Centers for Disease Control and Prevention
MMWR
Morbidity and Mortality Weekly Report
Weekly / Vol. 72 / No. 34
August 25, 2023

West Nile Virus and Other Nationally Notifiable Arboviral Diseases — United States, 2021

Anna C. Fagre, DVM, PhD[1,2]; Shelby Lyons, MPH[1]; J. Erin Staples, MD, PhD[1]; Nicole Lindsey, MS[1]

Abstract

Arthropod-borne viruses (arboviruses) are transmitted to humans primarily through the bites of infected mosquitoes or ticks, and in the continental United States, West Nile virus (WNV) is the leading cause of domestically acquired arboviral disease. Other arboviruses cause sporadic cases of disease as well as occasional outbreaks. This report summarizes 2021 surveillance data reported to CDC by U.S. jurisdictions for nationally notifiable arboviruses; the report excludes chikungunya, dengue, yellow fever, and Zika virus disease cases, because these infections were acquired primarily through travel during 2021. Forty-nine states and the District of Columbia reported 3,035 cases of domestic arboviral disease, including those caused by West Nile (2,911), La Crosse (40), Jamestown Canyon (32), Powassan (24), St. Louis encephalitis (17), unspecified California serogroup (six), and eastern equine encephalitis (five) viruses. Among the WNV disease cases, 2,008 (69%) were classified as neuroinvasive disease, for a national incidence of 0.61 cases per 100,000 population. Because arboviral diseases continue to cause serious illness, maintaining surveillance programs to monitor their transmission and prevalence is important to the direction and promotion of prevention activities. Health care providers should consider arboviral infections in the differential diagnosis of aseptic meningitis and encephalitis, obtain appropriate specimens for laboratory testing, and promptly report cases to public health authorities. Prevention depends on community and household efforts to reduce vector populations and personal protective measures to prevent mosquito and tick bites, such as use of Environmental Protection Agency–registered insect repellent and wearing protective clothing.

Introduction

Within the continental United States, West Nile virus (WNV) is the leading cause of domestically acquired disease caused by arthropod-borne viruses (arboviruses) (*1*). Arboviruses are maintained in transmission cycles between arthropods and vertebrate hosts, including humans and other animals (*2*). Humans primarily become infected when they are bitten by an infected tick or mosquito. Whereas most human infections are asymptomatic, symptomatic infections commonly manifest as a systemic febrile illness and less commonly as neuroinvasive disease.

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

Methods

Most domestic arboviral diseases are nationally notifiable and reported by state health departments to CDC through the national arboviral surveillance system (ArboNET) using standard surveillance case definitions that include clinical and laboratory criteria.* Confirmed† and probable§ cases are included in this analysis. Cases reported as meningitis, encephalitis, acute flaccid paralysis, or other neurologic illnesses are classified as neuroinvasive disease; the remainder are considered nonneuroinvasive disease. Incidence was calculated using neuroinvasive disease cases and the U.S. Census Bureau's 2021 midyear population estimates.¶ All statistical analyses were conducted using SAS software (version 9.4; SAS Institute). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.**

* https://ndc.services.cdc.gov/case-definitions/arboviral-diseases-neuroinvasive-and-non-neuroinvasive-2015

† A confirmed case meets clinical criteria for arboviral disease and has one or more of the following laboratory criteria: 1) isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, cerebrospinal fluid (CSF), or other body fluid, 2) a more than fourfold change in virus-specific quantitative antibody titers in paired sera, 3) virus-specific immunoglobulin (Ig)M antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, or 4) virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic in the region where exposure occurred.

§ A probable case meets clinical criteria for arboviral infection and virus-specific IgM antibodies in CSF or serum but with no other testing.

¶ https://www.census.gov/programs-surveys/popest.html

** 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.

Results

In 2021, a total of 3,035 domestic arboviral disease cases were reported to CDC. Among these, 2,113 (70%) were neuroinvasive. Cases were caused by the following viruses: WNV (2,911 cases; 96%), La Crosse (40; 1%), Jamestown Canyon (32; 1%), Powassan (24; 1%), St. Louis encephalitis (17; 1%), unspecified California serogroup (six; <1% [exact virus unknown]), and eastern equine encephalitis (five; <1%). Except for Hawaii, cases were reported from all states and the District of Columbia. Among the 3,143 U.S. counties, 500 (16%) reported at least one case of arboviral disease.

West Nile Virus Disease

Cases of WNV disease were reported from 432 counties in 49 states and the District of Columbia. Most (71%) patients had illness onset during July–September (Table 1). The median patient age was 65 years (IQR = 52–74 years), and 1,739 (60%) were male. A total of 2,099 (72%) patients were hospitalized, and 227 (8%) died. The median age of patients who died was 75 years (IQR = 68–82 years).

Among the 2,008 WNV neuroinvasive disease cases, 1,276 (64%) were reported as encephalitis, 602 (30%) as meningitis, 42 (2%) as acute flaccid paralysis, and 88 (4%) as unspecified neurologic illness. Twelve (29%) of the 42 patients with acute flaccid paralysis also had encephalitis or meningitis. Most patients with neuroinvasive disease (1,907; 95%) were hospitalized and 225 (11%) died. Nationally, the incidence of

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].

TABLE 1. Number and percentage of reported cases of nonneuroinvasive and neuroinvasive West Nile virus and other arboviral diseases, by virus type and selected patient characteristics — United States, 2021*

Characteristic	Virus type, no. of cases (%)					
	West Nile (n = 2,911)	La Crosse (n = 40)	Jamestown Canyon (n = 32)	Powassan (n = 24)	St. Louis encephalitis (n = 17)	Eastern equine encephalitis (n = 5)
Age group, yrs						
<18	38 (1)	35 (88)	1 (3)	3 (13)	0 (—)	0 (—)
18–59	1,055 (36)	3 (8)	16 (50)	5 (21)	2 (12)	2 (40)
≥60	1,817 (62)	2 (5)	15 (47)	16 (67)	15 (88)	3 (60)
Unknown	1 (<1)	0 (—)	0 (—)	0 (—)	0 (—)	0 (—)
Median age (IQR)	65 (52–74)	6 (5–11)	59 (41–71)	68 (48–75)	73 (63–76)	61 (57–61)
Sex						
Female	1,172 (40)	12 (30)	6 (19)	11 (46)	4 (24)	3 (60)
Male	1,739 (60)	28 (70)	26 (81)	13 (54)	13 (76)	2 (40)
Period of illness onset						
Jan–Mar	5 (<1)	1 (3)	0 (—)	0 (—)	0 (—)	0 (—)
Apr–Jun	34 (1)	5 (13)	9 (28)	13 (54)	0 (—)	0 (—)
Jul–Sep	2,067 (71)	32 (80)	18 (56)	5 (21)	6 (35)	3 (60)
Oct–Dec	705 (24)	2 (5)	5 (16)	6 (25)	11 (65)	2 (40)
Unknown	100 (3)	0 (—)	0 (—)	0 (—)	0 (—)	0 (—)
Clinical syndrome						
Nonneuroinvasive	903 (31)	1 (3)	11 (34)	1 (4)	6 (35)	0 (—)
Neuroinvasive	2,008 (69)	39 (98)	21 (66)	23 (96)	11 (65)	5 (100)
Encephalitis†	1,276 (64)	31 (78)	13 (41)	12 (50)	7 (41)	5 (100)
Meningitis†	602 (30)	8 (20)	4 (13)	8 (33)	4 (24)	0 (—)
AFP†,§	42 (2)	0 (—)	1 (3)	3 (13)	0 (—)	0 (—)
Unspecified†	88 (4)	0 (—)	3 (9)	0 (—)	0 (—)	0 (—)
Outcome						
Hospitalization	2,099 (72)	40 (100)	24 (75)	22 (92)	15 (88)	5 (100)
Death	227 (8)	0 (—)	2 (6)	3 (13)	0 (—)	2 (40)

Abbreviation: AFP = acute flaccid paralysis.
* Six unspecified California serogroup virus cases were also reported.
† Percentages of case of encephalitis, meningitis, AFP, and unspecified neurologic signs or symptoms are percentages of neuroinvasive cases.
§ Among the 42 West Nile virus disease cases with AFP, 12 (29%) also had encephalitis or meningitis.

neuroinvasive WNV disease was 0.61 per 100,000 population (Table 2), and the proportion of cases classified as neuroinvasive in 2021 (69%) was higher than the average proportion of cases classified as neuroinvasive during 2010–2020 (63%).††

Arizona reported the largest number of neuroinvasive cases (1,140) and the highest incidence of WNV neuroinvasive disease (15.7 per 100,000 population). Three counties in Arizona (Maricopa, Pima, and Pinal) accounted for >50% of WNV neuroinvasive disease cases nationwide. Jurisdictions with the next highest numbers of WNV disease cases were Texas (130), Colorado (101), California (96), and Nebraska (69). Incidence of neuroinvasive WNV disease was highest in several states within the Mountain and West North Central U.S. Census Bureau divisions§§ (Figure). Incidence increased with age, from 0.02 per 100,000 population among children aged <10 years to 2.4 among adults aged ≥70 years. Incidence was 60% higher overall among males (0.8) than among females (0.5).

†† Calculated based on publicly available historic ArboNet data (1999–2022). https://www.cdc.gov/westnile/statsmaps/historic-data.html
§§ https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf

La Crosse Virus Disease

Forty La Crosse virus disease cases were reported from eight jurisdictions. Jurisdictions with the highest neuroinvasive disease incidence included Ohio (0.14 per 100,000 population), Tennessee (0.10), and North Carolina (0.09) (Table 2). The median patient age was 6 years (IQR = 5–11 years), and 35 (88%) cases occurred among persons aged <18 years (Table 1). Most patients (80%) had illness onset during July–September. All 40 patients were hospitalized, and 98% had neuroinvasive disease; no deaths were reported.

Jamestown Canyon Virus Disease

Thirty-two Jamestown Canyon virus disease cases were reported from eight jurisdictions. Jurisdictions with the highest neuroinvasive disease incidence included New Hampshire (0.29 per 100,000 population) and Rhode Island (0.09) (Table 2). In 2021, Jamestown Canyon virus disease was reported from Indiana for the first time. The median patient age was 59 years (IQR = 41–71), and 26 (81%) patients were male (Table 1). Illness onset occurred during April–November,

TABLE 2. Number and rate* of reported cases of arboviral neuroinvasive disease, by virus type and U.S. Census Bureau division and jurisdiction — United States, 2021

U.S. Census Bureau division/ Jurisdiction	Neuroinvasive disease cases, by virus type, no. (incidence)*					
	West Nile	La Crosse	Jamestown Canyon	Powassan	St. Louis encephalitis	Eastern equine encephalitis
United States	**2,008 (0.61)**	**39 (<0.01)**	**21 (<0.01)**	**23 (<0.01)**	**11 (<0.01)**	**5 (<0.01)**
New England	**17 (0.11)**	—†	**6 (0.04)**	**13 (0.09)**	**—**	**—**
Connecticut	5 (0.14)	—	—	3 (0.08)	—	—
Maine	—	—	1 (0.07)	3 (0.22)	—	—
Massachusetts	9 (0.13)	—	—	6 (0.09)	—	—
New Hampshire	1 (0.07)	—	4 (0.29)	—	—	—
Rhode Island	1 (0.09)	—	1 (0.09)	1 (0.09)	—	—
Vermont	1 (0.15)	—	—	—	—	—
Middle Atlantic	**83 (0.20)**	**—**	**1 (<0.01)**	**2 (<0.01)**	**—**	**—**
New Jersey	26 (0.28)	—	1 (0.01)	—	—	—
New York	35 (0.18)	—	—	2 (0.01)	—	—
Pennsylvania	22 (0.17)	—	—	—	—	—
East North Central	**116 (0.25)**	**22 (0.05)**	**10 (0.02)**	**3 (<0.01)**	**—**	**2 (<0.01)**
Illinois	49 (0.39)	1 (<0.01)	—	—	—	—
Indiana	11 (0.16)	1 (0.01)	1 (0.01)	—	—	—
Michigan	38 (0.38)	1 (<0.01)	5 (0.05)	—	—	1 (<0.01)
Ohio	11 (0.09)	17 (0.14)	—	1 (<0.01)	—	—
Wisconsin	7 (0.12)	2 (0.03)	4 (0.07)	2 (0.03)	—	1 (0.02)
West North Central	**151 (0.70)**	**—**	**4 (0.02)**	**5 (0.02)**	**—**	**—**
Iowa	4 (0.13)	—	—	—	—	—
Kansas	10 (0.34)	—	—	—	—	—
Minnesota	27 (0.47)	—	4 (0.07)	5 (0.09)	—	—
Missouri	11 (0.18)	—	—	—	—	—
Nebraska	69 (3.51)	—	—	—	—	—
North Dakota	12 (1.55)	—	—	—	—	—
South Dakota	18 (2.01)	—	—	—	—	—
South Atlantic	**38 (0.06)**	**10 (0.02)**	**—**	**—**	**—**	**3 (<0.01)**
Delaware	3 (0.30)	—	—	—	—	—
District of Columbia	4 (0.60)	—	—	—	—	—
Florida	5 (0.02)	—	—	—	—	—
Georgia	3 (0.03)	—	—	—	—	2 (0.02)
Maryland	7 (0.11)	—	—	—	—	—
North Carolina	8 (0.08)	9 (0.09)	—	—	—	1 (<0.01)
South Carolina	6 (0.12)	—	—	—	—	—
Virginia	2 (0.02)	—	—	—	—	—
West Virginia	—	1 (0.06)	—	—	—	—
East South Central	**21 (0.11)**	**7 (0.04)**	**—**	**—**	**—**	**—**
Alabama	9 (0.18)	—	—	—	—	—
Kentucky	4 (0.09)	—	—	—	—	—
Mississippi	5 (0.17)	—	—	—	—	—
Tennessee	3 (0.04)	7 (0.10)	—	—	—	—
West South Central	**172 (0.42)**	**—**	**—**	**—**	**1 (<0.01)**	**—**
Arkansas	6 (0.20)	—	—	—	—	—
Louisiana	17 (0.37)	—	—	—	1 (0.02	—
Oklahoma	19 (0.48)	—	—	—	—	—
Texas	130 (0.44)	—	—	—	—	—
Mountain	**1,308 (5.18)**	**—**	**—**	**—**	**6 (0.02)**	**—**
Arizona	1,140 (15.67)	—	—	—	6 (0.08)	—
Colorado	101 (1.74)	—	—	—	—	—
Idaho	12 (0.63)	—	—	—	—	—
Montana	2 (0.18)	—	—	—	—	—
Nevada	1 (0.03)	—	—	—	—	—
New Mexico	31 (1.47)	—	—	—	—	—
Utah	21 (0.63)	—	—	—	—	—
Wyoming	—	—	—	—	—	—
Pacific	**102 (0.19)**	**—**	**—**	**—**	**4 (<0.01)**	**—**
Alaska	1 (0.14)	—	—	—	—	—
California	96 (0.24)	—	—	—	4 (0.01)	—
Hawaii	—	—	—	—	—	—
Oregon	1 (0.02)	—	—	—	—	—
Washington	4 (0.05)	—	—	—	—	—

* Cases per 100,000 population, based on July 1, 2021, U.S. Census Bureau population estimates.
† Dashes indicate no cases were reported.

Summary

What is already known about this topic?

West Nile virus (WNV), transmitted primarily through mosquitos, is the leading cause of arboviral disease in the continental United States, but other arboviruses cause sporadic cases of neuroinvasive disease.

What is added by this report?

Arizona experienced a significant WNV outbreak in 2021, with three counties reporting more than 50% of all reported WNV cases nationwide. Nationally, the rate of WNV neuroinvasive disease (0.61 per 100,000 population) surpassed the median rate during 2010–2020 (0.39) and was the highest since 2012.

What are the implications for public health practice?

Health care providers should consider arboviral infections in the differential diagnosis of aseptic meningitis and encephalitis, obtain appropriate specimens for laboratory testing, and promptly report cases to public health authorities.

with 18 (56%) patients reporting onset during July–September. Twenty-one (66%) cases were neuroinvasive, and 24 (75%) patients were hospitalized. Two (6%) patients died, both of whom were aged >60 years.

Powassan Virus Disease

Twenty-four Powassan virus disease cases were reported from eight jurisdictions, with highest neuroinvasive disease incidence in the New England (0.09 per 100,000 population) and West North Central (0.02) (Table 2) U.S. Census Bureau divisions. Powassan virus disease was reported for the first time from Ohio. The median patient age was 68 years (IQR = 48–75) and 13 (54%) were male (Table 1). Illness onset dates occurred during April–November, with 13 (54%) reporting onset during April–June. Twenty-three (96%) cases were neuroinvasive, and 22 (92%) patients were hospitalized. Three (13%) patients died, including two who were aged >60 years.

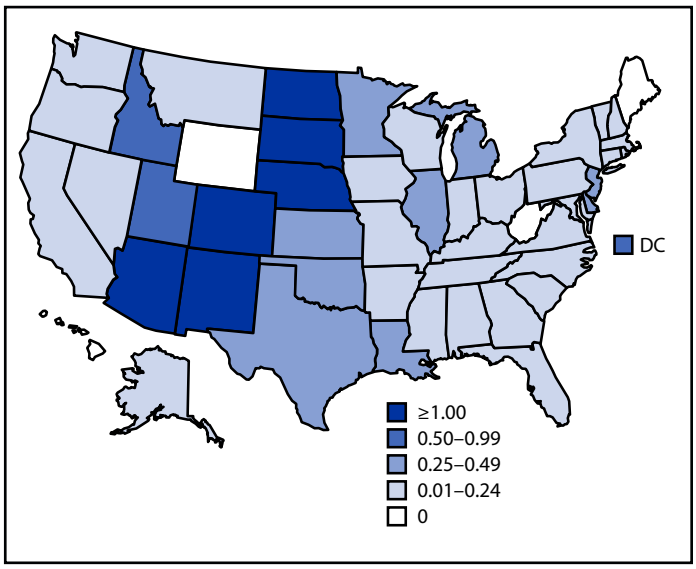
St. Louis Encephalitis Virus Disease

Seventeen cases of St. Louis encephalitis virus disease were reported from three states: Arizona (12), California (four), and Louisiana (one) (Table 1). Eleven (65%) cases were neuroinvasive (Table 2). Among all cases, the median patient age was 73 years (IQR = 63–76 years), and 13 (76%) were male (Table 1). Illness onset dates occurred during August–November, with 11 (65%) patients reporting onset during October–December. Fifteen (88%) patients were hospitalized, and none died.

Eastern Equine Encephalitis Virus Disease

Five cases of eastern equine encephalitis virus disease were reported from four states: Georgia (two), Michigan (one), North Carolina (one), and Wisconsin (one) (Table 2). The median patient age was 61 years (IQR = 57–61 years), and two (40%) were male. Illness onset dates occurred during July–October. All cases were neuroinvasive and resulted in hospitalization. Two (40%) patients died; both were aged <60 years.

FIGURE. Incidence* of reported cases of West Nile virus neuroinvasive disease — United States, 2021



Abbreviation: DC = District of Columbia.
* Cases per 100,000 population based on July 1, 2021, U.S. Census Bureau population estimates.

Discussion

As in previous years, WNV was the most common cause of neuroinvasive arboviral disease in the United States in 2021, accounting for 95% of reported neuroinvasive arboviral disease cases. The incidence of WNV neuroinvasive disease (0.61 per 100,000 population) surpassed the median during 2010–2020 (0.39) and was the highest since 2012 (0.92) (*3*,*4*). This increase was largely driven by a significant outbreak in Arizona (1,140 cases; 57% of all U.S. cases)[¶¶] (*5*), concentrated in Maricopa, Pinal, and Pima counties. Compared with previous years, the outbreak occurred later in the year, increasing the proportion of patients with illness onset during October–December. Reasons for the outbreak likely included late-season rain, recent population growth and housing development, and low levels of WNV circulation during the preceding year (*1*,*5*).

La Crosse virus continued to be the most common cause of neuroinvasive arboviral disease in children. In 2021, Jamestown Canyon virus was reported for the first time in Indiana, and Powassan virus was reported for the first time in Ohio (*6*,*7*). Detection of these viruses in new jurisdictions is likely caused by an increase in awareness and testing but could also reflect geographic expansion of these pathogens.

[¶¶] https://www.cdc.gov/westnile/statsmaps/cumMapsData.html

Although case numbers vary by year, virus, and geographic area, arboviruses continue to cause substantial morbidity in the United States. Weather, zoonotic host and vector abundance, and human behavior are all factors that can influence when and where outbreaks occur. This complexity makes it difficult to predict future locations and timing of cases and underscores the importance of surveillance to identify outbreaks quickly to direct public health prevention efforts.

Limitations

The findings in this report are subject to at least two limitations. First, because ArboNET does not require information about clinical signs and symptoms or laboratory findings, cases might be misclassified. Second, ArboNET is a passive surveillance system that only collects cases that are diagnosed and reported, resulting in underestimation of the actual incidence of disease. The COVID-19 pandemic likely exacerbated this trend (*8*); the percentage of cases classified as neuroinvasive disease during 2021 (69%) was higher than that reported during 2010–2020 (63%), indicating an underreporting of febrile disease cases. Previous studies have estimated that 30–70 nonneuroinvasive disease cases occur for every reported case of WNV neuroinvasive disease (*9*). On the basis of the number of neuroinvasive disease cases reported in 2021, it is likely that 60,240–140,560 nonneuroinvasive disease cases of WNV occurred; however, only 903 (1%–2%) were reported.

Implications for Public Health Practice

Understanding the epidemiology, seasonality, and geographic distribution of these viruses aids in clinical recognition and differentiation from other neurologic infections and guides vector control and community messaging efforts. Because there are no specific treatments for arboviral diseases, and human vaccines against domestic arboviruses are not available, prevention depends on community and household efforts to reduce vector populations,*** personal protective measures to decrease exposure to mosquitoes††† and ticks,§§§ and blood donor screening.¶¶¶ Health care providers should consider arboviral infections in the differential diagnosis of aseptic meningitis and encephalitis, obtain appropriate specimens for laboratory testing, and promptly report cases to public health authorities, particularly during the summer months when most infections occur (*1*,*3*).

