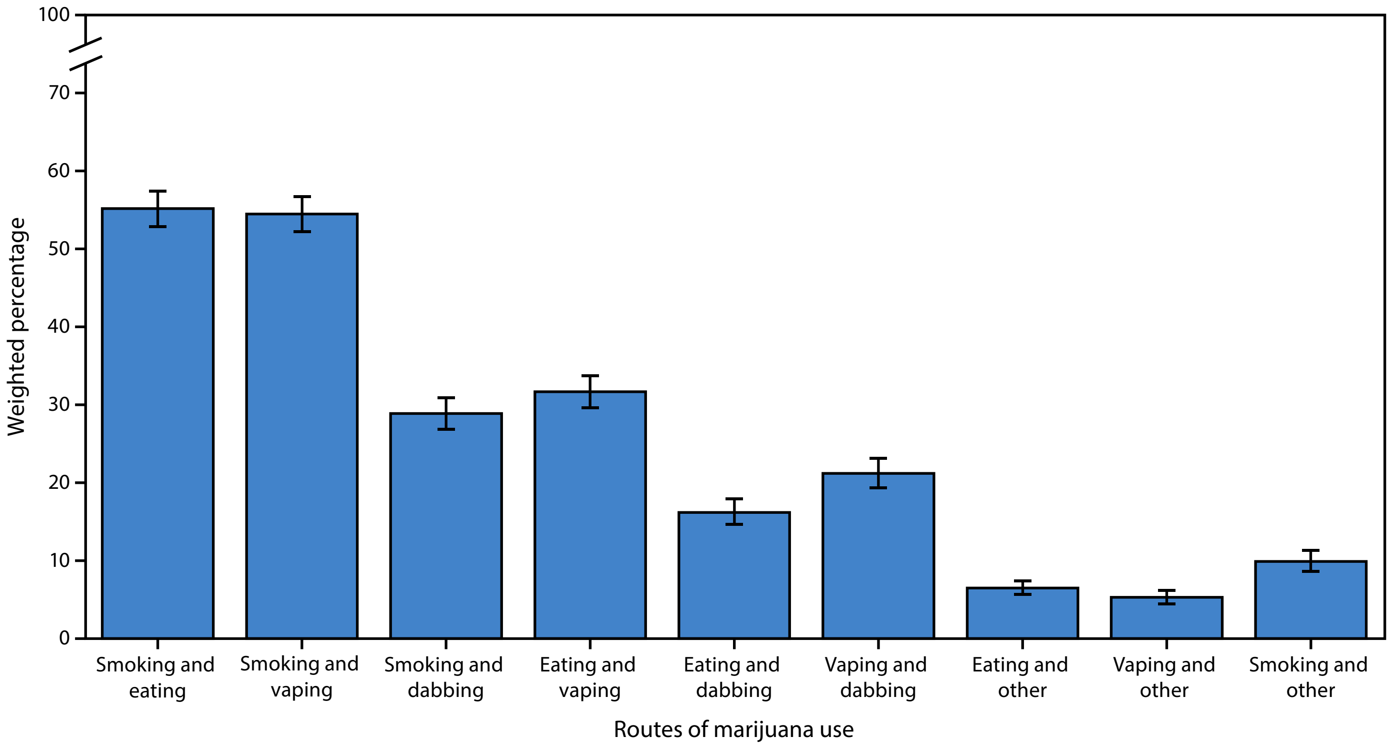
§ Reflects noninstitutionalized adults (aged ≥18 years) in Connecticut, Delaware, Hawaii, Illinois, Indiana, Kansas, Maine, Maryland, Massachusetts, Michigan, Mississippi, Montana, Nebraska, Nevada, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, Virginia, Wisconsin, Wyoming, Guam, and the U.S. Virgin Islands.

¶ Inhalation of highly concentrated tetrahydrocannabinol-based oils, often heated using a blowtorch.

** Persons of Hispanic or Latino (Hispanic) origin might be of any race but are categorized as Hispanic; all racial groups are non-Hispanic.

†† Pregnancy status only asked of women aged ≤49 years.

FIGURE. Combinations of routes of marijuana use among respondents who reported current use and two or more routes of use (N = 5,813) — Behavioral Risk Factor Surveillance System, 22 U.S. states and two territories,*,†,§ 2022



* 95% CIs indicated by bars.
† The term marijuana, rather than cannabis, is used when referring to survey findings to align with the Behavioral Risk Factor Surveillance System optional marijuana module. In this report, both terms refer to the dried flowers, leaves, stems, and seeds of the cannabis plant and do not include hemp-based or cannabidiol-only products.
§ Noninstitutionalized adults (aged ≥18 years) in Connecticut, Delaware, Hawaii, Illinois, Indiana, Kansas, Maine, Maryland, Massachusetts, Michigan, Mississippi, Montana, Nebraska, Nevada, New Mexico, North Dakota, Ohio, Oklahoma, Oregon, Virginia, Wisconsin, Wyoming, Guam, and the U.S. Virgin Islands.

Implications for Public Health Practice

Given the prevalence of cannabis smoking, eating, vaping, and dabbing, public health–related messaging specific to these routes of use can help guide persons about potential risks. Messaging can focus on the risks related to each of these routes of use, such as exposure to contaminants or adulterants with vaping, or exposure to high concentrations of THC from ingestion, vaping, and dabbing. These findings can be used to guide tailored educational messaging for cannabis-related harms. Continued surveillance of the frequency of cannabis use, routes of use, and concentrations of THC present in different products consumed is needed to understand health outcomes in the changing cannabis marketplace and protect those who use cannabis in its various forms.

