Centers for Disease Control and Prevention
MMWR
Morbidity and Mortality Weekly Report
Weekly / Vol. 72 / No. 26
June 30, 2023

Preliminary Incidence and Trends of Infections Caused by Pathogens Transmitted Commonly Through Food — Foodborne Diseases Active Surveillance Network, 10 U.S. Sites, 2022

Miranda J. Delahoy, PhD[1]; Hazel J. Shah, MPH[1]; Daniel Lowell Weller, PhD[1]; Logan C. Ray, MPH[1]; Kirk Smith, DVM, PhD[2]; Suzanne McGuire, MPH[3]; Rosalie T. Trevejo, DVM, PhD[4]; Elaine Scallan Walter, PhD[5]; Katie Wymore, MPH[6]; Tamara Rissman, MPH[7]; Marcy McMillian, MPH[8]; Sarah Lathrop, DVM, PhD[9]; Bethany LaClair, MPH[10]; Michelle M. Boyle, MPH[11]; Stic Harris, DVM[12]; Joanna Zablotsky-Kufel, PhD[13]; Kennedy Houck, MPH[1]; Carey J. Devine, MPH[1]; Carey E. Lau[1]; Robert V. Tauxe, MD[1]; Beau B. Bruce, MD, PhD[1]; Patricia M. Griffin, MD[1]; Daniel C. Payne, PhD[1]

Each year, infections from major foodborne pathogens are responsible for an estimated 9.4 million illnesses, 56,000 hospitalizations, and 1,350 deaths in the United States (*1*). To evaluate progress toward prevention of enteric infections in the United States, the Foodborne Diseases Active Surveillance Network (FoodNet) conducts surveillance for laboratory-diagnosed infections caused by eight pathogens transmitted commonly through food at 10 U.S. sites. During 2020–2021, FoodNet detected decreases in many infections that were due to behavioral modifications, public health interventions, and changes in health care–seeking and testing practices during the COVID-19 pandemic. This report presents preliminary estimates of pathogen-specific annual incidences during 2022, compared with average annual incidences during 2016–2018, the reference period for the U.S. Department of Health and Human Services' Healthy People 2030 targets (*2*). Many pandemic interventions ended by 2022, resulting in a resumption of outbreaks, international travel, and other factors leading to enteric infections. During 2022, annual incidences of illnesses caused by the pathogens *Campylobacter*, *Salmonella*, *Shigella*, and *Listeria* were similar to average annual incidences during 2016–2018; however, incidences of Shiga toxin-producing *Escherichia coli* (STEC), *Yersinia*, *Vibrio*, and *Cyclospora* illnesses were higher. Increasing culture-independent diagnostic test (CIDT) usage likely contributed to increased detection by identifying infections that would have remained undetected before widespread CIDT usage. Reducing pathogen contamination during poultry slaughter and processing of leafy greens requires collaboration among food growers and processors, retail stores, restaurants, and regulators.

CDC, 10 state health departments, the U.S. Department of Agriculture's Food Safety and Inspection Service (FSIS), and the Food and Drug Administration (FDA) collaborate to conduct active population-based surveillance of the FoodNet catchment area,* which included an estimated 51 million

* The FoodNet catchment includes Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, Tennessee, and selected counties in California, Colorado, and New York.

INSIDE

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

U.S. Department of Health and Human Services
Centers for Disease Control and Prevention

persons in 2022 (approximately 15% of the U.S. population). Laboratories diagnose bacterial infections by culture or CIDT and *Cyclospora* infections by microscopy or polymerase chain reaction.[†] Infection incidence was calculated by dividing the number of infections during 2022 by 2021 U.S. Census Bureau population estimates for the surveillance area and is reported as infections per 100,000 persons. A Bayesian, negative binomial model with penalized thin plate splines adjusting for state-specific trends and population changes[§] was used to estimate incidence changes during 2022 compared with the average annual incidence during 2016–2018 using the brms package (version 2.14.0) in R software (version 3.6.2, R Foundation).[¶] Incidence was described as increased or decreased relative to the reference period if the 95% credible interval (CrI) for the incidence rate ratio (IRR) did not cross the null value of 1. Incidence changes were also estimated using this method for the subset of infections that were domestically acquired.[**] Frequencies of hospitalizations, deaths, outbreak-associated infections, and international travel-associated infections were calculated overall and by pathogen.[††] The proportion of infections that were diagnosed by CIDT[§§] and diagnosed only by CIDT (meaning the specimen had a negative culture result or was not cultured), the proportion of infections diagnosed by CIDT for which a culture was performed, and the proportion of those cultures yielding an isolate were calculated by pathogen for bacterial infections.

A network of nephrologists and infection preventionists conducts surveillance for diagnosed pediatric post-diarrheal hemolytic uremic syndrome (HUS), a complication of STEC infection that most commonly occurs among young children; additional HUS data are collected by hospital discharge

[†] Reflex culture refers to the process of attempting to grow the identified pathogen in a laboratory culture medium after a CIDT-positive result. Reflex culture practices vary by state and pathogen, and depend on resources, state isolate submission requirements, and specimen viability.

[§] http://medrxiv.org/lookup/doi/10.1101/2022.09.14.22279742

[¶] Incidence for each year is calculated by dividing the number of infections during that year by the previous year's U.S. Census Bureau population estimate for the surveillance area. The average during 2016–2018 was calculated by averaging the three incidences for the years 2016, 2017, and 2018.

[**] Domestically acquired infections are defined as those for which the patient had no history of international travel or unknown travel history. A history of international travel refers to reported international travel during the 30 days before illness began for *Listeria* and *Salmonella* serotypes Typhi and Paratyphi, 14 days before illness began for *Cyclospora*, and 7 days before illness began for other pathogens. Travel information was missing for 24% of infections.

[††] Responses that were unknown were included in proportion denominators.

[§§] Refers to infections for which the specimen had a culture performed, regardless of the result, and infections for which the specimen was not cultured.

The *MMWR* series of publications is published by the Office of Science, Centers for Disease Control and Prevention (CDC), U.S. Department of Health and Human Services, Atlanta, GA 30329-4027.

Suggested citation: [Author names; first three, then et al., if more than six.] [Report title]. MMWR Morb Mortal Wkly Rep 2023;72:[inclusive page numbers].

review.[¶] This report includes HUS cases and incidence per 100,000 children and adolescents aged <18 years detected during 2021, the most recent year with available data. This activity was reviewed by CDC and conducted consistent with applicable federal law and CDC policy.[***]

During 2022, FoodNet identified 25,479 cases of infection, 5,981 hospitalizations, and 170 deaths (Table 1). Infection incidence was highest for *Campylobacter* (19.2 cases per 100,000 population), followed by *Salmonella* (16.3). Compared with pathogen-specific average annual incidences during 2016–2018, STEC, *Yersinia*, *Vibrio*, and *Cyclospora* infection incidences were higher during 2022. Overall infection incidence was stable for *Campylobacter*, *Salmonella*, *Shigella*, and *Listeria.* However, when limited to domestically acquired infections, *Campylobacter* incidence was higher during 2022 (IRR = 1.07, 95% CrI = 1.01–1.14), as were incidences for *Yersinia, Vibrio,* and *Cyclospora*. Compared with 2016–2018, similar percentages of infections during 2022 resulted in hospitalization (23.5% in 2022 versus 23.8%) and death (0.7% versus 0.5%) or were associated with outbreaks (4.3% versus 3.9%) or international travel (12.4% versus 12.8%). However, 62 *Salmonella* infections (0.7%) resulted in death during 2022, compared with an annual average of 37 (0.4%) during 2016–2018. Serotypes and characteristics of *Salmonella* infections resulting in death were similar to those during 2016–2018 (FoodNet, unpublished data, 2023).[†††]

Among 7,032 *Salmonella* infections with positive culture results during 2022, 6,345 isolates (90%) were fully serotyped. The five most common serotypes were Enteritidis (2.7 cases per 100,000 population), Typhimurium (1.6), Newport (1.4), Javiana (0.9), and I 4,[5],12:i:- (0.6), which have been the five most common serotypes each year since 2010. The incidences of two of these serotypes were lower during 2022 compared with those during 2016–2018: Enteritidis (IRR = 0.88, 95% CrI = 0.79–0.97) and I 4,[5],12:i:- (IRR = 0.69, 95% CrI = 0.56–0.86).

Among 2,882 STEC infections, specimens for 2,401 (83%) were cultured; 1,298 (54%) of those cultured yielded an isolate. The O antigen was determined for 1,187 (91%) of the cultured isolates; among those, serogroup O157 was most common (301; 25%), followed by O103 (164; 14%), O26 (155; 13%), and O111 (149; 13%). During 2021, 72 cases of post-diarrheal HUS among persons aged <18 years were reported (0.7 cases per 100,000) (IRR relative to 2016–2018 = 0.96, 95% CrI = 0.82–1.13), including 41 (57%) among persons <5 years old (1.5 per 100,000) (IRR = 0.95, 95% CrI = 0.79–1.18).

The percentage of bacterial infections diagnosed using CIDT increased from 49% during 2016–2018 to 73% in 2022 (Table 2). The percentage of bacterial infections diagnosed using only CIDT increased from 26% during 2016–2018 to 41% in 2022, and, by pathogen, was highest for *Yersinia* (77%), *Vibrio* (56%), and STEC (55%). The overall proportion of reflex cultures that yielded an isolate was similar during 2016–2018 (65%) and 2022 (62%), but decreased for *Salmonella,* STEC, *Shigella*, *Vibrio,* and most markedly for *Yersinia* (from 48% to 24%).

Discussion

Many COVID-19 pandemic-related factors influencing enteric disease transmission, detection, and reporting (*3*,*4*) ended by 2022. The incidence of infections caused by pathogens transmitted commonly through food during 2022 generally returned to levels observed during the pre-pandemic period, 2016–2018. Concerted efforts are needed now to implement strategies to reach national prevention targets and lower the prevalence of enteric infections.

This report highlights lack of progress in reducing enteric infection incidence. The incidence of *Salmonella* infections during 2022 was above the Healthy People 2030 target.[§§§] Also during 2022, the incidence of the most common domestically acquired infections, those caused by *Campylobacter* (17.4 per 100,000 population), was above the Healthy People 2030 target of 10.9. Poultry meat has been the most commonly identified source of *Campylobacter* infections in many countries for many years (*5*) and is also estimated to be the most common U.S. source of *Salmonella* infections (*6*).

Further efforts to reduce contamination during poultry slaughter and processing are needed to reduce the incidence of *Campylobacter, Salmonella,* and other foodborne pathogens (*7*). In 2021, FSIS published new guidelines for poultry slaughter and processing establishments to control *Campylobacter* in raw

[¶] To augment HUS case findings by pediatric nephrologists and infection control practitioners, FoodNet staff members annually review hospital discharge data for pediatric HUS cases to validate surveillance reports and identify additional cases by using *International Classification of Diseases, Tenth Revision* (ICD-10) and ICD-11 codes specifying HUS, acute renal failure with hemolytic anemia and thrombocytopenia, or thrombotic thrombocytopenic purpura with diarrhea caused by an unknown pathogen or *E. coli*.

[***] 45 C.F.R. part 46.102(l)(2), 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.

[†††] The most common serotypes associated with *Salmonella* deaths both during 2022 and during 2016–2018 were Enteritidis and Typhimurium. The median age for patients with *Salmonella* deaths during 2022 was 67 years (IQR = 56–76 years) and during 2016–2018 was 68 years (IQR = 53–78 years). During 2022, 10% of *Salmonella* deaths were associated with outbreaks compared with 5% during 2016–2018. In addition, during 2022, 3% of the *Salmonella* deaths with reported travel history were associated with international travel compared with 2% during 2016–2018. The numbers are small, limiting ability to detect differences between reporting periods.

[§§§] 11.5 domestically acquired infections per 100,000 population.

[¶¶¶] https://www.fsis.usda.gov/sites/default/files/media_file/2021-07/FSIS-GD-2021-0006.pdf

TABLE 1. Number of laboratory-diagnosed bacterial and parasitic infections, hospitalizations, deaths, outbreak-associated infections, crude incidence, and incidence rate ratios compared with 2016–2018 average annual incidence, domestic incidence, and Healthy People 2030 incidence targets,* by pathogen — Foodborne Diseases Active Surveillance Network, 10 U.S. sites,† 2022§

Pathogen	Infections,¶ no.	No. (%)			Crude average incidence 2016–2018	Crude incidence 2022¶¶	IRR (95% CrI)***	Domestic incidence†††	Healthy People 2030 (domestic) incidence target
		Hospitalizations**	Deaths††	Outbreak-associated infections§§					
Bacteria									
Campylobacter	9,751	1,938 (19.9)	42 (0.4)	59 (0.6)	18.8	19.2	1.02 (0.96–1.08)	17.4	10.9
Salmonella	8,285	2,228 (26.9)	62 (0.7)	756 (9.1)	17.0	16.3	0.95 (0.89–1.02)	14.5	11.5
STEC§§§	2,882	582 (20.2)	11 (0.4)	78 (2.7)	5.3	5.7	1.18 (1.02–1.36)	4.6	3.7
STEC O157¶¶¶	301	—****	—****	—****	0.9	0.6	0.76 (0.65–0.86)	—****	NA††††
STEC non-O157¶¶¶	992	—****	—****	—****	2.1	2.0	0.92 (0.77–1.13)	—****	NA††††
Shigella	2,478	758 (30.6)	6 (0.2)	136 (5.5)	5.1	4.9	0.95 (0.75–1.18)	3.9	NA††††
Yersinia	1,003	200 (19.9)	5 (0.5)	6 (0.6)	0.9	2.0	2.41 (2.03–2.88)	1.9	NA††††
Vibrio	504	117 (23.2)	13 (2.6)	0 (—)	0.8	1.0	1.57 (1.37–1.81)	0.9	NA††††
Listeria§§§§	136	128 (94.1)	30 (22.1)	7 (5.1)	0.3	0.3	1.06 (0.93–1.22)	0.26	0.22
Parasite									
Cyclospora	440	30 (6.8)	1 (0.2)	54 (12.3)	0.4	0.9	4.77 (2.60–10.7)	0.6	NA††††
Total	**25,479**	**5,981 (23.5)**	**170 (0.7)**	**1,096 (4.3)**	—****	—****	—****	—****	—****

Abbreviations: CIDT = culture-independent diagnostic test; CrI = credible interval; HHS = U.S. Department of Health and Human Services; IRR = incidence rate ratio; NA = not applicable; STEC = Shiga toxin-producing *Escherichia coli*.

* Healthy People 2030 is a 10-year plan for addressing critical public health priorities and challenges. HHS releases priority objectives as part of this plan, including incidence targets for select causes of foodborne illness (resulting from *Campylobacter*, *Salmonella*, STEC, and *Listeria*), to be met by 2030. https://health.gov/healthypeople/objectives-and-data/browse-objectives/foodborne-illness

† Data were obtained from laboratories in Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, Tennessee, and selected counties in California, Colorado, and New York.

§ 2022 data are preliminary.

¶ Bacterial infections were diagnosed using culture or CIDT. *Cyclospora* infections were diagnosed using microscopy or polymerase chain reaction.

** Admission to an inpatient unit or an observation stay of >24 hours within 7 days before or after specimen collection or determined to be related to the infection if beyond this time frame. Average percentage of infections resulting in hospitalizations during 2016–2018 by pathogen: *Campylobacter* (20%), *Salmonella* (27%), STEC (22%), *Shigella* (24%), *Yersinia* (26%), *Vibrio* (30%), *Listeria* (96%), *Cyclospora* (6%), and overall (24%). Infections with unknown hospitalization status (8% of infections during 2022 and 4% during 2016–2018) were included in the denominator only (i.e., classified as not hospitalized).

†† Attributed to infection when death occurred during hospitalization or within 7 days after specimen collection from nonhospitalized patients. Average percentage of infections resulting in death during 2016–2018 by pathogen: *Campylobacter* (0.4%), *Salmonella* (0.4%), STEC (0.4%), *Shigella* (0.1%), *Yersinia* (1.2%), *Vibrio* (2.1%), *Listeria* (18.6%), *Cyclospora* (0.2%), and overall (0.5%). Infections with unknown death status (9% of infections during 2022 and 3% during 2016–2018) were included in the denominator. *Salmonella* deaths occurred in nine of 10 surveillance sites. Among the 32 *Salmonella* deaths with information on travel, two (6%) were associated with international travel. Six *Salmonella* deaths were associated with outbreaks.

§§ Generally defined as ≥2 cases of similar illness associated with a common exposure; some sites also stipulate illnesses be from more than one household. Average percentage of outbreak-associated infections during 2016–2018 by pathogen: *Campylobacter* (<1%), *Salmonella* (7%), STEC (4%), *Shigella* (5%), *Yersinia* (<1%), *Vibrio* (4%), *Listeria* (5%), *Cyclospora* (24%), and overall (4%).

¶¶ Cases of infection per 100,000 population. Crude incidence is unadjusted and includes both infections among those who reported international travel before illness began (30 days for *Listeria* and *Salmonella* serotypes Typhi and Paratyphi, 14 days for *Cyclospora*, and 7 days for other pathogens) and domestically acquired infections (those for which the patient had no history of international travel or unknown travel history).

*** A Bayesian, negative binomial model with penalized thin plate splines adjusting for state-specific trends and population changes was used to estimate the percentage change in incidence during 2022 compared with the average annual incidence during 2016–2018. Incidence is described as increased or decreased relative to the reference period if the 95% CrI for the IRR did not cross the null value of 1. This model is based on crude incidence (i.e., includes both domestically acquired infections and those infections associated with international travel).

††† Domestic incidence refers to the incidence of domestically acquired infections. Healthy People 2030 incidence targets are based on incidences of domestically acquired infections only. Using the Bayesian, negative binomial model of the four pathogens with a Healthy People 2030 target (*Campylobacter*, *Salmonella*, STEC, and *Listeria*), no pathogen met the threshold for a decrease in domestically acquired infections, and one met the threshold for evidence of an increase (*Campylobacter*). IRRs for domestically acquired infections were as follows: *Campylobacter* (IRR = 1.07, 95% CrI = 1.01–1.14), *Salmonella* (0.95, 0.88–1.02), STEC (1.14, 1.00–1.30), *Shigella* (0.90, 0.69–1.13), *Yersinia* (2.44, 2.06–2.91), *Vibrio* (1.54, 1.34–1.77), *Listeria* (1.06, 0.92–1.22), and *Cyclospora* (5.30, 2.41–15.18).

§§§ Among 2,882 STEC infections, specimens for 2,401 (83%) were cultured; 1,298 (54%) of those cultured yielded an isolate. Of these isolates, 1,293 (>99%) were successfully classified as STEC O157 or STEC non-O157 and 1,187 (91%) had the specific O antigen determined. Therefore, among all STEC infections, 1,293 of 2,882 (45%) infections were classified as STEC O157 or STEC non-O157, and O antigen was determined for 1,187 of 2,882 (41%) infections. Incidences for STEC O157 and overall non-O157 STEC include only a proportion of the overall STEC incidence, because 1,589 STEC infections (55%) were not able to be classified as STEC O157 or STEC non-O157 during 2022, compared with 43% during 2016–2018. Thus, IRRs for STEC O157 and STEC non-O157 partially reflect the increasing proportion of STEC infections with unknown serogroup relative to 2016–2018.

¶¶¶ Among STEC isolates classified as O157 or non-O157 (N = 1,293).

**** Incidence rate not calculated.

†††† Pathogen for which there is no Healthy People 2030 target.

§§§§ For ease of comparison with the Healthy People 2030 incidence target, the reported incidence of domestically acquired *Listeria* infections during 2022 is shown to the second decimal place.

TABLE 2. Percentage of bacterial infections diagnosed by a culture-independent diagnostic test, only by a culture-independent diagnostic test, with a reflex culture, and percentage of reflex cultures that yielded an isolate — Foodborne Diseases Active Surveillance Network, 10 U.S. sites,* 2016–2018 and 2022†

	Infection diagnosed by CIDT,§ %		Infection diagnosed only by CIDT,¶ %		Positive CIDT with reflex culture,** %		Reflex culture yielded an isolate,†† %	
Pathogen	**2016–2018**	**2022**	**2016–2018**	**2022**	**2016–2018**	**2022**	**2016–2018**	**2022**
Campylobacter	53	78	36	53	60	54	55	58
Salmonella	30	54	9	15	79	86	88	84
STEC	100	100	43	55	88	83	65	54
Shigella	49	81	29	52	69	78	58	46
Yersinia	69	91	46	77	69	66	48	24
Vibrio	45	71	31	56	83	69	38	30
Listeria	4	24	0	1	100	100	88	94
Overall	**49**	**73**	**26**	**41**	**71**	**70**	**65**	**62**

Abbreviations: CIDT = culture-independent diagnostic test; STEC = Shiga toxin-producing *Escherichia coli*.

* Data were obtained from laboratories in Connecticut, Georgia, Maryland, Minnesota, New Mexico, Oregon, Tennessee, and selected counties in California, Colorado, and New York.

† 2022 data are preliminary.

§ Includes specimens that had a culture performed, regardless of the result, and those not cultured. The denominator is total infections.

¶ Includes specimens that had a negative culture result and those not cultured. The denominator is total infections.

** Specimens with a positive CIDT result that had a culture performed, regardless of the result. Denominator is infections diagnosed by CIDT.

†† Denominator is number of specimens having a reflex culture performed.

poultry.¶¶¶ Recommendations aim to reduce the incidence of pathogen colonization in birds (e.g., poultry vaccination and use of prebiotics and probiotics) and minimize contamination of poultry water, feed, and bedding. In 2022, FSIS proposed a new regulatory framework to control *Salmonella* in poultry products,**** guided by recommendations from the National Advisory Committee on Microbiological Criteria for Foods. In 2023, FSIS released a proposed notice of determination to declare *Salmonella* an adulterant in not-ready-to-eat breaded and stuffed chicken products.†††† Reducing leafy green contamination by improving agricultural water safety, as promoted by FDA§§§§ and the Food Safety Modernization Act,¶¶¶¶ could also reduce *Salmonella,* STEC, *Listeria,* and other pathogens that cause foodborne illnesses.

In 2022, 73% of infections detected by FoodNet surveillance had a CIDT result (ranging from 24% to 100% by pathogen). These rapid, highly sensitive assays permit prompt clinical diagnoses from a broad range of potential etiologies, enhancing detection of infections that would have otherwise remained undetected. However, CIDT adoption and the routine usage of culture methods has varied by time, pathogen, and market forces (*8*,*9*). These factors and the different sensitivity and specificity of CIDTs complicate the interpretation of surveillance data. Furthermore, having a lower proportion of cases with an isolate obtained by reflex culture limits public health response by reducing the number of isolates having sequenced genomes, which can hinder identification of outbreaks of genetically related infections and the determination of genes coding for antibiotic resistance.

The results of this analysis are subject to at least three limitations. First, the number of reported infections might be undercounted because some ill persons might not seek care, and recommended testing of ill persons might not always be conducted; conversely, false-positive results might cause some overcounting. Second, persons meeting FoodNet criteria for hospitalization or death are included in this report, although underlying reasons for hospitalization or death might be unknown.***** Finally, deaths associated with enteric infections occurring >1 week after specimen collection among patients not hospitalized, and occurring after discharge among those hospitalized (e.g., in hospice care), might have been omitted.

The incidences of infections caused by certain pathogens reported during 2022 were higher than during the prepandemic period 2016–2018, and substantial progress toward Healthy People 2030 objectives was not evident. Prevention measures targeted at reducing food contamination, including the FSIS-proposed *Salmonella* regulatory framework for reducing illnesses from poultry, are needed to mitigate the prevalence of disease and to meet Healthy People 2030 targets. Better understanding of reasons for decreased incidence of foodborne infections during the COVID-19 pandemic (2020–2021) that were not sustained during 2022 could help guide the creation of additional mitigation strategies.

**** https://www.fsis.usda.gov/sites/default/files/media_file/documents/FINAL-Salmonella-Framework-10112022-508-edited.pdf

†††† https://www.fsis.usda.gov/policy/federal-register-rulemaking/federal-register-rules/salmonella-not-ready-eat-breaded-stuffed

§§§§ https://www.fda.gov/food/foodborne-pathogens/leafy-greens-stec-action-plan

¶¶¶¶ https://www.fda.gov/food/guidance-regulation-food-and-dietary-supplements/food-safety-modernization-act-fsma

***** https://www.cdc.gov/foodnet/surveillance.html

Summary

What is already known about this topic?

Campylobacter and *Salmonella* are the leading causes of bacterial enteric infections transmitted commonly by food. Reported incidence of enteric infections was lower during the COVID-19 pandemic (2020–2021) compared with previous years.

What is added by this report?

