Centers for Disease Control and Prevention
MMWR
Morbidity and Mortality Weekly Report
Weekly / Vol. 72 / No. 7
February 17, 2023

Fruit, Vegetable, and Sugar-Sweetened Beverage Intake Among Young Children, by State — United States, 2021

Heather C. Hamner, PhD[1]; Carrie A. Dooyema, MPH, MSN[1]; Heidi M. Blanck, PhD[1]; Rafael Flores-Ayala, DrPH[1]; Jessica R. Jones, PhD[2]; Reem M. Ghandour, DrPH[2]; Ruth Petersen, MD[1]

Good nutrition in early childhood supports optimal growth, development, and health (*1*). Federal guidelines support a dietary pattern with daily fruit and vegetable consumption and limited added sugars, including limited consumption of sugar-sweetened beverages (*1*). Government-published dietary intake estimates for young children are outdated at the national level and unavailable at the state level. CDC analyzed data from the 2021 National Survey of Children's Health (NSCH)* to describe how frequently, according to parent report, children aged 1–5 years (18,386) consumed fruits, vegetables, and sugar-sweetened beverages, nationally and by state. During the preceding week, approximately one in three (32.1%) children did not eat a daily fruit, nearly one half (49.1%) did not eat a daily vegetable, and more than one half (57.1%) drank a sugar-sweetened beverage at least once. Estimates of consumption varied by state. In 20 states, more than one half of children did not eat a vegetable daily during the preceding week. In Vermont, 30.4% of children did not eat a daily vegetable during the preceding week, compared with 64.3% in Louisiana. In 40 states and the District of Columbia, more than one half of children drank a sugar-sweetened beverage at least once during the preceding week. The percentage of children drinking sugar-sweetened beverages at least once during the preceding week ranged from 38.6% in Maine to 79.3% in Mississippi. Many young children are not consuming fruits and vegetables daily and are regularly consuming sugar-sweetened beverages. Federal nutrition programs and state policies and programs can support improvements in diet quality by increasing access to and availability of fruits and vegetables and healthy beverages in places where young children live, learn, and play.

NSCH uses paper- and web-based questionnaires to collect information on the health and well-being of U.S. children and adolescents aged <18 years; it is funded and directed by the Health Resources and Services Administration's Maternal Child Health Bureau and conducted by the U.S. Census Bureau. Households are randomly sampled from the Census Bureau's Master Address File and contacted via mail to identify those with at least one child or adolescent aged <18 years. One child or adolescent per household is selected, and an age-specific questionnaire is completed by a household adult familiar with the selected child or adolescent's health and health care. Children aged <6 years are oversampled. The surveys were

* https://mchb.hrsa.gov/data-research/national-survey-childrens-health

INSIDE

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

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

available in English and Spanish. The 2021 weighted overall response and interview completion rates[†] were 40.3% and 79.5%, respectively. Data were collected during June 2021–January 2022.

Respondents were asked three questions about children aged 1–5 years regarding the frequency of consuming fruits,[§] vegetables,[¶] and sugar-sweetened beverages[**] during the preceding week. Response options included the following: did not consume item, 1–3 times in the preceding week, 4–6 times in the preceding week, 1 time per day, 2 times per day, and ≥3 times per day. Categories were recoded to provide an estimate of daily (≥1 time per day in preceding week) or less than daily (<1 time per day in preceding week) consumption of fruit and vegetables. Categories of sugar-sweetened beverages were dichotomized to indicate consumption at least once or no consumption during the preceding week. Among the 18,830 children aged 1–5 years, 444 (2.4%) were missing data on at least one item and were excluded, leaving a final analytic sample of 18,386. Weighted percentages are presented overall, by child's age, race and ethnicity, household food sufficiency,[††] and by state, using SPSS Complex Samples (version 1.0.0.1401; IBM) to account for the sampling procedures. Pearson Chi-square tests of independence were used to identify differences within each outcome by sociodemographic characteristics. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[§§]

In 2021, 32.1% of children aged 1–5 years did not eat a daily fruit, and 49.1% did not eat a daily vegetable during the preceding week; 57.1% drank a sugar-sweetened beverage at least once during the preceding week (Table 1). Daily consumption of fruit and vegetables and weekly consumption of sugar-sweetened beverages differed by age, race and ethnicity, and household food sufficiency. Children aged 1 year were more likely than were older children to eat either a daily fruit or a daily vegetable during the preceding week and were less likely to drink a sugar-sweetened beverage (chi-square $p<0.05$). The percentage of children who did not eat a daily fruit or vegetable was highest among non-Hispanic Black (Black) children and

[†] The weighted overall response rate is the probability that an address progresses through the three major stages of survey completion: resolution, screener, and topical questionnaire. The weighted interview completion rate is the probability that a household that initiates the survey will complete it.

[§] Fruit includes fresh, frozen, or canned. It does not include juice.

[¶] Vegetables includes fresh, frozen, or canned. It does not include french fries, fried potatoes, or potato chips.

[**] Sugar-sweetened beverages includes soda, fruit drinks, sports drinks, or sweet tea. It does not include 100% fruit juice.

[††] Food sufficiency was assessed by asking, "Which of the following best describes your household's ability to afford the food you need during the past 12 months?" Response options were recoded to food sufficiency (could always afford to eat good nutrition meals) marginal food sufficiency (could always afford enough to eat but not always the kinds of foods we should eat), and low food sufficiency (sometimes or often we could not afford enough to eat).

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

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 2023;72:[inclusive page numbers].

TABLE 1. Percentage of children aged 1–5 years who consumed fruit, vegetables, or sugar-sweetened beverages during the preceding week, by sociodemographic characteristics — National Survey of Children's Health, United States, 2021

Characteristic	Total no. (unweighted)*	% (95% CI)†		
		Fruit	Vegetables	Sugar-sweetened beverages
		Less than daily		At least once weekly
United States	**18,386**	**32.1 (30.4–33.7)**	**49.1 (47.3–50.8)**	**57.1 (55.4–58.8)**
Child age, yrs				
1	**2,438**	25.4 (21.5–29.7)§	43.9 (39.4–48.4)§	30.9 (26.7–35.5)§
2	**4,225**	31.6 (28.3–35.1)	47.7 (44.3–51.2)	51.4 (48.0–54.9)
3	**3,799**	31.8 (28.3–35.5)	49.7 (45.8–53.6)	61.4 (57.7–65.0)
4	**3,974**	34.9 (31.1–39.0)	50.5 (46.5–54.6)	67.8 (64.2–71.2)
5	**3,950**	36.2 (32.7–39.9)	53.2 (49.4–57.0)	72.3 (68.9–75.5)
Race and ethnicity¶				
Asian, non-Hispanic	**1,046**	42.2 (34.9–49.8)	47.5 (40.3–54.7)	56.2 (49.1–63.0)
Black or African American, non-Hispanic	**1,061**	50.7 (45.1–56.4)	64.8 (59.2–70.0)	71.7 (66.0–76.8)
Hispanic or Latino	**2,407**	33.6 (29.3–38.2)§	53.7 (48.9–58.5)§	67.2 (62.8–71.3)§
White, non-Hispanic	**12,305**	26.1 (24.6–27.7)	43.4 (41.6–45.2)	49.6 (47.8–51.5)
Multiracial, non-Hispanic	**1,567**	26.8 (22.6–31.6)	44.1 (39.0–49.3)	47.5 (42.5–52.6)
Food situation in the past 12 months**				
Food sufficiency: could always afford to eat good nutritious meals	**14,483**	29.6 (27.7–31.5)§	46.5 (44.5–48.5)§	53.1 (51.1–55.1)§
Marginal food sufficiency: could always afford enough to eat but not always the kinds of foods we should eat	**3,215**	36.9 (33.3–40.8)	56.2 (51.9–60.4)	69.2 (65.3–72.8)
Low food sufficiency: sometimes or often could not afford enough to eat	**348**	46.4 (36.4–56.6)††	59.0 (48.3–68.9)††	70.9 (61.2–79.0)

* Denominators might not sum to total because of missing sociodemographic data.
† Percentages are weighted to account for complex survey design and adjusted for the probability of selection, nonresponse, and demographic factors to represent noninstitutionalized children in the United States and in each jurisdiction.
§ For each outcome, a Pearson's chi-square test of independence was done to identify differences by sociodemographic characteristics; p<0.05 was considered statistically significant.
¶ Persons who indicated they were American Indian or Alaska Native, or Native Hawaiian or other Pacific Islander were included in the Multiracial, non-Hispanic group because point estimates for all three dietary outcomes were unstable and needed to be interpreted with caution.
** Food sufficiency was assessed by asking, "Which of the following best describes your household's ability to afford the food you need during the past 12 months?" Response options were recoded to Food sufficiency (could always afford to eat good nutrition meals), Marginal food sufficiency (could always afford enough to eat but not always the kinds of foods we should eat), or Low food sufficiency (sometimes or often we could not afford enough to eat).
†† Based on National Survey of Children's Health data, presentation criteria states that if the 95% CI width is >20 percentage points or 1.2 times the estimate (approximate relative SE >30%), data should be flagged for poor reliability and/or present a measure of statistical reliability (e.g., CI or statistical significance testing) to promote appropriate interpretation. https://www.census.gov/programs-surveys/nsch/data/datasets.html

lowest among non-Hispanic White (White) children. Drinking a sugar-sweetened beverage at least once during the preceding week ranged from 47.5% among multiracial non-Hispanic children to 71.7% among Black children. Compared with children living in food-sufficient households, those living in households with marginal or low food sufficiency were less likely to eat either a daily fruit or vegetable and were more likely to consume sugar-sweetened beverages during the preceding week.

Estimates of intake varied by state (Table 2). The percentage of children who did not eat fruit daily during the preceding week ranged from 16.3% in Vermont to 49.9% in Louisiana. Vegetable intake also varied: 30.4% of children in Vermont did not eat a daily vegetable, compared with 64.3% in Louisiana. The percentage of children who consumed a sugar-sweetened beverage at least once during the preceding week ranged from 38.8% (Maine) to 79.3% (Mississippi). In 20 states, more than one half of children did not eat a daily vegetable during the preceding week (Figure). In 40 states and the District of Columbia, more than one half of children drank a sugar-sweetened beverage at least once during the preceding week.

Discussion

In 2021, nearly one third (32.1%) of children aged 1–5 years did not eat a daily fruit, and nearly one half (49.1%) did not eat a daily vegetable during the preceding week; more than one half (57.1%) drank a sugar-sweetened beverage at least once during the preceding week. The percentage of children who did not eat a daily fruit or vegetable was higher among those who were aged 2–5 years, Black, or lived in households with limited food sufficiency. Similar patterns were seen for consumption of sugar-sweetened beverages. State-level estimates for all three dietary practices varied widely.

Young children need specific nutrients to support their optimal growth and development (*1*,*2*). A diet rich in fruits and vegetables can help provide these nutrients (*1*). Limiting or reducing foods and beverages higher in added sugars, including sugar-sweetened beverages, is important because added sugars are associated with increased risk of obesity, dental caries, diabetes, and cardiovascular disease (*3*–*6*). These data provide current assessments that states can use to prioritize actions to improve early childhood nutrition.

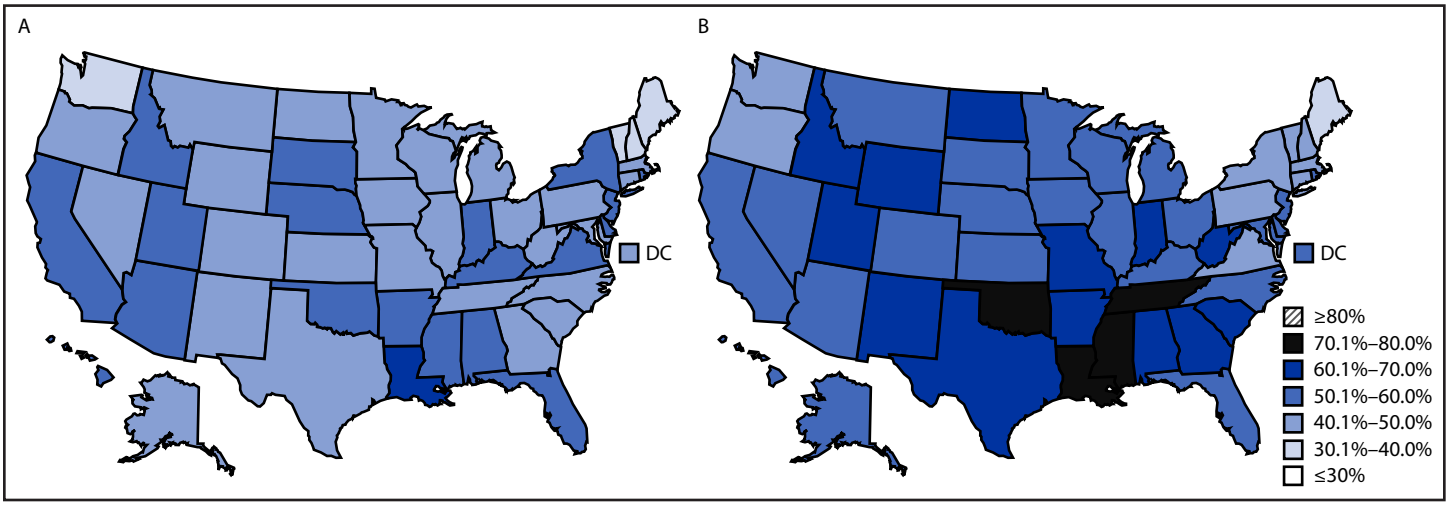
TABLE 2. Percentage of children aged 1–5 years who consumed fruit, vegetables, or sugar-sweetened beverages during the preceding week, by state — National Survey of Children's Health, 2021

