Centers for Disease Control and Prevention
MMWR
Morbidity and Mortality Weekly Report
Weekly / Vol. 71 / No. 6
February 11, 2022

Preventive Dental Care and Oral Health of Children and Adolescents With and Without Heart Conditions — United States, 2016–2019

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Approximately 900,000 U.S. children have heart conditions, such as congenital heart disease (*1*). These children might be at increased risk for life-threatening infective endocarditis from oral bacteria in the bloodstream (*2*). Therefore, preventive dental care (i.e., check-ups, dental cleaning, radiographs, fluoride treatment, or sealant) to maintain oral health is important. Oral health status and receipt of preventive dental care were compared between children with heart conditions (2,928) and without (116,826) using population-based 2016–2019 National Survey of Children's Health (NSCH) data. Approximately 83% of children with and 80% without heart conditions received preventive dental care in the past year (p = 0.06). Children with heart conditions were more likely than were those without to have poor oral health (17.2% versus 13.7%; p = 0.02) and teeth in fair or poor condition (9.9% versus 5.3%; p<0.01). Among those with a heart condition, having low household income; an intellectual or developmental disability; and no well-child visit or medical home were associated with poor oral health. Receipt of preventive dental care was higher among children aged ≥6 years and those with insurance. Public health practitioners and health care providers can implement strategies (e.g., parent and patient education and collaboration between pediatricians, dentists, and cardiologists) to improve oral health and care among children with heart conditions, especially those with fewer resources and intellectual or developmental disabilities.

The NSCH is an annual parent-reported survey to evaluate health, well-being, and related factors among U.S. persons aged 0–17 years.* One child from each household was randomly selected to be the subject of the survey. The overall weighted response rates per year for the 2016–2019 surveys were 40.7%, 37.4%, 43.1%, and 42.4%, respectively. Parents were asked whether a health care provider ever said their child had a heart condition. Only parents of children and adolescents aged 1–17 years with any teeth were asked about their child's oral health† and

* https://mchb.hrsa.gov/data/national-surveys

† To assess oral health, parents were asked about the condition of their child's teeth and experience with the following indicators of poor oral health during the past 12 months: frequent or chronic difficulty with toothaches, bleeding gums, or decayed teeth or cavities.

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receipt of dental care[§]. Children missing any data of interest were excluded. Characteristics of excluded and included children and adolescents were compared using Wald chi-square tests. Crude and adjusted associations between heart condition status and oral health and preventive dental care were assessed using Wald chi-square tests and with the predicted marginals obtained from logistic regression models. Among children and adolescents with a heart condition, adjusted prevalence ratios (aPRs) evaluated associations between their characteristics and receipt of preventive dental care, fair or poor condition of teeth, and one or more indicators of poor oral health. All models included sex, age, and race/ethnicity. Certain models also included household income as a percentage of federal poverty level and having intellectual or developmental disabilities, including Down syndrome.

Analyses were conducted using SAS-callable SUDAAN (version 11; RTI International). Design parameters accounting for complex sampling, weight, and nonresponse bias produced nationally representative, population-based estimates. Among 126,996 children and adolescents in NSCH aged ≥1 year who had one or more teeth, 6.3% were excluded because information on heart condition (0.3%), oral or dental outcomes (2.9%), or other characteristics (3.1%) was missing; although there was no difference in heart condition status between included and excluded persons, excluded persons more commonly had poor oral health and less commonly had preventive dental visits. In total, 2,928 children and adolescents with heart conditions (representing 1.4 million U.S. children and adolescents) and 116,826 children and adolescents without heart conditions (representing 6.4 million U.S. children and adolescents) were included.

Children and adolescents with heart conditions were less likely to be Hispanic or uninsured and more likely to be non-Hispanic White and have public insurance, intellectual or developmental disabilities, special health care needs, and well-child visits (Table 1). Approximately 84% of those with a heart condition received any dental care in the past 12 months (K Downing, CDC, unpublished data, 2022), and 83% received preventive dental care (Figure). Among children and adolescents who received preventive dental care, the majority received dental check-ups and dental cleanings (95% each), whereas application of sealant was least common (25%). Children and adolescents with a heart condition were more likely than were those without to receive preventive dental care overall as well as each of the individual services, although some CIs overlapped. Children and adolescents with a heart condition were approximately twice as likely to have teeth in fair or poor condition (10%) as were those without a heart condition (5%). Seventeen percent of children and adolescents

[§] To assess receipt of preventive dental care, parents were first asked if the child saw a dentist or oral health care provider for any oral health care during the past 12 months. If yes, they were asked if the child saw the oral health care provider for preventive dental care. Among children who received preventive dental care, the following were examined: check-ups, cleaning, instruction on tooth brushing and oral health care, radiographs, fluoride treatment, or sealant.

The *MMWR* series of publications is published by the Center for Surveillance, Epidemiology, and Laboratory Services, 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 2022;71:[inclusive page numbers].

TABLE 1. Characteristics of persons aged 1–17 years with and without a heart condition — National Survey of Children's Health,* United States, 2016–2019

Characteristic	Parental report of a heart condition: Never (n = 116,826) No.	Never (n = 116,826) Weighted % (95% CI)	Ever (n = 2,928) No.	Ever (n = 2,928) Weighted % (95% CI)
Sex				
Male	60,398	51.1 (50.4–51.7)	1,607	52.5 (48.8–56.3)
Female	56,428	48.9 (48.3–49.6)	1,321	47.5 (43.7–51.2)
Age group, yrs				
1–5	30,304	28.6 (28.0–29.2)	715	26.7 (23.6–29.9)
6–11	36,866	35.6 (35.0–36.3)	914	37.7 (33.9–41.6)
12–17	49,656	35.8 (35.2–36.4)	1,299	35.7 (32.3–39.1)
Race/Ethnicity				
Black, non-Hispanic	7,024	13.1 (12.6–13.6)	175	12.7 (10.3–15.6)
White, non-Hispanic	81,661	51.3 (50.6–51.9)	2,141	60.1 (56.2–63.9)
Hispanic	13,284	24.9 (24.2–25.6)	279	17.8 (14.5–21.6)
Multiracial/Other†	14,857	10.7 (10.4–11.0)	333	9.5 (7.6–11.7)
Insurance coverage				
Any private	89,487	63.3 (62.6–64.0)	2,119	59.7 (55.6–63.6)
Public only	22,520	30.3 (29.6–31.0)	717	36.3 (32.3–40.4)
None	4,819	6.4 (6.0–6.8)	92	4.1 (2.8–5.8)
Federal poverty level§				
<100%	12,483	19.6 (19.0–20.2)	370	23.4 (19.6–27.8)
100%–199%	18,527	21.7 (21.1–22.3)	493	19.3 (16.5–22.3)
200%–399%	36,185	27.6 (27.1–28.2)	959	29.1 (26.1–32.3)
≥400%	49,631	31.1 (30.6–31.6)	1,106	28.3 (25.5–31.2)
Has an intellectual or developmental disability	7,776	6.5 (6.2–6.8)	697	24.2 (21.4–27.3)
Has special health care needs¶	27,000	19.2 (18.7–19.7)	1,533	47.9 (44.2–51.6)
Attended well-child visit**	96,817	79.6 (79.0–80.1)	2,639	89.6 (87.1–91.6)
Has a medical home††	64,104	48.6 (47.9–49.2)	1,555	48.7 (44.9–52.4)

* The National Survey of Children's Health is weighted to be representative of the U.S. population of noninstitutionalized persons aged ≤17 years. https://www2.census.gov/programs-surveys/nsch/technical-documentation/methodology/NSCH-Guide-to-Multi-Year-Estimates.pdf

† "Other" category includes respondents who self-identified as Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or mixed race.

§ Based on U.S. Department of Health and Human Services poverty guidelines.

¶ Special health care needs are defined as one or more of the following five conditions: needing prescription medicine; having more health care encounters than other children their age; having limitations compared with other children their age; needing physical, occupational, or speech therapy; or having an emotional, developmental, or behavioral problem in need of counseling or treatment. To be classified as special health care needs, these conditions must be related to a medical, behavioral, emotional, developmental, or other health condition that lasts or is expected to last ≥12 months.

** Attended a well-child visit in the past 12 months.

†† https://www.childhealthdata.org/docs/medical-home/mhmanual_withappendices-updated-12-7-10-pdf

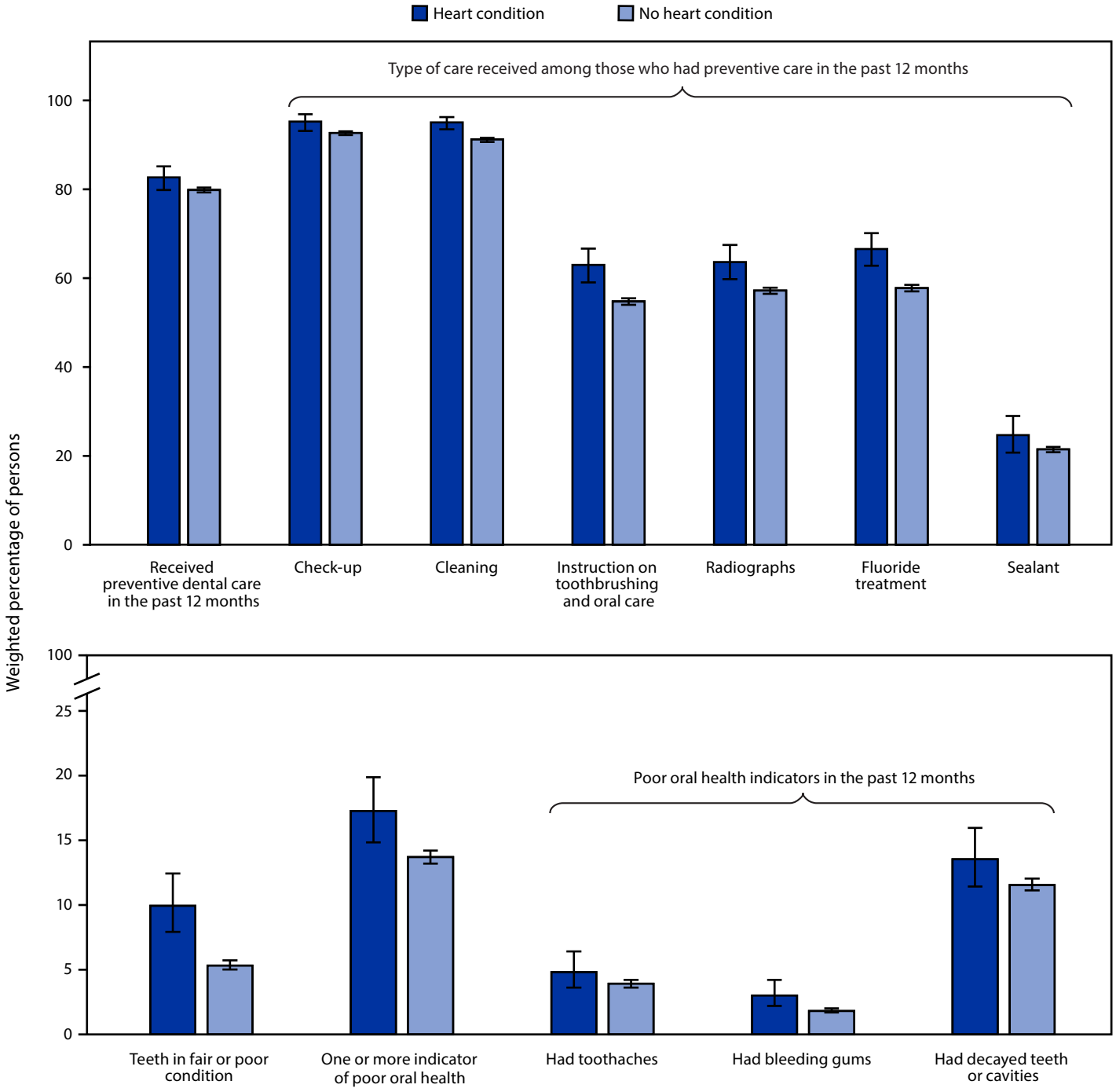
with a heart condition had one or more indicators of poor oral health during the past 12 months. Decayed teeth or cavities (14%) was the most prevalent indicator of poor oral health. Prevalence for all indicators was higher among children and adolescents with a heart condition than among those without, although some CIs overlapped.

The adjusted prevalence of receipt of preventive dental care was similar in children and adolescents with and without a heart condition (Table 2). Among those with a heart condition, receipt of preventive dental care was more prevalent among older age groups than youngest (6–11 years: aPR = 1.3; 12–17 years: aPR = 1.3). Point prevalence of preventive dental care was lowest among those without health insurance (55.7%; aPR = 0.6). Prevalence was also lower among those without a medical home¶ (aPR = 0.9).

Children and adolescents with a heart condition were more likely to have teeth in fair or poor condition (aPR = 1.8) and to have one or more poor oral health indicators (aPR = 1.2) than were those without a heart condition (Table 2). For both children and adolescents with teeth in fair or poor condition (aPR = 1.4) and those with one or more poor oral health indicators (aPR = 1.1), results were attenuated, but the former remained elevated, after adjusting for presence of intellectual disabilities (K Downing, CDC, unpublished data, 2022). Among children and adolescents

¶ https://www.childhealthdata.org/docs/medical-home/mhmanual_withappendices-updated-12-7-10-pdf

FIGURE. Weighted prevalence* of preventive dental care and oral health indicators† of persons aged 1–17 years with and without a heart condition — National Survey of Children's Health, United States, 2016–2019



* The National Survey of Children's Health is weighted to be representative of the U.S. population of noninstitutionalized persons aged ≤17 years. https://www2.census.gov/programs-surveys/nsch/technical-documentation/methodology/NSCH-Guide-to-Multi-Year-Estimates.pdf

† Parent reported that child had frequent or chronic difficulty with toothaches, bleeding gums, decayed teeth, or cavities in the past 12 months.

TABLE 2. Associations between oral health and dental care and ever having a heart condition among persons aged 1–17 years with and without heart conditions and associations with sociodemographic and health characteristics among persons with a heart condition — National Survey of Children's Health,* United States, 2016–2019

Characteristic	Received preventive dental care in the past 12 months		Teeth in fair or poor condition		One or more indicator of poor oral health†	
	Weighted % (95% CI)	aPR§ (95% CI)	Weighted % (95% CI)	aPR§ (95% CI)	Weighted % (95% CI)	aPR§ (95% CI)
Among all persons (N = 119,754)						
Heart condition¶						
Ever	82.6 (79.8–85.1)	1.0 (1.0–1.1)	9.9 (7.9–12.4)	1.8 (1.4–2.3)	17.2 (14.8–19.8)	1.2 (1.0–1.4)
Never	79.8 (79.2–80.3)	Ref	5.3 (5.0–5.7)	Ref	13.7 (13.2–14.2)	Ref
Among persons with a heart condition (n = 2,928)						
Sex¶,**						
Male	80.3 (76.1–83.9)	Ref	11.8 (8.8–15.7)	Ref	17.0 (14.0–20.5)	Ref
Female	85.1 (81.3–88.2)	1.0 (1.0–1.1)	7.9 (5.6–11.1)	0.9 (0.6–1.3)	17.3 (13.8–21.5)	1.1 (0.8–1.5)
Age group, yrs¶,**						
1–5	66.4 (60.1–72.2)	Ref	9.7 (5.9–15.7)	Ref	14.7 (10.4–20.3)	Ref
6–11	90.8 (86.4–93.9)	1.3 (1.2–1.5)	9.5 (6.5–13.7)	1.2 (0.7–2.0)	18.2 (14.3–22.9)	1.3 (0.9–1.9)
12–17	86.0 (81.3–89.6)	1.3 (1.1–1.4)	10.6 (7.6–14.6)	1.3 (0.8–2.1)	17.9 (14.3–22.2)	1.2 (0.8–1.9)
Race/Ethnicity¶,**						
Black, non-Hispanic	77.9 (68.6–85.0)	1.0 (0.9–1.1)	16.5 (9.1–28.0)	1.1 (0.6–1.9)	24.3 (16.1–34.9)	1.5 (0.9–2.3)
White, non-Hispanic	83.4 (80.2–86.3)	Ref	8.5 (6.5–11.1)	Ref	13.5 (11.3–16.2)	Ref
Hispanic	88.5 (81.6–93.1)	1.0 (1.0–1.1)	6.8 (3.6–12.2)	0.8 (0.4–1.5)	22.2 (15.1–31.2)	1.5 (1.0–2.3)
Multiracial/Other††	72.3 (59.3–82.3)	0.9 (0.8–1.0)	16.3 (8.4–29.2)	1.7 (0.9–3.1)	21.1 (14.5–29.8)	1.5 (1.0–2.2)
Insurance coverage**						
Any private	85.5 (82.6–88.0)	Ref	7.8 (6.0–10.2)	Ref	15.9 (13.1–19.2)	Ref
Public only	80.8 (75.1–85.4)	1.0 (0.9–1.0)	11.7 (8.0–16.9)	1.0 (0.7–1.5)	19.4 (15.1–24.5)	1.0 (0.7–1.4)
None	55.7 (36.8–73.1)	0.6 (0.5–0.9)	25.1 (10.0–50.4)	2.5 (1.1–5.4)	15.7 (7.5–30.0)	0.8 (0.4–1.7)
Federal poverty level¶,,§§**						
<100%	78.6 (70.3–85.1)	0.9 (0.8–1.0)	20.0 (13.2–29.1)	2.9 (1.7–4.9)	23.1 (16.8–31.0)	1.7 (1.1–2.6)
100%–199%	81.0 (74.7–86.0)	0.9 (0.9–1.0)	7.4 (4.9–11.0)	1.2 (0.7–2.1)	18.5 (13.3–25.2)	1.4 (0.9–2.2)
200%–399%	83.9 (78.9–87.8)	1.0 (0.9–1.1)	7.9 (5.5–11.4)	1.4 (0.9–2.4)	17.1 (13.3–21.7)	1.4 (1.0–2.1)
≥400%	85.7 (81.1–89.3)	Ref	5.5 (3.6–8.2)	Ref	11.4 (8.4–15.3)	Ref
Has an intellectual or developmental disability¶,**						
Yes	78.3 (71.8–83.7)	1.0 (0.9–1.1)	25.8 (19.9–32.8)	4.7 (3.0–7.4)	25.2 (20.0–31.2)	1.7 (1.3–2.3)
No	84.0 (80.9–86.6)	Ref	4.9 (3.3–7.0)	Ref	14.6 (12.1–17.5)	Ref
Has special health care needs¶,,¶¶**						
Yes	81.8 (77.4–85.6)	1.0 (0.9–1.1)	15.1 (11.5–19.5)	1.2 (0.7–2.1)	20.7 (17.3–24.7)	1.2 (0.8–1.6)
No	83.3 (79.6–86.4)	Ref	5.2 (3.5–7.7)	Ref	13.9 (10.9–17.6)	Ref
Attended well-child visit¶,,*****						
Yes	83.5 (80.6–86.0)	Ref	8.9 (7.1–11.1)	Ref	16.9 (14.5–19.7)	Ref
No	75.0 (63.2–84.0)	0.9 (0.8–1.0)	19.1 (9.7–34.2)	1.9 (1.2–3.2)	19.4 (12.3–29.1)	1.1 (0.7–1.7)
Has a medical home¶,,††† **						
Yes	87.9 (85.1–90.3)	Ref	5.6 (4.0–7.9)	Ref	16.2 (13.1–20.0)	Ref
No	77.5 (72.9–81.6)	0.9 (0.8–0.9)	14 (10.6–18.4)	1.9 (1.3–2.9)	18.0 (14.7–21.9)	1.0 (0.7–1.3)

Abbreviations: aPR = adjusted prevalence ratio; Ref = referent group.