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Controlled Substance Prescribing Patterns Among Fatal Overdose Decedents with an Opioid, Stimulant, or Both Contributing to Death — Pennsylvania, 2017–2022

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Abstract

Psychostimulant (stimulant)-related overdose death rates have increased sharply in the United States since 2010, and in 2022, 32% of all U.S. overdose deaths involved stimulants. Data on deaths during 2017–2022 from CDC's State Unintentional Drug Overdose Reporting System were linked to 2014–2022 Pennsylvania Prescription Drug Monitoring Program data; the Pennsylvania Department of Health's Office of Drug Surveillance and Misuse Prevention analyzed controlled substance dispensation patterns during the 3 years preceding death among overdose decedents for whom opioids, stimulants, or both contributed to death; statistical analyses were performed on prescription drug dispensation patterns. Comparing overdose deaths in 2022 with those in 2017, deaths involving opioids without stimulants decreased from 2,974 to 1,995, deaths involving stimulants without opioids increased from 300 to 549, and deaths involving both opioids and stimulants increased from 1,703 to 2,346. Irrespective of whether an opioid, stimulant, or both contributed to death, decedents filled more opioid (67.7%, 74.1%, and 63.9%, respectively) than stimulant (10.6%, 11.6%, and 13.4%, respectively) prescriptions preceding death. A higher proportion of stimulant overdose decedents without an opioid contributing to death (74.1%) filled opioid prescriptions compared with decedents whose deaths involved opioids without stimulants or both opioids and stimulants (67.7% and 63.9%, respectively). Opioid prescribing, rather than stimulant prescribing, might be an important potential risk factor for stimulant-related overdose death.

Introduction

The response to the U.S. drug overdose epidemic has focused on opioid-related overdose deaths. However, during the past decade, the number of psychostimulant (stimulant)-related overdose deaths has increased, with approximately 34,000 people dying from a drug overdose involving stimulants with abuse potential in 2022, accounting for approximately 32% of all drug overdose deaths that year (*1*–*3*). Although an established link between prescription opioid use and opioid-related overdose deaths has been demonstrated (*4*), the relationship between prescription stimulant use and stimulant-related overdose deaths isn't as clear (*5*,*6*). During 2017–2022, both controlled substance prescribing and drug overdose death trends in Pennsylvania shifted to reflect an increase in stimulant dispensing as well as an increase in stimulant-related overdose deaths, despite a decrease in overall unintentional drug overdose deaths. The evolution of these trends signals the need for a better understanding of potential risk factors contributing to the increase in stimulant-related overdose deaths, such as controlled substance prescribing preceding death. To better understand risk factors for stimulant-related overdose deaths, prescription drug dispensation patterns were analyzed using 2017–2022 overdose death data from CDC's State Unintentional Drug Overdose Reporting System (SUDORS) and 2014–2022 data from the Pennsylvania Prescription Drug Monitoring Program (PA PDMP).

Methods

Data Sources and Classification of Drug Involvement with Death

SUDORS data (*7*) from 2017–2022, which link death certificate data from the Pennsylvania Department of Health's Bureau of Health Statistics and Registries to toxicology data from participating coroners and medical examiners, were used for this analysis. Data were restricted to three overdose decedent groups characterized by the drug or drugs contributing to death: 1) opioid overdose deaths without a stimulant involved (opioids without stimulants), 2) stimulant overdose deaths without an opioid involved (stimulants without opioids), and 3) overdose deaths involving both opioids and stimulants (opioids and stimulants). For these analyses, stimulants were defined as amphetamine, cocaine, methamphetamine, or other prescription stimulants. Decedent data were linked to 2014–2022 PA PDMP data using Match*Pro probabilistic data linkage software,* linking by patient first name, last name, and date of birth. Decedents' controlled substance dispensation data were limited to the 3 years of PA PDMP data preceding each decedent's date of death. Demographic characteristics were tabulated by overdose decedent group and PA PDMP record status.

* https://seer.cancer.gov/tools/matchpro/

Data Analysis

Dispensation patterns were analyzed by performing Pearson's chi-square tests on the number of decedents by drug schedule,[†] drug class, final drug class dispensed preceding death, and the number of decedents who filled opioid (opioid-opioid) prescriptions or opioid and benzodiazepine (opioid-benzodiazepine) prescriptions that overlapped by 5 days' supply or 1 days' supply, respectively. Kruskal-Wallis tests were performed on the number of dispensations, number of days' supply, daily morphine milligram equivalents (MMEs)[§] per decedent, and interval from last dispensation to death. P-values <0.05 were considered statistically significant. All analyses were performed using SAS software (version 9.4; SAS Institute). The Pennsylvania Department of Health's Institutional Review Board Primary Review Team determined that this study was exempt from the Federal Policy for the Protection of Human Research Subjects.

Results

Drug Overdose Deaths, 2017–2022

Among 30,045 drug overdose deaths meeting SUDORS criteria reported during 2017–2022 in Pennsylvania, 28,053 (93%) contained contributing drug information, including 14,315 (51.0%) involving opioids without stimulants, 2,608 (9.3%) involving stimulants without opioids, and 11,130 (39.7%) involving both opioids and stimulants (Table 1). Comparing overdose deaths in 2022 with those in 2017, deaths involving opioids without stimulants decreased from 2,974 to 1,995, deaths involving stimulants without opioids increased from 300 to 549, and deaths involving both opioids and stimulants increased from 1,703 to 2,346. Overdose decedents were predominately male (70.8%), non-Hispanic White persons (73.1%), had a high school education or less (74.5%), and lived in urban-designated areas[¶] (80.4%). Decedents whose overdoses involved opioids without stimulants or both opioids and stimulants tended to be younger than those involving stimulants without opioids.

[†] The U.S. Drug Enforcement Administration classifies drugs into five distinct categories depending upon the drug's acceptable medical use and abuse potential. Schedule I drugs have no current medically accepted use; Schedule V drugs have the least potential for abuse. https://www.dea.gov/drug-information/drug-scheduling

[§] A value that represents the potency of an opioid dose relative to morphine. https://www.cdc.gov/mmwr/volumes/71/rr/rr7103a1.htm

[¶] Counties were designated as rural or urban on the basis of the Health Resources & Services Administration's classification criteria. https://www.hrsa.gov/rural-health/about-us/what-is-rural

Controlled Substances Dispensed During the 3 Years Preceding Death

At least one Schedule II–V controlled substance dispensation was recorded in the PA PDMP data during the 3 years preceding death for 6,869 (48.0%) decedents whose overdoses involved opioids without stimulants, 1,158 (44.6%) whose overdoses involved stimulants without opioids, and 6,710 (60.3%) decedents whose overdoses involved both opioids and stimulants (Table 2). A small percentage of decedents with a PA PDMP record filled at least one stimulant prescription during the 3 years preceding death, including 10.6% of those whose deaths involved opioids without stimulants, 11.6% of those whose deaths involved stimulants without opioids, and 13.4% of those whose deaths involved both opioids and stimulants. A higher percentage of decedents whose deaths involved stimulants without opioids (74.1%) filled opioid prescriptions during the 3 years preceding death than decedents whose deaths involved opioids without stimulants or both opioids and stimulants (67.7% and 63.9%, respectively). The percentage of decedents with opioid dispensations with a >5 days' supply overlap was higher among those whose deaths involved opioids without stimulants (23.0%) than among those whose deaths involved stimulants without opioids (11.1%) or both opioids and stimulants (12.6%) (p<0.001).

