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West Nile Virus and Other Nationally Notifiable Arboviral Diseases — United States, 2023

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Abstract

In the United States, arthropodborne viruses (arboviruses) are primarily transmitted by infected mosquitoes or ticks. Most infections are asymptomatic; symptomatic infections range from mild febrile illness to severe neuroinvasive disease. This report summarizes 2023 data for nationally notifiable domestic arboviral diseases. Forty-eight states and the District of Columbia reported 2,770 human arboviral disease cases, including 2,022 (73%) hospitalizations and 208 (8%) deaths. As in previous years, West Nile virus (WNV) was the most commonly reported domestic arboviral disease in 2023, accounting for 2,628 (95%) of all reported cases. A majority (91%) of case onsets occurred during July–September. Three WNV disease cases among patients infected though organ transplantation from two donors were reported in 2023. Powassan virus disease case reports were the second most common (n = 49), having increased from the previous record high in 2022, with onsets evenly distributed during April–December. La Crosse virus was the most common cause of arboviral disease among children, with most cases classified as neuroinvasive. Variations in annual arboviral disease incidence, distribution, and seasonal temporality highlight the importance of high-quality and timely surveillance. Clinicians should consider arboviral testing in patients with acute febrile or neurologic illness when mosquitoes and ticks are active and report positive test results to their health department. Reducing arboviral disease morbidity and mortality relies on population use of personal protective measures (e.g., insect repellent and protective clothing), implementing vector control efforts, and screening blood and organ donors for WNV.

Introduction

Arthropodborne viruses (arboviruses) are maintained in transmission cycles between arthropods and vertebrate hosts, including humans and other animals (*1*). In the United States, humans primarily become infected through the bites of infected mosquitoes or ticks; although rare, transmission can occur through blood transfusion or organ transplantation (*2*). The leading cause of arboviral disease in the United States is West Nile virus (WNV), which causes an average of 2,000 disease cases annually, including 1,200 life-threatening neurological illnesses and approximately 120 deaths (*3*). Other domestic arboviruses can cause sporadic cases and occasional outbreaks (*3*). Most infections are asymptomatic. Symptomatic infections can range from a mild febrile illness to severe neuroinvasive disease (*1*). Because no prophylactic agents or specific treatments are currently available for domestic arboviral infections, prevention is essential to reduce disease morbidity and mortality. This report includes an analysis of data for the six nationally notifiable domestic arboviral diseases (West Nile, Powassan, La Crosse, Jamestown Canyon, St. Louis encephalitis, and eastern equine encephalitis virus diseases), which typically have similar clinical features. This report provides an annual update on arboviral disease case

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numbers and incidence and increase awareness of the seasonal and geographic occurrence and characteristics of arboviral diseases in the United States (*3*,*4*).

Methods

Data Source

State health departments voluntarily report cases of the six nationally notifiable domestic arboviral diseases to CDC through ArboNET, the national arbovirus surveillance system, using standard surveillance case definitions that include clinical and laboratory criteria.* Confirmed and probable cases are included in this report; these cases are further classified as neuroinvasive (those with meningitis, encephalitis, acute flaccid paralysis, or other unspecified neurologic manifestation) or nonneuroinvasive (all other cases).

Analysis

Features of cases of the six domestic arboviral diseases are described, including incidence, demographic and clinical characteristics, period of illness onset, geographic distribution by location of residence, and outcomes. Incidence was calculated using 2023 midyear population estimates from the U.S. Census Bureau† as denominators. Incidence calculations were limited to neuroinvasive disease, though patterns seen for all cases are similar, because neuroinvasive disease cases are more consistently diagnosed and reported owing to severity of illness (*1*). Patient demographic and other characteristics were compared with previous year case data reported to ArboNET to identify consistencies and differences. This activity was reviewed by CDC, deemed not research, and conducted consistent with applicable federal law and CDC policy.§

Results

Reported Arboviral Disease Cases

A total of 2,770 confirmed (812; 29%) and probable (1,958; 71%) domestic arboviral disease cases with illness onset in 2023 were reported to CDC (Table 1). Overall, WNV accounted for 2,628 (95%) cases, followed by Powassan (49; 2%), La Crosse (35; 1%), Jamestown Canyon (27; 1%), St. Louis encephalitis (21; 1%), eastern equine encephalitis (seven; <1%), and unspecified California serogroup viruses¶ (three; <1%). Cases were reported from 772 (25%) of 3,143 U.S. counties and all 48 states in the contiguous United States and the District of Columbia (DC). More than one half (57%) of reported cases occurred in patients aged ≥60 years (except for La Crosse virus disease, incidence of which was highest in children), and 63% of all cases occurred in males.

* CDC | National Notifiable Diseases Surveillance System (NNDSS) | Arboviral Diseases, Neuroinvasive and Non-neuroinvasive 2015 Case Definition

† United States Census Bureau | State Population Totals and Components of Change: 2020–2024

§ 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.

¶ Unspecified California serogroup virus reports belong to the California serogroup (e.g., La Crosse, Jamestown Canyon, Snowshoe hare, and California encephalitis viruses) but the specific virus is unknown or not identified.

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West Nile Virus Disease

The 2,628 WNV disease cases identified in 2023 were reported from 692 (22%) counties in 46 states and DC. Similar to previous years, a majority of patients (91%) had illness onset during July–September. The median patient age was 63 years (IQR = 49–71 years), 63% were male, and 1,789 (68%) had neuroinvasive disease. A total of 1,891 (72%) patients were hospitalized, including 1,665 (88%) who had neuroinvasive disease. Overall, 194 (7%) patients with reported WNV died, including one of three patients who were infected through organ transplants received from two asymptomatic donors. The median age of all patients who died was 73 years (IQR = 66–82 years); 190 (98%) had neuroinvasive disease.