During 2022, FoodNet identified higher incidences of Shiga toxin-producing *Escherichia coli*, *Yersinia*, *Vibrio*, and *Cyclospora* infections compared with 2016–2018. *Campylobacter, Salmonella, Shigella*, and *Listeria* incidences did not change.

What are the implications for public health practice?

Progress in reducing enteric infection incidence was not observed during 2022, as influences of the COVID-19 pandemic subsided. Collaboration among food growers, processors, retail stores, restaurants, and regulators is needed to reduce pathogen contamination during poultry slaughter and to prevent contamination of leafy greens.

Acknowledgments

Work group members, Foodborne Diseases Active Surveillance Network (FoodNet), Emerging Infections Program, CDC; Robert Breazu, Staci Dixon, Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging and Zoonotic Infectious Diseases, CDC.

Corresponding author: Miranda J. Delahoy, vuo0@cdc.gov.

[1]Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging and Zoonotic Infectious Diseases, CDC; [2]Minnesota Department of Health; [3]New York State Department of Health; [4]Oregon Health Authority; [5]Colorado Department of Public Health and Environment; [6]California Emerging Infections Program, Oakland, California; [7]Connecticut Emerging Infections Program, New Haven, Connecticut; [8]Tennessee Department of Health; [9]University of New Mexico, Albuquerque, New Mexico; [10]Georgia Department of Public Health; [11]Maryland Department of Health; [12]Center for Food Safety and Applied Nutrition, Food and Drug Administration, College Park, Maryland; [13]Food Safety and Inspection Service, U.S. Department of Agriculture, Washington, DC.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Elaine Scallan Walter reports consulting fees for a peer review of a *Salmonella* risk profile for the U.S. Department of Agriculture Food Safety and Inspection Service via RTI International during 2022. No other potential conflicts of interest were disclosed.

References

1. Scallan E, Hoekstra RM, Angulo FJ, et al. Foodborne illness acquired in the United States—major pathogens. Emerg Infect Dis 2011;17:7–15. PMID:21192848 https://doi.org/10.3201/eid1701.p11101
2. Office of Disease Prevention and Health Promotion. Healthy People 2030: foodborne illness. Washington, DC: US Department of Health and Human Services; 2023. https://health.gov/healthypeople/objectives-and-data/browse-objectives/foodborne-illness
3. Collins JP, Shah HJ, Weller DL, et al. Preliminary incidence and trends of infections caused by pathogens transmitted commonly through food—Foodborne Diseases Active Surveillance Network, 10 U.S. sites, 2016–2021. MMWR Morb Mortal Wkly Rep 2022;71:1260–4. PMID:36201372 https://doi.org/10.15585/mmwr.mm7140a2
4. Ray LC, Collins JP, Griffin PM, et al. Decreased incidence of infections caused by pathogens transmitted commonly through food during the COVID-19 pandemic—Foodborne Diseases Active Surveillance Network, 10 U.S. sites, 2017–2020. MMWR Morb Mortal Wkly Rep 2021;70:1332–6. PMID:34555002 https://doi.org/10.15585/mmwr.mm7038a4
5. Domingues AR, Pires SM, Halasa T, Hald T. Source attribution of human campylobacteriosis using a meta-analysis of case-control studies of sporadic infections. Epidemiol Infect 2012;140:970–81. PMID:22214729 https://doi.org/10.1017/S0950268811002676
6. CDC; Food and Drug Administration; Food Safety and Inspection Service. The Interagency Food Safety Analytics Collaboration: foodborne illness source attribution estimates for 2020 for *Salmonella, Escherichia coli* O157, and *Listeria monocytogenes* using multi-year outbreak surveillance data, United States. Atlanta, GA: US Department of Health and Human Services, CDC; Washington, DC: US Department of Health and Human Services, Food and Drug Administration; Washington, DC: US Department of Agriculture, Food Safety and Inspection Service; 2022. https://www.cdc.gov/foodsafety/ifsac/pdf/P19-2020-report-TriAgency-508.pdf
7. Alter T. Prevention and mitigation strategies for *Campylobacter* with focus on poultry production [Chapter 6]. In: Klein G, ed. *Campylobacter:* features, detection, and prevention of foodborne disease. Amsterdam, Netherlands: Elsevier; 2017:111–29. https://linkinghub.elsevier.com/retrieve/pii/B978012803623500006X
8. Ray LC, Griffin PM, Wymore K, et al. Changing diagnostic testing practices for foodborne pathogens, Foodborne Diseases Active Surveillance Network, 2012–2019. Open Forum Infect Dis 2022;9:ofac344. PMID:35928506 https://doi.org/10.1093/ofid/ofac344
9. Cybulski RJ Jr, Bateman AC, Bourassa L, et al. Clinical impact of a multiplex gastrointestinal polymerase chain reaction panel in patients with acute gastroenteritis. Clin Infect Dis 2018;67:1688–96. PMID:29697761 https://doi.org/10.1093/cid/ciy357

Prevalence of Adverse Childhood Experiences Among U.S. Adults — Behavioral Risk Factor Surveillance System, 2011–2020

Elizabeth A. Swedo, MD[1]; Maria V. Aslam, PhD[2]; Linda L. Dahlberg, PhD[1]; Phyllis Holditch Niolon, PhD[1]; Angie S. Guinn, MPH[1]; Thomas R. Simon, PhD[1]; James A. Mercy, PhD[1]

Adverse childhood experiences (ACEs) are defined as preventable, potentially traumatic events that occur among persons aged <18 years and are associated with numerous negative outcomes; data from 25 states indicate that ACEs are common among U.S. adults (*1*). Disparities in ACEs are often attributable to social and economic environments in which some families live (*2*,*3*). Understanding the prevalence of ACEs, stratified by sociodemographic characteristics, is essential to addressing and preventing ACEs and eliminating disparities, but population-level ACEs data collection has been sporadic (*1*). Using 2011–2020 Behavioral Risk Factor Surveillance System (BRFSS) data, CDC provides estimates of ACEs prevalence among U.S. adults in all 50 states and the District of Columbia, and by key sociodemographic characteristics. Overall, 63.9% of U.S. adults reported at least one ACE; 17.3% reported four or more ACEs. Experiencing four or more ACEs was most common among females (19.2%), adults aged 25–34 years (25.2%), non-Hispanic American Indian or Alaska Native (AI/AN) adults (32.4%), non-Hispanic multiracial adults (31.5%), adults with less than a high school education (20.5%), and those who were unemployed (25.8%) or unable to work (28.8%). Prevalence of experiencing four or more ACEs varied substantially across jurisdictions, from 11.9% (New Jersey) to 22.7% (Oregon). Patterns in prevalence of individual and total number of ACEs varied by jurisdiction and sociodemographic characteristics, reinforcing the importance of jurisdiction and local collection of ACEs data to guide targeted prevention and decrease inequities. CDC has released prevention resources, including Preventing Adverse Childhood Experiences: Leveraging the Best Available Evidence, to help provide jurisdictions and communities with the best available strategies to prevent violence and other ACEs, including guidance on how to implement those strategies for maximum impact (*4*–*6*).

BRFSS is an annual survey of health-related risk behaviors and chronic health conditions representative of noninstitutionalized adults collected from all 50 states, the District of Columbia, and three U.S. territories (*7*). In addition to core questions administered annually to all participants, jurisdictions and territories can include jurisdiction-approved optional modules, as well as jurisdiction-added questions.* From 2011 to 2020, ACEs questions were included in the BRFSS questionnaire at least once by all 50 states and the District of Columbia as either an optional module (2011–2012 and 2019–2020) or jurisdiction-added questions (2013–2018). For jurisdictions that included ACEs questions in more than 1 year, the most recent year was included.

The optional ACEs module includes 11 questions to determine exposure to eight types of ACEs: physical abuse, emotional abuse, sexual abuse, witnessing intimate partner violence, household substance abuse, household mental illness, parental separation or divorce, and incarcerated household member† (*1*). The Arkansas and New Hampshire questionnaires differed from the optional ACEs module. Arkansas collapsed three sexual abuse questions into a single question, and New Hampshire omitted two of the three sexual abuse questions.§ The Arkansas questionnaire also combined household drug abuse and alcohol abuse questions into a single household substance abuse question.¶ Responses to all ACE types were dichotomized**; ACE scores were calculated for participants

* https://www.cdc.gov/violenceprevention/communicationresources/pub/technical-packages.html

† https://www.cdc.gov/brfss/questionnaires/index.htm

§ Arkansas' sexual abuse question was worded, "How often did anyone at least 5 years older than you or an adult ever touch you sexually, try to make you touch them sexually, or force you to have sex?" New Hampshire only included one of the three sexual abuse questions, "How often did anyone at least 5 years older than you or an adult ever touch you sexually?"

¶ Arkansas' substance abuse question was worded, "Did you live with anyone who was a problem drinker or alcoholic, or who used illegal street drugs or abused prescription medications?"

** Generally, for ACE questions with response options of "Yes/No/Don't know," "Yes" was coded as experiencing the ACE, "No" was coded as not experiencing the ACE, and "Don't know" was coded as missing. For ACEs questions with response options of "Never/Once/More than once/Don't know," "Never" was coded as not experiencing the ACE, "Once" or "More than once" was coded as experiencing the ACE, and "Don't know" was coded as missing. For the substance use ACE, a "Yes" response to either the alcohol use or illegal drug or prescription drug misuse questions was coded as experiencing the substance use ACE. If the response to either alcohol use or illegal drug or prescription drug misuse questions was "No" and the other question response was missing, the substance use ACE was coded as missing. For the divorce or separation ACE, "Yes" was coded as experiencing the ACE, "No" was coded as not experiencing the ACE, and responses of "Parents not married" or "Don't know" were coded as missing. For the sexual abuse ACE, three individual sexual abuse questions were combined to form a composite, dichotomous sexual abuse ACE. If answers to any of the sexual abuse questions was "Once" or "More than once," the composite sexual abuse ACE was coded as experiencing the ACE. If answers to all of the sexual abuse questions was "Never," the composite sexual abuse ACE was coded as not experiencing the ACE. If the respondent answered "Never" to one or more questions but was missing responses for one or more of the other sexual abuse questions, the response was coded as missing.

by summing affirmative responses to all eight ACE types and then categorized into zero, one, two to three, or four or more ACEs. Four or more ACEs were selected as the upper cut-off given the volume of research linking exposure to four or more ACEs with negative health and life outcomes (*1,2,8,9*). The New Hampshire questionnaire did not include divorce or emotional abuse questions; therefore, the maximum ACE score in New Hampshire was six.

Participants with missing data for any type of ACE were excluded (79,797), leaving 264,882 participants (72.5% of total). Weighted prevalence estimates and 95% CIs were calculated for individual ACEs and total ACE score, by jurisdiction and by sociodemographic characteristics (sex, age group, race and ethnicity, annual household income, educational attainment, and employment status). Age-stratified jurisdictional prevalence estimates for four or more ACEs were also calculated. All analyses accounted for survey design by using recommended weights and complex survey procedures in SAS software (version 9.4; SAS Institute). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[††]

Survey response rate ranged by jurisdiction from 30.6% (Illinois, 2017) to 67.2% (Mississippi, 2020) (Table 1). Nearly two thirds of U.S. adults (63.9%) experienced one or more ACE: 23.1% reported one; 23.5% reported two to three; and 17.3% reported four or more ACEs (Table 2). The prevalence of four or more ACEs was highest among females (19.2%), persons aged 25–34 years (25.2%), AI/AN adults (32.4%), and multiracial adults (31.5%). The prevalence of four or more ACEs was also higher among adults with household incomes <$15,000 (24.1%), those with less than a high school education (20.5%), and those who were unable to work (28.8%). Prevalence of four or more ACEs was lowest among persons aged ≥65 years (7.7%). Emotional abuse was the most reported type of ACE (34.0%), followed by parental separation or divorce (28.4%), and household substance abuse (26.5%) (Table 3). Patterns in prevalence of individual types of ACEs differed by sociodemographic characteristics.

Prevalence of individual ACEs (Table 3), total number of ACEs (Table 1), and four or more ACEs (Supplementary Figure 1, https://stacks.cdc.gov/view/cdc/128424) varied by jurisdiction. For example, Alaska had one of the highest prevalences of reported emotional abuse (42.2%) but one of the lower prevalences of physical abuse (19.4%). Among jurisdictions that asked all eight types of ACE questions, the prevalence of adults reporting four or more ACEs ranged from 11.9% (New Jersey) to 22.7% (Oregon). Geographic patterns of reporting four or more ACEs also differed by age group (Supplementary Figure 2, https://stacks.cdc.gov/view/cdc/130206), with some consistent regional differences observed across age groups (e.g., increased prevalence of reporting 4 or more ACEs among jurisdictions in the Pacific Northwest).

[††] 45 C.F.R. part 46.102(l)(2), 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.

Discussion

This study provides the first estimates of ACEs among U.S. adults for all 50 states and the District of Columbia using BRFSS data. During 2011–2020, nearly two thirds of U.S. adults reported at least one ACE, and approximately one in six U.S. adults reported four or more ACEs. Among certain sociodemographic groups, for example, AI/AN or multiracial adults, these numbers are even higher, reflecting inequities in socioeconomic conditions that increase risk for ACEs. These numbers also highlight the potential intergenerational impact of ACEs through lost opportunities and lasting impacts on behavior and health (*8*). The prevalence of ACEs is strikingly lower among adults aged ≥65 years than among younger age groups; although this might be due to recall bias or differing trends over time, it might also reflect the risk of premature mortality accompanying exposure to a high number of ACEs (*9*).

Patterns in individual and total number of ACEs varied widely by jurisdiction and among sociodemographic groups, reinforcing the importance of population-level and local collection of ACE data to inform targeted prevention and intervention strategies. Variations in ACEs can result from several factors: differing demographic patterns, jurisdiction-level policies related to domestic violence, economic supports for families, historical and ongoing trauma because of discrimination, and social conditions (*4*). Better understanding of the relative contributions of these factors to ACEs in individual jurisdictions can help policymakers identify the most promising areas for intervention and the populations with the greatest need for services (*4*). Jurisdictions could consider further contextualizing their ACEs data with other BRFSS questions, such as those examining social determinants of health. CDC has released prevention resources to help provide jurisdictions and communities with the best available strategies to prevent violence and other ACEs, including guidance on how to implement those strategies for maximum impact (*4–6*). Clinicians and others who work directly with families play an important role in mitigating and preventing ACEs, from primary prevention opportunities (e.g., home visitation programs), to secondary and tertiary prevention strategies that reduce harms associated with ACEs (e.g., trauma-informed care, ensuring required linkage to services, and supports for identified issues) (*10*).

The findings in this report are subject to at least four limitations. First, data were collected over a 10-year period; prevalence might have changed in jurisdictions without recent

TABLE 1. Prevalence of individual adverse childhood experience types among adults, by jurisdiction — Behavioral Factor Surveillance System, United States, 2011–2020

Jurisdiction*	Survey year	Survey response rate, %	Total no., unweighted	ACE category, weighted % (95% CI)							
				Emotional†	Physical	Sexual§	Witnessed intimate partner violence	Household substance use¶	Household mental illness	Parental separation or divorce†	Incarcerated household member
Alabama	2020	42.4	**4,281**	30.9 (29.1–32.7)	19.5 (17.8–21.1)	13.6 (12.3–15.0)	18.6 (17.0–20.1)	28.2 (26.4–30.0)	18.3 (16.7–19.8)	33.8 (31.9–35.7)	10.7 (9.3–12.0)
Alaska	2015	54.2	**3,062**	42.2 (39.3–45.1)	19.4 (17.0–21.9)	16.1 (14.1–18.2)	19.5 (17.1–22.0)	32.6 (29.8–35.4)	22.8 (20.2–25.5)	30.2 (27.5–33.0)	10.2 (8.4–12.1)
Arizona	2020	50.0	**7,682**	35.3 (33.8–36.9)	26.3 (24.9–27.8)	13.8 (12.7–14.9)	17.0 (15.7–18.2)	27.9 (26.4–29.3)	17.4 (16.1–18.7)	31.9 (30.4–33.5)	10.0 (8.9–11.0)
Arkansas	2018	55.6	**4,231**	31.9 (29.7–34.2)	17.5 (15.7–19.4)	14.3 (12.7–16.0)	19.1 (17.1–21.0)	26.4 (24.3–28.6)	20.4 (18.3–22.5)	35.7 (33.4–38.0)	10.1 (8.5–11.8)
California	2020	38.7	**1,485**	38.4 (35.2–41.6)	30.7 (27.6–33.8)	13.7 (11.5–16.0)	20.6 (17.9–23.3)	26.8 (23.9–29.8)	16.2 (13.8–18.6)	28.3 (25.4–31.2)	9.3 (7.1–11.4)
Colorado	2014	57.0	**3,553**	34.2 (32.1–36.3)	18.0 (16.2–19.7)	10.4 (9.1–11.7)	16.4 (14.7–18.0)	27.8 (25.9–29.8)	17.1 (15.5–18.7)	28.9 (26.9–31.0)	6.0 (4.9–7.2)
Connecticut	2017	37.1	**8,121**	32.5 (31.0–34.0)	15.5 (14.4–16.7)	9.1 (8.2–9.9)	13.5 (12.4–14.6)	26.0 (24.6–27.4)	15.1 (14.0–16.3)	23.8 (22.4–25.2)	6.5 (5.7–7.4)
Delaware	2019	38.2	**2,937**	35.5 (33.0–38.0)	29.2 (26.8–31.5)	12.0 (10.4–13.7)	18.0 (15.9–20.1)	27.7 (25.2–30.2)	17.2 (15.0–19.3)	27.4 (25.0–29.8)	8.5 (6.8–10.2)
District of Columbia	2020	45.1	**2,563**	36.2 (33.6–38.7)	21.0 (18.9–23.1)	12.7 (10.9–14.6)	14.4 (12.6–16.3)	21.8 (19.7–23.9)	18.2 (16.1–20.2)	33.2 (30.6–35.8)	9.4 (7.6–11.2)
Florida	2020	40.1	**7,928**	30.3 (28.0–32.7)	23.5 (21.4–25.5)	13.0 (11.2–14.7)	16.6 (14.8–18.4)	26.3 (24.0–28.5)	13.2 (11.7–14.7)	33.0 (30.5–35.5)	9.4 (7.8–11.0)
Georgia	2020	39.1	**6,595**	32.3 (30.4–34.2)	22.2 (20.4–23.9)	13.2 (11.8–14.5)	16.7 (15.2–18.1)	24.9 (23.2–26.7)	15.1 (13.6–16.5)	32.4 (30.5–34.3)	9.9 (8.6–11.3)
Hawaii	2020	42.0	**6,627**	34.0 (32.5–35.6)	25.5 (24.1–26.9)	10.8 (9.8–11.7)	17.5 (16.3–18.7)	23.5 (22.1–24.8)	13.4 (12.4–14.5)	26.3 (24.9–27.8)	9.4 (8.4–10.4)
Idaho	2020	51.0	**4,725**	36.9 (34.9–38.9)	22.9 (21.2–24.7)	13.5 (12.1–14.9)	15.5 (13.9–17.0)	28.5 (26.6–30.4)	20.9 (19.2–22.6)	30.0 (28.0–31.9)	11.7 (10.3–13.1)
Illinois	2017	30.6	**4,322**	33.8 (32.0–35.7)	16.6 (15.1–18.1)	10.8 (9.6–12.1)	16.9 (15.4–18.3)	26.6 (24.8–28.3)	16.1 (14.6–17.6)	24.0 (22.3–25.7)	7.5 (6.4–8.7)
Indiana	2019	46.2	**6,998**	35.8 (34.3–37.3)	25.2 (23.9–26.5)	14.1 (13.0–15.2)	17.9 (16.7–19.1)	26.9 (25.5–28.3)	19.9 (18.6–21.2)	30.2 (28.8–31.7)	9.6 (8.6–10.6)
Iowa	2020	55.5	**7,700**	34.9 (33.6–36.2)	21.2 (20.1–22.3)	11.9 (11.0–12.9)	16.0 (14.9–17.0)	25.0 (23.8–26.2)	19.4 (18.3–20.6)	25.0 (23.8–26.2)	7.8 (7.0–8.6)
Kansas	2020	57.8	**4,267**	35.9 (34.1–37.8)	22.8 (21.2–24.5)	13.5 (12.2–14.8)	16.4 (15.0–17.9)	27.1 (25.3–28.8)	21.8 (20.1–23.4)	29.3 (27.5–31.1)	8.3 (7.1–9.4)
Kentucky	2020	43.3	**3,101**	32.3 (30.2–34.4)	21.0 (19.2–22.8)	14.3 (12.8–15.8)	17.4 (15.7–19.1)	29.5 (27.5–31.6)	22.1 (20.2–24.0)	31.3 (29.2–33.4)	12.6 (11.1–14.2)
Louisiana	2016	30.7	**4,106**	30.7 (28.4–33.0)	14.6 (12.7–16.4)	12.0 (10.4–13.5)	20.4 (18.4–22.4)	28.0 (25.8–30.2)	17.0 (15.1–18.8)	34.2 (31.8–36.7)	10.6 (9.0–12.3)
Maine	2011	54.7	**3,555**	35.6 (33.2–38.0)	17.5 (15.7–19.4)	14.2 (12.5–15.9)	14.8 (13.1–16.6)	33.9 (31.5–36.2)	20.4 (18.2–22.6)	25.3 (23.0–27.6)	7.3 (5.7–8.9)
Maryland	2020	45.8	**3,678**	30.2 (28.1–32.4)	22.0 (20.1–24.0)	11.0 (9.6–12.4)	15.3 (13.7–17.0)	22.9 (21.0–24.9)	15.3 (13.6–17.0)	28.6 (26.4–30.7)	6.9 (5.7–8.1)
Massachusetts	2020	48.8	**2,452**	34.0 (31.5–36.5)	23.3 (21.0–25.5)	10.5 (8.9–12.0)	15.1 (13.1–17.1)	26.0 (23.7–28.3)	18.5 (16.5–20.5)	25.5 (23.2–27.8)	6.8 (5.3–8.2)
Michigan	2019	51.5	**8,900**	37.9 (36.5–39.3)	25.5 (24.3–26.8)	14.3 (13.3–15.3)	17.8 (16.7–18.9)	30.6 (29.3–31.9)	20.9 (19.7–22.1)	29.6 (28.3–30.9)	9.8 (8.8–10.8)
Minnesota	2011	51.9	**9,004**	33.8 (32.1–35.6)	15.2 (13.8–16.5)	9.5 (8.4–10.6)	14.2 (12.9–15.5)	26.7 (25.0–28.3)	15.3 (13.9–16.6)	19.2 (17.7–20.8)	6.5 (5.4–7.7)
Mississippi	2020	67.2	**5,673**	23.3 (21.7–24.9)	12.5 (11.3–13.6)	11.2 (10.0–12.3)	15.0 (13.8–16.3)	25.5 (23.9–27.0)	15.5 (14.1–16.9)	33.5 (31.8–35.3)	10.5 (9.3–11.7)
Missouri	2020	57.8	**7,672**	34.2 (32.7–35.6)	20.9 (19.7–22.2)	13.2 (12.2–14.2)	16.5 (15.4–17.7)	29.4 (28.1–30.8)	23.2 (21.9–24.5)	31.6 (30.2–33.0)	11.3 (10.3–12.3)
Montana	2020	50.4	**5,311**	38.9 (37.2–40.5)	24.6 (23.1–26.1)	14.2 (13.1–15.4)	18.1 (16.7–19.4)	34.3 (32.7–35.9)	24.6 (23.1–26.1)	31.1 (29.5–32.7)	10.6 (9.5–11.8)
Nebraska	2011	60.9	**9,288**	33.7 (31.8–35.6)	15.0 (13.6–16.5)	9.0 (8.0–10.1)	13.7 (12.4–15.1)	24.7 (23.0–26.5)	15.0 (13.5–16.5)	19.1 (17.4–20.8)	6.0 (4.8–7.1)

See table footnotes on the next page.