In addition, the percentage of decedents with opioid and benzodiazepine dispensations with a >1 days' supply overlap was higher among those whose deaths involved opioids without stimulants (22.7%) than among those whose deaths involved stimulants without opioids (16.5%) or both opioids and stimulants (15.7%) (p<0.001). Among decedents whose deaths involved either stimulants without opioids or both opioids and stimulants, the median number of any controlled substance dispensations (7.5 and 10.0, respectively) and opioid dispensations (3.0 each), as well as the median MMEs for opioid dispensations (29.6 and 31.2, respectively) were lower than those among decedents whose deaths involved opioids without stimulants (14 controlled substance dispensations, five opioid dispensations, and 33.8 MMEs) (p<0.001) (Table 3). Whereas median days' supply of stimulants was consistent among all decedent groups (30.0 days), the median days' supply of opioid dispensations was higher among those whose deaths involved opioids without stimulants (7.0 days) compared with those whose deaths involved stimulants without opioids (5.3 days) or both opioids and stimulants (5.0 days).

TABLE 1. Demographic characteristics of overdose decedents, by cause of death drug category and Pennsylvania Prescription Drug Monitoring Program record status (N = 28,053) — Pennsylvania, 2017–2022

	Cause of death drug category, no. (%)*								
	At least one PDMP dispensation during the 3 years preceding death								
	Opioids without stimulants			Stimulants without opioids			Opioids and stimulants		
Characteristic	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**	**Yes**	**No**	**Total**
Year of death									
2017–2022	**6,869 (48.0)**	**7,446 (52.0)**	**14,315 (100)**	**1,158 (44.6)**	**1,450 (55.4)**	**2,608 (100)**	**6,710 (60.3)**	**4,420 (39.7)**	**11,130 (100)**
2017	805 (27.1)	2,169 (72.9)	**2,974 (20.8)**	80 (26.7)	220 (73.3)	**300 (11.5)**	1,056 (62.0)	647 (38.0)	**1,703 (15.3)**
2018	1,034 (44.3)	1,301 (55.7)	**2,335 (16.3)**	154 (43.4)	201 (56.6)	**355 (13.6)**	900 (64.2)	502 (35.8)	**1,402 (12.6)**
2019	1,071 (49.3)	1,100 (50.7)	**2,171 (15.2)**	197 (46.5)	227 (53.5)	**424 (16.3)**	987 (63.0)	579 (37.0)	**1,566 (14.1)**
2020	1,414 (57.4)	1,048 (42.6)	**2,462 (17.2)**	236 (53.4)	206 (46.6)	**442 (16.9)**	1,247 (63.8)	708 (36.2)	**1,955 (17.6)**
2021	1,393 (48.6)	985 (41.4)	**2,378 (16.6)**	229 (42.6)	309 (57.4)	**538 (20.6)**	1,214 (56.3)	944 (43.7)	**2,158 (19.4)**
2022	1,152 (57.7)	843 (42.3)	**1,995 (13.9)**	262 (47.7)	287 (52.3)	**549 (21.1)**	1,306 (55.7)	1,040 (44.3)	**2,346 (21.1)**
Sex									
Female	2,344 (56.5)	1,806 (43.5)	**4,150 (29.0)**	401 (50.3)	396 (49.7)	**797 (30.6)**	2,235 (68.8)	1,013 (31.2)	**3,248 (29.2)**
Male	4,525 (44.5)	5,640 (55.5)	**10,165 (71.0)**	757 (41.8)	1,054 (58.2)	**1,811 (69.4)**	4,475 (56.8)	3,407 (43.2)	**7,882 (70.8)**
Age group, yrs									
<25	379 (32.8)	776 (67.2)	**1,155 (8.1)**	13 (25.5)	38 (74.5)	**51 (2.0)**	262 (49.3)	269 (50.7)	**531 (4.8)**
25–34	1,686 (41.1)	2,412 (58.9)	**4,098 (28.6)**	121 (41.6)	170 (58.4)	**291 (11.2)**	1,723 (58.7)	1,211 (41.3)	**2,934 (26.4)**
35–44	1,776 (48.0)	1,925 (52.0)	**3,701 (25.9)**	216 (48.0)	234 (52.0)	**450 (17.3)**	2,018 (61.1)	1,286 (38.9)	**3,304 (29.7)**
45–54	1,414 (52.7)	1,269 (47.3)	**2,683 (18.7)**	331 (45.5)	397 (54.5)	**728 (27.9)**	1,515 (62.2)	920 (37.8)	**2,435 (21.9)**
55–64	1,247 (58.7)	879 (41.3)	**2,126 (14.9)**	396 (45.9)	466 (54.1)	**862 (33.1)**	1,034 (62.3)	625 (37.7)	**1,659 (14.9)**
≥65	367 (66.7)	183 (33.3)	**550 (3.8)**	81 (36.0)	144 (64.0)	**225 (8.6)**	158 (59.4)	108 (40.6)	**266 (2.4)**
Race and ethnicity†									
Black or African American, NH	784 (46.9)	887 (53.1)	**1,671 (11.7)**	421 (41.2)	600 (58.8)	**1,021 (39.1)**	1,134 (51.8)	1,057 (48.2)	**2,191 (19.7)**
White, NH	5,665 (50.2)	5,621 (49.8)	**11,286 (78.8)**	684 (48.4)	728 (51.6)	**1,412 (54.1)**	5,144 (65.7)	2,685 (34.3)	**7,829 (70.3)**
Hispanic or Latino	346 (29.6)	822 (70.4)	**1,168 (8.2)**	44 (32.4)	92 (67.6)	**136 (5.2)**	362 (37.9)	592 (62.1)	**954 (8.6)**
Other, NH	74 (38.9)	116 (61.1)	**190 (1.3)**	9 (23.1)	30 (76.9)	**39 (1.5)**	70 (44.9)	86 (55.1)	**156 (1.4)**
Education									
High school or less	4,993 (47.5)	5,524 (52.5)	**10,517 (73.5)**	848 (43.6)	1,096 (56.4)	**1,944 (74.5)**	5,042 (59.7)	3,410 (40.3)	**8,452 (75.9)**
Some college	1,307 (49.8)	1,317 (50.2)	**2,624 (18.3)**	182 (47.3)	203 (52.7)	**385 (14.8)**	1,119 (63.1)	655 (36.9)	**1,774 (15.9)**
Bachelor’s degree	329 (46.2)	383 (53.8)	**712 (5.0)**	57 (44.2)	72 (55.8)	**129 (4.9)**	300 (64.0)	169 (36.0)	**469 (4.2)**
Master’s degree or above	102 (59.6)	69 (40.4)	**171 (1.2)**	22 (45.8)	26 (54.2)	**48 (1.8)**	67 (67.7)	32 (32.3)	**99 (0.9)**
Undetermined	138 (47.4)	153 (52.6)	**291 (2.0)**	49 (48.0)	53 (52.0)	**102 (3.9)**	182 (54.2)	154 (45.8)	**336 (3.0)**
Urbanicity§									
Rural	1,378 (45.5)	1,648 (54.5)	**3,026 (21.1)**	174 (45.3)	210 (54.7)	**384 (14.7)**	1,367 (65.9)	708 (34.1)	**2,075 (18.6)**
Urban	5,491 (48.6)	5,798 (51.4)	**11,289 (78.9)**	984 (44.2)	1,240 (55.8)	**2,224 (85.3)**	5,343 (59.0)	3,712 (41.0)	**9,055 (81.4)**