		% (95% CI)*		
		Fruit	Vegetables	Sugar-sweetened beverages
Jurisdiction	Total no. (unweighted)	Less than daily		At least once weekly
Alabama	339	39.3 (32.0–47.2)	57.3 (49.6–64.8)	66.5 (59.7–72.7)
Alaska	350	21.6 (15.5–29.3)	50.0 (41.8–58.1)	54.9 (46.7–62.7)
Arizona	315	30.0 (22.2–39.2)	50.6 (41.5–59.7)	59.6 (50.4–68.1)
Arkansas	327	36.3 (28.5, 44.8)	51.5 (42.9–60.1)	66.1 (57.8–73.6)
California	342	32.3 (24.9–40.7)	50.5 (42.5–58.4)	53.9 (46.0–61.5)
Colorado	503	25.6 (20.3–31.8)	47.2 (40.7–53.8)	56.1 (49.7–62.2)
Connecticut	368	33.5 (25.2–42.9)	48.5 (40.1–56.9)	42.5 (34.2–51.3)
Delaware	340	28.7 (22.6–35.6)	53.6 (45.5–61.5)	54.2 (46.1–62.0)
District of Columbia	388	37.0 (27.5–47.6)†	43.9 (34.3–53.9)	51.1 (41.5–60.7)
Florida	329	34.4 (26.7–43.1)	52.0 (43.4–60.5)	57.5 (48.9–65.6)
Georgia	453	37.6 (31.1–44.7)	47.9 (41.2–54.7)	62.5 (55.9–68.6)
Hawaii	400	38.6 (31.7–46.1)	55.5 (48.0–62.6)	54.3 (46.9–61.5)
Idaho	294	38.3 (29.9–47.4)	50.4 (42.0–58.8)	68.6 (60.4–75.9)
Illinois	379	31.0 (23.8–39.1)	49.8 (41.6–58.0)	52.3 (44.3–60.2)
Indiana	354	43.1 (35.6–51.0)	53.2 (45.5–60.8)	66.7 (59.5–73.1)
Iowa	358	32.3 (25.5–40.0)	49.9 (42.4–57.4)	54.7 (46.9, 62.2)
Kansas	372	34.8 (27.5–43.0)	43.4 (36.1–51.1)	56.2 (48.6–63.6)
Kentucky	337	42.7 (34.8–51.0)	54.4 (46.2–62.4)	59.0 (50.6–66.9)
Louisiana	330	49.9 (41.9–57.9)	64.3 (56.3–71.6)	70.2 (62.2–77.1)
Maine	394	20.0 (14.8–26.3)	33.9 (27.7–40.8)	38.6 (32.5–45.1)
Maryland	281	26.3 (19.7–34.3)	46.4 (37.6, 55.5)	57.6 (48.7–66.1)
Massachusetts	311	20.1 (14.8–26.8)	46.7 (38.3–55.3)	46.7 (38.7–54.8)
Michigan	324	31.0 (24.4–38.5)	44.3 (37.1–51.7)	53.2 (45.6–60.8)
Minnesota	304	22.1 (15.4–30.6)	41.2 (33.0–49.9)	55.5 (47.1–63.5)
Mississippi	323	47.3 (38.7–56.0)	55.8 (46.8–64.4)	79.3 (72.1–85.0)
Missouri	336	37.0 (29.4–45.2)	44.3 (36.4–52.5)	60.1 (52.0–67.7)
Montana	353	29.2 (21.9–37.7)	42.8 (35.1–50.8)	59.0 (50.3–67.2)
Nebraska	397	33.5 (26.4–41.6)	52.2 (44.4–59.8)	59.5 (51.9–66.5)
Nevada	314	33.4 (25.9–41.8)	44.2 (35.8–52.8)	57.0 (48.2–65.4)
New Hampshire	313	22.2 (16.3–29.6)	38.5 (31.3–46.2)	41.7 (34.2–49.6)
New Jersey	356	32.6 (25.3–40.7)	57.1 (49.2–64.6)	53.2 (45.2–60.9)
New Mexico	305	41.1 (31.7–51.2)	47.7 (38.0–57.6)	66.2 (56.2–75.0)
New York	315	37.8 (30.4–45.9)	55.6 (47.6–63.3)	49.3 (41.7–57.0)
North Carolina	304	26.4 (19.8–34.2)	49.1 (40.2–58.1)	54.0 (45.0–62.7)
North Dakota	325	32.7 (25.9–40.4)	44.3 (37.5–51.5)	63.6 (56.3–70.4)
Ohio	435	27.1 (21.8–33.2)	45.8 (39.5–52.3)	51.1 (45.1–57.1)
Oklahoma	342	37.5 (29.6–46.0)	57.5 (49.0–65.5)	72.6 (64.9–79.1)
Oregon	908	26.1 (21.9–30.7)	43.2 (38.4–48.2)	48.6 (43.7–53.5)
Pennsylvania	320	27.4 (20.2–36.0)	44.5 (36.1–53.1)	44.9 (36.4–53.7)
Rhode Island	346	34.1 (26.1–43.0)	56.2 (47.8–64.3)	52.6 (44.1–60.9)
South Carolina	321	34.3 (27.1–42.2)	47.5 (39.0–56.1)	61.5 (53.1–69.3)
South Dakota	353	36.7 (30.0–43.9)	52.7 (45.6–59.7)	58.1 (51.0–65.0)
Tennessee	336	36.2 (28.3–44.9)	42.5 (34.4–50.9)	72.1 (64.5–78.6)
Texas	315	29.9 (23.3–37.4)	47.3 (38.9–55.9)	68.8 (60.8–75.8)
Utah	377	28.4 (23.3–34.2)	52.5 (46.1–58.8)	66.6 (60.3–72.3)
Vermont	329	16.3 (11.8–22.1)	30.4 (23.6–38.3)	41.3 (33.8–49.2)
Virginia	302	30.8 (23.1–39.7)	51.8 (43.0–60.5)	45.7 (36.9–54.7)
Washington	359	19.4 (14.0–26.3)	35.5 (28.6–42.9)	46.3 (38.8–53.9)
West Virginia	342	40.0 (32.4–48.2)	49.6 (41.6–57.7)	64.9 (57.2–71.9)
Wisconsin	603	26.3 (21.6–31.6)	44.9 (39.4–50.6)	50.9 (45.3–56.4)
Wyoming	265	25.5 (19.7–32.4)	45.4 (37.2–53.8)	64.3 (55.4–72.4)

* Percentages are weighted to account for complex survey design and adjusted for the probability of selection, nonresponse, and demographic factors to represent noninstitutionalized children in the United States and in each jurisdiction.

† Based on National Survey of Children's Health data, presentation criteria states that if the 95% CI width exceeds 20 percentage points or 1.2 times the estimate (approximate relative SE >30%), data should be flagged for poor reliability and/or present a measure of statistical reliability (e.g., CI or statistical significance testing) to promote appropriate interpretation. https://www.census.gov/programs-surveys/nsch/data/datasets.html

FIGURE. Percentage of children aged 1–5 years who (A) ate vegetables* less than once a day during the preceding week or (B) drank at least one sugar-sweetened beverage† in the preceding week, by state — United States, 2021



Abbreviation: DC = District of Columbia.

* Percentage of children aged 1–5 years who ate vegetables less than once a day during the preceding week: ≤30%, n = 0; 30.1%–40.0%, n = 4; 40.1%–50.0%, n = 27; 50.1%–60.0%, n = 19; 60.1%–70.0%, n = 1; 70.1%–80.0%, n = 0; and ≥80%, n = 0.

† Percentage of children aged 1–5 years who drank at least one sugar-sweetened beverage in the preceding week: ≤30%, n = 0; 30.1%–40.0%, n = 1; 40.1%–50.0%, n = 9; 50.1%–60.0%, n = 24; 60.1%–70.0%, n = 13; 70.1%–80.0%, n = 4; and ≥80%, n = 0.

Summary

What is already known about this topic?

Good nutrition is important for young children's health. Dietary guidelines support daily intake of fruits and vegetables and limited intake of sugar-sweetened beverages.

What is added by this report?

Many children aged 1–5 years, are not eating fruits and vegetables daily and are regularly drinking sugar-sweetened beverages. In 20 states, more than one half of children did not eat a vegetable daily during the preceding week. In 40 states and the District of Columbia, more than one half of children drank a sugar-sweetened beverage at least once during the preceding week.

What are the implications for public health practice?

Emphasizing the importance of healthy dietary practices in existing programs and policies that affect young children could improve their nutrition and support optimal growth and health.

Programs and policies can support efforts to improve fruit and vegetable intake and reduce consumption of sugar-sweetened beverages among young children. The U.S. Department of Agriculture's (USDA) Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), a program for low-income families, provides nutrition education, supplemental foods, including fruits and vegetables, and referrals to health care services.[¶¶] WIC is an important conduit for reaching participating families with nutrition education messages and healthy supplemental foods. Nutrition standards in early care and education (ECE) systems and in the charitable food system can support access to fruits and vegetables and help limit the intake of foods and beverages with added sugars. CDC supports[***] system-level efforts, including standards in the ECE state licensing regulations that support healthy eating, professional development opportunities for ECE staff members, and programs that provide young children an opportunity to learn about food, agriculture, and gardening through hands-on experiences. Federally funded programs, such as produce voucher programs and the Child and Adult Care Food Program, have resulted in serving more nutritious foods to children (*7*). Federal nutrition programs are a system-level approach that can improve diet quality for young children. The effectiveness of federal, state, or local-level programs could be enhanced by education emphasizing the importance of daily fruit and vegetable consumption and reducing sugar-sweetened beverage intake across multiple settings. Examples of existing programs that support such educational efforts include home visiting programs,[†††] Healthy Start,[§§§] and USDA's Supplemental Nutrition Assistance Program Education.[¶¶¶] Health care providers can also convey the importance of healthy dietary choices through anticipatory guidance (i.e., Bright Futures[****]) and regular screening and counseling

[¶¶] https://www.fns.usda.gov/wic

[***] https://www.cdc.gov/obesity/strategies/early-care-education/cdc-funded-ece-projects.html

[†††] https://mchb.hrsa.gov/programs-impact/programs/home-visiting/maternal-infant-early-childhood-home-visiting-miechv-program

[§§§] https://mchb.hrsa.gov/programs-impact/healthy-start

[¶¶¶] https://www.fns.usda.gov/snap/snap-ed

[****] https://www.aap.org/en/practice-management/bright-futures/bright-futures-materials-and-tools/bright-futures-guidelines-and-pocket-guide/

on food and nutrition security and key dietary behaviors during health care encounters. Understanding how access, affordability, and taste preferences influence diet for young children (*8*,*9*) could help tailor programmatic, communication, and education efforts.

The findings in this report are subject to at least four limitations. First, children's dietary intake was reported by an adult who might not know everything a child ate. Second, frequency of intake was assessed, not the amount consumed; therefore, intake cannot be tied to a dietary recommendation. Third, information collection occurred in English or Spanish and might not represent families who speak other languages. Finally, questions reflect intake during the preceding week and might not represent usual intake.

With renewed national focus on nutrition, hunger, and health and the call to improve food and nutrition security,†††† these data provide information for decision makers and practitioners to ensure that young children have an opportunity for their healthiest start. Collectively, programs and policies aimed at supporting nutrition for young children could lead to improvements in dietary quality and support optimal growth and health.

†††† https://www.whitehouse.gov/wp-content/uploads/2022/09/White-House-National-Strategy-on-Hunger-Nutrition-and-Health-FINAL.pdf

Corresponding author: Heather C. Hamner, hfc2@cdc.gov.

[1]Division of Nutrition, Physical Activity, and Obesity, National Center for Chronic Disease Prevention and Health Promotion, CDC; [2]Office of Epidemiology and Research, Maternal and Child Health Bureau, Health Resources and Services Administration, Rockville, Maryland.

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

References

1. US Department of Agriculture. Dietary guidelines for Americans 2020–2025. Alexandria, VA: US Department of Agriculture, Food and Nutrition Service; 2020. https://www.dietaryguidelines.gov/sites/default/files/2020-12/Dietary_Guidelines_for_Americans_2020-2025.pdf
2. Schwarzenberg SJ, Georgieff MK, Daniels S, et al.; Committee on Nutrition. Advocacy for improving nutrition in the first 1,000 days to support childhood development and adult health. Pediatrics 2018;141:e20173716. PMID:29358479 https://doi.org/10.1542/peds.2017-3716
3. Yoshida Y, Simoes EJ. Sugar-sweetened beverage, obesity, and type 2 diabetes in children and adolescents: policies, taxation, and programs. Curr Diab Rep 2018;18:31–47. PMID:29671076 https://doi.org/10.1007/s11892-018-1004-6
4. Malik VS, Popkin BM, Bray GA, Després JP, Hu FB. Sugar-sweetened beverages, obesity, type 2 diabetes mellitus, and cardiovascular disease risk. Circulation 2010;121:1356–64. PMID:20308626 https://doi.org/10.1161/CIRCULATIONAHA.109.876185
5. Evans EW, Hayes C, Palmer CA, Bermudez OI, Cohen SA, Must A. Dietary intake and severe early childhood caries in low-income, young children. J Acad Nutr Diet 2013;113:1057–61. PMID:23706351 https://doi.org/10.1016/j.jand.2013.03.014
6. Vos MB, Kaar JL, Welsh JA, et al.; American Heart Association Nutrition Committee of the Council on Lifestyle and Cardiometabolic Health; Council on Clinical Cardiology; Council on Cardiovascular Disease in the Young; Council on Cardiovascular and Stroke Nursing; Council on Epidemiology and Prevention; Council on Functional Genomics and Translational Biology; and Council on Hypertension. Added sugars and cardiovascular disease risk in children: a scientific statement from the American Heart Association. Circulation 2017;135:e1017–34. PMID:27550974 https://doi.org/10.1161/CIR.0000000000000439
7. Gurzo K, Lee DL, Ritchie K, et al. Child care sites participating in the Federal Child and Adult Care Food Program provide more nutritious foods and beverages. J Nutr Educ Behav 2020;52:697–704. PMID:32268971 https://doi.org/10.1016/j.jneb.2020.02.009
8. Eicher-Miller HA, Zhao Y. Evidence for the age-specific relationship of food insecurity and key dietary outcomes among US children and adolescents. Nutr Res Rev 2018;31:98–113. PMID:29318982 https://doi.org/10.1017/S0954422417000245
9. Mennella JA, Reiter AR, Daniels LM. Vegetable and fruit acceptance during infancy: impact of ontogeny, genetics, and early experiences. Adv Nutr 2016;7(Suppl):211S–9S. PMID:26773029 https://doi.org/10.3945/an.115.008649

Typhoid Fever Surveillance, Incidence Estimates, and Progress Toward Typhoid Conjugate Vaccine Introduction — Worldwide, 2018–2022

Molly Hancuh, MSPH[1,*]; Jenny Walldorf, MD[2]; Anna A. Minta, MD[2]; Carol Tevi-Benissan, MD[2]; Kira A. Christian, DVM[3]; Yoann Nedelec, MPH[2]; Kristen Heitzinger; PhD[4]; Matthew Mikoleit, PhD[3]; Amanda Tiffany, PhD[5]; Adwoa D. Bentsi-Enchill, MD[2]; Lucy Breakwell, PhD[5]

Typhoid fever, an acute febrile illness caused by *Salmonella enterica* serovar Typhi (*S.* Typhi), is endemic in many low- and middle-income countries[†] (*1*). In 2015, an estimated 11–21 million typhoid fever cases and 148,000–161,000 associated deaths occurred worldwide (*2*). Effective prevention strategies include improved access to and use of infrastructure supporting safe water, sanitation, and hygiene (WASH); health education; and vaccination (*1*). The World Health Organization (WHO) recommends programmatic use of typhoid conjugate vaccines for typhoid fever control and prioritization of vaccine introduction in countries with the highest typhoid fever incidence or high prevalence of antimicrobial-resistant *S.* Typhi (*1*). This report describes typhoid fever surveillance, incidence estimates, and the status of typhoid conjugate vaccine introduction during 2018–2022. Because routine surveillance for typhoid fever has low sensitivity, population-based studies have guided estimates of case counts and incidence in 10 countries since 2016 (*3*–*6*). In 2019, an updated modeling study estimated that 9.2 million (95% CI = 5.9–14.1) typhoid fever cases and 110,000 (95% CI = 53,000–191,000) deaths occurred worldwide, with the highest estimated incidence in the WHO South-East Asian (306 cases per 100,000 persons), Eastern Mediterranean (187), and African (111) regions (*7*). Since 2018, five countries (Liberia, Nepal, Pakistan, Samoa [based on self-assessment], and Zimbabwe) with estimated high typhoid fever incidence (≥100 cases per 100,000 population per year) (*8*), high antimicrobial resistance prevalence, or recent outbreaks introduced typhoid conjugate vaccines into their routine immunization programs (*2*). To guide vaccine introduction decisions, countries should consider all available information, including surveillance of laboratory-confirmed cases, population-based and modeling studies, and outbreak reports. Establishing and strengthening typhoid fever surveillance will be important to measure vaccine impact.