*** https://www.cdc.gov/mosquitoes/mosquito-control/index.html
††† https://www.cdc.gov/mosquitoes/mosquito-bites/prevent-mosquito-bites.html
§§§ https://www.cdc.gov/ticks/tickbornediseases/tick-bites-prevention.html
¶¶¶ https://www.cdc.gov/bloodsafety/basics.html

Acknowledgments

National Arboviral Surveillance System surveillance coordinators in state and local health departments; Surveillance and Epidemiology Team, Arboviral Diseases Branch, CDC.

Corresponding author: Nicole Lindsey, frd3@cdc.gov.

[1]Division of Vector-Borne Diseases, National Center for Emerging and Zoonotic Infectious Diseases, CDC; [2]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. No potential conflicts of interest were disclosed.

References

1. Soto RA, Hughes ML, Staples JE, Lindsey NP. West Nile virus and other domestic nationally notifiable arboviral diseases—United States, 2020. MMWR Morb Mortal Wkly Rep 2022;71:628–32. PMID:35511710 https://doi.org/10.15585/mmwr.mm7118a3
2. American Academy of Pediatrics. Arboviruses. In: Kimberlin DW, Brady MT, Jackson MA, Long SS, eds. Red Book: 2018 report of the Committee on Infectious Diseases. 31st ed. Elk Grove Village, IL: American Academy of Pediatrics; 2018:220–7. https://doi.org/10.1542/9781610021470-part03-arboviruses
3. McDonald E, Mathis S, Martin SW, Erin Staples J, Fischer M, Lindsey NP. Surveillance for West Nile virus disease—United States, 2009–2018. Am J Transplant 2021;21:1959–74. PMID:33939278 https://doi.org/10.1111/ajt.16595
4. CDC. West Nile virus and other arboviral diseases—United States, 2012. MMWR Morb Mortal Wkly Rep 2013;62:513–7. PMID:23803959
5. Kretschmer M, Ruberto I, Townsend J, et al. Unprecedented outbreak of West Nile virus—Maricopa County, Arizona, 2021. MMWR Morb Mortal Wkly Rep 2023;72:452–7. PMID:37104168 https://doi.org/10.15585/mmwr.mm7217a1
6. CDC. Powassan virus: data and maps. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://www.cdc.gov/powassan/statistics.html
7. CDC. Jamestown Canyon virus: data and maps. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://www.cdc.gov/jamestown-canyon/statistics/index.html
8. McCormick DW, Kugeler KJ, Marx GE, et al. Effects of COVID-19 pandemic on reported Lyme disease, United States, 2020. Emerg Infect Dis 2021;27:2715–7. PMID:34545801 https://doi.org/10.3201/eid2710.210903
9. Petersen LR, Carson PJ, Biggerstaff BJ, Custer B, Borchardt SM, Busch MP. Estimated cumulative incidence of West Nile virus infection in US adults, 1999–2010. Epidemiol Infect 2013;141:591–5. PMID:22640592 https://doi.org/10.1017/s0950268812001070

Sepsis Program Activities in Acute Care Hospitals — National Healthcare Safety Network, United States, 2022

Raymund B. Dantes, MD[1,2]; Hemjot Kaur, MPH[2]; Beth A. Bouwkamp, MPH[2,3]; Kathryn A. Haass, MPH[2]; Prachi Patel, MPH[2]; Margaret A. Dudeck, MPH[2]; Arjun Srinivasan, MD[2]; Shelley S. Magill, MD, PhD[2]; W. Wyatt Wilson, MD[1,2]; Mary Whitaker, MSN[2]; Nicole M. Gladden[2]; Elizabeth S. McLaughlin[4]; Jennifer K. Horowitz[4]; Patricia J. Posa, MSA[5]; Hallie C. Prescott, MD[4]

Abstract

Sepsis, life-threatening organ dysfunction secondary to infection, contributes to at least 1.7 million adult hospitalizations and at least 350,000 deaths annually in the United States. Sepsis care is complex, requiring the coordination of multiple hospital departments and disciplines. Sepsis programs can coordinate these efforts to optimize patient outcomes. The 2022 National Healthcare Safety Network (NHSN) annual survey evaluated the prevalence and characteristics of sepsis programs in acute care hospitals. Among 5,221 hospitals, 3,787 (73%) reported having a committee that monitors and reviews sepsis care. Prevalence of these committees varied by hospital size, ranging from 53% among hospitals with 0–25 beds to 95% among hospitals with >500 beds. Fifty-five percent of all hospitals provided dedicated time (including assigned protected time or job description requirements) for leaders of these committees to manage a program and conduct daily activities, and 55% of committees reported involvement with antibiotic stewardship programs. These data highlight opportunities, particularly in smaller hospitals, to improve the care and outcomes of patients with sepsis in the United States by ensuring that all hospitals have sepsis programs with protected time for program leaders, engagement of medical specialists, and integration with antimicrobial stewardship programs. CDC's Hospital Sepsis Program Core Elements provides a guide to assist hospitals in developing and implementing effective sepsis programs that complement and facilitate the implementation of existing clinical guidelines and improve patient care. Future NHSN annual surveys will monitor uptake of these sepsis core elements.

Introduction

Sepsis, life-threatening organ dysfunction secondary to infection (*1*), contributes to at least 1.7 million adult hospitalizations and at least 350,000 deaths annually in the United States (*2*). Hospital quality improvement programs focused on sepsis have been associated with reductions in mortality, length of stay, and health care costs (*3*,*4*). In 2023, CDC has published the new Hospital Sepsis Program Core Elements (*5*) (Sepsis Core Elements), a guide to help hospitals develop multiprofessional programs to monitor and optimize early identification, management, and outcomes of sepsis.

CDC's National Healthcare Safety Network (NHSN)* is the nation's most widely used surveillance system for tracking patient and health care personnel safety measures, such as prevention of health care–associated infections. Hospitals reporting data to NHSN are required to complete an annual survey with questions regarding patient volume, laboratory practices, patient safety practices, and facility characteristics used in risk adjustment for quality measures.† Questions regarding hospital sepsis program practices were added to the 2022 NHSN annual survey to evaluate baseline practices.

Methods

All U.S. hospitals (approximately 6,129) are eligible to enroll in NHSN (*6*). Enrolled hospitals were required to complete the 2022 NHSN Patient Safety Component Annual Hospital Survey by March 1, 2023. Hospital staff members completed the survey electronically, on the basis of hospital practices during 2022, using the NHSN web-based application. Responses were provided to four required questions and to three additional required questions, conditional upon responses to the initial questions. The first question asked about the presence of a committee that monitors and reviews sepsis care and outcomes (sepsis committees), followed by three conditional questions regarding the functions of and staff member representation on the committee. The following three questions asked about leadership support for sepsis-related activities, approaches to rapid sepsis identification, and sepsis management protocols. Survey respondents were instructed to consult with persons leading sepsis efforts or other local expertise as needed to accurately complete the survey. Descriptive analysis, stratified by hospital size (number of beds), was completed on a data set generated on June 1, 2023, using SAS (version 9.4; SAS Institute). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.§

* https://www.cdc.gov/nhsn/about-nhsn/index.html
† https://www.cdc.gov/nhsn/forms/57.103_pshospsurv_blank.pdf
§ 45 C.F.R. part 46, 21C.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.

Results

As of June 1, 2023, among 5,397 hospitals enrolled in the NHSN Patient Safety Component, 5,228 had completed the survey. Seven surveys were excluded because of incomplete responses, which resulted in inclusion of 5,221 hospitals in the analysis (97% completion rate) (Table 1). Among these hospitals, 3,787 (73%) reported having a sepsis committee. These committees were least common in hospitals with 0–25 beds (53%), and progressively more prevalent as hospital size increased (Table 2). Antimicrobial stewardship and infectious disease representatives were integrated into 55% and 45% of sepsis committees, respectively. Monitoring and review of antimicrobial use in sepsis care was reported for 61% of sepsis committees.

Approximately one half (55%) of all hospitals (range = 35% [0–25 beds] to 78% [>500 beds]) reported that hospital leadership provided leaders of committees supervising sepsis activities with dedicated time as required to lead these activities as part of their job description or granted or assigned protected time from their other clinical or other job responsibilities to dedicate to sepsis activities (Table 3). Other indications of leadership support for hospital sepsis programs, such as data analytic or information technology resources, were reported more commonly by larger hospitals.

TABLE 1. Hospitals completing annual survey — Patient Safety Component, Annual Hospital Survey, National Healthcare Safety Network, United States, 2022

Hospital size, no. of beds	No. (%) of hospitals*
0–25	1,580 (30)
26–50	618 (12)
51–100	703 (13)
101–250	1,301 (25)
251–500	759 (15)
>501	260 (5)
Total	**5,221 (100)**

* Among 5,397 National Healthcare Safety Network–enrolled hospitals (overall 97% completion rate).

TABLE 2. Sepsis committee utilization, responsibilities, and representation in acute care hospitals — Patient Safety Component, Annual Hospital Survey, National Healthcare Safety Network, United States, 2022

	% of facilities responding						
		Hospital size, no. of beds					
Survey questions and responses	All hospitals N = 5,221	0–25 n = 1,580	26–50 n = 618	51–100 n = 703	101–250 n = 1,301	251–500 n = 759	>501 n = 260
Total, %	**100**	**30**	**12**	**13**	**25**	**15**	**5**
Our facility has a committee charged with monitoring and reviewing sepsis care and/or outcomes,* no. (%)	**3,787 (73)**	831 (53)	409 (66)	542 (77)	1,088 (84)	671 (88)	246 (95)
Responsibilities of this committee, % of facilities†,§,¶							
Monitor and review compliance with CMS SEP-1 measure	**84**	77	85	86	87	85	83
Monitor and review effectiveness of early sepsis identification strategies	**82**	77	77	82	85	86	87
Update sepsis identification and management protocols based on current evidence	**81**	77	78	80	84	85	84
Monitor and review outcomes among patients with sepsis	**81**	78	79	81	83	85	82
Develop educational materials for facility staff to improve sepsis care	**79**	72	75	79	82	84	83
Monitor and review antimicrobial use in sepsis care	**61**	59	56	58	64	65	62
Hospital location or service representation of this committee, % of facilities†,§,¶							
Emergency department	**85**	83	80	84	87	90	86
Hospital medicine	**76**	73	71	77	78	81	75
Neonatal intensive care	**6**	2	2	6	7	12	13
Critical care or intensive care	**65**	31	57	72	78	80	83
Labor and delivery	**17**	11	18	18	17	22	23
Pediatrics	**11**	7	9	10	9	16	20
Infectious disease	**45**	39	42	40	48	49	52
Antimicrobial stewardship	**55**	61	46	52	55	54	54
Infectious disease or antimicrobial stewardship**	**65**	69	60	61	65	65	64
Pharmacy	**71**	73	65	70	72	73	68
Laboratory	**55**	55	50	57	59	55	46
Information technology	**41**	28	34	40	45	48	55
Other	**22**	21	22	21	23	22	26

Abbreviation: CMS = Centers for Medicare & Medicaid; SEP-1 = CMS Severe Sepsis and Septic Shock: Management Bundle.

* Required survey question completed by all hospitals that submitted a 2022 Annual Hospital Survey; affirmative responses are shown.

† Conditional required survey question completed by facilities that answered in the affirmative to the required question.

§ Numerator is the number of facilities with a committee that reported a responsibility or type of representation; denominator is the number of facilities with a committee (responded in the affirmative to the required question) (example: 3,180 / 3,787 × 100 = 84%).

¶ Hospitals could select more than one response per question.

** Hospitals that responded with either infectious disease or antimicrobial stewardship representation, or both.

TABLE 3. Sepsis leadership, rapid identification, and management practices in acute care hospitals — Patient Safety Component, Annual Hospital Survey, National Healthcare Safety Network, United States, 2022

Survey questions and responses	% of facilities responding						
		Hospital size, no. of beds					
	All hospitals N = 5,221	0–25 n = 1,580	26–50 n = 618	51–100 n = 703	101–250 n = 1,301	251–500 n = 759	>501 n = 260
Total, %	**100**	**30**	**12**	**13**	**25**	**15**	**5**
Facility leadership has demonstrated commitment to improving sepsis care*,†							
Providing sepsis program leaders dedicated time to manage a sepsis program and conduct daily activities	**55**	35	49	59	65	73	78
Allocating resources (e.g., information technology or data analyst support, training for stewardship team) to support sepsis efforts	**65**	47	56	69	75	83	89
Having a senior executive who serves as a point of contact or champion to help ensure the program has resources and support to accomplish its mission	**60**	40	50	62	71	79	85
Presenting information on sepsis activities and outcomes to facility leadership and/or board at least annually	**71**	52	65	77	82	88	88
Ensuring the sepsis program has an opportunity to discuss resource needs with facility leadership or board, at least annually	**60**	40	52	62	71	78	83
Communicating to staff members about sepsis activities, via email, newsletters, events, or other avenues	**70**	56	61	75	78	82	83
Providing opportunities for hospital staff training on sepsis protocols	**74**	61	66	78	81	85	87
Ensuring that staff members from key support departments and groups (e.g., information technology and emergency medicine) are contributing to sepsis activities	**70**	49	62	74	80	89	92
None of the above	**12**	20	18	10	7	3	2
Our facility uses the following approaches to assist in the rapid identification of patients with sepsis, % of facilities*,†							
EHR-generated alert based on SIRS criteria	**65**	58	58	65	70	76	75
EHR-generated alert based on qSOFA	**13**	10	14	12	13	17	18
EHR-generated alert based on a predictive model	**33**	21	28	30	39	45	54
EHR-generated alert using other criteria not already specified	**15**	10	11	15	18	21	27
Manual screening (e.g., use of a checklist) using SIRS or similar criteria	**47**	41	48	51	50	49	38
No standardized process	**10**	15	15	9	6	3	1
Other§	**5**	4	5	4	6	6	8
Our facility uses the following approaches to assist in the management of patients with sepsis, % of facilities*,†							
Protocols that help identify and tailor care for patients with septic shock (e.g., vasopressor orders)	**79**	65	73	82	88	90	94
Protocols that prompt the ordering of sepsis diagnostic tests such as blood cultures, lactate, urinalysis, chest radiography, etc.	**85**	76	78	88	91	94	97
Protocols that prompt the ordering of preferred antimicrobial treatment regimens for sepsis or underlying infection types	**77**	64	70	78	84	88	92
Protocols that prompt the ordering of intravenous fluids	**80**	69	75	83	86	89	92
Protocols that prompt the reassessment of resuscitative efforts	**64**	51	60	65	70	74	80
Protocols that are tailored to specific populations (e.g., neonates, pregnant, oncology, or neutropenic patients, etc.)	**34**	21	28	34	40	47	57
Automated systems (e.g., EHR timers, prompts, or dashboards) that facilitate compliance with time sensitive aspects of sepsis care	**46**	32	39	45	53	62	70
No standardized sepsis protocols or automated systems for sepsis care prompting or monitoring	**10**	17	15	9	6	3	1
Other systematic approach§	**4**	4	4	4	4	4	5

Abbreviations: EHR = electronic health record; qSOFA = quick sequential organ failure assessment; SIRS = systemic inflammatory response syndrome.
* Required survey question completed by all hospitals that submitted a 2022 Annual Facility Survey.
† Hospitals could select more than one response per question.
§ This included a free-text option and because of low response rate was not included in analysis.

Hospitals reported using various approaches to rapidly identify patients with sepsis; the most frequent (65%) was electronic health record–generated alerts based on systemic inflammatory response syndrome criteria (*7*), followed by manual screening (47%), and predictive models (33%). Ten percent of hospitals reported having no standardized process for assisting with rapid sepsis identification. Having no standardized process was more common in hospitals with 0–25 beds (15%) than in hospitals with >500 beds (1%).

Hospitals frequently reported the existence of protocols to assist in the management of sepsis care, including those that prompt the ordering of diagnostic tests (85%), followed by those that prompt the ordering of intravenous fluids (80%), those that identify and tailor care for septic shock (79%), and those that prompt the ordering of preferred antimicrobials

Summary

What is already known about this topic?

Sepsis is a life-threatening organ dysfunction contributing to at least 350,000 deaths annually in the United States. Sepsis care is complex, requiring multidisciplinary coordination within a hospital.

What is added by this report?

In 2022, 73% of hospitals reported having a sepsis program, ranging from 53% among hospitals with 0–25 beds to 95% among hospitals with >500 beds. Only 55% of all hospitals provide sepsis program leaders with dedicated time to manage a sepsis program and conduct daily activities.

What are the implications for public health practice?

Opportunities exist to increase institutional support and improve the structure of hospital-based sepsis programs, which is the focus of CDC's Hospital Sepsis Program Core Elements.

for sepsis or underlying infection (77%). Sepsis protocols tailored to specific patient populations were available in one third (34%) of hospitals, ranging from 21% among hospitals with 0–25 beds to 57% among those with >500 beds. Overall, 10% of hospitals reported having no standardized protocol to assist in the management of sepsis care. Having no standardized protocol to assist in the management of sepsis care was more common in hospitals with 0–25 beds (17%) than those with >500 beds (1%).

Discussion

This survey of the majority of U.S. hospitals describes the current state of sepsis programs and identifies potential areas of improvement. Although sepsis committees are present in most hospitals, they occur less frequently in smaller hospitals, which might have access to fewer personnel and specialty resources. Further, just over one half of responding hospitals reported that dedicated time or assigned protected time was provided to sepsis program leadership. This survey highlights opportunities to further improve the institutional support and structure of hospital-based sepsis care.

Sepsis care is complex and requires coordination across multiple clinical disciplines and hospital care locations (e.g., emergency departments, intensive care units, and hospital wards). Evidence-based care guidelines (*8*), along with state-based (e.g., New York State Department of Health Sepsis Regulations)[¶] and federal initiatives (e.g., Centers for Medicare & Medicaid Services Severe Sepsis and Septic Shock: Management Bundle) (*9*) have emphasized the importance of protocols for early sepsis identification and prompt management. This survey demonstrated that most U.S. hospitals report having some tools and protocols for sepsis detection and early management. To achieve further improvements in sepsis care for patients throughout hospitalization and after discharge, CDC has developed Sepsis Core Elements (*5*). Sepsis Core Elements will provide a guide for creating, structuring, and resourcing comprehensive sepsis programs, so that hospitals can provide optimal sepsis care. Sepsis Core Elements are intended as a manager's guide to complement and support the implementation of existing sepsis guidelines.

Sepsis Core Elements was modeled after CDC's Core Elements of Hospital Antibiotic Stewardship Program (ASP),[**] (*5*) which provides a framework for structuring ASPs that lead to improvements in antibiotic prescribing and reductions in length of hospitalization (*10*). In the 2022 NHSN survey, approximately one half of sepsis programs reported involvement of ASPs. This survey also indicated that only 61% of sepsis committees monitor and review antimicrobial use in sepsis care, although these responsibilities might overlap with those of ASPs. Sepsis Core Elements recommends inclusion of ASP personnel on sepsis committees to facilitate rapid and optimized antimicrobial use in sepsis and discontinuation of antibiotics when underlying infection has been ruled out. Coordination and other respective ASP and sepsis program practices will continue to be tracked in future NHSN annual surveys.

Limitations

The findings in this report are subject to at least five limitations. First, the survey is limited to acute care hospitals enrolled in NHSN and might not reflect practices among all U.S. acute care hospitals; however, hospitals enrolled in NHSN represent at least 88% of U.S. acute care hospitals (*5*). Second, although hospitals reported whether specialty services such as pediatrics and labor and delivery were included in sepsis committees, these services are not within the scope of practice at all hospitals, and thus conclusions cannot be made regarding the frequency with which these services might be missing or absent from sepsis committees. Third, although many sepsis committees do not monitor antimicrobial use in sepsis, these responsibilities overlap with those of ASPs. Collaboration among sepsis programs and ASPs is emphasized in Sepsis Core Elements to ensure optimal antimicrobial use in treating sepsis. Fourth, NHSN surveys were self-reported, and answers were not independently confirmed. Finally, this survey did not strictly define criteria for a sepsis program and is subject to respondent interpretation. Sepsis Core Elements defines specific components of sepsis programs that will be tracked in future surveys.

[¶] https://www.health.ny.gov/regulations/public_health_law/section/405/

[**] https://www.cdc.gov/antibiotic-use/core-elements/index.html https://www.health.ny.gov/regulations/public_health_law/section/405/

Implications for Public Health Practice

These data highlight opportunities, particularly in smaller hospitals, to improve the early identification of, care for, and outcomes among patients with sepsis in the United States by ensuring that all hospitals have sepsis programs with protected time for program leaders, engagement of medical specialists, and integration with ASPs. Sepsis Core Elements provides a guide to assist hospitals in developing and implementing effective sepsis programs. Future NHSN annual surveys will monitor implementation of these sepsis core elements.

Corresponding author: Raymund B. Dantes, vic5@cdc.gov.

[1]Department of Medicine, Emory University School of Medicine, Atlanta, Georgia; [2]Division of Healthcare Quality Promotion, National Center for Emerging and Zoonotic Infectious Diseases, CDC; [3]CACI International Inc, Atlanta, Georgia; [4]Department of Internal Medicine, University of Michigan, Ann Arbor, Michigan; [5]Office of the Chief Nurse Officer, Adult Hospitals, University of Michigan, Ann Arbor, Michigan.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Mary Whitaker reported being secretary and board member of the Certification Board for Infection Control Test committee, Georgia Infection Prevention Network; Elizabeth S. McLaughlin reported participation in Blue Cross Blue Shield of Michigan Value Partnership Program and funding support for program management with the Michigan Hospital Medicine Safety Consortium. Patricia J. Posa reported receiving support to attend the American Association of Critical Nurses' National Teaching Institute during 2022 and 2023; Hallie C. Prescott reported receiving honoraria for grand rounds or talks at academic medical centers, conference travel funds to International Sepsis Forum and International Symposium of Intensive Care and Emergency Medicine conferences, serving on data safety monitoring boards unrelated to this manuscript, and serving as co-chair of the Surviving Sepsis Campaign 2021 Adult Guidelines.