Abbreviations: NH = non-Hispanic; PDMP = prescription drug monitoring program.
* Percentages in total columns are column percentages per characteristic; all other percentages are row percents per characteristic.
† Other, NH race includes all other races not designated as Black or African American, NH or White, NH.
§ Counties were designated as rural or urban on the basis of the Health Resources & Services Administration’s classification criteria. https://www.hrsa.gov/rural-health/about-us/what-is-rural

Interval Between Last Drug Dispensation and Death, by Drug Class

The median number of days between a decedent’s last dispensation and death varied by drug class. Among decedents whose last dispensation preceding death was an opioid, the median interval was shorter among those whose deaths involved opioids without stimulants (138.0 days) than among those whose deaths involved stimulants without opioids and both opioids and stimulants (299.5 and 281.0 days, respectively). However, among decedents whose last dispensation was a stimulant, the median interval was longer among those whose deaths involved opioids without stimulants (50.5 days) than among those whose deaths involved stimulants without opioids or both opioids and stimulants (24.0 days for both groups).

Discussion

The increase in Pennsylvania overdose deaths involving stimulants without opioids during 2017–2022 permitted exploration of controlled substance prescribing patterns among decedents preceding death. Based on the link between prescription opioid use and risk for opioid overdose death (*4*), it was hypothesized that persons who died from an overdose involving stimulants without opioids might have a history of prescription stimulant dispensations. In this analysis, irrespective of whether an opioid, stimulant, or both contributed to death, only a small percentage of decedents (6.3%) filled a stimulant prescription during the 3 years preceding death, suggesting that receiving a stimulant prescription might not be predictive for subsequent stimulant-involved overdose. In addition, a larger

TABLE 2. Characteristics of overdose decedents with at least one drug dispensation during the 3 years preceding death, by cause of death drug category — Pennsylvania, 2017–2022

Characteristic*	Cause of death drug category, no. (%) Opioids without stimulants (n = 6,869)	Stimulants without opioids (n = 1,158)	Opioids and stimulants (n = 6,710)	p-value†
Drug schedule§				
II	4,477 (65.2)	805 (69.5)	4,150 (61.8)	<0.001
III	3,142 (45.7)	348 (30.1)	3,412 (50.8)	<0.001
IV	3,835 (55.8)	644 (55.6)	3,309 (49.3)	<0.001
V	652 (9.5)	115 (9.9)	532 (7.9)	0.002
Drug class dispensed§				
Benzodiazepine	3,011 (43.8)	429 (37)	2,479 (36.9)	<0.001
Buprenorphine	2,501 (36.4)	204 (17.6)	2,856 (42.6)	<0.001
Opioid	4,651 (67.7)	858 (74.1)	4,286 (63.9)	<0.001
Stimulant	728 (10.6)	134 (11.6)	899 (13.4)	<0.001
Other	1,525 (22.2)	239 (20.6)	1,242 (18.5)	<0.001
Final drug class prescription filled before death				
Benzodiazepines	1,561 (22.7)	231 (19.9)	1,276 (19.0)	<0.001
Buprenorphine	1,816 (26.4)	147 (12.7)	2,166 (32.3)	<0.001
Opioids	2,775 (40.4)	607 (52.3)	2,477 (36.9)	<0.001
Stimulants	278 (4.0)	75 (6.3)	389 (5.8)	<0.001
Other	439 (6.4)	98 (8.5)	402 (6.0)	0.006
At least one overlapping prescription				
Opioid-benzodiazepine¶	1,558 (22.7)	191 (16.5)	1,054 (15.7)	<0.001
Opioid-opioid**	1,578 (23.0)	128 (11.1)	847 (12.6)	<0.001

* Characteristics are not mutually exclusive: a single decedent could be counted more than once within each group because of dispensations of various drug schedules, drug classes, or both.
† On the basis of the chi-square test of independence; p-values <0.05 were considered statistically significant.
§ The U.S. Drug Enforcement Administration classifies drugs into five distinct categories depending on the drug's acceptable medical use and abuse potential. Schedule I drugs have no current medically accepted use; Schedule V drugs have the least potential for abuse. https://www.dea.gov/drug-information/drug-scheduling
¶ Opioid and benzodiazepine prescriptions for which the number of days' supply of prescriptions filled overlapped in time by >1 day.
** Opioid prescriptions for which the number of days' supply of prescriptions filled overlapped in time by >5 days.