Surveillance and Estimates of Disease Incidence and Antimicrobial Resistance Prevalence

WHO recommends that countries with endemic typhoid fever[§] establish health facility–based surveillance with laboratory confirmation to determine disease burden,[¶] monitor antimicrobial resistance patterns, facilitate rapid outbreak detection, and assess vaccine impact (*3*). Because the clinical presentation of typhoid fever is often indistinguishable from that of other acute febrile illnesses common in areas with endemic typhoid (e.g., malaria and dengue), diagnosis is dependent upon laboratory confirmation, typically blood culture (*3*). However, blood culture has a low sensitivity (40%–60%), which is further reduced by widespread use of prediagnosis antibiotic use, has limited availability at health care facilities, and is not systematically obtained from febrile patients (*1*–*3*). Therefore, the number of laboratory-confirmed *S.* Typhi cases represents a small proportion of the actual disease incidence. Countries report data on selected vaccine-preventable diseases to WHO and UNICEF annually using the electronic Joint Reporting Form (eJRF). During 2018–2021, 59–62 countries reported laboratory-confirmed typhoid fever through eJRF.[**] Reported cases increased from approximately 8,800 in 2018, when typhoid fever surveillance was first added to eJRF, to 1 million in 2021.

Because of the low sensitivity of typhoid fever surveillance, specially designed population-based studies have been implemented to estimate disease incidence. Since 2016, typhoid fever incidence has been estimated in specific countries through three surveillance projects: 1) the Strategic Typhoid Alliance across Africa and Asia (for Bangladesh, Malawi, and Nepal); 2) the Surveillance for Enteric Fever in Asia Project (for Bangladesh, Nepal, and Pakistan); and 3) the Severe Typhoid in Africa program (for Burkina Faso, Democratic Republic of the Congo,

[*] Consultant.

[†] World Bank gross national income (GNI) classification cutoffs per capita in U.S. dollars in 2021: high income >$12,695, upper-middle–income = $4,096–12,695, lower-middle–income = $1,046–4,095, and low income ≤$1,046. https://blogs.worldbank.org/opendata/new-world-bank-country-classifications-income-level-2021-2022

[§] Countries with endemic disease are those where typhoid fever is common, typically low- and middle-income countries, and where much of the population lacks access to clean water, adequate sanitation, and standard hygiene.

[¶] "Disease burden" is defined as an overall measure of the public health impact of typhoid fever on a given population. Disease burden can be measured as a composite of a variety of indicators, including morbidity (e.g., incidence and complications), mortality, and economic impact.

[**] Data on typhoid cases are reported by countries to WHO and UNICEF through eJRF and currently are not available online.

Ethiopia, Ghana, Madagascar, and Nigeria) (Table 1) (*4*–*6*). Modeling data from the Global Burden of Disease study estimated that 9.2 million (95% CI = 5.9–14.1) typhoid fever cases and 110,000 (95% CI = 53,000–191,000) associated deaths occurred worldwide in 2019 (*7*). The highest estimated 2019 incidence, by region, occurred in the WHO South-East Asian (306 cases per 100,000 persons), Eastern Mediterranean (187), and African (111) regions (Table 1) (Figure) and, by age group, occurred in children aged 5–9 years, followed by children and adolescents aged 10–14 years and children aged 1–4 years, respectively.[††]

An additional indication of typhoid fever burden can be obtained through analysis of outbreak[§§] data. During 2017–2022, seven confirmed typhoid fever outbreaks were identified from ongoing outbreak monitoring activities by CDC's Global Disease Detection Operation Center,[¶¶] including the Philippines (2022: 14,056 cases) and three in Zimbabwe (January–March 2017: 1,312 cases; November 2017–February 2018: 3,187 cases; and August–December 2018: 7,134 cases), as well as outbreaks with confirmed antimicrobial-resistant cases in Pakistan (January 2018–December 2019: 14,894 cases) and China (2022: 23 cases) (*9*).

Apart from high disease incidence, the need for action is enhanced by the increasing prevalence of antimicrobial resistance in many countries with endemic typhoid fever. During 2010–2018, approximately 35% of reported *S.* Typhi isolates in Asia and 75% of those in Africa were resistant to chloramphenicol, ampicillin, and trimethoprim-sulfamethoxazole (defined as multidrug resistant [MDR]) (*10*). After a typhoid outbreak in Hyderabad, Pakistan in 2016, Pakistan became the first country to report MDR strains with additional resistance

[††] Incidence by region and age group is determined by Global Burden of Disease Collaborative Network, Global Burden of Disease study, 2019. https://www.healthdata.org/gbd/gbd-2019-resources

[§§] Confirmed typhoid fever outbreaks are defined as an excess of suspected cases above what would normally be expected during a defined period for a defined community, geographic area, or season, with a minimum of two blood culture–confirmed cases.

[¶¶] Event-based surveillance data collected during the time of the report might not reflect all cases, deaths, and reports of antimicrobial resistance associated with the stated outbreak. Outbreaks meeting criteria associated with International Health Regulations, Annex 2, are monitored by CDC's Global Disease Detection Operation Center. https://www.cdc.gov/globalhealth/healthprotection/gddopscenter/index.html (Accessed January 6, 2023).

TABLE 1. Population-based and modeling estimates of typhoid fever incidence* — worldwide, 2016–2020

Study	Site	Period	Observed no. of cases reported	Incidence* (95% CI)	
				Crude	Adjusted
SEAP[†]	Bangladesh: Dhaka Shishu Hospital and Shishu Shasthya Foundation Hospital	Sep 2016–Sep 2019	4,131	103 (97–109)	913 (765–1095)
	Nepal: Dhulikhel Hospital	Sep 2016–Sep 2019	NA	36 (24–51)	268 (202–362)
	Nepal: Kathmandu Medical College	Sep 2016–Sep 2019	NA	31 (26–37)	330 (230–480)
	Pakistan: Aga Khan University Hospital	Sep 2016–Sep 2019	NA	12 (10–14)	103 (85–126)
	Pakistan: Kharadar General Hospital	Sep 2016–Sep 2019	NA	24 (21–28)	176 (144–216)
STRATAA[§]	Blantyre, Malawi	Nov 2016–Oct 2018	115	58 (48–70)	444 (347–717)
	Kathmandu, Nepal	Jan 2017–Dec 2018	150	74 (62–87)	1,062 (683–1,839)
	Dhaka, Bangladesh	Jan 2017–Dec 2018	359	161 (145–179)	1,135 (898–1,480)
SETA[¶]	Nioko and Polesgo, Burkina Faso	May 2016–Jan 2020	11	8	1,189 (490–2,940)
	Kavuaya and Nkandu, DRC	Jan 2018–May 2020	51	30	348 (259–553)
	Sodo, Ethiopia	Jul 2017–Sep 2019	7	2	23 (10–67)
	Agogo, Ghana	May 2016–Apr 2019	60	10	112 (84–164)
	Imerintsiatosika, Madagascar	Feb 2016–Feb 2020	49	27	168 (135–233)
	Mahajanga, Madagascar	Jun 2018–Jan 2020	1	5	106 (9–710)
	Ibadan, Nigeria	Feb 2017–May 2020	65	1	42 (28–77)
GBD**	Eastern Mediterranean Region	2019	NA	NA	187 (118–281)
	Western Pacific Region		NA	NA	23 (15–33)
	Region of the Americas		NA	NA	3 (3–4)
	South-East Asia Region		NA	NA	306 (192–478)
	African Region		NA	NA	111 (71–166)
	European Region		NA	NA	2 (2–4)
	Global		NA	NA	119 (77–183)

Abbreviations: DRC = Democratic Republic of the Congo; GBD = Global Burden of Disease; NA = not available; SEAP = Surveillance for Enteric Fever in Asia Project; SETA = Severe Typhoid Fever in Africa; STRATAA = Strategic Typhoid Alliance Across Africa and Asia.

* Cases per 100,000 population.

† https://doi.org/10.1016/S2214-109X(22)00119-X

§ https://doi.org/10.1016/S2214-109X(21)00370-3

¶ https://doi.org/10.2139/ssrn.4292849

** Global Burden of Disease Collaborative Network, GBD study, 2019. https://www.healthdata.org/gbd/gbd-2019-resources

to fluoroquinolones and third-generation cephalosporins (defined as extensively drug resistant [XDR]); Pakistan continues to report high proportions of XDR *S.* Typhi cases (*2*). Resistance to an increasing number of antimicrobials, including fluoroquinolones, third-generation cephalosporins, and azithromycin (a macrolide), has been documented in Asia (*10*).

Typhoid Conjugate Vaccine Introduction

WHO has prequalified two typhoid conjugate vaccines: Typbar-TCV (Bharat Biotech International Limited) and TYPHIBEV (Biological E. Limited)*** (*2*). Typhoid conjugate vaccines may be administered to persons aged ≥6 months, which facilitates their inclusion in routine immunization programs (*2*). A single dose administered to children has been shown to be safe and 79%–95% effective, with an antibody response persisting up to 7 years (*2*). Co-administration of typhoid conjugate vaccine with routinely administered vaccines (e.g., measles-containing vaccines, yellow fever vaccine, and serogroup A meningococcal conjugate vaccines) does not interfere with the immune response to typhoid conjugate vaccines or to the other simultaneously administered vaccines.

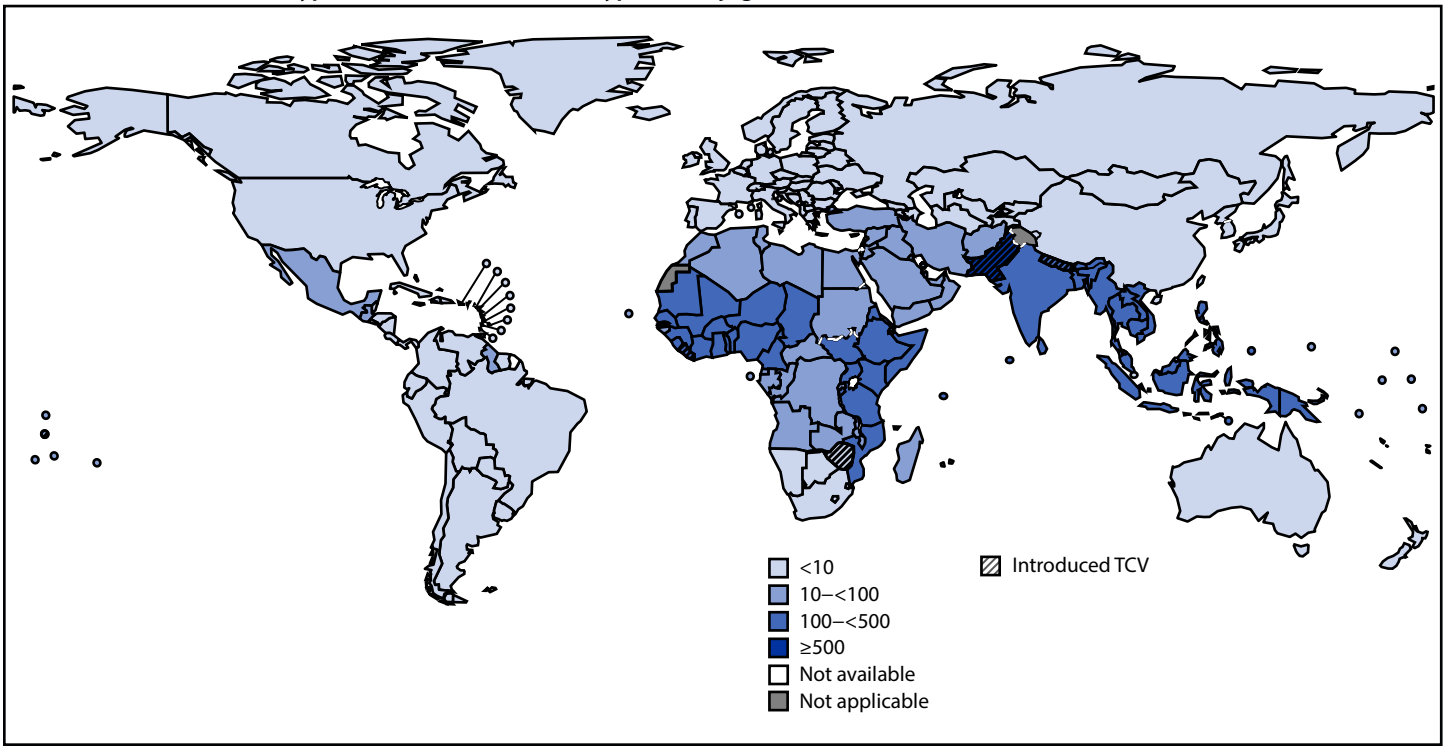
*** https://extranet.who.int/pqweb/vaccines

Use of typhoid conjugate vaccine has been shown to be cost-effective for countries with high to very high typhoid fever incidence (*1*,*2*).