References

1. Singer M, Deutschman CS, Seymour CW, et al. The third international consensus definitions for sepsis and septic shock (Sepsis-3). JAMA 2016;315:801–10. PMID:26903338 https://doi.org/10.1001/jama.2016.0287
2. Rhee C, Dantes R, Epstein L, et al.; CDC Prevention Epicenter Program. Incidence and trends of sepsis in US hospitals using clinical vs claims data, 2009–2014. JAMA 2017;318:1241–9. PMID:28903154 https://doi.org/10.1001/jama.2017.13836
3. Afshar M, Arain E, Ye C, et al. Patient outcomes and cost-effectiveness of a sepsis care quality improvement program in a health system. Crit Care Med 2019;47:1371–9. PMID:31306176 https://doi.org/10.1097/CCM.0000000000003919
4. Sreeramoju P, Voy-Hatter K, White C, et al. Results and lessons from a hospital-wide initiative incentivised by delivery system reform to improve infection prevention and sepsis care. BMJ Open Qual 2021;10:e001189. PMID:33547154 https://doi.org/10.1136/bmjoq-2020-001189
5. CDC. Hospital Sepsis Program Core Elements. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://www.cdc.gov/sepsis/core-elements.html
6. American Hospital Association. Fast facts on U.S. hospitals, 2023. Chicago, IL: American Hospital Association; 2023. https://www.aha.org/statistics/fast-facts-us-hospitals
7. Bone RC, Balk RA, Cerra FB, et al.; The ACCP/SCCM Consensus Conference Committee. American College of Chest Physicians/Society of Critical Care Medicine. Definitions for sepsis and organ failure and guidelines for the use of innovative therapies in sepsis. Chest 1992;101:1644–55. PMID:1303622 https://doi.org/10.1378/chest.101.6.1644
8. Dellinger RP, Rhodes A, Evans L, et al. Surviving sepsis campaign: Crit Care Med 2023;51:431–44. PMID:36928012 https://doi.org/10.1097/CCM.0000000000005804
9. Centers for Medicare & Medicaid Services. Sepsis resources. Baltimore, MD: US Department of Health and Human Services, Centers for Medicare & Medicaid Services; 2023. https://qualitynet.cms.gov/inpatient/specifications-manuals/sepsis-resources
10. Davey P, Marwick CA, Scott CL, et al. Interventions to improve antibiotic prescribing practices for hospital inpatients. Cochrane Database Syst Rev 2017;2:CD003543. PMID:28178770 https://doi.org/10.1002/14651858.CD003543.pub4

Vaccination Coverage Among Adolescents Aged 13–17 Years — National Immunization Survey–Teen, United States, 2022

Cassandra Pingali, MPH, MS[1]; David Yankey, PhD[1]; Laurie D. Elam-Evans, PhD[1]; Lauri E. Markowitz, MD[2]; Madeleine R. Valier, MPH[1,3]; Benjamin Fredua, MS[1,4]; Samuel J. Crowe, PhD[5]; Carla L. DeSisto, PhD[2]; Shannon Stokley, DrPH[1]; James A. Singleton, PhD[1]

Abstract

Three vaccines are routinely recommended for adolescents to prevent pertussis, meningococcal disease, and cancers caused by human papillomavirus (HPV). CDC analyzed data from the 2022 National Immunization Survey–Teen for 16,043 adolescents aged 13–17 years to assess vaccination coverage. Birth cohort analyses were conducted to assess trends in vaccination coverage by age 13 years (i.e., before the 13th birthday) and by age 14 years (i.e., before the 14th birthday) among adolescents who were due for routine vaccination before and during the COVID-19 pandemic. Cross-sectional analysis was used to assess coverage estimates among adolescents aged 13–17 years. In 2022, vaccination coverage by age 14 years among adolescents born in 2008 continued to lag that of earlier birth cohorts and varied by sociodemographic factors and access to health care compared with coverage among earlier birth cohorts. Vaccination coverage by age 13 years among adolescents born in 2009 was similar to coverage estimates obtained before the COVID-19 pandemic. Among all adolescents aged 13–17 years, 2022 vaccination coverage levels did not differ from 2021 levels; however, initiation of the HPV vaccination series decreased among those who were insured by Medicaid. Coverage with ≥1 dose of tetanus, diphtheria, and acellular pertussis vaccine and ≥1 dose meningococcal conjugate vaccine was high and stable (around 90%). Providers should review adolescent vaccination records, especially among those born in 2008 and those in populations eligible for the Vaccines for Children program, to ensure adolescents are up to date with all recommended vaccines.

Introduction

In the United States, the Advisory Committee on Immunization Practices (ACIP) recommends that children aged 11–12 years receive tetanus, diphtheria, and acellular pertussis vaccine (Tdap), meningococcal conjugate vaccine (MenACWY), and human papillomavirus (HPV) vaccine (HPV vaccine can be started at age 9 years). A booster dose of MenACWY is recommended at age 16 years, and using shared clinical decision-making, adolescents and young adults aged 16–23 years may also receive serogroup B meningococcal vaccine (MenB). ACIP also recommends that adolescents stay up to date with COVID-19 vaccines,* acquire any missed childhood vaccines (catch-up vaccination), and receive an annual influenza vaccine† (*1*). Results from 2021 National Immunization Survey–Teen (NIS-Teen) revealed declines in MenACWY§ and Tdap¶ coverage among adolescents born in 2008; these persons were due for their routine adolescent vaccines in 2020, during the height of the COVID-19 pandemic (*2*). Ongoing assessment of adolescent vaccination coverage can help guide progress in implementation of ACIP recommendations and identify populations and areas with low coverage.

Methods

NIS-Teen is a random-digit–dialed telephone survey** conducted among households that include adolescents aged 13–17 years in the 50 states, the District of Columbia, selected local areas, and some U.S. territories.†† Parents and guardians are interviewed to obtain adolescent, maternal, and household information and are asked to provide consent for their adolescent's vaccine providers to be contacted. Immunization history questionnaires are mailed to all vaccine providers identified by the parent or guardian to obtain the adolescent's complete vaccination record. The 2022 NIS-Teen vaccination coverage estimates

* COVID-19 vaccination is recommended for all persons aged ≥6 months (https://www.cdc.gov/coronavirus/2019-ncov/vaccines/stay-up-to-date.html). Estimates of COVID-19 vaccination coverage are available at https://covid.cdc.gov/covid-data-tracker/#vaccination-states-jurisdictions and https://www.cdc.gov/vaccines/imz-managers/coverage/covidvaxview/interactive/children.html.

† Influenza vaccination is recommended for all persons aged ≥6 months. Influenza vaccination coverage estimates are available at https://www.cdc.gov/flu/fluvaxview/index.htm.

§ Meningococcal conjugate vaccination coverage represents coverage with the quadrivalent meningococcal conjugate vaccine or meningococcal-unknown type vaccine.

¶ Tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine coverage represents coverage with ≥1 Tdap dose at age ≥10 years.

** Persons living in all identified households with mobile telephones were eligible for interview. Sampling weights were adjusted for survey nonresponse, adolescent multiplicity (number of chances of selection), and noncoverage of the survey sampling frame, and were calibrated to known population totals. During 2015–2017, NIS-Teen sampled from a landline frame in addition to a mobile telephone frame; therefore, sampling weights were also adjusted for overlapping samples of mixed telephone users. https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/pubs-presentations/dual-to-single-frame-teen.html

†† Local areas that received federal immunization funds under Section 317 of the Public Health Service Act were sampled separately. Those areas included Chicago, Illinois; New York, New York; Philadelphia County, Pennsylvania; Bexar County, Texas; and Houston, Texas. Two territories were sampled separately in 2022: Guam and Puerto Rico.

were based on provider-reported vaccination histories from 16,043 adolescents aged 13–17 years[§§] who were born during January 2004–January 2010[¶¶] and included any vaccines received before the household interview date. Recent trends in vaccination coverage were assessed by comparing vaccination coverage by age among the 2008 and 2009 birth cohorts (i.e., those who reached their 12th and 11th birthdays, respectively, in 2020) to vaccination coverage in earlier birth cohorts (i.e., adolescents born in 2006 and 2007) whose routine vaccinations were not affected by the pandemic. Cross-sectional analysis was used to estimate vaccination coverage among adolescents aged 13–17 years. The household response rate[***] was 23.0%, and 38.8% of adolescents with completed interviews had adequate provider data.[†††] To better understand recent trends in vaccination coverage, estimates by age and birth year (2006–2009) were obtained; Kaplan-Meier techniques were used to account for censoring of vaccination status at age ≥14 years. Z-tests were used to compare differences in vaccination coverage by survey year, birth year, and among sociodemographic groups; differences with p-values <0.05 were considered statistically significant. Data were weighted[§§§] and analyses were conducted using SAS-callable SUDAAN (version 11; RTI International). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[¶¶¶]

Results

Vaccination Coverage Among Adolescents Aged 13–17 Years

In 2022, coverage with all routine, catch-up,[****] and other[††††] vaccinations recommended for adolescents was similar to coverage in 2021 (Table 1) (Supplementary Figure 1, https://stacks.cdc.gov/view/cdc/131939). In 2022, 89.9% of adolescents aged 13–17 years had received ≥1 Tdap dose, 88.6% had received ≥1 MenACWY dose, 76.0% had received ≥1 HPV[§§§§] vaccine dose, and 62.6% were up to date with HPV vaccination (HPV UTD).[¶¶¶¶] During 2015–2021, among adolescents aged 13–17 years, coverage with ≥1 HPV vaccine dose was higher among those insured by Medicaid than among those with private insurance (Supplementary Figure 2, https://stacks.cdc.gov/view/cdc/131940); however, in 2022, coverage with ≥1 HPV vaccine dose among Medicaid beneficiaries declined by 3.3 percentage points compared with coverage in 2021, whereas ≥1-dose HPV coverage among those with private insurance was stable, resulting in similar coverage between the two groups in 2022. Coverage with ≥1 HPV vaccine dose remains lowest among uninsured adolescents. Coverage with all routine vaccines varied widely by jurisdiction (Supplementary Table, https://stacks.cdc.gov/view/cdc/132006). Coverage with ≥1 Tdap dose ranged from 82.7% in California to 97.3% in Iowa, and ≥1-dose MenACWY coverage ranged from 55.5% in Mississippi to 97.9% in Iowa. Coverage with ≥1 HPV vaccine dose ranged from 61.0% in Mississippi to 94.6% in Rhode Island, and the percentage of adolescents UTD with HPV vaccine ranged from 38.5% in Mississippi to 85.2% in Rhode Island.

Trends in Vaccination Coverage by Age 13 and by Age 14 Years

Vaccination coverage by age 13 years among adolescents born in 2009 was similar to that attained by those born in 2006 and 2007 for all vaccinations recommended for adolescents[*****] (Figure). By age 13 years, coverage with ≥1 Tdap was 3.2 percentage points lower in the 2008 birth cohort than in the 2007 birth cohort, and coverage with ≥1 MenACWY dose was 3.0 percentage points lower (Table 2). By age 14 years, coverage rates with ≥1 Tdap dose, ≥1 HPV dose, and HPV UTD status were 3.8, 3.8, and 5.7 percentage points lower in the 2008 birth cohort than in the 2007 birth cohort, respectively.

[§§] The 2022 NIS-Teen sample included 7,623 females and 8,420 males. Adolescents from Guam (240) and Puerto Rico (671) were excluded from the national estimates.

[¶¶] Estimates in this report include persons who might have received vaccinations on time or as catch-up. Influenza vaccination coverage data are not included in this report but are available at https://www.cdc.gov/flu/fluvaxview/index.htm.

[***] The Council of American Survey Research Organizations response rate is the product of three other rates: 1) the resolution rate (the proportion of telephone numbers that can be identified as either business or residence), 2) the screening rate (the proportion of qualified households that complete the screening process), and 3) the cooperation rate (the proportion of contacted eligible households for which a completed interview is obtained).

[†††] Teens with at least one non–COVID-19 vaccination reported by a provider and those who had received no vaccinations were considered to have adequate provider data. "No vaccinations" indicates that the vaccination status is known because the parent or guardian indicated there were no vaccinations and the providers returned no immunization history forms or returned them indicating that no vaccinations had been administered.

[§§§] https://www.cdc.gov/vaccines/imz-managers/nis/downloads/NIS-TEEN-PUF21-DUG.pdf

[¶¶¶] 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.

[****] Hepatitis A; hepatitis B; varicella; and measles, mumps, and rubella vaccines are considered childhood vaccinations and are recommended for adolescents who are not up to date with these vaccinations. Except as noted, coverage estimates for ≥1 and ≥2 varicella vaccine doses were obtained among adolescents with no history of varicella disease.

[††††] MenB vaccination is not routinely recommended for all adolescents. Vaccines are administered to adolescents and young adults aged 16–23 years based on individual shared clinical decision-making. Coverage estimates for ≥1 and ≥2 MenB doses were calculated among adolescents who were aged 17 years at the time of interview.

[§§§§] HPV vaccination coverage includes receipt of any HPV vaccine and does not distinguish between nine-valent (9vHPV), quadrivalent (4vHPV), or bivalent (2vHPV) vaccines. Some adolescents might have received more than the 2 or 3 recommended HPV vaccine doses.

[¶¶¶¶] HPV up to date includes adolescents with ≥3 doses, and those with 2 doses when the first HPV vaccine dose was initiated at age <15 years and there was ≥5 months minus 4 days between the first and second dose (https://www.cdc.gov/vaccines/programs/iis/cdsi.html). This update to the HPV vaccination recommendation occurred in December 2016. Some adolescents might have received more than the 2 or 3 recommended HPV vaccine doses.

[*****] NIS-Teen data during 2015–2022 were combined, and Kaplan-Meier methods were used to calculate cumulative vaccination coverage estimates by age in days, stratified by annual birth cohort (2006 = 13,251; 2007 = 9,234; 2008 = 5,036; and 2009 = 1,655).

TABLE 1. Estimated vaccination coverage with selected vaccines and doses among adolescents aged 13–17 years,* by age at interview — National Immunization Survey–Teen, United States, 2022

Vaccine/ Population group	Age at 2022 interview, yrs, % (95% CI)†					Total, % (95% CI)†	
	13 (n = 3,198)	14 (n = 3,399)	15 (n = 3,219)	16 (n = 3,208)	17 (n = 3,019)	2022 (N = 16,043)	2021 (N = 18,002)
Tdap ≥1 dose§	85.1 (81.7–88.0)	90.7 (88.8–92.3)¶	91.5 (89.6–93.1)¶	91.1 (88.9–93.0)¶	91.4 (89.2–93.2)¶	**89.9 (88.9–90.9)**	**89.6 (88.6–90.5)**
MenACWY**							
≥1 dose	84.5 (81.3–87.2)	89.2 (87.1–91.0)¶	89.0 (86.7–91.0)¶	89.8 (87.4–91.8)¶	90.7 (88.7–92.3)¶	**88.6 (87.6–89.6)**	**89.0 (87.9–90.0)**
≥2 doses††	NA	NA	NA	NA	60.8 (57.5–63.9)	**60.8 (57.5–63.9)**	**60.0 (56.6–63.3)**
MenB§§							
≥1 dose	NA	NA	NA	NA	29.4 (26.5–32.4)¶	**29.4 (26.5–32.4)**	**31.4 (28.2–34.8)**
≥2 doses	NA	NA	NA	NA	11.9 (10.0–14.1)	**11.9 (10.0–14.1)**	**NA**
HPV¶¶ vaccine							
All adolescents							
≥1 dose	68.9 (65.4–72.2)	75.8 (73.0–78.4)¶	78.5 (75.7–81.1)¶	79.6 (76.8–82.2)¶	77.4 (74.5–80.0)¶	**76.0 (74.7–77.3)**	**76.9 (75.6–78.2)**
HPV vaccine UTD***	50.0 (46.4–53.5)	60.3 (57.1–63.4)¶	65.8 (62.7–68.8)¶	68.8 (65.8–71.7)¶	68.3 (65.3–71.2)¶	**62.6 (61.1–64.0)**	**61.7 (60.2–63.2)**
Females							
≥1 dose	72.8 (67.7–77.3)	76.5 (72.4–80.2)	79.5 (75.3–83.2)¶	81.3 (76.8–85.1)¶	79.0 (75.0–82.5)¶	**77.8 (75.8–79.6)**	**78.5 (76.6–80.4)**
HPV UTD	52.3 (47.1–57.4)	61.7 (57.3–65.9)¶	68.5 (63.9–72.8)¶	70.8 (66.2–75.0)¶	70.9 (66.7–74.8)¶	**64.6 (62.5–66.6)**	**63.8 (61.5–65.9)**
Males							
≥1 dose	65.0 (60.0–69.7)	75.1 (71.2–78.7)¶	77.5 (73.7–80.9)¶	78.1 (74.3–81.4)¶	75.9 (71.8–79.5)¶	**74.4 (72.5–76.1)**	**75.4 (73.5–77.2)**
HPV UTD	47.6 (42.8–52.4)	58.8 (54.3–63.2)¶	63.3 (59.0–67.4)¶	67.0 (62.9–70.8)¶	66.0 (61.7–70.0)¶	**60.6 (58.6–62.6)**	**59.8 (57.6–61.8)**
MMR ≥2 doses	90.5 (87.6–92.8)	92.6 (90.4–94.4)	91.0 (88.7–92.8)	92.0 (90.0–93.6)	89.9 (87.3–92.0)	**91.2 (90.2–92.1)**	**92.2 (91.2–93.2)**
Hepatitis A vaccine ≥2 doses†††	84.8 (81.5–87.5)	86.6 (83.9–88.9)	86.7 (84.2–88.8)	84.6 (81.9–87.0)	82.3 (79.7–84.7)	**85.0 (83.8–86.1)**	**85.0 (83.8–86.1)**
Hepatitis B vaccine ≥3 doses	90.5 (87.6–92.8)	92.6 (90.6–94.2)	91.0 (88.8–92.8)	91.2 (88.9–93.1)	90.7 (88.3–92.6)	**91.2 (90.2–92.1)**	**92.3 (91.3–93.1)**
Varicella							
History of varicella§§§	4.6 (3.4–6.3)	6.4 (5.0–8.1)	7.4 (5.8–9.3)¶	7.4 (5.9–9.2)¶	9.3 (7.5–11.4)¶	**7.0 (6.3–7.8)**	**7.3 (6.5–8.2)**
No history of varicella disease							
≥1 dose vaccine	93.5 (90.9–95.5)	95.2 (93.5–96.5)	93.4 (91.1–95.1)	94.4 (92.8–95.6)	93.8 (91.4–95.5)	**94.1 (93.2–94.8)**	**94.9 (94.0–95.7)**
≥2 doses vaccine	89.4 (86.2–91.9)	91.9 (89.5–93.8)	91.3 (89.1–93.2)	91.1 (89.0–92.9)	90.4 (87.9–92.4)	**90.8 (89.8–91.8)**	**91.5 (90.5–92.5)**
History of varicella or receipt of ≥2 varicella vaccine doses	89.9 (86.9–92.3)	92.4 (90.1–94.2)	92.0 (89.9–93.7)	91.8 (89.8–93.4)	91.3 (89.0–93.1)	**91.5 (90.5–92.4)**	**92.2 (91.2–93.1)**

Abbreviations: HPV = human papillomavirus; MenACWY = quadrivalent meningococcal conjugate vaccine; MenB = serogroup B meningococcal vaccine; MMR = measles, mumps, and rubella vaccine; NA = not applicable; NIS = National Immunization Survey; Tdap = tetanus, diphtheria, and acellular pertussis vaccine; UTD = up to date.

* Adolescents in the 2022 NIS–Teen were born during January 7, 2004–January 10, 2010.

† Estimates with 95% CIs widths >20 might not be reliable.

§ Includes percentages receiving Tdap vaccine at age ≥10 years.

¶ Statistically significant difference (p<0.05) in estimated vaccination coverage by age; referent group was adolescents aged 13 years.

** Includes percentages receiving MenACWY or an unknown type of meningococcal vaccine.

†† ≥2 doses of MenACWY or unknown type of meningococcal vaccine among adolescents aged 17 years at interview and does not include adolescents who received 1 dose of MenACWY vaccine at age ≥16 years.

§§ Calculated only among adolescents who were aged 17 years at time of interview with vaccine administered based on individual clinical decision.

¶¶ HPV vaccine, nine-valent (9vHPV), quadrivalent (4vHPV), or bivalent (2vHPV). For ≥1 dose and HPV UTD measures, percentages are reported among females and males combined (16,043) and for females only (7,623) and males only (8,420).

*** HPV vaccine UTD includes those with ≥3 doses, and those with 2 doses when the first HPV vaccine dose was initiated at age <15 years, and there were ≥5 months minus 4 days between the first and second dose (https://www.cdc.gov/vaccines/programs/iis/cdsi.html). This update to the HPV recommendation occurred in December 2016.