TABLE 3. Controlled substance prescribing patterns among overdose decedents with at least one dispensation during the 3 years preceding death, by cause of death drug category — Pennsylvania, 2017–2022

Characteristic	Cause of death drug category, median (IQR) Opioids without stimulants	Stimulants without opioids	Opioids and stimulants	p-value†
No. of dispensations				
Any drug*	14.0 (3.0–41.0)	7.5 (2.0–30.0)	10.0 (3.0–33.0)	<0.001
Opioid	5.0 (2.0–23.0)	3.0 (1.0–10.0)	3.0 (1.0–11.0)	<0.001
Stimulant	10.0 (4.0–23.0)	11.5 (3.0–32.0)	13.0 (4.0–29.0)	0.001
No. of days' supply				
Any drug*	17.2 (7.0–26.2)	15.6 (5.0–29.6)	14.0 (6.1–24.6)	<0.001
Opioid	7.0 (3.5–22.0)	5.3 (3.3–16.5)	5.0 (3.0–15.0)	<0.001
Stimulant	30.0 (29.0–30.0)	30.0 (29.0–30.0)	30.0 (28.8–30.0)	0.20
Daily morphine milligram equivalent§				
Opioid	33.8 (24.2–55.6)	29.6 (20.4–39.9)	31.2 (22.5–45.0)	<0.001
No. of days from last dispensation to death				
Any drug*	68.0 (12.0–335.0)	147.5 (23.0–541.0)	124.5 (17.0–433.0)	<0.001
Opioid	138.0 (16.0–465.0)	299.5 (59.0–669.0)	281.0 (61.0–612.0)	<0.001
Stimulant	50.5 (10.0–301.0)	24.0 (10.0–165.0)	24.0 (10.0–240.0)	0.082

* Any controlled substance recorded in the Pennsylvania Prescription Drug Monitoring Program database.
† P-values <0.05 were considered statistically significant based on the Kruskal-Wallis test.
§ A value that represents the potency of an opioid dose relative to morphine. https://www.cdc.gov/mmwr/volumes/71/rr/rr7103a1.htm

proportion of decedents whose deaths involved stimulants without opioids filled opioid prescriptions during the 3 years preceding death (74%), compared with those whose deaths involved opioids without stimulants (68%) or both opioids and stimulants (64%), suggesting a need for further investigation into the role of opioid prescribing as a potential risk factor for future overdose resulting from the use of nonopioid drugs, including stimulants. In addition, decedents whose last dispensation preceding death was a stimulant had received that prescription closer to their date of death than did decedents whose last dispensation was an opioid. This finding likely relates to the common practice of prescribing and dispensing stimulants monthly over longer periods of time for chronic conditions, such as attention deficit disorder.

Because of the small proportion of decedents in each group who filled stimulant prescriptions, these findings do not support the hypothesis that increased stimulant prescribing alone is contributing to increases in overdose deaths from stimulants without opioids. Rather, this analysis highlights the implications of opioid prescribing among all overdose decedents, regardless of the drug contributing to death. However, the increasing mortality resulting from stimulant use warrants further analysis, including a longer history of PA PDMP data, enhanced monitoring as new data become available, and investigation of risk factors outside of controlled substance prescribing. In addition, some persons who use opioids have reported that they also use stimulants to compensate for the effects of synthetic opioids (e.g., fentanyl), thereby improving alertness and their ability to function, and this polysubstance use also warrants further exploration (*8*).

Summary

What is already known about this topic?

Rates of psychostimulant (stimulant)-related overdose deaths in the United States have increased substantially since 2010; in 2022, 32% of all overdose deaths involved stimulants.

What is added by this report?

In Pennsylvania, opioid prescribing (as opposed to stimulant prescribing) during the 3 years preceding death was more common among decedents whose overdose deaths involved stimulants and was more common among all decedents, regardless of the drugs contributing to death.

What are the implications for public health practice?

Pre-overdose opioid prescribing is a risk marker for fatal overdose from opioids alone, stimulants alone, or both; pre-overdose stimulant prescribing might not be a risk marker for fatal overdose attributable to stimulants. Identifying risk factors specific to stimulant misuse could better guide development of harm reduction practices to prevent fatal stimulant-related overdoses.

Limitations

The findings in this report are subject to at least three limitations. First, before July 2016, PA PDMP only collected Schedule II drug prescriptions and might not fully characterize controlled substance prescribing patterns among decedents from earlier years of the analysis period (i.e., deaths during January 2017–June 2019). Second, PA PDMP data cannot account for drugs used illicitly by persons for whom they were not prescribed, and many stimulants contributing to overdose and death are used illicitly with few or no approved prescription applications (e.g., cocaine, methamphetamine, and 3,4-methylenedioxymethamphetamine) (*1*). Finally, data from the PA PDMP do not contain information on the condition for which the drug is prescribed and represent controlled substance prescriptions filled, which might not reflect actual use.

Implications for Public Health Practice

The evolving landscape of the U.S. drug overdose epidemic requires continued evaluation of potential risk factors for overdose. Opioid prescribing should be further investigated as a risk factor for future overdose death resulting from use of nonopioid drugs, such as stimulants; however, the findings in this report highlight the importance of identifying additional overdose risk factors for stimulant-related overdoses. Continued analyses of the latest prescription and overdose death data could identify opportunities for education and intervention if a potential stimulant epidemic emerges.

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Notes from the Field

Recreational Nitrous Oxide Misuse — Michigan, 2019–2023

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Nitrous oxide is a colorless gas used clinically as an inhalational anesthetic, analgesic, and anxiolytic. It is a common component of some commercial products, most notably as a propellant in steel aerosol containers used in whipped cream dispensers, from which it can be inhaled (whippets) (*1–3*). Acute nitrous oxide use induces a rapid onset of euphoric, anxiolytic, and hallucinogenic effects that are short-lived, disappearing within minutes (*2*). The inhalant is an increasingly popular recreational substance, particularly among teenagers and young adults (aged 20–39 years), offering users a low cost and currently legal option easily accessible online and widely available at vape stores, grocery and convenience stores, and gas stations (*1–3*). Despite misconceptions among recreational users that nitrous oxide is safe (*1*,*2*), frequent or chronic long-term use can cause disabling neurologic sequelae, including neuronal demyelination and subacute combined spinal cord degeneration consequent to functional vitamin B12 deficiency (*2*,*4*). Treatment involves permanent cessation of nitrous oxide use along with high-dose intramuscular vitamin B12 supplementation; recovery is often protracted and incomplete (*4*,*5*).