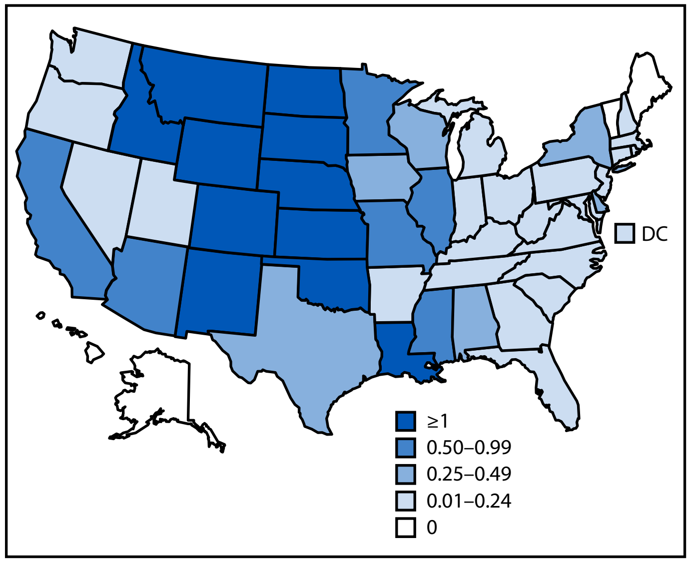
The national incidence of WNV neuroinvasive disease was 0.53 cases per 100,000 population (Table 2). The highest WNV neuroinvasive disease incidences were in Colorado (5.38 per 100,000), South Dakota (5.00), and Nebraska (4.60) (Figure); these states also had the highest incidence of total cases.** The largest numbers of WNV neuroinvasive disease cases were reported from California (334), Colorado (316), and Texas (122), accounting for 43% of neuroinvasive disease cases nationwide. WNV neuroinvasive disease incidence increased with age from 0.02 per 100,000 among persons aged <10 years to 1.56 per 100,000 among those aged ≥70 years. Incidence of WNV neuroinvasive disease was higher among males (0.68 per 100,000) than among females (0.38).

Powassan Virus Disease

Forty-nine cases of Powassan virus disease were reported from 11 states, representing the highest number of cases reported to ArboNET since 2004 when Powassan was added as a separate reportable disease condition. Illness onset for 96% of cases occurred during April–December, with cases evenly distributed across this period (Table 1). Two patients, both in New England, experienced illness onset in December. Maryland reported its first Powassan virus disease case in a resident who contracted the virus in Canada.†† Median patient age was 68 years (IQR = 58–72 years), and 65% were male. Forty-seven (96%) patients had neuroinvasive disease, 44 (90%) were hospitalized, and eight (16%) died. The median age of patients who died was 71 years (IQR = 67–78 years). States with the highest Powassan virus neuroinvasive disease incidence were Maine (0.50 per 100,000), New Hampshire (0.29), and Vermont (0.15) (Table 2).

** [Data and Maps for West Nile | West Nile Virus | CDC]
†† [Maryland Department of Health Announces First Travel-Related Case, Death due to Tickborne Illness Powassan]

FIGURE. Incidence* of confirmed† and probable§ cases of neuroinvasive¶ West Nile virus disease, by state — United States, 2023



Abbreviations: CSF = cerebrospinal fluid; DC = District of Columbia; Ig = immunoglobulin.
* Cases per 100,000 population.
† A confirmed case meets clinical criteria for arboviral disease and at least one of the following laboratory criteria: 1) isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid; 2) fourfold or higher change in virus-specific quantitative antibody titers in paired sera; 3) virus-specific IgM 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 test 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 without other testing.
¶ Cases with meningitis, encephalitis, acute flaccid paralysis, or other unspecified neurologic manifestation.

La Crosse Virus Disease

Thirty-five cases of La Crosse virus disease were reported from 10 states. Twenty-seven (77%) patients had illness onset during July–September (Table 1), and, similar to past years, 60% of patients were male, and most patients (91%) were aged <18 years. Thirty-four (97%) patients had neuroinvasive disease. All 35 patients were hospitalized; none died. Ohio reported the highest number of neuroinvasive La Crosse virus disease cases (12; 35%) (Table 2). States with the highest neuroinvasive La Crosse virus disease incidence were West Virginia (0.28 per 100,000), Ohio (0.10), and Tennessee (0.07).

Jamestown Canyon Virus Disease

Twenty-seven cases of Jamestown Canyon virus disease were reported from seven states. In 85% of cases, illness onset occurred during April–September (Table 1). Median patient age was 60 years, and 74% of patients were male. Twenty (74%) patients had neuroinvasive disease, 25 (93%) were

TABLE 1. Confirmed* and probable† cases of nationally notifiable arboviral disease, by virus type and selected patient characteristics (N = 2,770)§ — United States, 2023

	Virus type, no. (%)¶ of cases					
Characteristic	**West Nile n = 2,628**	**Powassan n = 49**	**La Crosse n = 35**	**Jamestown Canyon n = 27**	**St. Louis encephalitis n = 21**	**Eastern equine encephalitis n = 7**
Age group, yrs						
<18	40 (2)	4 (8)	32 (91)	3 (11)	0 (—)	2 (29)
18–59	1,072 (41)	11 (22)	1 (3)	10 (37)	7 (33)	1 (14)
≥60	1,516 (58)	34 (69)	2 (6)	14 (52)	14 (67)	4 (57)
Median age (IQR)	63 (49–71)	68 (58–72)	7 (4–11)	60 (40–73)	62 (54–73)	64 (7–72)
Sex						
Female	965 (37)	17 (35)	14 (40)	7 (26)	7 (33)	1 (14)
Male	1,663 (63)	32 (65)	21 (60)	20 (74)	14 (67)	6 (86)
Quarter of illness onset						
Jan–Mar	7 (<1)	2 (4)	0 (—)	0 (—)	0 (—)	0 (—)
Apr–Jun	73 (3)	16 (33)	0 (—)	10 (37)	1 (5)	2 (29)
Jul–Sep	2,389 (91)	16 (33)	27 (77)	13 (48)	17 (81)	5 (71)
Oct–Dec	155 (6)	15 (31)	8 (23)	4 (15)	3 (14)	0 (—)
Unknown	4 (<1)	0 (—)	0 (—)	0 (—)	0 (—)	0 (—)
Clinical syndrome						
Nonneuroinvasive	839 (32)	2 (4)	1 (3)	7 (26)	7 (33)	0 (—)
Neuroinvasive**	1,789 (68)	47 (96)	34 (97)	20 (74)	14 (67)	7 (100)
Encephalitis	1,107 (62)	34 (72)	31 (91)	17 (85)	5 (36)	5 (71)
Meningitis	464 (26)	2 (4)	3 (9)	3 (15)	2 (14)	0 (—)
AFP††,§§,¶¶	70 (4)	7 (15)	0 (—)	0 (—)	0 (—)	1 (14)
Unspecified	148 (8)	4 (9)	0 (—)	0 (—)	7 (50)	1 (14)
Outcome						
Hospitalization	1,891 (72)	44 (90)	35 (100)	25 (93)	17 (81)	7 (100)
Death	194 (7)	8 (16)	0 (—)	3 (11)	2 (10)	1 (14)

Abbreviations: AFP = acute flaccid paralysis; CSF = cerebrospinal fluid; Ig = immunoglobulin.
* A confirmed case meets clinical criteria for arboviral disease and at least one of the following laboratory criteria: 1) isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid; 2) fourfold or higher change in virus-specific quantitative antibody titers in paired sera; 3) virus-specific IgM 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 test 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 without other testing.
§ Three unspecified California serogroup virus cases were also reported but are not included in the table.
¶ Percentages might not sum to 100 because of rounding.
** Percentages of cases of encephalitis, meningitis, AFP, and unspecified neurologic signs or symptoms are percentages of neuroinvasive cases.
†† Among the 70 West Nile virus disease cases with AFP, 25 (36%) also had encephalitis or meningitis.
§§ Among the seven Powassan virus disease cases with AFP, six also had encephalitis.
¶¶ The one eastern equine encephalitis virus disease case with AFP also had encephalitis.

hospitalized, and three (11%) died. The highest incidences of neuroinvasive disease were reported from Wisconsin (0.19 per 100,000), Michigan (0.05), and Minnesota (0.03) (Table 2).