††† In July 2020, ACIP revised recommendations for hepatitis A vaccination to include catch-up vaccination for persons aged 2–18 years who have not previously received hepatitis A vaccine at any age. https://pubmed.ncbi.nlm.nih.gov/32614811/

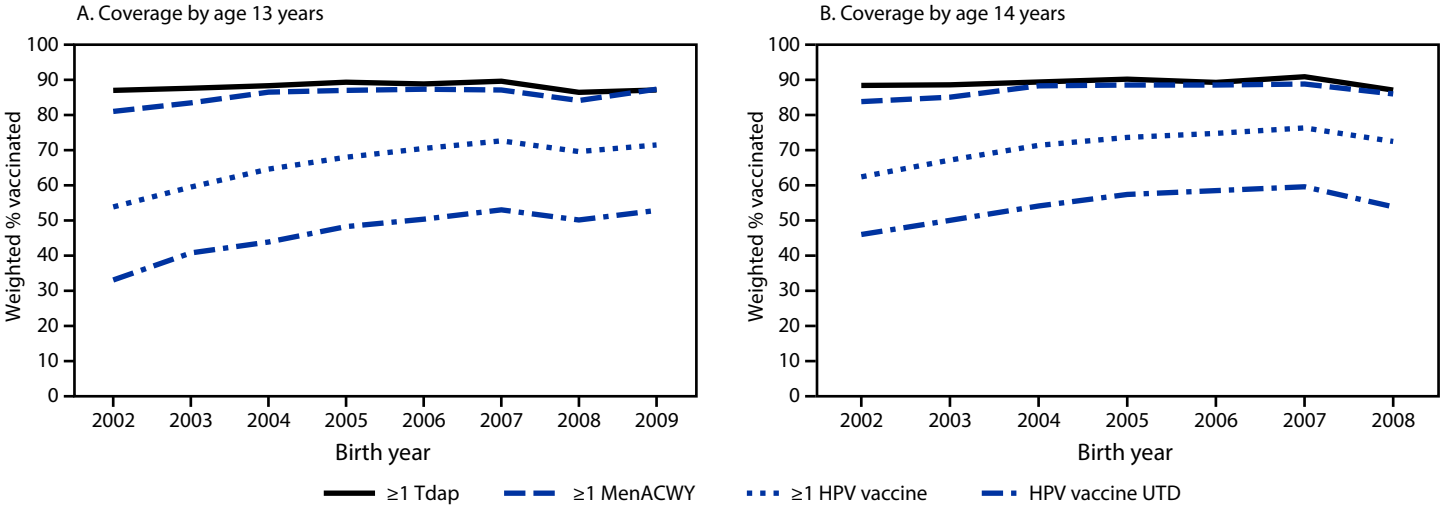
§§§ By parent or guardian report or provider records.

By age 14 years, among adolescents born in 2008, coverage with ≥1 Tdap dose was 3–4 percentage points lower, and HPV UTD status was 5.0–6.0 percentage points lower among adolescents living at or above the federal poverty level,†††† those who were non-Hispanic White, and those privately insured than among those born in 2007. Among adolescents born in 2008, coverage with ≥1 Tdap dose by age 14 years was 4.3 percentage points lower among those living in mostly suburban areas§§§§§ and

†††† Poverty status was unknown for 435 adolescents. Adolescents were classified as being below the federal poverty level if their total family income was less than the level specified for the applicable family size and number of children and adolescents aged <18 years. All others were classified as at or above the federal poverty level. https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html

§§§§§ Metropopulation statistical area (MSA) status was determined from household reported city and county of residence and was grouped into three categories: MSA principal city, MSA nonprincipal city, and non-MSA. Non-MSAs include urban populations not located within an MSA and completely rural areas. https://www.census.gov/programs-surveys/metro-micro.html

FIGURE. Estimated coverage with ≥1 dose of tetanus, diphtheria, and acellular pertussis vaccine, ≥1 dose of quadrivalent meningococcal conjugate vaccine, and ≥1 dose of human papillomavirus vaccine, and percentage of adolescents up to date with human papillomavirus vaccination, among adolescents born during 2002–2009* by age 13 years† (A) and 14 years§ (B) — National Immunization Survey-Teen, United States, 2015–2022



Abbreviations: HPV = human papillomavirus; MenACWY = quadrivalent meningococcal conjugate vaccine; Tdap = tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine; UTD = up to date.
* The 2008 and 2009 birth cohorts reached their 12th and 11th birthdays, respectively, in 2020 during the COVID-19 pandemic.
† Includes vaccinations received before the 13th birthday.
§ Includes vaccinations received before the 14th birthday.

4.6 percentage points lower among those insured by Medicaid than among those born in 2007. All four vaccine measures ranged from 3.9 to 11.7 percentage points lower among those living in mostly urban areas in the 2008 birth cohort compared with the 2007 birth cohort.

Discussion

This report used two analyses of 2022 NIS-Teen data to examine vaccination coverage among U.S. adolescents: birth cohort analyses were conducted to assess recent trends in vaccination coverage and a cross-sectional analysis evaluated coverage among adolescents aged 13–17 years during 2022. The birth cohort analysis identified lower coverage with ≥1 Tdap dose and ≥1 MenACWY dose by age 13 years, and lower coverage with ≥1 Tdap dose, ≥1 HPV dose, and HPV UTD by age 14 years, among adolescents born during 2008 (i.e., those who reached their 12th birthday during 2020) compared with those born during 2007. The continued lower coverage by age 14 years indicates that vaccination coverage did not rebound among this birth cohort in 2022. Coverage with all routinely recommended vaccines among adolescents born during 2008 and living in mostly urban areas was lower than coverage among those born during 2007, indicating that pandemic disruptions might have differentially affected urban areas. In contrast to findings for the 2008 birth cohort, coverage by age 13 years was not lower for the 2009 birth cohort compared with the two earlier birth cohorts, perhaps because these adolescents had an additional year after the peak of the pandemic to receive routinely recommended vaccines before becoming overdue, and because many primary care offices returned to normal operations.

The cross-sectional analysis showed that for the first time since 2013, HPV vaccination initiation did not increase among adolescents aged 13–17 years. HPV vaccination initiation fell among adolescents insured by Medicaid and remained lowest among the uninsured (two of the four groups that constitute the Vaccines for Children [VFC]–eligible population), highlighting the continued need for outreach among adolescents eligible for VFC.¶¶¶¶¶ VFC vaccine ordering data provide additional evidence that HPV vaccination coverage might be declining in VFC-eligible populations. VFC provider orders for HPV vaccines decreased 24% during 2020, 9% during 2021, and 12% during 2022 compared with 2019, and provider orders for non-HPV vaccines have rebounded to prepandemic levels (Whitlatch F, CDC unpublished data, 2023). The VFC program is vital to reach and administer vaccines to eligible adolescents to maintain vaccination coverage in underserved communities.

¶¶¶¶¶ Persons aged ≤18 years who are Medicaid-eligible, uninsured, or American Indian or Alaska Native (as defined by the Indian Health Care Improvement Act) are eligible to receive vaccines from providers through the VFC program. Children categorized as underinsured because their health plans do not include coverage for recommended vaccinations are eligible to receive VFC vaccines if they are served by a rural health clinic or federally qualified health center or under an approved deputization agreement. https://www.cdc.gov/vaccines/programs/vfc/providers/eligibility.html

TABLE 2. Coverage with ≥1 dose of tetanus, diphtheria, and acellular pertussis vaccine, ≥1 dose of quadrivalent meningococcal conjugate vaccine, ≥1 dose of human papillomavirus vaccine, and percentage of adolescents up to date with human papillomavirus vaccination, among adolescents born during 2006–2009,* by age 13 years and 14 years,† metropolitan statistical area status,§ poverty status,¶ race and ethnicity, and health insurance status†† — National Immunization Survey-Teen, United States, 2020–2022**

Age group/ Characteristic	Vaccination coverage,% (95% CI)§§															
	≥1 Tdap				≥1 MenACWY				≥1 HPV				HPV vaccine UTD			
	Birth year				Birth year				Birth year				Birth year			
	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009
By age 13 yrs																
All adolescents	88.8 (87.7–89.9)	89.6 (88.5–90.7)	86.4 (84.1–88.5)¶¶	87.1 (83.0–90.7)	87.3 (86.0–88.5)	87.1 (85.5–88.5)	84.1 (81.5–86.4)¶¶	87.3 (84.1–90.2)	70.4 (68.8–72.0)	72.6 (70.8–74.5)	69.5 (66.8–72.1)	71.4 (67.1–75.6)	50.2 (48.5–51.9)	52.9 (50.8–55.0)	50.0 (47.2–52.8)	52.7 (48.0–57.6)
MSA																
MSA, principal city	88.4 (86.4–90.2)	90.0 (88.3–91.5)	86.6 (83.2–89.7)	86.3 (78.5–92.3)	86.7 (84.4–88.9)	89.0 (87.2–90.7)	81.8 (77.3–85.8)¶¶	87.8 (82.2–92.3)	73.3 (70.7–75.9)	77.9 (75.4–80.3)	69.4 (64.8–73.8)¶¶	74.8 (67.4–81.7)	52.4 (49.6–55.1)	56.8 (53.6–60.0)	49.2 (44.6–54.0)¶¶	55.1 (47.3–63.3)
MSA, nonprincipal city	90.0 (88.4–91.4)	89.3 (87.4–91.0)	85.5 (81.9–88.7)	87.6 (82.4–91.8)	89.0 (87.4–90.5)	85.7 (82.9–88.2)	85.6 (82.0–88.8)	87.3 (82.9–91.1)	69.3 (66.9–71.6)	68.8 (65.7–71.8)	69.9 (66.1–73.7)	69.3 (63.3–75.0)	49.6 (47.1–52.1)	50.8 (47.6–53.9)	50.7 (46.9–54.7)	52.5 (46.2–59.2)
Non–MSA	85.6 (82.4–88.4)	89.9 (87.3–92.1)	89.5 (85.4–92.9)	88.6 (79.2–95.0)	81.8 (78.8–84.6)	85.4 (82.3–88.1)	86.2 (82.0–89.9)	84.9 (75.3–92.3)	64.3 (60.4–68.1)	69.3 (65.3–73.2)	67.7 (61.1–74.2)	67.0 (56.3–77.4)	44.6 (40.4–49.1)	47.1 (42.5–52.0)	49.5 (43.3–56.2)	43.3 (32.0–56.6)
Poverty status																
At or above federal poverty level	89.1 (87.8–90.3)	89.4 (88.2–90.6)	86.6 (84.1–88.8)¶¶	88.5 (84.6–91.8)	87.5 (86.0–88.9)	87.3 (85.6–89.0)	85.2 (82.6–87.5)	87.6 (83.8–90.8)	68.8 (67.0–70.5)	71.2 (69.1–73.3)	68.5 (65.6–71.4)	70.2 (65.2–75.0)	49.4 (47.6–51.3)	52.4 (50.1–54.7)	49.5 (46.6–52.5)	51.1 (45.9–56.4)
Below federal poverty level	89.1 (86.9–91.1)	90.6 (87.2–93.3)	83.0 (75.9–88.9)¶¶	89.5 (82.6–94.5)	86.8 (84.2–89.3)	86.0 (82.0–89.5)	78.1 (69.6–85.6)	89.4 (82.6–94.4)***	79.0 (75.5–82.2)	79.1 (74.6–83.3)	74.3 (66.8–81.2)	77.7 (68.7–85.6)	54.3 (50.1–58.7)	55.0 (49.4–60.7)	52.6 (44.6–61.1)	57.8 (46.6–69.4)
Race and ethnicity																
AI/AN, NH	79.4 (57.3–94.7)	92.5 (85.4–96.9)	91.1 (78.0–97.9)	NA	79.1 (57.1–94.4)	82.4 (67.9–93.0)	83.6 (68.8–94.0)	NA	63.6 (45.8–81.2)	72.5 (52.9–89.1)	69.1 (51.4–85.1)	NA	49.2 (34.3–66.5)	54.4 (35.9–75.1)	51.3 (33.9–71.3)	31.8 (14.2–61.6)
Asian, NH	87.3 (81.7–91.8)	84.0 (76.1–90.4)	87.5 (77.6–94.4)	75.4 (50.2–94.0)	91.4 (87.1–94.8)	88.1 (81.9–93.0)	94.4 (89.5–97.5)	NA	76.8 (70.6–82.4)	76.7 (68.7–83.9)	64.6 (52.2–76.8)	57.6 (34.4–82.6)	58.5 (50.9–66.3)	60.7 (50.6–71.0)	50.7 (39.5–63.1)	49.2 (28.6–74.3)
Black or African American, NH	88.5 (85.6–91.1)	90.3 (87.2–92.9)	84.6 (78.8–89.5)	89.0 (80.8–94.7)	87.8 (84.6–90.6)	86.1 (81.6–89.9)	81.8 (74.7–87.9)	82.6 (72.8–90.5)	76.6 (72.9–80.2)	79.4 (74.3–84.0)	72.6 (65.4–79.4)	70.7 (60.1–80.6)	53.9 (49.4–58.6)	57.3 (51.7–63.1)	54.4 (47.3–61.8)	54.9 (43.1–67.5)
Hispanic or Latino	87.4 (84.1–90.3)	89.2 (86.3–91.7)	84.4 (77.7–90.0)	82.7 (71.3–91.5)	86.8 (83.2–90.1)	86.6 (82.2–90.3)	81.0 (73.4–87.5)	87.8 (79.5–93.8)	72.8 (68.6–76.8)	74.4 (69.6–79.0)	74.5 (67.6–80.9)	78.6 (69.7–86.4)	54.8 (50.5–59.2)	54.8 (49.8–60.1)	52.9 (45.7–60.4)	57.8 (47.2–68.8)
White, NH	89.9 (88.7–91.1)	90.2 (88.8–91.5)	87.7 (85.3–90.0)	91.3 (88.1–93.9)	87.0 (85.5–88.4)	87.2 (85.5–88.7)	85.4 (82.7–87.8)	89.4 (86.1–92.2)	66.8 (64.9–68.6)	69.2 (67.0–71.5)	66.8 (63.6–70.1)	67.0 (61.1–72.7)	46.0 (44.1–47.9)	50.0 (47.6–52.5)	46.7 (43.6–49.8)	47.5 (41.8–53.6)
Health insurance status																
Private insurance only	89.6 (88.1–91.0)	91.0 (89.7–92.3)	87.9 (85.3–90.2)¶¶	89.0 (83.8–93.1)	88.6 (87.2–90.0)	88.3 (86.1–90.3)	86.8 (84.0–89.4)	92.3 (89.1–94.8)¶¶,***	68.9 (66.9–70.9)	71.2 (68.5–73.8)	69.8 (66.4–73.2)	73.9 (68.3–79.2)	50.5 (48.4–52.6)	52.7 (49.8–55.5)	50.4 (47.0–53.9)	55.2 (49.1–61.5)
Any Medicaid insurance	88.5 (86.3–90.4)	88.8 (86.6–90.9)	84.5 (80.5–88.2)	86.5 (78.6–92.6)	87.1 (84.6–89.4)	86.1 (83.6–88.4)	82.0 (77.4–86.1)	84.0 (78.2–89.0)	74.2 (71.2–77.1)	75.6 (72.6–78.5)	71.8 (67.3–76.2)	70.6 (63.2–77.8)	52.4 (49.3–55.6)	55.3 (51.8–58.9)	51.9 (47.0–56.9)	52.2 (44.0–60.9)
Other insurance	88.6 (85.5–91.3)	88.8 (85.0–92.1)	94.2 (91.4–96.3)¶¶	79.0 (66.4–89.4)	85.8 (81.9–89.3)	88.7 (85.0–91.8)	86.7 (76.6–93.9)	75.5 (64.1–85.5)	70.2 (65.4–74.9)	74.0 (68.7–79.0)	66.1 (55.9–76.0)	63.8 (51.7–75.8)	45.0 (39.6–50.8)	50.2 (43.8–56.9)	48.5 (38.2–59.8)	45.6 (33.5–59.7)
Uninsured	80.2 (71.9–87.3)	79.2 (69.1–87.8)	71.1 (49.3–89.7)	82.1 (55.4–97.4)	69.7 (59.7–79.1)	75.3 (63.3–85.8)	63.2 (42.7–83.3)	74.5 (43.4–96.3)	NA	58.0 (46.5–70.0)	46.5 (29.9–66.7)	59.9 (34.1–86.4)	NA	34.9 (25.0–47.3)	26.9 (15.1–45.0)	39.3 (18.4–70.5)

See table footnotes on page 918.

TABLE 2. (*Continued*) Coverage with ≥1 dose of tetanus, diphtheria, and acellular pertussis vaccine, ≥1 dose of quadrivalent meningococcal conjugate vaccine, ≥1 dose of human papillomavirus vaccine, and percentage of adolescents up to date with human papillomavirus vaccination, among adolescents born during 2006–2009,* by age 13 years and 14 years,† metropolitan statistical area status,§ poverty status,¶ race and ethnicity, and health insurance status†† — National Immunization Survey-Teen, United States, 2020–2022**

Age group/ Characteristic	Vaccination coverage,% (95% CI)§§															
	≥1 Tdap				≥1 MenACWY				≥1 HPV				HPV vaccine UTD			
	Birth year				Birth year				Birth year				Birth year			
	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009
By age 14 yrs†††																
All adolescents	89.3 (88.2–90.4)	90.9 (89.7–91.9)	87.1 (84.9–89.2)§§§	NA	88.5 (87.3–89.7)	88.8 (87.2–90.2)	86.0 (83.2–88.6)	NA	74.8 (73.1–76.4)	76.3 (74.4–78.2)	72.5 (69.5–75.5)§§§	NA	58.5 (56.7–60.3)	59.6 (57.4–61.9)	53.9 (50.9–56.9) §§§,¶¶¶	NA
MSA																
MSA, principal city	88.9 (86.9–90.7)	91.2 (89.5–92.7)	87.3 (83.8–90.4)§§§	NA	88.5 (86.3–90.5)	90.8 (89.1–92.4)	83.3 (78.7–87.3) §§§,¶¶¶	NA	78.4 (75.8–80.8)	80.3 (77.8–82.7)	71.9 (67.0–76.5) §§§,¶¶¶	NA	60.9 (58.0–63.8)	63.8 (60.4–67.2)	52.1 (47.2–57.2) §§§,¶¶¶	NA
MSA, Nonprincipal city	90.2 (88.6–91.7)	90.7 (88.8–92.4)	86.4 (82.7–89.6)§§§	NA	89.6 (87.9–91.1)	87.4 (84.6–90.0)	88.3 (84.0–91.8)	NA	73.3 (70.9–75.7)	73.7 (70.4–76.8)	74.0 (69.6–78.3)	NA	57.7 (55.1–60.3)	56.9 (53.6–60.3)	55.3 (51.2–59.6)	NA
Non–MSA	87.2 (84.1–89.9)	90.2 (87.6–92.5)	90.1 (86.1–93.4)	NA	84.0 (81.1–86.7)	86.4 (83.4–89.1)	87.0 (82.8–90.6)	NA	66.9 (63.1–70.8)	72.2 (68.2–76.1)	68.2 (61.6–74.6)	NA	52.2 (47.9–56.7)	55.7 (50.0–61.5)	54.9 (48.3–61.7)	NA
Poverty status																
At or above poverty level	89.6 (88.3–90.8)	90.6 (89.3–91.7)	86.7 (84.2–89.0) §§§,¶¶¶	NA	88.9 (87.5–90.2)	88.9 (87.2–90.5)	86.8 (83.8–89.4)	NA	73.9 (72.1–75.6)	75.2 (73.0–77.3)	71.9 (68.5–75.2)	NA	57.5 (55.6–59.4)	58.9 (56.5–61.4)	53.0 (50.0–56.1) §§§,¶¶¶	NA
Below poverty level	89.6 (87.4–91.5)	92.4 (88.9–95.2)	86.4 (79.4–91.9)	NA	87.9 (85.2–90.2)	88.6 (84.5–92.1)	80.1 (71.5–87.5)	NA	80.8 (77.3–84.0)	82.0 (77.4–86.2)	75.3 (67.7–82.3)	NA	63.8 (59.4–68.2)	61.2 (55.4–67.0)	55.2 (46.8–64.0)	NA

See table footnotes on the next page.

Summary

What is already known about this topic?

Tetanus, diphtheria, and acellular pertussis vaccine, meningococcal conjugate vaccine, and human papillomavirus (HPV) vaccine are routinely recommended for children at age 11–12 years.

What is added by this report?

Analyses of recent trends in routine vaccination coverage show declines in coverage by age 13 and 14 years among adolescents born in 2008. Among adolescents aged 13–17 years, routine vaccination coverage in 2022 was similar to coverage in 2021. Coverage with ≥1 HPV vaccine dose declined among adolescents insured by Medicaid.

What are the implications for public health?

Providers should review adolescent immunization histories, particularly those of adolescents born in 2008 and those eligible for the Vaccines for Children program, to ensure that adolescents are up to date with all recommended vaccinations.

Limitations

The findings in this report are subject to at least two limitations. First, selection bias due to low household response rate might have occurred if selected participants differed systematically from nonparticipants (*3*). Second, data were weighted to account for nonresponse and households without telephones, but some bias might remain. Recent total survey error assessments indicated that NIS-Teen estimates might underestimate actual coverage, with the largest underestimation occurring for Tdap (–5.0 percentage points) (*4,5*). In addition, the findings suggested no evidence of change in accuracy of NIS-Teen estimates from 2021 to 2022 for routine adolescent vaccines and for most catch-up vaccines (*5*).

Implications for Public Health Practice

In the wake of the COVID-19 pandemic, many families might have missed well-child appointments when vaccinations were due (*6*). Ensuring that adolescents are up to date with recommended vaccines (Tdap, MenACWY, and HPV vaccine) is the best way to protect them from vaccine-preventable diseases. Particular focus is needed for subgroups that experienced larger recent declines in vaccination coverage or substantially lower coverage, including those born during 2008 and VFC-eligible populations. Resources for supporting catch-up vaccination are available at https://www.cdc.gov/vaccines/partners/routine-immunizations-lets-rise.html.