TABLE 1. (*Continued*) Prevalence of individual adverse childhood experience types among adults, by jurisdiction — Behavioral Factor Surveillance System, United States, 2011–2020

Jurisdiction*	Survey year	Survey response rate, %	Total no., unweighted	ACE category, weighted % (95% CI)							
				Emotional†	Physical	Sexual§	Witnessed intimate partner violence	Household substance use¶	Household mental illness	Parental separation or divorce†	Incarcerated household member
Nevada	2020	47.9	**1,659**	38.5 (35.2–41.8)	28.0 (24.9–31.0)	15.0 (12.6–17.4)	22.0 (19.0–25.1)	32.7 (29.5–35.9)	17.9 (15.4–20.3)	35.2 (31.9–38.4)	10.4 (8.2–12.6)
New Hampshire	2016	42.2	**5,515**	Not asked	14.9 (13.6–16.3)	11.0 (9.8–12.1)	18.0 (16.5–19.6)	29.6 (27.7–31.4)	19.1 (17.4–20.7)	Not asked	5.6 (4.5–6.6)
New Jersey	2020	34.5	**2,733**	33.4 (31.0–35.7)	24.9 (22.8–27.1)	8.6 (7.2–10.0)	14.8 (13.0–16.6)	19.7 (17.9–21.5)	13.4 (11.8–15.1)	21.7 (19.8–23.7)	5.2 (4.1–6.3)
New Mexico	2019	52.2	**4,951**	36.0 (34.1–37.9)	28.7 (26.9–30.6)	16.7 (15.2–18.2)	20.0 (18.3–21.6)	31.9 (30.1–33.8)	20.8 (19.1–22.4)	29.5 (27.6–31.4)	8.8 (7.6–10)
New York	2019	37.3	**3,571**	31.2 (29.1–33.4)	24.9 (22.9–26.9)	11.1 (9.6–12.6)	14.9 (13.3–16.6)	20.3 (18.4–22.1)	14.9 (13.1–16.6)	24.6 (22.6–26.7)	4.8 (3.7–5.9)
North Carolina	2014	37.5	**2,913**	28.1 (25.6–30.5)	13.5 (11.7–15.4)	11.9 (10.1–13.7)	16.5 (14.6–18.5)	27.4 (25.0–29.8)	15.2 (13.1–17.3)	29.7 (27.1–32.3)	7.0 (5.6–8.4)
North Dakota	2020	55.6	**3,790**	34.0 (31.8–36.2)	20.7 (18.8–22.6)	11.1 (9.6–12.7)	13.5 (11.9–15.1)	27.9 (25.8–30.0)	18.2 (16.3–20.1)	23.0 (21.0–25.1)	8.1 (6.7–9.5)
Ohio	2019	46.4	**7,366**	38.2 (36.4–40.1)	24.8 (23.1–26.4)	12.9 (11.7–14.2)	17.3 (15.9–18.8)	27.6 (25.9–29.2)	20.3 (18.7–21.9)	31.6 (29.8–33.5)	10.9 (9.5–12.3)
Oklahoma	2020	52.4	**2,029**	30.0 (27.4–32.7)	19.4 (17.2–21.5)	12.8 (11.0–14.7)	17.2 (15.1–19.4)	28.2 (25.6–30.7)	19.8 (17.6–22.0)	34.2 (31.5–37.0)	10.7 (8.8–12.6)
Oregon	2018	39.8	**2,969**	40.0 (34.6–45.4)	22.2 (18.2–26.2)	18.0 (16.0–20.0)	19.4 (15.8–23.0)	32.3 (28.7–36.0)	23.9 (20.3–27.4)	32.7 (25.0–40.5)	10.0 (6.3–13.7)
Pennsylvania	2019	46.6	**5,219**	36.0 (34.3–37.7)	25.5 (23.9–27.0)	11.8 (10.7–12.9)	16.7 (15.4–18.1)	28.0 (26.4–29.6)	19.2 (17.8–20.6)	26.8 (25.2–28.4)	9.7 (8.6–10.8)
Rhode Island	2020	39.1	**4,235**	34.1 (31.9–36.3)	24.0 (22.0–25.9)	10.1 (8.8–11.3)	15.3 (13.7–17.0)	25.6 (23.6–27.6)	18.9 (17.0–20.8)	29.5 (27.3–31.6)	6.6 (5.3–7.9)
South Carolina	2020	47.9	**2,987**	31.3 (29.1–33.4)	21.3 (19.5–23.2)	14.8 (13.1–16.4)	15.2 (13.6–16.8)	29.3 (27.2–31.5)	19.0 (17.1–20.8)	30.6 (28.4–32.8)	10.3 (8.8–11.7)
South Dakota	2020	61.2	**5,584**	34.2 (31.3–37.1)	20.4 (18.0–22.7)	10.5 (8.7–12.3)	12.2 (10.4–14.1)	25.5 (22.8–28.1)	16.2 (13.8–18.7)	25.9 (23.1–28.7)	7.7 (6.0–9.4)
Tennessee	2019	42.0	**4,508**	34.5 (32.5–36.5)	23.9 (22.1–25.7)	15.8 (14.2–17.3)	18.9 (17.2–20.5)	31.4 (29.4–33.4)	20.5 (18.8–22.2)	34.1 (32.0–36.1)	10.7 (9.2–12.2)
Texas	2020	40.6	**7,603**	30.9 (28.8–33.0)	26.5 (24.5–28.6)	12.3 (10.9–13.7)	17.8 (16.0–19.5)	23.7 (21.7–25.6)	13.8 (12.3–15.3)	28.4 (26.4–30.4)	7.9 (6.8–9.1)
Utah	2020	55.4	**9,155**	42.3 (40.9–43.6)	27.6 (26.4–28.8)	15.5 (14.5–16.5)	17.1 (16.1–18.2)	25.3 (24.1–26.5)	28.1 (26.9–29.3)	24.0 (22.8–25.2)	9.1 (8.3–9.9)
Vermont	2011	49.9	**5,960**	33.0 (31.2–34.8)	14.7 (13.4–16.1)	10.4 (9.3–11.5)	14.4 (13.1–15.7)	28.1 (26.3–29.8)	17.2 (15.7–18.7)	23.1 (21.4–24.8)	5.6 (4.4–6.8)
Virginia	2020	41.5	**7,167**	32.6 (31.0–34.2)	21.9 (20.6–23.3)	11.0 (10.0–12.0)	15.5 (14.3–16.7)	23.3 (21.9–24.7)	15.7 (14.5–17.0)	27.7 (26.2–29.2)	8.1 (7.1–9.1)
Washington	2011	44.3	**12,798**	40.1 (38.6–41.5)	19.9 (18.7–21.1)	14.7 (13.7–15.7)	19.5 (18.3–20.7)	31.2 (29.9–32.6)	20.5 (19.3–21.7)	28.2 (26.8–29.5)	8.0 (7.0–8.9)
West Virginia	2019	49.6	**4,523**	29.9 (28.1–31.7)	20.1 (18.5–21.8)	13.1 (11.8–14.5)	17.8 (16.3–19.4)	27.1 (25.3–28.9)	19.4 (17.7–21.1)	26.9 (25.0–28.7)	9.0 (7.7–10.4)
Wisconsin	2020	53.8	**3,951**	38.1 (36.0–40.3)	25.6 (23.7–27.6)	12.3 (10.9–13.8)	16.6 (14.9–18.3)	27.2 (25.3–29.2)	18.0 (16.2–19.8)	23.9 (21.9–25.9)	7.6 (6.3–8.9)
Wyoming	2020	55.9	**3,879**	36.5 (34.2–38.8)	24.9 (22.8–27.0)	11.8 (10.3–13.4)	17.2 (15.3–19.1)	29.5 (27.3–31.7)	20.1 (18.1–22.2)	30.9 (28.7–33.2)	11.2 (9.4–13.0)

Abbreviation: ACE = adverse childhood experience.

* For jurisdictions that included ACE questions in >1 year, the most recent year was included.

† New Hampshire did not include these questions on its survey.

§ Arkansas collapsed three sexual abuse questions into a single question; New Hampshire omitted two of the three sexual abuse questions. Arkansas' sexual abuse question was worded, "How often did anyone at least 5 years older than you or an adult ever touch you sexually, try to make you touch them sexually, or force you to have sex?" New Hampshire only included one of the three sexual abuse questions, "How often did anyone at least 5 years older than you or an adult ever touch you sexually?"

¶ The Arkansas questionnaire combined household drug abuse and alcohol abuse questions into a single household substance abuse question, "Did you live with anyone who was a problem drinker or alcoholic, or who used illegal street drugs or abused prescription medications?"

TABLE 2. Adverse childhood experiences scores among adults, by sociodemographic characteristics and jurisdiction — Behavioral Risk Factor Surveillance System, United States, 2011–2020

Characteristic	Total no.,* unweighted	ACE score, weighted % (95% CI)			
		0	1	2–3	≥4
Total	**264,882**	**36.1 (35.6–36.6)**	**23.1 (22.7–23.6)**	**23.5 (23.0–23.9)**	**17.3 (16.9–17.7)**
Sex (missing = 20)					
Female	**149,565**	36 (35.3–36.7)	22.1 (21.5–22.7)	22.7 (22.1–23.4)	19.2 (18.6–19.8)
Male	**115,297**	36.3 (35.5–37.0)	24.2 (23.6–24.9)	24.2 (23.5–25.0)	15.2 (14.6–15.9)
Age group, yrs (missing = 2,961)					
18–24	**13,483**	28.9 (27.2–30.6)	23.1 (21.6–24.7)	25.9 (24.2–27.6)	22.1 (20.6–23.6)
25–34	**23,731**	27.3 (26.1–28.6)	22.2 (21.0–23.3)	25.3 (23.9–26.7)	25.2 (23.8–26.5)
35–44	**31,113**	32.8 (31.3–34.3)	21.9 (20.7–23.2)	24.8 (23.5–26.1)	20.5 (19.3–21.7)
45–54	**40,962**	34.1 (32.8–35.3)	23.2 (22.1–24.3)	24.1 (23.0–25.3)	18.6 (17.5–19.7)
55–64	**55,571**	37.5 (36.4–38.7)	23.7 (22.8–24.7)	24.1 (23.1–25.2)	14.6 (13.8–15.4)
≥65	**97,061**	49.3 (48.3–50.4)	24.1 (23.2–25.0)	18.8 (18.1–19.6)	7.7 (7.1–8.2)
Race and ethnicity (missing = 6,940)					
AI/AN, non-Hispanic	**4,256**	25.4 (21.8–29.0)	17.6 (14.9–20.3)	24.6 (21.1–28.1)	32.4 (27.7–37.2)
Asian, non-Hispanic	**5,199**	49.8 (45.4–54.3)	23.0 (19.0–27.0)	18.8 (15.2–22.4)	8.3 (5.9–10.8)
Black or African American, non-Hispanic	**18,558**	29.9 (28.5–31.2)	26.0 (24.6–27.4)	26.1 (24.6–27.5)	18.1 (16.9–19.2)
NH/OPI, non-Hispanic	**876**	33.3 (24.7–42.0)	20.4 (14.6–26.3)	23.0 (16.9–29.2)	23.2 (13.6–32.9)
White, non-Hispanic	**205,306**	37.1 (36.5–37.6)	23.1 (22.6–23.5)	23.1 (22.6–23.5)	16.8 (16.4–17.3)
Hispanic or Latino	**16,995**	34.9 (33.0–36.8)	22.6 (21.1–24.1)	23.9 (22.2–25.6)	18.6 (17.1–20.1)
Multiracial, non-Hispanic	**5,105**	22.9 (19.0–26.8)	16.2 (13.8–18.5)	29.5 (25.1–33.9)	31.5 (27.4–35.5)
Other race, non-Hispanic	**1,647**	28.5 (22.9–34.1)	21.5 (16.6–26.3)	26.8 (18.8–34.7)	23.3 (17.3–29.3)
Household income, USD (missing = 39,409)					
<$15,000	**18,902**	31.6 (29.4–33.7)	19.8 (18.3–21.4)	24.5 (22.5–26.6)	24.1 (22.3–25.9)
$15,000–$24,999	**34,874**	33.1 (31.8–34.4)	22.5 (21.3–23.7)	22.5 (21.3–23.6)	21.9 (20.8–23.1)
$25,000–$34,999	**23,665**	31.9 (30.4–33.5)	23.8 (22.3–25.2)	24.3 (22.6–26.0)	20.0 (18.5–21.5)
$35,000–$49,999	**32,252**	34.9 (33.4–36.4)	23.6 (22.2–24.9)	22.6 (21.5–23.8)	18.9 (17.6–20.1)
≥$50,000	**115,780**	36.8 (35.9–37.6)	23.5 (22.8–24.2)	24.5 (23.7–25.2)	15.3 (14.6–15.9)
Education level (missing = 584)					
Less than high school diploma	**16,944**	35.2 (33.4–37.1)	22.9 (21.3–24.4)	21.4 (19.8–23.0)	20.5 (19.0–22.0)
High school diploma or GED	**71,799**	35.3 (34.3–36.3)	23.7 (22.8–24.6)	22.5 (21.7–23.4)	18.4 (17.5–19.3)
Some college	**74,362**	32.3 (31.4–33.2)	22.4 (21.6–23.2)	25.5 (24.6–26.5)	19.8 (19.0–20.6)
College degree	**101,193**	41.2 (40.4–42.1)	23.5 (22.7–24.2)	23.1 (22.3–23.8)	12.2 (11.6–12.8)
Employment status (missing = 1,484)					
Employed	**130,794**	34.0 (33.3–34.7)	23.7 (23.1–24.3)	24.3 (23.7–24.9)	18.0 (17.4–18.6)
Unemployed	**12,470**	25.6 (23.3–27.8)	20.9 (18.9–22.8)	27.7 (25.4–30.1)	25.8 (23.6–28.0)
Unable to work	**17,833**	26.0 (24.3–27.7)	19.6 (18.3–20.9)	25.6 (23.8–27.3)	28.8 (27.1–30.4)
Other	**102,301**	44.3 (43.3–45.2)	23.4 (22.5–24.2)	20.5 (19.7–21.4)	11.8 (11.1–12.6)
Jurisdiction					
Alabama	**4,281**	36.0 (34.2–37.9)	23.6 (21.9–25.3)	21.7 (20.1–23.3)	18.7 (17.0–20.3)
Alaska	**3,062**	31.9 (29.3–34.5)	22.2 (19.7–24.7)	23.5 (21.1–25.8)	22.3 (19.7–25.0)
Arizona	**7,682**	33.2 (31.6–34.7)	23.2 (21.9–24.6)	24.8 (23.3–26.2)	18.9 (17.6–20.2)
Arkansas†	**4,231**	36.4 (34.3–38.4)	23.1 (21.0–25.1)	21.0 (19.1–22.9)	19.6 (17.6–21.6)
California	**1,485**	31.7 (28.7–34.8)	20.9 (18.2–23.5)	28.5 (25.5–31.4)	19.0 (16.3–21.6)
Colorado	**3,553**	36.9 (34.9–39.0)	24.1 (22.3–26.0)	23.8 (21.8–25.7)	15.1 (13.6–16.7)
Connecticut	**8,121**	40.2 (38.8–41.7)	24.1 (22.8–25.5)	22.6 (21.3–24.0)	13.0 (11.9–14.1)
Delaware	**2,937**	33.2 (30.8–35.6)	23.5 (21.3–25.7)	25.4 (23.0–27.7)	17.9 (15.8–20.1)
District of Columbia	**2,563**	31.1 (28.7–33.5)	26.0 (23.7–28.4)	27.7 (25.3–30.1)	15.2 (13.2–17.1)
Florida	**7,928**	37.3 (34.9–39.8)	23.4 (21.2–25.5)	22.2 (20.1–24.4)	17.1 (15.2–18.9)
Georgia	**6,595**	35.3 (33.5–37.2)	24.6 (22.8–26.3)	23.4 (21.6–25.1)	16.7 (15.2–18.3)
Hawaii	**6,627**	37.3 (35.7–38.9)	23.6 (22.2–25.0)	23.6 (22.3–25.0)	15.4 (14.3–16.6)
Idaho	**4,725**	35.3 (33.3–37.2)	22.7 (21.1–24.4)	22.5 (20.8–24.2)	19.5 (17.8–21.3)
Illinois	**4,322**	41.2 (39.3–43.1)	22.8 (21.2–24.4)	19.7 (18.1–21.3)	16.4 (14.9–17.9)
Indiana	**6,998**	34.2 (32.9–35.6)	23.5 (22.2–24.8)	23.2 (21.9–24.5)	19.1 (17.8–20.3)
Iowa	**7,700**	39.4 (38.1–40.6)	22.9 (21.8–24.0)	21.1 (20.0–22.2)	16.6 (15.5–17.7)
Kansas	**4,267**	35.1 (33.4–36.9)	23.6 (21.9–25.2)	22.9 (21.2–24.5)	18.4 (16.9–20.0)
Kentucky	**3,101**	35.9 (33.8–38.0)	22.0 (20.1–23.9)	23.0 (21.1–24.9)	19.1 (17.3–20.9)
Louisiana	**4,106**	36.0 (33.7–38.3)	23.1 (21.0–25.2)	23.4 (21.3–25.6)	17.5 (15.6–19.4)
Maine	**3,555**	36.9 (34.6–39.2)	22.5 (20.3–24.6)	22.1 (20.2–24.1)	18.5 (16.4–20.5)
Maryland	**3,678**	38.1 (35.8–40.4)	24.2 (22.2–26.2)	22.7 (20.8–24.6)	15.0 (13.4–16.7)
Massachusetts	**2,452**	38.5 (36.0–41.0)	21.5 (19.4–23.6)	23.8 (21.5–26.0)	16.2 (14.2–18.2)
Michigan	**8,900**	31.7 (30.4–32.9)	23.8 (22.7–25.0)	24.7 (23.5–25.9)	19.8 (18.6–21.0)
Minnesota	**9,004**	42.0 (40.2–43.8)	23.2 (21.6–24.7)	21.6 (20.1–23.1)	13.2 (11.9–14.6)
Mississippi	**5,673**	40.4 (38.8–42.1)	25.8 (24.2–27.3)	19.1 (17.7–20.5)	14.7 (13.4–16.1)

See table footnotes on the next page.

TABLE 2. (*Continued*) Adverse childhood experiences scores among adults, by sociodemographic characteristics and jurisdiction — Behavioral Risk Factor Surveillance System, United States, 2011–2020

Characteristic	Total no.,* unweighted	ACE score, weighted % (95% CI)			
		0	1	2–3	≥4
Missouri	**7,672**	35.1 (33.7–36.5)	23.2 (21.9–24.4)	21.7 (20.5–23.0)	20.0 (18.7–21.2)
Montana	**5,311**	31.8 (30.3–33.2)	22.1 (20.8–23.5)	23.8 (22.4–25.2)	22.3 (20.8–23.8)
Nebraska	**9,288**	44.0 (42.1–45.9)	22.9 (21.3–24.6)	20.7 (19.1–22.3)	12.4 (11.0–13.8)
Nevada	**1,659**	30.2 (27.0–33.4)	21.0 (18.2–23.7)	26.8 (23.7–29.9)	22.1 (19.3–24.9)
New Hampshire†	**5,515**	52.6 (50.6–54.5)	22.0 (20.4–23.6)	17.8 (16.3–19.3)	7.6 (6.5–8.8)
New Jersey	**2,733**	38.3 (35.9–40.8)	25.5 (23.4–27.7)	24.3 (22.2–26.3)	11.9 (10.3–13.4)
New Mexico	**4,951**	32.0 (30.2–33.9)	22.3 (20.6–23.9)	24.6 (22.9–26.3)	21.1 (19.4–22.8)
New York	**3,571**	39.1 (36.7–41.4)	24.4 (22.4–26.4)	23.1 (21.1–25.0)	13.5 (11.9–15.1)
North Carolina	**2,913**	39.8 (37.3–42.3)	24.7 (22.4–27.0)	20.3 (18.1–22.5)	15.2 (13.2–17.3)
North Dakota	**3,790**	40.9 (38.8–43.0)	22.4 (20.6–24.2)	20.3 (18.4–22.1)	16.4 (14.6–18.2)
Ohio	**7,366**	32.4 (30.7–34.0)	22.8 (21.2–24.4)	26.1 (24.4–27.7)	18.8 (17.2–20.3)
Oklahoma	**2,029**	38.6 (35.9–41.4)	22.5 (20.1–24.9)	19.4 (17.2–21.5)	19.5 (17.2–21.8)
Oregon	**2,969**	31.5 (26.7–36.2)	22.5 (20.1–24.8)	23.4 (21.7–25.0)	22.7 (17.2–28.2)
Pennsylvania	**5,219**	35.9 (34.2–37.6)	22.4 (21.0–23.9)	22.8 (21.3–24.3)	18.9 (17.5–20.3)
Rhode Island	**4,235**	36.5 (34.3–38.6)	24.2 (22.2–26.1)	23.1 (21.2–25.0)	16.3 (14.5–18.0)
South Carolina	**2,987**	35.3 (33.1–37.5)	25.1 (23.0–27.2)	21.2 (19.3–23.1)	18.4 (16.5–20.2)
South Dakota	**5,584**	39.7 (37.0–42.4)	23.3 (20.7–25.8)	22.2 (19.6–24.9)	14.8 (12.6–16.9)
Tennessee	**4,508**	33.2 (31.3–35.1)	21.6 (20.0–23.2)	23.4 (21.6–25.2)	21.8 (20.0–23.6)
Texas	**7,603**	37.5 (35.2–39.8)	24.0 (22.1–26.0)	22.4 (20.5–24.2)	16.1 (14.5–17.8)
Utah	**9,155**	32.2 (31.0-33.4)	21.5 (20.5–22.6)	26.1 (24.9–27.2)	20.2 (19.1–21.3)
Vermont	**5,960**	40.4 (38.6–42.2)	24.2 (22.5–25.8)	20.9 (19.4–22.4)	14.5 (13.1–16.0)
Virginia	**7,167**	38.3 (36.7–39.9)	24.5 (23.0–25.9)	21.5 (20.1–22.8)	15.8 (14.5–17.0)
Washington	**12,798**	33.1 (31.8–34.4)	22.8 (21.6–24.0)	24.6 (23.3–25.8)	19.5 (18.3–20.7)
West Virginia	**4,523**	41.6 (39.8–43.4)	20.0 (18.5–21.4)	19.8 (18.2–21.4)	18.6 (17.0–20.3)
Wisconsin	**3,951**	35.5 (33.5–37.6)	24.1 (22.2–26.0)	23.6 (21.7–25.5)	16.8 (15.1–18.5)
Wyoming	**3,879**	36.0 (33.9–38.2)	22.5 (20.6–24.4)	21.5 (19.6–23.4)	20.0 (18.0–22.0)

Abbreviations: ACE = adverse childhood experience; AI/AN = American Indian or Alaska Native; GED = general educational development certificate; NH/OPI = Native Hawaiian or other Pacific Islander; USD = U.S. dollars.

* For jurisdictions that included ACE questions in >1 year, the most recent year was included.

† Arkansas and New Hampshire's questionnaires differed slightly from the optional ACEs module. Arkansas collapsed three sexual abuse questions into a single question; New Hampshire omitted two of the three sexual abuse questions. Arkansas' sexual abuse question was worded, "How often did anyone ≥5 years older than you or an adult ever touch you sexually, try to make you touch them sexually, or force you to have sex?" New Hampshire only included one of the three sexual abuse questions, "How often did anyone at least 5 years older than you or an adult ever touch you sexually?" In addition, the Arkansas questionnaire combined household drug abuse and alcohol abuse questions into a single household substance abuse question, "Did you live with anyone who was a problem drinker or alcoholic, or who used illegal street drugs or abused prescription medications?" New Hampshire omitted questions related to emotional abuse and parental separation or divorce; therefore, its maximum ACE score was 6, rather than 8.

data. In addition, jurisdiction-specific prevalences reflect the experiences of adults living in that jurisdiction, but do not necessarily represent the jurisdiction in which the ACE occurred. Second, although most jurisdictions used identical measures, two states (Arkansas and New Hampshire) collapsed or omitted sexual abuse questions, and one state (New Hampshire) omitted two types of ACEs. As a result, estimates for emotional abuse and parental separation or divorce are unavailable for New Hampshire. The reported prevalences of ACEs might be underestimated because respondents with missing ACEs data (79,797) were excluded from the analysis; these respondents reported higher prevalence of individual ACEs on the questions they did answer than those who answered all of the ACEs questions. Third, recall and social desirability biases might reduce the accuracy of self-reported ACEs, leading to underestimation, because participants might no longer remember or be willing to disclose potentially traumatic events from their childhood. Finally, BRFSS questions measure a limited set of ACEs and do not reflect the full range, severity, or frequency of ACEs. It is possible that ACEs included in BRFSS are experienced differently by certain groups, thereby shaping some of the demographic and geographic differences observed. In addition, certain limitations need to be considered when interpreting jurisdiction-specific estimates. First, BRFSS records a small subset of potential ACEs; there might be ACEs that are particularly relevant in certain parts of the country that are not included on BRFSS (e.g., experiences of racism or discrimination and community violence) and are thereby not reflected in estimates. Second, adults with six or more ACEs die approximately 20 years earlier on average than do those without ACEs *(9)*; survivorship bias might undercount ACE prevalence in regions affected by premature mortality related to ACEs. Despite these limitations, the findings from this study update the baseline for ACEs measurement from previous estimates from 25 states (*1*), providing actionable data for all 50 states and the District of Columbia.