* The National Survey of Children's Health is weighted to be representative of the U.S. population of noninstitutionalized persons aged ≤17 years. https://www2.census.gov/programs-surveys/nsch/technical-documentation/methodology/NSCH-Guide-to-Multi-Year-Estimates.pdf

† Parent reported that child had frequent or chronic difficulty with toothaches, bleeding gums, decayed teeth, or cavities in the past 12 months.

§ Multivariable model includes sex, age, and race/ethnicity.

¶ Model also includes percentage of the federal poverty level.

** Model also includes having intellectual or developmental disabilities.

†† "Other" category includes respondents who self-identified as Asian, American Indian or Alaska Native, Native Hawaiian or other Pacific Islander, or mixed race.

§§ Based on U.S. Department of Health and Human Services poverty guidelines.

¶¶ Defined as having one or more of the following five conditions: needing prescription medicine, having more health care encounters than other children their age; having limitations compared with other children their age; needing physical, occupational, or speech therapy or having an emotional, developmental, or behavioral problem in need of counseling or treatment. To be classified as special health care needs, these conditions must be related to a medical, behavioral, emotional, developmental, or other health condition that lasts or is expected to last ≥12 months.

*** Attended a well-child visit in the past 12 months.

††† https://www.childhealthdata.org/docs/medical-home/mhmanual_withappendices-updated-12-7-10-pdf

with a heart condition, the prevalence of having teeth in fair or poor condition was highest among those with intellectual or developmental disabilities (25.8%; aPR = 4.7), those without insurance (25.1%; aPR = 2.5), and those living at <100% of the federal poverty level (20.0%; aPR = 2.9). This prevalence was elevated among persons without well-child visits (aPR = 1.9) and without a medical home (aPR = 1.9). The percentage of children and adolescents with one or more poor oral health indicators was highest among those with an intellectual or developmental disability (25.2%; aPR = 1.7) and was elevated among those living at <100% of the federal poverty level (aPR = 1.7).

Discussion

In this large, population-based sample from the 2016–2019 NSCH, approximately 10% of children and adolescents with a heart condition had teeth in fair or poor condition, and 17% had one or more indicators of poor oral health, such as toothaches, bleeding gums, or cavities in the past 12 months. Furthermore, one in six had not received preventive dental care in the past 12 months. Prevalence of preventive dental care was consistently higher among children with a heart condition than among children without, although some differences did not reach statistical significance. Prevalence of poor oral health was also higher among children with a heart condition, although some differences were not statistically significant.

Some small, non-U.S., clinic-based studies have reported that children with congenital heart defects have worse oral health than children without heart defects (*3*–*6*), whereas others suggest no difference (*7*,*8*). Factors associated with preventive dental care and oral health among children with a heart condition have been less studied. In a 2016 NSCH analysis among all U.S. children, preventive dental care was similarly associated with older age and having insurance (*9*). Better condition of teeth was associated with well-child visits, although not with household income. In other literature, children with intellectual or developmental disabilities (who account for approximately one in five children with heart conditions in NSCH) had some of the highest rates of poor oral health (*10*).

The findings in this report are subject to at least five limitations. First, all data were parent-reported and not clinically confirmed. Second, sample size limited the ability to examine outcomes by heart condition severity, and data on heart condition type (congenital or acquired) were not collected. Third, some children might have had heart conditions in the past that were resolved. Fourth, 6% of surveys were excluded for missing data but are not expected to affect findings. Finally, only data from 2019 and earlier were available at the time of analysis, and receipt of dental treatment and oral health might have changed since then.

Summary

What is already known about this topic?

U.S. children with heart conditions might be at increased risk for infective endocarditis from oral bacteria; however, little is known about their oral health.

What is added by this report?

During 2016–2019, only 83% of persons aged 1–17 years with heart conditions received preventive dental care. However, 17% had symptoms of poor oral health during a 12-month period, and 10% had teeth in fair or poor condition. Those with lower household incomes and intellectual and developmental disabilities had worse oral health.

What are the implications for public health practice?

Public health practitioners and health care providers can implement strategies to improve oral health and care among children with heart conditions, especially those with fewer resources and intellectual or developmental disabilities.

Children and adolescents with a heart condition, particularly those with intellectual disabilities, were more likely than those without a heart condition to have teeth in fair or poor condition. Approximately one in six children with a heart condition had toothaches, bleeding gums, or decay, and approximately one in six had not received preventive dental care during the past 12 months; although rates of some outcomes were similar to those without a heart condition, poor oral health and missed preventive dental care might have additional health implications for children with heart conditions. Among children and adolescents with a heart condition, oral health was notably worse for those with intellectual or developmental disabilities, those living in poverty, and those without insurance. These findings could guide strategies, such as parent and patient education and collaboration between pediatricians, dentists, and cardiologists, to improve oral health and care among children with heart conditions, especially those with fewer resources and intellectual or developmental disabilities.

Acknowledgment

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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.

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Progress Toward Rubella and Congenital Rubella Syndrome Control and Elimination — Worldwide, 2012–2020

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Rubella virus is a leading cause of vaccine-preventable birth defects and can cause epidemics. Although rubella virus infection usually produces a mild febrile rash illness in children and adults, infection during pregnancy, especially during the first trimester, can result in miscarriage, fetal death, stillbirth, or an infant born with a constellation of birth defects known as congenital rubella syndrome (CRS). A single dose of rubella-containing vaccine (RCV) can provide lifelong protection against rubella (*1*). The Global Vaccine Action Plan 2011–2020 (GVAP) included a target to achieve elimination of rubella in at least five of the six World Health Organization (WHO) regions* by 2020 (*2*), and WHO recommends capitalizing on the accelerated measles elimination activities as an opportunity to introduce RCV (*1*). This report updates a previous report (*3*) and summarizes global progress toward control and elimination of rubella and CRS from 2012, when accelerated rubella control activities were initiated, through 2020. Among 194 WHO Member States, the number with RCV in their immunization schedules has increased from 132 (68%) in 2012 to 173 (89%) in 2020; 70% of the world's infants were vaccinated against rubella in 2020. Reported rubella cases declined by 48%, from 94,277 in 2012 to 49,136 in 2019, and decreased further to 10,194 in 2020. Rubella elimination has been verified in 93 (48%) of 194 countries including the entire Region of the Americas (AMR). To increase the equity of protection and make further progress to eliminate rubella, it is important that the 21 countries that have not yet done so should introduce RCV. Likewise, countries that have introduced RCV can achieve and maintain rubella elimination with high vaccination coverage and surveillance for rubella and CRS. Four of six WHO regions have established rubella elimination goals; the two WHO regions that have not yet established an elimination goal (the African [AFR] and Eastern Mediterranean [EMR] regions) have expressed a commitment to rubella elimination and should consider establishing a goal.

Immunization Activities

The preferred strategy for introducing RCV into national immunization programs is to conduct an initial vaccination campaign targeting the majority of persons who might not have been naturally exposed to rubella, usually children and adolescents aged ≤14 years (*1*), a strategy that has been used to eliminate rubella and CRS in AMR (*4*). WHO recommends that countries that introduce RCV achieve and maintain a minimum coverage of at least 80% with at least 1 dose of RCV delivered through routine services or campaigns (*1*).

Each year, countries report immunization data to WHO and UNICEF using the Joint Reporting Form, which includes information on immunization schedules and the number of vaccine doses administered through routine immunization services and vaccination campaigns.† Because RCV first became available in high-income countries, the World Bank income groupings for 2020 were used to evaluate national income-related disparities.§

In 2020, RCV had been introduced in 173 (89%) of 194 countries, a 31% increase compared with the 132 (68%) countries that offered RCV in 2012 (Figure 1). All countries in AMR, the European Region (EUR), the South-East Asia Region (SEAR), and the Western Pacific Region (WPR), have introduced RCV. In the two remaining regions, RCV has been introduced in 31 (66%) of 47 countries in AFR, and 16 (76%) of 21 countries in EMR (Table).

The introduction of RCV within income groups has increased over time (Figure 2). In 2012, RCV had been introduced in all 59 high-income countries, 91% of 54 upper middle-income countries, and 43% of 54 lower middle-income countries, but only 4% of 28 low-income countries. By 2020, RCV introduction within income groups increased to 94% of upper middle-income countries, 93% of lower middle-income countries, and 48% of low-income countries.

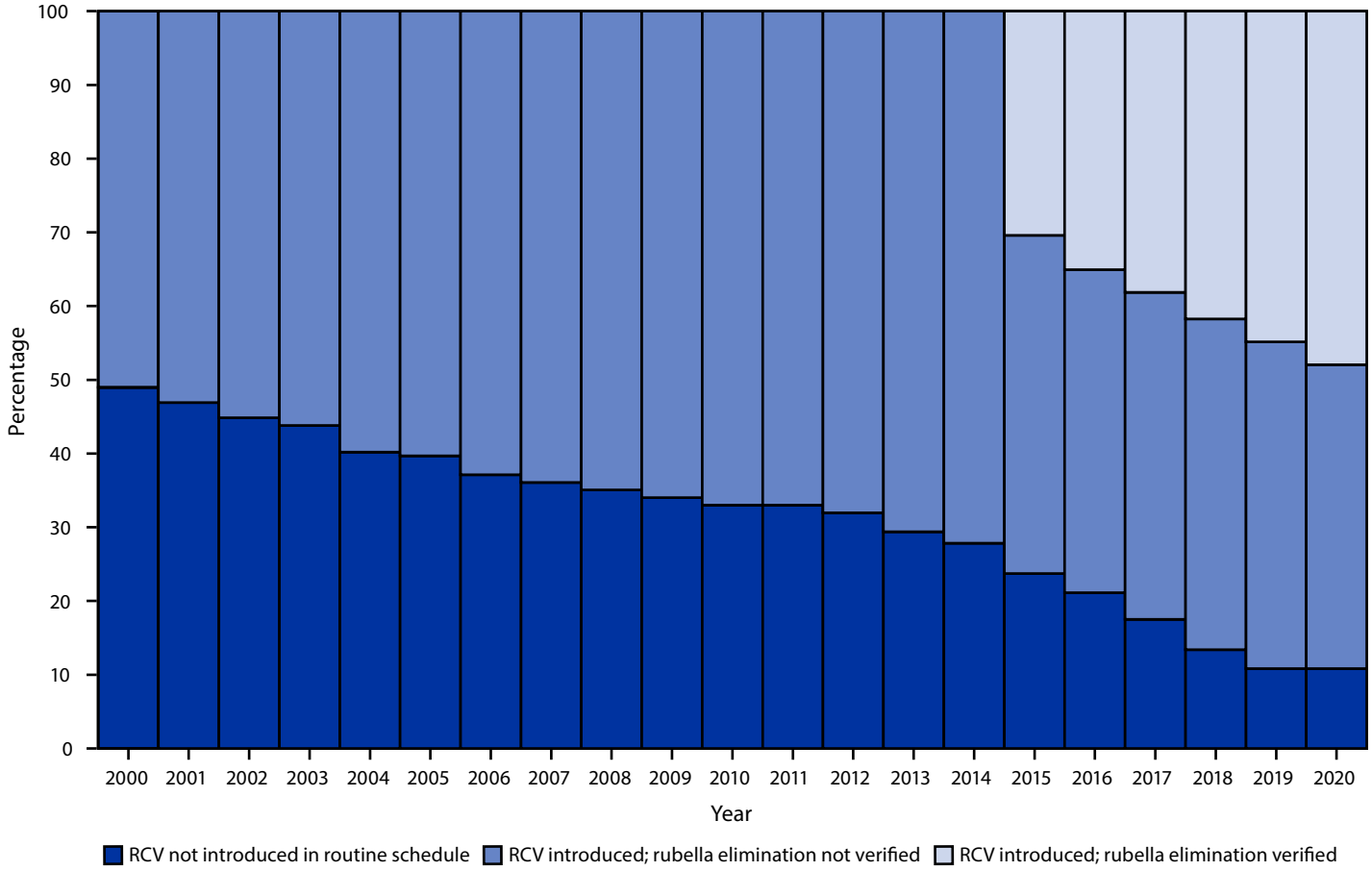
According to the WHO/UNICEF Estimates of National Immunization Coverage, global infant RCV coverage estimates increased from 40% in 2012 to 70% in 2020, with wide regional variation (range = 36%–95%) (Table). In 2020, rubella vaccination coverage was 26% in low-income counties, 76% in lower middle-income countries and upper middle-income countries combined, and 93% in high-income countries.

* https://www.who.int/countries

† https://immunizationdata.who.int/pages/coverage/rcv.html?CODE=Global&YEAR=

§ World Bank annually publishes gross national income classification cutoffs per capita in U.S. dollars. The 2022 fiscal year provides classification data for 2020: high income >$12,695; upper middle income = $4,096–$12,695; lower middle income = $1,046–$4,095; and low income ≤$1,045). https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (Accessed January 3, 2022).

FIGURE 1. Percentage of countries that have introduced rubella-containing vaccine in the routine immunization schedule and the percentage with verified rubella elimination, by year — worldwide, 2000–2020



Abbreviation: RCV = rubella-containing vaccine.

Surveillance Activities and Reported Rubella and CRS Incidence

Rubella and CRS surveillance data are reported through the Joint Reporting Form using standard case definitions (*5*). Rubella and CRS surveillance data complement each other to provide a more complete picture of program progress. Rubella surveillance relies on the measles surveillance system to detect cases because both illnesses cause fever and rash; however, rubella is typically milder than measles, resulting in a lower percentage of persons with rubella seeking health care and a lower percentage of cases being identified. CRS cases are detected through separate surveillance systems, often using a few sentinel sites, which might not be nationally representative (*6*).

In 2020, all 194 countries conducted rubella surveillance, and 193 (99%) had access to standardized quality-controlled laboratory testing through the WHO Global Measles and Rubella Laboratory Network.[¶] The number of countries reporting rubella cases (including the reporting of zero cases) increased from 175 (90%) in 2012 to 179 (92%) in 2019, but then decreased to 135 (70%) in 2020 during the COVID-19 pandemic. Similarly, the number of countries reporting CRS cases increased from 130 (67%) in 2012 to 131 (68%) in 2019, but then decreased to 112 (58%) in 2020. Compared with the 94,277 rubella cases reported in 2012, case counts declined by 48%, to 49,136 in 2019, with a further decrease to 10,194 in 2020. Reported CRS cases increased from 302 in 2012 to 603 in 2020, primarily because of initiation of CRS surveillance and reporting in several populous countries (Bangladesh, India, Indonesia, and Pakistan) since 2012 and changes in reporting

[¶] São Tomé and Príncipe did not have access to standardized quality-controlled testing by the WHO Measles and Rubella Laboratory Network in 2020.

TABLE. Global progress toward control and elimination of rubella and congenital rubella syndrome, by World Health Organization region — worldwide, 2012, 2019, and 2020

Characteristic	WHO region (no. of countries)						
	AFR (47)	AMR (35)	EMR (21)	EUR (53)	SEAR (11)	WPR (27)	Worldwide (194)
Regional rubella or CRS target	None	Elimination	None	Elimination	Elimination	Elimination	None
Countries verified eliminated, no. (%)*							
2012	NA	NA	NA	NA	NA	NA	NA
2019	NA	35 (100)	3 (14)	45 (85)	N/A	4 (15)	87 (45)
2020	NA	35 (100)	3 (14)	49 (92)	2 (18)	4 (15)	93 (48)
Countries with RCV in schedule, no. (%)							
2012	3 (6)	35 (100)	14 (67)	53 (100)	5 (45)	22 (81)	132 (68)
2019	31 (66)	35 (100)	16 (76)	53 (100)	11 (100)	27 (100)	173 (89)
2020	31 (66)	35 (100)	16 (76)	53 (100)	11 (100)	27 (100)	173 (89)
Regional rubella vaccination coverage (%)†							
2012	0	94	38	95	5	86	40
2019	33	87	45	96	93	95	71
2020	36	85	45	94	87	95	70
Countries reporting rubella cases, no. (%)							
2012	41 (87)	35 (100)	18 (86)	47 (89)	11 (100)	23 (85)	175 (90)
2019	45 (96)	34 (97)	19 (90)	49 (93)	10 (91)	22 (81)	179 (92)
2020	38 (81)	30 (86)	13 (62)	33 (62)	8 (73)	13 (48)	135 (70)
Reported rubella cases, no.							
2012	10,850	15	1,681	30,579	6,877	44,275	94,277
2019	6,027	25	2,603	671	4,537	35,273	49,136
2020	4,883	7	732	92	1,514	2,966	10,194
Countries reporting CRS cases, no. (%)							
2012	20 (43)	35 (100)	9 (43)	43 (81)	6 (55)	17 (63)	130 (67)
2019	18 (38)	32 (91)	13 (62)	42 (79)	7 (64)	19 (70)	131 (68)
2020	13 (28)	32 (91)	10 (48)	38 (72)	8 (73)	11 (41)	112 (58)
Reported CRS cases, no.							
2012	69	3	20	62	14	134	302
2019	9	0	26	8	358	22	423
2020	28	2	309	2	248	14	603

Abbreviations: AFR = African Region; AMR = Region of the Americas; CRS = congenital rubella syndrome; EMR = Eastern Mediterranean Region; EUR = European Region; NA = not available; RCV = rubella-containing vaccine; SEAR = South-East Asia Region; WHO = World Health Organization; WPR = Western Pacific Region.
* Established regional verification commissions verify achievement of elimination in five regions (AMR, EMR, EUR, SEAR, and WPR).
† Coverage estimates for RCVs are determined by WHO and UNICEF estimates of national immunization coverage.

in Pakistan in 2020** (Table). Between 2018 and 2021, 4,588 rubella sequences from 25 countries were reported to the global Rubella Virus Nucleotide Surveillance database††; 3,205 (70%) were genotype 1E and 1,382 (30%) were genotype 2B. However, 98% of the sequences were from China and Japan, highlighting the need to enhance global virologic surveillance for rubella.