St. Louis Encephalitis Virus Disease

Twenty-one cases of St. Louis encephalitis virus disease were reported from three states, including the first-ever human disease case reported from South Carolina. Illness onset occurred during July–September in 81% of cases (Table 1). Median patient age was 62 years and 67% were male. Fourteen (67%) patients had neuroinvasive disease, 17 (81%) were hospitalized, and two (10%) died. The highest incidence of St. Louis encephalitis virus neuroinvasive disease was reported in California (0.03 per 100,000) (Table 2).

Eastern Equine Encephalitis Virus Disease

Seven cases of eastern equine encephalitis virus disease were reported from four states in 2023, which is the same as the median number of cases reported during 2003–2022. Illness onset in five of the seven cases occurred during July–September; two cases occurred during April–June (Table 1). Median patient age was 64 years, and six of the seven patients were male. All seven patients had neuroinvasive disease and were hospitalized; one patient died.

Discussion

WNV was reported most commonly, and La Crosse virus was the most common cause of neuroinvasive arboviral disease in children among the six notifiable domestic arboviral diseases reported during 2023. Whereas the 2,770 arboviral disease

TABLE 2. Confirmed[*] and probable[†] cases and incidence[§] of nationally notifiable arboviral neuroinvasive disease, by virus type and U.S. Census Bureau division and jurisdiction — United States, 2023

U.S. Census Bureau division/jurisdiction	No. (incidence) of neuroinvasive disease cases, by virus type[*]					
	West Nile	Powassan	La Crosse	Jamestown Canyon	St. Louis encephalitis	Eastern equine encephalitis
United States	**1,789 (0.53)**	**47 (0.01)**	**34 (0.01)**	**20 (0.01)**	**14 (<0.01)**	**7 (<0.01)**
New England	**11 (0.07)**	**28 (0.18)**	**—[¶]**	**—**	**—**	**—**
Connecticut	4 (0.11)	5 (0.14)	—	—	—	—
Maine	—	7 (0.50)	—	—	—	—
Massachusetts	5 (0.07)	10 (0.14)	—	—	—	—
New Hampshire	1 (0.07)	4 (0.29)	—	—	—	—
Rhode Island	1 (0.09)	1 (0.09)	—	—	—	—
Vermont	—	1 (0.15)	—	—	—	—
Middle Atlantic	**82 (0.20)**	**8 (0.02)**	**—**	**2 (<0.01)**	**—**	**—**
New Jersey	11 (0.12)	—	—	1 (0.01)	—	—
New York	53 (0.27)	6 (0.03)	—	1 (0.01)	—	—
Pennsylvania	18 (0.14)	2 (0.02)	—	—	—	—
East North Central	**175 (0.37)**	**2 (<0.01)**	**14 (0.03)**	**16 (0.03)**	**—**	**—**
Illinois	104 (0.83)	—	—	—	—	—
Indiana	9 (0.13)	—	1 (0.01)	—	—	—
Michigan	22 (0.22)	—	—	5 (0.05)	—	—
Ohio	16 (0.14)	—	12 (0.10)	—	—	—
Wisconsin	24 (0.41)	2 (0.03)	1 (0.02)	11 (0.19)	—	—
West North Central	**305 (1.40)**	**8 (0.04)**	**2 (0.01)**	**2 (0.01)**	**—**	**—**
Iowa	12 (0.37)	—	1 (0.03)	—	—	—
Kansas	46 (1.56)	—	—	—	—	—
Minnesota	44 (0.77)	8 (0.14)	1 (0.02)	2 (0.03)	—	—
Missouri	33 (0.53)	—	—	—	—	—
Nebraska	91 (4.60)	—	—	—	—	—
North Dakota	33 (4.21)	—	—	—	—	—
South Dakota	46 (5.00)	—	—	—	—	—
South Atlantic	**75 (0.11)**	**1 (<0.01)**	**13 (0.02)**	**—**	**1 (<0.01)**	**3 (<0.01)**
Delaware	4 (0.39)	—	—	—	—	—
District of Columbia	1 (0.15)		—	—	—	—
Florida	9 (0.04)	—	—	—	—	2 (0.01)
Georgia	17 (0.15)	—	—	—	—	1 (0.01)
Maryland	9 (0.15)	1 (0.02)	—	—	—	—
North Carolina	15 (0.14)	—	5 (0.05)	—	—	—
South Carolina	9 (0.17)	—	1 (0.02)	—	1 (0.02)	—
Virginia	9 (0.10)	—	2 (0.02)	—	—	—
West Virginia	2 (0.11)	—	5 (0.28)	—	—	—

See table footnotes on the next page.

cases reported in 2023 represented more than a doubling of the 1,247 cases reported in 2022 (*3*), this number was lower than the 3,035 cases reported in 2021, when a large focal WNV outbreak in Maricopa County, Arizona accounted for approximately one half of the total cases reported (*4*,*5*). The increase in reported arboviral disease cases from 2022 to 2023 was largely driven by a 132% increase in reported WNV disease cases (from 1,132 in 2022 to 2,628 in 2023), although the number of Powassan virus disease cases reported to ArboNET was the highest since reporting began in 2004, and the number of St. Louis encephalitis virus disease cases was the third highest in 2 decades (*3*).[§§]

[§§] Data and Maps for Powassan | Powassan Virus | CDC; Data and Maps for St. Louis Encephalitis | St. Louis Encephalitis Virus | CDC

Most domestic arboviral disease cases occur during July–September; however, Powassan virus disease cases were more evenly distributed during April–December, and Jamestown Canyon virus transmission began earlier in the spring compared with other mosquitoborne diseases. Differences in seasonality of arbovirus transmission partly reflect differences in the ecology and vectors transmitting these viruses. For example, ticks that can transmit Powassan virus are more active in cooler temperatures than are mosquitoes, and Jamestown Canyon virus is transmitted by a wide variety of mosquitoes (*6*). Changes in weather that support expansions in vector populations or animal hosts also likely affect disease occurrence (*5*).