Since 2018, WHO has recommended that typhoid conjugate vaccine introduction be prioritized in countries with the highest typhoid fever incidence or a high prevalence of antimicrobial-resistant *S.* Typhi. Vaccine introduction should be implemented in combination with health education, WASH improvements, and health care worker training on typhoid fever diagnosis and treatment (*1*). The first public health introduction of typhoid conjugate vaccine occurred in 2018 in Navi Mumbai Municipal Corporation, India, as part of a program evaluation activity (*2*). Subsequently, typhoid conjugate vaccine has been introduced nationally into the routine immunization schedule for children at either age 9 months or 15–18 months in Pakistan (2019 Phase 1, 2021 Phase 2, and 2022 Phase 3), Liberia (2021), Zimbabwe (2021), Nepal (2022), and Samoa (2021 Phase 1 and 2022 Phase 2) (*4*) (Figure) (Table 2). Introduction in Malawi is planned for 2023.

Catch-up vaccination campaigns targeting children aged 6 months–14 years are recommended at the time of introduction of typhoid conjugate vaccines into the routine immunization schedule, when feasible and supported by epidemiologic data,

FIGURE. Estimated national typhoid fever incidence* and typhoid conjugate vaccine introduction† status — worldwide, 2019 and 2022



Source: Global Burden of Disease Collaborative Network, Global Burden of Disease study, 2019. https://www.healthdata.org/gbd/gbd-2019-resources
Abbreviation: TCV = typhoid conjugate vaccine.
* Cases per 100,000 population.
† Liberia, Nepal, Pakistan, Samoa, and Zimbabwe have introduced TCV.

TABLE 2. Typhoid conjugate vaccine introductions into routine immunization programs — worldwide, 2019–2022

Country	Program strategy	Targeted vaccination area*	Phase	Target population size†	Integrated health or other interventions	Catch-up campaign dates	Campaign status	Post campaign coverage, %§	Age at administration in routine program, mos
Pakistan	National, phased	Sindh	1	10,013,569	—	Nov 2019	Completed	82	9
		Punjab and Islamabad	2a	12,383,108	bOPV	Feb 2021	Completed	88 (Punjab) 69 (Islamabad)	
		Broader Punjab	2b	29,005,881	bOPV	Jun 2021	Completed	95	
		All other provinces	3	5,500,000	bOPV	Oct 2022	Completed	NA	
Liberia	National	—	—	1,900,000	—	Apr 2021	Completed	63	9
Zimbabwe	National	—	—	8,861,235	IPV, HPV, vitamin A	May 2021	Completed	NA	9
Samoa¶	National, phased	Upolu, Apia urban area	1	26,358	—	Aug–Sep 2021	Completed	84	9–12
			2	—	—	Ongoing	Ongoing	—	
Nepal	National	—	—	7,500,000	Hygiene education/ promotion and identification of under- and unvaccinated children	Apr–May 2022	Completed	NA	15

Abbreviations: bOPV = bivalent oral poliovirus vaccine; HPV = human papillomavirus vaccine; IPV = inactivated polio vaccine; NA = not available.
* If subnational.
† Persons aged 9 months–14 years.
§ Post campaign coverage is based on immunization coverage survey.
¶ Country-financed introduction.

Summary

What is already known about this topic?

An estimated 11–21 million typhoid fever cases and 148,000–161,000 associated deaths occurred in 2015. The World Health Organization (WHO) recommends safe, effective typhoid conjugate vaccines (TCV) for typhoid fever control.

What is added by this report?

Population-based and modeling studies confirm high typhoid incidence in the WHO South-East Asian, Eastern Mediterranean, and African regions. Since 2018, five countries have introduced TCV into their national routine immunization schedule.

What are the implications for public health practice?

To guide evidence-based TCV introduction decisions, countries with endemic typhoid should consider all available information, including surveillance of laboratory-confirmed cases, population-based and modeling studies, and outbreak reports. Establishing and strengthening typhoid fever surveillance will be important to measure vaccine impact.

to maximize vaccination impact (*1*). Overall, more than 75 million children have received typhoid conjugate vaccines during catch-up campaigns, with post-campaign coverage estimates ranging from 63% to 95% (*2*). Nepal, Pakistan, and Zimbabwe conducted integrated campaigns that included other routine vaccines or identification of unvaccinated and undervaccinated children (*2*). Typhoid conjugate vaccine has also been used in outbreak response in Pakistan and Zimbabwe (*2*).

Discussion

Since WHO recommended the use of typhoid conjugate vaccine to prevent typhoid fever in countries with endemic disease in 2018, only five countries, including three (7%) of the 44 countries and freely associated states with estimated high typhoid fever incidence based on Global Burden of Disease study estimates,††† have introduced typhoid conjugate vaccines into their routine immunization schedule. Probable factors leading to delayed vaccine introduction include the presence of competing health priorities, particularly the COVID-19 pandemic, and insufficient disease burden data to guide national vaccine introduction decisions. Typhoid fever surveillance data are frequently limited to clinically suspected cases and serologic diagnostic tests with poor specificity. Population-based incidence studies are costly, time-consuming, technically challenging, and not available in most countries. Data on the prevalence of antimicrobial-resistant strains of *S.* Typhi are important for typhoid vaccine introduction decisions, but such data are lacking because of limited typhoid surveillance. Since 2018, additional data on the safety and effectiveness of typhoid

††† The 44 countries and freely associated states with high or very high incidence of typhoid fever, according to Global Burden of Disease 2019 estimates, are Bangladesh, Benin, Bhutan, Burkina Faso, Burma, Burundi, Cambodia, Cameroon, Chad, Côte d'Ivoire, Eritrea, Ethiopia, Gambia, Ghana, Guinea, India, Indonesia, Kenya, Laos, Liberia, Malaysia, Maldives, Mali, Mauritania, Mozambique, Nepal, Niger, Nigeria, Pakistan, Palau, Papua New Guinea, Philippines, Senegal, Seychelles, Sierra Leone, Somalia, South Sudan, Sri Lanka, Tanzania, Thailand, Timor-Leste, Togo, Uganda, and Vietnam.

conjugate vaccine and the lack of interference with other coadministered routine vaccines have become available and support the WHO typhoid vaccine introduction recommendation (*2*). Insufficient data from surveillance or population-based studies should not preclude considering typhoid conjugate vaccine introduction. Countries with endemic typhoid fever are encouraged to review regional and neighboring countries' data, as well as national data sources such as published population-based studies, modeling data, laboratory-confirmed cases, antimicrobial testing studies, outbreak reports, and case reports of intestinal perforation (a hallmark of severe typhoid fever) to guide assessments of typhoid fever disease burden, and vaccine introduction decisions.

The five countries that have introduced typhoid conjugate vaccine have shared lessons learned regarding introduction strategies and integrated campaign opportunities. Among these five countries, Nepal, Pakistan, and Zimbabwe conducted integrated campaigns, including the simultaneous administration of other routine vaccines, vitamin A supplementation, hygiene promotion, or identification of undervaccinated children (*2*). Given the wide recommended age range for typhoid conjugate vaccine catch-up campaigns (6 months–14 years), school-based vaccination was found to be a useful strategy in Nepal, Pakistan, and Zimbabwe. However, drawbacks to such campaigns included difficulty reaching out-of-school children and increased absences on vaccination days, which schools ascribed to vaccine hesitancy stemming from misinformation related to the COVID-19 pandemic (*2*). Further country engagement is needed to better understand and address barriers to vaccination. Notably, four of the five countries that have introduced typhoid conjugate vaccine benefited from financial support from Gavi, the Vaccine Alliance (Gavi).[§§§] Among the 44 countries considered to have high typhoid fever incidence, 11 middle-income countries are ineligible for Gavi support and might face financial barriers to typhoid conjugate vaccine introduction.

WHO recommends that countries with endemic typhoid fever establish and strengthen health care facility–based surveillance with laboratory confirmation, either through passive or active reporting to monitor disease trends and measure vaccine impact (*3*). Sentinel site surveillance has been critical for monitoring vaccine impact and disease trends for other vaccine-preventable diseases. Expanding blood culture diagnostic capacity strengthens surveillance for other invasive bacterial pathogens as well as typhoid fever and is integral to *S.* Typhi antimicrobial resistant strain surveillance. In addition, the development and validation of improved diagnostic tests and environmental surveillance might expand or augment typhoid surveillance in the future (*2*,*3*). In areas with endemic typhoid fever, nontraumatic intestinal perforation cases should be considered probable cases of typhoid or paratyphoid fever and have been used to identify outbreaks (*3*). Countries are encouraged to report laboratory-confirmed typhoid fever case data through eJRF to facilitate the monitoring of global typhoid fever incidence.

The findings in this report are subject to at least three limitations. First, data for both annual cases and outbreaks are underreported because of limited laboratory capacity. Second, the identification of typhoid fever outbreaks often relies on potentially incomplete reports from media, governments, or in-country technical partners including CDC and WHO; thus, outbreaks are likely underreported. Finally, recent programmatic experience with typhoid conjugate vaccine is still limited and accruing; therefore, data on routine typhoid conjugate vaccine coverage and its impact on disease are not yet available.

Use of typhoid conjugate vaccine in immunization programs is part of the multisectoral typhoid fever prevention approach, including WASH improvement and strengthened national surveillance, and will help countries reduce typhoid fever morbidity and mortality. Countries' experiences with successful typhoid conjugate vaccine introductions and catch-up campaigns that included integrated health interventions could serve as examples for other countries planning to introduce typhoid conjugate vaccine. Sustained financial and technical commitment are needed at the national and international levels for improving WASH implementation, compiling national typhoid fever disease prevalence data, and increasing typhoid conjugate vaccination coverage to further advance typhoid fever control.

Acknowledgments

Regional and country WHO new vaccine introduction counterparts; Susan A. Wang, CDC.

Corresponding author: Lucy Breakwell, xdc3@cdc.gov.

[1]CDC Foundation, Atlanta, Georgia; [2]Department of Immunization, Vaccines, and Biologicals, World Health Organization, Geneva, Switzerland; [3]Division of Global Health Protection, Center for Global Health, CDC; [4]Division of Foodborne, Waterborne, and Environmental Diseases, National Center for Emerging, Zoonotic, and Infectious Diseases, CDC; [5]Global Immunization Division, Center for Global Health, CDC.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Anna A. Minta reports support from the International Vaccine Institute for attendance at the Africa Regional Meeting on typhoid and typhoid conjugate vaccines, and from Sabin Institute for attendance at the Asia Regional meeting on typhoid and typhoid conjugate vaccines. Lucy Breakwell reports uncompensated participation on a PATH-convened data safety monitoring board for a Typbar typhoid conjugate vaccine clinical trial. No other potential conflicts of interest were disclosed.

[§§§] In 2022, 54 countries were eligible for Gavi support because their average GNI per capita was ≤US $1,660 during the previous 3 years, based on World Bank data.

References

1. World Health Organization. Typhoid vaccines: WHO position paper, March 2018–recommendations. Vaccine 2019;37:214–6. PMID:29661581 https://doi.org/10.1016/j.vaccine.2018.04.022
2. World Health Organization. Department of Immunization, Vaccines and Biologicals (IVB). Presented at SAGE meeting. Geneva, Switzerland: World Health Organization, Department of Immunization, Vaccines and Biologicals; April 4–7, 2022. https://terrance.who.int/mediacentre/data/sage/SAGE_eYB_Apr2022.pdf
3. World Health Organization. Typhoid and other invasive salmonellosis. Geneva, Switzerland: World Health Organization; 2018. https://cdn.who.int/media/docs/default-source/immunization/vpd_surveillance/vpd-surveillance-standards-publication/who-surveillancevaccinepreventable-21-typhoid-r2.pdf?sfvrsn=993904a6_10&download=true
4. Garrett DO, Longley AT, Aiemjoy K, et al. Incidence of typhoid and paratyphoid fever in Bangladesh, Nepal, and Pakistan: results of the Surveillance for Enteric Fever in Asia Project. Lancet Glob Health 2022;10:e978–88. PMID:35714648 https://doi.org/10.1016/S2214-109X(22)00119-X
5. Meiring JE, Shakya M, Khanam F, et al.; STRATAA Study Group. Burden of enteric fever at three urban sites in Africa and Asia: a multicentre population-based study. Lancet Glob Health 2021;9:e1688–96. PMID:34798028 https://doi.org/10.1016/S2214-109X(21)00370-3
6. Marks F, Im J, Park SE, et al. The Severe Typhoid in Africa Program: incidences of typhoid fever in Burkina Faso, Democratic Republic of Congo, Ethiopia, Ghana, Madagascar, and Nigeria. SSRN scholarly paper [Preprint posted online December 7, 2022]. https://doi.org/10.2139/ssrn.4292849
7. Institute for Health Metrics and Evaluation. Typhoid fever–level 4 cause. Seattle, WA: Institute for Health Metrics and Evaluation, Global Burden of Disease Collaborative Network; 2020. https://www.healthdata.org/results/gbd_summaries/2019/typhoid-fever-level-4-cause
8. Antillón M, Warren JL, Crawford FW, et al. The burden of typhoid fever in low- and middle-income countries: a meta-regression approach. PLoS Negl Trop Dis 2017;11:e0005376. PMID:28241011 https://doi.org/10.1371/journal.pntd.0005376
9. Wang Y, Lu D, Jin Y, et al. Extensively drug-resistant (XDR) *Salmonella* typhi outbreak by waterborne infection—Beijing Municipality, China, January–February 2022. China CDC Wkly 2022;4:254–8. PMID:35433085 https://doi.org/10.46234/ccdcw2022.062
10. Marchello CS, Carr SD, Crump JA. A systematic review on antimicrobial resistance among *Salmonella* typhi worldwide. Am J Trop Med Hyg 2020;103:2518–27. PMID:32996447 https://doi.org/10.4269/ajtmh.20-0258

Morbidity and Mortality Weekly Report

Preliminary Estimates of Effectiveness of Monovalent mRNA Vaccines in Preventing Symptomatic SARS-CoV-2 Infection Among Children Aged 3–5 Years — Increasing Community Access to Testing Program, United States, July 2022–February 2023

Katherine E. Fleming-Dutra, MD[1]; Allison Avrich Ciesla, PhD[1,2]; Lauren E. Roper, MPH[1]; Zachary R. Smith, MA[3]; Joseph D. Miller, PhD[3]; Emma K. Accorsi, PhD[1,4]; Jennifer R. Verani, MD[1]; Nong Shang, PhD[1]; Gordana Derado, PhD[1]; Ryan E. Wiegand, PhD[1]; Tamara Pilishvili, PhD[1]; Amadea Britton, MD[1]; Ruth Link-Gelles, PhD[1]

On June 18, 2022, the Advisory Committee on Immunization Practices (ACIP) issued interim recommendations for use of the 2-dose monovalent Moderna COVID-19 vaccine as a primary series for children aged 6 months–5 years* and the 3-dose monovalent Pfizer-BioNTech COVID-19 vaccine as a primary series for children aged 6 months–4 years,† based on safety, immunobridging, and limited efficacy data from clinical trials (*1*–*3*). Monovalent mRNA vaccine effectiveness (VE) against symptomatic SARS-CoV-2 infection was evaluated using the Increasing Community Access to Testing (ICATT) program, which provides SARS-CoV-2 testing to persons aged ≥3 years at pharmacy and community-based testing sites nationwide (*4*,*5*). Among children aged 3–5 years with one or more COVID-19–like illness symptoms for whom a nucleic acid amplification test (NAAT) was performed during August 1, 2022–February 5, 2023, VE of 2 monovalent Moderna doses (complete primary series) against symptomatic infection was 60% (95% CI = 49% to 68%) 2 weeks–2 months after receipt of the second dose and 36% (95% CI = 15% to 52%) 3–4 months after receipt of the second dose. Among symptomatic children aged 3–4 years with NAATs performed during September 19, 2022–February 5, 2023, VE of 3 monovalent Pfizer-BioNTech doses (complete primary series) against symptomatic infection was 31% (95% CI = 7% to 49%) 2 weeks–4 months after receipt of the third dose; statistical power was not sufficient to estimate VE stratified by time since receipt of the third dose. Complete monovalent Moderna and Pfizer-BioNTech primary series vaccination provides protection for children aged 3–5 and 3–4 years, respectively, against symptomatic infection for at least the first 4 months after vaccination. CDC expanded recommendations for use of updated bivalent vaccines to children aged ≥6 months on December 9, 2022 (*6*), which might provide increased protection against currently circulating SARS-CoV-2 variants (*7*,*8*). Children should stay up to date with recommended COVID-19 vaccines, including completing the primary series; those who are eligible should receive a bivalent vaccine dose.