TABLE 3. Prevalence of individual adverse childhood experiences among adults, by sociodemographic characteristics — Behavioral Risk Factor Surveillance System, United States, 2011–2020

Characteristic	Total no.,* unweighted	Weighted % (95% CI)	Emotional†	Physical	Sexual§	ACE category, weighted % (95% CI)				
						Witnessed intimate partner violence	Household substance use¶	Household mental illness	Parental separation or divorce†	Incarcerated household member
Total	**264,882**	**NA**	**NA**	**23.3 (22.8–23.8)**	**12.6 (12.2–13.0)**	**17.2 (16.8–17.7)**	**26.5 (26.0–27.0)**	**17.3 (16.9–17.7)**	**28.4 (27.9–28.9)**	**8.6 (8.3-9)**
Sex (missing = 20)										
Female	**149,565**	52.0 (51.4–52.5)	34.0 (33.3–34.7)	22.7 (22.0–23.3)	17.7 (17.1–18.3)	18.1 (17.5–18.7)	27.9 (27.2–28.5)	19.9 (19.4–20.5)	28.4 (27.7–29.1)	8.1 (7.6–8.5)
Male	**115,297**	47.5 (47.4–48.5)	34.0 (33.2–34.8)	24.0 (23.3–24.7)	7.0 (6.6–7.4)	16.3 (15.7–16.9)	25.0 (24.3–25.7)	14.4 (13.8–14.9)	28.4 (27.7–29.1)	9.3 (8.7–9.8)
Age group, yrs (missing = 2,961)										
18–24	**13,483**	11.9 (11.5–12.4)	43.1 (41.3–45.0)	23.0 (21.4–24.6)	11.5 (10.2–12.8)	16.9 (15.6–18.3)	27.5 (25.9–29.2)	27.0 (25.5–28.6)	36.5 (34.8–38.2)	15.4 (14.0–16.7)
25–34	**23,731**	16.1 (15.6–16.5)	42.5 (40.9–44.0)	25.5 (24.1–27.0)	13.1 (12.1–14.2)	21.7 (20.3–23.0)	31.9 (30.4–33.3)	25.6 (24.3–26.8)	40.2 (38.7–41.7)	15.7 (14.5–16.9)
35–44	**31,113**	16.0 (15.6–16.45)	36.3 (34.9–37.8)	25.3 (23.9–26.7)	13.4 (12.5–14.3)	19.2 (18.1–20.3)	28.6 (27.3–29.9)	19.5 (18.3–20.7)	35.2 (33.8–36.6)	10.2 (9.2–11.2)
45–54	**40,962**	16.2 (15.8–16.6)	35.7 (34.4–36.9)	25.4 (24.2–26.7)	15.9 (14.8–16.9)	19.3 (18.2–20.4)	28.3 (27.1–29.5)	16.0 (15.0–16.9)	29.1 (27.9–30.2)	6.9 (6.1–7.7)
55–64	**55,571**	17.1 (16.7–17.4)	31.8 (30.7–32.9)	23.9 (22.8–25.0)	12.9 (12.2–13.6)	17.1 (16.2–18.0)	26.8 (25.8–27.9)	13.5 (12.8–14.2)	22.3 (21.4–23.3)	5.2 (4.7–5.7)
≥65	**97,061**	22.1 (21.7–22.5)	21.6 (20.8–22.5)	18.5 (17.7–19.2)	9.4 (8.8–10.0)	11.3 (10.6–12.1)	18.9 (18.2–19.6)	8.0 (7.5–8.5)	14.6 (13.9–15.2)	2.6 (2.3–2.8)
Race and ethnicity (missing = 6,940)										
AI/AN, non-Hispanic	**4,256**	1.0 (0.9–1.1)	42.1 (37.5–46.8)	31.9 (27.2–36.7)	18.8 (16.2–21.5)	29.9 (25.3–34.4)	44.5 (39.9–49.1)	26.3 (21.3–31.2)	42.0 (37.4–46.6)	17.3 (14.5–20.1)
Asian, non-Hispanic	**5,199**	4.8 (4.4–5.2)	27.9 (23.9–31.9)	20.8 (17.1–24.4)	7.5 (5.2–9.8)	15.5 (11.6–19.3)	10.7 (7.8–13.6)	8.8 (6.3–11.3)	11.5 (9.0–14.1)	3.6 (1.5–5.7)
Black or African American, non-Hispanic	**18,558**	11.0 (10.7–11.3)	30.5 (29.1–32.0)	22.5 (21.2–23.9)	14.6 (13.5–15.6)	20.4 (19.1–21.7)	24.2 (22.9–25.4)	11.9 (10.9–12.8)	41.7 (40.2–43.3)	14.2 (13.2–15.2)
NH/OPI, non-Hispanic	**876**	0.2 (0.2–0.2)	38.8 (29.5–48.1)	30.1 (20.6–39.6)	21.2 (11.4–30.9)	27.3 (17.5–37.1)	30.4 (20.8–39.9)	17.2 (9.5–24.9)	27.3 (20.6–34.1)	10.5 (6.8–14.3)
White, non-Hispanic	**205,306**	63.2 (62.6–63.8)	34.9 (34.4–35.5)	21.4 (20.9–21.9)	12.0 (11.7–12.4)	15.3 (14.9–15.7)	27.9 (27.4–28.4)	19.5 (19.0–20.0)	26.2 (25.7–26.7)	7.5 (7.1–7.8)
Hispanic or Latino	**16,995**	15.9 (15.4–16.4)	32.2 (30.3–34.0)	30.1 (28.2–31.9)	13.3 (11.9–14.7)	21.3 (19.8–22.9)	25.2 (23.6–26.9)	12.5 (11.3–13.7)	30.7 (28.9–32.4)	9.5 (8.4–10.7)
Multiracial, non-Hispanic	**5,105**	1.4 (1.3–1.5)	48.0 (43.5–52.4)	31.5 (27.7–35.3)	21.6 (18.1–25.1)	25.4 (21.8–29.1)	37.9 (33.7–42.1)	31.6 (27.3–36.0)	40.4 (36.1–44.6)	17.5 (14.0–21.1)
Other race, non-Hispanic	**1,647**	0.4 (0.4–0.5)	42.8 (35.2–50.4)	35.6 (27.5–43.7)	16.4 (11.6–21.1)	21.8 (16.8–26.8)	26.0 (20.1–31.8)	19.0 (13.3–24.6)	29.3 (23.3–35.3)	10.1 (5.4–14.7)
Household income, USD (missing = 39,409)										
<$15,000	**18,902**	8.2 (7.8–8.5)	35.8 (33.7–38.0)	31.0 (28.9–33.2)	19.1 (17.5–20.8)	24.8 (22.8–26.8)	30.6 (28.7–32.6)	18.6 (17.2–20.0)	33.9 (31.9–35.9)	12.4 (11.0–13.7)
$15,000–$24,999	**34,874**	13.1 (12.7–13.4)	34.1 (32.8–35.4)	27.3 (26–28.6)	15.5 (14.5–16.4)	21.1 (20.0–22.2)	29.8 (28.5–31.0)	17.8 (16.8–18.8)	34.2 (32.9–35.6)	11.4 (10.5–12.2)
$25,000–$34,999	**23,665**	8.3 (8.0–8.6)	34.5 (32.7–36.3)	26.3 (24.6–28.0)	15.3 (13.6–17.1)	20.0 (18.6–21.4)	29.3 (27.8–30.9)	18.1 (16.7–19.5)	32.8 (31.0–34.6)	10.3 (9.2–11.3)
$35,000–$49,999	**32,252**	11.1 (10.8–11.4)	34.5 (33.0–35.9)	23.7 (22.4–25.1)	15.3 (13.6–17.1)	17.7 (16.6–18.7)	27.4 (26.0–28.8)	18.6 (17.5–19.8)	29.1 (27.7–30.5)	10.0 (9.0–11.0)
>$50,000	**115,780**	44.9 (44.3–45.4)	35.2 (34.4–36.1)	21.3 (20.5–22.0)	10.8 (10.3–11.3)	15.6 (14.9–16.3)	25.7 (24.9–26.4)	17.4 (16.7–18.1)	25.5 (24.8–26.3)	7.1 (6.5–7.6)
Education level (missing = 584)										
Less than high school	**16,944**	12.3 (11.9-12.7)	29.8 (28.1-31.6)	29.2 (27.4-31.1)	14.6 (13.2-16.0)	22.3 (20.7-23.8)	29.0 (27.3-30.7)	13.3 (12.2-14.4)	32.2 (30.5-34.0)	11.9 (10.8-13.0)
High school diploma or GED	**71,799**	27.6 (27.1–28.1)	32.6 (31.6–33.6)	23.5 (22.6–24.5)	11.9 (11.3–12.6)	17.9 (17.1–18.8)	28.3 (27.3–29.2)	16.0 (15.2–16.8)	32.3 (31.3–33.3)	10.5 (9.8–11.3)
Some college	**74,362**	31.0 (30.5–31.5)	38.2 (37.2–39.2)	24.8 (23.9–25.7)	14.4 (13.7–15.2)	18.6 (17.8–19.4)	29.2 (28.3–30.1)	20.5 (19.7–21.3)	30.5 (29.6–31.4)	9.4 (8.8–10.1)
College degree	**101,193**	28.8 (28.4–29.3)	32.8 (31.9–33.6)	19.0 (18.2–19.7)	10.4 (9.9–10.9)	13.0 (12.4–13.7)	21.0 (20.4–21.7)	16.7 (16.1–17.3)	20.9 (20.1–21.6)	4.6 (4.2–5.0)

See table footnotes on the next page.

TABLE 3. (*Continued*) Prevalence of individual adverse childhood experiences among adults, by sociodemographic characteristics — Behavioral Risk Factor Surveillance System, United States, 2011–2020

Characteristic	Total no.,* unweighted	Weighted % (95% CI)	ACE category, weighted % (95% CI)							
			Emotional†	Physical	Sexual§	Witnessed intimate partner violence	Household substance use¶	Household mental illness	Parental separation or divorce†	Incarcerated household member
Employment status (missing = 1,484)										
Employed	**130,794**	55.4 (54.8–55.9)	35.7 (35.0–36.4)	23.1 (22.5–23.8)	11.6 (11.1–12.1)	17.4 (16.8–17.9)	27.5 (26.8–28.1)	18.2 (17.6–18.7)	31.0 (30.3–31.7)	9.4 (8.9–9.9)
Unable to work	**17,833**	6.5 (6.2–6.7)	40.1 (38.3–41.9)	33.1 (31.3–34.9)	23.5 (22.0–25.0)	26.0 (24.4–27.6)	37.1 (35.4–38.9)	24.2 (22.6–25.7)	37.1 (35.3–38.9)	13.8 (12.4–15.2)
Unemployed	**12,470**	6.7 (6.4–7.1)	43.8 (41.3–46.3)	32.0 (29.5–34.6)	16.7 (15.1–18.4)	24.2 (22.0–26.5)	32.4 (30.1–34.7)	23.1 (21.1–25.0)	39.0 (36.6–41.5)	15.1 (13.2–16.9)
Other	**102,301**	30.7 (30.2–31.2)	27.7 (26.7–28.6)	19.7 (18.9–20.6)	11.2 (10.4–11.9)	13.7 (12.9–14.5)	21.4 (20.6–22.2)	13.0 (12.3–13.7)	19.5 (18.8–20.3)	4.8 (4.3–5.2)

Abbreviations: ACE = adverse childhood experience; AI/AN = American Indian or Alaska Native; GED = general educational development certificate; NA = not applicable; NH/OPI = Native Hawaiian or other Pacific Islander; USD = U.S. dollars.

* For jurisdictions that included ACE questions in >1 year, the most recent year was included.

† New Hampshire did not include these questions on its survey.

§ Arkansas collapsed three sexual abuse questions into a single question; New Hampshire omitted two of the three sexual abuse questions. Arkansas' sexual abuse question was worded, "How often did anyone at least 5 years older than you or an adult ever touch you sexually, try to make you touch them sexually, or force you to have sex?" New Hampshire only included one of the three sexual abuse questions, "How often did anyone at least 5 years older than you or an adult ever touch you sexually?"

¶ The Arkansas questionnaire combined household drug abuse and alcohol abuse questions into a single household substance abuse question, "Did you live with anyone who was a problem drinker or alcoholic, or who used illegal street drugs or abused prescription medications?"

Summary

What is already known about this topic?

Adverse childhood experiences (ACEs) are associated with numerous negative outcomes. Previous data from 25 states indicated that ACEs are common among U.S. adults.

What is added by this report?

Among U.S. adults from all 50 states and the District of Columbia surveyed during 2011–2020, approximately two thirds reported at least one ACE; one in six reported four or more ACEs. ACEs were highest among women, persons aged 25–34 years, non-Hispanic American Indian or Alaska Native adults, non-Hispanic multiracial adults, adults with less than a high school education, and adults who were unemployed or unable to work. Prevalence of individual and total number of ACEs varied across jurisdictions.

What are the implications for public health practice?

CDC's Preventing Adverse Childhood Experiences: Leveraging the Best Available Evidence provides strategies for preventing and mitigating ACEs, particularly among disproportionately affected populations.

ACEs are common, but not equally distributed within the population. Differing patterns by jurisdiction and sociodemographic characteristics demonstrate the importance of collecting ACEs data at the jurisdiction level to understand the scope of the problem, identify populations more affected by ACEs, and ACEs-related outcomes; to help guide prevention and mitigation interventions and policies (*6*). CDC has released prevention resources to help provide jurisdictions and communities with the best available strategies to prevent violence and other ACEs, and with guidance on how to implement those strategies for maximum impact (*4*–*6*). Clinicians and others who work directly with families play an important role in mitigating and preventing ACEs, from primary prevention opportunities (e.g., home visitation programs) to secondary and tertiary prevention strategies that reduce harms associated with ACEs (e.g., trauma-informed care, ensuring appropriate linkage to services, and supports for identified issues) (*10*).

Acknowledgments

Alaska Department of Health and Social Services Division of Public Health; Arkansas Department of Health; Colorado Department of Health and Environment; Connecticut Department of Public Health; Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion, CDC; Illinois Department of Public Health; Louisiana Department of Health; New Hampshire Division of Public Health Services; North Carolina Division of Public Health State Center for Health Statistics; Oregon Health Authority Public Health Division.

Corresponding author: Elizabeth A. Swedo, eswedo@cdc.gov.

[1]Division of Violence Prevention, National Center for Injury Prevention and Control, CDC; [2]Division of Injury Prevention, National Center for Injury Prevention and Control, CDC.

All authors have completed and submitted the International Committee Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflicts of interest were disclosed.

References

1. Merrick MT, Ford DC, Ports KA, et al. Vital signs: estimated proportion of adult health problems attributable to adverse childhood experiences and implications for prevention—25 states, 2015–2017. MMWR Morb Mortal Wkly Rep 2019;68:999–1005. PMID:31697656 https://doi.org/10.15585/mmwr.mm6844e1
2. Sedlak A, Mettenburg J, Basena M, et al. Fourth national incidence study of child abuse and neglect (NIS-4): report to congress. Executive Summary. Washington, DC: US Department of Health and Human Services, Administration for Children and Families; 2010. https://www.acf.hhs.gov/opre/report/fourth-national-incidence-study-child-abuse-and-neglect-nis-4-report-congress
3. Font SA, Maguire-Jack K. Pathways from childhood abuse and other adversities to adult health risks: the role of adult socioeconomic conditions. Child Abuse Negl 2016;51:390–9. PMID:26059537 https://doi.org/10.1016/j.chiabu.2015.05.013
4. CDC. Preventing adverse childhood experiences: leveraging the best available evidence. Atlanta, GA: US Department of Health and Human Services; CDC; 2019. https://www.cdc.gov/violenceprevention/pdf/preventingACEs.pdf
5. Fortson B, Klevens J, Merrick M, Gilbert L, Alexander S. Preventing child abuse and neglect: a technical package for policy, norm, and programmatic activities. Atlanta, GA: US Department of Health and Human Services, CDC; 2016. https://www.cdc.gov/violenceprevention/pdf/can-prevention-technical-package.pdf
6. CDC. Policy in action: preventing child abuse and neglect. Atlanta, GA: US Department of Health and Human Services, CDC; 2019. https://vetoviolence.cdc.gov/apps/main/prevention-information/policy-in-action/introduction
7. CDC. Behavioral Risk Factor Surveillance System. Atlanta, GA: US Department of Health and Human Services; 2022. https://www.cdc.gov/brfss
8. Metzler M, Merrick M, Klevens J, Ports KA, Ford D. Adverse childhood experiences and life opportunities: shifting the narrative. Child Youth Serv Rev 2017;72:141–9. https://doi.org/10.1016/j.childyouth.2016.10.021
9. Brown DW, Anda RF, Tiemeier H, et al. Adverse childhood experiences and the risk of premature mortality. Am J Prev Med 2009;37:389–96. PMID:19840693 https://doi.org/10.1016/j.amepre.2009.06.021
10. Jones CM, Merrick MT, Houry DE. Identifying and preventing adverse childhood experiences: implications for clinical practice. JAMA 2020;323:25–6. PMID:31689343 https://doi.org/10.1001/jama.2019.18499

Hepatitis C Virus Clearance Cascade — United States, 2013–2022

Carolyn Wester, MD[1]; Ademola Osinubi, MS[1]; Harvey W. Kaufman, MD[2]; Hasan Symum, PhD[3]; William A. Meyer III, PhD[2]; Xiaohua Huang, MS[2]; William W. Thompson, PhD[1]

Approximately 2.4 million adults were estimated to have hepatitis C virus (HCV) infection in the United States during 2013–2016 (*1*). Untreated, hepatitis C can lead to advanced liver disease, liver cancer, and death (*2*). The Viral Hepatitis National Strategic Plan for the United States calls for ≥80% of persons with hepatitis C to achieve viral clearance by 2030 (*3*). Characterizing the steps that follow a person's progression from testing to viral clearance and subsequent infection (clearance cascade) is critical for monitoring progress toward national elimination goals. Following CDC guidance (*4*), a simplified national laboratory results-based HCV five-step clearance cascade was developed using longitudinal data from a large national commercial laboratory throughout the decade since highly effective hepatitis C treatments became available. During January 1, 2013–December 31, 2021, a total of 1,719,493 persons were identified as ever having been infected with HCV. During January 1, 2013–December 31, 2022, 88% of those ever infected were classified as having received viral testing; among those who received viral testing, 69% were classified as having initial infection; among those with initial infection, 34% were classified as cured or cleared (treatment-induced or spontaneous); and among those persons, 7% were categorized as having persistent infection or reinfection. Among the 1.0 million persons with evidence of initial infection, approximately one third had evidence of viral clearance (cured or cleared). This simplified national HCV clearance cascade identifies substantial gaps in cure nearly a decade since highly effective direct-acting antiviral (DAA) agents became available and will facilitate the process of monitoring progress toward national elimination goals. It is essential that increased access to diagnosis, treatment, and prevention services for persons with hepatitis C be addressed to prevent progression of disease and ongoing transmission and achieve national hepatitis C elimination goals.

An 8–12 week short-course of well-tolerated, oral-only treatment with DAA agents is recommended for nearly all persons with HCV infection (*5*) and results in a cure in ≥95% of cases (*6*). A national program to eliminate hepatitis C in the United States was proposed earlier this year (*7*) to provide an opportunity to accelerate national efforts toward eliminating hepatitis C. The Viral Hepatitis National Strategic Plan for the United States calls for ≥80% of persons with hepatitis C to achieve viral clearance by 2030 (*1*). Characterizing the HCV clearance cascade is critical for monitoring progress toward national elimination goals, identifying gaps in care and program effectiveness, and prioritizing public health resource allocations. Developing a comprehensive national hepatitis C care cascade is challenging, because no single data source sufficiently describes all steps of the cascade. Previous HCV care cascades have required using data from a variety of sources (e.g., household surveys, cohort studies, laboratory testing, and pharmacy claims) to inform distinct steps in the cascade (*8*). In response to these challenges, CDC developed guidance for generating a simplified, laboratory results–based HCV clearance cascade (*4*). Following this methodology and using data from a large national commercial laboratory, this report presents a national HCV clearance cascade during the DAA era (January 1, 2013–December 31, 2022).

Data were analyzed from patients living in all 50 states and the District of Columbia who received hepatitis C testing by Quest Diagnostics. Quest Diagnostics programming was applied to de-identify and de-duplicate data. Tests included HCV antibody (anti-HCV), HCV RNA nucleic acid (quantitative or qualitative), and HCV genotype. The HCV clearance cascade characterized persons according to five steps, 1) ever infected, defined as any receipt of a positive HCV test result (i.e., any reactive anti-HCV or detectable HCV RNA or genotype) during January 1, 2013–December 31, 2021 (index period); 2) viral testing, defined as evidence of ≥1 HCV RNA test performed during January 1, 2013–December 31, 2022 (the follow-up period) for a person characterized as having ever been infected; 3) initial infection, defined as evidence of a detectable HCV RNA during the follow-up period in any person with viral testing; 4) cured or cleared, defined (among persons with an initial infection) as evidence of subsequent undetectable HCV RNA during the follow-up period (approximately one third of persons with acute infection will self-clear initial HCV infection without treatment); and 5) persistent infection or reinfection, defined as evidence of subsequent detectable HCV RNA in any person categorized as cured or cleared, during the follow-up period (*4*).

Frequencies of persons at each cascade step were calculated. Conditional proportions for each step were calculated using the number of persons identified who met the definition for being at a particular step divided by the number that met the definition from the previous step, following the methods in the CDC guidance document (*4*).

Persons in each of the HCV clearance cascade steps were analyzed by age group, sex, and payor type. Age group was categorized as 0–19, 20–39, 40–59, and ≥60 years. Payor type was categorized as Medicare, Medicaid, commercial, other (client or self-pay), and unspecified (no payor type provided). This activity was reviewed by CDC and conducted consistent with applicable federal law and CDC policy.*

A total of 1,719,493 persons were identified as ever having been infected. (Figure 1). For subsequent steps, 1,520,592 (88%) of those ever infected were categorized as having had viral testing; 1,042,082 (69%) of those with viral testing were categorized as having an initial infection; 356,807 (34%) of those with initial infection as cured or cleared; and 23,518 (7%) of those categorized as cured or cleared as having persistent infection or reinfection.

Among those ever infected, 29%, 43%, and 27% were persons aged 20–39 years, 40–59 years, and ≥60 years, respectively; 60% were male. Among the 1,719,493 persons ever infected, 862,905 (50%) were covered by commercial health insurance, followed by 386,755 (23%) by other payor, 186,464 (11%) by Medicaid, 151,217 (9%) by unspecified payor, and 132,152 (8%) by Medicare (Table).

The prevalence of viral testing ranged from 79% (unspecified payor) to 91% (commercial and Medicare payors). Initial infection was lowest among those aged 0–19 years (41%); payor type ranged from 63% for those with commercial insurance to 82% for those with unspecified payor type. The prevalence of being cured or cleared was lowest among persons aged 20–29 years (24%), and highest among those aged ≥60 years (42%). By payor type, cured or cleared prevalences ranged from 23% for other to 45% for Medicare.

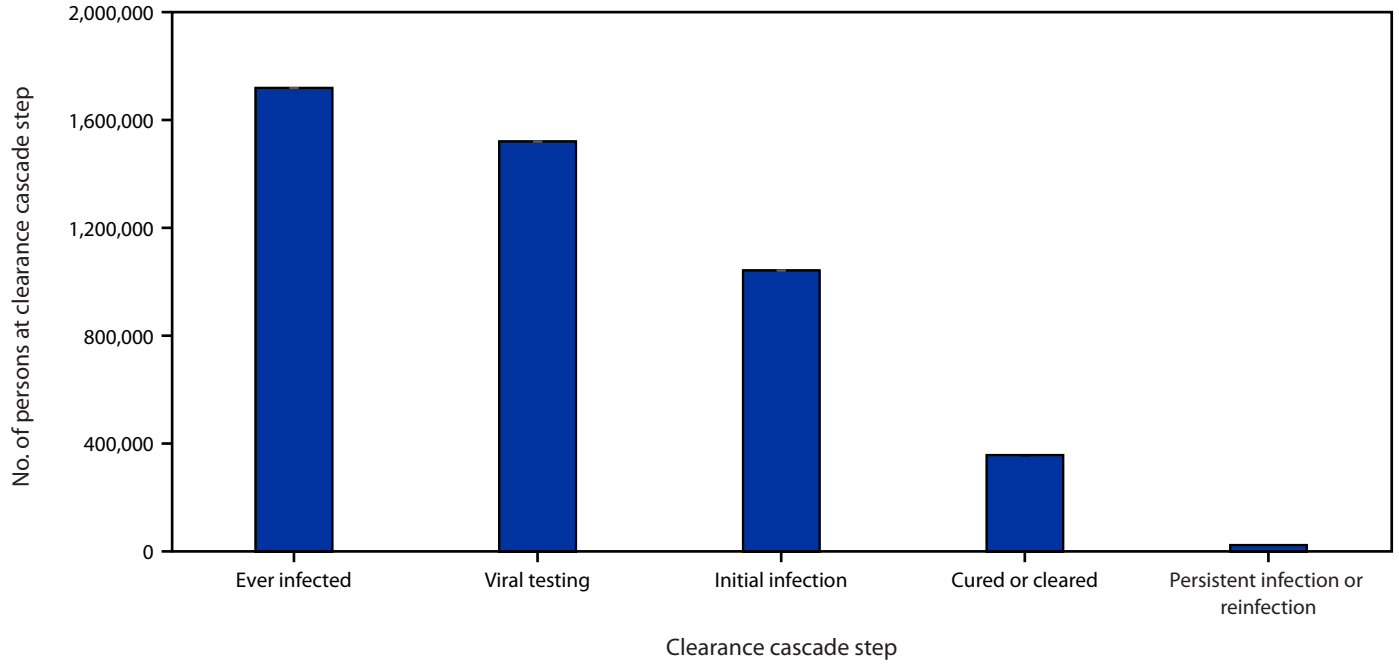
Hepatitis C viral clearance increased with age when stratified by payor type among those with initial infection (Figure 2). The lowest proportion of cured or cleared, across all age groups, was among those with other payor (range = 16%–29%), followed by unspecified (20%–41%) and Medicaid (23%–38%), and then by commercial (29%–49%) and Medicare (33%–46%) payors. The highest proportion of cured or cleared among all age groups and payors was 49% for commercially insured persons aged ≥60 years. Persistent infection or reinfection was highest among persons aged 20–39 years (9%).