Arboviral diseases continue to cause substantial morbidity in the United States. Over 7 of the past 10 years (excluding

TABLE 2. (*Continued*) Confirmed* and probable† cases and incidence§ of nationally notifiable arboviral neuroinvasive disease, by virus type and U.S. Census Bureau division and jurisdiction — United States, 2023

U.S. Census Bureau division/jurisdiction	No. (incidence) of neuroinvasive disease cases, by virus type* West Nile	Powassan	La Crosse	Jamestown Canyon	St. Louis encephalitis	Eastern equine encephalitis
East South Central	**75 (0.38)**	—	**5 (0.03)**	—	—	**3 (0.02)**
Alabama	25 (0.49)	—	—	—	—	3 (0.06)
Kentucky	10 (0.22)	—	—	—	—	—
Mississippi	27 (0.92)	—	—	—	—	—
Tennessee	13 (0.18)	—	5 (0.07)	—	—	—
West South Central	**216 (0.51)**	—	—	—	—	**1 (<0.01)**
Arkansas	7 (0.23)	—	—	—	—	—
Louisiana	46 (1.01)	—	—	—	—	1 (0.02)
Oklahoma	41 (1.01)	—	—	—	—	—
Texas	122 (0.40)	—	—	—	—	—
Mountain	**504 (1.96)**	—	—	—	—	—
Arizona	64 (0.86)	—	—	—	—	—
Colorado	316 (5.38)	—	—	—	—	—
Idaho	27 (1.37)	—	—	—	—	—
Montana	23 (2.03)	—	—	—	—	—
Nevada	2 (0.06)	—	—	—	—	—
New Mexico	54 (2.55)	—	—	—	—	—
Utah	5 (0.15)	—	—	—	—	—
Wyoming	13 (2.23)	—	—	—	—	—
Pacific	**346 (0.65)**	—	—	—	**13 (0.02)**	—
Alaska	—	—	—	—	—	—
California	334 (0.86)	—	—	—	13 (0.03)	—
Hawaii	—	—	—	—	—	—
Oregon	9 (0.21)	—	—	—	—	—
Washington	3 (0.04)	—	—	—	—	—

Abbreviations: CSF = cerebrospinal fluid; Ig = immunoglobulin.
* A confirmed case meets clinical criteria for arboviral disease and at least one of the following laboratory criteria: 1) isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid; 2) fourfold or higher change in virus-specific quantitative antibody titers in paired sera; 3) virus-specific IgM 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 test 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 without other testing.
§ Cases per 100,000 population, based on July 1, 2023, U.S. Census Bureau population estimates.
¶ Dashes indicate no reported cases.

2019, 2020, and 2022, during which the COVID-19 pandemic likely affected reporting), reported WNV human disease cases have consistently exceeded 2,000 cases per year (*3*,*4*,*7*). Although WNV human disease cases have previously only been associated with lineage 1 and 2 strains of the virus, in 2023, a patient in the United States was found to be coinfected with lineage 1b (the common U.S. strain) and lineage 3, which had only been found before in mosquitoes in central Europe (*8*). The prevalence of lineage 3 in the United States and its significance in human disease and transmission is unknown (*8*). Surveillance for human and animal disease cases and infected vectors are necessary to understand more about this novel lineage. Surveillance is important to lowering arboviral disease incidence by prompting timely prevention messaging and vector control activities.

Since the last WNV transplant transmission cluster was reported in 2018, four additional clusters were identified in 2021, 2022, and 2023 involving eight infected recipients with encephalitis and three deaths (*2*,*3*). These reports underscore the ongoing risk for transmission through solid organ transplantation associated with high morbidity and mortality and the need to potentially screen organ donors for the presence of viral RNA during periods of elevated WNV risk (*2*,*3*).

Limitations

The findings in this report are subject to at least two limitations. First, because ArboNET does not require inclusion of clinical signs and symptoms or diagnostic laboratory test results in case reports,¶¶ cases might be misclassified. Second, ArboNET is a passive surveillance system that relies on patients seeking health care, appropriate testing by clinicians, and reporting of arboviral disease cases; thus, prevalence is likely underestimated. Previous studies estimated that 30–70 nonneuroinvasive disease cases occur for every reported case of WNV neuroinvasive disease (*1*). Based

¶¶ CDC | West Nile Virus | Guidelines for West Nile Virus Surveillance and Control

Summary

What is already known about this topic?

U.S. arboviral infections occur primarily through bites from infected mosquitoes or ticks. West Nile virus (WNV) is the leading cause of arboviral disease, which typically manifests as acute febrile or neurologic illness.

What is added by this report?

In 2023, arboviral disease cases were reported from all contiguous U.S. states; most occurred during April–December. WNV cases were most common, followed by Powassan virus disease cases, which increased from the previous record high in 2022. Three WNV disease cases were reported among patients infected though organ transplantation from two donors. La Crosse virus was the most common cause of arboviral disease among children, with most cases classified as neuroinvasive.

What are the implications for public health practice?

Clinicians should consider arboviral testing for patients with acute febrile or neurologic illnesses when ticks and mosquitoes are active. Timely surveillance is needed to identify areas that pose a risk for arboviral infection. Personal prevention, vector control, and blood and organ donor screening for WNV are essential to reduce arboviral disease morbidity and mortality.

on the 1,789 neuroinvasive disease cases reported in 2023, an estimated 53,670–125,230 nonneuroinvasive disease cases likely occurred; however, only 839 (0.7%–1.6% of the estimated total) were reported.

Implications for Public Health Practice

Understanding the epidemiology, seasonality, and geographic distribution of domestic arboviruses is important for clinical recognition and guides community messaging efforts and vector control activities. Arboviral disease testing should be considered by clinicians for patients with an acute febrile or neurologic illness, including recipients of organ transplants or blood transfusions, particularly during times when ticks and mosquitoes are active. Testing for the specific causative agent should take into consideration the timing of illness onset and location of exposures. Although most testing can be done commercially, testing for less common viruses and confirmatory testing is often done at public health laboratories. WNV and Powassan virus testing are not typically included in commercial arboviral panels and should be ordered specifically if needed. For Powassan virus disease, the risk for infection is highest from spring to late fall in the Northeast and upper Midwest; thus, messaging (e.g., media and newsletters) to increase patient and provider awareness of the prolonged risk for infection should be considered. Because no prophylactic agents (e.g., human vaccines) or specific treatments (e.g., antiviral medications) are currently available to prevent or treat domestic arboviral infections, management is supportive, and prevention and control rely on personal protective measures (e.g., using insect repellent registered by the Environmental Protection Agency and wearing protective clothing),[***] vector control efforts both at household and community levels,[†††,§§§] and WNV blood and organ donor screening to minimize transfusion- and transplant-associated transmission.[¶¶¶]

[***] CDC | Mosquitoes | Preventing Mosquito Bites
[†††] CDC | Ticks | Preventing Tick Bites
[§§§] CDC | Mosquitoes | Mosquito Control
[¶¶¶] CDC | Blood Safety | Blood Safety Basics