TABLE 2. (*Continued*) Coverage with ≥1 dose of tetanus, diphtheria, and acellular pertussis vaccine, ≥1 dose of quadrivalent meningococcal conjugate vaccine, ≥1 dose of human papillomavirus vaccine, and percentage of adolescents up to date with human papillomavirus vaccination, among adolescents born during 2006–2009,* by age 13 years and 14 years,† metropolitan statistical area status,§ poverty status,¶ race and ethnicity, and health insurance status†† — National Immunization Survey-Teen, United States, 2020–2022**

Age group/ Characteristic	Vaccination coverage,% (95% CI)§§															
	≥1 Tdap				≥1 MenACWY				≥1 HPV				HPV vaccine UTD			
	Birth year				Birth year				Birth year				Birth year			
	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009	2006	2007	2008	2009
Race and ethnicity																
Asian, NH	87.8 (82.2–92.3)	84.8 (76.9–91.2)	90.3 (79.6–96.7)	NA	92.3 (88.0–95.6)	88.9 (82.7–93.7)	94.6 (89.7–97.6)	NA	80.2 (74.1–85.6)	83.8 (76.5–89.8)	72.6 (56.4–86.7)	NA	67.1 (59.7–74.4)	67.4 (57.8–76.8)	58.1 (44.6–72.2)	NA
AI/AN, NH	NA	94.2 (87.0–98.1)	NA	NA	79.2 (57.2–94.6)	85.2 (70.1–95.1)	NA	NA	63.9 (46.0–81.5)	74.8 (54.6–91.0)	NA	NA	55.2 (38.3–73.7)	63.6 (43.6–83.1)	61.1 (41.6–80.8)	NA
Black or African American, NH	88.7 (85.7–91.2)	93.3 (90.3–95.6)¶¶¶	85.6 (79.7–90.5)§§§	NA	88.1 (84.9–90.9)	90.9 (86.9–94.1)	83.5 (76.2–89.6)	NA	79.4 (75.6–82.9)	84.6 (79.5–89.1)	NA	NA	63.1 (58.4–67.8)	66.1 (59.6–72.5)	59.4 (51.7–67.2)	NA
Hispanic or Latino	87.7 (84.4–90.6)	90.6 (87.7–93.1)	86.5 (79.9–91.9)	NA	88.6 (85.2–91.6)	88.2 (83.6–92.0)	82.6 (74.9–89.0)	NA	77.6 (73.5–81.5)	76.9 (71.9–81.6)	75.6 (68.7–81.9)	NA	61.0 (56.6–65.5)	61.0 (55.5–66.6)	56.4 (48.6–64.5)	NA
White, NH	90.7 (89.5–91.8)	90.9 (89.5–92.2)	87.9 (85.5–90.1) §§§,¶¶¶	NA	88.2 (86.7–89.6)	88.1 (86.5–89.7)	87.7 (84.5–90.6)	NA	71.4 (69.5–73.3)	72.7 (70.4–75.0)	70.3 (66.3–74.2)	NA	55.3 (53.2–57.4)	56.6 (54.0–59.2)	50.2 (46.9–53.6) §§§,¶¶¶	NA
Health insurance status																
Private insurance only	90.2 (88.7–91.6)	92.0 (90.7–93.2)	88.0 (85.4–90.3)§§§	NA	89.7 (88.2–91.1)	89.4 (87.2–91.5)	88.9 (85.3–91.9)	NA	74.3 (72.3–76.3)	75.4 (72.6–78.1)	74.0 (69.8–78.1)	NA	59.1 (56.9–61.3)	60.4 (57.3–63.5)	54.6 (50.8–58.5)§§§	NA
Any Medicaid insurance	88.9 (86.7–90.8)	90.2 (87.9–92.2)	85.6 (81.5–89.2)§§§	NA	88.7 (86.4–90.8)	87.8 (85.2–90.0)	84.2 (79.7–88.2)	NA	77.7 (74.7–80.5)	77.8 (74.8–80.7)	72.7 (68.1–77.2)	NA	60.4 (57.1–63.7)	61.3 (57.6–65.1)	56.3 (51.1–61.7)	NA
Other insurance	89.2 (86.0–91.9)	89.8 (85.9–93.0)	95.1 (92.0–97.2) §§§,¶¶¶	NA	86.5 (82.5–90.0)	89.6 (85.9–92.7)	87.0 (76.7–94.3)	NA	72.5 (67.6–77.1)	77.9 (72.6–82.8)	68.9 (57.8–79.3)	NA	52.2 (46.3–58.3)	55.8 (49.2–62.6)	48.9 (38.6–60.3)	NA
Uninsured	80.7 (72.4–87.8)	84.0 (73.7–91.9)	82.3 (59.8–96.3)	NA	71.2 (61.1–80.6)	90.0 (80.2–96.3)¶¶¶	NA	NA	52.1 (41.6–63.4)	70.4 (57.2–82.6)¶¶¶	58.1 (39.3–78.0)	NA	38.4 (28.2–50.9)	37.1 (26.9–49.7)	28.3 (16.3–46.1)	NA

Abbreviations: AI/AN = American Indian or Alaska Native; HPV = human papillomavirus; MenACWY = quadrivalent meningococcal conjugate vaccine; MSA = metropolitan statistical area; NA= not applicable; NH = non-Hispanic; Tdap = tetanus, diphtheria, and acellular pertussis vaccine; UTD = up to date.

* Data for the 2006 birth year are from survey years 2019, 2020, 2021, and 2022; data for the 2007 birth year are from survey years 2020, 2021, and 2022; data for the 2008 birth year are from survey years 2021, and 2022; data for the 2009 birth year are from survey year 2022.

† Includes vaccinations received by age 13 years (before the 13th birthday) and by age 14 years (before the 14th birthday).

§ MSA status was determined from household reported city and county of residence and was grouped into three categories: MSA principal city, MSA nonprincipal city, and non-MSA. MSA nonprincipal city and MSA principal city were as defined by the U.S. Census Bureau (https://www.census.gov/programs-surveys/metro-micro.html). Non-MSAs include urban populations not located within an MSA and completely rural areas.

¶ Adolescents were classified as being below the federal poverty level if their total family income was less than the level specified for the applicable family size and number of children and adolescents aged <18 years. All others were classified as at or above the federal poverty level (https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html). Poverty status was unknown for 435 adolescents.

** Adolescents' race and ethnicity was reported by their parent or guardian. Adolescents identified in this report as White, Black or African American, Asian, American Alaska Native or Indian, Native Hawaiian or other Pacific Islander, or multiple races were reported by the parent or guardian as non-Hispanic. Adolescents identified as having multiple races had more than one race category selected. Adolescents identified as Hispanic or Latino might be of any race. Estimates for Native Hawaiian or other Pacific Islander and multiracial adolescents were suppressed because of small sample size.

†† Adolescents' health insurance status was reported by their parent or guardian. "Other insurance" includes the Children's Health Insurance Program, military insurance, Indian Health Service, and any other type of health insurance not mentioned elsewhere.

§§ Estimates with 95% CIs > 20 might not be reliable. Estimates with sample size <30 were suppressed and marked with NA.

¶¶ Statistically significant difference (p<0.05) in estimated vaccination coverage by age 13 years; referent group was 2007 birth year.

*** Statistically significant difference (p<0.05) in estimated vaccination coverage by age 13 years; referent group was 2008 birth year.

††† Adolescents in the 2009 birth cohort reach their 14th birthday in 2023, and thus vaccinations by their 14th birthday in 2023 were not assessed by the 2022 NIS-Teen. These table cells were marked NA.

§§§ Statistically significant difference (p<0.05) in estimated vaccination coverage by age 14 years; referent group was 2007 birth year.

¶¶¶ Statistically significant difference (p<0.05) in estimated vaccination coverage by age 14 years; referent group was 2006 birth year.

Acknowledgment

Tami H. Skoff, CDC.

Corresponding author: Cassandra Pingali, ncu9@cdc.gov.

[1]Immunization Services Division, National Center for Immunization and Respiratory Diseases, CDC; [2]Division of Viral Diseases, National Center for Immunization and Respiratory Diseases, CDC; [3]Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee; [4]Leidos Health, Inc., Atlanta, Georgia; [5]Division of Bacterial Diseases, National Center for Immunization and Respiratory Diseases, CDC.

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. Wodi AP, Murthy N, McNally V, Cineas S, Ault K. Advisory Committee on Immunization Practices recommended immunization schedule for children and adolescents aged 18 years or younger—United States, 2023. MMWR Morb Mortal Wkly Rep 2023;72:137–40. PMID:36757872 https://doi.org/10.15585/mmwr.mm7206a1
2. Pingali C, Yankey D, Elam-Evans LD, et al. National vaccination coverage among adolescents aged 13–17 years—National Immunization Survey–Teen, United States, 2021. MMWR Morb Mortal Wkly Rep 2022;71:1101–8. PMID:36048724 https://doi.org/10.15585/mmwr.mm7135a1
3. Pew Research Center. What low response rates mean for telephone surveys. Washington, DC: Pew Research Center; 2017. https://www.pewresearch.org/methods/2017/05/15/what-low-response-rates-mean-for-telephone-surveys/
4. CDC. NIS-Teen data and documentation for 2015 to present. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. https://www.cdc.gov/vaccines/imz-managers/nis/datasets-teen.html
5. CDC. Error profile for the 2022 NIS-Teen: National Immunization Survey. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/downloads/error-profile-2022-nis-teen.pdf
6. Badeh SM, Elam-Evans LD, Hill HA, Fredua B. Disrupted routine medical visits in children and adolescents during the COVID-19 pandemic. AJPM Focus 2023. Epub June 8, 2023. PMID:37362397 https://doi.org/10.1016/j.focus.2023.100119

Use of Nirsevimab for the Prevention of Respiratory Syncytial Virus Disease Among Infants and Young Children: Recommendations of the Advisory Committee on Immunization Practices — United States, 2023

Jefferson M. Jones, MD[1]; Katherine E. Fleming-Dutra, MD[1]; Mila M. Prill, MSPH[1]; Lauren E. Roper, MPH[1]; Oliver Brooks MD[2]; Pablo J. Sánchez, MD[3]; Camille N. Kotton, MD[4]; Barbara E. Mahon, MD[1]; Sarah Meyer, MD[5]; Sarah S. Long, MD[6]; Meredith L. McMorrow, MD[1]

Abstract

Respiratory syncytial virus (RSV) is the leading cause of hospitalization among U.S. infants. In July 2023, the Food and Drug Administration approved nirsevimab, a long-acting monoclonal antibody, for passive immunization to prevent RSV-associated lower respiratory tract infection among infants and young children. Since October 2021, the Advisory Committee on Immunization Practices (ACIP) Maternal and Pediatric RSV Work Group has reviewed evidence on the safety and efficacy of nirsevimab among infants and young children. On August 3, 2023, ACIP recommended nirsevimab for all infants aged <8 months who are born during or entering their first RSV season and for infants and children aged 8–19 months who are at increased risk for severe RSV disease and are entering their second RSV season. On the basis of pre–COVID-19 pandemic patterns, nirsevimab could be administered in most of the continental United States from October through the end of March. Nirsevimab can prevent severe RSV disease among infants and young children at increased risk for severe RSV disease.

Introduction

In July 2023, the Food and Drug Administration (FDA) approved nirsevimab (Beyfortus, Sanofi and AstraZeneca), a long-acting monoclonal antibody, for the prevention of respiratory syncytial virus (RSV)–associated lower respiratory tract infection (LRTI) among infants and children aged <24 months (*1*).* Nirsevimab is administered as a 1-dose intramuscular injection shortly before or during the RSV season (typically fall through spring).† Since October 2021, the Advisory Committee on Immunization Practices (ACIP) Maternal and Pediatric RSV Work Group (Work Group) has reviewed data on RSV among infants and young children and evidence regarding the safety and efficacy of nirsevimab, and assessed the quality of the efficacy and safety evidence using the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) framework (*2*,*3*). The Evidence to Recommendation (EtR) Framework was used to develop recommendations (*4*,*5*). Evidence regarding potential use of nirsevimab was presented to ACIP at meetings during June 2022–August 2023. On August 3, 2023, ACIP recommended nirsevimab for infants aged <8 months who are born during or entering their first RSV season and for infants and children aged 8–19 months who are at increased risk for severe RSV disease and are entering their second RSV season.

RSV Among Infants and Young Children

RSV infection is the leading cause of hospitalization among U.S. infants (*6*); most children are infected during the first year of life, and nearly all have been infected by age 2 years (*7*,*8*). Infants with RSV infection frequently develop bronchiolitis, an LRTI that can be severe and result in hospitalization. Approximately 50,000–80,000 RSV-associated hospitalizations (*9*,*10*) and 100–300 RSV-associated deaths (*11*,*12*) occur annually among U.S. infants and children aged <5 years.

The rate of RSV-associated hospitalization among infants born at ≤30 weeks' gestation (premature) is three times that of term infants (*13*). Premature infants also have higher rates of RSV-associated intensive care unit (ICU) admission (*14*). Although prematurity is a recognized risk factor for RSV-associated hospitalization, RSV is also the leading cause of hospitalization among healthy term infants. An estimated 79% of infants and children aged <2 years hospitalized with RSV have no underlying medical conditions (*13*).

Before licensure of nirsevimab, the only FDA-approved product to prevent severe RSV disease among infants and young children was palivizumab, another monoclonal antibody. However, the American Academy of Pediatrics (AAP) recommends palivizumab only for children with certain underlying medical conditions (comprising <5% of all infants), and its use is further limited by high cost and the requirement for monthly dosing (*15*,*16*).

*https://www.fda.gov/news-events/press-announcements/fda-approves-new-drug-prevent-rsv-babies-and-toddlers

† The recommended dosage for infants born during or entering their first RSV season and weighing <5 kg (<11 lb) is 50 mg; for those weighing ≥5 kg (≥11 lb), the recommended dosage is 100 mg. The recommended dosage for infants and children aged 8–19 months at increased risk for severe disease entering their second RSV season is 200 mg (2 x 100 mg injections).

Methods

Since October 2021, the Work Group has conducted a systematic literature search and reviewed available evidence regarding the efficacy and safety of nirsevimab (*2*,*3*). The Work Group considered a priori outcomes that were critical or important to policy decisions.[§] For infants born during or entering their first RSV season, evidence regarding efficacy and safety was derived from multicountry trials[¶] that randomized infants, in a 2:1 ratio, to receive nirsevimab or placebo; a phase 2b trial that enrolled 1,453 preterm infants born at 29–34 weeks' gestation (phase 2b trial) (*17*); and a phase 3 trial that enrolled 3,012 late preterm and term infants born at ≥35 weeks' gestation (phase 3 trial) (*18*).[**] For children at increased risk for severe disease entering their second RSV season, evidence regarding efficacy and safety was obtained from a multicountry trial that randomized children to receive nirsevimab or palivizumab (*19*). The Work Group used the GRADE approach to assess the certainty of evidence for outcomes related to nirsevimab, rated on a scale of very low to high certainty (*2*,*3*). The Work Group then used the EtR Framework to guide its deliberations on recommendation of nirsevimab, reviewing data on the public health problem, benefits and harms, value to the target population, acceptability to key stakeholders, feasibility, resource use, and equity (*4*,*5*).

Nirsevimab Efficacy and Safety

Among infants aged <8 months who were born during or entering their first RSV season, efficacy was evaluated through 150 days after injection. For the GRADE assessment, results from the phase 3 and phase 2b trials were pooled (*17*,*18*). Only infants who received the recommended dose of nirsevimab were included in pooled estimates.[††] Pooled efficacy in preventing medically attended RSV-associated LRTI[§§] was 79.0% (95% CI = 68.5%–86.1%; 31 of 2,579 in nirsevimab arm and 80 of 1,293 in placebo arm), efficacy in preventing RSV-associated LRTI with hospitalization was 80.6% (95% CI = 62.3%–90.1%; 12 of 2,579 in nirsevimab arm and 33 of 1,293 in placebo arm), and efficacy in preventing RSV-associated LRTI with ICU admission was 90.0% (95% CI = 16.4%–98.8%; one of 2,579 in nirsevimab arm and six of 1,293 in placebo arm). No deaths attributable to RSV were reported in either trial.[¶¶] The incidence of serious adverse events[***] was not increased in the nirsevimab arm compared with that in the placebo arm.[†††] The overall evidence certainty using GRADE criteria was rated as moderate. The GRADE evidence profile and supporting evidence for the EtR Framework are available at https://www.cdc.gov/vaccines/acip/recs/grade/nirsevimab-season1-rsv-infants-children.html and https://www.cdc.gov/vaccines/acip/recs/grade/nirsevimab-season1-rsv-infants-children-etr.html.

[§] Critical outcomes include medically attended RSV-associated LRTI, RSV-associated LRTI with hospitalization, RSV-associated LRTI with ICU admission, and RSV-associated death. Important outcomes include all-cause medically attended LRTI, all-cause LRTI-associated hospitalization, and serious adverse events.

[¶] Phase 2b trial locations: Argentina, Australia, Brazil, Bulgaria, Canada, Chile, Czechia, France, Hungary, Italy, New Zealand, Poland, Russia, South Africa, Spain, United Kingdom, and United States; phase 3: Austria, Belgium, Bulgaria, Canada, Czechia, Estonia, Finland, France, Germany, Israel, Japan, Latvia, Lithuania, Poland, Russia, South Africa, South Korea, Spain, Sweden, United Kingdom, and United States.

[**] An additional trial was conducted that enrolled 615 preterm infants born at <35 weeks' gestation and who were eligible to receive palivizumab and 310 infants with either chronic lung disease and requiring medical intervention within 6 months of randomization or hemodynamically significant CHD. Participants were randomized (2:1) to either receive 1 dose of nirsevimab or monthly injections of palivizumab. The trial was designed as a pharmacokinetic study and was not designed to measure efficacy. A nirsevimab concentration target was established based on the phase 2b and phase 3 trials. The preterm, CHD, and chronic lung disease cohorts all met the threshold. In addition, day 150 postinjection concentrations in the increased risk trial were comparable or higher than in the phase 3 trial. This study did not meet criteria for inclusion in GRADE for efficacy of infants in their first RSV season because there was no placebo control group.

[††] In the phase 2b trial, all infants in the treatment arm received 50 mg nirsevimab. Among infants who weighed ≥5 kg (≥11 lb), nirsevimab concentrations and efficacy were found to be lower. In the phase 3 trial, the dose remained 50 mg for those who weighed <5 kg (<11 lb) and increased to 100 mg for those who weighed ≥5 kg (≥11 lb). Among 969 infants in the phase 2b trial treatment arm, 399 (41%) were excluded from pooled analyses.

[§§] Medically attended LRTI was defined as at least one documented physical examination finding localized to the lower respiratory tract, clinical signs and symptoms of severe respiratory disease, an inpatient or outpatient encounter, and a positive RSV polymerase chain reaction test result.

[¶¶] For benefit outcomes rated as important for policy decisions by the Work Group, nirsevimab lowered the risk for all-cause medically attended LRTI (efficacy = 34.8% [95% CI = 23.0%–44.7%]) and all-cause LRTI-associated hospitalization (efficacy = 44.9% [95% CI = 24.9%–59.6%]).

[***] Serious adverse events were defined in the protocol as any adverse event that results in death, is immediately life-threatening, requires inpatient hospitalization or prolongs an existing hospitalization, results in persistent or significant disability/incapacity, or is an important medical event that might jeopardize the subject or might require medical intervention to prevent one of the outcomes listed.

[†††] No adverse events of anaphylaxis or immune complex disease were reported. Two adverse events of special interest, both thrombocytopenia, were reported. One event was diagnosed as heparin-induced thrombocytopenia, and one occurred in a patient with a diagnosis of sepsis; neither was assessed as being attributable to or related to nirsevimab. Among the initially enrolled 1,490 infants in the phase 3 trial, the incidence of medically attended RSV-associated LRTI 351–510 days after injection was not significantly different in the nirsevimab (0.7%) and control (0.2%) arms, suggesting that protection provided from nirsevimab does not result in a shift in the RSV burden to the second year of life. The incidence of new onset chronic disease was similar in the nirsevimab (0.3%) and placebo (0.4%) arms. Among all participants in the phase 2b and phase 3 trials, adverse events were reported in 1.2% of participants who received nirsevimab within 360 days of the injection. Most (97%) of these were mild to moderate in intensity. Adverse reactions that were more common among infants who received nirsevimab than placebo were rash occurring within 14 days of injection (0.9% of nirsevimab recipients versus 0.6% of placebo recipients) and injection site reactions occurring within 7 days of injection (0.3% of nirsevimab recipients versus 0% of placebo recipients).

Among infants at increased risk for severe disease who are entering their second RSV season, evidence was derived from a single trial that enrolled 615 preterm infants born at <35 weeks' gestation who were eligible to receive palivizumab and 310 infants with either chronic lung disease requiring medical intervention within 6 months of randomization or hemodynamically significant congenital heart disease (CHD) (*19*). Participants were randomized to receive nirsevimab or palivizumab.[§§§] Efficacy against medically attended RSV-associated LRTI was extrapolated from pharmacokinetic data.[¶¶¶] Nirsevimab concentration levels among infants and children aged ≤24 months with chronic lung disease or CHD who received 200 mg nirsevimab entering their second RSV season were comparable to levels among those who received 50 mg if weighing <5 kg (<11 lb) and 100 mg if weighing ≥5 kg (≥11 lb) in their first RSV season. During the participants' second RSV season, the incidence of serious adverse events did not significantly differ between the nirsevimab and palivizumab arms. The overall evidence certainty using GRADE criteria was rated as very low. Because nirsevimab appears to have efficacy as high as, or higher than, palivizumab (although no head-to-head efficacy trials exist) (*20*), and is assumed to be less costly (*21*), replacing palivizumab with nirsevimab for the palivizumab-eligible children entering their second season is expected to be cost saving. The GRADE evidence profile and supporting evidence for the EtR Framework are available at https://www.cdc.gov/vaccines/acip/recs/grade/nirsevimab-season2-rsv-infants-children.html and https://www.cdc.gov/vaccines/acip/recs/grade/nirsevimab-season2-rsv-infants-children-etr.html.

Cost Effectiveness

The cost effectiveness for use of nirsevimab for infants aged <8 months born during or entering their first RSV season (at $445 per dose) was estimated to be $102,811 per quality adjusted life year (*21*). Because infants and children entering their second RSV season are at reduced risk for severe RSV disease compared with infants during their first RSV season, cost effectiveness for use of nirsevimab for the general population of children entering their second season (at $890 per dose)[****] was estimated to be $1,557,544 per quality adjusted life year (*21*). Data to assess the incidence of severe RSV disease and death by type of chronic disease during their second RSV season are limited (*21*), as are data on efficacy and safety of nirsevimab among infants and children in their second RSV season.