Discussion

Using U.S. longitudinal commercial laboratory data, this report presents an HCV clearance cascade with data for approximately 1.7 million persons with evidence of a history of HCV infection during the DAA era. Analysis revealed that 88% of persons with evidence of a history of HCV infection received viral RNA testing, and among the 1.0 million persons with evidence of initial infection, approximately one third had evidence of viral clearance (cured or cleared); 7% of those with

*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.

FIGURE 1. Hepatitis C virus clearance cascade using national commercial laboratory data — United States, 2013–2022



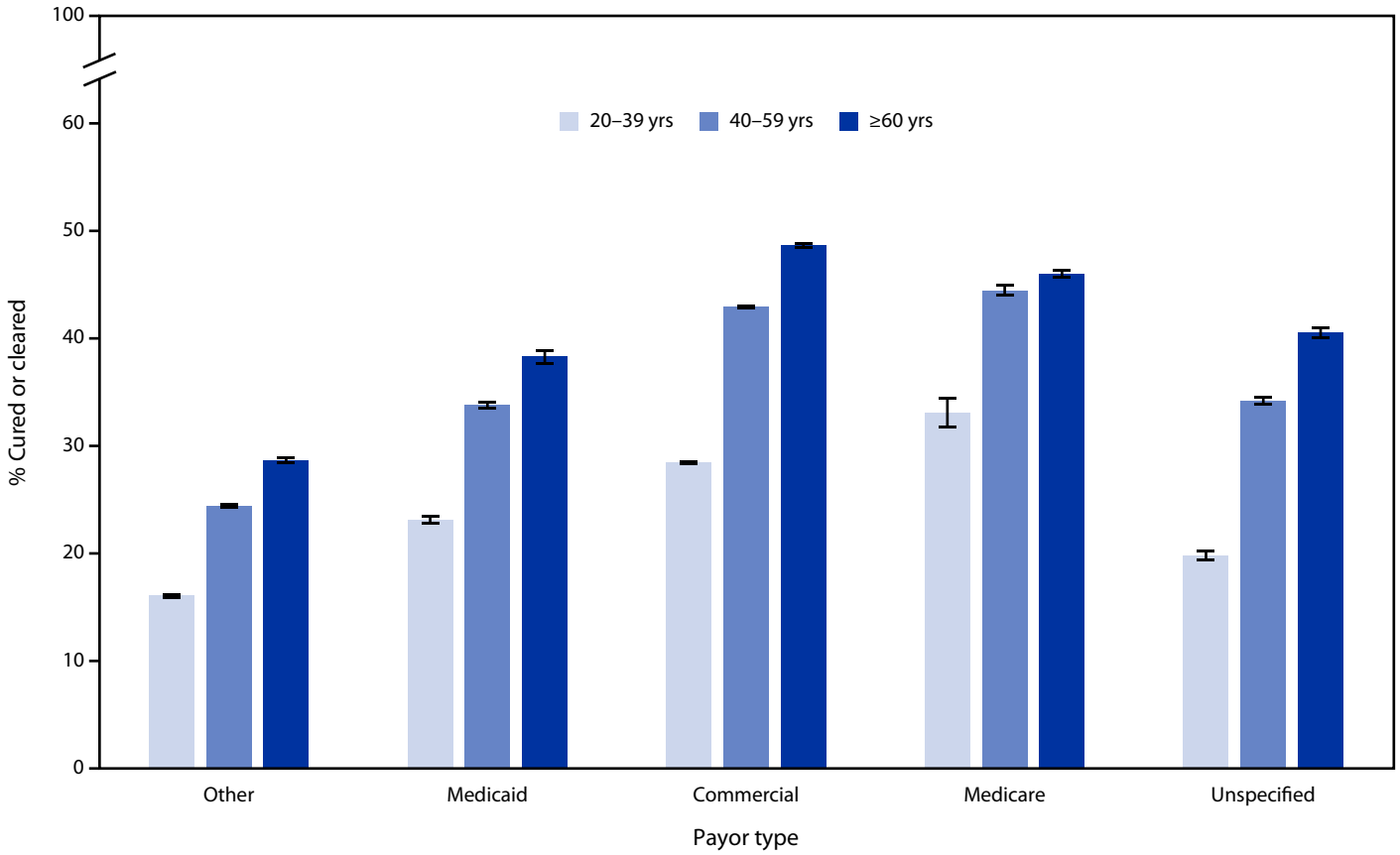
Source: Quest Diagnostics (January 1, 2013–December 31, 2022).

TABLE. Hepatitis C virus clearance cascade, by selected demographics — United States, 2013–2022

Characteristic	No. of persons at clearance cascade step				
	Ever infected*	Viral testing† (%)§	Initial infection† (%)§	Cured or cleared† (%)§	Persistent infection or reinfection† (%)§
Age group, yrs¶					
0–19	18,035	15,370 (85.2)	6,274 (40.8)	1,581 (25.2)	107 (6.8)
20–39	490,190	434,922 (88.7)	304,022 (69.9)	72,362 (23.8)	6,644 (9.2)
40–59	738,534	650,353 (88.1)	458,284 (70.5)	167,835 (36.6)	10,813 (6.4)
≥60	472,319	419,640 (88.8)	273,329 (65.1)	114,995 (42.1)	5,953 (5.2)
Sex¶					
Male	1,031,819	910,407 (88.2)	663,711 (72.9)	226,208 (34.1)	17,622 (7.8)
Female	682,383	606,891 (88.9)	376,033 (62.0)	130,147 (34.6)	5,868 (4.5)
Payor type					
Medicare	132,152	119,693 (90.6)	76,719 (64.1)	34,356 (44.8)	1,993 (5.8)
Medicaid	186,464	164,324 (88.1)	112,654 (68.6)	34,817 (30.9)	2,009 (5.8)
Commercial	862,905	783,199 (90.8)	496,429 (63.4)	196,789 (39.6)	15,125 (7.7)
Other (self-pay or client bill)	386,755	333,335 (86.2)	258,425 (77.5)	58,548 (22.7)	2,306 (3.9)
Unspecified	151,217	120,041 (79.4)	97,855 (81.5)	32,297 (33.0)	2,085 (6.5)

* The ever infected category was assessed during the baseline period of January 1, 2013–December 31, 2021.
† The viral testing, initial infection, cured or cleared, and persistent infection or reinfection categories were assessed during the follow-up period of January 1, 2013–December 31, 2022.
§ Conditional proportion based on immediately preceding column.
¶ Age and sex weren't reported for 415 and 5,291 persons, respectively, in the ever infected category.

FIGURE 2. Proportion* of hepatitis C virus–infected persons with evidence of viral clearance, by age group† and payor type§ — United States, 2013–2022¶



Source: Quest Diagnostics (January 1, 2013–December 31, 2022).
* With 95% CIs indicated by error bars.
† Persons aged 0–19 years were not included because of small sample sizes.
§ Other payor includes client or self-pay, and unspecified includes persons with no payor type provided in the record.
¶ Includes all persons with initial infection during January 1, 2013–December 31, 2022.

viral clearance had evidence of subsequent viremia (persistent infection or reinfection). These findings reveal substantial missed opportunities to diagnose, treat, and prevent hepatitis C in the United States.

Among the approximately 1.0 million persons in this analysis with initial infection, only 34% had laboratory evidence of viral clearance. Persons with other, unspecified, or Medicaid payor type had lower viral clearance (23%, 33%, and 31%, respectively) than persons with Medicare and commercial payors (40% and 45%, respectively). These observations are consistent with recently published hepatitis C treatment coverage data among insured adults (*9*) and highlight the large gap between current viral clearance and the nation's goal of ≥80% viral clearance among persons with diagnosed hepatitis C by 2030 (*3*).

Overall, viral clearance was lowest among persons aged 20–39 years (24%). Within this age group, those with other, unspecified or Medicaid payor type had lower viral clearance prevalences (16%, 20%, and 23%, respectively) than did persons with Medicare and commercial payors (33% and 29%, respectively). Similarly, persistent infection or reinfection was highest among persons aged 20–39 years (9%). These findings highlight the disproportionate need for increased access to hepatitis C treatment and prevention services among younger adults.

The application of commercial laboratory data to this simplified, standard, laboratory result–based HCV clearance cascade fills a substantial data gap nationally, including assessments of complete diagnosis, viral clearance, and subsequent viremia. This analysis, using one large commercial laboratory can be easily updated, and along with the large sample size, provides the precision needed to follow trends over time. Identifying and quantifying progress and gaps in the HCV clearance cascade will help guide the implementation of hepatitis C diagnosis, treatment, and prevention activities in support of national hepatitis C elimination goals.

The findings in this report are subject to at least six limitations. First, the results were based on a population of persons who received a positive test result for HCV and do not represent all persons with HCV infection. Second, data from a single laboratory are not necessarily nationally representative. Nevertheless, during 2013–2022, approximately 1.0 million persons in this analysis were identified with initial infection, consistent with approximately 42% of the estimated 2.4 million persons to have hepatitis C in the United States (*1*). Third, the follow-up period is not uniform, which might contribute to variations in rates along steps in the cascade. Fourth, the cascade does not capture persons who did not receive a subsequent HCV RNA test after initial infection, those being cured or cleared, or those having persistent infection or reinfection, and therefore, likely underestimates the number and percentage of persons within these steps of the cascade. Fifth, persons who received HCV laboratory testing from both Quest Diagnostics and other laboratories would not have the other laboratory results represented in these estimates, which could lead to different estimates reported in each step. Finally, using other care cascade models might be preferable when prevalence and comprehensive diagnosis and treatment data are available.

Increased access to diagnosis, treatment, and prevention services for persons with or at risk for acquiring hepatitis C needs to be addressed to prevent progression of disease and ongoing transmission, and to achieve national hepatitis C elimination goals. Overcoming these barriers requires implementation of universal hepatitis C screening recommendations including HCV RNA testing for all persons with reactive HCV antibody results, provision of treatment for all persons regardless of payor, and prevention services for persons at risk for acquiring new HCV infection.

Summary

What is already known about this topic?

The Viral Hepatitis National Strategic Plan for the United States calls for ≥80% of persons with hepatitis C to achieve viral clearance by 2030. Assessing progress toward elimination goals requires monitoring hepatitis C virus (HCV) clearance.

What is added by this report?

An analysis of the HCV clearance cascade using 2013–2022 national HCV testing data found that the prevalence of viral clearance among persons with diagnosed hepatitis C was only 34% overall and was even lower (16%) among persons aged 20–39 years with other payor (client or self-pay) insurance.

What are the implications for public health practice?

Increased access to diagnosis, treatment, and prevention services for persons with hepatitis C would prevent progression of disease and ongoing transmission and achieve national hepatitis C elimination goals.

Acknowledgments

Mona Doshani, Martha Montgomery, Noele Nelson.

Corresponding author: Carolyn Wester, nhe3@cdc.gov.

[1]Division of Viral Hepatitis, National Center for HIV, Viral Hepatitis, STD, and TB Prevention, CDC; [2]Quest Diagnostics, Secaucus, New Jersey; [3]Office of the Director, National Center for HIV, Viral Hepatitis, STD, and TB Prevention, CDC.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Harvey W. Kaufman is an employee of and owns stock in Quest Diagnostics. William A. Meyer III is a consultant to Quest Diagnostics. No other potential conflicts of interest were disclosed.

References

1. Hofmeister MG, Rosenthal EM, Barker LK, et al. Estimating prevalence of hepatitis C virus infection in the United States, 2013–2016. Hepatology 2019;69:1020–31. PMID:30398671 https://doi.org/10.1002/hep.30297
2. Liang TJ, Rehermann B, Seeff LB, Hoofnagle JH. Pathogenesis, natural history, treatment, and prevention of hepatitis C. Ann Intern Med 2000;132:296–305. PMID:10681285 https://doi.org/10.7326/0003-4819-132-4-200002150-00008
3. US Department of Health and Human Services. Viral Hepatitis National Strategic Plan for the United States: a roadmap to elimination for the United States, 2021–2025. Washington, DC: US Department of Health and Human Services; 2020. https://www.hhs.gov/sites/default/files/Viral-Hepatitis-National-Strategic-Plan-2021-2025.pdf
4. Montgomery MP, Sizemore L, Wingate H, et al. Development of a standardized, laboratory result-based hepatitis C virus clearance cascade for public health jurisdictions. Public Health Rep 2023. Epub May 4, 2023. PMID:37140162 https://doi.org/10.1177/00333549231170044
5. Ghany MG, Morgan TR; AASLD-IDSA hepatitis C guidance panel. Hepatitis C guidance 2019 update: American Association for the Study of Liver Diseases–Infectious Diseases Society of America recommendations for testing, managing, and treating hepatitis C virus infection. Hepatology 2020;71:686–721. PMID:31816111 https://doi.org/10.1002/hep.31060
6. Falade-Nwulia O, Suarez-Cuervo C, Nelson DR, Fried MW, Segal JB, Sulkowski MS. Oral direct-acting agent therapy for hepatitis C virus infection: a systematic review. Ann Intern Med 2017;166:637–48. PMID:28319996 https://doi.org/10.7326/M16-2575
7. Fleurence RL, Collins FS. A national hepatitis C elimination program in the United States: a historic opportunity. JAMA 2023;329:1251–2. PMID:36892976 https://doi.org/10.1001/jama.2023.3692
8. Ferrante ND, Newcomb CW, Forde KA, et al. The hepatitis C care cascade during the direct-acting antiviral era in a United States commercially insured population. Open Forum Infect Dis 2022;9:ofac445. PMID:36092829 https://doi.org/10.1093/ofid/ofac445
9. Thompson WW, Symum H, Sandul A, et al. Vital signs: hepatitis C treatment among insured adults—United States, 2019–2020. MMWR Morb Mortal Wkly Rep 2022;71:1011–7. PMID:35951484 https://doi.org/10.15585/mmwr.mm7132e1

Illicitly Manufactured Fentanyl–Involved Overdose Deaths with Detected Xylazine — United States, January 2019–June 2022

Mbabazi Kariisa, PhD[1]; Julie O'Donnell, PhD[1]; Sagar Kumar, MPH[1]; Christine L. Mattson, PhD[1]; Bruce A. Goldberger, PhD[2]

In 2022, provisional data indicated that more than two thirds (68%) of the reported 107,081 drug overdose deaths in the United States involved synthetic opioids other than methadone, principally illicitly manufactured fentanyls (IMFs) (*1*). Xylazine, a nonopioid sedative not approved for human use and with no known antidote, has been increasingly detected in IMF products in the U.S. drug supply* and in IMF-involved overdose deaths (*2*). Limited studies suggest xylazine can cause central nervous system depression, respiratory depression, bradycardia, and hypotension in humans (*3*,*4*); chronic use might lead to severe withdrawal symptoms† as well as skin ulcerations (*4*). This report uses data from CDC's State Unintentional Drug Overdose Reporting System (SUDORS) to describe IMF-involved§ overdose deaths with and without xylazine detected that occurred during January 2019–June 2022. Among 21 jurisdictions, which included 20 states and the District of Columbia, the monthly percentage of IMF-involved deaths with xylazine detected increased 276%, from 2.9% to 10.9%. Among IMF-involved deaths during January 2021–June 2022 in 32 jurisdictions, xylazine was detected in a higher percentage of jurisdictions in the Northeast U.S. Census Bureau region; listing detected xylazine as a cause of death varied across jurisdictions. Expanded postmortem and illicit drug product testing for xylazine is needed to clarify prevalence in drug supplies; further investigation of xylazine's effects on humans is necessary to characterize morbidity and overdose risk. It is important for overdose prevention and response messages to highlight the potential presence of xylazine in IMF products and emphasize the need for respiratory and cardiovascular support to address the sedative effects of xylazine.

Jurisdictions entered information on drug overdose deaths that were unintentional or of undetermined intent into SUDORS using death certificates, medical examiner and coroner reports (including information about circumstances of the overdose from scene evidence and witness reports), and toxicology reports. Monthly counts of IMF-involved deaths¶ with xylazine detected and co-involved as a cause of death, and proportions of IMF-involved deaths with xylazine detected were examined in 21 jurisdictions** for January 2019–June 2022. The most recent 18 months of data (January 2021–June 2022) were further examined among 32 jurisdictions.†† The number and percentage of IMF-involved deaths with xylazine detected, and the proportion of those with xylazine detected for which xylazine was listed as a cause of death, were calculated for each jurisdiction. The number and percentage of IMF-involved deaths with and without xylazine detected were calculated, stratified by decedent demographics, U.S.

* https://www.dea.gov/sites/default/files/2022-12/The%20Growing%20Threat%20of%20Xylazine%20and%20its%20Mixture%20with%20Illicit%20Drugs.pdf

† https://hip.phila.gov/document/2524/PDPH-HAN_Alert_1_Xylazine_03.16.2022.pdf

§ A drug was considered involved or co-involved if it was listed as a cause of death on the death certificate or in the medical examiner or coroner report. Fentanyl was classified as likely illicitly manufactured using toxicology, scene, and witness evidence. For the 8% of deaths involving fentanyl that had insufficient evidence for classification as illicit or prescription, fentanyl was classified as illicit because the vast majority of fentanyl overdose deaths involve illicit fentanyl. All fentanyl analogs except alfentanil, remifentanil, and sufentanil, which have legitimate human medical use, were included as IMFs.

¶ Analyses were restricted to IMF-involved deaths because xylazine is known to be mixed mainly in IMF products and because 99.5% of the deaths in the current analysis with xylazine detected involved IMFs. Among the 42 deaths that did not involve IMFs, IMFs were detected but not part of the cause of death in 17, and not detected in 25. Xylazine was the only drug listed as involved for four deaths.

** Connecticut, Delaware, District of Columbia, Georgia, Illinois, Maine, Massachusetts, Minnesota, Nevada, New Hampshire, New Jersey, New Mexico, Ohio, Oklahoma, Pennsylvania, Rhode Island, Utah, Vermont, Virginia, Washington, and West Virginia. Illinois, Pennsylvania, and Washington reported deaths from counties that accounted for ≥75% of drug overdose deaths in the state in 2017 per SUDORS funding requirements; all other jurisdictions reported deaths from the full jurisdiction. Four funded states that would have been included in the analysis were excluded because programmatic data indicated they were not testing for xylazine during the analysis period. Unpublished programmatic data indicate that xylazine testing was not necessarily uniform within each jurisdiction or over time during the analysis period (e.g., some counties initiated testing sooner than others and testing protocols varied for which cases received xylazine testing).

†† Arizona, Arkansas, Colorado, Connecticut, Delaware, District of Columbia, Georgia, Illinois, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Virginia, Washington, and West Virginia. Illinois, Louisiana, Pennsylvania, and Washington reported deaths from counties that accounted for ≥75% of drug overdose deaths in the state in 2017, per SUDORS funding requirements; all other jurisdictions reported deaths from the full jurisdiction. Analyses of overdose circumstances were further restricted to jurisdictions with coroner or medical examiner reports available for ≥75% of deaths in the included periods (this resulted in the same 32 jurisdictions) and to decedents with an available coroner or medical examiner report (52,684). Four funded states that would have been included in analyses were excluded because programmatic data indicated they were not testing for xylazine during the analysis period. Unpublished programmatic data indicate that xylazine testing was not necessarily uniform within each jurisdiction or over time during the analysis period (e.g., some counties initiated testing sooner than others and testing protocols varied for which cases received xylazine testing).

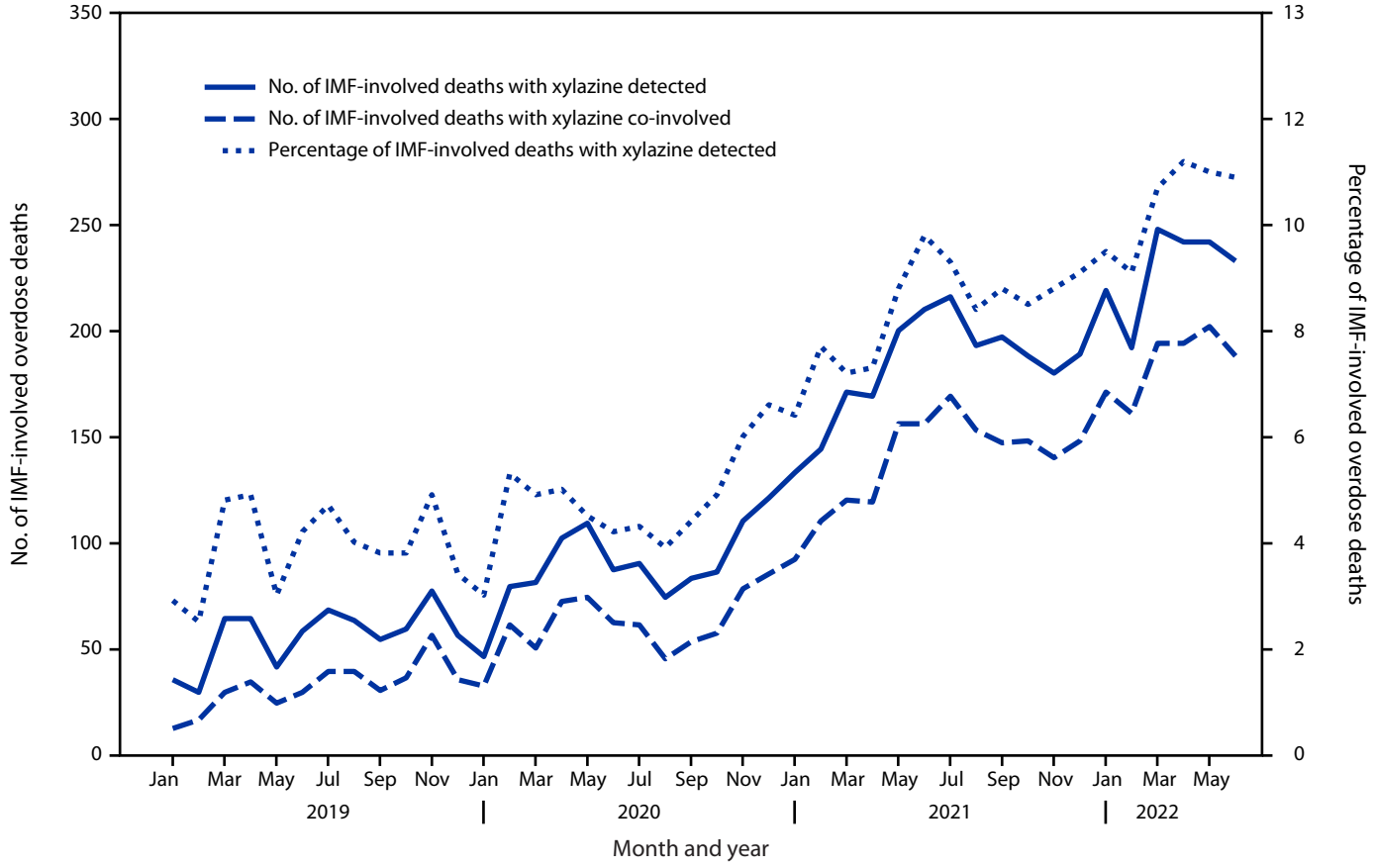
Census Bureau region,[§§] co-involved drugs, and overdose circumstances (e.g., route of drug use, decedent drug use history, and overdose response efforts). Jurisdictions were included in analyses if toxicology reports were available for ≥75% of deaths for the relevant study periods, resulting in variation in the number of states included in each analysis; analyses were restricted to deaths with toxicology reports or with xylazine listed as a cause of death on the death certificate. Analyses were performed using SAS (version 9.4; SAS Institute). This activity was reviewed by CDC and conducted consistent with applicable federal law and CDC policy.[¶¶]

Among 21 jurisdictions, the monthly proportion of IMF-involved deaths with xylazine detected increased 276% from January 2019 (2.9%) to June 2022 (10.9%) (Figure 1). The monthly number of IMF-involved deaths with xylazine co-involved increased from 12 in January 2019 to 188 in

[§§] *Northeast:* Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Pennsylvania, Rhode Island, and Vermont; *Midwest:* Illinois, Iowa, Kansas, Michigan, Minnesota, Nebraska, Ohio, and South Dakota; *South:* Arkansas, Delaware, District of Columbia, Georgia, Louisiana, Maryland, Oklahoma, Virginia, and West Virginia; *West:* Arizona, Colorado, Nevada, New Mexico, Oregon, Utah, and Washington.