Progress Toward Elimination

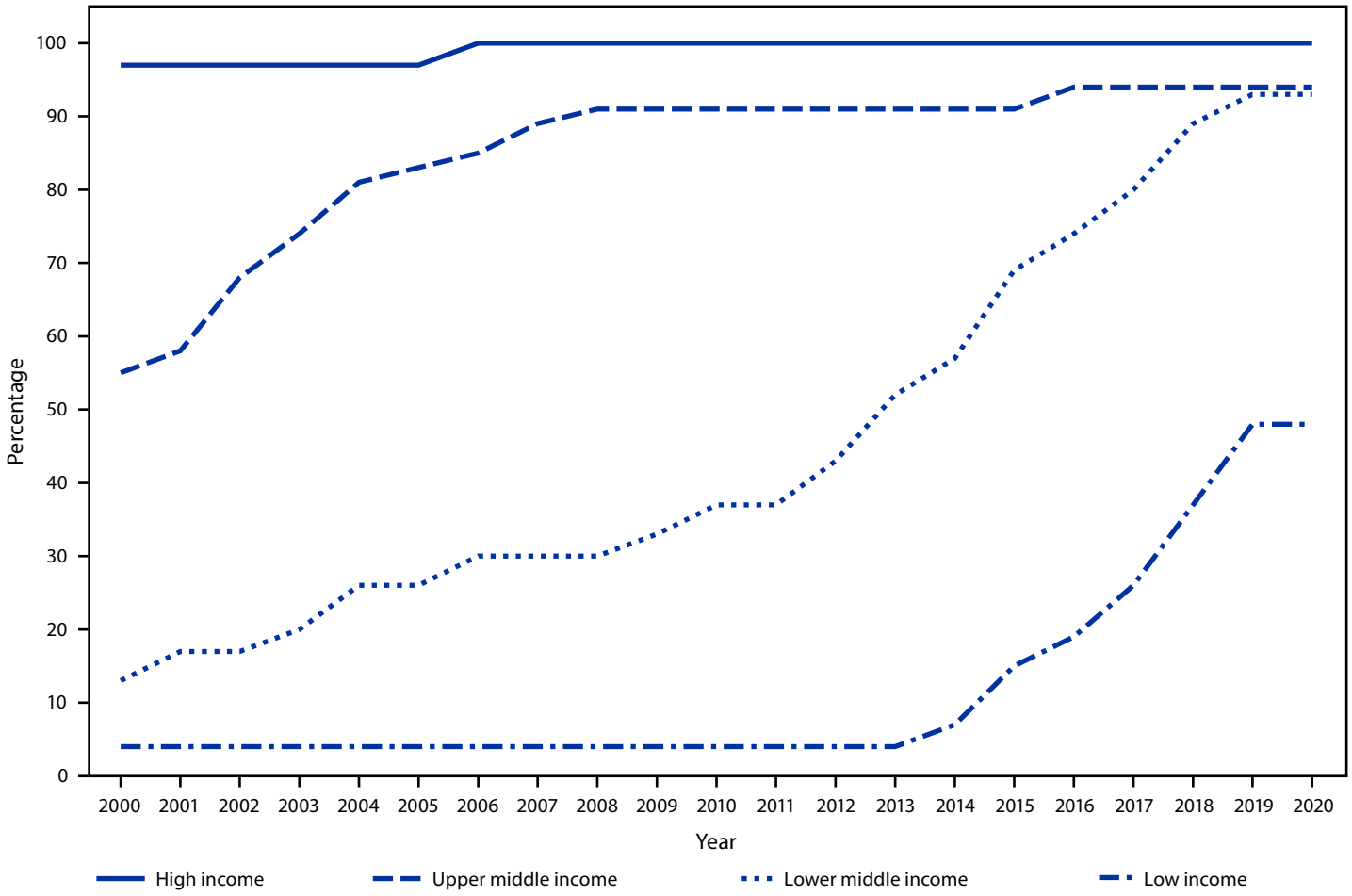
Progress toward regional goals is measured by the number of countries introducing RCV and the number verified as having eliminated rubella and CRS. The interruption of endemic rubella virus transmission is defined as at least 12 months without ongoing local transmission. When interruption of transmission is sustained for 36 months, an independent regional commission verifies countries as having eliminated rubella (*7*). Data on verification of elimination are available in regional verification commission reports.§§,¶¶,***,†††

During 2019, SEAR advanced its rubella control goal to an elimination goal, joining AMR, EUR, and WPR as regions with rubella and CRS regional elimination goals. Although AFR and EMR have yet to set elimination goals, the regions have expressed a commitment to achieving elimination (*8*). The AMR commission verified that the entire region had eliminated rubella and CRS in 2015; verification commissions in EMR, EUR, SEAR, and WPR assess rubella elimination status on a

** Pakistan initiated CRS surveillance in 2018 at four sentinel sites and reported only laboratory-confirmed cases in 2018 (29) and in 2019 (12). In 2020, however, Pakistan added an additional sentinel surveillance site and reported both 22 laboratory-confirmed cases and 279 clinically confirmed cases, for a total of 301 cases in 2020.
†† https://who-gmrln.org/rubens2/

§§ http://www.emro.who.int/media/news/rvc-declared-bahrain-oman-iran-rubella-measles-free.html
¶¶ https://apps.who.int/iris/handle/10665/344160
*** https://apps.who.int/iris/handle/10665/350119
††† https://www.euro.who.int/en/health-topics/communicable-diseases/measles-and-rubella/activities/regional-verification-commission-for-measles-and-rubella-elimination-rvc/conclusions-of-the-9th-meeting-of-the-european-regional-verification-commission-for-measles-and-rubella-elimination-rvc

FIGURE 2. Percentage of countries that have introduced rubella-containing vaccine in the routine schedule, by World Bank income group* and year — worldwide, 2000–2020†



* Gross National Income per capita in U.S. dollars in 2020: high income >$12,695; upper middle income = $4,096–$12,695; lower middle income = $1,046–$4,095; and low income ≤$1,045. https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups
† In 2020, there were 59 high-income, 54 upper middle-income, 54 lower middle-income, and 27 low-income countries.

country-by-country basis. The elimination of endemic rubella has been verified in 93 countries: 35 (100%) in AMR, three (14%) of 21 in EMR, 49 (92%) of 53 in EUR, two (18%) of 11 in SEAR, and four (15%) of 27 in WPR.

Discussion

Progress toward rubella elimination has accelerated since 2012, and in 2020, rubella elimination had been verified in approximately one half of the countries in the world. The considerable progress made toward elimination has been driven by the establishment of regional WHO rubella elimination goals, an increase in commitment to elimination by countries, and the availability of financial support from global partners for RCV introduction.

Progress is reflected in an increase in the number of countries introducing RCV into national childhood immunization schedules and the coverage achieved. From 2012 to 2020, the number of countries that have introduced RCV increased from 132 to 173, and global coverage increased from 40% to 70%. Although vaccine availability increased, as more low-income countries and lower middle-income countries have introduced RCV, coverage estimates continue to reflect barriers to access in lower-income groups; however, coverage declined only one percentage point from 2019 to 2020 during the COVID-19 pandemic.

Progress has also been reflected in the decline in reported rubella cases, including a 48% decrease during 2012–2019, with a further decrease in 2020. The extent to which rubella transmission declined in 2020 is unclear, however, because fewer reported cases might reflect the impact of COVID-19 mitigation measures or an underreporting of cases in 2020 because of reductions in health care–seeking behavior from patients, health facility availability and reporting, or overall

pandemic-related health system disruptions (*9*). The increase in the number of reported CRS cases during 2012–2020 reflects improved surveillance in several populous countries that initiated CRS surveillance after 2012, rather than an increase in rubella among susceptible pregnant women and CRS in their infants. The Measles and Rubella Strategic Framework 2021–2030 outlines potential actions to improve surveillance, including strengthening comprehensive surveillance supported by laboratory networks; promoting training of health workers in early detection, notification and investigation of cases using standardized definitions, tools, and templates for collecting data; and supplementing routine data collection with serosurveys to identify immunity gaps (*8*).

In countries that have not yet introduced RCV, providing policy makers with data on the impact of the investment to introduce RCV can help them determine whether their country should introduce RCV. The decision-making process benefits from 1) evaluation of the impact of RCV introduction on CRS, 2) consideration of the opportunities offered by accelerated measles elimination activities, and 3) evaluation of the long-term sustainability of financing for RCV along with other vaccines (*3*). Countries that had initially introduced RCV in selected populations (usually females only) to control CRS or that introduced RCV without a wide age-range campaign, should identify and address existing immunity gaps to achieve elimination. The Immunization Agenda 2030, the global immunization strategy for 2021–2030, includes rubella in its call for five regions to achieve elimination targets (*10*). Because all six WHO Regions have either established or expressed a commitment to rubella elimination, recommended strategic priorities include improving the collection and use of surveillance data, increasing community demand for and coverage with RCVs, and ensuring the availability of vaccine supplies and laboratory reagents (*8*). Because rubella and measles vaccines are administered as a combined vaccine and the surveillance systems are intricately connected, the progress toward rubella elimination might be a motivating marker of progress toward measles elimination.

The findings in this report are subject to at least two limitations. First, the accuracy and reliability of surveillance and immunization data remain a challenge, limiting the ability to identify immunity gaps, to focus immunization-strengthening activities, and to demonstrate the interruption of rubella virus transmission. Second, the decrease in the number of countries reporting and the effects of the COVID-19 pandemic on the quality of surveillance data limit the ability to monitor progress in 2020.

Considerable progress has been made in control and elimination of rubella and CRS since 2012. By 2020, only 21 (11%) countries have yet to introduce RCV into the immunization schedule, global RCV coverage has increased by 30%, and one region has eliminated rubella and a second region is close. The commitment to elimination by all regions indicates that global rubella elimination is in sight. As the remaining countries introduce RCVs, surveillance and coverage data will become crucial to identifying and closing immunity gaps and maintaining high routine coverage, with periodic campaigns conducted as necessary to achieve and maintain elimination status.

Summary

What is already known about this topic?

Congenital rubella syndrome, a devastating constellation of birth defects, is caused by rubella infection during pregnancy. Since 2012, rubella-containing vaccine (RCV) introduction efforts have accelerated worldwide, and a 2020 global policy update recommended that introduction efforts use a strategy that leads to elimination.

What is added by this report?

By 2020, 173 (89%) of 194 countries had introduced RCVs, and 93 (48%) had been verified as having eliminated rubella transmission. Vaccination introduction equity improved substantially among lower income countries, but vaccination coverage remains a concern.

What are the implications for public health practice?

To further progress, it is important the 21 remaining countries introduce rubella vaccine and that all countries enhance vaccination coverage and surveillance to achieve and maintain elimination.

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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.

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Identifying Higher-Volume Antibiotic Outpatient Prescribers Using Publicly Available Medicare Part D Data — United States, 2019

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Antibiotic prescribing can lead to adverse drug events and antibiotic resistance, which pose ongoing urgent public health threats (*1*). Adults aged ≥65 years (older adults) are recipients of the highest rates of outpatient antibiotic prescribing and are at increased risk for antibiotic-related adverse events, including *Clostridioides difficile* and antibiotic-resistant infections and related deaths (*1*). Variation in antibiotic prescribing quality is primarily driven by prescribing patterns of individual health care providers, independent of patients' underlying comorbidities and diagnoses (*2*). Engaging higher-volume prescribers (the top 10% of prescribers by antibiotic volume) in antibiotic stewardship interventions, such as peer comparison audit and feedback in which health care providers receive data on their prescribing performance compared with that of other health care providers, has been effective in reducing antibiotic prescribing in outpatient settings and can be implemented on a large scale (*3–5*). This study analyzed data from the Centers for Medicare & Medicaid Services (CMS) Part D Prescriber Public Use Files (PUFs)* to describe higher-volume antibiotic prescribers in outpatient settings compared with lower-volume prescribers (the lower 90% of prescribers by antibiotic volume). Among the 59.4 million antibiotic prescriptions during 2019, 41% (24.4 million) were prescribed by the top 10% of prescribers (69,835). The antibiotic prescribing rate of these higher-volume prescribers (680 prescriptions per 1,000 beneficiaries) was 60% higher than that of lower-volume prescribers (426 prescriptions per 1,000 beneficiaries). Identifying health care providers responsible for a higher volume of antibiotic prescribing could provide a basis for additional assessment of appropriateness and outreach. Public health organizations and health care systems can use publicly available data to guide focused interventions to optimize antibiotic prescribing to limit the emergence of antibiotic resistance and improve patient outcomes.

Approximately 70% of Medicare beneficiaries are enrolled in Medicare Part D, the prescription drug benefit program for adults aged ≥65 years and persons with disabilities or end-stage renal disease. CMS Medicare Part D Prescribers by Provider is a publicly available data set that contains prescriber-level aggregate counts of outpatient prescription drug events by three drug types (antibiotics, antipsychotics, and opioids) and provider characteristics, including names, National Provider Identifier, specialty (including prescriber type), and zip code. There is a 2-year lag in data availability, during which prescription drug claims are finalized. Because beneficiary and antibiotic claim counts fewer than 11 are suppressed, the 2019 Medicare Part D Prescribers by Provider data set was used to assess prescriber-level antibiotic prescriptions among health care providers in the United States who distributed 11 or more antibiotic prescriptions.

Higher-volume prescribers were defined as those in the highest 10th percentile of prescriber-level antibiotic volume (number of antibiotic prescriptions filled) across all Medicare providers nationwide. The cumulative percentage of antibiotic volume prescribed by higher-volume prescribers was assessed overall, and the percentage of higher-volume prescribers in each U.S. Census Bureau region† and specialty were described. To verify that antibiotic volume was not exclusively driven by the number of Medicare beneficiaries attributed to an individual prescriber, the percentage of beneficiaries with an antibiotic prescription and the prescriber's antibiotic volume per 1,000 beneficiaries were calculated. The antibiotic prescribing rate was compared between the defined national subset of higher-volume prescribers and lower-volume prescribers by specialty and U.S. Census Bureau region. Ten beneficiaries were imputed for suppressed beneficiary counts to provide a conservative estimate of the prescribing rate. The Wilcoxon rank-sum test was used to compare median prescribing rates among prescribers. All analyses were performed using SAS (version 9.4; SAS Institute). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.§

During 2019, the Medicare Part D Prescribers by Provider data set included 1.2 million prescribers. After excluding prescribers with fewer than 11 antibiotic prescriptions and

* https://data.cms.gov/provider-summary-by-type-of-service/medicare-part-d-prescribers/medicare-part-d-prescribers-by-provider (Accessed October 18, 2021).

† U.S. Census Bureau regions: *Northeast*: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. *Midwest*: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. *South*: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. *West*: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

§ 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.

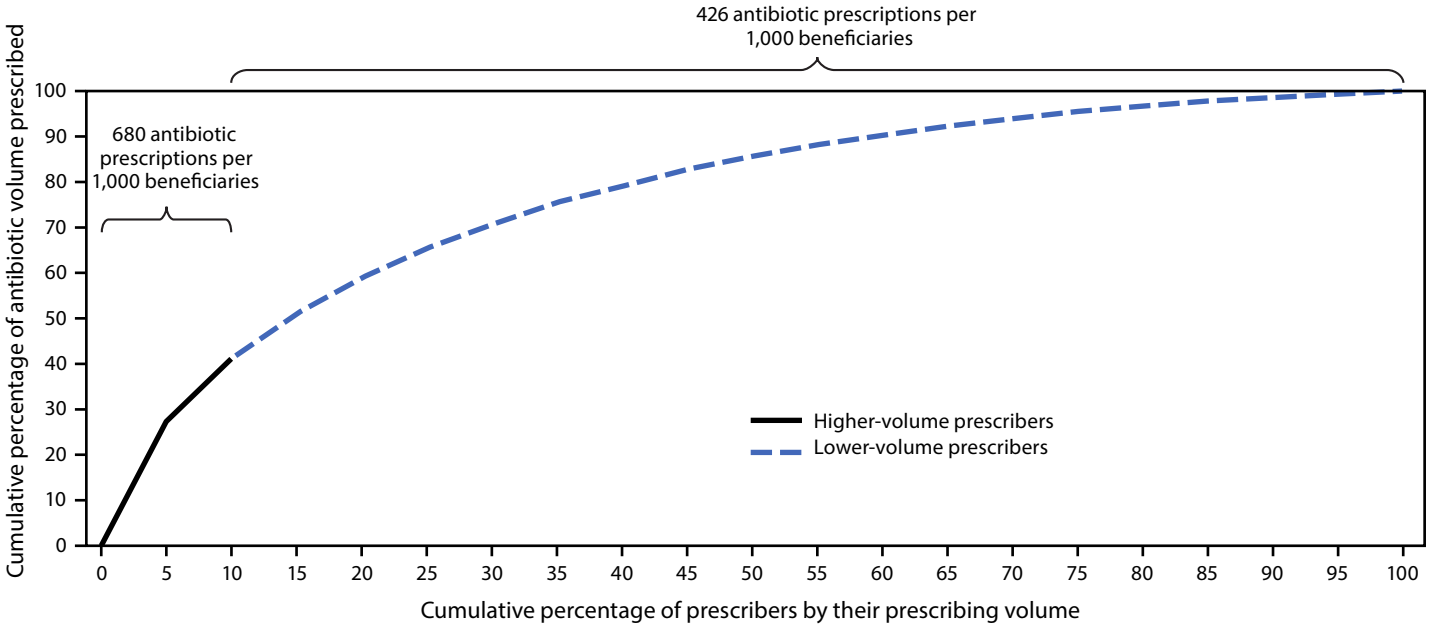
those in U.S. territories or overseas military bases, 697,065 (56%) prescribers were included in the analysis. A total of 59.4 million antibiotic prescriptions were filled by Part D beneficiaries, with a median of 47 (IQR = 23–100) antibiotic prescriptions per prescriber. Among all antibiotic prescriptions, 41% (24.4 million) were written by the top 10% (69,835) of antibiotic prescribers by number of prescriptions written (antibiotic volume) (Figure); these prescribers wrote a median of 284 antibiotic prescriptions (IQR = 230–393) compared with a median of 41 (IQR = 21–78) among lower-volume prescribers. Higher-volume prescribers prescribed antibiotics to a median of 38% of their patient panel (i.e., group of patients assigned to a specific health care provider or clinical team) compared with a median of 32% among lower-volume prescribers. In addition, the median antibiotic prescribing rate among higher-volume prescribers was 60% higher than that of lower-volume prescribers (680 versus 426 prescriptions per 1,000 beneficiaries) ($p<0.001$).