In late 2023, an increase in the number of patients hospitalized with neurologic signs and symptoms secondary to nitrous oxide misuse was detected in Michigan Poison & Drug Information Center (MiPDC) data by the MiPDC director and clinical toxicologist. Toxicosurveillance monitoring was prompted by an observed corresponding increase in nitrous oxide–associated poisoning consultations involving the poison center and its toxicologists. MiPDC and the Michigan Department of Health and Human Services collaborated to investigate poison center cases, emergency department (ED) visits, and emergency medical service (EMS) responses to analyze trends in nitrous oxide–associated poisoning exposures and health care encounters in Michigan.

Summary

What is already known about this topic?

Nitrous oxide is a widely accessible recreational substance that induces rapid euphoric and hallucinogenic effects. Often thought by users to be harmless, nitrous oxide can cause severe neurologic, cardiovascular, and psychiatric signs and symptoms with repeated use.

What is added by this report?

In Michigan in 2023, annual poison center exposures, emergency department visits, and emergency medical service responses related to nitrous oxide misuse were four to five times those in 2019.

What are the implications for public health practice?

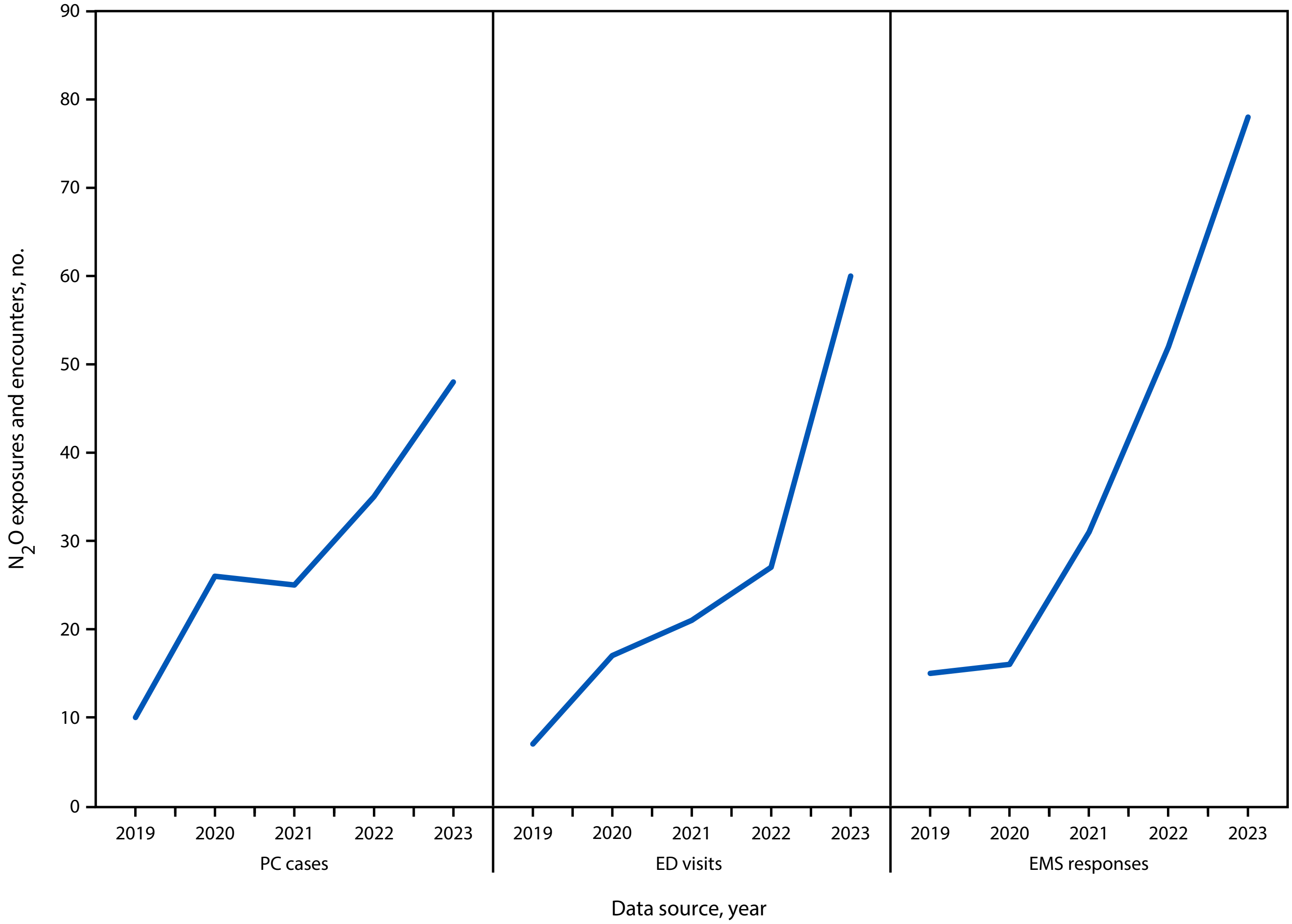
Widespread availability of nitrous oxide and increasing medical encounters related to its use warrant targeted public health education for recreational users, parents, caregivers, and clinicians. Because no reliable screening test for nitrous oxide is available, increased clinical awareness, including a detailed recreational drug history, is needed for accurate and timely diagnosis of misuse.

Investigation and Outcomes

Poison center data from January 1, 2019, to December 31, 2023, were accessed by the poison center director and clinical toxicologist via the MiPDC ToxSentry electronic medical record database. Michigan ED visits (via Michigan Syndromic Surveillance System) and EMS responses (via biospatial, Inc.) were analyzed for key words (nitrous, whippets, and spelling variations) and *International Classification of Diseases, Tenth Revision, Clinical Modification* diagnosis code T59.0 (toxic effects of nitrogen oxides). Two epidemiologists and a clinical toxicologist reviewed EMS and ED cases, removing 59 of 383 that did not indicate nitrous oxide misuse. This research was performed in accordance with ethical principles, including ensuring responsible data handling and maintaining confidentiality. This surveillance research study was reviewed and approved as exempt human subjects research by the Institutional Review Board associated with MiPDC as well as falling under the ongoing public health surveillance responsibilities from the Michigan Department of Health and Human Services.