Recommendations for Use of Nirsevimab

ACIP recommends 1 dose of nirsevimab for all infants aged <8 months born during or entering their first RSV season (50 mg for infants weighing <5 kg [<11 lb] and 100 mg for infants weighing ≥5 kg [≥11 lb]). ACIP recommends 1 dose of nirsevimab (200 mg, administered as two 100 mg injections given at the same time at different injection sites) for infants and children aged 8–19 months who are at increased risk for severe RSV disease and entering their second RSV season[††††] (Box). The recommendations for nirsevimab apply to infants and children recommended to receive palivizumab by AAP.[§§§§] These recommendations will be updated as new evidence becomes available.

Clinical Guidance

Timing of Nirsevimab Administration

Providers should administer nirsevimab to infants aged <8 months and to infants and children aged 8–19 months who are at increased risk for severe RSV disease beginning shortly before the start of the RSV season. On the basis of pre–COVID-19 pandemic patterns, nirsevimab could be administered in most of the continental United States from October through the end of March. Infants born shortly before or during the RSV season should receive nirsevimab within 1 week of birth. Nirsevimab administration can occur during the birth hospitalization or in the outpatient setting. Optimal timing for nirsevimab administration is shortly before the RSV

[§§§] Among infants in their first RSV season, those in the nirsevimab arm received 50 mg if they weighed <5 kg (<11 lb) and 100 mg if they weighed ≥5 kg (≥11 lb). Participants with chronic lung disease or CHD who received nirsevimab in season 1 also received nirsevimab in season 2, and those who received palivizumab in season 1 were rerandomized in a 1:1 ratio to receive nirsevimab or palivizumab in season 2. In season 2, nirsevimab was administered as a 200 mg dose followed by four monthly injections of placebo. Palivizumab was administered as 5 monthly 15 mg/kg doses.

[¶¶¶] Pharmacokinetic extrapolation was used and based on comparable pharmacokinetic levels from efficacy data among infants aged <12 months for prevention of the first medically attended RSV-associated LRTI to pharmacokinetic levels among infants and children aged ≤24 months with chronic lung disease or CHD entering their second RSV season. On the basis of pharmacokinetic and efficacy data from the phase 2b and phase 3 (MELODY) trials, a target area under the curve nirsevimab concentration of >12.8 mg*day/mL was established. For the chronic lung disease cohort, 129 of 132 (98%) participants met the target nirsevimab concentration, and for the CHD cohort, all participants met the target. In addition, the concentration of nirsevimab 150 days after injection was higher compared with the 150-day concentration in the phase 3 trial nirsevimab arm population.

[****] Assumes that the cost of 200 mg of nirsevimab will be twice that of 100 mg. The cost of 50 mg and 100 mg of nirsevimab was assumed to be the same. https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2023-08-3/02-RSV-jones-508.pdf

[††††] Infants and children aged ≥8 months have likely experienced an RSV season and are at decreased risk for severe RSV-associated disease compared with younger infants without previous RSV exposure. Children aged ≥20 months have likely experienced two RSV seasons and are at decreased risk for severe disease compared with younger children who have experienced only one RSV season.

[§§§§] AAP has released guidance on the use of palivizumab and nirsevimab. https://publications.aap.org/redbook/resources/25379

Summary

What is already known about this topic?

In July 2023, the Food and Drug Administration approved nirsevimab, a long-acting monoclonal antibody, for prevention of respiratory syncytial virus (RSV) lower respiratory tract disease in infants.

What is added by this report?

On August 3, 2023, the Advisory Committee on Immunization Practices recommended nirsevimab for infants aged <8 months born during or entering their first RSV season and for infants and children aged 8–19 months who are at increased risk of severe RSV disease entering their second RSV season.

What are the implications for public health practice?

Nirsevimab can prevent severe RSV disease among infants and children aged <20 months at increased risk for severe RSV disease.

season begins; however, nirsevimab may be administered to age-eligible infants and children who have not yet received a dose at any time during the season. Only a single dose of nirsevimab is recommended for an RSV season. Infants with prolonged birth hospitalizations related to prematurity or other causes should receive nirsevimab shortly before or promptly after hospital discharge.[¶¶¶¶] No evidence is available to support use of nirsevimab for prevention of hospital-acquired RSV infection, and nirsevimab is not recommended for this indication.

Because the timing of the onset, peak, and decline of RSV activity might vary geographically, providers can adjust administration schedules based on local epidemiology. RSV seasonality in tropical climates (including southern Florida, Guam, Hawaii, Puerto Rico, U.S.-affiliated Pacific Islands, and U.S. Virgin Islands) might differ from that of most of the continental United States or be unpredictable (*21*–*23*). In Alaska, RSV seasonality is less predictable, and the duration of RSV activity is often longer than the national average duration (*24*). Providers in these jurisdictions should consult state, local, or territorial guidance on timing of nirsevimab administration.

Coadministration with Routine Childhood Vaccines

On the basis of limited data from clinical trials, coadministration of nirsevimab with routine vaccines resulted in a similar rate of adverse events compared with administration of vaccines alone (*25*). Nirsevimab is not expected to interfere with the immune response to other routine childhood immunizations (*26*). In accordance with general best practices for immunization, simultaneous administration of nirsevimab with age-appropriate vaccines is recommended (*27*).

[¶¶¶¶] Consistent with general best practices for immunization, the chronologic (not corrected) age of preterm infants should be used to determine timing and eligibility for nirsevimab administration.

Infants and Children Aged 8–19 Months at Increased Risk for Severe RSV Disease and Entering Their Second RSV Season

Infants and children aged 8–19 months who are at increased risk for severe RSV disease and who are entering their second RSV season (timing of season as defined above) are recommended to receive nirsevimab. Replacing palivizumab with nirsevimab is expected to be cost saving, and ACIP recommends nirsevimab for eligible children entering their second RSV season, similar to groups of children recommended by AAP for palivizumab during their second RSV season (*16*) (Box). In addition, research suggests that some American Indian or Alaska Native (AI/AN) children experience high rates of severe RSV disease. A recent study found that incidence of RSV-associated hospitalization among some AI/AN children aged 12–23 months was four to 10 times that of similar-aged children across seven sites in the United States (*28*). These studies have been limited to specific populations and might not be broadly representative of risk in all AI/AN children. Some AI/AN communities live in remote regions, making transportation of children with severe RSV more challenging (*16*). Given the available evidence, ACIP also recommends nirsevimab for AI/AN children entering their second RSV season.

Precautions and Contraindications

When administering nirsevimab to children with increased risk for bleeding, providers should follow ACIP's general best practice guidelines for immunization (*27*). Nirsevimab is contraindicated in persons with a history of severe allergic reaction (e.g., anaphylaxis) after a previous dose or to a product component. Adverse reactions might occur after administration of nirsevimab alone; these reactions may be reported to

BOX. Infants and children aged 8–19 months with increased risk for severe disease who are recommended to receive nirsevimab when entering their second respiratory syncytial virus season

- Children with chronic lung disease of prematurity who required medical support (chronic corticosteroid therapy, diuretic therapy, or supplemental oxygen) any time during the 6-month period before the start of the second RSV season
- Children with severe immunocompromise
- Children with cystic fibrosis who have either 1) manifestations of severe lung disease (previous hospitalization for pulmonary exacerbation in the first year of life or abnormalities on chest imaging that persist when stable) or 2) weight-for-length <10th percentile
- American Indian or Alaska Native children

Abbreviation: RSV = respiratory syncytial virus.

MedWatch online (https://www.fda.gov/medwatch), by fax, by mail, or by contacting FDA at 1-800-FDA-1088.*****

Adverse reactions might occur after the coadministration of nirsevimab with a vaccine; these reactions should be reported to the Vaccine Adverse Event Reporting System (VAERS), and reports should specify that the patient received nirsevimab on the VAERS form.††††† Reports can be submitted to VAERS online, by fax, or by mail. Additional information about VAERS is available by telephone (1-800-822-7967) or online (https://vaers.hhs.gov). When adverse reactions that occur after the coadministration of nirsevimab with a vaccine are reported to VAERS, additional reporting of the same adverse reactions to MedWatch is not necessary.

***** Adverse events can be reported to MedWatch because FDA has classified nirsevimab as a drug.

††††† Specifically, in Section 9: "Prescriptions, over-the-counter medications, dietary supplements, or herbal remedies being taken at the time of vaccination."

Acknowledgments

Voting members of the Advisory Committee on Immunization Practices (in addition to listed authors): Lynn Bahta, Minnesota Department of Health; Wilbur H. Chen, University of Maryland School of Medicine; Sybil Cineas, Warren Alpert Medical School of Brown University; Matthew F. Daley, Kaiser Permanente Colorado; Grace M. Lee, Stanford University School of Medicine; Jamie Loehr, Cayuga Family Medicine; Veronica V. McNally, Franny Strong Foundation; Katherine A. Poehling, Wake Forest School of Medicine; H. Keipp Talbot, Vanderbilt University Medical Center.

ACIP Pediatric/Maternal RSV Work Group

Chair: Sarah S. Long, Drexel University College of Medicine; ACIP Members: Oliver Brooks, Watts Healthcare Corporation; Camille N. Kotton, Harvard Medical School; Pablo J. Sánchez, The Research Institute at Nationwide Children's Hospital; Consultants: Kevin Ault, Western Michigan University; Carol Baker, McGovern Medical School, University of Texas Health Science Center; Helen Chu, University of Washington; Daniel Feikin, World Health Organization; Natasha Halasa, Vanderbilt University; Denise Jamieson, Emory University School of Public Health; Cody Meissner, Dartmouth Geisel School of Medicine; Liaison Representatives: Nicole Chaisson, American Academy of Family Physicians; Molly Howell, Association of Immunization Managers; Brenna L. Hughes, American College of Obstetricians and Gynecologists; James McAuley, Infectious Diseases Society of America; Sean T. O'Leary, American Academy of Pediatrics; Jennifer Schuster, Pediatric Infectious Diseases Society; Patsy Stinchfield, National Foundation for Infectious Diseases; Ex-officio Members: Judy Beeler, Food and Drug Administration; Yodit Belew, Food and Drug Administration; Terry Dalle-Tezze, Department of Health and Human Services, Health Resources and Services Administration; Nicholas Geagan, Food and Drug Administration; April Killikelly, Public Health Agency of Canada; Sonnie Kim, National Institute of Allergy and Infectious Diseases; Jessica Lee, Centers for Medicare & Medicaid Services; Lucia Lee, Food and Drug Administration; Valerie Marshall, Office of the Assistant Secretary for Health; Winnie Siu, Public Health Agency of Canada; Prabha Viswanathan, Food and Drug Administration; Rachel Zhang, Food and Drug Administration; CDC Leads: Katherine Fleming-Dutra, Jefferson Jones; CDC Contributors: Amadea Britton, Karen R. Broder, Angie Campbell, Doug Campos-Outcalt, Melissa Coughlin, Nicole Dowling, Sally Ezra, Monica Godfrey, Aron Hall, Anne Hause, Fiona Havers, Andrew Leidner, Ruth Link-Gelles, Elizabeth Greene, Jessica MacNeil, Meredith McMorrow, Michael Melgar, Claire Midgley, Noelle-Angelique Molinari, Heidi Moline, Rebecca Morgan, Danielle Moulia, Neil Murthy, Christine Olson, Ismael Ortega-Sanchez, Manisha Patel, Pragna Patel, Amanda Payne, Jamison (Jamie) Pike, Derrell Powers, Mila Prill, Lauren Roper, Hannah Rosenblum, Heather Scobie, Andrea Sharma, David Shay, Tom Shimabukuro, Tami Skoff, Chris Taylor, Naomi Tepper, Stephanie Thomas, Natalie Thornburg, Megan Wallace, Melinda Wharton, Raigan Wheeler, Amber Winn, Patricia (Akpobome) Wodi.

Corresponding author: Jefferson M. Jones, media@cdc.gov.

[1]Coronavirus and Other Respiratory Viruses Division, National Center for Immunization and Respiratory Diseases, CDC; [2]Watts Healthcare Corporation, Los Angeles California; [3]Nationwide Children's Hospital, The Ohio State University College of Medicine, Columbus, Ohio; [4]Harvard Medical School, Boston, Massachusetts; [5]Immunization Services Division, National Center for Immunization and Respiratory Diseases, CDC; [6]Drexel University College of Medicine, Philadelphia, Pennsylvania.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Oliver Brooks reports advocacy work with the Immunize LA Families Coalition; no payments were received as part of this work. No other potential conflicts of interest were disclosed.

References

1. Food and Drug Administration. Beyfortus (nirsevimab-alip) product label. Silver Spring, MD: US Department of Health and Human Services, Food and Drug Administration; 2023. https://www.accessdata.fda.gov/drugsatfda_docs/label/2023/761328s000lbl.pdf
2. CDC. Grading of recommendations, assessment, development, and evaluation (GRADE): nirsevimab, season 1. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://www.cdc.gov/vaccines/acip/recs/grade/nirsevimab-season1-rsv-infants-children.html
3. CDC. Grading of recommendations, assessment, development, and evaluation (GRADE): nirsevimab, season 2. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://www.cdc.gov/vaccines/acip/recs/grade/nirsevimab-season2-rsv-infants-children.html
4. CDC. ACIP evidence to recommendations for use of nirsevimab in infants born during RSV season and entering their first RSV vaccine. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://www.cdc.gov/vaccines/acip/recs/grade/nirsevimab-season1-rsv-infants-children-etr.html
5. CDC. ACIP evidence to recommendations for use of nirsevimab in children 8–19 months of age with increased risk of severe disease entering their second RSV season. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://www.cdc.gov/vaccines/acip/recs/grade/nirsevimab-season2-rsv-infants-children-etr.html

6. Suh M, Movva N, Jiang X, et al. Respiratory syncytial virus is the leading cause of United States infant hospitalizations, 2009–2019: a study of the national (nationwide) inpatient sample. J Infect Dis 2022;226(Suppl 2):S154–63. PMID:35968878 https://doi.org/10.1093/infdis/jiac120
7. Glezen WP, Taber LH, Frank AL, Kasel JA. Risk of primary infection and reinfection with respiratory syncytial virus. Am J Dis Child 1986;140:543–6. PMID:3706232 https://doi.org/10.1001/archpedi.1986.02140200053026
8. Cohen C, Kleynhans J, Moyes J, et al. Incidence and transmission of respiratory syncytial virus in urban and rural communities in South Africa, 2017–2018: results of the PHIRST cohort study. Lancet [Preprint posted online May 11, 2023]. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4444438
9. Hall CB, Weinberg GA, Iwane MK, et al. The burden of respiratory syncytial virus infection in young children. N Engl J Med 2009;360:588–98. PMID:19196675 https://doi.org/10.1056/NEJMoa0804877
10. McLaughlin JM, Khan F, Schmitt HJ, et al. Respiratory syncytial virus-associated hospitalization rates among US infants: a systematic review and meta-analysis. J Infect Dis 2022;225:1100–11. PMID:33346360 https://doi.org/10.1093/infdis/jiaa752
11. Hansen CL, Chaves SS, Demont C, Viboud C. Mortality associated with influenza and respiratory syncytial virus in the US, 1999–2018. JAMA Netw Open 2022;5:e220527. PMID:35226079 https://doi.org/10.1001/jamanetworkopen.2022.0527
12. Thompson WW, Shay DK, Weintraub E, et al. Mortality associated with influenza and respiratory syncytial virus in the United States. JAMA 2003;289:179–86. PMID:12517228 https://doi.org/10.1001/jama.289.2.179
13. Hall CB, Weinberg GA, Blumkin AK, et al. Respiratory syncytial virus-associated hospitalizations among children less than 24 months of age. Pediatrics 2013;132:e341–8. PMID:23878043 https://doi.org/10.1542/peds.2013-0303
14. McLaurin KK, Farr AM, Wade SW, Diakun DR, Stewart DL. Respiratory syncytial virus hospitalization outcomes and costs of full-term and preterm infants. J Perinatol 2016;36:990–6. PMID:27490190 https://doi.org/10.1038/jp.2016.113
15. Ambrose CS, Chen X, Kumar VR. A population-weighted, condition-adjusted estimate of palivizumab efficacy in preventing RSV-related hospitalizations among US high-risk children. Hum Vaccin Immunother 2014;10:2785–8. PMID:25483483 https://doi.org/10.4161/hv.32082
16. Kimberlin DW, Barnett ED, Lynfield R, Sawyer MH, eds. American Academy of Pediatrics, Committee on Infectious Diseases. Respiratory syncytial virus [Section 3]. In: Red Book: 2021–2024 report of the Committee on Infectious Diseases. Itasca, IL: American Academy of Pediatrics; 2021:628–36.
17. Griffin MP, Yuan Y, Takas T, et al.; Nirsevimab Study Group. Single-dose nirsevimab for prevention of RSV in preterm infants. N Engl J Med 2020;383:415–25. PMID:32726528 https://doi.org/10.1056/NEJMoa1913556
18. Muller WJ, Madhi SA, Seoane Nuñez B, et al.; MELODY Study Group. Nirsevimab for prevention of RSV in term and late-preterm infants. N Engl J Med 2023;388:1533–4. PMID:37018470 https://doi.org/10.1056/NEJMc2214773
19. Domachowske J, Madhi SA, Simões EAF, et al.; MEDLEY Study Group. Safety of nirsevimab for RSV in infants with heart or lung disease or prematurity. N Engl J Med 2022;386:892–4. PMID:35235733 https://doi.org/10.1056/NEJMc2112186
20. Zhu Q, McLellan JS, Kallewaard NL, et al. A highly potent extended half-life antibody as a potential RSV vaccine surrogate for all infants. Sci Transl Med 2017;9:eaaj1928. PMID:28469033 https://doi.org/10.1126/scitranslmed.aaj1928
21. Jones J. Evidence to recommendations framework: nirsevimab updates [Presentation slides]. Presented at the Advisory Committee on Immunization Practices meeting, Atlanta, GA; August 3, 2023. https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2023-08-3/02-RSV-jones-508.pdf
22. Hamid S, Winn A, Parikh R, et al. Seasonality of respiratory syncytial virus—United States, 2017–2023. MMWR Morb Mortal Wkly Rep 2023;72:355–61. PMID:37022977 https://doi.org/10.15585/mmwr.mm7214a1
23. Matías I, García I, García-Fragoso L, et al. Trends of respiratory syncytial virus infections in children under 2 years of age in Puerto Rico. P R Health Sci J 2015;34:98–101. PMID:26061061
24. Bruden DJ, Singleton R, Hawk CS, et al. Eighteen years of respiratory syncytial virus surveillance: changes in seasonality and hospitalization rates in southwestern Alaska Native children. Pediatr Infect Dis J 2015;34:945–50. PMID:26065863 https://doi.org/10.1097/INF.0000000000000772
25. Food and Drug Administration, Antimicrobial Drugs Advisory Committee. FDA briefing document. Silver Spring, MD: US Department of Health and Human Services, Food and Drug Administration; 2023. https://www.fda.gov/media/169226/download
26. Esposito S, Abu-Raya B, Bonanni P, et al. Coadministration of anti-viral monoclonal antibodies with routine pediatric vaccines and implications for nirsevimab use: a white paper. Front Immunol 2021;12:708939. PMID:34456918 https://doi.org/10.3389/fimmu.2021.708939
27. CDC. General best practice guidelines for immunization. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://www.cdc.gov/vaccines/hcp/acip-recs/general-recs/index.html
28. Atwell JE, Hartman RM, Parker D, et al. RSV among American Indian and Alaska Native children: 2019 to 2020. Pediatrics 2023;152:e2022060435. PMID:37449336 https://doi.org/10.1542/peds.2022-060435

Asthma-Associated Emergency Department Visits During the Canadian Wildfire Smoke Episodes — United States, April– August 2023

Cristin E. McArdle, PhD[1,2]; Tia C. Dowling, MPhil[2,3]; Kelly Carey, MPH[4]; Jourdan DeVies, MS[4]; Dylan Johns, MS[4,5]; Abigail L. Gates, MSPH[4]; Zachary Stein, MPH[4]; Katharina L. van Santen, MSPH[4,5]; Lakshmi Radhakrishnan, MPH[4]; Aaron Kite-Powell, MS[4]; Karl Soetebier, MAPW[4]; Jason D. Sacks, MPH[6]; Kanta Sircar, PhD[2]; Kathleen P. Hartnett, PhD[4]; Maria C. Mirabelli, PhD[2]

Abstract

During April 30–August 4, 2023, smoke originating from wildfires in Canada affected most of the contiguous United States. CDC used National Syndromic Surveillance Program data to assess numbers and percentages of asthma-associated emergency department (ED) visits on days with wildfire smoke, compared with days without wildfire smoke. Wildfire smoke days were defined as days when concentrations of particulate matter (particles generally ≤2.5 μm in aerodynamic diameter) ($PM_{2.5}$) triggered an Air Quality Index ≥101, corresponding to the air quality categorization, "Unhealthy for Sensitive Groups." Changes in asthma-associated ED visits were assessed across U.S. Department of Health and Human Services regions and by age. Overall, asthma-associated ED visits were 17% higher than expected during the 19 days with wildfire smoke that occurred during the study period; larger increases were observed in regions that experienced higher numbers of continuous wildfire smoke days and among persons aged 5–17 and 18–64 years. These results can help guide emergency response planning and public health communication strategies, especially in U.S. regions where wildfire smoke exposure was previously uncommon.

Introduction

Millions of U.S. adults and children have been exposed to wildfire smoke* caused by smoke plumes originating from wildfires in Canada that began in April 2023 (*1*). Wildfire smoke is a complex mixture containing gases and particles, where particulate matter (particles generally ≤2.5 μm in aerodynamic diameter) ($PM_{2.5}$) is the pollutant of most health concern because it can exacerbate existing cardiovascular, metabolic, and respiratory conditions and thus lead to increased emergency department (ED) visits and hospitalizations based on day-to-day changes in wildfire smoke exposure (*2–4*). However, little is known about the health implications of prolonged episodes of high concentrations of wildfire smoke, such as those experienced during the recent wildfires in Canada. As a result, rapid assessment of related health impacts is needed to guide risk communications and reduce exposures and health effects attributed to wildfire smoke.