Approximately one half (48%) of higher-volume prescribers practiced in the South and prescribed 49% (12.3 million) of the total antibiotic prescriptions in this region (Table). Higher-volume prescribers in the South also had the highest median antibiotic prescribing rate (696 antibiotic prescriptions per 1,000 beneficiaries) compared with higher-volume prescribers in other regions (649 in the West) ($p<0.001$). The most common specialties of higher-volume prescribers were family practice and internal medicine, with 21% (19,213 of 89,759) and 20% (17,185 of 85,442) of prescribers, respectively classified as higher-volume prescribers. Family practice and internal medicine higher-volume prescribers accounted for approximately 60% of the antibiotics prescribed within their respective specialties and 22% of the total antibiotic volume, collectively. Although urologists only contributed 1% of the total prescriber number during 2019, one half (50%) of urologists were higher-volume prescribers and prescribed 2.0 million antibiotic prescriptions, or 83% of urology-prescribed antibiotic volume. Higher-volume prescribers, as expected, had higher antibiotic prescribing rates within each specialty, with the highest rate among dentists.

Discussion

The goal of antibiotic stewardship is to improve the way health care providers prescribe antibiotics to optimize patient outcomes and reduce emergence of antibiotic resistance. During 2019, 41% of all Medicare Part D antibiotic prescriptions were prescribed by 10% of antibiotic prescribers, indicating that a small proportion of prescribers accounted for a disproportionately large number of antibiotic prescriptions. A similar 2016 study using claims data in Tennessee found that 50% of the state's antibiotic volume was attributed to 9% of prescribers (*6*). This substantial difference in prescribing practices presents opportunities for improved prescribing through antibiotic

FIGURE. Cumulative percentage of antibiotics prescribed by Medicare Part D* prescribers, by prescribing volume and rate among higher-volume and lower-volume prescribers† — United States, 2019



* Centers for Medicare & Medicaid Services Part D Prescribers by Provider data set, 2019.
† Higher-volume prescribers are the top 10% of prescribers by antibiotic volume; lower-volume prescribers are the lower 90% of prescribers by antibiotic volume.

TABLE. Number of antibiotic prescribers, number of outpatient antibiotic prescriptions, and prescribing rate per 1,000 beneficiaries* among higher-volume prescribers and lower-volume prescribers,† by U.S. Census Bureau region and specialty — United States, 2019

	Higher-volume prescribers (top 10%)			Lower-volume prescribers (lower 90%)			Total prescribers§		
	Prescribers (n = 69,835)	Prescriptions (n = 24.4 million)	Prescriptions per 1,000 beneficiaries	Prescribers (n = 627,230)	Prescriptions (n = 35.0 million)	Prescriptions per 1,000 beneficiaries	Prescribers (N = 697,065)	Prescriptions (N = 59.4 million)	Prescriptions per 1,000 beneficiaries
Characteristics	**No. (%)**	**No. (%)**	**Median (IQR)**	**No. (%)**	**No. (%)**	**Median (IQR)**	**No. (%)**	**No. (%)**	**Median (IQR)**
U.S. Census Bureau region¶									
South	33,571 (48.1)	12,277,664 (50.3)	696 (516–925)	217,854 (34.7)	12,800,940 (36.6)	434 (250–714)	251,425 (36.1)	25,078,604 (42.2)	471 (277–765)
Midwest	15,096 (21.6)	5,163,003 (21.2)	681 (507–912)	141,561 (22.6)	8,110,378 (23.2)	435 (260–714)	156,657 (22.5)	13,273,381 (22.4)	461 (278–750)
Northeast	11,188 (16.0)	3,715,665 (15.2)	655 (472–893)	129,416 (20.6)	6,802,148 (19.4)	410 (224–708)	140,604 (20.2)	10,517,813 (17.7)	432 (238–736)
West	9,980 (14.3)	3,241,995 (13.3)	649 (467–879)	138,399 (22.1)	7,270,835 (20.8)	419 (230–731)	148,379 (21.3)	10,512,830 (17.7)	436 (240–750)
Specialty									
Family practice	19,213 (27.5)	6,815,010 (27.9)	611 (463–796)	70,546 (11.2)	5,341,667 (15.3)	303 (201–455)	89,759 (12.9)	12,156,677 (20.5)	358 (225–553)
Internal medicine	17,185 (24.6)	6,476,428 (26.5)	590 (429–816)	68,257 (10.9)	4,716,606 (13.5)	333 (209–477)	85,442 (12.3)	11,193,034 (18.8)	375 (237–545)
Nurse practitioner	9,857 (14.1)	2,920,894 (12.0)	711 (553–866)	98,182 (15.7)	5,934,913 (17.0)	398 (244–587)	108,039 (15.5)	8,855,807 (14.9)	425 (258–625)
Urology	4,738 (6.8)	2,020,285 (8.3)	760 (603–961)	4,687 (0.7)	426,424 (1.2)	500 (370–660)	9,425 (1.4)	2,446,709 (4.1)	632 (462–839)
Physician assistant	5,200 (7.4)	1,553,698 (6.4)	686 (537–816)	61,273 (9.8)	3,634,949 (10.4)	407 (251–567)	66,473 (9.5)	5,188,647 (8.7)	427 (265–594)
Dentist	2,063 (3.0)	552,858 (2.3)	1,271 (1,122–1,450)	110,629 (17.6)	5,004,506 (14.3)	1,068 (914–1,222)	112,692 (16.2)	5,557,364 (9.4)	1,071 (917–1,228)
Other**	11,579 (16.6)	4,059,154 (16.6)	850 (583–1,239)	213,656 (34.1)	9,925,236 (28.4)	360 (188–533)	225,235 (32.3)	13,984,390 (23.5)	375 (197–560)

Abbreviation: CMS = Centers for Medicare & Medicaid Services.

* CMS Part D Prescribers by Provider data set, 2019.

† Higher-volume prescribers are the top 10% of prescribers by antibiotic volume; lower-volume prescribers are the lower 90% of prescribers by antibiotic volume.

§ Total number of prescribers includes prescribers with ≥11 antibiotic prescription drug events filled at their direction by Medicare Part D beneficiaries during 2019.

¶ U.S. Census Bureau regions: *Northeast*: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. *Midwest*: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. *South*: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. *West*: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

** "Other" includes the remaining provider specialties in the CMS Part D Prescribers by Provider data set. The top six prescriber specialties with the largest number of prescribers in the highest 10th percentile by antibiotic prescription volume are represented.

stewardship activities focusing on these higher-volume prescribers, independent of specialty. Total antibiotic volume is associated with unnecessary prescribing rates and might be a reasonable proxy for unnecessary prescribing in primary care settings (*7*). Furthermore, higher-volume prescribers prescribed antibiotics to a larger share of their patient panel and their prescribing rate was 60% higher than that of lower-volume prescribers, indicating that their prescribing practices might be independent of the number of beneficiaries under their care. Thus, prioritizing higher-volume prescribers for focused stewardship interventions has the potential to have a sizeable impact on antibiotic prescribing, even when data on visit volume, prescribing indications, and appropriateness are not available.

This study demonstrates a way to identify antibiotic prescribers who account for a large proportion of prescribing and could provide a basis for additional assessment of appropriateness and outreach. For example, public health organizations could use Medicare Part D data to identify individual higher-volume antibiotic prescribers by specialty for focused stewardship interventions. The higher-volume prescribers in primary care specialties prescribed one-quarter of the total Medicare Part D antibiotic volume during 2019. Studies indicate that primary care providers have varying prescribing rates, suggesting opportunities for improvement in settings in which most antibiotics are prescribed (*5*). Urologists and dentists also have high prescribing rates and should be considered for antibiotic stewardship interventions (*8*,*9*). Further evaluation of prescribing practices by and within specialties and specific conditions are needed to identify areas for improvement in antibiotic prescribing. Similar to this analysis, studies have described higher rates of total outpatient antibiotic prescribing in the South (*8*), which could not be explained by differences in underlying conditions in older adults (*10*). Further evaluation of inequities in social determinants of health, underlying patient comorbidities, and access to care is needed to assess whether these factors might contribute to higher rates of prescribing observed in the South.

The publicly available CMS Part D Prescribers by Provider data set might enable public health organizations and health care systems to efficiently identify prescribers for stewardship outreach in their jurisdictions without the need for complex analytic methods or need to acquire prescription claims data or diagnosis data.¶ Prioritizing higher-volume prescribers for antibiotic stewardship interventions could facilitate larger reductions than targeting lower-volume prescribers. Prescriber feedback letters with peer comparison, which is an evidence-based, low-cost, and scalable intervention (*3*–*5*) can be used to engage specific health care providers or geographic areas.** In

¶ https://www.cdc.gov/antibiotic-use/pdfs/Outpatient-Rx-Analytic-Guide-508.pdf

** CDC provides outpatient antibiotic stewardship resources, including prescriber feedback letters. https://www.cdc.gov/antibiotic-use/core-elements/outpatient.html

Summary

What is already known about this topic?

Health care providers vary in their propensity to prescribe antibiotics. Peer comparison audit and feedback is an effective antibiotic stewardship intervention to improve antibiotic prescribing.

What is added by this report?

The highest 10% of antibiotic prescribers prescribed 41% of total antibiotic prescriptions for Medicare Part D beneficiaries in 2019. The antibiotic prescribing rate of these higher-volume prescribers was 60% higher than that of lower-volume prescribers.

What are the implications for public health practice?

Publicly available Medicare Part D data can be used by public health organizations and health care systems to guide antibiotic stewardship interventions and optimize antibiotic prescribing to limit the emergence of antibiotic resistance and improve patient outcomes.

a randomized clinical trial among primary care physicians in Ontario, Canada receipt of a single letter informing prescribers they were in the top 25th percentile of prescribed antibiotic volume compared with their peers, along with recommendations about prescribing duration, resulted in a 5% relative reduction in total antibiotic use (*4*).

The findings in this report are subject to at least four limitations. First, the CMS Part D Prescribers by Provider data set captured prescription claims submitted to Medicare Part D and is thus not representative of the entire older adult population. Second, these data might not reflect health care providers' prescribing behavior for their entire patient population and might overrepresent health care providers with a larger share of Medicare beneficiaries, patients with complex medical conditions, or visits for conditions for which antibiotics are prescribed. Third, this data only describes volume of prescribing and does not report diagnosis and underlying conditions; therefore, the data cannot be used to assess appropriateness of prescribing. Finally, the 2-year lag in data availability affects timeliness, which would be important for real-time audit and feedback. Nonetheless, these data are useful for characterizing provider prescribing behaviors and supporting public health stewardship outreach.

This report demonstrates how publicly available data might be leveraged to monitor antibiotic use and identify higher-volume prescribers. CMS Part D Prescribers by Provider data can be used by public health organizations and health care systems to guide antibiotic stewardship interventions and optimize antibiotic prescribing to limit the emergence of antibiotic resistance and improve patient outcomes.

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All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Lauri A. Hicks reports being an unpaid elected board member of the Society for Healthcare Epidemiology of America and an unpaid member of the American College of Physicians Clinical Guidelines Committee. No other potential conflicts of interest were disclosed.

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Genomic Surveillance for SARS-CoV-2 Variants: Predominance of the Delta (B.1.617.2) and Omicron (B.1.1.529) Variants — United States, June 2021–January 2022

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Genomic surveillance is a critical tool for tracking emerging variants of SARS-CoV-2 (the virus that causes COVID-19), which can exhibit characteristics that potentially affect public health and clinical interventions, including increased transmissibility, illness severity, and capacity for immune escape. During June 2021–January 2022, CDC expanded genomic surveillance data sources to incorporate sequence data from public repositories to produce weighted estimates of variant proportions at the jurisdiction level and refined analytic methods to enhance the timeliness and accuracy of national and regional variant proportion estimates. These changes also allowed for more comprehensive variant proportion estimation at the jurisdictional level (i.e., U.S. state, district, territory, and freely associated state). The data in this report are a summary of findings of recent proportions of circulating variants that are updated weekly on CDC's COVID Data Tracker website to enable timely public health action.[†] The SARS-CoV-2 Delta (B.1.617.2 and AY sublineages) variant rose from 1% to >50% of viral lineages circulating nationally during 8 weeks, from May 1–June 26, 2021. Delta-associated infections remained predominant until being rapidly overtaken by infections associated with the Omicron (B.1.1.529 and BA sublineages) variant in December 2021, when Omicron increased from 1% to >50% of circulating viral lineages during a 2-week period. As of the week ending January 22, 2022, Omicron was estimated to account for 99.2% (95% CI = 99.0%–99.5%) of SARS-CoV-2 infections nationwide, and Delta for 0.7% (95% CI = 0.5%–1.0%). The dynamic landscape of SARS-CoV-2 variants in 2021, including Delta- and Omicron-driven resurgences of SARS-CoV-2 transmission across the United States, underscores the importance of robust genomic surveillance efforts to inform public health planning and practice.

In November 2020, CDC expanded its genomic surveillance program to track SARS-CoV-2 lineages at the national and U.S. Department of Health and Human Services (HHS) regional levels (*1*,*2*). CDC also initiated SARS-CoV-2 Sequencing for Public Health Emergency Response, Epidemiology, and Surveillance[§] (SPHERES), a national SARS-CoV-2 genomic surveillance consortium. Currently, the national genomic surveillance program integrates three principal sources of SARS-CoV-2 sequence data: 1) the National SARS-CoV-2 Strain Surveillance (NS3) program[¶]; 2) CDC-contracted commercial sequencing data; and 3) sequences from public health, academic, and clinical laboratories that are tagged[**] as baseline surveillance in public genomic data repositories, such as Global Initiative on Sharing All Influenza Data (GISAID) and National Center for Biotechnology Information (NCBI) GenBank. Inclusion of tagged SARS-CoV-2 sequence data was instituted in October 2021 to enhance the geographic representativeness and precision of variant proportion estimates and to enhance the surveillance program's sustainability.

SARS-CoV-2 consensus sequences[††] submitted or tagged for national genomic surveillance were combined, assessed for quality, deduplicated, and analyzed for weekly estimation of variant proportions at the national, HHS regional, and jurisdictional levels. SARS-CoV-2 variant proportions (with 95% CIs) were estimated weekly for variants of concern, variants of interest, variants being monitored,[§§] and any other lineages accounting for >1% of sequences nationwide during the preceding 12 weeks. Proportion estimation methods used a complex survey design with statistical weights to correct

*These authors contributed equally to this report.

† Estimates on CDC COVID Data Tracker may vary slightly from those in this report because the estimates were calculated on different days. https://covid.cdc.gov/covid-data-tracker/#variant-proportions

§ https://www.cdc.gov/coronavirus/2019-ncov/variants/spheres.html

¶ https://www.aphl.org/programs/preparedness/Crisis-Management/COVID-19-Response/Pages/Sequence-Based-Surveillance-Submission.aspx

** Sequence tagging allows for sequencing partners to tag or label randomly sampled SARS-CoV-2 sequences submitted via GISAID EpiCov and NCBI GenBank to be used in CDC genomic surveillance estimates. https://www.aphl.org/programs/preparedness/Crisis-Management/Documents/Technical-Assistance-for-Categorizing-Baseline-Surveillance-Update-Oct2021.pdf

†† A consensus sequence is produced by aligning SARS-CoV-2 nucleotide sequences produced through sequencing a sample and then determining the most common nucleotide at each position. It is an interoperable genomic surveillance unit that can be combined from laboratory sources.

§§ https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/variant-surveillance/variant-info.html

potential biases because samples selected for sequencing might not be representative of all SARS-CoV-2 infections (Box).[¶¶] Each submitting laboratory source was considered a primary sampling unit, and the geographic level (i.e., jurisdictional, HHS regional, or national) and week of sample collection for each sequence, a stratum. Weights account for the probability that a sample from an infection is sequenced and are trimmed to the 99th percentile. Variant proportion estimates that did not meet the National Center for Health Statistics' data presentation standards for proportions were flagged.[***] During June 2021–January 2022, the median interval from SARS-CoV-2 sample collection to availability of consensus sequences was 15 days. Therefore, to estimate variant proportions during the most recent 2 weeks, multinomial regression models were fit for national and regional estimates to nowcast (*2*) variant proportions with corresponding 95% projection intervals[†††] using the most recent 21 weeks of data for prediction. To compare the speeds of initial variant transmission, the doubling time of each variant was calculated using the "time" covariate in nowcast models. All analyses used PANGO SARS-CoV-2

[¶¶] https://github.com/CDCgov/SARS-CoV-2_Genomic_Surveillance

[***] Flagged estimates are presented with a note indicating they might be less reliable. https://www.cdc.gov/nchs/data/series/sr_02/sr02_175.pdf

[†††] CIs show uncertainty around an estimate describing observed data; prediction intervals show uncertainty around predictions of unobserved data, such as the nowcast variant proportions.

BOX. SARS-CoV-2 variant* proportion estimation methods,† — United States, June–December 2021

Estimated weighted proportions: weighted analysis using complex survey design methods to produce weekly estimates

Survey design

- Primary sampling unit
  - Laboratory source of the sequence
- Strata
  - Geography (region/jurisdiction) and week
- Analysis weights
  - Number of infections represented by each sequence
  - Adjusted for known oversampling of S-gene target failure (SGTF) specimens
  - Weights greater than 99th percentile are trimmed and redistributed

Variants included

- Variant of concern
- Variant of interest
- Variant being monitored
- >1% of unweighted sequences in the 12 weeks before the most recent 2 weeks

Geographic level of analysis

- Jurisdiction
- U.S. Department of Health and Human Services (HHS) region
- National

Period

- Jurisdictions: variant proportions for the combined 4 weeks preceding the most recent 2 weeks
- HHS Region and National: weekly variant proportions for the past 3–12 weeks

Nowcast model: multinomial regression analysis of complex survey data

Survey design

- Primary sampling unit
  - Laboratory source of the sequence
- Strata
  - Geography (region/jurisdiction) and week
- Analysis weights
  - Number of infections represented by each sequence
  - Adjusted for known oversampling of SGTF specimens
  - Weights greater than 99th percentile are trimmed and redistributed

Variants included

- Variant of concern
- Variant of interest
- Variant being monitored
- >1% of unweighted sequences in the 12 weeks before the most recent 2 weeks

Geographic level of analysis

- HHS region
- National

Period

- Weekly variant proportions for the most recent 2 weeks

* https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/variant-surveillance/variant-info.html

† https://github.com/CDCgov/SARS-CoV-2_Genomic_Surveillance

lineage nomenclature and sublineages were aggregated under the parent lineage (*3*). This activity was reviewed by CDC and conducted consistent with applicable federal law and CDC policy.[§§§]

Genomic sequencing capacity in the United States has increased in both throughput and participating laboratories during the COVID-19 pandemic, with 1,189,459 sequences submitted during June 2021–January 2022. The corresponding average of 35,431 sequences per week is approximately three times higher than the 10,643 sequences per week during the surveillance period covered by the previous report (December 2020–May 2021) (*2*). As of the week ending January 22, 2022, a total of 1,469,400 SARS-CoV-2 sequences met the criteria[¶¶¶] for being included in national genomic surveillance estimates; 88% of sequences were from CDC-contracted commercial diagnostic laboratories, 2% from NS3, and 10% were baseline-tagged sequences. Sequences originated from 56 jurisdictions: 50 U.S. states, District of Columbia, American Samoa, Guam, Northern Mariana Islands, Puerto Rico, and U.S. Virgin Islands.