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Health Care Use Preceding Suicide by Firearm Compared with Suicide by Other Means — Alaska, Colorado, and Washington, 2020–2022

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Abstract

Firearms are the most common means of suicide in the United States and a leading cause of death among all persons aged 10–64 years. Most persons who die by suicide see a clinician in the year preceding their death; thus, health care encounters are important opportunities for suicide prevention. Persons who die by firearm suicide differ demographically and clinically from those who die by other suicide means, suggesting that opportunities for prevention might also differ between these groups. This report examined patterns of health care use in the year preceding suicide death to identify potential opportunities for prevention among persons who died by firearm suicide and those who died by other means of suicide. State cause-of-death records for 2020–2022 were linked to electronic health records from health systems in Alaska (Southcentral Foundation) and Colorado and Washington (both Kaiser Permanente). Quarterly past-year health care use preceding death was examined across service settings, including primary care, outpatient mental health specialty care, emergency care, and inpatient care. During 2020–2022, across the three health systems, 683 persons died by suicide. The majority of these deaths (54.6%) occurred by firearm. Patterns of past-year health care use preceding suicide were similar for persons who died by firearm and other suicide means, with the exception of mental health care, which was significantly lower in specialty and primary care settings. These findings suggest that many persons who die by firearm suicide do not access mental health care before their death. Suicide prevention practices in health care, designed to help identify and engage persons at risk in supportive care, need to reach beyond mental health encounters, particularly for firearm suicide prevention.

Introduction

Suicide is the second leading cause of death in the United States among persons aged 10–44 years, and firearms are the most common means.* Health care encounters might represent important suicide prevention opportunities. Research has demonstrated that approximately 45% of persons who die by suicide have seen a clinician in the month before death, and most have seen a clinician in the year preceding suicide (*1*). Firearm suicide decedents have different demographic and clinical characteristics than do those who die by other means of suicide (*2*,*3*). For example, one recent study found that firearm suicide rates were highest among military service members, men, adults aged ≥65 years, and those living in rural areas (*2*). Another study found that persons who died by firearm suicide were less likely to have a diagnosed mental health condition, a substance use condition, or a previous suicide attempt documented in their medical record than did those who died by other suicide means (*3*).

Less clear is whether or how these demographic and clinical differences might affect prevention opportunities in health care systems. Research on care use preceding suicide death indicates that, whereas many decedents used primary health care services in the months preceding death, a smaller proportion used mental health specialty care (*1*). How these patterns in rates of care use might differ among those who die by firearm versus other suicide means is unknown.

This report examined patterns of health care use among persons who died by firearm suicide compared with those who died by other means of suicide in three large U.S. health care systems, to identify whether and how those patterns might differ among persons at risk for firearm suicide. Study results could help guide development and implementation of suicide prevention practices in health care systems nationwide.

Methods

Data Source and Study Population

State death records and electronic health records (EHRs) were obtained from three participating nonprofit health care systems, jointly serving more than one million persons. These included the Colorado and Washington regions of Kaiser Permanente, which are integrated insurance and health care providers each serving approximately 500,000 members, and the Southcentral Foundation, which serves approximately 70,000 American Indian and Alaska Native persons in the southcentral region of Alaska. Approvals to conduct these analyses were obtained from the Kaiser Permanente institutional review board, the Southcentral Foundation and Alaska Native Tribal Health Consortium research review committees, and the Indian Health Service Alaska Area institutional review board.

* Web-based Injury Statistics Query and Reporting System Leading Causes of Death – CDC; Web-based Injury Statistics Query and Reporting System Leading Causes of Death in the U.S., 1981–2023 – CDC

State medical examiner cause-of-death records were linked to EHR data to identify all persons enrolled in the three participating health care systems who died by suicide during 2020–2022. All Kaiser Permanente members and Southcentral Foundation customer-owners,† collectively referred to as patients in this report, aged ≥13 years who received care at least once in the 3 years preceding death, were included in the study sample. This inclusion was consistent with population-based denominator definitions (e.g., "enrolled" or "empanelled") used by care delivery leaders to determine how to improve the quality of care (i.e., prevention) and improve outcomes among patients considered to be actively receiving care from their organizations.

Data Measures

Cause-of-death indicators for means of death were defined using *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10-CM) mortality codes for intentional self-harm (X60–X84 and Y87.0), further categorized as having occurred by firearm (X72–X74) or nonfirearm means.§ Care use measures included all past-year health care visits preceding death for each suicide decedent and were categorized into subgroups of use using the service setting type; EHR data were supplemented with claims data at Kaiser Permanente sites. These health care visits included virtual or in-person primary care, urgent care, emergency care, inpatient care, and mental health specialty care encounters between a health care provider and patient. Asynchronous encounters, such as EHR-based reminders and messages were not included. Mental health ICD-10-CM codes (as defined in the Mental Health Research Network diagnosis codes)¶ were linked with health care encounters to better distinguish health care encounters that included a mental health component from health care provided for other conditions. Self-reported firearm access and patient characteristics known to be associated with suicide were used to describe the study population, on the basis of previous research at Kaiser Permanente Washington (*4*). Variables extracted from EHR data included patients' sociodemographic characteristics (age, sex, race and ethnicity, rural residency, and education [measured as percentage of the population with a college degree stratified by U.S. Census Bureau tract]), clinical characteristics (depression, anxiety, substance use disorders, suicide attempt, illness, and medical comorbidity [measured using the Charlson Comorbidity Index]) (*5*), and source of health insurance coverage.

† Customer-Ownership – Southcentral Foundation
§ ICD-10 Classification – World Health Organization
¶ 2024 Diagnosis Codes – Mental Health Research Network

Statistical Analysis

Analyses compared demographic and clinical characteristics of persons who died by firearm suicide with those of persons who died by other suicide means. Statistically significant differences were identified using Pearson's chi-square tests. Care-use plots were generated to examine quarterly use of health services received in primary care, outpatient mental health specialty care, emergency care, and inpatient care service settings in the year preceding death. Asymptotic 95% CIs were constructed based on the normal distribution. The mean and median number of visits across these service settings, during the 3, 6, and 12 months preceding death, were also calculated among those who received any care during the same time. Two-sided t-tests ($\alpha = 0.05$) were conducted to compare (among persons who used care) the mean number of health care visits among those who died by firearm suicide with the number among those who died by other suicide means. Post-hoc stratified analyses were added to further explore differences in care use patterns among males and females who died by firearm suicide versus other means.

Results

Sociodemographic and Clinical Characteristics

A total of 683 suicide deaths were recorded by three health care organizations in Alaska, Colorado, and Washington during 2020–2022, including 373 (54.6%) deaths by firearm and 310 (45.4%) by other means (Table). A higher proportion of males compared with females died by firearm suicide (87.9 versus 12.1%; p<0.01) and other means of suicide (62.6% versus 37.4%; p<0.01). The average age of persons who died by firearm suicide (50 years) was higher than those who died by other means (45 years; p<0.01).