Methods

Wildfire smoke event days are defined at the U.S. Department of Health and Human Services (HHS) region† level when at least one Environmental Protection Agency (EPA) air quality monitor§ in the region measures ambient 24-hour average $PM_{2.5}$ concentrations ≥35.5 $\mu g/m^3$ (*5*), corresponding to the EPA Air Quality Index (AQI)¶ value of 101. AQI of 101 was selected because AQI ≥101 is the threshold for categorizing air quality as unhealthy. As the AQI increases, air quality becomes increasingly unhealthy (i.e., "Unhealthy for Sensitive Groups" [AQI = 101–150], "Unhealthy" [AQI = 150–200], "Very Unhealthy" [AQI = 201–300], and "Hazardous" [AQI ≥301]).

CDC analyzed data from the National Syndromic Surveillance Program (NSSP). NSSP collects data from approximately 6,000 EDs, representing 76% of all eligible facilities in the United States; 4,317 facilities, representing 85% of all NSSP facilities, were included in this analysis (*6*). Asthma-associated ED visits were defined as those with mention of asthma as the chief complaint for the ED visit.

Observed daily numbers and percentages of asthma-associated ED visits during April 30–August 4, 2023, were compared with expected numbers and percentages, stratified by HHS region and age group (0–4, 5–17, 18–64, and ≥65 years). Observed visits were defined as the number of visits reported to NSSP on a given day and expected visits were calculated using anomaly detection algorithms** (*6*) applied to

* Approximation based on U.S. Census Bureau estimated decennial population distribution by U.S. Department of Health and Human Services region and Environmental Protection Agency monitors meeting at least one measured 24-hour average concentration ≥35.5 $\mu g/m^3$ for $PM_{2.5}$ during April 30–August 4, 2023.

† Puerto Rico and U.S. Virgin Islands currently do not report data to the National Syndromic Surveillance Program. https://www.hhs.gov/about/agencies/iea/regional-offices/index.html

§ $PM_{2.5}$ values are reported at air quality monitors and aggregated across 24-hour periods. These air quality monitor-level data are used at the HHS regional level, with the maximum and minimum air quality monitor daily $PM_{2.5}$ values. Air quality monitors from all 50 states and District of Columbia are included. For the given period, 971–1,012 air quality monitors were reporting on a given day. Air quality monitors can report negative numbers or zero values. Air quality monitors not reporting on a given day were not categorized. Consistent reporting of air quality measures was reported during the study period with more than 76% of air quality monitors in each region reporting daily.

¶ https://www.airnow.gov/

** The anomaly detection method is automated to alternate between adaptive multiple linear regression and exponentially weighted moving average (EWMA) based on baseline data. When the regression model does not fit the baseline data well based on adjusted R-squared values (adjusted R-squared <0.60), then EWMA is used. Adaptive multiple linear regression fits a model to a baseline of 28 days and forecasts a predicted value 3 days after the last day of the baseline. The model adjusts for linear trends, day-of-week effects, and holidays. The predicted value is compared with the observed value and divided by the SE of prediction. In EWMA, weighted averages of recent data are compared with the average of the 28-day baseline and divided by the SD. When the p-value resulting from the Student's *t*-test applied to the test statistic is <0.05, the data point is classified as an anomaly.

the preceding 30 days of ED visits, excluding the most recent 2 days. Excess asthma-associated ED visits were calculated as the sum of observed visits minus the sum of expected visits for days with wildfire smoke exposure. Visit anomalies (i.e., higher-than-expected numbers of asthma-associated ED visits) were detected when either the number or percentage of asthma-associated ED visits was significantly higher than expected. Student *t*-tests were used to derive p-values, and $p<0.05$ was considered statistically significant. NSSP data were extracted from the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE) via the Rnssp package[††] and analyzed using R software (version 4.3.1; R Foundation). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[§§]

Results

During days of wildfire smoke occurring during April 30–August 4, 2023, overall observed asthma-associated ED visits[¶¶] were 17% higher than expected among all age groups and HHS regions. Increased (excess) asthma-associated ED visits were detected more commonly on days with a higher percentage of air quality monitors reporting $PM_{2.5}$ concentrations indicative of a wildfire smoke day (Supplementary Table, https://stacks.cdc.gov/view/cdc/132183). Specifically, Region 2 (Figure 1), Region 3 (Figure 2), and Region 5 (Figure 3) experienced the most wildfire smoke days with the highest reported $PM_{2.5}$ concentrations, the highest percentages of air quality monitors detecting wildfire smoke, and the highest number of excess asthma-associated ED visits.

Region 3 experienced 5 wildfire smoke event days, the highest total amount for any region with more than 1% of air quality monitors reporting AQI ≥101, with a maximum 24-hour average $PM_{2.5}$ concentration of 259 $\mu g/m^3$, and Region 2 and Region 5 experienced a total of 4 wildfire smoke event days, with each reporting a maximum 24-hour average $PM_{2.5}$ concentration of 204 $\mu g/m^3$ and 216 $\mu g/m^3$, respectively. Within the identified smoke event days, the percentages of air quality monitors reporting wildfire smoke by HHS region ranged from 0.5%–69.0% (Supplementary Table, https://stacks.cdc.gov/view/cdc/132183).

Region 2 experienced the largest increase in asthma-associated ED visits. During June 6–8, higher-than-expected asthma-associated ED visits occurred for all age groups on 2 days, representing 364 excess visits, and among patients aged 5–17 (2 days, 123 excess visits), 18–64 (2 days, 251 excess visits), and ≥65 years (2 days, 12 excess visits) (Figure 1) (Supplementary Table, https://stacks.cdc.gov/view/cdc/132183). On another day (June 29), wildfire smoke was detected at 2.4% of stations, but no days of higher-than-expected asthma-associated ED visits were detected in any age group (Figure 1).

In Region 3, during June 6–8, 1 day of higher-than-expected asthma-associated ED visits was observed among all age groups combined (179 excess visits), and 2 days of higher-than-expected visits were observed among patients aged 18–64 years (128 excess visits). During June 28–29, no higher-than-expected asthma-associated ED visits were observed (Figure 2). In Region 5 during June 27–29, 1 day of higher-than-expected asthma-associated ED visits was observed among all age groups (172 excess visits) and among persons aged 5–17 years (14 excess visits); among persons aged 18–64 years, 2 days of higher than expected asthma-associated ED visits were observed (155 excess visits).

Regions 1, 4, and 9 each experienced 1 day of wildfire smoke and, within these regions, higher-than-expected asthma-associated ED visits were only observed in Region 4. Region 7 experienced 4 days of wildfire smoke, but asthma-associated ED visits were not increased. In Region 8, 3 wildfire smoke days and 1 day of higher-than-expected asthma-associated ED visits occurred among persons aged 18–64 years, representing 18 excess visits. In Region 10, 4 wildfire smoke days with less than 1% of air quality monitors reporting AQI ≥101 had higher-than-expected asthma-associated ED visits representing 14 excess visits among persons aged 18–64 years.

Discussion

During 2023, wildfire smoke traveled hundreds of miles and affected communities resulting in multijurisdictional emergencies, air quality alerts, and significant increases in asthma-associated ED visits. Wildfire smoke had affected all HHS regions except Region 6 during April 30–August 4, 2023, resulting in ≥1 day of wildfire smoke. Increases in asthma-associated ED visits occurring during days of wildfire smoke highlight the need to reduce wildfire smoke exposure during such events and wildfire smoke–related morbidity across all age groups.

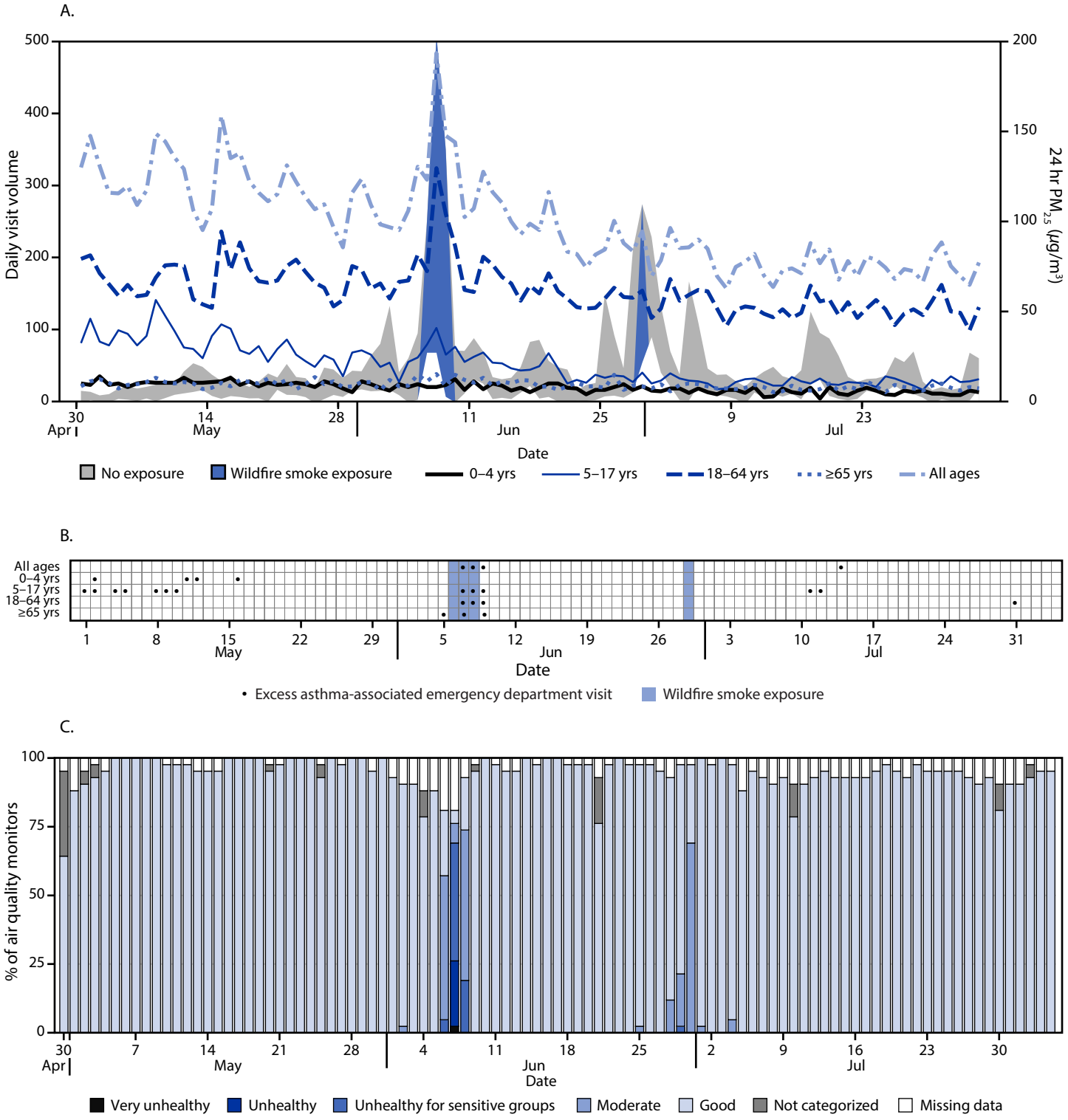
Asthma-associated ED visits increased in response to regional wildfire smoke patterns and when a higher percentage of air quality monitors reported AQI values ≥101 ($PM_{2.5}$ ≥35.5 $\mu g/m^3$) indicative of more wildfire smoke. Higher-than-expected asthma-associated ED visits were observed among persons of all ages and those aged 5–17, 18–64, and ≥65 years but were most common among persons aged 18–64 years. Information was not available about the extent to which patients with asthma were able to follow

[††] https://github.com/CDCgov/Rnssp

[§§] 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.

[¶¶] Calculated as the percentage with no age stratification for each HHS region during the exposure days using the equation [(excess ED visits / expected ED visit) x 100]. The percentage therefore represents the equation {[(observed ED visits – expected ED visits for exposure days) / expected ED visits] x 100}.

FIGURE 1. Trends in asthma-associated emergency department visits (A), excess asthma-associated emergency department visit detection (B), and the percentage of air quality monitors* reporting concentrations of fine particulate matter ≤2.5 μm in aerodynamic diameter indicative of wildfire smoke (C), by day — U.S. Department of Health and Human Services Region 2,† April 30, 2023–August 4, 2023§



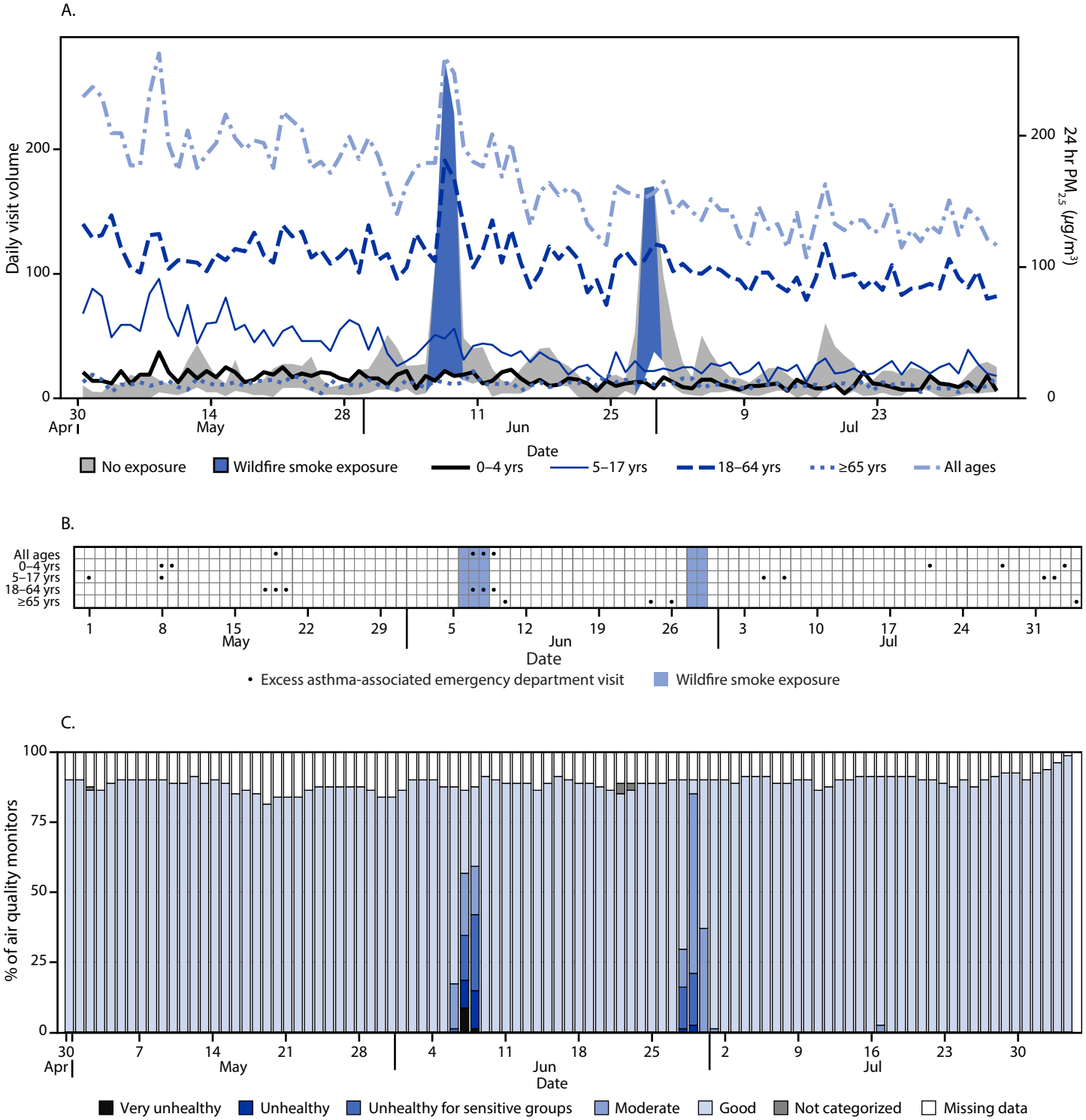
Abbreviation: $PM_{2.5}$ = particulate matter with aerodynamic diameter ≤2.5 μm.

* https://www.airnow.gov/aqi/aqi-basics/

† New Jersey and New York (Puerto Rico and U.S. Virgin Islands do not report data to the National Syndromic Surveillance Program).

§ A wildfire smoke exposure day occurs when at least one air quality monitor in the region reports $PM_{2.5}$ concentrations corresponding to an Air Quality Index of ≥101.

FIGURE 2. Trends in asthma-associated emergency department visits (A), excess asthma-associated emergency department visit detection (B), and the percentage of air quality monitors* reporting concentrations of fine particulate matter ≤2.5 μm in aerodynamic diameter indicative of wildfire smoke (C), by day — U.S. Department of Health and Human Services Region 3,† April 30, 2023–August 4, 2023§



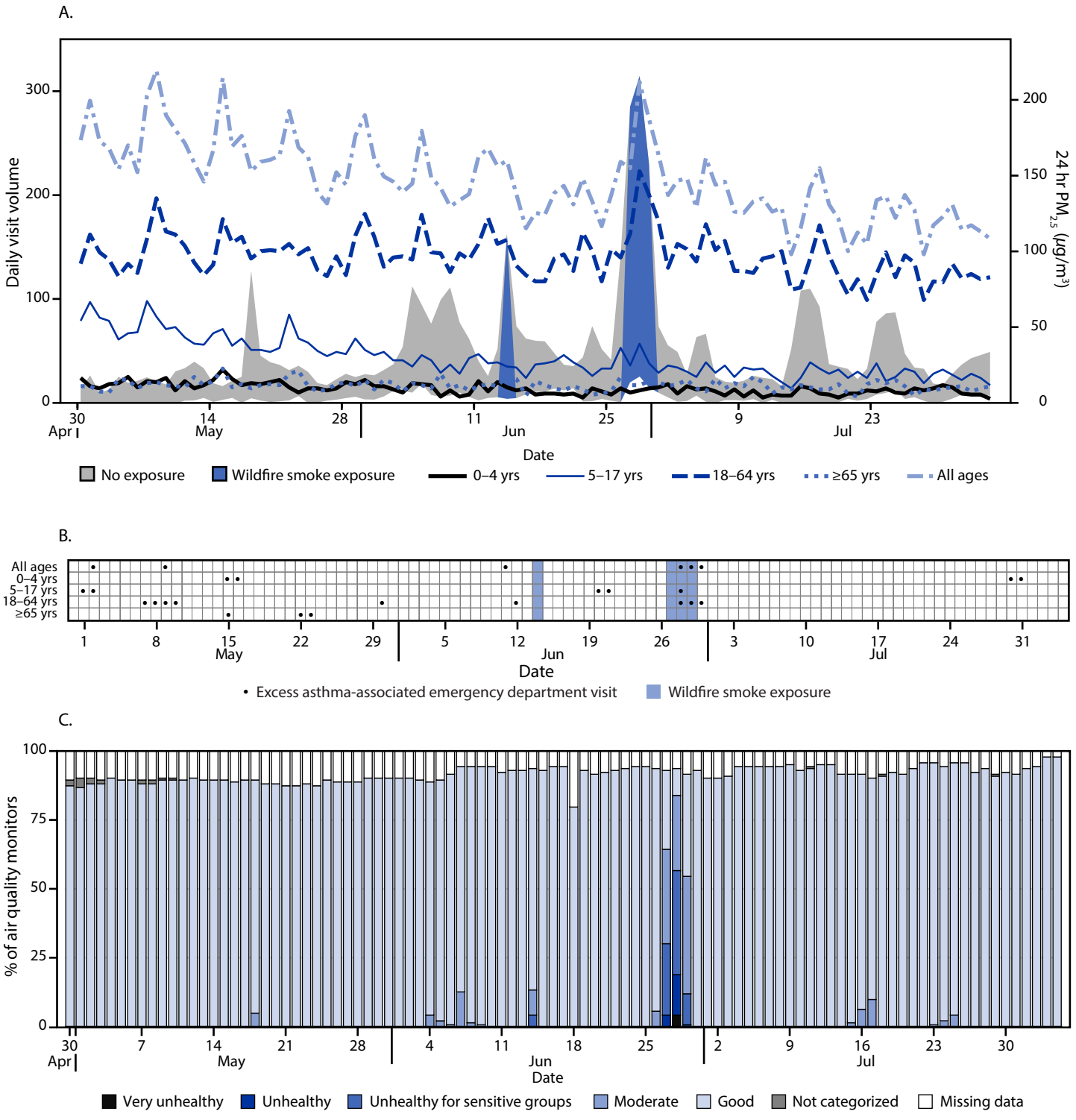
Abbreviation: $PM_{2.5}$ = particulate matter with aerodynamic diameter ≤2.5 μm.

* https://www.airnow.gov/aqi/aqi-basics/

† Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia.

§ A wildfire smoke exposure day occurs when at least one air quality monitor in the region reports $PM_{2.5}$ concentrations corresponding to an Air Quality Index of ≥101.

FIGURE 3. Trends in asthma-associated emergency department visits (A), excess asthma-associated emergency department visit detection (B), and the percentage of air quality monitors* reporting concentrations of fine particulate matter ≤2.5 μm in aerodynamic diameter indicative of wildfire smoke (C), by day — U.S. Department of Health and Human Services Region 5,† April 30, 2023–August 4, 2023§



Abbreviation: $PM_{2.5}$ = particulate matter with aerodynamic diameter ≤2.5 μm.

* https://www.airnow.gov/aqi/aqi-basics/

† Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin.

§ A wildfire smoke exposure day occurs when at least one air quality monitor in the region reports $PM_{2.5}$ concentrations corresponding to an Air Quality Index of ≥101.

Summary

What is already known about this topic?

As wildfires and wildfire smoke increase across the United States, symptoms of wildfire smoke exposure are of increasing public health concern.

What is added by this report?

Emergency department visits for asthma were 17% higher than expected during 19 days of wildfire smoke that occurred during April–August 2023.

What are the implications for public health practice?

Changes in asthma-associated emergency department visits during and after periods of wildfire smoke can be used by public health communicators, clinicians, policymakers, and the public to monitor and reduce exposure to wildfire smoke for persons with asthma.

exposure reduction measures during periods of high $PM_{2.5}$ concentration. Asthma-associated ED visit anomalies, which represent higher-than-expected visits, were also detected on days without wildfire smoke. These anomalies were primarily among persons aged <5 years and 5–17 years and during the first one half of the study period.