[¶¶] 45 C.F.R. part 46.102(l)(2), 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.

FIGURE 1. Number and percentage of drug overdose deaths involving* illicitly manufactured fentanyls,† by month and xylazine detection or co-involvement — State Unintentional Drug Overdose Reporting System, 21 jurisdictions,§ January 2019–June 2022



Abbreviations: IMF = illicitly manufactured fentanyl; SUDORS = State Unintentional Drug Overdose Reporting System.

* A drug was considered involved or co-involved if it was listed as a cause of death on the death certificate or medical examiner or coroner report.

† Fentanyl was classified as likely illicitly manufactured using toxicology, scene, and witness evidence. For the 8% of deaths involving fentanyl that had insufficient evidence for classification as illicit or prescription, fentanyl was classified as illicit because the vast majority of fentanyl overdose deaths involve illicit fentanyl. All fentanyl analogs except alfentanil, remifentanil, and sufentanil, which have legitimate human medical use, were included as IMFs.

§ Connecticut, Delaware, District of Columbia, Georgia, Illinois, Maine, Massachusetts, Minnesota, Nevada, New Hampshire, New Jersey, New Mexico, Ohio, Oklahoma, Pennsylvania, Rhode Island, Utah, Vermont, Virginia, Washington, and West Virginia. Illinois, Pennsylvania, and Washington reported deaths from counties that accounted for ≥75% of drug overdose deaths in the state in 2017 per SUDORS funding requirements; all other jurisdictions reported deaths from the full jurisdiction. Jurisdictions were included if data were available for each 6-month period (January–June 2019, July–December 2019, January–June 2020, July–December 2020, January–June 2021, July–December 2021, and January–June 2022), and toxicology reports were available for ≥75% of deaths in the included period or periods. Analysis was restricted to decedents with an available toxicology report or with xylazine listed as a cause of death on the death certificate.

June 2022. During January 2021–June 2022, among 32 jurisdictions, xylazine was detected in 9.0% (4,859) of 53,969 IMF-involved deaths (Table) and co-involved in 6.9% (3,735). Xylazine detection varied by jurisdiction (Figure 2). The highest percentages and numbers of IMF-involved deaths with xylazine detected were in Maryland (27.7%; 923 deaths), Connecticut (26.4%; 507), and Pennsylvania (23.3%; 1,285). The proportion of IMF-involved deaths with xylazine detected in which xylazine was determined to be a cause of death ranged from none to ≥90% across jurisdictions. Although jurisdictions

TABLE. Characteristics of illicitly manufactured fentanyl-involved* overdose decedents and circumstances surrounding death, by xylazine detection — State Unintentional Drug Overdose Reporting System, 31 states and District of Columbia,† January 2021–June 2022

Characteristic	No. (%) of IMF-involved overdose deaths		
	Total	With xylazine detected	Without xylazine detected
Overall	**53,969 (100)**	**4,859 (9.0)**	**49,110 (91.0)**
Sex			
Female	**14,638 (27.1)**	1,318 (27.1)	13,320 (27.1)
Male	**39,330 (72.9)**	3,541 (72.9)	35,789 (72.9)
Race and ethnicity§			
American Indian or Alaska Native, non-Hispanic	**721 (1.3)**	13 (0.3)	708 (1.5)
Asian, non-Hispanic	**302 (0.6)**	26 (0.5)	276 (0.6)
Black or African American, non-Hispanic	**12,117 (22.6)**	1,155 (23.9)	10,962 (22.5)
Hispanic or Latino	**6,056 (11.3)**	443 (9.2)	5,613 (11.5)
Native Hawaiian or other Pacific Islander, non-Hispanic	**32 (0.1)**	0 (—)	32 (0.1)
White, non-Hispanic	**33,812 (63.1)**	3,167 (65.6)	30,645 (62.9)
Multiracial, non-Hispanic	**519 (1.0)**	26 (0.5)	493 (1.0)
Age group, yrs			
<15	**125 (0.2)**	10 (0.2)	115 (0.2)
15–24	**3,955 (7.3)**	229 (4.7)	3,726 (7.6)
25–34	**13,627 (25.3)**	1,200 (24.7)	12,427 (25.3)
35–44	**14,473 (26.8)**	1,338 (27.5)	13,135 (26.7)
45–54	**10,664 (19.8)**	1,007 (20.7)	9,567 (19.7)
55–64	**8,900 (16.5)**	866 (17.8)	8,034 (16.4)
≥65	**2,221 (4.1)**	209 (4.3)	2,012 (4.1)
U.S. Census Bureau region¶			
Northeast	**16,411 (30.4)**	2,423 (49.9)	13,988 (28.5)
Midwest	**15,175 (28.1)**	826 (17.0)	14,349 (29.2)
South	**14,219 (26.3)**	1,556 (32.0)	12,663 (25.8)
West	**8,164 (15.1)**	54 (1.1)	8,110 (16.5)
Co-involved drugs**			
Heroin††	**6,675 (12.4)**	709 (14.6)	5,966 (12.1)
Prescription opioids§§	**6,371 (11.8)**	695 (14.3)	5,676 (11.6)
Alcohol	**9,636 (17.9)**	724 (14.9)	8,912 (18.1)
Benzodiazepines	**6,213 (11.5)**	656 (13.5)	5,557 (11.3)
Cocaine	**16,653 (30.9)**	1,708 (35.2)	14,945 (30.4)
Methamphetamine	**11,815 (21.9)**	874 (18.0)	10,941 (22.3)
No. of deaths with coroner or medical examiner data	**52,684 (97.6)**	4,704 (96.8)	47,980 (97.7)
Evidence of overdose circumstances†			
Potential bystander present¶¶	**23,717 (45.0)**	2,128 (45.2)	21,589 (45.0)
Naloxone administration§	**12,442 (23.7)**	1,142 (24.3)	11,300 (23.6)
No pulse at first responder arrival§	**31,433 (61.4)**	2,445 (53.3)	28,988 (62.2)
Seen in the emergency department	**9,160 (18.0)**	708 (15.4)	8,452 (18.3)
History of previous overdose	**6,693 (12.7)**	546 (11.6)	6,147 (12.8)
Current or past treatment for substance use disorders	**8,066 (15.3)**	921 (19.6)	7,145 (14.9)
History of mental health diagnosis	**12,666 (24.0)**	1067 (22.7)	11,599 (24.2)
Recent release from institutional setting	**4,614 (9.1)**	528 (11.5)	4,086 (8.8)
Homelessness or housing instability	**4,712 (9.2)**	459 (10.0)	4,253 (9.2)
Route of drug use***			
Injection	**10,696 (20.3)**	1,347 (28.6)	9,349 (19.5)
Smoking	**11,402 (21.6)**	807 (17.2)	10,595 (22.1)
Ingestion	**7,411 (14.1)**	473 (10.1)	6,938 (14.5)
Snorting/Sniffing	**10,098 (19.2)**	764 (16.2)	9,334 (19.5)
Other route of drug use†††	**163 (0.3)**	12 (0.3)	151 (0.3)
No reported route of drug use	**24,439 (46.4)**	2,136 (45.4)	22,303 (46.5)

See table footnotes on the next page.

TABLE. (*Continued*) Characteristics of illicitly manufactured fentanyl-involved* overdose decedents and circumstances surrounding death, by xylazine detection — State Unintentional Drug Overdose Reporting System, 31 states and District of Columbia,† January 2021–June 2022

Abbreviations: IMF = illicitly manufactured fentanyl; SUDORS = State Unintentional Drug Overdose Reporting System.

* Fentanyl was classified as likely illicitly manufactured using toxicology, scene, and witness evidence. For the 8% of deaths involving fentanyl that had insufficient evidence for classification as illicit or prescription, fentanyl was classified as illicit because the vast majority of fentanyl overdose deaths involve illicit fentanyl. All fentanyl analogs except alfentanil, remifentanil, and sufentanil, which have legitimate human medical use, were included as IMFs.

† Arizona, Arkansas, Colorado, Connecticut, Delaware, District of Columbia, Georgia, Illinois, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Virginia, Washington, and West Virginia. Illinois, Louisiana, Pennsylvania, and Washington reported deaths from counties that accounted for ≥75% of drug overdose deaths in the state in 2017, per SUDORS funding requirements; all other jurisdictions reported deaths from the full jurisdiction. Jurisdictions were included if data were available for the full period of January 2021–June 2022, including toxicology reports for ≥75% of deaths. Analysis was restricted to decedents with an available toxicology report; or, if no toxicology report was available, deaths were also included if xylazine was listed as part of the cause of death on the death certificate. Analysis of overdose circumstances was further restricted to jurisdictions with coroner or medical examiner report data for ≥75% of deaths during January 2021–June 2022 (resulting in the same 32 jurisdictions), and to deaths with a coroner or medical examiner report.

§ Missing values were excluded from calculations of percentages. Percentages might not sum to 100% because of rounding.

¶ *Northeast:* Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Pennsylvania, Rhode Island, and Vermont; *Midwest:* Illinois, Iowa, Kansas, Michigan, Minnesota, Nebraska, Ohio, and South Dakota; *South:* Arkansas, Delaware, District of Columbia, Georgia, Louisiana, Maryland, Oklahoma, Virginia, and West Virginia; *West:* Arizona, Colorado, Nevada, New Mexico, Oregon, Utah, and Washington.

** A drug was considered involved or co-involved if it was listed as a cause of death on the death certificate or in the medical examiner or coroner report. Percentages sum to >100% because drug categories are not mutually exclusive.

†† Drug entries coded as heroin were heroin and 6-acetylmorphine. In addition, morphine was coded as heroin if detected along with 6-acetylmorphine or if scene, toxicology, or witness evidence indicated presence of known heroin adulterants or impurities (including quinine, procaine, xylazine, noscapine, papaverine, thebaine, or acetylcodeine), injection, illicit drug use, or a history of heroin use.

§§ Drug entries coded as prescription opioids were alfentanil, buprenorphine, butorphanol, codeine, dextrorphan, dihydrocodeine, hydrocodone, hydromorphone, levorphanol, meperidine, methadone, morphine, nalbuphine, noscapine, oxycodone, oxymorphone, pentazocine, prescription fentanyl, propoxyphene, sufentanil, tapentadol, and tramadol. Also included as prescription opioids were brand names and metabolites (e.g., nortramadol) of these drugs and combinations of these drugs and nonopioids (e.g., acetaminophen-oxycodone). Morphine was included as prescription only if scene or witness evidence did not indicate likely heroin use and if 6-acetylmorphine was not also detected. Fentanyl was coded as a prescription opioid based on scene, toxicology, or witness evidence.

¶¶ For SUDORS, a potential bystander is defined as a person aged ≥11 years who was physically nearby either during or shortly preceding a drug overdose and potentially had an opportunity to intervene or respond to the overdose. This includes any persons in the same structure (e.g., same room or same building, but different room) as the decedent during that time; a family member who was in another room during the fatal incident would be considered a potential bystander if they might have had an opportunity to provide lifesaving measures (e.g., naloxone administration), if adequate resources were available, and if they were aware that an overdose event could occur. Persons in different self-contained parts of larger buildings (e.g., a different apartment in the same apartment building) would not be considered potential bystanders.

*** Evidence of injection, smoking, snorting, ingestion, and other route of drug use are not mutually exclusive; a death could have evidence of more than one of these routes. Routes of use cannot be linked to a specific drug or type of drug.

††† Other routes of drug use were buccal, sublingual, transdermal, and suppository.

that did not submit toxicology reports to SUDORS for ≥75% of deaths were excluded from analyses, death certificate data provided to SUDORS indicated that xylazine was co-involved in IMF-involved deaths in several excluded states, including New York, which recorded 735 such deaths.***

During January 2021–June 2022, decedent demographics, overdose circumstances, and other drug co-involvement were largely similar in comparisons of IMF-involved deaths with and without xylazine detected (Table). However, compared with IMF-involved deaths without xylazine, a lower percentage of those with xylazine detected had evidence of no pulse when first responders arrived (53.3% versus 62.2%) and a higher percentage had evidence of injection drug use††† (28.6% versus 19.5%). Compared with IMF-involved deaths without xylazine, a higher proportion of IMF-involved deaths with xylazine detected were in the Northeast U.S. Census Bureau region (49.9% versus 28.5%) and a lower proportion were in the West (1.1% versus 16.5%).

Discussion

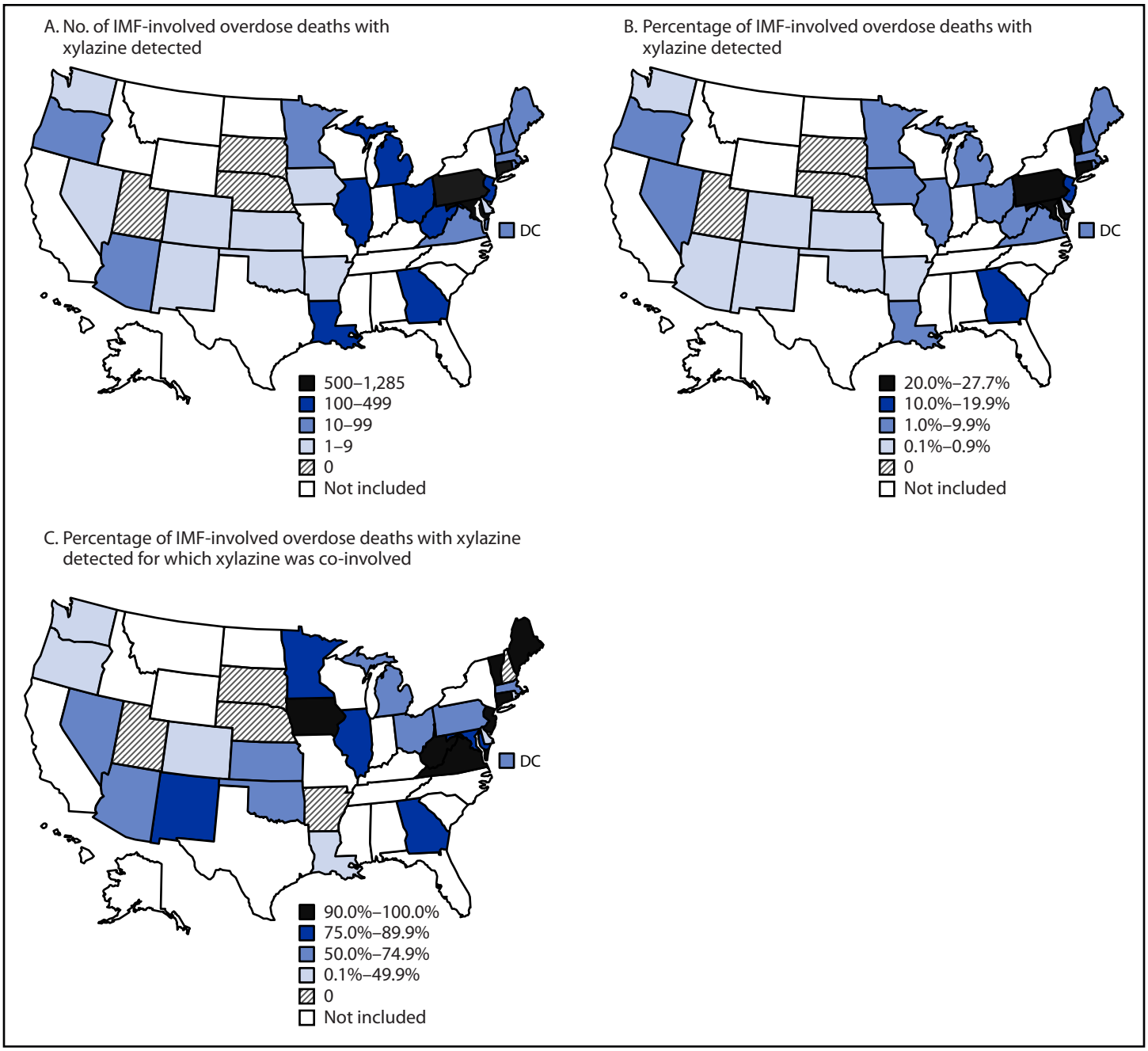
This report highlights four findings related to detection of xylazine in IMF-involved deaths. First, the percentage of IMF-involved deaths with xylazine detected increased 276% from January 2019 to June 2022. Second, xylazine was detected in <12.0% of IMF-involved deaths overall, but varied by jurisdiction from none to 27.7%, and was highest in the Northeast. Third, when xylazine was detected, whether it was determined to cause death varied by jurisdiction. Finally, demographic characteristics, drug co-involvement, and circumstances were largely similar among IMF-involved deaths with and without xylazine detected.

The timing and magnitude of increase in detection of xylazine among IMF-involved deaths might reflect both increased frequency of testing and true increased presence in

*** Toxicology report data were not available for ≥75% of all overdose deaths in eight states with complete death certificate data for January 2021–June 2022, and these states were excluded from analyses, but death certificate data identified IMF-involved deaths with xylazine co-involved (indicating that it was detected by postmortem toxicology testing even though the toxicology reports were not submitted to SUDORS): Alabama (46 deaths), Florida (261), Indiana (82), Mississippi (10), Missouri (93), New York (735), South Carolina (178), and Tennessee (167).

††† Route of drug use cannot be directly linked to specific drugs if more than one drug was detected and more than one route reported (e.g., if there was evidence of injection and snorting, both would be documented; if more than one drug was detected, it cannot be determined which was injected and which was snorted).

FIGURE 2. Number and percentage of drug overdose deaths involving* illicitly manufactured fentanyls,† by xylazine detection or co-involvement — State Unintentional Drug Overdose Reporting System, 31 states and District of Columbia,§ January 2021–June 2022



Abbreviations: DC = District of Columbia; IMF = illicitly manufactured fentanyl; SUDORS = State Unintentional Drug Overdose Reporting System.

* A drug was considered involved or co-involved if it was listed as a cause of death on the death certificate or in the medical examiner or coroner report.

† Fentanyl was classified as likely illicitly manufactured using toxicology, scene, and witness evidence. For the 8% of deaths involving fentanyl that had insufficient evidence for classification as illicit or prescription, fentanyl was classified as illicit because the vast majority of fentanyl overdose deaths involve illicit fentanyl. All fentanyl analogs except alfentanil, remifentanil, and sufentanil, which have legitimate human medical use, were included as IMFs.

§ Arizona, Arkansas, Colorado, Connecticut, Delaware, District of Columbia, Georgia, Illinois, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Utah, Vermont, Virginia, Washington, and West Virginia. Illinois, Louisiana, Pennsylvania, and Washington reported deaths from counties that accounted for ≥75% of drug overdose deaths in the state in 2017, per SUDORS funding requirements; all other jurisdictions reported deaths from the full jurisdiction. Jurisdictions were included if data were available for the full period of January 2021–June 2022, including toxicology reports for ≥75% of deaths. Analysis was restricted to decedents with an available toxicology report; or, if no toxicology report was available, deaths were also included if xylazine was listed as part of the cause of death on the death certificate. Four funded states were excluded from analyses because they were known to have not tested for xylazine during the analysis period. Toxicology report data were not available for ≥75% of all deaths in eight states with complete death certificate data for January 2021–June 2022, and they were therefore excluded from analyses, but death certificate data identified IMF-involved deaths with xylazine co-involved: Alabama (46 deaths), Florida (261), Indiana (82), Mississippi (10), Missouri (93), New York (735), South Carolina (178), and Tennessee (167).

the drug supply in recent years[§§§,¶¶¶] (*5*,*6*); however, because of inconsistent testing, detection is still likely underestimated. In April 2023, the White House Office of National Drug Control Policy designated fentanyl adulterated with xylazine an emerging threat[****]; some jurisdictions have scheduled or are trying to schedule xylazine as a controlled substance.[††††] Because replacement by similar substances or analogs has previously followed scheduling of certain substances (*7*), monitoring xylazine trends and other sedatives such as medetomidine (*8*) that have recently appeared in the drug supply is important.

The observed geographic variation in xylazine detection could reflect differences in postmortem toxicology testing protocols as well as its varying presence in regional drug supplies. Detection of xylazine and its co-involvement in IMF-involved deaths were most frequent in the Northeast, where IMF-involved deaths increased earlier (*9*) and IMFs are predominantly found in powdered form (*10*). Xylazine detection was lowest in the West, where IMF-involved deaths increased later (*9*) and IMFs are more commonly found in counterfeit pills (*10*). The Drug Enforcement Administration reported that in 2022, 23% of seized fentanyl powder and 7% of seized fentanyl pills contained xylazine.[§§§§] More information about relative prevalence of xylazine in different forms of IMF products could help tailor overdose prevention efforts to persons using various forms of IMFs.

Decedent demographics, drug co-involvement in death, and overdose circumstances were largely similar among IMF-involved deaths with and without xylazine detected, which suggests that particular demographic groups are not disproportionately affected by xylazine, and certain drugs are not more often used with IMF products with versus without xylazine. Further investigation of whether persons who use drugs are aware of xylazine presence in their products, and motivations for seeking it out or avoiding it, could help tailor prevention messaging.

Among IMF-involved overdose deaths in which xylazine was detected, the percentage for which xylazine was listed as a cause of death ranged from none to ≥90% among jurisdictions. Medical examiners and coroners might differ regarding whether they consider xylazine to increase fatal overdose risk, or they might be unfamiliar with xylazine and therefore not list it on death certificates. This variation highlights the importance of collecting postmortem toxicology data on all drugs detected in overdose deaths, rather than just those listed on the death certificate, especially for emerging drugs. Although health consequences of xylazine in humans are unclear, xylazine can act as a central nervous system depressant and is hypothesized to potentiate sedative effects of opioids (*3*). In this report, xylazine detection was not associated with higher proportions of naloxone administration (among decedents, this would indicate naloxone was administered but failed to reverse the overdose and prevent death) or decedents having no pulse (therefore less likely to respond to rescue measures) when first responders arrived. Further information is needed to understand xylazine's impact on overdose. Although xylazine has no known antidote and naloxone cannot reverse xylazine-related sedation (*4*), naloxone should be administered to reverse effects of opioids even if xylazine is suspected to be present because xylazine is mainly found in IMF products, which do respond to naloxone. Additional medical care should be sought immediately if overdose involving opioids, xylazine, or both is suspected. Respiratory and cardiovascular support can help address the nonopioid sedative effects of xylazine.

Limited studies indicate that repeated xylazine injections are associated with skin lesions, ulcerations, and abscesses (*4*), suggesting potential long-term xylazine-associated morbidity. Injection drug use evidence was slightly higher among IMF-involved deaths with versus without detection of xylazine; prevention messages could be tailored to persons who inject drugs to promote safe injection practices and proper wound management. Furthermore, harm reduction measures such as using xylazine test strips have shown high efficacy in detecting xylazine in drug products,[¶¶¶¶] and in conjunction with fentanyl test strips, could inform persons about contents of drug products. This might prevent morbidity or mortality if further evidence supports reports that xylazine contributes to skin lesions or increases overdose risk.

The findings in this report are subject to at least two limitations. First, because analyses were not nationally representative, results might not be generalizable. Second, toxicological testing of xylazine in decedents was not uniform across jurisdictions or over time, likely underestimating the true prevalence of xylazine in overdose deaths, and potentially overestimating the true increase during the analysis period.

[§§§] https://www.dea.gov/sites/default/files/2022-12/The%20Growing%20Threat%20of%20Xylazine%20and%20its%20Mixture%20with%20Illicit%20Drugs.pdf

[¶¶¶] https://www.accessdata.fda.gov/cms_ia/importalert_1179.html (Accessed May 24, 2023).