During 2019–2023, 144 poison center cases, 132 ED visits, and 192 EMS responses involving nitrous oxide were identified. Notable increases were observed in 2023 as compared with 2019 in poison center calls (10 to 48), ED visits (seven to 60), and EMS responses (15 to 78) (Figure). Nitrous oxide events occurred most frequently among persons aged 20–39 years (median age: poison center = 26 [IQR 21–33]; ED = 29 [IQR 24–33]; and EMS = 32 [IQR 25–39] years) and in metropolitan counties (poison center = 91.7%; ED = 94.7%; and EMS = 94.3% of events). Among the 192 EMS responses, 14 (7.3%) involved fatalities, including three suspected suicides. Cause of death cannot be determined in EMS data, but nitrous oxide involvement was documented

FIGURE. Poison center cases, emergency department visits, and emergency medical service responses related to recreational nitrous oxide misuse — Michigan, 2019–2023



Abbreviations: ED = emergency department; EMS = emergency medical service; N_2O = nitrous oxide; PC = poison center.

among these fatalities. Polysubstance involvement occurred in 30% of poison center cases, most commonly benzodiazepines (9.7%), cannabis/delta-9-tetrahydrocannabinol (9.0%), and alcohol (8.3%). The most common clinical effects among nitrous oxide–involved poison center cases were tachycardia (19.4%), other-neurologic (18.8%), and numbness (16.7%) (Supplementary Table, https://stacks.cdc.gov/view/cdc/177219#tabs-3).

Preliminary Conclusions and Actions

These data demonstrate a sharp increase in adverse medical encounters associated with nitrous oxide misuse in Michigan during 2019–2023. Widespread availability, ease of access, and minimal legislative restrictions are potential factors contributing to the observed increase (*1*,*3*,*4*). These statewide data likely underestimate actual morbidity and mortality, because clinical suspicion of nitrous oxide toxicity is often low (*1*,*2*). No reliable screening test for nitrous oxide is available (*1*,*2*). Therefore, diagnosis is nuanced and predicated upon obtaining a detailed recreational drug history and interpreting surrogate serum biomarkers in the context of patient diagnostics and symptomatology (*2*,*4*,*5*). Toxicity stemming from chronic long-term nitrous oxide misuse is primarily characterized by neurologic, psychiatric, and hematologic findings (*2*,*4*,*5*). Neurologic manifestations include weakness, gait instability, and paresthesia that can progress to sensorimotor polyneuropathy with demyelinating features with or without evidence of subacute combined spinal cord degeneration (*2*,*4*). Psychiatric symptoms can include hallucinations, anxiety, depression, delirium, and memory impairment (*2*,*5*). Chronic nitrous oxide misuse–related hematologic abnormalities include those resembling megaloblastic or pernicious anemias, and myelosuppression (*2*). Recent evidence suggests a direct or indirect pathophysiological role in pulmonary embolism and deep vein thrombosis (*2*).

Although nitrous oxide is not a federally controlled substance (*3*), individual states, including Michigan, have enacted or are considering expanded legislation to regulate nitrous oxide possession, sale, and distribution. This report supports the need for enhanced surveillance of nitrous oxide exposures using poison center and health care encounter data. Targeted education for recreational users, parents, caregivers, and clinicians in conjunction with prevention campaigns to warn the public of the dangers of nitrous oxide misuse are warranted.

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Notes from the Field

Suicidal Thoughts and Knowing Someone Who Died by Suicide Among Adults — United States, 2023

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Suicide is a leading cause of death in the United States with approximately 49,000 deaths in 2023 (*1*), and many more persons seriously think about suicide (*2*). Timely data on suicidal thoughts and knowing someone who died by suicide, which can increase one's risk for suicide (*3*), can guide public health planning and interventions.

Investigation and Outcomes

The National Center for Health Statistics Rapid Surveys System (RSS) is an online survey based on two probability-based panels. Round 2 RSS was fielded in October–November 2023, consists of responses from 7,046 adults, and includes survey weights to approximate nationally representative estimates for U.S. adults* (*4*). Prevalences of a "Yes" response to the following questions were measured overall and by eight demographic characteristics: "At any time in the past 12 months, did you seriously think about trying to kill yourself?" and "Do you personally know anyone who has died by suicide?" ProcSurvey procedures (SAS version 9.4; SAS Institute), using the Taylor series linearization method for estimating variances, were used to calculate weighted numbers, percentages, and associated 95% CIs (*4*). These activities were reviewed by CDC, deemed not research, and conducted consistent with applicable federal law and CDC policy.†

Overall, 5.3% of U.S. adults reported suicidal thoughts during the past 12 months (Table). The prevalence of suicidal thoughts was higher among persons aged 18–24 and 25–44 years and persons with lower household income. Results also varied by sexual orientation, with the highest percentage among bisexual persons. Overall, 42.4% of adults reported knowing someone who died by suicide. Percentages were higher among persons aged ≥45 years, non-Hispanic White persons, veterans, persons with at least some college education, and nonmetropolitan residents. Among those who reported suicidal thoughts, more than one half (57.9%) reported knowing someone who died by suicide, compared with 41.6% among those who did not report suicidal thoughts.

Summary

What is already known about this topic?

Suicide is a leading cause of death in the United States, with approximately 49,000 deaths in 2023. Many more persons experience suicidal thoughts.

What is added by this report?

Using data from two probability-based online survey panels that approximate nationally representative estimates for U.S. adults, during October–November 2023 CDC estimates that more than two in five U.S. adults (42.4%) personally knew someone who died by suicide, and 5.3% of U.S. adults had suicidal thoughts during the past 12 months.

What are the implications for public health practice?

Suicide has a far-reaching impact on communities, and CDC recommends implementing multiple suicide prevention strategies described in CDC's Suicide Prevention Resource for Action (e.g., lessening harms and preventing future risk). https://www.cdc.gov/suicide/resources/prevention.html

Preliminary Conclusions and Actions

This investigation provides timely national estimates of and demographic variation of suicidal thoughts and knowing someone who died by suicide. This type of rapid data collection can be replicated by CDC to get the right data, in the right place, at the right time to help guide decision-making and facilitate quick action (https://www.cdc.gov/surveillance/policy-standards/data-authority.html). This study provides the latest estimates of the prevalence of knowing someone who died by suicide during one's lifetime based on a nationally representative sample.