Jurisdictions interested in using syndromic surveillance to monitor the public health implications of wildfire smoke might consider using asthma as an initial indicator to develop strategies to reduce exacerbations and reach populations at increased risk for both exposure and adverse health effects. Expanded monitoring of health conditions, including cardiopulmonary-related ED visits, might also improve understanding of the severity of the impact of wildfire smoke on health outcomes and amplify prevention efforts to reduce these exacerbations.

Limitations

The findings in this report are subject to at least four limitations. First, AQI ≥101 occurred during the period of wildfires and the wildfire smoke plumes, but this report cannot directly attribute the increase in AQI to wildfires in Canada. Second, NSSP data are not nationally representative, and participation varies by HHS region. This report is aggregated by HHS region level and might not reflect subregional patterns of wildfire smoke health effects, especially in areas where air quality monitors and facilities do not have the same geographic distribution within HHS regions. Third, NSSP data contain information on persons who seek care through an emergency setting only and do not capture asthma-related visits through other health care settings (e.g., primary care and urgent care), which might underestimate the incidence of wildfire smoke–related health effects if those experiencing adverse health effects did not seek emergency care. Finally, wildfire smoke days were defined using AQI ≥101, which might not fully capture increases in $PM_{2.5}$ attributed to wildfire smoke, specifically in areas with low $PM_{2.5}$ concentrations where sharp increases can still result in AQI <101.

Public Health Implications

The risk of wildfire smoke exposure is increasing because of climate change, land management practice, and growth of wildland-urban interface areas, particularly in locations that have not historically experienced wildfire smoke (*7*). Syndromic surveillance data identified excess asthma-associated ED visits related to wildfire smoke and serve as some of the earliest available detection indicators. Community preparedness and appropriate and prompt response are crucial to reduce wildfire smoke exposure and morbidity. Recommended actions include assessing a possible health care utilization surge related to wildfire smoke exposure. Clinicians can consider counseling patients on protective measures (e.g., awareness of current and predicted air quality levels, staying indoors, using air filtration, and using properly fitted N95 respirators when outdoors), especially among persons with asthma, chronic obstructive pulmonary disease, cardiovascular disease, or children, older adults, and pregnant persons (*8*). Additional guidance to protect from wildfire smoke can be found online (*9*) and by using AirNow's Fire and Smoke Map, the AirNow app, or by listening to the Emergency Alert System and the National Oceanic and Atmospheric Administration's Weather Radio to monitor wildfire smoke levels. The findings from this report provide actionable information to identify and engage in wildfire smoke preparedness and risk communications to meet the needs of populations at highest risk for wildfire smoke–related adverse health effects.

Corresponding Author: Cristin E. McArdle, cmcardle@cdc.gov.

[1]Epidemic Intelligence Service, CDC; [2]Division of Environmental Health Science and Practice, National Center for Environmental Health, CDC; [3]Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee; [4]Detect and Monitor Division, Office of Public Health Data, Surveillance, and Technology, CDC; [5]ICF International, Reston, Virginia; [6]Center for Public Health and Environmental Assessment, Office of Research and Development, Environmental Protection Agency, Research Triangle Park, North Carolina.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Jason D. Sacks reports support from the European Respiratory Society to travel to and participate in the meeting, Clean Air in Europe for All Air Pollution and Health: Taking Stock of the Proposed Revisions to the Ambient Air Quality Directive, in Brussels, Belgium in May 2023, and serving as vice chair of the Career Mentoring Committee, American College of Epidemiology. No other potential conflicts of interest were disclosed.

References

1. Canadian Interagency Forest Fire Centre. Fire information. Winnipeg, Canada: Canadian Interagency Forest Fire Centre; 2023. https://www.ciffc.ca/
2. Cascio WE. Wildland fire smoke and human health. Sci Total Environ 2018;624:586–95. PMID:29272827 https://doi.org/10.1016/j.scitotenv.2017.12.086
3. Heaney A, Stowell JD, Liu JC, Basu R, Marlier M, Kinney P. Impacts of fine particulate matter from wildfire smoke on respiratory and cardiovascular health in California. GeoHealth 2022;6:1–14. PMID:35795228 https://doi.org/10.1029/2021gh000578
4. Environmental Protection Agency. Integrated science assessment (ISA) for particulate matter (final report, Dec 2019). Washington, DC: Environmental Protection Agency; 2019. https://cfpub.epa.gov/ncea/risk/recordisplay.cfm?deid=347534
5. Environmental Protection Agency. Technical assistance document for the reporting of daily air quality – the Air Quality Index (AQI). Washington, DC: Environmental Protection Agency; 2018. https://www.airnow.gov/sites/default/files/2020-05/aqi-technical-assistance-document-sept2018.pdf
6. Burkom H, Loschen W, Wojcik R, et al. Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE): overview, components, and public health applications. JMIR Public Health Surveill 2021;7:e26303. PMID:34152271 https://doi.org/10.2196/26303
7. National Academies of Sciences, Engineering, and Medicine. The chemistry of fires at the wildland-urban interface. Washington, DC: National Academies Press; 2022. PMID:36657007 https://doi.org/10.17226/26460
8. CDC. Wildfire smoke exposure poses threat to at-risk populations. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. https://emergency.cdc.gov/han/2023/han00495.asp
9. Environmental Protection Agency. Wildfire smoke factsheet. Reduce your smoke exposure. Washington, DC: Environmental Protection Agency; 2021. https://www.airnow.gov/sites/default/files/2021-07/reduce-your-smoke-exposure.pdf

Notes from the Field

Asthma-Associated Emergency Department Visits During a Wildfire Smoke Event — New York, June 2023

Haillie C. Meek, DVM[1,2]; Heather Aydin-Ghormoz, MS, MPA[1]; Kathleen Bush, PhD[1]; Neil Muscatiello, PhD[1]; Cristin E. McArdle, PhD[2,3]; Charlene X. Weng, MS[1]; Dina Hoefer, PhD[1]; Wan-Hsiang Hsu, PhD[1]; Eli S. Rosenberg, PhD[1,4]

During June 6–8, 2023, smoke from Eastern Canadian wildfires caused poor air quality across New York, driven by concentrations of particulate matter with aerodynamic diameter ≤2.5 μm ($PM_{2.5}$)*; air quality index reached "unhealthy" or "very unhealthy" levels across the state.† $PM_{2.5}$ from wildfire smoke is associated with an increased risk for medical emergencies, including asthma exacerbations (*1*). Characterizing such health outcomes during this wildfire smoke event can guide current and future response efforts.

Investigations and Outcomes

Daily mean $PM_{2.5}$ values were calculated using hourly measured concentrations (in $\mu g/m^3$) from one New York State Department of Environmental Conservation§ air monitor in each of eight regions¶ during June 1–14.** Asthma-associated emergency department (ED) visits were identified from chief complaints in the New York State Department of Health's Electronic Syndromic Surveillance System (ESSS), capturing all 134 EDs in New York, excluding New York City (NYC).†† Daily mean $PM_{2.5}$ concentration was compared with a $PM_{2.5}$ 10-year baseline (2013–2022) for June.§§ Daily asthma-associated ED visits were compared between the mean of June 1–5 and June 7, 2023, stratified by region and age group.¶¶ June 1–14 Pearson's correlation coefficients (rho [ρ]) between paired daily mean $PM_{2.5}$ and daily asthma-associated ED visits for each region were estimated. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.***

During June 1–14, daily mean $PM_{2.5}$ was highest on June 7 for all regions, except the Adirondacks,††† ranging from 55.2 $\mu g/m^3$ (Western) to 122.3 $\mu g/m^3$ (NYC metro), representing 590% and 1,229% increases, respectively, above 10-year baseline concentrations (8.0 $\mu g/m^3$ in Western and 9.2 $\mu g/m^3$ in NYC metro). During June 1–14, a total of 1,310 asthma-associated ED visits were identified through ESSS (Figure). Compared with the mean number of ED visits during June 1–5, asthma-associated ED visits on June 7 increased 81.9% (from 80.8 to 147 visits) statewide and at least 35.4% for all regions except the Adirondacks.§§§ In those regions, the June 1–14 $PM_{2.5}$ and asthma-associated ED visit ρ ranged from 0.31 (Western) to 0.80 (Central). The largest region-specific increases in asthma-associated ED visits and highest ρ estimates were in the Eastern Lake Ontario (179.1% [from 8.6 to 24.0 visits], ρ = 0.70), Central (132.8% [from 11.6 to 27.0 visits], ρ = 0.80), and Upper Hudson Valley (86.4% [from 11.8 to 22.0 visits], ρ = 0.68) regions (Figure). Among persons aged 10–29, 30–49, 50–69, and ≥70 years, statewide asthma-associated ED visits increased 197.6% (from 16.8 to 50.0 visits), 77.1% (from 19.2 to 34.0 visits), 89.0% (from 16.4 to 31.0 visits), and 76.5% (from 6.8 to 12.0 visits), respectively, and decreased 7.4% (from 21.6 to 20.0 visits) for persons aged 0–9 years, from the June 1–5 mean to June 7.¶¶¶

* https://www.epa.gov/newsreleases/epa-statement-wildfire-smoke

† Air quality index is a measure that reflects the concentration of five major air pollutants regulated by the Clean Air Act and is based on the health-based national ambient air quality standard for each pollutant. During June 6–7, 2023, $PM_{2.5}$ was the pollutant of concern for all regions. https://www.airnow.gov/state/?name=new-york

§ Data from one monitor per region were used. Nonoptical monitors were preferred; however, in two regions only optical monitors were available. For the New York City (NYC) metro region, a non-NYC monitor was chosen because ED visit data were only for non-NYC counties. Where more than one monitor was eligible, selection was based on data completeness, mean and maximum daily $PM_{2.5}$ concentration, and centrality of location. A monitor in Westchester County was selected for NYC metro region because NYC was not included in this analysis.

¶ New York State Department of Environmental Conservation Air Quality Regions: *Long Island:* Nassau and Suffolk counties; *NYC metro:* Rockland and Westchester counties; *Lower Hudson:* Dutchess, Orange, Putnam, Sullivan, and Ulster counties; *Upper Hudson:* Albany, Columbia, Fulton, Greene, Montgomery, Rensselaer, Saratoga, Schenectady, Schoharie, and Washington counties; *Adirondacks:* Clinton, Essex, Franklin, Hamilton, Lewis, St. Lawrence, and Warren counties; *Eastern Lake Ontario:* Jefferson, Monroe, Oswego, and Wayne counties; *Central:* Allegany, Broome, Cayuga, Chemung, Chenango, Cortland, Delaware, Herkimer, Livingston, Madison, Oneida, Onondaga, Ontario, Otsego, Schuyler, Seneca, Steuben, Tioga, Tompkins, and Yates counties; *Western:* Cattaraugus, Chautauqua, Erie, Genesee, Niagara, Orleans, and Wyoming counties.

** NYC was not included in this analysis. Data collected during June 1–14 were analyzed to characterize 2 weeks of data with ≥5 days of air quality index <150 in all regions before and after the smoke event (June 6–8).

†† Chief complaint search terms were "asthma" and "airway," excluding "foreign" and "wheeze."

§§ Ten-year climatological $PM_{2.5}$ baseline levels were tabulated for each region on a monthly basis by New York State Department of Environmental Conservation.

¶¶ Comparisons were made with June 1–5, the period before the wildfire smoke event began and air quality reached unhealthy levels. Patients were assigned to region based on hospital location. Analyses excluded 31 asthma-associated ED visits that were missing hospital data.

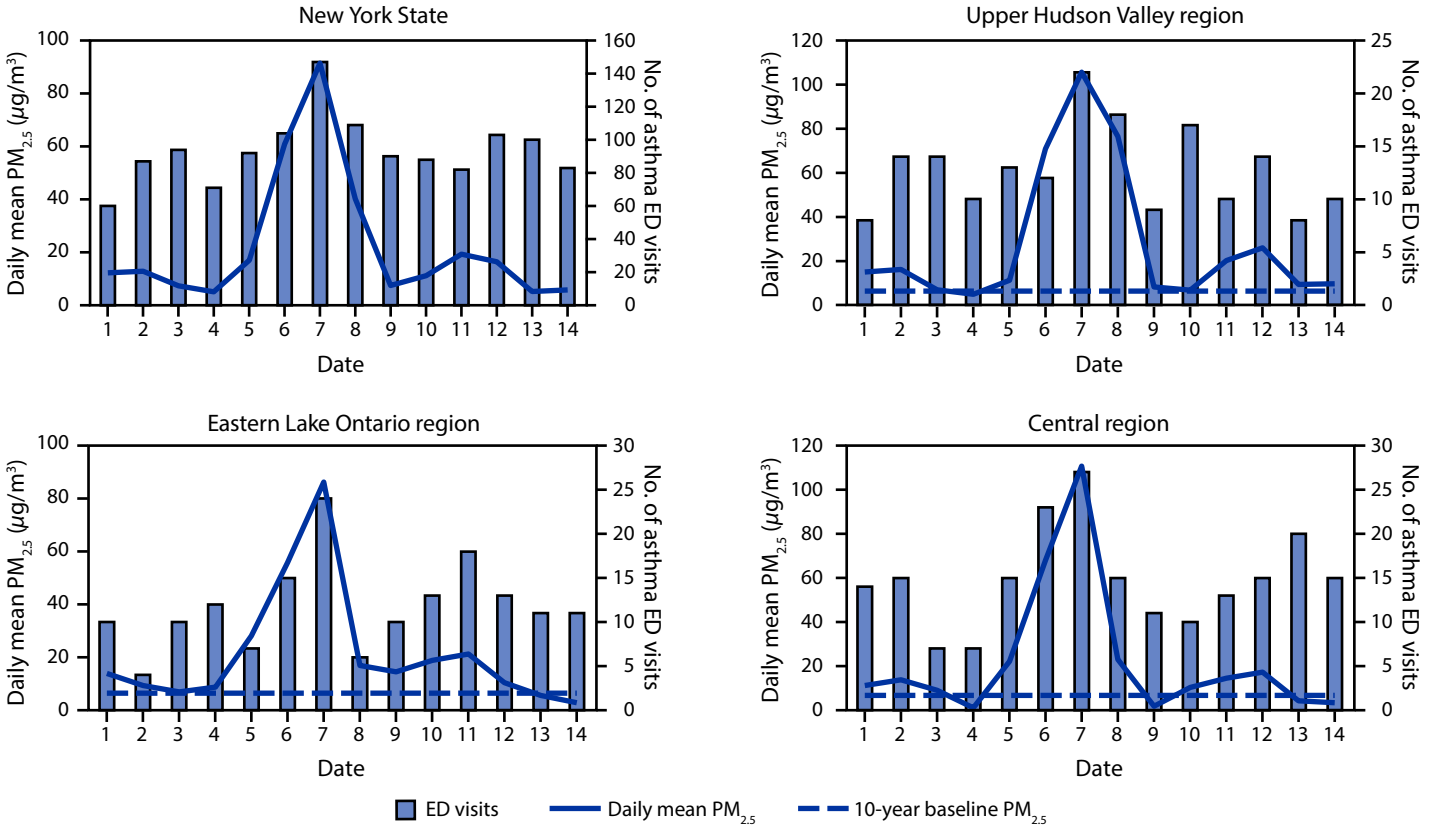
*** 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

††† In the Adirondacks region, the highest daily mean $PM_{2.5}$ concentration occurred on June 6.

§§§ In the Adirondacks region, compared to the June 1–5 daily mean, June 7 asthma-associated ED visits decreased by 16.7% (2.4 to 2 visits).

¶¶¶ In the Adirondacks region, ρ for daily mean $PM_{2.5}$ and asthma-associated ED visits on June 7 was −0.42.

FIGURE. Daily mean particulate matter with aerodynamic diameter ≤2.5 μm and number of asthma-associated emergency department visits statewide* and selected regions† — New York excluding New York City, June 1–14, 2023



Abbreviations: ED = emergency department; $PM_{2.5}$ = particulate matter with aerodynamic diameter ≤2.5 μm.
* Statewide mean $PM_{2.5}$ based on the region-specific daily mean from each of the eight air quality regions.
† Selected regions had the largest increases in June 7 asthma-associated ED visits compared with the mean during June 1–5.

Preliminary Conclusions and Actions

During this wildfire smoke event, increased concentration of $PM_{2.5}$ was linked to increased asthma-associated ED visits across New York, with twofold increases in the Eastern Lake Ontario and Central regions and a nearly threefold increase among older children and young adults. Limitations included the attribution of one air quality monitor to an entire region, potential underreporting of asthma exacerbations, and limited covariate data; however, these metrics represent excellent regional, near real-time data, which supported response efforts including recommendations to limit outdoor activities (*2*).

As wildfire smoke events become more frequent and widespread, the findings from this analysis can enhance risk communication and better focus response efforts toward persons at increased risk for asthma exacerbations (*2*,*3*). Children and non-Hispanic Black or African American persons disproportionately experience asthma exacerbations necessitating emergency care****; extreme weather events might worsen these health inequities (*4*). It is essential that public health responses prioritize strategies that reach these populations and promote health equity (*5*). These strategies include collaboration with physicians to ensure proactive communication about the risks of wildfire smoke to their patients with asthma and with schools to ensure effective wildfire smoke response plans.

**** https://www.cdc.gov/asthma/data-visualizations/default.htm (Accessed August 9, 2023).

Acknowledgments

Dirk Felton, Yasi Hassanzadeh, Margaret LaFarr, Julia Stuart, Amanda Teora, Randi Walker, Marilyn Wurth, New York State Department of Environmental Conservation; Kim Botto, Stephanie Mack, Lynley Siag, Samira Skochko, Brooke Turcotte, New York State Department of Health.

Corresponding author: Haillie C. Meek, qfg6@cdc.gov.

[1]New York State Department of Health; [2]Epidemic Intelligence Service, CDC; [3]Division of Environmental Health Science and Practice, National Center for Environmental Health, CDC; [4]Department of Epidemiology and Biostatistics, University at Albany School of Public Health, State University of New York, Rensselaer, New York.

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.

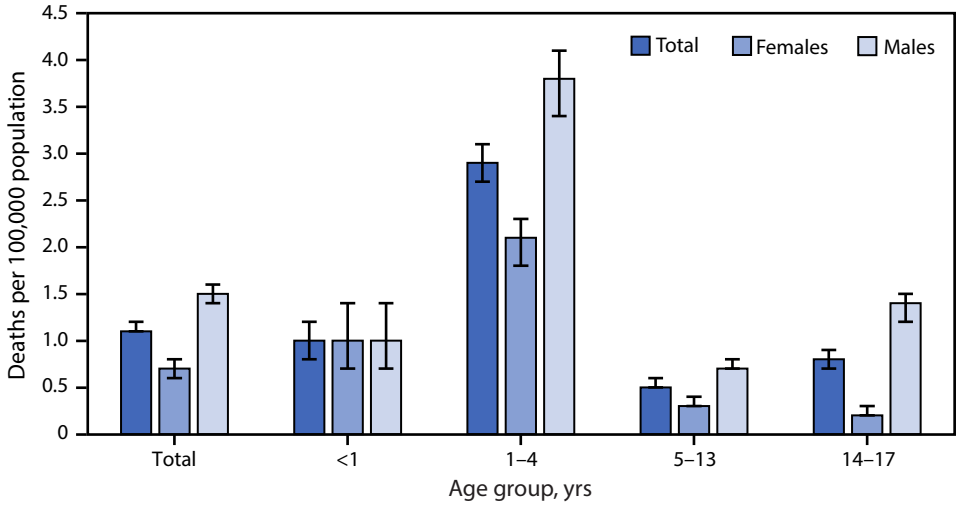
References

1. Reid CE, Brauer M, Johnston FH, Jerrett M, Balmes JR, Elliott CT. Critical review of health impacts of wildfire smoke exposure. Environ Health Perspect 2016;124:1334–43. PMID:27082891 https://doi.org/10.1289/ehp.1409277
2. New York State. Governor Hochul updates New Yorkers on statewide air quality issues and provides guidance for safe weekend activities [Press release]. Albany, NY: New York State, Office of the Governor; 2023. https://www.governor.ny.gov/news/governor-hochul-updates-new-yorkers-statewide-air-quality-issues-and-provides-guidance-safe
3. Brown EK, Wang J, Feng Y. US wildfire potential: a historical view and future projection using high-resolution climate data. Environ Res Lett 2021;16:1–11. https://doi.org/10.1088/1748-9326/aba868
4. Environmental Protection Agency. Climate change and social vulnerability in the United States: a focus on six impacts. Washington, DC: Environmental Protection Agency; 2021. https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf
5. CDC. Wildfire smoke exposure poses threat to at-risk populations. Atlanta, GA: US Department of Health and Human Services, CDC; 2023. Accessed August 4, 2023. https://stacks.cdc.gov/view/cdc/130523

QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Unintentional Drowning* Death Rates† of Children and Adolescents Aged 0–17 Years, by Sex and Age Group — United States, 2020–2021



* Unintentional drowning deaths were identified using *International Classification of Diseases, Tenth Revision* underlying cause-of-death codes W65–W74 (accidental drowning and submersion), V90 (accident to watercraft causing drowning and submersion), and V92 (water-transport–related drowning and submersion without accident to watercraft).
† Crude deaths per 100,000 population; 95% CIs indicated by error bars.

During 2020–2021, the unintentional drowning death rate was 1.1 deaths per 100,000 population among children and adolescents aged 0–17 years. Rates were higher among males (1.5) than females (0.7). Among children aged <1 year, boys and girls had similar unintentional drowning death rates (1.0), whereas rates were higher for males than for females among those aged 1–4 (3.8 versus 2.1), 5–13 (0.7 versus 0.3), and 14–17 years (1.4 versus 0.2). Rates were highest among those aged 1–4 years among all children and adolescents and among all males and females compared with other age groups.

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

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

For more information on this topic, CDC recommends the following link: https://www.cdc.gov/drowning/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)