[****] https://www.whitehouse.gov/ondcp/briefing-room/2023/04/12/biden-harris-administration-designates-fentanyl-combined-with-xylazine-as-an-emerging-threat-to-the-united-states/

[††††] https://agri.ohio.gov/home/news-and-events/all-news/xylazine-drug-veterinarians-controlle-substance-ohio; https://www.governor.pa.gov/newsroom/governor-shapiro-directs-administration-to-schedule-xylazine-as-a-controlled-substance-taking-action-against-dangerous-drug-contributing-to-opioid-overdoses/

[§§§§] https://www.dea.gov/alert/dea-reports-widespread-threat-fentanyl-mixed-xylazine

[¶¶¶¶] https://www.cfsre.org/images/content/reports/drug_checking/CFSRE_Xylazine_Report-Rev-1-18-23.pdf

Summary

What is already known about this topic?

Xylazine, a nonopioid sedative, has been increasingly detected in illicitly manufactured fentanyl (IMF) drug products and overdose deaths.

What is added by this report?

Among 21 jurisdictions, the monthly percentage of IMF-involved deaths with xylazine detected increased 276% from January 2019 (2.9%) to June 2022 (10.9%). During January 2021–June 2022 in 32 jurisdictions, xylazine was detected in a higher percentage of IMF-involved deaths in the Northeast U.S. Census Bureau region; listing xylazine as cause of death varied across jurisdictions.

What are the implications for public health practice?

Routine xylazine testing in suspected overdose deaths is critical for surveillance; further investigation of xylazine's effects on humans is needed to guide prevention efforts. Overdose prevention and response messages should emphasize the need to seek treatment beyond naloxone administration.

Routine toxicology testing for xylazine in suspected overdose cases is critical for accurate surveillance, and further investigation of xylazine's potency and effects on humans is needed to clarify morbidity and overdose risks and to guide prevention and response efforts. Insight into motivations for adding xylazine to IMF products, and whether persons actively seek xylazine, could help anticipate future drug supply changes and tailor prevention and response efforts. Examining overdose mortality data in conjunction with other data sources, such as drug seizure and nonfatal overdose data, could provide further information about short-and long-term effects of xylazine use.

Acknowledgments

Jurisdictions participating in CDC's Overdose Data to Action (OD2A) program and providing data to the State Unintentional Drug Overdose Reporting System, including state and jurisdictional health departments, vital registrar offices, and coroner and medical examiner offices; CDC OD2A team; Lauren Tanz, Division of Overdose Prevention, National Center for Injury Prevention and Control, CDC.

Corresponding author: Mbabazi Kariisa, mkariisa@cdc.gov.

[1]Division of Overdose Prevention, National Center for Injury Prevention and Control, CDC; [2]Forensic Medicine Division, Department of Pathology, Immunology and Laboratory Medicine, College of Medicine, University of Florida, Gainesville, Florida.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No potential conflicts of interest were disclosed.

References

1. Ahmad FB, Cisewski JA, Rossen LM, Sutton P. Provisional drug overdose death counts. Atlanta, GA: US Department of Health and Human Services, CDC, National Center for Health Statistics; 2023. Accessed June 16, 2023. https://www.cdc.gov/nchs/nvss/vsrr/drug-overdose-data.htm
2. Alexander RS, Canver BR, Sue KL, Morford KL. Xylazine and overdoses: trends, concerns, and recommendations. Am J Public Health 2022;112:1212–6. PMID:35830662 https://doi.org/10.2105/AJPH.2022.306881
3. Ruiz-Colón K, Chavez-Arias C, Díaz-Alcalá JE, Martínez MA. Xylazine intoxication in humans and its importance as an emerging adulterant in abused drugs: a comprehensive review of the literature. Forensic Sci Int 2014;240:1–8. PMID:24769343 https://doi.org/10.1016/j.forsciint.2014.03.015
4. Reyes JC, Negrón JL, Colón HM, et al. The emerging of xylazine as a new drug of abuse and its health consequences among drug users in Puerto Rico. J Urban Health 2012;89:519–26. PMID:22391983 https://doi.org/10.1007/s11524-011-9662-6
5. Johnson J, Pizzicato L, Johnson C, Viner K. Increasing presence of xylazine in heroin and/or fentanyl deaths, Philadelphia, Pennsylvania, 2010–2019. Inj Prev 2021;27:395–8. PMID:33536231 https://doi.org/10.1136/injuryprev-2020-043968
6. Holt AC, Schwope DM, Le K, Schrecker JP, Heltsley R. Widespread distribution of xylazine detected throughout the United States in healthcare patient samples. J Addict Med 2023. Epub January 6, 2023. PMID:36728486 https://doi.org/10.1097/ADM.0000000000001132
7. Almeida AS, Silva B, Pinho PG, Remião F, Fernandes C. Synthetic cathinones: recent developments, enantioselectivity studies and enantioseparation methods. Molecules 2022;27:2057. PMID:35408456 https://doi.org/10.3390/molecules27072057
8. Sisco E, Appley M. Identification of the veterinary sedative medetomidine in combination with opioids and xylazine in Maryland. J Forensic Sci 2023. Epub March 26, 2023. PMID:36966471 https://doi.org/10.1111/1556-4029.15242
9. O'Donnell JK, Gladden RM, Seth P. Trends in deaths involving heroin and synthetic opioids excluding methadone, and law enforcement drug product reports, by Census region—United States, 2006–2015. MMWR Morb Mortal Wkly Rep 2017;66:897–903. PMID:28859052 https://doi.org/10.15585/mmwr.mm6634a2
10. Kilmer B, Pardo B, Pujol TA, Caulkins JP. Rapid changes in illegally manufactured fentanyl products and prices in the United States. Addiction 2022;117:2745–9. PMID:35543081 https://doi.org/10.1111/add.15942

Disparities in COVID-19 Disease Incidence by Income and Vaccination Coverage — 81 Communities, Los Angeles, California, July 2020–September 2021

John M. Masterson, MD[1]; Michael Luu, MPH[1,2]; Kai B. Dallas, MD[3]; Lauren P. Daskivich, MD[4]; Brennan Spiegel, MD[5,6]; Timothy J. Daskivich, MD[1,6]

COVID-19 has disproportionately affected socially vulnerable communities characterized by lower income, lower education attainment, and higher proportions of minority populations, among other factors (*1–4*). Disparities in COVID-19 incidence and the impact of vaccination on incidence disparities by community income were assessed among 81 communities in Los Angeles, California. Median community vaccination coverage and COVID-19 incidence were calculated across household income strata using a generalized linear mixed effects model with Poisson distribution during three COVID-19 surge periods: two before vaccine availability (July 2020 and January 2021) and the third after vaccines became widely available in April 2021 (September 2021). Adjusted incidence rate ratios (aIRRs) during the peak month of each surge were compared across communities grouped by median household income percentile. The aIRR between communities in the lowest and highest median income deciles was 6.6 (95% CI = 2.8–15.3) in July 2020 and 4.3 (95% CI = 1.8–9.9) in January 2021. However, during the September 2021 surge that occurred after vaccines became widely availabile, model estimates did not identify an incidence disparity between the highest- and lowest-income communities (aIRR = 0.80; 95% CI = 0.35–1.86). During this surge, vaccination coverage was lowest (59.4%) in lowest-income communities and highest (71.5%) in highest-income communities (p<0.001). However, a significant interaction between income and vaccination on COVID-19 incidence (p<0.001) indicated that the largest effect of vaccination on disease incidence occured in the lowest-income communities. A 20% increase in community vaccination was estimated to have resulted in an additional 8.1% reduction in COVID-19 incidence in the lowest-income communities compared with that in the highest-income communities. These findings highlight the importance of improving access to vaccination and reducing vaccine hesitancy in underserved communities in reducing disparities in COVID-19 incidence.

Eighty-one communities in Los Angeles with available vaccination and incidence data (total population = 5,083,093; median = 47,450) were included in the analysis (Supplementary Table 1, https://stacks.cdc.gov/view/cdc/129934). Community-level COVID-19 vaccination coverage and incidence data from March 2020 through September 2021 were obtained from the Los Angeles Times COVID-19 data repository, which is populated with California Department of Public Health data.* COVID-19 incidence data from this repository and sociodemographic data from the U.S. Census Bureau† were available by community name within Los Angeles County. Vaccination coverage data were available by zip code. Los Angeles Times COVID-19 incidence and vaccination data were linked to census data using zip codes as a common identifier.

A generalized linear mixed effects model with a Poisson distribution was used to estimate COVID-19 incidence and, separately, vaccination coverage across strata of median community household income. Covariates in the model included percentage of persons in each community who had completed the primary COVID-19 vaccination series§ and the following community characteristics: percentage of persons who were 1) aged ≥65 years; 2) male or female; 3) non–U.S.-born; 4) non-Hispanic White, non-Hispanic Black or African American, or Hispanic or Latino; 5) who had completed at least high school; and 6) who had no health insurance; and the average number of persons residing in each household. Time (number of months since data collection began in March 2020) and vaccination coverage were included in the model as polynomial splines to allow flexibility in estimating the nonlinear effects of time and vaccination coverage on COVID-19 incidence. Interaction terms along with main effects for median income and vaccination coverage, and median income and time in months were included to adjust for differential effects of median income on COVID-19 incidence across levels of vaccination coverage and time.¶ Unadjusted** and adjusted IRRs with predicted marginal effects for COVID-19 incidence were calculated across percentiles of median community household

* Summary: https://www.latimes.com/projects/california-coronavirus-cases-tracking-outbreak/; primary data: https://github.com/datadesk/california-coronavirus-data (Accessed October 1, 2022).

† https://www.census.gov/quickfacts/fact/table/US/PST045221 (Accessed October 1, 2022).

§ Receipt of 1 dose of Janssen (Johnson & Johnson) vaccine or 2 doses of Pfizer-BioNTech or Moderna vaccines.

¶ The interaction between income and time was included to account for differential effects of median income on COVID-19 incidence at different time points. Without this interaction term, it would be assumed that the effect of median income on COVID-19 incidence is independent of time and hence fixed across the analyzed time points. The interaction between vaccination and time was not included in the model because widespread vaccination did not occur until the end of the time horizon of the study and was therefore relevant only to the final surge in September 2021.

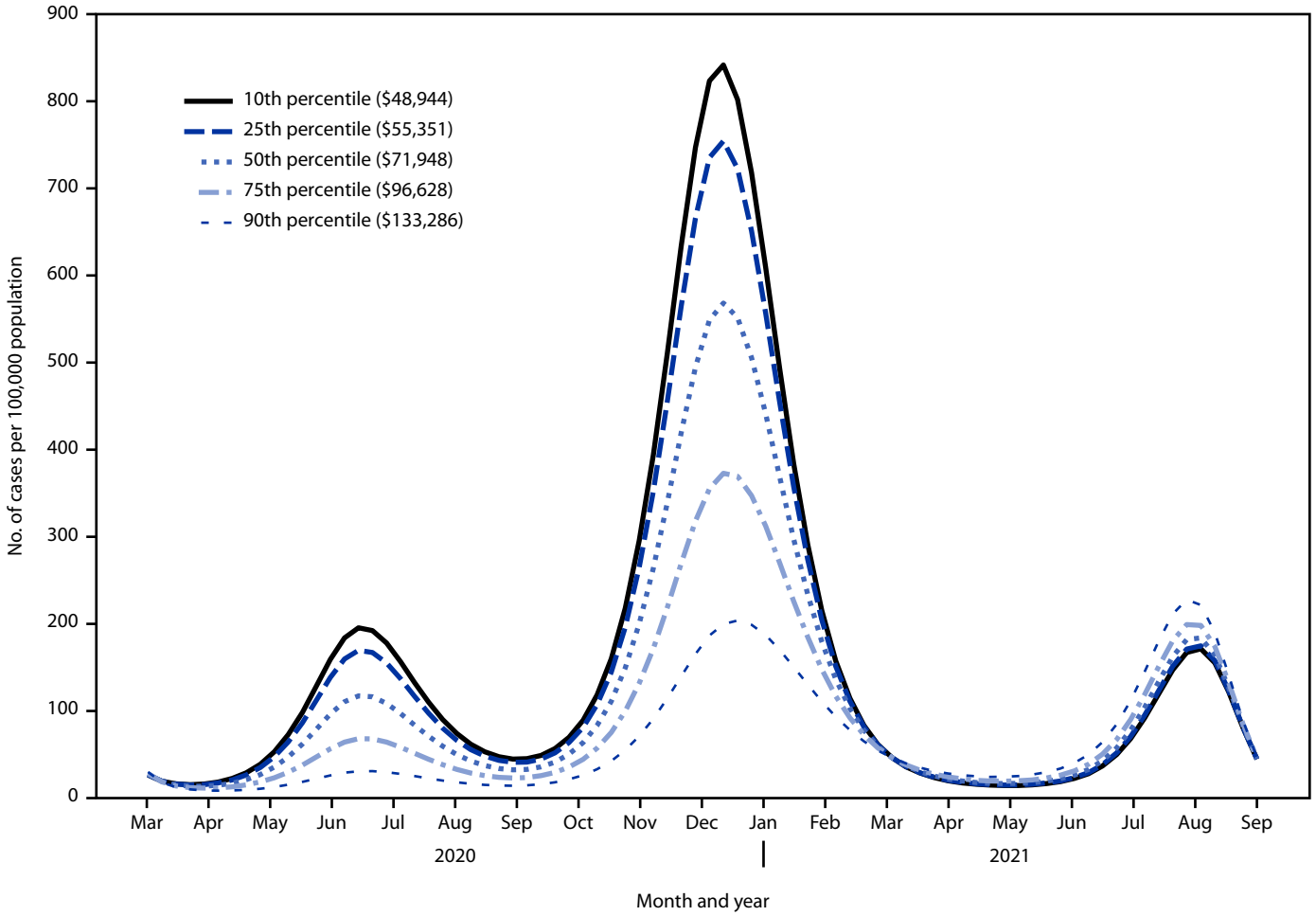
** Univariable (unadjusted) models included time in months relative to the start of data collection (March 2020), income, and the interaction of income by time.

income during July 2020, January 2021, and September 2021. The aIRRs during the peak month of each surge were compared across income strata using the Wald's test with p-values adjusted using Tukey's method for multiple comparisons. Median community vaccination coverage and reduction in COVID-19 incidence associated with a 20% increase in community vaccination coverage in September 2021 were estimated independently with the multivariable mixed effects Poisson models and were compared across income strata using pairwise contrasts of Wald's test, with p-values adjusted using Tukey's method for multiple comparisons. Statistical tests were performed using R software (version 4.1.1; R Foundation). All tests were two-sided with a significance threshold of $p<0.05$. This study was deemed exempt from IRB review by the Cedars-Sinai Institutional Review Board.

COVID-19 incidence was significantly higher in communities with lower median household income than in those with higher median household income during both July 2020 (aIRR = 6.6, 95% CI = 2.8–15.3) and January 2021 (aIRR = 4.3; 95% CI = 1.8–9.9) (Figure) (Table 1).[††] In September 2021, however, incidence was not significantly different across communities irrespective of median household income (aIRR = 0.8; 95% CI = 0.35–1.86). By September 2021, higher median

[††] A significant interaction was identified between income and time ($p<0.001$) in the mixed effects model predicting COVID-19 incidence, in which the effects of income on COVID-19 incidence was dependent on time.

FIGURE. Estimated COVID–19 incidence,* by median community income percentile[†,§] — 81 communities, Los Angeles, California, March 2020–September 2021



* Cases per 100,000 population. Incidence was estimated across median community income strata using the multivariable Poisson mixed effects model corrected for community-level median vaccination coverage, age, sex, non–U.S.-born status, race, ethnicity, education level, number of persons per household, insurance status, and interaction terms for income by vaccination and income by time in months since data collection began in March 2020.

† In U.S. dollars. $p<0.001$ for all comparisons of COVID-19 incidence between median community income strata in July 2020 and January 2021 (independently) using Wald's test adjusted for multiple comparisons.

§ In U.S. dollars. $p<0.05$ for all comparisons of COVID-19 incidence between median community income strata in September 2021 using Wald's test adjusted for multiple comparisons.

TABLE 1. Comparison of COVID-19 unadjusted and adjusted incidence rate ratios,* by median community income percentile† — 81 communities, Los Angeles, California, July 2020, January 2021, and September 2021

Median community income percentile§ comparison	IRR (95% CI), by month and year					
	Jul 2020§		Jan 2021§		Sep 2021	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
10th vs. 25th	1.14 (1.11–1.17)	1.15 (1.08–1.23)	1.09 (1.06–1.12)	1.12 (1.05–1.19)	1.03 (0.99–1.06)	0.98 (0.92–1.05)
10th vs. 50th	1.59 (1.43–1.77)	1.67 (1.33–2.11)	1.37 (1.23–1.52)	1.49 (1.18–1.87)	1.10 (0.98–1.22)	0.94 (0.75–1.18)
10th vs. 75th	2.63 (2.11–3.28)	2.91 (1.80–4.69)	1.92 (1.54–2.40)	2.28 (1.42–3.68)	1.22 (0.98–1.52)	0.88 (0.54–1.41)
10th vs. 90th	5.52 (3.74–8.16)	6.61 (2.84–15.38)	3.18 (2.16–4.69)	4.30 (1.85–9.99)	1.41 (0.96–2.09)	0.79 (0.34–1.84)

Abbreviation: IRR = incidence rate ratio.

* IRRs were estimated from multivariable Poisson mixed effects model for COVID-19 incidence. Univariable (unadjusted) models included time in months since data collection began in March 2020, income, and the interaction of income by time. Multivariable (adjusted) models included community-level median vaccination coverage, age, sex, non–U.S.-born status, race, ethnicity, education level, number of persons per household, insurance status, and interaction terms for income by vaccination and income by time.

† Median community income percentiles (in U.S. dollars): 10th = $48,944; 25th = $55,351; 50th = $71,948; 75th = $96,628; and 90th = $133,286.

§ p<0.001 for IRR comparisons between median community income strata at the specified time point using the Wald's test adjusted for multiple comparisons.

household income was associated with higher community vaccination coverage across all percentiles of income, with median vaccination coverage of 59.4% (95% CI = 57.6%–61.2%) for the lowest- and 71.5% (95% CI = 68.5%–74.4%) for the highest-income communities (p<0.001) (Supplementary Figure, https://stacks.cdc.gov/view/cdc/129936) (Supplementary Table 2, https://stacks.cdc.gov/view/cdc/129935). A significant interaction was observed between median household income and vaccination coverage on COVID-19 incidence (p<0.001). Within each income stratum, vaccination coverage was inversely associated with COVID-19 incidence; however, the effect was largest in the lowest-income communities. A 20% increase in community vaccination coverage was predicted to result in an additional 8.1% (95% CI = 7.7%–8.4%) reduction in COVID-19 incidence in the lowest-income communities compared with the highest-income communities (p<0.001) (Table 2).

TABLE 2. Predicted absolute reduction* in COVID-19 incidence rate ratios associated with a 20% increase in community primary series coverage† — 81 communities, Los Angeles, California, September 2021

Median community income percentile, (USD)	Absolute reduction in COVID-19 incidence,§,¶ % (95% CI)
90th ($133,286)	Ref
75th ($96,628)	−3.6 (−3.2 to −4.0)
50th ($71,948)	−5.9 (−5.7 to −6.2)
25th ($55,351)	−7.5 (−7.2 to −7.8)
10th ($48,944)	−8.1 (−7.7 to −8.4)

Abbreviations: Ref = referent group; USD = U.S. dollars.

* Reductions in incidence rate ratios estimated from the multivariable Poisson mixed effects model corrected for community-level median vaccination coverage, age, sex, non–U.S.-born status, race, ethnicity, education level, number of persons per household, insurance status, and interaction terms for income by vaccination and income by time in months since data collection began in March 2020.

† Receipt of 1 dose of Janssen (Johnson & Johnson) vaccine or 2 doses of Pfizer-BioNTech or Moderna vaccines.

§ COVID-19 vaccination and incidence data were obtained from the Los Angeles Times COVID-19 data repository (https://www.latimes.com/projects/california-coronavirus-cases-tracking-outbreak/). Sociodemographic data was obtained from 2019 U.S. Census Bureau data.

¶ p<0.001 for pairwise comparisons versus the 90th percentile median community income using the Wald's test adjusted for multiple comparisons.

Discussion

This study adds to the body of evidence showing the disproportionate impact of COVID-19 on the lowest-income communities early in the pandemic and the impact of vaccination in reducing these disparities. These disparities were mitigated during the third pandemic surge, after COVID-19 vaccines became widely available. Although vaccination coverage was inversely associated with disease incidence during the third surge in all income groups, the estimated impact of vaccination on COVID-19 incidence was largest in the lowest-income communities, despite lower overall vaccination coverage in these communities. The higher impact of vaccination in those communities might be due to the higher risk for SARS-CoV-2 exposure in lower-income communities, potentially related to higher population density, more use of public transportation, and increased likelihood of working in service industries in which remote work might not be feasible (*5*). Higher COVID-19 incidence in lower-income communities might also have contributed to higher levels of postinfection immunity before the third surge, with 17% of the population in the lowest-income communities having received a positive COVID-19 test result before the third surge compared with only 4% in the highest-income communities.

Vaccination coverage differed by income despite public health programs to enhance access to vaccination in lower-income communities. Efforts in California included allocating 40% of vaccination appointments to communities in the lowest quartile of the California Healthy Places Index (HPI) (https://www.healthyplacesindex.org/) early in the vaccine rollout (i.e., March 2021) (*6*). HPI reflects 25 community characteristics using data related to household income, education level, health care access, housing, neighborhoods, clean environment, transportation, and social environment. California's zip codes (≥1,650) were stratified by the HPI Index (*7*). All communities in the lowest decile of median income in this study were also in

the lowest quartile of HPI. This vaccine allocation effort and other factors likely contributed to the relatively narrow range of estimated adult primary series vaccination coverage rates (59.4%–71.5%) observed across income strata in Los Angeles County communities at the time of the September 2021 surge.

Efforts to improve vaccination access and vaccine confidence are needed to mitigate income-related vaccination disparities (*8*). Racial, ethnic, income, birth origin, and education inequalities in adult routine vaccination are longstanding, highlighting the continued need to build vaccine confidence for COVID-19 and routine immunization (*9*).

The findings in this report are subject to at least three limitations. First, these data sets do not include person-level data to enable direct estimation of the impact of individual vaccination on COVID-19 incidence by income, which precluded accounting for individual immunity acquired from previous infection. Second, it was not possible to adjust for differential access to or use of testing between communities over time, which has potential to inflate or dampen observed disaparities. Finally, these results might not be generalizable outside Los Angeles or to other pandemic waves, the latter due to differences in vaccine effectiveness among different COVID-19 variants.

The COVID-19 pandemic has highlighted the impact of social determinants of health on health disparities (*10*). Future planning is needed to ensure readiness to quickly implement strategies to mitigate disparities during pandemics affecting lower-income communities while vaccines are being developed, including efforts to improve access to vaccination and vaccine confidence in disproportionately affected communities. Reducing barriers to vaccination in lower-income communities, including providing updated (bivalent) COVID-19 vaccine boosters, is critical to reducing disparities in disease impact, and decreasing COVID-19–related illness in the United States.

Corresponding author: Timothy J. Daskivich, Timothy.Daskivich@cshs.org.

[1]Department of Urology, Cedars-Sinai Medical Center, Los Angeles, California; [2]Department of Biostatistics, Cedars-Sinai Medical Center, Los Angeles, California; [3]Division of Urology, City of Hope, Duarte, California; [4]Los Angeles County Department of Health Services, Los Angeles, California; [5]Department of Medicine, Cedars-Sinai Medical Center, Los Angeles, California; [6]Cedars-Sinai Center for Outcomes Research and Education, Cedars-Sinai Medical Center, Los Angeles, California.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. No other potential conflicts of interest were disclosed.

Summary

What is already known about this topic?

The COVID-19 pandemic disproportionately affected lower-income communities.

What is added by this report?

In 81 communities in Los Angeles, California, COVID-19 incidence during two surges before vaccine availability (July 2020 and January 2021) was higher in lower-income communities compared with higher-income communities. During the first surge after vaccines became available (September 2021), a disparity in COVID-19 incidence between the highest- and lowest-income communities was not observed. The impact of vaccination on COVID-19 incidence was highest in the lowest-income communities despite their lower vaccination coverage.

What are the implications for public health practice?

Addressing barriers to vaccination within lower-income communities is critical to reducing disparities in disease incidence and COVID-19–related illness in the United States.