Results are subject to potential nonresponse bias because of the survey design (*4*); however, the finding that 5.3% of U.S. adults who reported suicidal thoughts is similar to 5.0% reported in the 2023 National Survey on Drug Use and Health (NSDUH) (*2,5*). Estimated percentages of persons reporting suicidal thoughts for most subgroups in RSS also aligned with NSDUH estimates. RSS has a lower response rate than other surveys conducted by CDC, and might underrepresent certain subpopulations; however, data undergo extensive quality review (*4*). The findings in this report do not infer a causal relationship; however, knowing someone who died by suicide can influence suicidal thoughts (https://www.cdc.gov/suicide/prevention/cluster.html).

This report is the first to use national survey data to indicate that more than two in five adults (42.4%) knew someone who had died by suicide, and more than one half of adults (57.9%)

* Cumulative response rates of the two panels were 3.8% and 4.0%, and Round 2 RSS overall completion rate was 37.6%.

† 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

TABLE. Numbers and percentages of persons experiencing suicidal thoughts and knowing someone who died by suicide — United States, October–November 2023*

Characteristic	Suicidal thoughts† (n = 7,010)§		Know someone who died by suicide¶ (n = 6,984)§	
	Weighted no., thousands**	Weighted % (95% CI)**	Weighted no., thousands**	Weighted % (95% CI)**
Overall	**13,550**	**5.3 (4.6–5.9)**	**108,243**	**42.4 (41.0–43.8)**
Age group, yrs				
18–24	2,913	10.5 (7.5–13.4)	7,958	28.7 (23.8–33.6)
25–44	7,676	8.3 (7.0–9.6)	35,500	38.4 (35.9–40.9)
45–64	2,158	2.8 (2.1–3.5)	36,747	47.5 (45.1–50.0)
≥65	803	1.4 (0.7–2.1)	28,038	48.6 (46.0–51.1)
Sex				
Female	7,380	5.6 (4.7–6.5)	54,245	41.5 (39.5–43.5)
Male	6,170	4.9 (4.1–5.8)	53,997	43.4 (41.3–45.5)
Sexual orientation				
Bisexual	2,191	20.3 (14.2–26.3)	4,710	44.0 (36.8–51.2)
Gay or lesbian	543	7.9 (3.9–11.9)	3,418	49.9 (41.4–58.4)
Straight	9,016	4.1 (3.5–4.8)	91,808	42.3 (40.8–43.8)
Something else	890	18.1 (10.1–26.2)	1,791	37.0 (25.8–48.1)
Missing	910	5.7 (2.9–8.5)	6,516	41.1 (35.3–46.9)
Race and ethnicity††				
Black or African American	1,558	5.0 (3.1–6.8)	8,888	28.2 (24.4–32.1)
White	8,531	5.4 (4.6–6.2)	77,607	49.3 (47.6–51.0)
Other	817	4.0 (2.0–6.1)	7,050	35.2 (30.1–40.2)
Hispanic or Latino	2,515	5.7 (4.0–7.3)	13,637	31.1 (27.7–34.6)
Veteran status				
Veteran	725	3.5 (1.9–5.1)	10,078	48.8 (44.4–53.3)
Not a veteran	11,538	5.3 (4.6–6.0)	90,258	41.7 (40.1–43.2)
Missing	1,287	7.2 (4.0–10.3)	7,907	44.0 (38.2–49.8)
Education				
High school graduate or less	6,002	6.2 (5.0–7.4)	36,224	37.5 (35.0–40.0)
Some college	3,865	5.5 (4.4–6.7)	31,736	45.6 (43.1–48.1)
Bachelor's degree or above	3,683	4.1 (3.2–5.0)	40,282	45.3 (43.1–47.4)
Household income, $				
0–49,999	6,782	8.4 (7.0–9.9)	30,980	38.7 (36.1–41.4)
50,000–99,999	3,487	4.6 (3.6–5.7)	32,676	43.5 (40.9–46.1)
≥100,000	3,280	3.3 (2.5–4.1)	44,587	44.6 (42.4–46.7)
Rural/Urban				
Metropolitan	11,525	5.2 (4.6–5.9)	90,595	41.2 (39.7–42.7)
Nonmetropolitan	2,024	5.7 (3.9–7.6)	17,648	49.8 (46.0–53.7)
At any time in the past 12 months, did you seriously think about trying to kill yourself?††				
Yes	NA	NA	7,778	57.9 (51.5–64.4)
No	NA	NA	100,188	41.6 (40.1–43.0)

Source: National Center for Health Statistics, Rapid Surveys System, Round 2, October–November 2023. https://www.cdc.gov/nchs/data/series/sr_02/sr02_175.pdf

Abbreviation: NA = not applicable.

* All estimates included meet the National Center for Health Statistics standards of reliability.

† Based on a "Yes" response to the survey question, "At any time in the past 12 months, did you seriously think about trying to kill yourself?"

§ Calculations are based only on responses of "Yes" and "No". Suicidal thoughts: 36 refused or skipped the question; know someone who died by suicide: 62 refused, skipped the question, or didn't know.

¶ Based on a "Yes" response to the survey question, "Do you personally know anyone who has died by suicide?"

** Nationally representative weights calibrated to the National Health Interview Survey were created to reduce coverage and nonresponse biases. Variances were estimated using the Taylor series linearization method that takes survey design into account. Weighted numbers were rounded to the nearest thousand, and weighted percentages were calculated as row percentages.

†† Persons identified as Hispanic or Latino (Hispanic) might be of any race. Persons identified as Black or African American, White, or Other are all non-Hispanic. Other race includes persons who identify as Asian, American Indian or Alaska Native, Middle Eastern or North African, Native Hawaiian or other Pacific Islander, or multiracial.

experiencing suicidal thoughts knew someone who had died by suicide. Identifying and supporting persons at risk for suicide, providing postvention support after a suicide occurs (i.e., activities that promote healing among survivors), and promoting safe messaging, which emphasizes that suicide is preventable, can be effective strategies and approaches in reducing suicide and future suicide risk (*3*). Strategies in CDC's Suicide Prevention Resource for Action can normalize protective factors such as help-seeking behaviors and promoting healthy peer norms, while also reducing risk factors such as stigma about suicide and mental illness. Finally, upstream approaches including creating healthy organizational policies and protective environments, such as in places of employment and education, are also important because they can prevent a crisis point in the first place and reduce future suicide risk§ (*3*).

§ For persons in crisis, help is available through the U.S. Substance Abuse and Mental Health Services Administration's 988 Suicide and Crisis Lifeline (https://www.988lifeline.org) or by texting or calling 988.

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