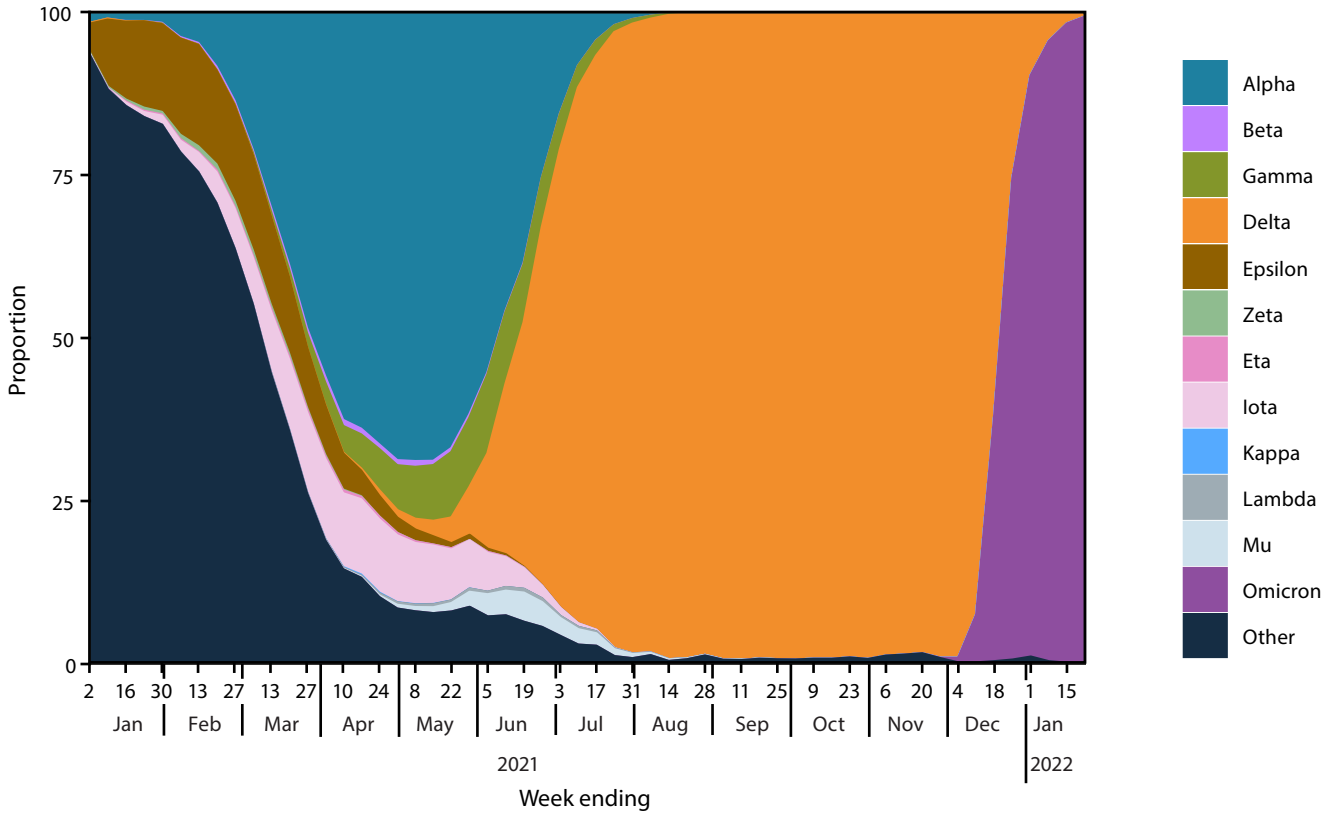
During June 2021, the proportion of several variants changed markedly (Figure 1). Alpha (B.1.1.7 and Q sublineages) continued to decline nationally. Gamma (P.1 and descendent lineages) peaked at 12.1% (95% CI = 9.8%–14.7%) during the week ending June 5, 2021, before declining; Mu (B.1.621) and Lambda (C.37) increased to their peaks of 4.5% (95% CI = 3.5%–5.6%) and 0.6% (95% CI = 0.3%–0.9%), respectively, for the week ending June 19, before declining as Delta (B.1.617.2 and AY sublineages) reached predominance (>50%).[****] The overall effect was a reduction in SARS-CoV-2 variant diversity because of Delta's growth in proportion, with

[§§§] 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.0 Sect.552a; 44 U.S.C. Sect. 3501 et seq.

[¶¶¶] Sequences are first excluded if they are not assigned a PANGO lineage, and then are filtered to include only human hosts and U.S.-specific sequences. This pool of sequences is then deduplicated, and finally, sequences with invalid state names, laboratory sources, and weights are dropped.

[****] Predominance refers to a variant accounting for >50% of national circulating SARS-CoV-2 lineages among infections.

FIGURE 1. National weekly proportion estimates* of SARS-CoV-2 variants† — United States, January 2, 2021–January 22, 2022



Abbreviations: NS3 = National SARS-CoV-2 Strain Surveillance program; PANGO = Phylogenetic Assignment of Named Global Outbreak; WHO = World Health Organization.

* Sequences are reported to CDC through NS3, contract laboratories, public health laboratories, and other U.S. institutions. Variant proportion estimation methods use a complex survey design and statistical weights to account for the probability that a specimen is sequenced.

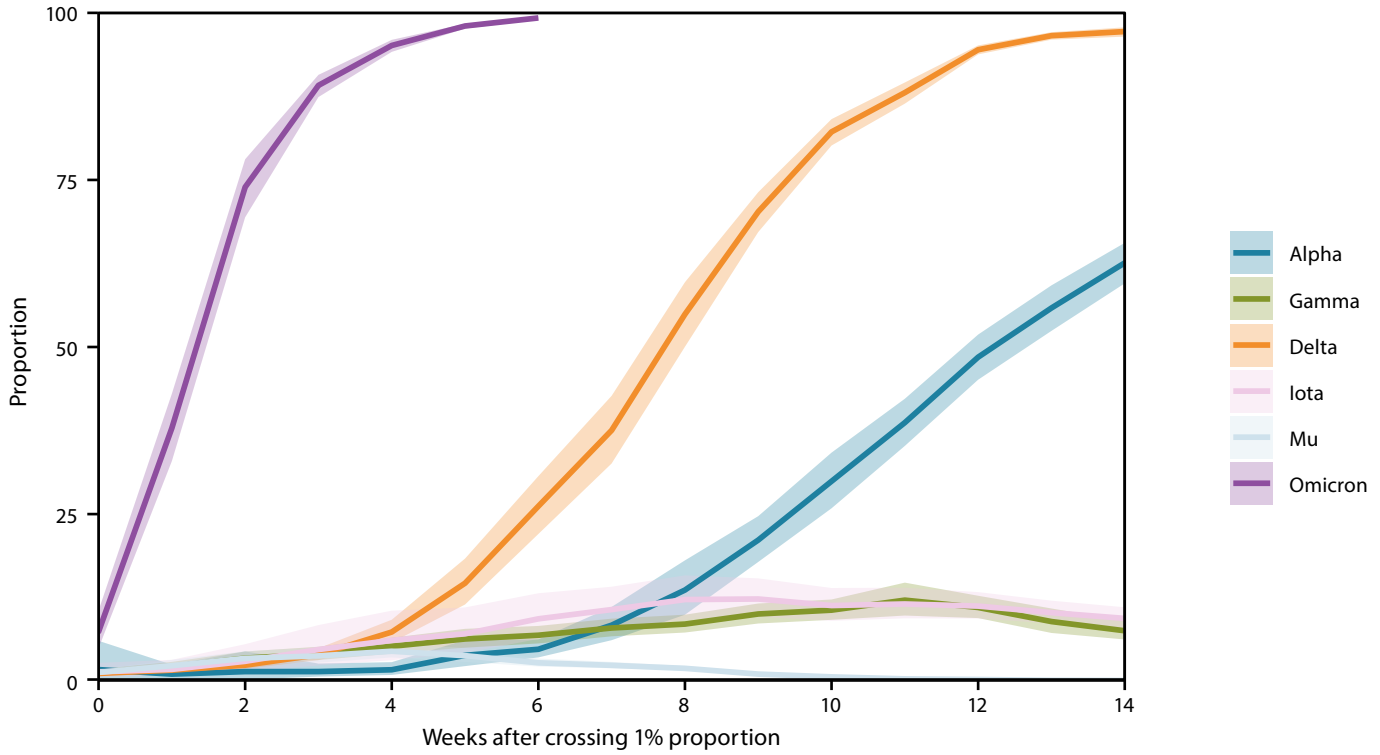
† SARS-CoV-2 WHO variant label and PANGO lineage: Alpha (B.1.1.7); Beta (B.1.351); Gamma (P.1); Delta (B.1.617.2), Epsilon (B.1.427/B.1.429); Zeta (P.2); Eta (B.1.525); Iota (B.1.526); Kappa (B.1.617.1); Lambda (C.37); Mu (B.1.621); and Omicron (B.1.1.529). https://www.cdc.gov/coronavirus/2019-ncov/variants/variant-classifications.html

five variants being monitored circulating at >1% in June and only one variant circulating above this threshold in September. The Delta variant rose from 1% of circulating SARS-CoV-2 viruses nationally during the week ending May 1, to >50% by the week ending June 26, and to >95% by the week ending July 31. Delta prevalence was >95% in all 10 HHS regions†††† by the week ending July 31 and remained >50% in each region for ≥24 weeks.

†††† *Region 1*: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; *Region 2*: New Jersey, New York, Puerto Rico, and U.S. Virgin Islands; *Region 3*: Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia; *Region 4*: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee; *Region 5*: Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin; *Region 6*: Arkansas, Louisiana, New Mexico, Oklahoma, and Texas; *Region 7*: Iowa, Kansas, Missouri, and Nebraska; *Region 8*: Colorado, Montana, North Dakota, South Dakota, Utah, and Wyoming; *Region 9*: American Samoa, Arizona, California, Guam, Hawaii, Marshall Islands, Nevada, Northern Mariana Islands, Federated States of Micronesia, and Palau, *Region 10*: Alaska, Idaho, Oregon, and Washington.

The Omicron variant proportion rapidly increased after the first U.S. case was reported on December 1 (*4*). Omicron first accounted for >1% of circulating lineages nationally during the week ending December 11, 2021, >50% of viruses for the week ending December 25, and >95% by the week ending January 8, 2021. As of the week ending January 22, 2022, national genomic surveillance estimates were 99.2% (95% CI = 99.0%–99.5%) for Omicron and 0.7% (95% CI = 0.5%–1.0%) for Delta. Region 7 had the highest proportion of Delta (3.0%; 95% CI = 1.9%–4.4%) and the lowest proportion of Omicron (97.0%; 95% CI =95.6%–98.1%). Region 9 had the highest proportion of Omicron (99.8%; 95% CI = 99.6%–99.9%) and the lowest proportion of Delta (0.2%; 95% CI = 0.1%–0.4%). Omicron's variant proportion had an estimated initial doubling time of 3.2 days (95% CI = 3.1–3.4 days), which was faster than those of Delta (7.2 days; 95% CI = 7.0–7.4 days), Alpha (11.0 days; 95% CI = 8.3–16.1 days), Gamma (13.1 days; 95% CI = 12.0–14.3 days), and Mu (14.7 days; 95% CI = 13.8–15.7 days). Omicron rose from 1% to 99%

FIGURE 2. Estimated variant proportions with 95% confidence intervals* during the first 14 weeks of each variant's emergence (from the time of exceeding 1% of national circulating viruses) for six SARS-CoV-2 variants† — United States, November 2020–January 2022



Abbreviations: NS3 = National SARS-CoV-2 Strain Surveillance program; PANGO = Phylogenetic Assignment of Named Global Outbreak; WHO = World Health Organization.

* 95% CIs for estimates are shown by shaded areas. Sequences are reported to CDC through NS3, contract laboratories, public health laboratories, and other U.S. institutions. The methods for estimating variant proportions and 95% CIs use a complex survey design and statistical weights to account for the probability that a specimen is sequenced.

† SARS-CoV-2 WHO variant label and PANGO lineage: Alpha (B.1.1.7), Beta (B.1.351), Gamma (P.1), Delta (B.1.617.2), Mu (B.1.621), and Omicron (B.1.1.529). https://www.cdc.gov/coronavirus/2019-ncov/variants/variant-classifications.html

of infections nationally in 6 weeks, compared with 18 weeks for Delta (Figure 2).

Discussion

This report summarizes CDC's weekly surveillance of variant proportions, which are used to drive public health action. The proportional distribution of SARS-CoV-2 variants circulating in the United States changed considerably during 2021. In spring 2021, Alpha co-circulated nationally with several other variants (e.g., Gamma, Delta, Eta, and Iota), but Delta became the predominant variant nationally in late June. Delta remained the only SARS-CoV-2 variant circulating at a high proportion from August–November but was rapidly overtaken by Omicron in late December. The rises of the Delta and Omicron variants were associated with major surges in COVID-19 cases during July–September 2021 and December 2021–January 2022, respectively.[§§§§] The Omicron-driven wave that started in December 2021 is declining. These variant dynamics illustrate how SARS-CoV-2 has continued to evolve, with different variants defining different phases of the COVID-19 pandemic.

Variant emergence and growth are likely influenced by a combination of viral and host population factors. Factors contributing to Delta's rise in prevalence include increased transmissibility and a subtle increase in immune escape relative to previous variants (*5*,*6*). Omicron's rise in prevalence was likely driven by increased transmissibility (*7*) that might be due primarily to immune escape[¶¶¶¶] (*8*), which also decreases the effectiveness of vaccines and monoclonal antibodies (*9*). However, early studies suggest that the relative severity of disease attributed to Omicron infections is lower than that resulting from infections with other SARS-CoV-2 variants.[*****,†††††] A variant's ability to spread and cause disease is affected by population susceptibility (duration of variant-specific immunity, cross-protection from previous infections, and vaccine-induced immunity). Transmission is also influenced by human behavior, particularly through prevention strategies.

The findings of this report are subject to at least four limitations. First, estimates might be biased by nonrandom sampling of specimens or differential timing of reporting (e.g., prioritizing sequences with S-gene target failure[§§§§§] or sequences from international travelers). Second, the precision of estimates of newly emerging variants is initially affected by relatively small numbers of available sequences, especially at the jurisdictional and regional levels. Third, current variant estimation analyses might differ from past analyses because of changes in PANGO lineage definitions over time. Finally, the presented dates correspond to clinical testing, and noted variants were likely present before these periods; for example, wastewater surveillance indicates that Omicron was circulating in the United States >1 week before the first reported case (*10*).

CDC's national SARS-CoV-2 genomic surveillance program has expanded data sources and refined analytic methods to enhance the timeliness and accuracy of national and regional variant proportion estimates. These changes have enhanced the robustness and representativeness of variant proportion estimates. Nowcast modeling at multiple geographic levels has enabled more timely estimation and demonstrated an ability to monitor emerging variants, even those circulating at low levels. SARS-CoV-2 variants are expected to continue emerging; a future variant might challenge the predominance of Omicron and exhibit different characteristics that affect public health and clinical interventions. Consequently, it is important to maintain SARS-CoV-2 genomic surveillance to ensure emerging variants are monitored and to promptly inform public health planning and practice.

Summary

What is already known about this topic?

CDC conducts genomic surveillance to track SARS-CoV-2 variants in the United States.

What is added by this report?

CDC's SARS-CoV-2 genomic surveillance has been expanded to incorporate sequence data from public repositories and to produce weighted estimates of variant proportions at the jurisdiction level. The Delta (B.1.617.2 and AY sublineages) variant rose to predominance in late June 2021, followed by the rapid rise of Omicron (B.1.1.529 and BA sublineages) in December 2021.

What are the implications for public health practice?

The dynamic landscape of SARS-CoV-2 variants in 2021, including Delta- and Omicron-driven resurgences of SARS-CoV-2 transmission across the United States, underscores the importance of robust genomic surveillance efforts to inform public health planning and practice.

Acknowledgments

Public health program and laboratory staff members who contribute to National SARS-CoV-2 Strain Surveillance NS3, including the Association of Public Health Laboratories, commercial laboratory staff members, laboratories submitting tagged baseline SARS-CoV-2 sequences via GISAID EpiCov and NCBI GenBank; SARS-CoV-2 Sequencing for Public Health Emergency Response; Epidemiology and Surveillance (SPHERES); CDC COVID-19

§§§§ https://covid.cdc.gov/covid-data-tracker/#trends_dailycases
¶¶¶¶ https://www.biorxiv.org/content/10.1101/2021.12.31.474032v1
***** https://www.medrxiv.org/content/10.1101/2021.12.30.21268495v1.full.pdf
††††† https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3996320
§§§§§ S-gene target failure: widely used TaqPath COVID-19 Combo Kit polymerase chain reaction assay used for screening and as a proxy for Alpha and Omicron variant detection.

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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.

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Effectiveness of Face Mask or Respirator Use in Indoor Public Settings for Prevention of SARS-CoV-2 Infection — California, February–December 2021

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On February 4, 2022, this report was posted as an MMWR *Early Release on the* MMWR *website (https://www.cdc.gov/mmwr).*

The use of face masks or respirators (N95/KN95) is recommended to reduce transmission of SARS-CoV-2, the virus that causes COVID-19 (*1*). Well-fitting face masks and respirators effectively filter virus-sized particles in laboratory conditions (*2*,*3*), though few studies have assessed their real-world effectiveness in preventing acquisition of SARS-CoV-2 infection (*4*). A test-negative design case-control study enrolled randomly selected California residents who had received a test result for SARS-CoV-2 during February 18–December 1, 2021. Face mask or respirator use was assessed among 652 case-participants (residents who had received positive test results for SARS-CoV-2) and 1,176 matched control-participants (residents who had received negative test results for SARS-CoV-2) who self-reported being in indoor public settings during the 2 weeks preceding testing and who reported no known contact with anyone with confirmed or suspected SARS-CoV-2 infection during this time. Always using a face mask or respirator in indoor public settings was associated with lower adjusted odds of a positive test result compared with never wearing a face mask or respirator in these settings (adjusted odds ratio [aOR] = 0.44; 95% CI = 0.24–0.82). Among 534 participants who specified the type of face covering they typically used, wearing N95/KN95 respirators (aOR = 0.17; 95% CI = 0.05–0.64) or surgical masks (aOR = 0.34; 95% CI = 0.13–0.90) was associated with significantly lower adjusted odds of a positive test result compared with not wearing any face mask or respirator. These findings reinforce that in addition to being up to date with recommended COVID-19 vaccinations, consistently wearing a face mask or respirator in indoor public settings reduces the risk of acquiring SARS-CoV-2 infection. Using a respirator offers the highest level of personal protection against acquiring infection, although it is most important to wear a mask or respirator that is comfortable and can be used consistently.