ICATT is a CDC program** that contracts with pharmacy- and community-based testing vendors to provide no-cost SARS-CoV-2 testing nationwide (*4*,*5*). At registration, caregivers of minors report information on the presence of COVID-19–like illness symptoms, previous SARS-CoV-2 infection,†† underlying health conditions,§§ and COVID-19 vaccination status. Caregivers are asked to report total number of COVID-19 vaccine doses received, the manufacturer of each dose, and the month and year of receipt of the most recent dose.¶¶ Testing vendors report SARS-CoV-2 test data directly to CDC, including collection date and result.

NAATs from children with one or more COVID-19–like illness symptom were eligible for inclusion in the test-negative design case-control study. Tests from children were excluded if the caregiver reported any of the following conditions: immunocompromise, positive SARS-CoV-2 test within 3 months,

* Moderna COVID-19 vaccine primary series consists of two 25 μg doses separated by at least 4–8 weeks.

† Pfizer-BioNTech COVID-19 vaccine primary series consists of three 3 μg doses, with at least 3–8 weeks between doses 1 and 2 and ≥8 weeks between doses 2 and 3.

§ At nearly all ICATT sites, test eligibility is restricted to persons aged ≥3 years. Therefore, this analysis was limited to children aged ≥3 years.

¶ At test registration, caregivers reported the presence of any of the following COVID-19–like illness symptoms: fever, cough, shortness of breath, recent loss of sense of smell or taste, muscle pain, fatigue, chills, headache, sore throat, congestion or runny nose, vomiting, or diarrhea, which were reported to CDC as asymptomatic or symptomatic with one or more symptom.

** https://www.cdc.gov/icatt/index.html (Accessed February 10, 2023).

†† During the analytic period, different versions of the questionnaire were used. Persons who reported a history of previous SARS-CoV-2 infection were also asked to report when the previous positive test result occurred and to select all applicable options. One version asked if the previous SARS-CoV-2 positive test result was within 90 days or ≥90 days ago, and another version asked if the previous positive test result was within the last week, between 1 week and 3 months ago, or >3 months ago.

§§ The following underlying conditions were included on the questionnaire: heart conditions, high blood pressure, overweight or obesity, diabetes, current or former smoker, kidney failure or end stage renal disease, cirrhosis of the liver, chronic lung disease (e.g., chronic obstructive pulmonary disease, moderate to severe asthma, cystic fibrosis, or pulmonary embolism), and immunocompromising conditions. For immunocompromising conditions, the following examples were provided on the questionnaire: immunocompromising medications, solid organ or blood stem cell transplant, HIV, or other immunocompromising conditions.

¶¶ Only month and year of receipt were reported for the vaccine dose from some participating pharmacies, and some questionnaires included the month and year of each dose, and others included the month and year of only the most recent dose. Therefore, the number of months between the most recent vaccine dose received and testing is a whole number calculated as the difference between the month and year of testing and the month and year of the most recent dose.

receipt of a non-mRNA COVID-19 vaccine or mixed product regimen,*** COVID-19 vaccine dose receipt within 2 weeks of test date,††† or third COVID-19 vaccine dose received during or after December 2022 (when bivalent vaccines were recommended for this age group).§§§ Data included NAATs performed among children aged 3–5 years (Moderna analysis) and aged 3–4 years (Pfizer-BioNTech analysis).¶¶¶ VE, stratified by vaccine product and dose number, was estimated by comparing odds of COVID-19 vaccination versus being unvaccinated in case-patients (those who received a positive SARS-CoV-2 test result) and control-patients (those who received a negative test result). VE was calculated as (1 – adjusted odds ratio) x 100.**** Analysis periods varied for each product and dose combination. Children became eligible to be included in each analysis 2 weeks after the initial date a child could have received each product and dose combination, affecting comparability of product-specific estimates.†††† VE for a partial series (1 dose of Moderna; 1 or 2 doses of Pfizer-BioNTech) was assessed from 2 weeks after receipt of the most recent dose through the recommended interval to the next dose.§§§§ Consistent with previous studies (*7*,*8*), VE estimates with 95% CI width >50 percentage points were considered imprecise and not reported. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.¶¶¶¶

Among NAATs performed through ICATT during July 4–February 5, 2023, among children with one or more COVID-19–like illness symptom (before applying exclusion criteria), 18%, 17%, and 26% of those aged 3, 4, and 5 years, respectively, had received ≥1 COVID-19 vaccine dose.***** After applying exclusion criteria, 37,010 NAATs performed at 8,741 ICATT testing sites for children aged 3–5 years were included in the Moderna VE analysis, and 24,094 NAATs performed at 7,615 ICATT testing sites for children aged 3–4 years were included in the Pfizer-BioNTech VE analysis. In the Moderna analysis, 26%, 39% and 35% of children were aged 3, 4, and 5 years, respectively; in the Pfizer-BioNTech analysis, 40% and 60% of children were aged 3 and 4 years, respectively (Table 1). VE of one monovalent Moderna dose (partial primary series) was 40% at 2 weeks–1 month after dose 1 (Table 2). VE of two monovalent Moderna doses (complete primary series) was 60% at 2 weeks–2 months after dose 2 and 36% at 3–4 months. VE of one monovalent Pfizer-BioNTech dose (partial primary series) was 19% at 2 weeks–1 month after dose 1. VE of 2 monovalent Pfizer-BioNTech doses (partial primary series) was 40% at 2 weeks–3 months after dose 2, reflecting the interval between doses 2 and 3. VE of three monovalent Pfizer-BioNTech doses (complete primary series) was 31% at 2 weeks–4 months after dose 3; statistical power was not sufficient to estimate VE stratified by time since dose 3.

Discussion

Postauthorization estimates of COVID-19 VE against symptomatic infection in young children indicate that complete primary series vaccination with either monovalent Moderna or Pfizer-BioNTech provides protection for children aged 3–5 and 3–4 years, respectively, against symptomatic infection for at least the first 4 months after vaccination. The goal of the U.S. COVID-19 vaccination program is to prevent severe disease and hospitalization (*9*); however, postauthorization VE against symptomatic infection provides important insight into vaccine protection, as estimates of VE against severe disease in this age group are not yet available. Effectiveness of mRNA vaccines has generally been higher against more severe outcomes than for symptomatic infection (*10*). Vaccination is an important tool for protecting children from COVID-19. Children should stay up to date with recommended COVID-19 vaccines, including

*** Children who received both Moderna and Pfizer-BioNTech COVID-19 vaccines were considered to have a mixed product regimen.

††† For doses received in the same month as or the month preceding SARS-CoV-2 testing, respondents were asked to specify whether the dose was received ≥2 weeks before testing if the most recent vaccination date was not directly reported. Only doses received ≥2 weeks before testing were included.

§§§ On December 9, 2022, children aged 6 months–5 years who had received 2 monovalent Moderna vaccine doses were recommended to receive a single bivalent booster dose ≥2 months after their last dose, and children aged 6 months–4 years who had received 2 monovalent Pfizer-BioNTech vaccine doses but had not yet received the third dose of the primary series were recommended to receive a bivalent vaccine dose as their third dose. In the analysis of Moderna VE, 38 tests were excluded from children who received a presumed bivalent third vaccine dose in December 2022 or later. In the analysis of Pfizer-BioNTech VE, 11 tests were excluded from children who received a presumed bivalent third vaccine dose in December 2022 or later.

¶¶¶ Children who received Pfizer-BioNTech COVID-19 vaccine were excluded from the analyses of Moderna VE, and children who received Moderna COVID-19 vaccine were excluded from the analyses of Pfizer-BioNTech VE.

**** Odds ratios were calculated using multivariable logistic regression, adjusting for single year of age, gender, race, ethnicity, Social Vulnerability Index of the testing location, underlying conditions (presence versus absence), U.S. Department of Health and Human Services region, pharmacy chain conducting the test, local incidence (cases per 100,000 population by site county in the 7 days before test date), and testing calendar date.

†††† Eligibility for each product and dose number combination began on the following dates: 1 dose of Moderna and Pfizer-BioNTech on July 4, 2022; 2 doses of Pfizer-BioNTech on July 25, 2022; 2 doses of Moderna on August 1, 2022; and 3 doses of Pfizer-BioNTech on September 19, 2022.

§§§§ VE for 1 dose was assessed at 2 weeks–1 month after the dose (i.e., tests conducted in the same month or month following the dose) to correspond to the recommended interval between doses 1 and 2 of at least 3–8 weeks for Pfizer-BioNTech and at least 4–8 weeks for Moderna. VE for 2 Pfizer-BioNTech doses was assessed at 2 weeks–3 months after dose 2 to correspond to the recommended interval of ≥8 weeks between doses 2 and 3.

¶¶¶¶ 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.

***** Among children with one or more COVID-19–like illness symptom with a negative SARS-CoV-2 NAAT in ICATT during July 4– February 5, 2023, before applying exclusion criteria, 20%, 19%, and 28% of those aged 3, 4, and 5 years had received ≥1 COVID-19 vaccine dose, respectively.

TABLE 1. Characteristics of children aged 3–5 years with symptoms of COVID-19–like illness and SARS-CoV-2 nucleic acid amplification test results — Increasing Community Access to Testing program, United States, July 4, 2022–February 5, 2023

Characteristic	No. (column %)			
	Moderna analyses*		Pfizer-BioNTech analyses†	
	SARS-CoV-2 test result		SARS-CoV-2 test result	
	Positive (case-patients) (n = 9,807)	Negative (control-patients) (n = 27,203)	Positive (case-patients) (n = 6,517)	Negative (control-patients) (n = 17,577)
Age group, yrs				
3	2,609 (27)	7,052 (26)	2,636 (40)	7,022 (40)
4	3,837 (39)	10,449 (38)	3,881 (60)	10,555 (60)
5	3,361 (34)	9,702 (36)	NA	NA
Gender				
Female	4,950 (50)	13,863 (51)	3,260 (50)	8,914 (51)
Male	4,817 (49)	13,162 (48)	3,230 (50)	8,550 (49)
Other	40 (0.4)	178 (1)	27 (0.4)	113 (1)
Race and ethnicity§				
Black or African American, NH	2,075 (21)	5,167 (19)	1,352 (21)	3,373 (19)
Hispanic or Latino	2,960 (30)	7,140 (26)	1,965 (30)	4,492 (26)
White, NH	2,519 (26)	8,414 (31)	1,605 (25)	5,411 (31)
Other, NH	1,526 (16)	4,239 (16)	1,107 (17)	2,842 (16)
Unknown	727 (7)	2,243 (8)	488 (7)	1,459 (8)
HHS testing site region¶				
Region 1	393 (4)	1,703 (6)	266 (4)	1,173 (7)
Region 2	631 (6)	2,360 (9)	458 (7)	1,606 (9)
Region 3	685 (7)	2,106 (8)	473 (7)	1,439 (8)
Region 4	2,718 (28)	7,469 (27)	1,753 (27)	4,654 (26)
Region 5	1,369 (14)	4,264 (16)	921 (14)	2,735 (16)
Region 6	2,084 (21)	4,297 (16)	1,343 (21)	2,774 (16)
Region 7	225 (2)	621 (2)	141 (2)	422 (2)
Region 8	118 (1)	316 (1)	77 (1)	203 (1)
Region 9	1,489 (15)	3,678 (14)	1,023 (16)	2,325 (13)
Region 10	95 (1)	389 (1)	62 (1)	246 (1)
SVI, mean (SD)**	0.6 (0.3)	0.5 (0.3)	0.6 (0.3)	0.5 (0.3)

See table footnotes on the next page.

completing the primary series; those who are eligible should receive a bivalent vaccine dose.

In this analysis, 1 dose of monovalent Moderna vaccine provided detectable protection against symptomatic infection in children aged 3–5 years; however, the point estimate only reflects the short period from 2 weeks after dose 1 to receipt of dose 2 (in the 2 weeks–1 month after the dose). Significant protection was not observed in the 2 weeks–1 month period after a single monovalent Pfizer-BioNTech vaccine dose. However, 2 Pfizer-BioNTech doses (which is an incomplete primary series for this age group) provided detectable protection against symptomatic infection, indicating that children who are awaiting their third dose had protection against symptomatic infection, but this VE is only reflective of protection provided during the interval between dose 2 and 3. In the Pfizer-BioNTech clinical trial, the prespecified immunobridging criteria were met after dose 3 but not after dose 2 among children aged 2–5 years (*3*). Receipt of a complete COVID-19 vaccination primary series is important to optimize vaccine-conferred protection in young children (*1*,*6*).