Many sociodemographic characteristics were similar among persons who died by firearm suicide and those who died by other means of suicide. However, in the year preceding death, a lower percentage of persons who died by firearm suicide had received a mental health diagnosis than had those who died by other means of suicide, including anxiety (24.9% versus 39.0%; p<0.01), chronic serious mental illness (7.2% versus 11.6%; p = 0.07), depression (25.5% versus 35.8%; p<0.01), substance use problem (12.9% versus 20.0%; p = 0.02), and nonfatal suicidal self-harm or suicide attempt (7.0% versus 11.6%; p = 0.03). In contrast, a higher percentage of firearm suicide decedents had a Charlson Comorbidity Index score ≥2 (a medical comorbidity associated with increased risk for death) than did those who died by other suicide means (15.5% versus 7.1%; p<0.01).

TABLE. Characteristics of patients who died by firearm suicide versus other means of suicide — three health care systems,* Alaska, Colorado, and Washington, 2020–2022

Characteristic	No. (%)			p-value[†]
		Means of death		
	All suicide decedents N = 683	Firearm n = 373	Other n = 310	
Age group, yrs				
13–17	**27 (4.0)**	15 (4.0)	12 (3.9)	
18–39	**246 (36.0)**	127 (34.0)	119 (38.4)	
40–64	**248 (36.3)**	119 (31.9)	129 (41.6)	<0.01
≥65	**162 (23.7)**	112 (30.0)	50 (16.1)	
Mean (SD)	**48 (20)**	50 (22)	45 (19)	
Sex				
Female	**161 (23.6)**	45 (12.1)	116 (37.4)	<0.01
Male	**522 (76.4)**	328 (87.9)	194 (62.6)	
Race and ethnicity[§]				
American Indian or Alaska Native	**40 (5.9)**	13 (3.5)	27 (8.7)	<0.01
Asian or Pacific Islander	**18 (2.6)**	7 (1.9)	11 (3.5)	0.26
Black or African American	**18 (2.6)**	12 (3.2)	6 (1.9)	0.42
Hispanic or Latino	**44 (6.4)**	16 (4.3)	28 (9.0)	0.02
Native Hawaiian or Pacific Islander	**6 (0.9)**	4 (1.1)	2 (0.6)	—
White	**397 (58.1)**	236 (63.3)	161 (51.9)	<0.01
Other	**20 (2.9)**	12 (3.2)	8 (2.6)	0.79
Multiracial	**7 (1.0)**	6 (1.6)	1 (0.3)	—
Unknown	**166 (24.3)**	85 (22.8)	81 (26.1)	0.36
Health care insurance				
Commercial	**349 (51.1)**	188 (50.4)	161 (51.9)	
Indian Health Service	**32 (4.7)**	9 (2.4)	23 (7.4)	
Medicaid	**14 (2.0)**	6 (1.6)	8 (2.6)	<0.01
Medicare	**178 (26.1)**	119 (31.9)	59 (19.0)	
Private pay	**83 (12.2)**	39 (10.5)	44 (14.2)	
Other or none	**27 (4.0)**	12 (3.2)	15 (4.8)	
Percentage of decedent's U.S. Census Bureau tract population with college degree[¶]				
<25%	**505 (73.9)**	279 (74.8)	226 (72.9)	0.62
≥25%	**143 (20.9)**	83 (22.3)	60 (19.4)	
Percentage of decedent's U.S. Census Bureau tract population earning >200% of FPL[¶]				
<75%	**613 (89.8)**	345 (92.5)	268 (86.5)	0.47
≥75%	**35 (5.1)**	17 (4.6)	18 (5.8)	
Residence**				
Rural	**25 (3.7)**	11 (2.9)	14 (4.5)	
Suburban	**248 (36.3)**	141 (37.8)	107 (34.5)	0.42
Urban	**410 (60.0)**	221 (59.2)	189 (61.0)	
Mental health diagnosis in year preceding death[††]				
Anxiety	**214 (31.3)**	93 (24.9)	121 (39.0)	<0.01
Chronic serious mental illness	**63 (9.2)**	27 (7.2)	36 (11.6)	0.07
Depression	**206 (30.2)**	95 (25.5)	111 (35.8)	<0.01
Substance use problem	**110 (16.1)**	48 (12.9)	62 (20.0)	0.02
Suicidal self-harm or suicide attempt	**62(9.1)**	26 (7.0)	36 (11.6)	0.03
Charlson Comorbidity Index score[§§]				
0	**564 (82.6)**	292 (78.3)	272 (87.7)	
1	**39 (5.7)**	23 (6.2)	16 (5.2)	<0.01
≥2	**80 (11.7)**	58 (15.5)	22 (7.1)	

Abbreviation: FPL = federal poverty level.
* Southcentral Foundation (Alaska) and Kaiser Permanente (Colorado and Washington).
† Calculated using Pearson's chi-squared tests; values not reported when sample sizes were not large enough to meet test conditions.
§ Categories sum to >100% of patient sample because all persons who identified as Hispanic or Latino are included in this category. All persons who identified as multiple races identified as multiracial. The other race and ethnicity group includes responses that are not possible to categorize into one of the broader categories (e.g., Irish, Ashkenazi Jewish, or human race).
¶ U.S. Census Bureau tract variables available for Kaiser Permanente patients only.
** On the basis of a condensed version of the 2013 National Center for Health Statistics urban-rural categorization for counties. Urban = large central metropolitan, large suburban = large fringe metropolitan (described as a large suburban area in data briefs), smaller suburban = medium metropolitan and small metropolitan, and most rural = micropolitan and noncore.
†† Mental health diagnostic codes used to create the analytic data set used for this analysis are available (2024 Diagnosis Codes – Mental Health Research Network); chronic serious mental illness diagnoses include bipolar disorder, schizophrenia, other psychosis, or personality disorders.
§§ Predicts the mortality for a person on the basis of 17 comorbid conditions.