References

1. Adhikari S, Pantaleo NP, Feldman JM, Ogedegbe O, Thorpe L, Troxel AB. Assessment of community-level disparities in coronavirus disease 2019 (COVID-19) infections and deaths in large US metropolitan areas. JAMA Netw Open 2020;3:e2016938. PMID:32721027 https://doi.org/10.1001/jamanetworkopen.2020.16938
2. Liao TF, De Maio F. Association of social and economic inequality with coronavirus disease 2019 incidence and mortality across US counties. JAMA Netw Open 2021;4:e2034578. PMID:33471120 https://doi.org/10.1001/jamanetworkopen.2020.34578
3. Hawkins D. Social determinants of COVID-19 in Massachusetts, United States: an ecological study. J Prev Med Public Health 2020;53:220–7. PMID:32752590 https://doi.org/10.3961/jpmph.20.256
4. Tai DBG, Sia IG, Doubeni CA, Wieland ML. Disproportionate impact of COVID-19 on racial and ethnic minority groups in the United States: a 2021 update. J Racial Ethn Health Disparities 2022;9:2334–9. PMID:34647273 https://doi.org/10.1007/s40615-021-01170-w
5. Wong DWS, Li Y. Spreading of COVID-19: density matters. PLoS One 2020;15:e0242398. PMID:33362283 https://doi.org/10.1371/journal.pone.0242398
6. California Department of Public Health. Ending the pandemic through equitable vaccine administration. Sacramento, CA: California Department of Public Health; 2021. https://www.gov.ca.gov/wp-content/uploads/2021/03/Equitable-Vaccine-Administration-Fact-Sheet.pdf
7. Maizlish N, Delaney T, Dowling H, et al. California Healthy Places Index: frames matter. Public Health Rep 2019;134:354–62. PMID:31095451 https://doi.org/10.1177/0033354919849882
8. CDC. COVID-19 vaccine confidence. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. https://www.cdc.gov/vaccines/covid-19/vaccinate-with-confidence.html
9. Lu P-J, Srivastav A, Vashist K, et al. COVID-19 booster dose vaccination coverage and factors associated with booster vaccination among adults, United States, March 2022. Emerg Infect Dis 2023;29:133–40. PMID:36480674 https://doi.org/10.3201/eid2901.221151
10. Abrams EM, Szefler SJ. COVID-19 and the impact of social determinants of health. Lancet Respir Med 2020;8:659–61. PMID:32437646 https://doi.org/10.1016/S2213-2600(20)30234-4

Notes from the Field

Multistate Outbreak of *Escherichia coli* O157:H7 Infections Linked to a National Fast-Food Chain — United States, 2022

Christan Stager, DVM[1]; Danielle Donovan, MS[2]; Lauren Edwards, MPH[3]; Evelyn Pereira, MPH[4]; Laurie Williams, MS[5]; Jennifer Freiman, MPH[6]; Colin Schwensohn, MPH[7]; Laura Gieraltowski, PhD[7]

In August 2022, the Michigan Department of Health and Human Services alerted CDC to an approximately fivefold increase in regional cases of *Escherichia coli* O157:H7 infection. Whole genome sequencing was used to characterize isolates from laboratory-confirmed infections in ill persons. Initial patient interviews indicated that many had consumed meals from the same national fast-food chain. Federal, state, and local officials initiated an investigation to identify the outbreak source and prevent additional cases. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.*

CDC defined a case as an *E. coli* O157:H7 infection with an isolate highly related to the outbreak strain (within 0–2 alleles) by core genome multilocus sequence typing, with illness onset during July 26–August 24, 2022. PulseNet, CDC's national molecular subtyping network for enteric disease surveillance, detected 109 cases from six states, including Michigan (67; 61%), Ohio (24; 22%), Indiana (11; 10%), Pennsylvania (four; 4%), Kentucky (two; 2%) and New York (one; 1%). The median patient age was 22 years (range = 1–94 years), and 49 (45%) were female. Fifty-two (48%) patients were hospitalized, and 13 (12%) developed hemolytic-uremic syndrome, a recognized complication of *E. coli* O157:H7 infection; no deaths occurred.

Hypothesis-generating interviews were conducted with 84 (77%) patients; among these, 70 (83%) reported eating at the same fast-food chain during the week preceding illness onset. Investigation identified 11 restaurant clusters (groups of unrelated ill persons who ate at the same restaurant). Ill persons reported eating food ingredients commonly served together on several menu items. Among 68 patients who provided detailed information, the most commonly reported exposures were beef patties (53; 78%) and romaine lettuce on sandwiches (46; 68%). Early in the investigation, romaine lettuce exposure exceeded 90%, prompting the fast-food chain to remove lettuce in states with outbreak-associated cases. Food handlers infected with the outbreak strain were identified but were unlikely to be the ultimate source. Although ill food handlers might have amplified the outbreak at some locations, many restaurant clusters had no affected food handlers.

Considering menu items reported by ill persons, and that foodborne *E. coli* O157:H7 outbreaks are often linked to leafy greens and beef (*1*), the Food and Drug Administration (FDA) traced romaine lettuce and the U.S. Department of Agriculture's Food Safety and Inspection Service (USDA-FSIS) traced beef patties to determine their source. Neither traceback identified a single production lot that could explain all outbreak-associated illnesses. In the absence of another restaurant cluster outside of the national fast-food chain, FDA and USDA were unable to use triangulation to identify convergence of a specific food item to a common source. States tested food from restaurants, and FDA tested foods and environmental samples from the supply chain; however, the outbreak strain was not identified in the tested samples.

Investigators linked this large multistate outbreak of *E. coli* O157:H7 infections to eating at a national fast-food chain. Despite epidemiologic, traceback, and microbiologic investigations, the contaminated ingredient was not confirmed. This outbreak highlights recurring challenges associated with investigating outbreaks linked to single restaurant chains (*2*,*3*). Ingredient collinearity (i.e., the sharing of many ingredients among multiple menu items) precluded identification of a single item associated with illnesses. Cross-contamination among ingredients or from ill food handlers also complicated source identification. The absence of restaurant clusters with an independent supply system outside the fast-food chain prevented use of triangulation to identify the source (*4*). Despite these challenges, clear communication with state partners, FDA, USDA-FSIS, and the restaurant chain led to rapid public health action to remove suspected romaine lettuce from identified restaurants. No outbreak-associated illnesses were reported after the suspected romaine lettuce was removed.

Corresponding author: Christan Stager, christan.stager@gmail.com.

[1]Epidemic Intelligence Service, CDC; [2]Michigan Department of Health and Human Services; [3]Michigan Department of Agriculture and Rural Development; [4]Coordinated Outbreak Response and Evaluation Network, Food and Drug Administration, College Park, Maryland; [5]Retail Food Policy Team, Office for Food Safety, Center for Food Safety and Applied Nutrition, Food and Drug Administration, Silver Spring, Maryland; [6]Office of Public Health Science, Food Safety and Inspection Service, U.S. Department of Agriculture, Washington, DC; [7]Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging and Zoonotic Infectious Diseases, CDC.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Lauren Edwards's salary is partially paid through the Food and Drug Administration's Rapid Response Team grant. No other potential conflicts of interest were disclosed.

* 45 C.F.R. part 46.102(l)(2), 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.

References

1. Heiman KE, Mody RK, Johnson SD, Griffin PM, Gould LH. *Escherichia coli* O157 outbreaks in the United States, 2003–2012. Emerg Infect Dis 2015;21:1293–301. PMID:26197993 https://doi.org/10.3201/eid2108.141364
2. Sodha SV, Lynch M, Wannemuehler K, et al. Multistate outbreak of *Escherichia coli* O157:H7 infections associated with a national fast-food chain, 2006: a study incorporating epidemiological and food source traceback results. Epidemiol Infect 2011;139:309–16. PMID:20429971 https://doi.org/10.1017/S0950268810000920
3. Bottichio L, Keaton A, Thomas D, et al. Shiga toxin–producing *Escherichia coli* infections associated with romaine lettuce—United States, 2018. Clin Infect Dis 2020;71:e323–30. PMID:31814028 https://doi.org/10.1093/cid/ciz1182
4. Irvin K, Viazis S, Fields A, et al. An overview of traceback investigations and three case studies of recent outbreaks of *Escherichia coli* O157:H7 infections linked to romaine lettuce. J Food Prot 2021;84:1340–56. PMID:33836048 https://doi.org/10.4315/JFP-21-112

Notes from the Field

Outbreak of Cryptosporidiosis Among Collegiate Swimmers and Evidence of Secondary Transmission — Massachusetts and Rhode Island, 2023

Geena Chiumento, MPH[1]; Anthony Osinski, MPH[1]; Kelsey DeVoe, MSN[2]; Amelia Houghton, MS, MSN[3]; Akita Joshi, MS[1]; Caryn Ivanof[1]; Emma Creegan, MPH[4]; Michael Gosciminski, MPH, MT[4]; Alexandra P. Newman, DVM[5]; Susan Madison-Antenucci, PhD[5]; Michele C. Hlavsa, MPH[6]; Erin Imada, MPH[6]; Colleen Lysen, MS[6]; Shanna Miko, DNP[6,7]; Jordan Schultz, MPH[1]; Emily Harvey[1]; Johanna Vostok, MPH[1]; Catherine M. Brown, DVM[1]

Inadvertent ingestion of recreational waters contaminated with feces containing *Cryptosporidium* spp., an extremely chlorine-tolerant parasite, can result in gastrointestinal illness. In early 2023, a Massachusetts college notified the Massachusetts Department of Public Health (MDPH) that 19 of 50 (38%) members of the men's and women's swim teams had experienced diarrhea beginning 3 days after their return from a weeklong training trip to Puerto Rico. One ill swimmer reported receiving a positive ova and parasite test result for *Cryptosporidium*. On days 5 and 6 after return from Puerto Rico, symptomatic Massachusetts swimmers competed in two meets against New York and Rhode Island collegiate teams (meet 1 and meet 2, respectively), raising concern about the potential for secondary transmission.

Upon notifying MDPH of the ill swimmers (9 days after returning from Puerto Rico), ill Massachusetts swimmers were encouraged to submit stool specimens to the Massachusetts State Public Health Laboratory for testing with the BioFire FilmArray Gastrointestinal Panel.* A case in this investigation was defined as a gastrointestinal illness in a swim team member following the team's travel to Puerto Rico. *Cryptosporidium*-positive specimens were forwarded to CDC and New York CryptoNet laboratories for molecular characterization (*1*,*2*). Swimmers with positive test results for *Cryptosporidium* were interviewed using a standardized questionnaire. On the same day as initial notification, MDPH notified the Puerto Rico, New York, and Rhode Island health departments; both the New York and Rhode Island health departments worked with their respective swim teams to identify secondary cases. At the same time, the Massachusetts college closed its swimming pool and hired a vendor to hyperchlorinate the pool water to inactivate *Cryptosporidium*.† This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.§

Among the 19 symptomatic Massachusetts swimmers, 18 received testing, and stool specimens for 13 had positive test results for *Cryptosporidium* (Figure); the 13 patients ranged in age from 18 to 22 years, and eight were male. No hospitalizations occurred. Symptoms commenced 3 to 7 days after return to Massachusetts. Reported exposures to water sources while in Puerto Rico by the 13 patients with positive test results included the training pool (13), a waterfall (13), and the ocean (10). Swimmers with cryptosporidiosis were excluded from swimming activities until 2 weeks after resolution of diarrhea.¶

No additional related cryptosporidiosis cases were identified or reported in Massachusetts or among potentially exposed New York swimmers at meet 1. Rhode Island officials reported that two swimmers became ill 7 days after meet 2 and received positive stool *Cryptosporidium* test results. Symptoms in these two swimmers began just after participating in another meet (meet 3) against another out-of-state university; no illnesses associated with that meet were reported. *Cryptosporidium parvum* IIaA16G3R1 was identified in specimens from five Massachusetts swimmers and IIaA17G2 and IIaA15G2R1 from one Massachusetts swimmer each. Subtype IIaA16G3R1 was also identified in specimens from the two Rhode Island swimmers, suggesting that secondary transmission occurred at meet 2.

This investigation highlights three important points. First, although there was no evidence of subsequent transmission from the Rhode Island swimmers, because of the regular intercollegiate competition and subsequent championship schedule, the potential exists for sustained *Cryptosporidium* transmission among competitive swimmers (*3*,*4*). Second, without the initial laboratory diagnosis of cryptosporidiosis in the Massachusetts swimmer, *Cryptosporidium* might not have been suspected and the pool might not have been immediately closed and disinfected, which could have led to further transmission, illustrating the importance of prompt testing of stool specimens from patients. Finally, there is an ongoing need to promote healthy swimming,** including recommendations for persons not to swim if they have diarrhea and to avoid swallowing swimming pool water to prevent waterborne disease.

* https://www.biofiredx.com/products/the-filmarray-panels/filmarraygi/

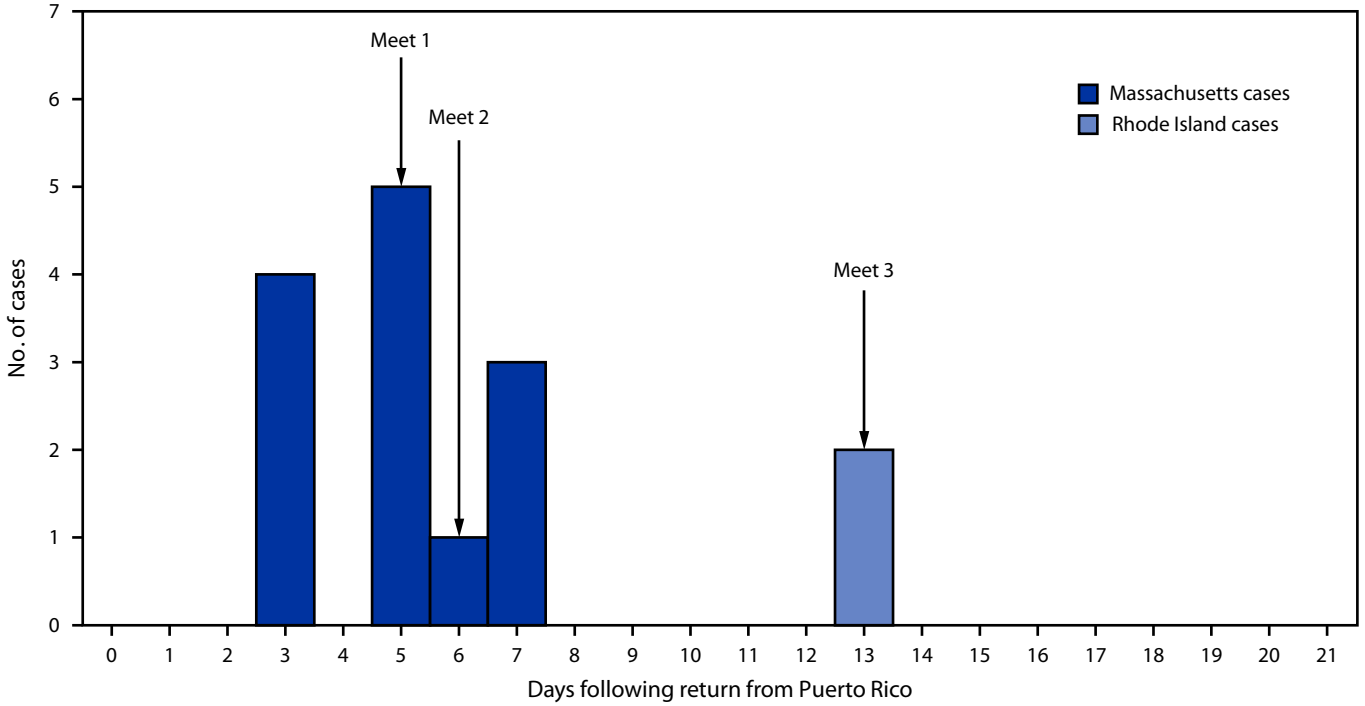
† CDC hyperchlorination recommendations in the Model Aquatic Health Code (MAHC) call for raising the free available chlorine (the active disinfectant form of chlorine) for a prolonged period to achieve 3-$\log_{10}$ (99.9%) *Cryptosporidium* inactivation (e.g., raising the free available chlorine to 20 ppm for 12.75 hours [MAHC 6.5.3.2]). www.cdc.gov/mahc

§ 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.

¶ https://www.cdc.gov/parasites/crypto/gen_info/prevention-general-public.html (Accessed April 11, 2023).

** https://www.cdc.gov/healthywater/swimming/swimmers/rwi/diarrheal-illness.html (Accessed May 26, 2023).

FIGURE. Cryptosporidiosis cases* among competitive collegiate swimmers at three swim meets, by state† (N = 15) — Massachusetts and Rhode Island, 2023



* Confirmed by BioFire FilmArray Gastrointestinal Panel. https://www.biofiredx.com/products/the-filmarray-panels/filmarraygi/
† Thirteen cases in Massachusetts and two in Rhode Island.

Acknowledgments

Alyssa Price, College of the Holy Cross; Patricia Kludt, Massachusetts Department of Public Health.

Corresponding author: Geena Chiumento, geena.m.chiumento@mass.gov.

[1]Massachusetts Department of Public Health; [2]College of the Holy Cross, Worcester, Massachusetts; [3]Worcester Division of Public Health, Central Massachusetts Regional Public Health Alliance, Worcester, Massachusetts; [4]Rhode Island Department of Health; [5]New York State Department of Health; [6]Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging and Zoonotic Infectious Diseases, CDC; [7]Epidemic Intelligence Service, CDC.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Catherine M. Brown reports support from the Council of State and Territorial Epidemiologists (CSTE) to attend the CSTE annual conference, and serving as chair of the CSTE Infectious Diseases Steering Committee and as an unpaid CSTE Board Member-at-Large. No other potential conflicts of interest were disclosed.

References

1. Xiao L. Molecular epidemiology of cryptosporidiosis: an update. Exp Parasitol 2010;124:80–9. PMID:19358845 https://doi.org/10.1016/j.exppara.2009.03.018
2. Hlavsa MC, Roellig DM, Seabolt MH, et al. Using molecular characterization to support investigations of aquatic facility-associated outbreaks of cryptosporidiosis—Alabama, Arizona, and Ohio, 2016. MMWR Morb Mortal Wkly Rep 2017;66:493–7. PMID:28520707 https://doi.org/10.15585/mmwr.mm6619a2
3. Dufour AP, Behymer TD, Cantú R, Magnuson M, Wymer LJ. Ingestion of swimming pool water by recreational swimmers. J Water Health 2017;15:429–37. PMID:28598347 https://doi.org/10.2166/wh.2017.255
4. McCann R, Jones R, Snow J, et al. An outbreak of cryptosporidiosis at a swimming club—can rapid field epidemiology limit the spread of illness? Epidemiol Infect 2014;142:51–5. PMID:23673004 https://doi.org/10.1017/S0950268813001143

Expression of Concern: Timing of Introduction of Complementary Foods — United States, 2016–2018

On May 25, *MMWR* Editors were informed by authors of "Timing of Introduction of Complementary Foods — United States, 2016–2018" (*1*) that there was an overestimation in surveillance data of the proportion of children aged 1–5 years who were introduced early (age <4 months) to complementary foods. A U.S. Census Bureau April 2023 data correction technical document describes a data processing error in the National Survey of Children's Health for data collected during 2016–2021 (*2*). Because of this, the report authors are undertaking a thorough reanalysis using the corrected data. In accordance with December 2017 guidance from the International Committee of Medical Journal Editors (*3*), this Expression of Concern notice is to alert readers that the reanalysis is currently being conducted to correct the estimates and assess the validity of conclusions in the publication. A corrected report will be published in the coming weeks.

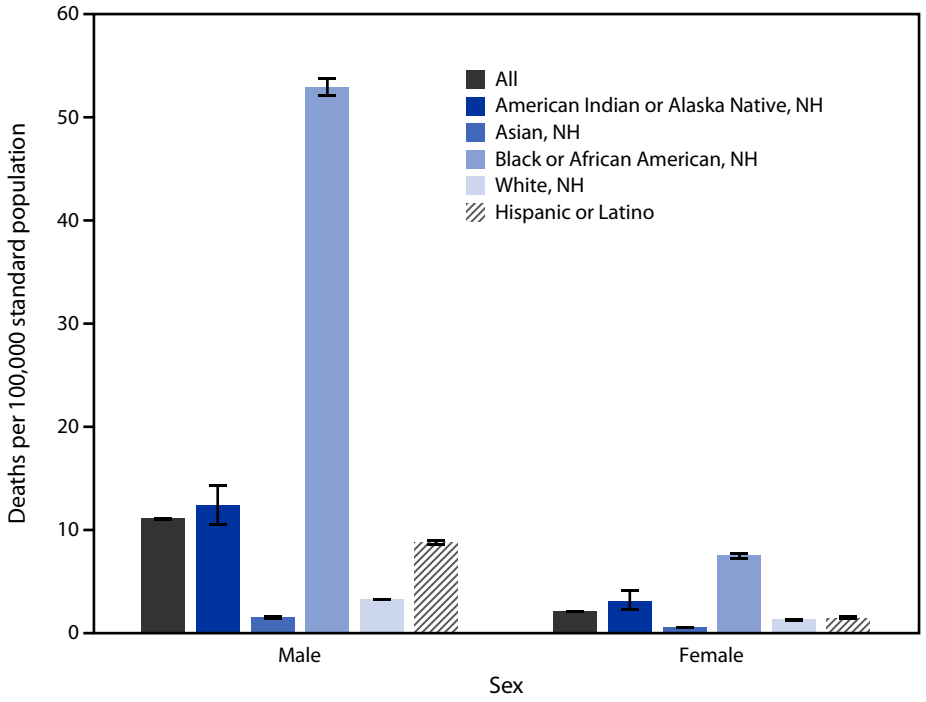
References

1. Chiang KV, Hamner HC, Li R, Perrine CG. Timing of introduction of complementary foods—United States, 2016–2018. MMWR Morb Mortal Wkly Rep 2020;69:1787–91. PMID:33237894 https://doi.org/10.15585/mmwr.mm6947a4
2. US Census Bureau. National Survey of Children's Health: data revision for breastfeeding, formula and solid foods variables. Washington, DC: US Department of Commerce; 2023. https://www2.census.gov/programs-surveys/nsch/technical-documentation/Data_Correction_for_BREASTFEDEND_FRSTFORMULA_and_FRSTSOLIDS.pdf
3. International Committee of Medical Journal Editors. Corrections, retractions, republications and version control. Vancouver, British Columbia: International Committee of Medical Journal Editors; 2017. https://www.icmje.org/recommendations/browse/publishing-and-editorial-issues/corrections-and-version-control.html

QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Age-Adjusted Rates* of Firearm-Related Homicide,† by Race,§ Hispanic Origin, and Sex — National Vital Statistics System, United States, 2021



Abbreviation: NH = non-Hispanic.

* Deaths per 100,000 population are age-adjusted to the 2000 U.S. standard population, with 95% CIs indicated by error bars. In 2021, the age-adjusted rate of firearm-related homicide was 11.1 deaths per 100,000 standard population for males and 2.1 for females.

† Firearm-related homicides were identified using *International Classification of Diseases, Tenth Revision* underlying cause-of-death codes U01.4 and X93–X95.

§ Race groups are non-Hispanic; persons of Hispanic origin can be of any race. Native Hawaiian or other Pacific Islander persons are not shown separately because of small numbers. All includes all race and Hispanic origin groups including those not shown. Death rates for Asian, American Indian or Alaska Native, and Hispanic or Latino (Hispanic) persons might be affected by misclassification of race and Hispanic origin on death certificates. https://www.cdc.gov/nchs/data/series/sr_02/sr02_172.pdf

In 2021, among males, Black or African American (Black) males had the highest age-adjusted rate of firearm-related homicide (52.9 deaths per 100,000 standard population), and Asian males had the lowest rate (1.5). Among females, Black females had the highest rate (7.5), and Asian females had the lowest rate (0.5). Males had higher rates than females across all race and Hispanic origin groups.

Source: National Center for Health Statistics, National Vital Statistics System, Mortality Data, 2021. https://www.cdc.gov/nchs/nvss/deaths.htm

Reported by: Matthew F. Garnett, MPH, Mgarnett@cdc.gov; Merianne R. Spencer MPH.

For more information on this topic, CDC recommends the following link: https://www.cdc.gov/vitalsigns/firearm-deaths/index.html

The *Morbidity and Mortality Weekly Report (MMWR)* Series is prepared by the Centers for Disease Control and Prevention (CDC) and is available free of charge in electronic format. To receive an electronic copy each week, visit *MMWR* at *https://www.cdc.gov/mmwr/index.html*.

Readers who have difficulty accessing this PDF file may access the HTML file at https://www.cdc.gov/mmwr/index2023.html. Address all inquiries about the *MMWR* Series to Editor-in-Chief, *MMWR* Series, Mailstop V25-5, CDC, 1600 Clifton Rd., N.E., Atlanta, GA 30329-4027 or to mmwrq@cdc.gov.

ISSN: 0149-2195 (Print)