This study used a test-negative case-control design, enrolling persons who received a positive (case-participants) or negative (control-participants) SARS-CoV-2 test result, from among all California residents, without age restriction, who received a molecular test result for SARS-CoV-2 during February 18–December 1, 2021 (*5*). Potential case-participants were randomly selected from among all persons who received a positive test result during the previous 48 hours and were invited to participate by telephone. For each enrolled case-participant, interviewers enrolled one control-participant matched by age group, sex, and state region; thus, interviewers were not blinded to participants' SARS-CoV-2 infection status. Participants who self-reported having received a previous positive test result (molecular, antigen, or serologic) or clinical diagnosis of COVID-19 were not eligible to participate. During February 18–December 1, 2021, a total of 1,528 case-participants and 1,511 control-participants were enrolled in the study among attempted calls placed to 11,387 case- and 17,051 control-participants (response rates were 13.4% and 8.9%, respectively).

After obtaining informed consent from participants, interviewers administered a telephone questionnaire in English or Spanish. All participants were asked to indicate whether they had been in indoor public settings (e.g., retail stores, restaurants or bars, recreational facilities, public transit, salons, movie theaters, worship services, schools, or museums) in the 14 days preceding testing and whether they wore a face mask or respirator all, most, some, or none of the time in those settings. Interviewers recorded participants' responses regarding COVID-19 vaccination status, sociodemographic characteristics, and history of exposure to anyone known or suspected to have been infected with SARS-CoV-2 in the 14 days before participants were tested. Participants enrolled during September 9–December 1, 2021, (534) were also asked to indicate the type of face covering typically worn (N95/KN95 respirator, surgical mask, or cloth mask) in indoor public settings.

The primary analysis compared self-reported face mask or respirator use in indoor public settings 14 days before SARS-CoV-2 testing between case- (652) and control- (1,176) participants. Secondary analyses accounted for consistency of face mask or respirator use all, most, some, or none of the time. To understand the effects of masking on community transmission, the analysis included the subset of participants who, during the 14 days before they were tested, reported visiting indoor public settings and who reported no known exposure to persons known or suspected to have been infected with SARS-CoV-2. An additional analysis assessed differences in protection against SARS-CoV-2 infection by the type of face covering worn, and was limited to a subset of participants

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enrolled after September 9, 2021, who were asked to indicate the type of face covering they typically wore; participants who indicated typically wearing multiple different mask types were categorized as wearing either a cloth mask (if they reported cloth mask use) or a surgical mask (if they did not report cloth mask use). Adjusted odds ratios comparing history of mask-wearing among case- and control-participants were calculated using conditional logistic regression. Match strata were defined by participants' week of SARS-CoV-2 testing and by county-level SARS-CoV-2 risk tiers as defined under California's Blueprint for a Safer Economy reopening scheme.[†] Adjusted models accounted for self-reported COVID-19 vaccination status (fully vaccinated with ≥2 doses of BNT162b2 [Pfizer-BioNTech] or mRNA-1273 [Moderna] or 1 dose of Ad.26.COV2.S [Janssen (Johnson & Johnson)] vaccine >14 days before testing versus zero doses), household income, race/ethnicity, age, sex, state region, and county population density. Statistical significance was defined by two-sided Wald tests with p-values <0.05. All analyses were conducted using R software (version 3.6.1; R Foundation). This activity was approved as public health surveillance by the State of California Health and Human Services Agency Committee for the Protection of Human Subjects.

A total of 652 case- and 1,176 control-participants were enrolled in the study equally across nine multi-county regions in California (Table 1). The majority of participants (43.2%) identified as non-Hispanic White; 28.2% of participants identified as Hispanic (any race). A higher proportion of case-participants (78.4%) was unvaccinated compared with control-participants (57.5%). Overall, 44 (6.7%) case-participants and 42 (3.6%) control-participants reported never wearing a face mask or respirator in indoor public settings (Table 2), and 393 (60.3%) case-participants and 819 (69.6%) control-participants reported always wearing a face mask or respirator in indoor public settings. Any face mask or respirator use in indoor public settings was associated with significantly lower odds of a positive test result compared with never using a face mask or respirator (aOR = 0.51; 95% CI = 0.29–0.93). Always using a face mask or respirator in indoor public settings was associated with lower adjusted odds of a positive test result compared with never wearing a face mask or respirator (aOR = 0.44; 95% CI = 0.24–0.82); however, adjusted odds of a positive test result suggested stepwise reductions in protection among participants who reported wearing a face mask or respirator most of the time (aOR = 0.55; 95% CI = 0.29–1.05) or some of the time (aOR = 0.71; 95% CI = 0.35–1.46) compared with participants who reported never wearing a face mask or respirator.

[†] https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/COVID-19/COVID19CountyMonitoringOverview.aspx

Wearing an N95/KN95 respirator (aOR = 0.17; 95% CI = 0.05–0.64) or wearing a surgical mask (aOR = 0.34; 95% CI = 0.13–0.90) was associated with lower adjusted odds of a positive test result compared with not wearing a mask (Table 3). Wearing a cloth mask (aOR = 0.44; 95% CI = 0.17–1.17) was associated with lower adjusted odds of a positive test compared with never wearing a face covering but was not statistically significant.

Discussion

During February–December 2021, using a face mask or respirator in indoor public settings was associated with lower odds of acquiring SARS-CoV-2 infection, with protection being highest among those who reported wearing a face mask or respirator all of the time. Although consistent use of any face mask or respirator indoors was protective, the adjusted odds of infection were lowest among persons who reported typically wearing an N95/KN95 respirator, followed by wearing a surgical mask. These data from real-world settings reinforce the importance of consistently wearing face masks or respirators to reduce the risk of acquisition of SARS-CoV-2 infection among the general public in indoor community settings.

These findings are consistent with existing research demonstrating that face masks or respirators effectively filter viruses in laboratory settings and with ecological studies showing reductions in SARS-CoV-2 incidence associated with community-level masking requirements (*6*,*7*). While this study evaluated the protective effects of mask or respirator use in reducing the risk the wearer acquires SARS-CoV-2 infection, a previous evaluation estimated the additional benefits of masking for source control, and found that wearing face masks or respirators in the context of exposure to a person with confirmed SARS-CoV-2 infection was associated with similar reductions in risk for infection (*8*). Strengths of the current study include use of a clinical endpoint of SARS-CoV-2 test result, and applicability to a general population sample.

The findings in this report are subject to at least eight limitations. First, this study did not account for other preventive behaviors that could influence risk for acquiring infection, including adherence to physical distancing recommendations. In addition, generalizability of this study is limited to persons seeking SARS-CoV-2 testing and who were willing to participate in a telephone interview, who might otherwise exercise other protective behaviors. Second, this analysis relied on an aggregate estimate of self-reported face mask or respirator use across, for some participants, multiple indoor public locations. However, the study was designed to minimize recall bias by enrolling both case- and control-participants within a 48-hour window of receiving a SARS-CoV-2 test result. Third, small strata limited the ability to differentiate between types of cloth masks or participants who wore different types of face

TABLE 1. Characteristics of case- and control-participants included in analysis of the effectiveness of mask use in indoor public settings, by SARS-CoV-2 test result — California,* February–December 2021

Characteristic	No. (%) Case-participants (SARS-CoV-2–positive) N = 652	Control-participants (SARS-CoV-2–negative) N = 1,176
Age group, yrs		
0–6	8 (1.2)	43 (3.7)
7–12	15 (2.3)	49 (4.2)
13–17	25 (3.8)	57 (4.8)
18–29	210 (32.2)	359 (30.5)
30–49	237 (36.3)	409 (34.8)
50–64	109 (16.7)	180 (15.3)
≥65	48 (7.4)	79 (6.7)
Sex		
Male	321 (49.2)	581 (49.4)
Female	331 (50.8)	595 (50.6)
Annual household income		
<$50,000	191 (29.3)	258 (21.9)
$50,000–$99,999	147 (22.5)	254 (21.6)
$100,000–$150,000	60 (9.2)	171 (14.5)
>$150,000	77 (11.8)	197 (16.8)
Refused	106 (16.3)	184 (15.6)
Not sure	71 (10.9)	112 (9.5)
State region†		
San Francisco Bay Area	79 (12.1)	147 (12.5)
Greater Los Angeles Area	77 (11.8)	130 (11.1)
Greater Sacramento Area	53 (8.1)	131 (11.1)
San Diego and southern border	73 (11.2)	142 (12.1)
Central Coast	87 (13.3)	132 (11.2)
Northern Sacramento Valley	69 (10.6)	134 (11.4)
San Joaquin Valley	79 (12.1)	130 (11.1)
Northwestern California	78 (12.0)	113 (9.6)
Sierras	57 (8.7)	117 (9.9)
Race/Ethnicity		
White, non-Hispanic	292 (44.8)	506 (43.0)
Black, non-Hispanic	39 (6.0)	42 (3.6)
Hispanic (any race)	201 (30.8)	315 (26.8)
Asian, non-Hispanic	56 (8.6)	134 (11.4)
American Indian or Alaska Native, non-Hispanic	9 (1.4)	10 (0.9)
Native Hawaiian or Other Pacific Islander, non-Hispanic	2 (0.3)	12 (1.0)
More than one race	40 (6.1)	131 (11.1)
Refused	13 (2.0)	26 (2.2)
COVID-19 vaccination status§		
Unvaccinated or incompletely vaccinated	511 (78.4)	676 (57.5)
Fully vaccinated	115 (17.6)	377 (32.1)
Unknown	26 (4.0)	123 (10.5)
Reopening tier in California¶		
Tier 1 (most restrictive)	125 (19.2)	237 (20.2)
Tier 2	152 (23.3)	255 (21.7)
Tier 3	119 (18.3)	272 (23.1)
Tier 4 (least restrictive)	18 (2.8)	32 (2.7)
After June 15, 2021	238 (36.5)	380 (32.3)
Reasons for SARS-CoV-2 testing**		
Experiencing symptoms	508 (77.9)	196 (16.7)
Testing required for medical procedure	40 (6.1)	199 (16.9)
Routine screening through work or school	71 (10.9)	507 (43.1)
Pre-travel test	33 (5.1)	120 (10.2)
Just wanted to see if I was infected	65 (10.0)	172 (14.6)
Test required for admission to an event or gathering	3 (0.5)	21 (1.8)

* A random sample of California residents with a molecular SARS-CoV-2 test result was invited to participate in a telephone-based survey to document frequency of face mask or respirator use and type of face mask or respirator typically worn in indoor public settings 2 weeks before testing. For each enrolled case-participant (person with a positive SARS-CoV-2 test result), interviewers attempted to enroll one control-participant (person with a negative SARS-CoV-2 test result) whose test result was posted to the reportable disease registry during the 48 hours preceding the call and matched the case-participant by age group, sex, and state region. Among 1,947 case- and control-participants who visited indoor public settings and did not report a known or suspected exposure to SARS-CoV-2 in the 14 days before getting a SARS-CoV-2 test, 119 (6.1%) participants were unable to report face mask use and were excluded from analysis. Parents or guardians served as proxy respondents and answered questions throughout the telephone survey on behalf of children aged <13 years.

† California counties were divided into nine geographic regions. Counties included in each geographic region are listed online in Table S1. https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciab640/6324500#supplementary-data

§ Vaccination status was defined using self-reported dates and manufacturers of doses received. Participants were asked to reference their COVID-19 vaccination card while providing vaccination history. Participants who could not provide a complete vaccination history (dates of doses received and manufacturers) were coded as unknown. Full vaccination was defined as receipt of 2 doses of BNT162b2 [Pfizer-BioNTech] or mRNA-1273 [Moderna], or receipt of 1 dose of Ad.26.COV2.S (Janssen [Johnson & Johnson]) >14 days before SARS-CoV-2 testing. Of the 492 fully vaccinated participants, 22 (4.5%) had received a booster dose at the time of enrollment. All other participants were considered unvaccinated or incompletely vaccinated.

¶ Reopening tiers in California were determined by the Blueprint for a Safer Economy the State of California implemented during February 24 to June 15, 2021. This was a tiered system of public health restrictions tied to county-level positive test results and incidence. On June 15, 2021, California retired the tiered reopening system and removed most restrictions on public gatherings, while some counties maintained guidelines for guests and workers to show proof of vaccination or a negative test result to gather in certain types of venues and workplaces. The tier of a given participant was determined by using the date that occurred 14 days before the SARS-CoV-2 specimen collection date recorded for each participant in the California Reportable Disease Registry.

** Case- and control-participants were asked to indicate their reasons for seeking a SARS-CoV-2 test as a free-text response. Trained interviewers (N = 29) recategorized the free-text response into the categories listed in the table. Interviewers were trained to ask probing questions if the free-text response could not be categorized into the reasons listed above. Probing questions and coding decisions may slightly vary by interviewer. Reasons for testing might sum to numbers larger than the total number of case-participants or control-participants because participants could indicate more than one reason for seeking a SARS-CoV-2 test.

TABLE 2. Face mask or respirator use in indoor public settings among persons with positive and negative SARS-CoV-2 test results — California, February–December 2021

	SARS-CoV-2 infection status, no. (%)		Odds ratio (95% CI)	
Mask type and use*	Positive (case-participant) N = 652	Negative (control-participant) N = 1,176	Unadjusted† [p-value]	Adjusted§ [p-value]
None (Ref)	44 (6.7)	42 (3.6)	—	—
Any use†	608 (93.3)	1,134 (96.4)	0.57 (0.37–0.90) [0.02]	0.51 (0.29–0.93) [0.03]
Some of the time	62 (9.5)	76 (6.5)	0.81 (0.47–1.41) [0.49]	0.71 (0.35–1.46) [0.36]
Most of the time	153 (23.5)	239 (20.3)	0.64 (0.40–1.05) [0.08]	0.55 (0.29–1.05) [0.07]
All of the time	393 (60.3)	819 (69.6)	0.49 (0.31–0.78) [<0.01]	0.44 (0.24–0.82) [<0.01]

Abbreviation: Ref = referent group.

* Trained interviewers administered a structured telephone-based questionnaire and asked participants to indicate whether they attended indoor public spaces during the 2 weeks before seeking a SARS-CoV-2 test. Participants who indicated attending these settings were further asked to specify whether they typically wore a face mask or respirator all, most, some, or none of the time while in these settings.

† Conditional logistic regression models were used to estimate the unadjusted odds of mask use by type of face mask or respirator worn in indoor public settings during the 2 weeks before testing. Models included matching strata defined by (for the period before June 15, 2021) the reopening tier of California in the county of residence and the week of SARS-CoV-2 testing.

§ Conditional logistic regression models were used to estimate the odds of face mask or respirator use in indoor public settings during the 2 weeks before testing, adjusting for COVID-19 vaccination status, household income, race/ethnicity, age group, sex, state region, and county population density. All models included matching strata defined by (for the period before June 15, 2021) the reopening tier of California in the county of residence, and the week of SARS-CoV-2 testing. To understand the effects of masking in community settings, this analysis was restricted to a subset of persons who did not indicate a known or suspected exposure to a SARS-CoV-2 case within 14 days of seeking a SARS-CoV-2 test. Adjusted models used a complete case analysis (454 case-participants and 789 control-participants). A sensitivity analysis using multiple imputation of missing covariate values obtained results similar to those reported in the table: adjusted odds ratios were 0.54 (95% CI = 0.33–0.89) for any mask use, 0.44 (95% CI = 0.27–0.73) for mask use all of the time, 0.62 (95% CI = 0.37–1.04) for mask use most of the time, and 0.77 (95% CI = 0.43–1.40) for mask use some of the time. An additional sensitivity analysis was conducted with additional adjustment for the reasons for SARS-CoV-2 testing as listed in Table 1 (experiencing symptoms, testing required for medical procedure, routine screening through work or school, pre-travel test, just wanted to see if I was infected, test required for admission to an event or gathering). The adjusted odds ratio was 0.42 (95% CI = 0.20–0.89) for any mask use as compared to no mask use upon additional adjustment for testing indications.

TABLE 3. Types of face mask or respirator worn in indoor public settings among persons with positive or negative SARS-CoV-2 test results — California, September–December 2021

	SARS-CoV-2 infection status, no. (%)		Odds ratio (95% CI)	
Mask type*	Positive (case-participant) N = 259	Negative (control-participant) N = 275	Unadjusted† [p-value]	Adjusted§ [p-value]
None (Ref)	24 (9.3)	11 (4.0)	—	—
Cloth mask	112 (43.2)	104 (37.8)	0.50 (0.23–1.06) [0.07]	0.44 (0.17–1.17) [0.10]
Surgical mask	113 (43.6)	139 (50.5)	0.38 (0.18–0.81) [0.01]	0.34 (0.13–0.90) [0.03]
N95/KN95 respirator	10 (3.9)	21 (7.6)	0.22 (0.08–0.62) [<0.01]	0.17 (0.05–0.64) [<0.01]

Abbreviation: Ref = referent group.

* Trained interviewers administered a structured telephone-based questionnaire and asked participants enrolled after September 9, 2021, to identify the type of face covering typically worn in indoor public settings during the 2 weeks before seeking a SARS-CoV-2 test. Participants who indicated typically wearing multiple different mask types were categorized as wearing either a cloth mask (if they reported cloth mask use) or a surgical mask (if they didn't report cloth mask use).

† Conditional logistic regression models were used to estimate the unadjusted odds of mask use by type of face mask or respirator worn in indoor public settings during the 2 weeks before testing. Models included matching strata defined by the week of SARS-CoV-2 testing.

§ This analysis was not restricted to persons with no self-reported known or suspected SARS-CoV-2 contact given that this secondary analysis was underpowered upon exclusion of these participants (N = 316) because adjusted models did not converge. Instead, models adjusted for history of known or suspected contact as a covariate. In a sensitivity analysis restricting to participants who did not report known or suspected contact (N = 316), conditional logistic regression models were used to estimate that the unadjusted odds ratios of face mask use by type of face mask with matching strata defined by the week of SARS-CoV-2 testing: 0.13 (95% CI = 0.03–0.61), 0.32 (95% CI = 0.12–0.89), and 0.36 (95% CI = 0.13–1.00) for N95/KN95 respirators, surgical masks, or cloth masks, respectively, relative to no face mask or respirator use.

masks in differing settings, and also resulted in wider CIs and statistical nonsignificance for some estimates that were suggestive of a protective effect. Fourth, estimates do not account for face mask or respirator fit or the correctness of face mask or respirator wearing; assessing the effectiveness of face mask or respirator use under real-world conditions is nonetheless important for developing policy. Fifth, data collection occurred before the expansion of the SARS-CoV-2 B.1.1.529 (Omicron) variant, which is more transmissible than earlier variants. Sixth, face mask or respirator use was self-reported, which could introduce social desirability bias. Seventh, small strata limited the ability to account for reasons for testing in the adjusted analysis, which may be correlated with face mask or respirator use. Finally, this analysis does not account for potential differences in the intensity of exposures, which could vary by duration, ventilation system, and activity in each of the various indoor public settings visited.