Health Care Use

Mental health care use patterns were broadly similar across study sites. Most suicide decedents had one or more outpatient visits preceding recorded in the EHR in the year preceding suicide, with comparable proportions among those who died by firearm (86.0%) and by other means (91.6%). Cumulative care-use plots, which showed patterns of all health care use in the year preceding suicide death, including primary care, were similar for persons who died by firearm and other suicide means, including any primary care; however, fewer persons who died by firearm suicide than persons who died by other suicide means received any mental health care in specialty or primary care settings (Figure 1). In the four quarters before suicide death, 18.2% versus 33.9% received mental health specialty care, and 26.3% versus 37.7% received primary care with a mental health diagnosis, respectively. Proportions of persons receiving any emergency or inpatient care were similar between groups (Figure 2). Across service settings, cumulative rates of past-year health care use among persons who died by suicide were highest for primary care (62.5%) (Supplementary Table 1), followed by emergency care (38.4%), outpatient mental health specialty care (24.6%), inpatient care (18.2%), and urgent care (16.5%). However, among persons who used care in these settings, the mean number of visits was highest among those who received mental health specialty care and was similar among those who died by firearm and those who died by other means of suicide (7.3 versus 10.9 visits; p = 0.10). The second highest mean number of visits was among those who received primary care and was also similar among those who died by firearm and other means (4.0 versus 4.4; p = 0.34). This was followed by the number of emergency care visits, which was lower among those who died by firearm (1.9 visits) than by other suicide means (2.9 visits; p<0.01). Sex-stratified analyses indicated that prevalences of primary care and outpatient mental health specialty care use were higher overall for females than for males (Supplementary Table 2). The mean number of health care visits by females and males were generally similar among those who died by firearm and those who died by other means. However, among females, those who died by firearm tended to have fewer mental health care specialty visits (mean = 5.8–12.2 during the 3, 6, and 12 months preceding death) than did females who died by other suicide means (mean = 6.2–16.3).

Discussion

Among suicide decedents who received care through three health care organizations in Alaska, Colorado, and Washington, health care use patterns in the year preceding death were similar among those who died by firearm and those who died by other means, with the exception of mental health care use, which was significantly lower among persons who died by firearm suicide than among those who died by other suicide means. Moreover, less than one fourth (24.6%) of all persons who died by suicide received mental health specialty care, highlighting the importance of identifying opportunities for suicide prevention during other types of health care encounters, such as primary and emergency care encounters.

This study builds on previous research studies that found high rates of primary care use in the year preceding suicide death (*1*), as well as lower likelihood of having diagnosed mental health conditions, substance use conditions, and suicide attempts documented in medical records among persons who die by firearm suicide compared with those who die by other suicide means (*6*,*7*). Another recent study demonstrated that implementation of depression screening followed by suicide risk assessment and safety planning in primary care settings resulted in a 25% reduction in the suicide attempt rate in the 90 days following primary care visits (*8*,*9*). However, evidence for the effectiveness of these practices in longer-term suicide prevention (i.e., in the year after health care encounters) is limited. The findings in this report highlight the possible value of primary care–based suicide prevention practices for firearm suicide prevention specifically, because those who died by firearm suicide were less likely to have received care in outpatient specialty mental health care settings than were those who died by other suicide means.

Summary

What is already known about this topic?

Many persons at risk for suicide seek health care before their death by suicide, but patterns of care use might be different for persons who die by firearm suicide than for those who die by other suicide means.

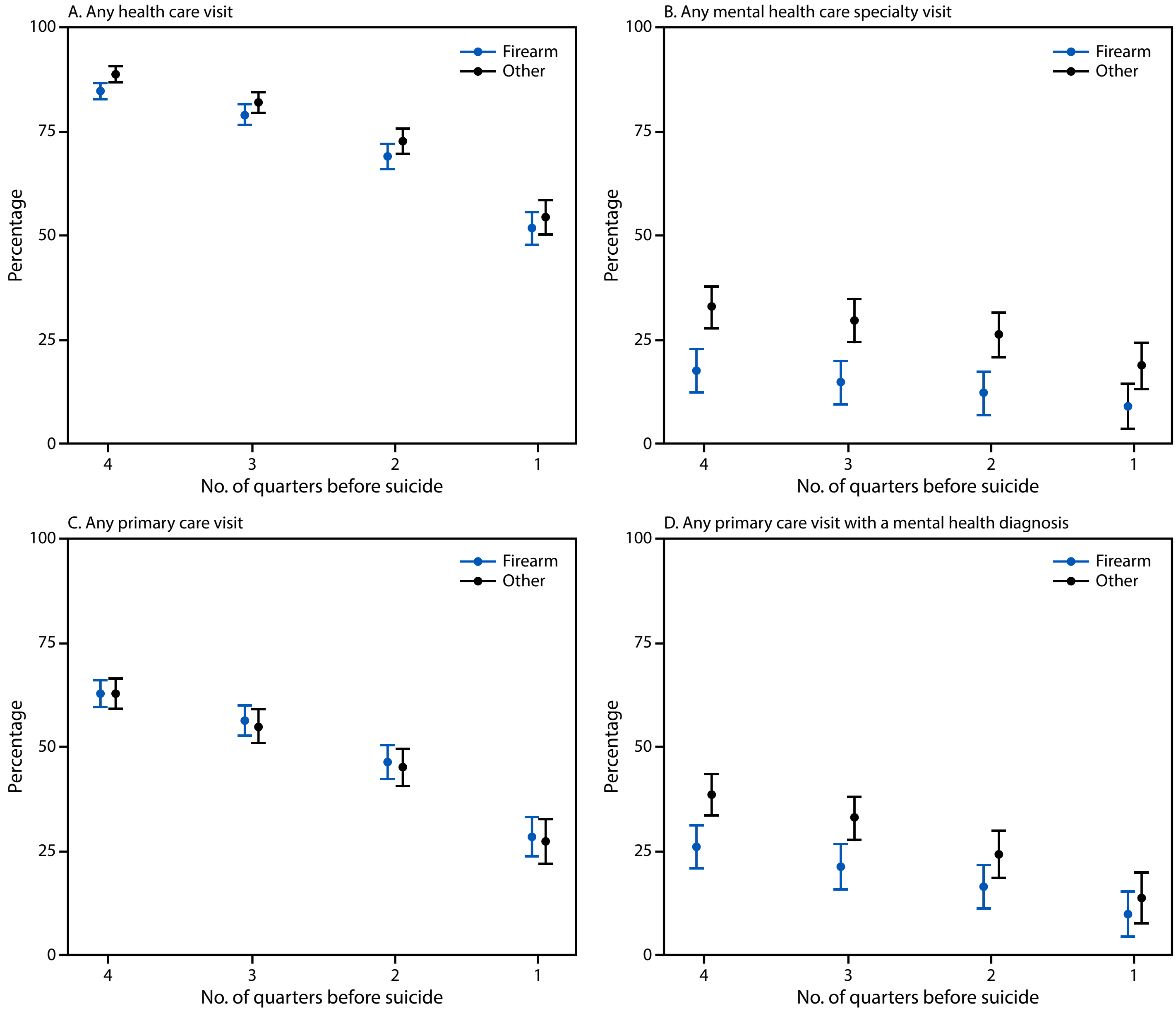
What is added by this report?