Several studies have demonstrated that monovalent mRNA VE wanes among older children and adults, particularly during Omicron variant predominance (*4*,*5*). The current analysis suggests that waning of complete monovalent Moderna primary series VE against symptomatic infection might occur among children aged 3–5 years by 3–4 months after the second dose based on point estimates (although CIs overlapped), similar to patterns seen in older children and adults in the first months after vaccination. Waning of monovalent Pfizer-BioNTech VE could not be assessed but is also likely based on analyses in older children and adults (*4*,*5*). Bivalent vaccines were introduced to address reduced VE against Omicron variants and waning protection (*9*). As of December 9, 2022, children aged 6 months–4 years receiving a Pfizer-BioNTech primary series are recommended to receive a monovalent vaccine for doses 1 and 2 and a bivalent vaccine as dose 3, and children aged 6 months–5 years who received the 2-dose Moderna primary series are recommended to receive a bivalent booster dose ≥2 months after completion of the primary series (*6*). Bivalent vaccines provide additional protection against infection and hospitalization in adults who have previously received monovalent COVID-19 vaccines (*7*,*8*); benefits in children are expected to be similar.

TABLE 1. (*Continued*) Characteristics of children aged 3–5 years with symptoms of COVID-19–like illness and SARS-CoV-2 nucleic acid amplification test results — Increasing Community Access to Testing program, United States, July 4, 2022–February 5, 2023

Characteristic	No. (column %)			
	Moderna analyses*		Pfizer-BioNTech analyses†	
	SARS-CoV-2 test result		SARS-CoV-2 test result	
	Positive (case-patients) (n = 9,807)	Negative (control-patients) (n = 27,203)	Positive (case-patients) (n = 6,517)	Negative (control-patients) (n = 17,577)
Period				
Jul 4–Jul 31, 2022	3,885 (40)	6,330 (23)	2,626 (40)	4,253 (24)
Aug 1–Sep 18, 2022	3,839 (39)	9,588 (35)	2,501 (38)	6,198 (35)
Sep 19–Nov 30, 2022	1,083 (11)	7,500 (28)	765 (12)	4,805 (27)
Dec 1, 2022–Feb 5, 2023	1,000 (10)	3,785 (14)	625 (10)	2,321 (13)
Caregiver-reported history of SARS-CoV-2 positive test result for child				
None	8,662 (88)	21,120 (78)	5,788 (89)	13,794 (78)
Positive >90 days before current test	1,145 (12)	6,083 (22)	729 (11)	3,783 (22)
SARS-CoV-2 test type				
Rapid NAAT††	3,430 (35)	9,583 (35)	2,119 (33)	5,877 (33)
Laboratory-based NAAT§§	6,377 (65)	17,620 (65)	4,398 (67)	11,700 (67)
Caregiver-reported one or more chronic underlying conditions for child¶¶				
No	9,551 (97)	26,501 (97)	6,354 (97)	17,139 (98)
Yes	256 (3)	702 (3)	163 (3)	438 (2)
Vaccination status* **				
Unvaccinated	9,523 (97)	25,459 (94)	6,212 (95)	16,111 (92)
1 dose Moderna	107 (1)	402 (1)	NA	NA
2 doses Moderna	177 (2)	1,342 (5)	NA	NA
1 dose Pfizer-BioNTech	NA	NA	114 (2)	329 (2)
2 doses Pfizer-BioNTech	NA	NA	137 (2)	796 (5)
3 doses Pfizer-BioNTech	NA	NA	54 (1)	341 (2)

Abbreviations: HHS = U.S. Department of Health and Human Services; ICATT = Increasing Community Access to Testing; NA = not applicable; NAAT = nucleic acid amplification test; NH = non-Hispanic; SVI = Social Vulnerability Index; VE = vaccine effectiveness.

* Children who received Pfizer-BioNTech COVID-19 vaccine were excluded from the Moderna VE analyses.

† Children who received Moderna COVID-19 vaccine were excluded from the Pfizer-BioNTech VE analyses.

§ Children whose caregiver reported NH ethnicity and any of the following for race were classified as Other, NH: American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, or other race, or whose caregiver reported not Hispanic or Latino with no corresponding race chosen. Children whose caregiver did not report race and ethnicity were classified as unknown.

¶ Regions are defined by HHS and include only states, territories, and freely associated states with ICATT sites. U.S. Virgin Islands (Region 2) and Federated States of Micronesia, Guam, Marshall Islands, Northern Mariana Islands, Palau, and American Samoa (Region 9) were not included because they did not have pharmacies participating in ICATT. https://www.hhs.gov/about/agencies/iea/regional-offices/index.html

** SVI is a tool that uses U.S. Census Bureau data on 16 social factors to rank vulnerability by U.S. Census Bureau tract. The scale is from 0 to 1; higher SVIs represent more vulnerable communities. Tests with missing SVI data (<1% of total) were excluded from all analyses. Data in this study use 2020 SVI. https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html

†† Rapid NAAT was performed on-site on self-collected nasal swabs using ID Now (Abbott Diagnostics Scarborough, Inc.) and Accula (Thermo Fisher Scientific).

§§ Laboratory-based NAAT was performed on self-collected nasal swabs at contracted laboratories using a variety of testing platforms.

¶¶ Underlying conditions included on the questionnaire were heart conditions, high blood pressure, overweight or obesity, diabetes, current or former smoker, kidney failure or end stage renal disease, cirrhosis of the liver, and chronic lung disease (e.g., chronic obstructive pulmonary disease, moderate to severe asthma, cystic fibrosis, or pulmonary embolism). The questionnaire also included immunocompromising conditions; examples provided include immunocompromising medications, solid organ or blood stem cell transplant, HIV, or other immunocompromising conditions. Tests from children were excluded if the caregiver reported an immunocompromising condition.

*** Vaccination status categories are mutually exclusive. Percentages reflect column percentages among analytic sample and because exclusion criteria do not reflect vaccine coverage in the population of children seeking testing within ICATT.

The findings in this report are subject to at least seven limitations. First, VE estimates for Moderna and Pfizer-BioNTech are not directly comparable because of different dates of eligibility for completion of the primary series, which might affect product-specific VE estimates. Decreased SARS-CoV-2 circulation during September 19, 2022–February 5, 2023 (when VE for a complete primary series for both products could be assessed), compared with that during August 1–September 18, 2022††††† (when only Moderna complete primary series VE could be assessed) limited statistical power to estimate potential waning of 3-dose Pfizer-BioNTech VE. Second, vaccination coverage in this analysis is low, albeit

††††† https://covid.cdc.gov/covid-data-tracker/#trends_weeklycases_select_00 (Accessed February 10, 2023).

TABLE 2. Monovalent vaccine effectiveness against symptomatic SARS-CoV-2 infection among young children, by vaccine product, number of doses, and time since last dose — Increasing Community Access to Testing program, United States, July 2022–February 2023

Vaccine product, age group, analysis period,* no. of doses (time since last dose)†,§	No. (%) of positive test results	No. (%) of negative test results	VE¶ (95% CI)
Monovalent Moderna COVID-19 vaccine, children aged 3–5 yrs			
1-dose VE analysis, Jul 4, 2022–Feb 5, 2023			
Unvaccinated (Ref)	9,523 (27)	25,459 (73)	Ref
1 dose only (2 wks–1 mo)	107 (21)	402 (79)	40 (26 to 52)
2-dose VE analysis, Aug 1, 2022–Feb 5, 2023			
Unvaccinated (Ref)	5,690 (23)	19,359 (77)	Ref
2 doses			
2 doses (2 wks–2 mos)	81 (10)	735 (90)	60 (49 to 68)
2 doses (3–4 mos)	58 (12)	437 (88)	36 (15 to 52)
2 doses (5–6 mos)**	NA	NA	NA
Monovalent Pfizer-BioNTech COVID-19 vaccine, children aged 3–4 yrs			
1-dose VE analysis, Jul 4, 2022– Feb 5, 2023			
Unvaccinated (Ref)	6,212 (28)	16,111 (72)	Ref
1 dose only (2 wks–1 mo)	114 (26)	329 (74)	19 (–1 to 35)
2-dose VE analysis, Jul 25, 2022–Feb 5, 2023			
Unvaccinated (Ref)	4,298 (25)	13,136 (75)	Ref
2 doses only (2 wks–3 mos)	137 (15)	796 (85)	40 (28 to 50)
3-dose VE analysis, Sep 19, 2022–Feb 5, 2023††			
Unvaccinated (Ref)	1,273 (17)	6,275 (83)	Ref
3 doses only (2 wks–4 mos)	53 (13)	342 (87)	31 (7 to 49)

Abbreviations: NA = not applicable; Ref = referent group; VE = vaccine effectiveness.

* Different analysis periods were used for each vaccine product and dose number. Children became eligible to be included in each analysis 2 weeks after the initial date a child could have received each vaccine product and dose combination: 1 dose of Moderna and Pfizer-BioNTech on July 4, 2022; 2 doses of Pfizer-BioNTech on July 25, 2022; 2 doses of Moderna on August 1, 2022; and 3 doses of Pfizer-BioNTech on September 19, 2022.

† Only month and year of receipt of each vaccine dose were reported from some participating pharmacies; therefore, the number of months between a vaccine dose and testing is a whole number calculated as the difference between the month and year of testing and the month and year of the vaccine dose. Tests from children for whom receipt of a third COVID-19 vaccine dose on or after December 2022 (when bivalent COVID-19 vaccine doses were recommended for this age group) was reported were excluded.

§ For doses received in the same month or the month before SARS-CoV-2 testing, an additional question was asked to ascertain whether the dose was received ≥2 weeks before testing if the most recent vaccination date included only month and year. Only doses received ≥2 weeks before testing were included.

¶ VE = (1 − adjusted odds ratio) x 100. Odds ratios were calculated using multivariable logistic regression, adjusting for single year of age, gender, race, ethnicity, Social Vulnerability Index of the testing location, underlying conditions (presence versus absence), U.S. Department of Health and Human Services region of testing site, pharmacy chain conducting the test, local incidence (cases per 100,000 population by site county in the 7 days before test date), and testing calendar date.

** Moderna 2 dose VE at 5–6 months after receipt of the second dose did not meet precision threshold as CI width >50 percentage points, and thus data are not shown. Among second dose recipients, 165 and 43 children received a second dose of Moderna vaccine 5 months and 6 months before testing, respectively.

†† Pfizer-BioNTech 3-dose VE estimates did not have sufficient power to stratify by time since vaccination.

Summary

What is already known about this topic?

Since June 2022, COVID-19 primary series vaccination has been recommended for young children with either Moderna for children aged 6 months–5 years or Pfizer-BioNTech for children aged 6 months–4 years; however, postauthorization vaccine effectiveness data are limited.

What is added by this report?

Complete monovalent Moderna and Pfizer-BioNTech primary series vaccination provides protection for children aged 3–5 and 3–4 years, respectively, against symptomatic SARS-CoV-2 infection for at least the first 4 months after vaccination.

What are the implications for public health practice?

Children should stay up to date with COVID-19 vaccines, including completing the primary series; those who are eligible should receive a bivalent vaccine dose. Continued vaccine effectiveness monitoring in young children is needed.

higher than among children aged 2–4 years in the United States overall.§§§§§ Vaccinated children might be systematically different from unvaccinated children in COVID-19 risk or likelihood of seeking SARS-CoV-2 testing, which could bias VE results; thus, these early VE estimates should be considered preliminary. Third, data on hospitalization or severe outcomes are not available in ICATT. Fourth, vaccination status was reported by caregivers and was not verified, which could have resulted in misclassification of vaccination history. Fifth, this analysis reflects VE in children with a high prevalence of pre-vious infection. By November–December 2022, 87% of U.S. children aged 6 months–4 years had evidence of infection-induced SARS-CoV-2 immunity¶¶¶¶¶; however, caregivers reported previous SARS-CoV-2 infection >3 months earlier for only approximately 20% of children in this analysis, and, therefore, the analysis was not adjusted for previous infection. Consequently, vaccine effectiveness in this analysis reflects the current situation among young children in the United States. Sixth, data were not collected on behaviors affecting COVID-19 risk (e.g., child care attendance), which could result in residual confounding. Finally, these VE estimates reflect circulation of a mix of Omicron sublineages.******

Complete monovalent Moderna and Pfizer-BioNTech primary series vaccination provided protection against

§§§§§ https://covid.cdc.gov/covid-data-tracker/#vaccination-demographics-trends (Accessed February 10, 2023).

¶¶¶¶¶ https://covid.cdc.gov/covid-data-tracker/#pediatric-seroprevalence (Accessed February 10, 2023).

****** https://covid.cdc.gov/covid-data-tracker/#variant-proportions (Accessed February 10, 2023).

symptomatic infection in children aged 3–5 and 3–4 years, respectively, for at least the first 4 months after vaccination. CDC will continue to monitor VE in young children. All children should stay up to date with recommended COVID-19 vaccines, including completing the primary series; those who are eligible should receive a bivalent vaccine dose.

Acknowledgment

Stephanie Schrag, CDC.

Corresponding author: Katherine E. Fleming-Dutra, media@cdc.gov.

[1]National Center for Immunization and Respiratory Diseases, CDC; [2]Eagle Health Analytics, San Antonio, Texas; [3]Center for Preparedness and Response, CDC; [4]Epidemic Intelligence Service, CDC.