The findings of this report reinforce that in addition to being up to date with recommended COVID-19 vaccinations, consistently wearing face masks or respirators while in indoor public settings protects against the acquisition of SARS-CoV-2 infection (*9*,*10*).

Summary

What is already known about this topic?

Face masks or respirators (N95/KN95s) effectively filter virus-sized particles in laboratory settings. The real-world effectiveness of face coverings to prevent acquisition of SARS-CoV-2 infection has not been widely studied.

What is added by this report?

Consistent use of a face mask or respirator in indoor public settings was associated with lower odds of a positive SARS-CoV-2 test result (adjusted odds ratio = 0.44). Use of respirators with higher filtration capacity was associated with the most protection, compared with no mask use.

What are the implications for public health practice?

In addition to being up to date with recommended COVID-19 vaccinations, consistently wearing a comfortable, well-fitting face mask or respirator in indoor public settings protects against acquisition of SARS-CoV-2 infection; a respirator offers the best protection.

This highlights the importance of improving access to high-quality masks to ensure access is not a barrier to use. Using a respirator offers the highest level of protection from acquisition of SARS-CoV-2 infection, although it is most important to wear a well-fitting mask or respirator that is comfortable and can be used consistently.

California COVID-19 Case-Control Study Team

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All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Joseph A. Lewnard discloses receipt of research grants and consulting fees from Pfizer, Inc., unrelated to the current study. No other potential conflicts of interest were disclosed.

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Clinical Characteristics and Outcomes Among Adults Hospitalized with Laboratory-Confirmed SARS-CoV-2 Infection During Periods of B.1.617.2 (Delta) and B.1.1.529 (Omicron) Variant Predominance — One Hospital, California, July 15–September 23, 2021, and December 21, 2021–January 27, 2022

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On February 4, 2022, this report was posted as an MMWR *Early Release on the* MMWR *website (https://www.cdc.gov/mmwr).*

In mid-December 2021, the B.1.1.529 (Omicron) variant of SARS-CoV-2, the virus that causes COVID-19, surpassed the B.1.617.2 (Delta) variant as the predominant strain in California.§ Initial reports suggest that the Omicron variant is more transmissible and resistant to vaccine neutralization but causes less severe illness compared with previous variants (*1*–*3*). To describe characteristics of patients hospitalized with SARS-CoV-2 infection during periods of Delta and Omicron predominance, clinical characteristics and outcomes were retrospectively abstracted from the electronic health records (EHRs) of adults aged ≥18 years with positive reverse transcription–polymerase chain reaction (RT-PCR) SARS-CoV-2 test results admitted to one academic hospital in Los Angeles, California, during July 15–September 23, 2021 (Delta predominant period, 339 patients) and December 21, 2021–January 27, 2022 (Omicron predominant period, 737 patients). Compared with patients during the period of Delta predominance, a higher proportion of adults admitted during Omicron predominance had received the final dose in a primary COVID-19 vaccination series (were fully vaccinated) (39.6% versus 25.1%), and fewer received COVID-19–directed therapies. Although fewer required intensive care unit (ICU) admission and invasive mechanical ventilation (IMV), and fewer died while hospitalized during Omicron predominance, there were no significant differences in ICU admission or IMV when stratified by vaccination status. Fewer fully vaccinated Omicron-period patients died while hospitalized (3.4%), compared with Delta-period patients (10.6%). Among Omicron-period patients, vaccination was associated with lower likelihood of ICU admission, and among adults aged ≥65 years, lower likelihood of death while hospitalized. Likelihood of ICU admission and death were lowest among adults who had received a booster dose. Among the first 131 Omicron-period hospitalizations, 19.8% of patients were clinically assessed as admitted for non–COVID-19 conditions. Compared with adults considered likely to have been admitted because of COVID-19, these patients were younger (median age = 38 versus 67 years) and more likely to have received at least one dose of a COVID-19 vaccine (84.6% versus 61.0%). Although 20% of SARS-CoV-2–associated hospitalizations during the period of Omicron predominance might be driven by non–COVID-19 conditions, large numbers of hospitalizations place a strain on health systems. Vaccination, including a booster dose for those who are fully vaccinated, remains critical to minimizing risk for severe health outcomes among adults with SARS-CoV-2 infection.

Periods of Delta and Omicron predominance (July 15–September 23, 2021, and December 21, 2021–January 27, 2022, respectively) were defined to correspond to peaks in SARS-CoV-2 hospitalizations during which each variant accounted for ≥50% of sequenced SARS-CoV-2 isolates in California (Supplementary Figure, https://stacks.cdc.gov/view/cdc/113987). RT-PCR–positive test results were determined via the hospital's internal flagging system for SARS-CoV-2 admissions, which incorporated laboratory results and provider documentation.¶ Vaccination status was ascertained through electronic linkage from the EHR to the California Immunization Registry (CAIR).** Patient demographic and clinical characteristics were abstracted from the EHR. For early Omicron-period hospitalizations (December 21–January 2), detailed chart review was performed by one of four clinicians to determine whether the reason for admission was likely or not likely due to COVID-19, following prespecified criteria.††

Patient demographic and clinical characteristics were compared between Delta- and Omicron-period hospitalizations,

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§ https://covid19.ca.gov/variants/

¶ This flagging can be triggered in one of two ways: either by a laboratory report indicating a positive SARS-CoV-2 RT-PCR test result from any time during hospitalization or during a 14-day lookback window preceding admission, which included tests performed in ambulatory and inpatient settings, or by admitting physician confirmation of RT-PCR positivity from an outside facility via patient interview, during which time a patient was queried about positive RT-PCR test results and any related COVID-19 symptoms over the preceding 14 days. Hospitalizations were included in the study if they occurred among adults without another hospitalization associated with a positive SARS-CoV-2 RT-PCR result during the preceding 90 days, or if there was a hospitalization associated with a positive RT-PCR result during the preceding 90 days, but the patient's symptoms had resolved before readmission as determined by the admitting provider.

overall and stratified by vaccination status (partially vaccinated persons were excluded from stratified analyses because of small sample size). Because booster doses were not yet recommended during the period of Delta predominance,[§§] Omicron-period patients who had received a booster dose were excluded from Delta- and Omicron-period comparisons of illness severity indicators (ICU admission, IMV, and death while hospitalized) among fully vaccinated persons. During Delta predominance, the EHR linkage to CAIR did not record booster doses. Fully vaccinated persons hospitalized during Delta predominance were assumed not to have received a booster dose. Among Omicron-period hospitalizations, these severity indicators were compared by four-level vaccination status (unvaccinated, partially vaccinated, fully vaccinated without a booster dose, and fully vaccinated with a booster dose). Patients who remained hospitalized as of January 27, 2022, were excluded from comparisons of death while hospitalized. Demographic and clinical characteristics were also compared between hospitalizations attributed to COVID-19 and those attributed to non-COVID-19 conditions during the early Omicron predominance period. Fisher's exact tests were used to compare categorical variables and the Mann-Whitney U test was used to compare ordinal or continuous variables. Two-tailed p-values <0.05 were considered statistically significant. All analyses were conducted with R software (version 4.1.2; R Foundation). This study was reviewed and approved by the Cedars-Sinai Institutional Review Board.[¶¶]

Compared with 339 adults hospitalized during the Delta predominant period, the 737 adults hospitalized during the Omicron period included more fully vaccinated persons (39.6% versus 25.1%; p<0.01), and fewer unvaccinated persons (56.4% versus 71.1%; p<0.01) (Table 1). The median age increased both overall and among unvaccinated persons (Omicron = 64 years; Delta = 54 years; p<0.01), but not among fully vaccinated persons. The proportion of fully vaccinated adults who were Hispanic was higher during Omicron predominance (21.9%) than during Delta predominance (10.6%) (p = 0.02). Conversely, non-Hispanic White persons accounted for fewer admissions among fully vaccinated adults during Omicron predominance than during Delta predominance (46.6% versus 62.4%; p = 0.01). Fewer patients admitted during Omicron predominance than during Delta predominance received COVID-19–directed therapies, both among unvaccinated (57.9% and 81.7%; respectively) (p<0.01) and fully vaccinated adults (52.4% and 76.5%, respectively) (p<0.01). Compared with Delta-period patients, fewer Omicron-period patients required ICU admission (16.8% versus 23.3%; p = 0.01) or IMV (9.2% versus 13.6%; p = 0.03), and fewer died while hospitalized (4.0% versus 8.3%; p = 0.01). When stratified by vaccination status, however, differences in ICU admission and IMV between the two periods were not significant, despite lower percentages during Omicron predominance. Fewer fully vaccinated adults hospitalized during Omicron predominance died while hospitalized (3.4%) compared with those hospitalized during Delta predominance (10.6%) (p = 0.02). Among adults hospitalized during Omicron predominance, increasing vaccination was associated with lower likelihood of ICU admission (p = 0.02) and, among adults aged ≥65 years, lower likelihood of death while hospitalized (p = 0.04) (Figure). Fully vaccinated patients who had received a booster dose had the lowest likelihood of these outcomes.

Of 131 early Omicron-period hospitalizations (December 21–January 2), 105 (80.2%) patients were assessed to have been likely admitted for COVID-19, and 26 (19.8%) were admitted primarily for non–COVID-19 conditions (Table 2). Compared with adults hospitalized for COVID-19, those hospitalized for other conditions were younger (median age 38 versus 67 years; p<0.01), more likely to have received at least one dose of a COVID-19 vaccine (84.6% versus 61.0%; p = 0.02), less likely to experience symptoms and signs of a COVID-like illness, and less likely to receive COVID-19–directed therapies.

** Fully vaccinated adults were those who were not immunocompromised and had received the second of a 2-dose COVID-19 vaccine series or a single dose of a 1-dose product ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Immunocompromised adults were considered fully vaccinated if they had received a third dose of a 3-dose primary series or a single dose of a 1-dose product ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Fully vaccinated adults were considered to have received a booster dose if they had received an additional dose (third or fourth) of an mRNA COVID-19 vaccine ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Adults whose positive SARS-CoV-2 test date was ≥14 days after the first dose of a 2-dose series (or second dose of a 3-dose series) but <14 days after receipt of the second dose (or third dose) were considered partially vaccinated, as were those who had received only a single dose of a 2-dose series (or 1 or 2 doses of a 3-dose series). Adults with no documented receipt of any COVID-19 vaccine dose before the test date were considered unvaccinated.

†† Chart review included notes by the emergency department provider, admitting provider, initial infectious disease consultant (when consulted), and discharging provider when available. Admissions associated with a positive SARS-CoV-2 RT-PCR result were classified as likely due to COVID-19 if the admitting provider affirmed that COVID-19 was the reason for admission or, in the absence of explicit determination, if reviewers could not determine a clear alternative reason for admission that was not plausibly linked to SARS-CoV-2 infection. Alternative reasons for admission included uncomplicated labor, a surgical procedure, trauma, psychiatric care, or a medical diagnosis not plausibly linked to COVID-19 (cellulitis [six patients], gastrointestinal bleeding [two], small bowel obstruction [two], and osteomyelitis [one]). Exacerbations of chronic conditions (e.g., congestive heart failure, chronic obstructive pulmonary disease, and asthma) were attributed to COVID-19. Any positive RT-PCR test results ≥7 days after initial negative test results on admission were considered to represent nosocomial SARS-CoV-2 infections, and therefore, the admission was not attributed to COVID-19. This applied to three hospitalizations included in this report.

§§ https://www.cdc.gov/media/releases/2021/p0924-booster-recommendations-.html

¶¶ 45 C.F.R. part 46; 21 C.F.R. part 56.

TABLE 1. Demographic characteristics, clinical characteristics, and clinical outcomes among 1,076 hospitalized adults with SARS-CoV-2 infection by vaccination status and period of variant predominance — one hospital, California, July 15–September 23, 2021 (Delta period) and December 21, 2021–January 27, 2022 (Omicron period)

Characteristic	No. (%)								
	Total hospitalizations (N = 1,076)			Unvaccinated (n = 657)			Fully vaccinated (n = 377)		
	Delta period	Omicron period	p-value	Delta period	Omicron period	p-value	Delta period	Omicron period	p-value
Total	**339**	**737**	—	**241**	**416**	—	**85**	**292**	—
Vaccination status*,†									
Unvaccinated	241 (71.1)	416 (56.4)	<0.01	241 (100)	416 (100)	—	—	—	—
At least 1 dose	98 (28.9)	321 (43.6)	<0.01	—	—	—	85 (100)	292 (100)	—
Fully vaccinated	85 (25.1)	292 (39.6)	<0.01	—	—	—	85 (100)	292 (100)	—
Fully vaccinated and booster dose	—§	70 (9.5)	—	—	—	—	—§	70 (24.0)	—
Age, yrs, median (IQR)	**60 (43–73)**	**66 (49–79)**	**<0.01**	**54 (38–68)**	**64 (48–78)**	**<0.01**	**71 (5–82)**	**69 (51–80)**	**0.36**
Sex									
Men	190 (56.0)	377 (51.2)	0.15	130 (53.9)	221 (53.1)	0.87	52 (61.2)	142 (48.6)	0.05
Women	149 (44.0)	360 (48.8)		111 (46.1)	195 (46.9)		33 (38.8)	150 (51.4)	
Race and ethnicity									
White, non-Hispanic	163 (48.1)	336 (45.6)	0.47	105 (43.6)	184 (44.2)	0.94	53 (62.4)	136 (46.6)	0.01
Black, non-Hispanic	69 (20.4)	145 (19.7)	0.81	54 (22.4)	87 (20.9)	0.69	12 (14.1)	52 (17.8)	0.51
Hispanic	56 (16.5)	157 (21.3)	0.07	45 (18.7)	87 (20.9)	0.54	9 (10.6)	64 (21.9)	0.02
Asian, non-Hispanic	10 (2.9)	33 (4.5)	0.31	4 (1.7)	17 (4.1)	0.11	6 (7.1)	16 (5.5)	0.60
Other, non-Hispanic¶	41 (12.1)	66 (9.0)	0.12	33 (13.7)	41 (9.9)	0.16	5 (5.9)	24 (8.2)	0.64
COVID-19 therapies received									
Any	273 (80.5)	412 (55.9)	<0.01	197 (81.7)	241 (57.9)	<0.01	65 (76.5)	153 (52.4)	<0.01
Dexamethasone	245 (72.3)	360 (48.8)	<0.01	178 (73.9)	216 (51.9)	<0.01	57 (67.1)	129 (44.2)	<0.01
Remdesivir	234 (69.0)	293 (39.8)	<0.01	170 (70.5)	173 (41.6)	<0.01	54 (63.5)	106 (36.3)	<0.01
Other therapies**	76 (22.4)	92 (12.5)	<0.01	47 (19.5)	58 (13.9)	0.08	23 (27.1)	30 (10.3)	<0.01
Intensive care unit admission	**79 (23.3)**	**124 (16.8)**	**0.01**	**55 (22.8)**	**79 (19.0)**	**0.27**	**20 (23.5)**	**34 (15.3)††**	**0.10**
Invasive mechanical ventilation	**46 (13.6)**	**68 (9.2)**	**0.03**	**37 (15.4)**	**45 (10.8)**	**0.11**	**8 (9.4)**	**19 (8.6)††**	**0.82**
Death while hospitalized	**28 (8.3)**	**22 (4.0)§§**	**0.01**	**19 (7.9)**	**14 (4.9)¶¶**	**0.21**	**9 (10.6)**	**6 (3.4)*****	**0.02**

* Vaccination status was ascertained from the California Immunization Registry. Fully vaccinated adults were those who were not immunocompromised and had received the second dose of a 2-dose COVID-19 vaccine series or a single dose of a 1-dose product ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Immunocompromised adults were considered fully vaccinated if they had received a third dose of a 3-dose primary series or a single dose of a 1-dose product ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Fully vaccinated adults were considered to have received a booster dose if they had received an additional dose (third or fourth) of an mRNA COVID-19 vaccine ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Adults whose positive SARS-CoV-2 test date was ≥14 days after the first dose of a 2-dose series (or second dose of a 3-dose series) but <14 days after receipt of the second dose (or third dose) were considered partially vaccinated, as were those who had received only a single dose of a 2-dose product (or 1 or 2 doses of a 3-dose series). Adults with no documented receipt of any COVID-19 vaccine dose before the test date were considered unvaccinated.

† Partially vaccinated adults were not included in analyses stratified by vaccination status because of small sample size. However, they were included in overall proportions and comparisons not stratified by vaccination status; thus, the total number of patients exceeds the sum of fully vaccinated and unvaccinated patients.

§ Vaccination status was ascertained from the California Immunization Registry. Booster status was unavailable for hospitalizations before December 1, 2021.

¶ Includes Native Hawaiian, other Pacific Islander, American Indian, and Alaska Native persons, and persons of unknown race or ethnicity.

** Includes baricitinib, casirivimab-imdevimab, convalescent plasma, sotrovimab, and tocilizumab.

†† Denominator excludes 70 fully vaccinated patients who also received a booster dose.

§§ Denominator excludes 188 patients who remained hospitalized as of January 27, 2022.