Approximately one half (54.6%) of 683 suicide decedents whose deaths were recorded by three health care organizations in Alaska, Colorado, and Washington during 2020–2022 died by firearms. Among the decedents who received care from these organizations, use of mental health care services was significantly less in the year before death among persons who died by firearm suicide than among those who died by other suicide means.

What are the implications for public health practice?

Persons who die by firearm suicide might not access mental health care services. Suicide prevention practices in health care, designed to help identify and engage persons at risk in supportive care, need to reach beyond mental health encounters, particularly for firearm suicide prevention.

FIGURE 1. Percentage* of suicide decedents who had any health care visit (A), any mental health care specialty visit (B), any primary care visit (C), or any primary care visit with a mental health diagnosis (D), in the year preceding suicide, by means of suicide (firearm or other) — three health care systems,† Alaska, Colorado, and Washington, 2020–2022



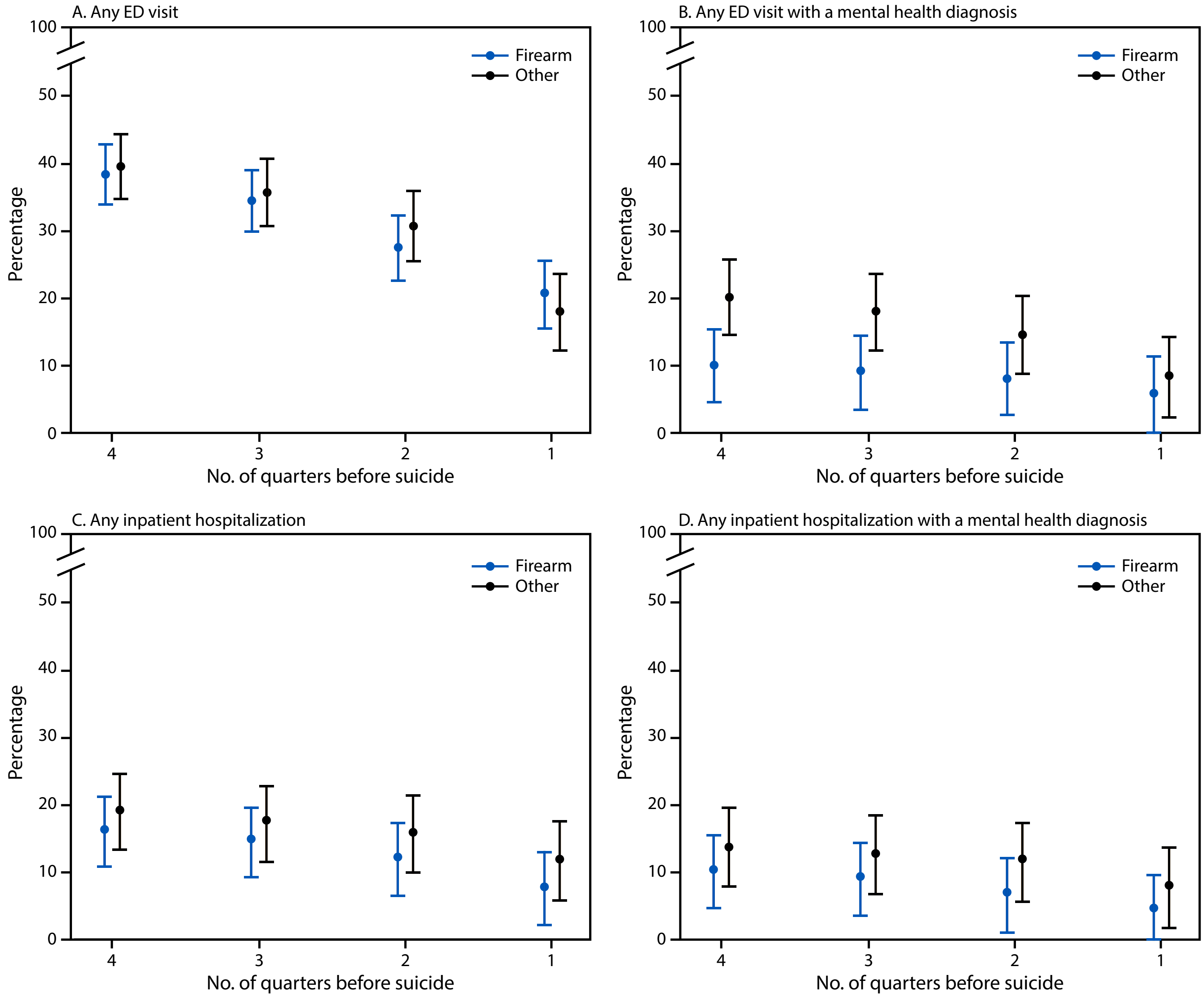
* Values are cumulative over the entire period; 95% CIs are indicated by bars.
† Southcentral Foundation (Alaska) and Kaiser Permanente (Colorado and Washington).

Suicide risk screening and assessment, when combined with safety planning, appear helpful for prevention (*9*). However, some patients only experience suicidal thoughts a short time before their suicide attempt (*10*), and risk identification practices, such as screening for suicidal thoughts, might miss some patients at risk for suicide but who are not experiencing suicidal thoughts at the time of their health care encounters, particularly when these encounters do not occur in close proximity to events precipitating suicide attempts. Future research exploring how to improve identification and engagement of patients at risk for suicide across care settings, specifically in primary and emergency care settings, will be needed for continued practice improvement.

Limitations

The findings in this report are subject to at least two limitations. First, this analysis included three health care systems serving populations with demographic characteristics (i.e., sex,

FIGURE 2. Percentage* of suicide decedents who had any emergency department visit (A), any emergency department visit with a mental health diagnosis (B), any inpatient hospitalization (C), or any inpatient hospitalization with a mental health diagnosis (D), in the year preceding suicide, by means of suicide (firearm or other) — three health care systems,† Alaska, Colorado, and Washington, 2020–2022



Abbreviation: ED = emergency department.
* Values are cumulative over the entire period; 95% CIs are indicated by bars.
† Southcentral Foundation (Alaska) and Kaiser Permanente (Colorado and Washington).

age, insurance status, and medical conditions) that might not be generalizable to other U.S. health care systems. Second, the study period included the year 2020, when the COVID-19 pandemic temporarily affected trends in health care use.

Implications for Public Health Practice

This report highlights how suicide prevention practices in health care, designed to help identify and engage persons at risk in supportive care, need to reach beyond mental health encounters, particularly for firearm suicide prevention. These findings are guiding the development and implementation of suicide prevention practices in the systems included in this analysis and could be similarly useful to other health care systems in efforts to reduce the second leading cause of death among persons aged 10–44 years in the United States. For persons in crisis, help is available through the Substance Abuse and Mental Health Services Administration's 988 Suicide and Crisis Lifeline or by texting or calling 988).

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