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

References

1. Fleming-Dutra KE, Wallace M, Moulia DL, et al. Interim recommendations of the Advisory Committee on Immunization Practices for use of Moderna and Pfizer-BioNTech COVID-19 vaccines in children aged 6 months–5 years—United States, June 2022. MMWR Morb Mortal Wkly Rep 2022;71:859–68. PMID:35771731 https://doi.org/10.15585/mmwr.mm7126e2
2. Anderson EJ, Creech CB, Berthaud V, et al.; KidCOVE Study Group. Evaluation of mRNA-1273 vaccine in children 6 months to 5 years of age. N Engl J Med 2022;387:1673–87. PMID:36260859 https://doi.org/10.1056/NEJMoa2209367
3. Food and Drug Administration; Vaccines and Related Biological Products Advisory Committee. FDA briefing document: EUA amendment request for Pfizer-BioNTech COVID-19 vaccine for use in children 6 months through 4 years of age. Presented at the Vaccines and Related Biological Products Advisory Committee meeting, Silver Spring, MD; June 15, 2022. https://www.fda.gov/media/159195/download
4. Accorsi EK, Britton A, Fleming-Dutra KE, et al. Association between 3 doses of mRNA COVID-19 vaccine and symptomatic infection caused by the SARS-CoV-2 Omicron and Delta variants. JAMA 2022;327:639–51. PMID:35060999 https://doi.org/10.1001/jama.2022.0470
5. Fleming-Dutra KE, Britton A, Shang N, et al. Association of prior BNT162b2 COVID-19 vaccination with symptomatic SARS-CoV-2 infection in children and adolescents during Omicron predominance. JAMA 2022;327:2210–9. PMID:35560036 https://doi.org/10.1001/jama.2022.7493
6. CDC. Interim clinical considerations for use of COVID-19 vaccines currently approved or authorized in the United States. Atlanta, GA: US Department of Health and Human Services, CDC, 2023. Accessed January 18, 2023. https://www.cdc.gov/vaccines/covid-19/clinical-considerations/covid-19-vaccines-us.html
7. Link-Gelles R, Ciesla AA, Fleming-Dutra KE, et al. Effectiveness of bivalent mRNA vaccines in preventing symptomatic SARS-CoV-2 infection—Increasing Community Access to Testing Program, United States, September–November 2022. MMWR Morb Mortal Wkly Rep 2022;71:1526–30. PMID:36454688 https://doi.org/10.15585/mmwr.mm7148e1
8. Tenforde MW, Weber ZA, Natarajan K, et al. Early estimates of bivalent mRNA vaccine effectiveness in preventing COVID-19–associated emergency department or urgent care encounters and hospitalizations among immunocompetent adults—VISION Network, nine states, September–November 2022. MMWR Morb Mortal Wkly Rep 2022;71:1616–24. PMID:36580430 https://doi.org/10.15585/mmwr.mm715152e1
9. Rosenblum HG, Wallace M, Godfrey M, et al. Interim recommendations from the Advisory Committee on Immunization Practices for the use of bivalent booster doses of COVID-19 vaccines—United States, October 2022. MMWR Morb Mortal Wkly Rep 2022;71:1436–41. PMID:36355612 https://doi.org/10.15585/mmwr.mm7145a2
10. Thompson MG, Natarajan K, Irving SA, et al. Effectiveness of a third dose of mRNA vaccines against COVID-19–associated emergency department and urgent care encounters and hospitalizations among adults during periods of Delta and Omicron variant predominance—VISION Network, 10 states, August 2021–January 2022. MMWR Morb Mortal Wkly Rep 2022;71:139–45. PMID:35085224 https://doi.org/10.15585/mmwr.mm7104e3

COVID-19 Vaccination Coverage and Demographic Characteristics of Infants and Children Aged 6 Months–4 Years — United States, June 20–December 31, 2022

Bhavini Patel Murthy, MD[1,2]; Hannah E. Fast, MPH[1,2]; Elizabeth Zell, MStat[1,2,3]; Neil Murthy, MD[1,3]; Lu Meng, PhD[2]; Lauren Shaw, MS[1,2]; Tara Vogt, PhD[1,2]; Kevin Chatham-Stephens, MD[2,4]; Tammy A. Santibanez, PhD[1,2]; Lynn Gibbs-Scharf, MPH[1,2]; LaTreace Q. Harris, MPH[1,2]

Although severe COVID-19 illness and hospitalization are more common among older adults, children can also be affected (*1*). More than 3 million cases of COVID-19 had been reported among infants and children aged <5 years (children) as of December 2, 2022 (*2*). One in four children hospitalized with COVID-19 required intensive care; 21.2% of cases of COVID-19–related multisystem inflammatory syndrome in children (MIS-C) occurred among children aged 1–4 years, and 3.2% of MIS-C cases occurred among infants aged <1 year (*1*,*3*). On June 17, 2022, the Food and Drug Administration issued an Emergency Use Authorization (EUA) of the Moderna COVID-19 vaccine for children aged 6 months–5 years and the Pfizer-BioNTech COVID-19 vaccine for children aged 6 months–4 years. To assess COVID-19 vaccination coverage among children aged 6 months–4 years in the United States, coverage with ≥1 dose* and completion of the 2-dose or 3-dose primary vaccination series† were assessed using vaccine administration data for the 50 U.S. states and District of Columbia submitted from June 20 (after COVID-19 vaccine was first authorized for this age group) through December 31, 2022. As of December 31, 2022, ≥1-dose COVID-19 vaccination coverage among children aged 6 months–4 years was 10.1% and was 5.1% for series completion. Coverage with ≥1 dose varied by jurisdiction (range = 2.1% [Mississippi] to 36.1% [District of Columbia]) as did coverage with a completed series (range = 0.7% [Mississippi] to 21.4% [District of Columbia]), respectively. By age group, 9.7 % of children aged 6–23 months and 10.2% of children aged 2–4 years received ≥1 dose; 4.5% of children aged 6–23 months and 5.4% of children aged 2–4 years completed the vaccination series. Among children aged 6 months–4 years, ≥1-dose COVID-19 vaccination coverage was lower in rural counties (3.4%) than in urban counties (10.5%). Among children aged 6 months–4 years who received at least the first dose, only 7.0% were non-Hispanic Black or African American (Black), and 19.9% were Hispanic or Latino (Hispanic), although these demographic groups constitute 13.9% and 25.9% of the population, respectively (*4*). COVID-19 vaccination coverage among children aged 6 months–4 years is substantially lower than that among older children (*5*). Efforts are needed to improve vaccination coverage among children aged 6 months–4 years to reduce COVID-19–associated morbidity and mortality.

Data on COVID-19 vaccine administration in the United States are reported to CDC by jurisdictions, pharmacies, and federal entities through immunization information systems (IISs),§ the Vaccine Administration Management System (VAMS),¶ or through direct data submission.** Children aged 6 months–4 years residing in one of 50 states or the District of Columbia who received ≥1 COVID-19 vaccine dose as of December 31, 2022, and whose data were reported to CDC by February 9, 2023, were included in this analysis.††

Daily and cumulative numbers of children initiating COVID-19 vaccination were calculated. Receipt of ≥1 COVID-19 vaccine dose and series completion among children aged 6 months–4 years were calculated overall and by age group§§ (6–23 months and 2–4 years), sex (male and female), and jurisdiction (50 states and the District of Columbia). Population size by age group and sex were obtained for the 50 states and District of Columbia from the U.S. Census Bureau's 2020 Population Estimates Program (*4*). Vaccination coverage with the first dose and series completion was calculated. Tests for statistical significance were not conducted because these data reflect the U.S. population and were not based on population samples.

* Defined as having received either ≥1 Pfizer-BioNTech or Moderna vaccine dose.
† Defined as receipt of 2 doses of Moderna or 3 doses of Pfizer-BioNTech COVID-19 vaccines.

§ IISs are confidential, computerized, population-based systems that collect and consolidate vaccination data from providers in 64 public health jurisdictions and can be used to track administered vaccines and measure vaccination coverage. The 64 IIS jurisdictions comprise the 50 U.S. states, eight U.S. territories and freely associated states (Puerto Rico, U.S. Virgin Islands, American Samoa, Northern Mariana Islands, Guam, Marshall Islands, Palau, and the Federated States of Micronesia), and six local jurisdictions (Chicago, Illinois; District of Columbia; Houston, Texas; New York, New York; Philadelphia, Pennsylvania; and San Antonio, Texas).
¶ https://www.cdc.gov/vaccines/covid-19/reporting/vams/program-information.html
** https://www.cdc.gov/vaccines/covid-19/reporting/overview/IT-systems.html
†† Providers are required to document vaccination in their medical records within 24 hours of administration and to their jurisdiction's immunization information systems within 72 hours of administration.
§§ Age was calculated based on date of birth provided. However, for nine jurisdictions (Alaska, California, Colorado, Hawaii, Illinois, Massachusetts, North Dakota, Philadelphia, and Virginia) that only report year of birth to CDC, July 1 (i.e., midyear) was used to calculate age, and for five jurisdictions (Arkansas, North Carolina, Oregon, South Carolina, and Vermont) that only report month and year of birth to CDC, the 15th day (i.e., midmonth) was used to calculate age. Persons with age reported as zero years at time of vaccination were assumed to be aged ≥6 months.

Race and ethnicity data were available for 71.4% of children aged 6 months–4 years and were analyzed by the following categories: Black, Hispanic, non-Hispanic American Indian or Alaska Native, non-Hispanic Asian (Asian), non-Hispanic Native Hawaiian or other Pacific Islander, non-Hispanic White (White), and non-Hispanic multiple races or other (multiracial/other). The percentage of children aged 6 months–4 years receiving the first dose of COVID-19 vaccine was calculated by race and ethnicity.

To investigate disparities in vaccination coverage by urban-rural environment, first-dose coverage was also calculated by two- and six-level urban-rural classifications according to the 2013 National Center for Health Statistics (NCHS) urban-rural classification scheme (*6*). To dichotomize counties as urban versus rural, four of these six categories (large central metropolitan, large fringe metropolitan, medium metropolitan, and small metropolitan) were combined and considered urban areas, and two (micropolitan and noncore) were combined and considered as rural areas (*6*). Eight counties in California with <20,000 residents were excluded from the analysis because of data-sharing restrictions on county-level information reported to CDC. All analyses were conducted using SAS software (version 9.4; SAS Institute). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[¶¶]

As of December 31, 2022, a total of 1,755,596 (10.1%) children aged 6 months–4 years had received ≥1 dose of a COVID-19 vaccine (Table), and approximately 39% of these children received the first dose within 1 month of vaccine authorization (Supplementary Figure, https://stacks.cdc.gov/view/cdc/124660). Overall, 5.1% of children in this age group completed the series during the study period (Supplementary Table, https://stacks.cdc.gov/view/cdc/124661). Among those who received their first dose of Pfizer-BioNTech vaccine by September 4, 2022, or of Moderna vaccine by October 23, 2022, approximately 70% had completed the vaccination series.[***] COVID-19 vaccination coverage with ≥1 dose varied by jurisdiction (range = 2.1% [Mississippi] to 36.1% [District of Columbia]), as it did for series completion (0.7% [Mississippi] to 21.4% [District of Columbia]), with lower coverage in the southeastern United States (Figure 1). Coverage was slightly higher among children aged 2–4 years (10.2% for ≥1 dose; 5.4% for series completion) than among those aged 6–23 months (9.7% for ≥1 dose; 4.5% for series completion). Coverage was similar among males and females.

Among vaccinated children aged 6 months–4 years, race and ethnicity were known for 71.4%. Among those with known race and ethnicity who received at least the first dose, 7.0% were Black, and 19.9% were Hispanic, whereas these groups account for 13.9% and 25.9%, respectively, of the U.S. population of children aged 6 months–4 years. In contrast, 55.3% of vaccine recipients were White, and 13.4% were Asian children; these groups account for 48.4% and 5.7% of the U.S. population of children aged 6 months–4 years, respectively (*4*) (Figure 2). Race and ethnicity were unknown or not reported for 501,899 (28.6%) children, either because race and ethnicity had not been recorded (24.5%), was reported as "other" (3.6%), or was not reported (0.5%) because of jurisdictional policy or law (Vermont and eight counties in California).

COVID-19 vaccination coverage with ≥1 dose was lower among children aged 6 months–4 years residing in rural counties (3.4%) than among those residing in urban counties (10.5%), according to the two-level urban-rural classification (Table). The six-level classification indicated that coverage was highest (12.5%) among children residing in large metro areas and declined as areas became more rural, with the lowest coverage (2.7%) among children residing in noncore (i.e., most rural) areas. Overall, coverage in 41 jurisdictions was higher in urban counties, in two jurisdictions (Arizona and Wyoming) was higher in rural counties, and in four jurisdictions (Louisiana, Michigan, Mississippi, and Nevada) coverage was similar (i.e., within two percentage points) in urban and rural counties. Coverage comparisons could not be made for four jurisdictions (Delaware, District of Columbia, New Jersey, and Rhode Island) that have only urban counties.

Discussion

Even after 5 months since COVID-19 vaccines were authorized for children aged 6 months–4 years, coverage with ≥1 dose among this age group substantially lags behind that in older children. Two months after vaccine was approved for children aged 5–11 years and 12–15 years, coverage was 24.0% and 33.3%, respectively, in these age groups (*5*). The low coverage to date in children aged 6 months–4 years is concerning and might indicate challenges to future vaccination coverage, especially given that bivalent booster doses are now authorized for this pediatric population as well.[†††]

Disparities in COVID-19 vaccination coverage that have emerged in the COVID-19 vaccine rollout (*5*) are evident among children aged 6 months–4 years. The lower coverage observed among children residing in rural counties than among those in urban counties is consistent with results from a recent

[¶¶] 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.

[***] Among persons who received their first dose on or before October 15, 2022, for Pfizer-BioNTech (i.e., ≥11 weeks earlier) or December 3, 2022, for Moderna (i.e., ≥4 weeks earlier). This calculation does not include data from Texas because of data sharing restrictions.