¶¶ Denominator excludes 129 patients who remained hospitalized as of January 27, 2022

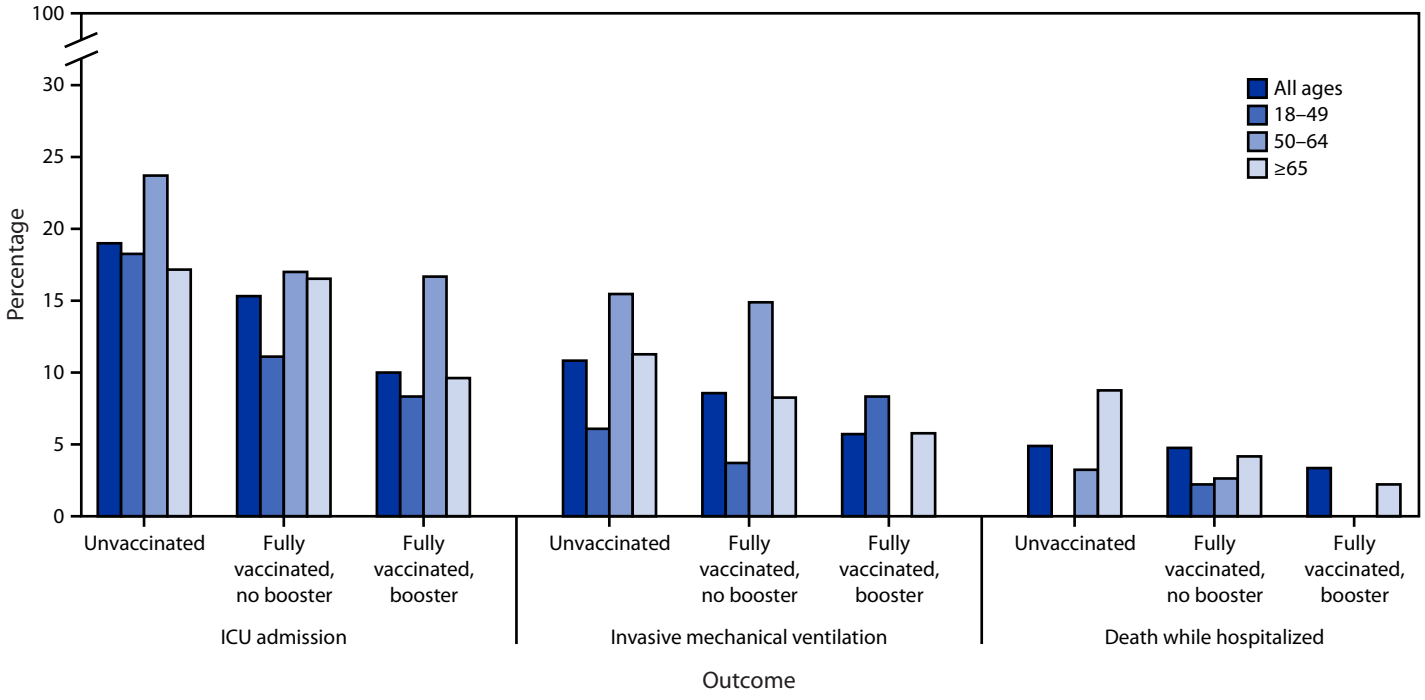
*** Denominator excludes 70 fully vaccinated patients who also received a booster dose and 43 patients who remained hospitalized as of January 27, 2022.

Among the 105 patients hospitalized for COVID-19, 63.8% had lower respiratory tract symptoms, 51.4% had abnormal chest radiography, and 39.0% had hypoxemia.

Discussion

Among adults hospitalized with SARS-CoV-2 infection at a single hospital in California during the Omicron-predominant period (December 21, 2021–January 27, 2022), COVID-19 vaccination, particularly receipt of a booster dose, was associated with lower likelihood of ICU admission, and, among adults aged ≥65 years, lower likelihood of death while hospitalized. Compared with the period of Delta predominance, a higher proportion of adults hospitalized during Omicron predominance were fully vaccinated. Consistent with earlier findings (*3*), Omicron-period hospitalizations were associated with a lower likelihood of ICU admission, IMV, and death while hospitalized, compared with Delta-period hospitalizations. However, the proportion requiring ICU admission and

FIGURE. Intensive care unit admission, use of invasive mechanical ventilation, and death while hospitalized among 737 adults hospitalized with SARS-CoV-2 infection during Omicron variant predominance, by age group and vaccination status*,† — one hospital, California, December 21, 2021–January 27, 2022



Abbreviation: ICU = intensive care unit.
* The following were statistically significantly associated with increasing vaccination: ICU admission (all ages); death while hospitalized (age ≥65 years).
† Percentages among partially vaccinated adults were included in analysis but are not displayed because of small sample size.

IMV did not differ significantly when stratified by vaccination status, suggesting that much of the lower disease severity observed during Omicron predominance might be driven by increased population-level vaccine-conferred immunity. These findings support the continued importance of COVID-19 vaccination, including booster doses, in mitigating the risk of severe illness associated with SARS-CoV-2 infection.

From mid-July through mid-December 2021, the proportion of fully vaccinated adults in Los Angeles County increased nearly 20%, from approximately 65% to 77%,*** but the proportion of SARS-CoV-2 hospitalizations occurring in fully vaccinated adults increased almost 60%, from approximately 25% to 40%. The increase in the percentage of fully vaccinated Hispanic adults and the decrease in the percentage of non-Hispanic White adults hospitalized between the two periods likely reflect increased vaccination coverage among Hispanic persons during fall 2021. Increases in infections among vaccinated persons during the period of Omicron predominance were likely driven both by waning vaccine-derived immunity over time and by relative resistance to vaccine neutralization in the Omicron variant compared with the Delta variant (*2*,*4*). This is consistent with the observed decline in effectiveness of 2-dose vaccination against COVID-19 hospitalization during the Omicron period (*5*). A previous study also found that, compared with the period of Delta predominance, the period of Omicron predominance in Los Angeles County was associated with a decrease in the degree of protection against COVID-19 and hospitalization (*6*). Despite this, COVID-19 vaccination, including a booster dose, was associated with lower likelihood of ICU admission during the Omicron period, and lower likelihood of death among adults aged ≥65 years, who are at higher risk for severe outcomes when hospitalized with COVID-19 (*7*,*8*).

Early reports suggest that the Omicron variant has lower replication competence in lung parenchyma,†††,§§§ possibly contributing to a decreased severity of illness compared with earlier variants (*3*). However, among patients hospitalized for COVID-19 during the early Omicron predominant period, most had lower respiratory symptoms and abnormal chest imaging, approximately one third had hypoxemia, and 10% required IMV. These findings demonstrate that, despite observed changes compared with Delta, Omicron variant infection still causes severe lower respiratory illness. Similar data on

*** https://covid19.ca.gov/vaccination-progress-data/

††† https://www.researchsquare.com/article/rs-1189219/v1
§§§ https://www.researchsquare.com/article/rs-1211792/v1

TABLE 2. Demographic and clinical characteristics and clinical outcomes among 131 adults hospitalized with SARS-CoV-2 infection during early Omicron variant predominance, by primary reason for admission — one hospital, California, December 21, 2021–January 2, 2022

Characteristic	No. (column %)			
	Total hospitalizations (N = 131)	Hospitalizations not likely due to COVID-19 (n = 26)	Hospitalizations likely due to COVID-19 (n = 105)	p-value
Age, yrs, median (IQR)	63 (38–79)	38 (29–62)	67 (47–79)	<0.01
Sex				
Men	61 (46.6)	11 (42.3)	50 (47.6)	
Women	70 (53.4)	15 (57.7)	55 (52.4)	0.67
Race and ethnicity				
White, non-Hispanic	59 (45.0)	9 (34.6)	50 (47.6)	0.28
Hispanic	32 (24.4)	10 (38.5)	22 (21.0)	0.08
Black, non-Hispanic	26 (19.8)	5 (19.2)	21 (20.0)	>0.99
Asian, non-Hispanic	5 (3.8)	2 (7.7)	3 (2.9)	0.26
Other, non-Hispanic*	9 (6.9)	0 (—)	9 (8.6)	0.20
Vaccination status†				
Unvaccinated	45 (34.4)	4 (15.4)	41 (39.0)	0.02
At least 1 dose	86 (65.6)	22 (84.6)	64 (61.0)	0.02
Fully vaccinated	80 (61.1)	20 (76.9)	60 (57.1)	0.07
Fully vaccinated and booster dose	18 (13.7)	4 (15.4)	14 (13.3)	0.76
Initial symptoms and signs				
Lower respiratory symptoms§	68 (51.9)	1 (3.8)	67 (63.8)	<0.01
Abnormal chest radiograph¶	55 (42.0)	1 (3.8)	54 (51.4)	<0.01
Hypoxemia	41 (31.3)	0 (—)	41 (39.0)	<0.01
Fever**	39 (29.8)	5 (19.2)	34 (32.4)	0.24
Gastrointestinal symptoms††	32 (24.4)	7 (26.9)	25 (23.8)	0.80
Underlying medical conditions				
Obesity (BMI ≥30)	46 (35.1)	8 (30.8)	38 (36.2)	0.65
Renal disease	14 (10.7)	2 (7.7)	12 (11.4)	0.74
Hypertension	13 (9.9)	0 (—)	13 (12.4)	0.07
Cardiovascular disease§§	11 (8.4)	0 (—)	11 (10.5)	0.11
Diabetes mellitus	6 (4.6)	0 (—)	6 (5.7)	0.60
Chronic pulmonary disease¶¶	2 (1.5)	0 (—)	2 (1.9)	>0.99
COVID-19 therapies administered				
Any	73 (55.7)	4 (15.4)	69 (65.7)	<0.01
Dexamethasone	63 (48.1)	3 (11.5)***	60 (57.1)	<0.01
Remdesivir	51 (38.9)	2 (7.7)†††	49 (46.7)	<0.01
Other therapies§§§	29 (19.8)	0 (—)	26 (24.8)	<0.01
Intensive care unit admission	**17 (13.0)**	**2 (7.7)**	**15 (14.3)**	**0.52**
Invasive mechanical ventilation	**12 (9.2)**	**2 (7.7)**	**10 (9.5)**	**>0.99**
Death while hospitalized	**2 (1.9)¶¶¶**	**0 (—)****	**2 (2.4)†††**	**>0.99**

Abbreviation: BMI = body mass index.

* Includes Native Hawaiian, other Pacific Islander, American Indian, and Alaska Native persons, and persons of unknown race or ethnicity.

† Fully vaccinated adults were those who were not immunocompromised and had received the second dose of a 2-dose COVID-19 vaccine series or a single dose of a 1-dose product ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Immunocompromised adults were considered fully vaccinated if they had received a third dose of a 3-dose primary series or a single dose of a 1-dose product ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Fully vaccinated adults were considered to have received a booster dose if they had received an additional (third or fourth) dose of an mRNA COVID-19 vaccine ≥14 days before receiving a positive SARS-CoV-2 test result associated with their hospitalization. Adults whose positive SARS-CoV-2 test date was ≥14 days after the first dose of a 2-dose series (or second dose of a 3-dose series) but <14 days after receipt of the second dose (or third dose) were considered partially vaccinated, as were those who had received only a single dose of a 2-dose product (or 1 or 2 doses of a 3-dose series). Adults with no documented receipt of any COVID-19 vaccine dose before the test date were considered unvaccinated.

§ Includes dyspnea, cough, and wheezing.

¶ Includes presence of opacities or nonspecific densities.

** Either documented temperature >100.4°F (38°C) on admission or identification of fever in a clinical note by the emergency physician or admitting provider.

†† Includes nausea, vomiting, and diarrhea.

§§ Includes coronary artery disease, congestive heart failure, arrhythmias, valvular heart disease, stroke, and peripheral vascular disease.

¶¶ Includes chronic obstructive pulmonary disease, pulmonary fibrosis, and asthma.

*** Dexamethasone was administered for neurosurgical indications (two) and for suspected bacterial meningitis (one).

††† Remdesivir was administered in the setting of difficulty extubating after a gastrointestinal procedure (one) and for unclear indication in a patient admitted for psychiatric care (one).

§§§ Includes baricitinib, casirivimab-imdevimab, convalescent plasma, sotrovimab, and tocilizumab.

¶¶¶ Denominator does not include 25 patients who remained hospitalized as of January 11, 2022.

**** Denominator does not include two patients who remained hospitalized as of January 11, 2022.

†††† Denominator does not include 23 patients who remained hospitalized as of January 11, 2022.

patient symptoms were not available for Delta-period hospitalizations. However, fewer Omicron-period patients received COVID-19-directed therapies, which might suggest lower proportion with hypoxemia, compared with Delta-period patients. Alternatively, this change might have been driven by changes in prescribing practices or other unmeasured factors.

Approximately 20% of SARS-CoV-2 admissions during early Omicron predominance were likely for reasons other than COVID-19, a proportion even higher among young and vaccinated adults. Given high rates of SARS-CoV-2 community transmission, this is not unexpected. This estimate stands in contrast to an estimated 63% of patients admitted with incidental SARS-CoV-2 infection reported from South Africa (*9*). While this difference might be driven, in part, by differences in demographics and population immunity, the present study's classification methodology might have overestimated the number of persons whose admission was driven by COVID-19. One third of patients classified as having been admitted for COVID-19 received no COVID-19–directed therapies. Alternatively, high population-level immunity from vaccination, previous SARS-CoV-2 infection, or both might have modulated the clinical presentation of patients with COVID-19 during Omicron predominance and atypical presentations might have been underrecognized (e.g., exacerbations of chronic medical conditions), or lesser illness severity might have resulted in fewer therapies. However, the pandemic health care burden is not limited to hospitalizations for symptomatic COVID-19. Even patients with positive SARS-CoV-2 test results admitted for non-COVID-19 conditions require isolation rooms and use of personal protective equipment and might transmit infection to health care workers, exacerbating staff shortages.

The findings in this report are subject to at least six limitations. First, sequencing data were not available to identify the SARS-CoV-2 variant. However, based on California genomic surveillance data, which is based on sequencing of ≥10% of all positive RT-PCR tests in the state,¶¶¶ and on recent genomic surveillance for Los Angeles County (*7*), the Delta and Omicron variants accounted for the majority of sequenced isolates throughout their respective predominance periods. Second, the proportion of Omicron-period hospitalizations attributed to COVID-19 could not be compared with earlier periods, so it is unclear whether the proportion represented a change from an earlier period. Third, the study might have been underpowered to detect Omicron-specific reductions in illness severity after stratifying by vaccination status. Fourth, the analysis could not account for the interval since the last dose of COVID-19 vaccine, which might have been longer among Omicron-period patients. Fifth, there might have been incomplete ascertainment of deaths in the recent weeks of Omicron predominance; severely ill patients might remain hospitalized and might be at high risk of death. A longer period of observation might have reduced differences in death between the two periods. Finally, these findings are from a single hospital in Los Angeles and cannot be generalized to the United States. However, the hospital has a large catchment area in a racially and ethnically diverse region.

In this single-hospital study, adults hospitalized with SARS-CoV-2 infection during Omicron predominance had less severe illness compared with adults hospitalized during Delta predominance. Much of this effect appears to be driven by increased proportion of patients who were fully vaccinated. Approximately 20% of Omicron-period hospitalizations among adults with a positive SARS-CoV-2 RT-PCR result were driven by non–COVID-19 conditions, which might be attributed to high SARS-CoV-2 community transmission and high population vaccination coverage. COVID-19 vaccination was associated with lower likelihood of ICU admission during Omicron predominance. COVID-19 vaccination, including a booster dose for those who are fully vaccinated, is critical to minimizing the risk for severe health outcomes among adults with COVID-19.

Summary

What is already known about this topic?

The SARS-CoV-2 Omicron variant became predominant in the United States in mid-December 2021, coinciding with a rise in SARS-CoV-2–associated hospitalizations.

What is added by this report?

Among adults hospitalized with SARS-CoV-2 infection during Omicron predominance, COVID-19 vaccination, including with a booster dose, was associated with lower likelihood of intensive care unit admission. Compared with patients during the period of Delta predominance, Omicron-period patients had less severe illness, largely driven by an increased proportion who were fully vaccinated. Approximately 20% of early Omicron-period hospitalizations were for non–COVID-19 conditions, particularly among young and vaccinated adults.

What are the implications for public health practice?

COVID-19 vaccination, particularly a booster dose, continues to be critical in mitigating the health care burden of the Omicron variant.

Acknowledgments

Keren Dunn, Cedars-Sinai Medical Center; Meredith McMorrow, CDC COVID-19 Emergency Response Team.

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¶¶¶ https://www.cdph.ca.gov/Programs/CID/DCDC/Pages/COVID-19/COVID-Variants.aspx

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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.

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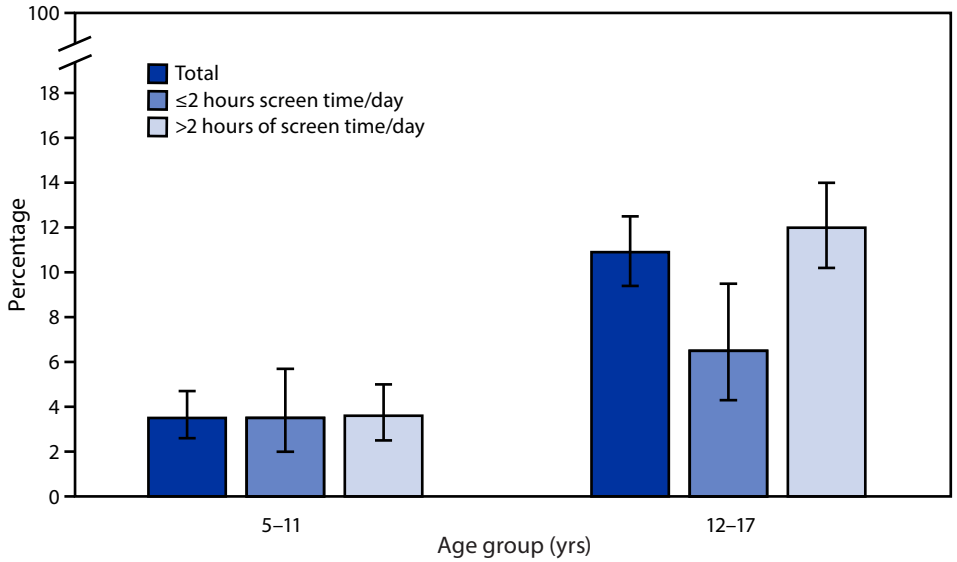
QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Children and Adolescents Aged 5–17 Years Who Reported Being Tired Most Days or Every Day,† by Age Group and Hours of Screen Time§ — National Health Interview Survey, United States, 2020¶



* With 95% CIs indicated by error bars.
† Based on a response to the question, "In a typical school week how often does (child's name) complain about being tired during the day?" Response choices were "never," "some days," "most days," or "every day."
§ Based on a response to the question, "On most weekdays does (child's name) spend more than 2 hours a day in front of a TV, computer, cellphone, or other electronic device watching programs, playing games, accessing the Internet, or using social media?" Respondents were instructed not to include time spent for schoolwork.
¶ Estimates are based on household interviews of a sample of the civilian, noninstitutionalized U.S. population.

In 2020, 3.5% of children aged 5–11 years and 10.9% of adolescents aged 12–17 years reported being tired on most days or every day. Among adolescents aged 12–17, the percentage reporting being tired was higher (12.0%) for those who reported >2 hours of screen time (in addition to that for schoolwork) per weekday than for those who reported ≤2 hours of screen time each day (6.5%). In children aged 5–11 years, the percentage reporting being tired did not differ by hours of screen time (3.6% for >2 hours versus 3.5% for ≤2 hours). Regardless of the amount of screen time reported, adolescents aged 12–17 years were more likely to report being tired on most days or every day than were children aged 5–11 years.

Source: National Center for Health Statistics, National Health Interview Survey, 2020. https://www.cdc.gov/nchs/nhis.htm

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ISSN: 0149-2195 (Print)