[†††] https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-authorizes-updated-bivalent-covid-19-vaccines-children-down-6-months

TABLE. Vaccination coverage among children aged 6 months–4 years who received ≥1 dose* of a COVID-19 vaccination series, by jurisdiction,† sex,§ age group,¶ and urban-rural classification — United States, June 20–December 31, 2022**

	No. vaccinated (%)												
						Urban-rural classification							
		Sex		Age group		Two-level		Six-level					
Jurisdiction	Total	Female	Male	6–23 mos	2–4 yrs	Urban	Rural	Large metro-politan	Large fringe metropolitan	Medium metro-politan	Small metro-politan	Micropolitan	Noncore
United States	**1,755,596 (10.1)**	**858,987 (10.1)**	**889,394 (10.0)**	**547,089 (9.7)**	**1,208,507 (10.2)**	**1,587,826 (10.5)**	**79,527 (3.4)**	**693,265 (12.5)**	**487,550 (11.3)**	**310,526 (8.4)**	**96,485 (6.2)**	**53,737 (3.8)**	**25,790 (2.7)**
Alabama	**8,122 (3.1)**	3,998 (3.1)	4,122 (3.1)	2,621 (3.1)	5,501 (3.1)	7,249 (3.5)	625 (1.1)	2,694 (7.2)	520 (2.0)	2,646 (3.6)	1,389 (2.1)	380 (1.3)	245 (0.8)
Alaska	**4,141 (9.2)**	2,017 (9.3)	2,109 (9.1)	1,420 (9.8)	2,721 (8.9)	3,034 (10.0)	1,081 (7.5)	—	—	2,651 (10.9)	383 (6.3)	304 (14.0)	777 (6.3)
Arizona	**34,356 (8.9)**	16,892 (9.0)	17,438 (8.9)	10,081 (8.1)	24,275 (9.3)	30,561 (8.4)	3,369 (17.0)	16,847 (6.8)	1,006 (4.3)	8,173 (16.2)	4,535 (10.5)	2,168 (15.2)	1,201 (21.5)
Arkansas	**7,254 (4.3)**	3,496 (4.3)	3,636 (4.2)	2,228 (4.1)	5,026 (4.4)	6,367 (5.8)	757 (1.3)	—	23 (0.7)	5,929 (6.9)	415 (2.0)	437 (1.5)	320 (1.1)
California	**267,893 (12.8)**	131,621 (12.9)	136,161 (12.8)	84,860 (12.6)	183,033 (12.9)	264,101 (12.9)	1,937 (5.0)	189,611 (14.8)	43,291 (15.4)	26,119 (6.2)	5,080 (7.3)	1,752 (6.7)	185 (1.5)
Colorado	**51,075 (17.4)**	25,189 (17.5)	25,868 (17.3)	18,076 (19.1)	32,999 (16.6)	48,183 (18.5)	2,634 (8.1)	11,758 (31.7)	23,615 (20.4)	12,072 (13.2)	738 (4.6)	1,771 (9.5)	863 (6.2)
Connecticut	**25,415 (15.6)**	12,449 (15.7)	12,956 (15.6)	7,337 (14.1)	18,078 (16.4)	24,396 (15.7)	838 (12.5)	6,862 (16.0)	2,158 (19.0)	15,376 (15.1)	—	838 (12.5)	—
Delaware	**4,865 (9.9)**	2,392 (9.9)	2,465 (9.8)	1,505 (9.5)	3,360 (10.1)	4,846 (9.8)	—	—	3,735 (13.2)	730 (6.8)	381 (3.8)	—	—
District of Columbia	**14,308 (36.1)**	6,964 (36.2)	7,309 (35.8)	5,445 (40.3)	8,863 (33.9)	14,187 (35.7)	—	14,187 (35.7)	—	—	—	—	—
Florida	**37,146 (3.6)**	18,521 (3.7)	18,592 (3.6)	10,298 (3.1)	26,848 (3.9)	36,578 (3.7)	266 (0.8)	16,812 (4.3)	10,900 (3.7)	8,223 (3.1)	643 (1.4)	165 (0.9)	101 (0.6)
Georgia	**32,055 (5.5)**	15,593 (5.4)	16,356 (5.5)	10,051 (5.3)	22,004 (5.6)	23,907 (4.9)	1,038 (1.1)	5,943 (11.1)	14,457 (5.2)	1,699 (2.5)	1,808 (2.0)	696 (1.2)	342 (0.9)
Hawaii	**8,616 (11.3)**	4,227 (11.5)	4,379 (11.2)	2,738 (11.2)	5,878 (11.4)	7,770 (12.5)	650 (4.7)	—	—	7,269 (13.6)	501 (5.8)	650 (4.7)	—
Idaho	**5,347 (5.2)**	2,561 (5.1)	2,786 (5.3)	1,688 (5.2)	3,659 (5.2)	4,367 (6.3)	931 (2.7)	—	—	3,617 (8.9)	750 (2.6)	758 (2.8)	173 (2.4)
Illinois	**84,131 (12.8)**	41,332 (12.8)	42,754 (12.7)	24,777 (11.7)	59,354 (13.3)	78,905 (13.4)	1,635 (2.3)	44,817 (16.6)	26,266 (12.3)	2,736 (5.6)	5,086 (9.5)	1,122 (2.7)	513 (1.8)
Indiana	**24,119 (6.4)**	11,728 (6.4)	12,364 (6.4)	8,117 (6.7)	16,002 (6.3)	22,338 (7.6)	1,535 (1.9)	5,679 (9.2)	9,570 (8.3)	2,901 (5.1)	4,188 (6.9)	1,117 (2.0)	418 (1.6)
Iowa	**17,473 (10.0)**	8,627 (10.1)	8,840 (10.0)	5,869 (10.5)	11,604 (9.8)	14,660 (13.7)	2,523 (3.8)	—	—	9,300 (12.9)	5,360 (15.2)	1,167 (4.5)	1,356 (3.3)
Kansas	**17,680 (10.7)**	8,693 (10.8)	8,975 (10.6)	5,863 (11.0)	11,817 (10.5)	15,501 (13.7)	1,320 (2.5)	—	11,018 (21.1)	1,643 (4.3)	2,840 (12.3)	922 (2.9)	398 (1.9)
Kentucky	**14,182 (5.8)**	6,932 (5.8)	7,241 (5.8)	4,557 (5.7)	9,625 (5.9)	11,861 (8.1)	2,066 (2.1)	5,080 (11.9)	2,792 (7.4)	3,203 (7.9)	786 (3.1)	1,178 (2.5)	888 (1.7)
Louisiana	**6,961 (2.6)**	3,409 (2.6)	3,548 (2.6)	1,978 (2.3)	4,983 (2.8)	6,472 (2.9)	450 (1.1)	2,171 (11.0)	1,597 (3.2)	2,069 (2.0)	635 (1.2)	350 (1.5)	100 (0.5)
Maine	**11,068 (19.3)**	5,400 (19.3)	5,654 (19.3)	3,831 (20.4)	7,237 (18.8)	8,477 (24.4)	2,421 (10.8)	—	—	7,267 (31.7)	1,210 (10.2)	778 (14.3)	1,643 (9.6)
Maryland	**57,217 (17.7)**	27,798 (17.5)	28,810 (17.5)	18,306 (17.3)	38,911 (17.8)	56,682 (17.9)	276 (4.0)	4,894 (15.4)	50,461 (19.4)	696 (4.3)	631 (6.8)	167 (5.3)	109 (2.9)
Massachusetts	**68,704 (21.6)**	33,917 (21.9)	34,772 (21.4)	17,055 (16.5)	51,649 (24.1)	64,375 (20.5)	506 (12.8)	8,353 (23.3)	45,874 (23.0)	9,252 (13.9)	896 (7.8)	505 (15.5)	1 (0.1)
Michigan	**26,465 (5.2)**	13,069 (5.3)	13,323 (5.2)	133 (0.1)	26,332 (7.7)	11,161 (2.6)	1,059 (1.3)	2,977 (2.1)	4,127 (2.9)	3,067 (3.8)	990 (1.7)	825 (1.5)	234 (0.8)
Minnesota	**55,522 (17.8)**	27,226 (17.8)	28,241 (17.7)	19,113 (19.0)	36,409 (17.2)	50,835 (20.5)	4,313 (6.6)	27,506 (26.6)	15,967 (16.5)	1,935 (18.7)	5,427 (14.7)	2,933 (8.3)	1,380 (4.6)
Mississippi	**3,463 (2.1)**	1,673 (2.1)	1,790 (2.1)	908 (1.7)	2,555 (2.3)	2,113 (2.8)	1,329 (1.5)	—	545 (3.7)	1,336 (2.5)	232 (2.6)	864 (1.7)	465 (1.3)
Missouri	**28,903 (8.7)**	13,991 (8.7)	14,901 (8.8)	9,734 (9.0)	19,169 (8.6)	26,315 (10.5)	921 (1.1)	7,516 (13.3)	15,851 (12.4)	883 (3.2)	2,065 (5.3)	568 (1.5)	353 (0.8)
Montana	**4,655 (8.6)**	2,073 (7.8)	2,198 (7.9)	1,482 (8.7)	3,173 (8.5)	1,804 (9.5)	2,424 (6.9)	—	—	—	1,804 (9.5)	1,477 (9.0)	947 (5.1)
Nebraska	**11,811 (10.2)**	5,780 (10.2)	6,020 (10.1)	3,961 (10.5)	7,850 (10.0)	10,725 (13.7)	1,001 (2.7)	—	—	10,415 (14.7)	310 (4.1)	641 (3.3)	360 (2.0)

See table footnotes on the next page.

TABLE. (*Continued*) Vaccination coverage among children aged 6 months–4 years who received ≥1 dose* of a COVID-19 vaccination series, by jurisdiction,† sex,§ age group,¶ and urban-rural classification — United States, June 20–December 31, 2022**

	No. vaccinated (%)												
		Sex		Age group		Urban-rural classification							
						Two-level		Six-level					
Jurisdiction	Total	Female	Male	6–23 mos	2–4 yrs	Urban	Rural	Large metro-politan	Large fringe metropolitan	Medium metro-politan	Small metro-politan	Micropolitan	Noncore
Nevada	**6,827 (4.1)**	3,355 (4.1)	3,469 (4.1)	1,949 (3.6)	4,878 (4.3)	6,176 (4.0)	291 (2.1)	4,025 (3.2)	—	2,052 (8.4)	99 (3.5)	270 (2.2)	21 (1.3)
New Hampshire	**7,237 (12.7)**	3,533 (12.6)	3,701 (12.7)	2,311 (12.6)	4,926 (12.7)	4,725 (12.5)	1,922 (9.9)	—	2,877 (15.8)	1,848 (9.5)	—	1,730 (9.7)	192 (12.2)
New Jersey	**48,612 (10.5)**	23,892 (10.5)	24,635 (10.4)	13,993 (9.3)	34,619 (11.1)	48,319 (10.4)	—	15,530 (12.9)	28,292 (9.6)	3,821 (10.7)	676 (5.6)	—	—
New Mexico	**13,520 (12.6)**	6,604 (12.5)	6,794 (12.5)	4,071 (11.8)	9,449 (12.9)	9,471 (13.8)	3,927 (10.2)	—	—	6,780 (15.3)	2,691 (11.0)	3,688 (10.7)	239 (6.1)
New York	**112,570 (11.3)**	55,398 (11.4)	56,923 (11.2)	35,138 (10.6)	77,432 (11.6)	107,622 (11.5)	3,541 (5.8)	67,838 (12.6)	25,646 (9.4)	10,039 (11.6)	4,099 (11.0)	2,763 (6.2)	778 (4.5)
North Carolina	**50,533 (9.2)**	24,506 (9.1)	25,430 (9.1)	15,992 (9.0)	34,541 (9.4)	43,206 (9.8)	3,889 (3.6)	19,336 (15.3)	3,086 (4.1)	18,242 (9.9)	2,542 (4.7)	3,203 (4.0)	686 (2.4)
North Dakota	**4,340 (9.1)**	2,152 (9.3)	2,186 (8.8)	1,456 (9.4)	2,884 (8.9)	2,834 (12.2)	1,275 (5.2)	—	—	—	2,834 (12.2)	505 (3.9)	770 (6.5)
Ohio	**59,516 (9.6)**	28,971 (9.6)	30,345 (9.6)	19,917 (9.9)	39,599 (9.5)	54,742 (11.1)	3,154 (2.6)	28,633 (15.0)	12,944 (10.2)	12,629 (8.3)	536 (2.2)	2,785 (2.8)	369 (1.5)
Oklahoma	**9,336 (4.1)**	4,629 (4.1)	4,705 (4.0)	3,003 (4.1)	6,333 (4.1)	7,596 (4.9)	1,441 (1.9)	3,107 (6.1)	1,793 (5.7)	2,522 (3.9)	174 (2.3)	1,121 (2.5)	320 (1.1)
Oregon	**25,919 (13.0)**	12,648 (13.0)	13,252 (12.9)	9,062 (14.3)	16,857 (12.3)	24,242 (14.5)	1,481 (4.5)	8,025 (22.3)	9,898 (17.1)	3,496 (8.7)	2,823 (8.4)	1,255 (4.5)	226 (4.7)
Pennsylvania	**88,733 (14.3)**	41,546 (13.7)	43,419 (13.6)	29,614 (14.7)	59,119 (14.0)	83,219 (14.9)	1,714 (2.7)	31,081 (21.2)	34,219 (19.8)	14,464 (7.8)	3,455 (6.6)	1,248 (2.6)	466 (2.7)
Rhode Island	**7,562 (15.6)**	3,673 (15.4)	3,879 (15.7)	2,524 (16.2)	5,038 (15.3)	7,055 (14.5)	—	3,811 (11.7)	3,244 (20.1)	—	—	—	—
South Carolina	**14,124 (5.4)**	6,922 (5.4)	7,190 (5.3)	4,370 (5.1)	9,754 (5.5)	12,693 (5.6)	554 (1.6)	—	1,049 (4.8)	11,110 (6.2)	534 (2.0)	378 (1.8)	176 (1.2)
South Dakota	**5,212 (9.6)**	2,527 (9.4)	2,667 (9.6)	1,644 (9.3)	3,568 (9.7)	2,966 (11.0)	2,191 (8.0)	—	—	—	2,966 (11.0)	912 (7.1)	1,279 (8.7)
Tennessee	**18,834 (5.1)**	9,337 (5.2)	9,457 (5.0)	6,401 (5.3)	12,433 (5.0)	17,883 (6.1)	816 (1.1)	8,823 (9.0)	4,119 (5.4)	4,220 (4.7)	721 (2.6)	550 (1.2)	266 (0.8)
Texas	**133,499 (7.5)**	65,793 (7.5)	67,682 (7.5)	38,650 (6.8)	94,849 (7.8)	126,925 (7.9)	2,519 (1.5)	62,698 (7.3)	25,166 (7.5)	36,806 (12.1)	2,255 (2.0)	733 (0.8)	1,786 (2.4)
Utah	**24,148 (11.1)**	11,766 (11.1)	12,341 (11.1)	8,485 (11.9)	15,663 (10.7)	23,034 (11.7)	1,057 (5.2)	12,530 (17.2)	348 (6.8)	8,981 (9.0)	1,175 (6.0)	805 (7.0)	252 (2.8)
Vermont	**8,120 (31.7)**	4,051 (32.2)	4,067 (31.3)	2,859 (34.7)	5,261 (30.3)	3,271 (34.4)	2,862 (17.8)	—	—	—	3,271 (34.4)	1,462 (15.3)	1,400 (21.5)
Virginia	**63,435 (14.0)**	30,851 (13.9)	32,567 (14.0)	19,971 (13.5)	43,464 (14.2)	34,814 (8.5)	549 (1.2)	6,350 (8.8)	25,493 (9.5)	629 (2.0)	2,342 (6.3)	77 (0.7)	472 (1.4)
Washington	**75,287 (18.5)**	37,044 (18.7)	38,120 (18.3)	26,749 (20.5)	48,538 (17.6)	72,066 (19.5)	2,471 (6.7)	39,816 (35.1)	19,645 (15.6)	8,148 (10.3)	4,457 (8.7)	1,992 (6.5)	479 (7.4)
West Virginia	**3,251 (3.9)**	1,570 (3.9)	1,613 (3.8)	962 (3.6)	2,289 (4.1)	2,596 (5.0)	611 (2.0)	—	227 (8.5)	737 (4.5)	1,632 (5.0)	332 (2.4)	279 (1.6)
Wisconsin	**39,543 (13.4)**	19,407 (13.5)	20,100 (13.3)	13,177 (13.8)	26,366 (13.2)	34,279 (15.3)	4,465 (6.4)	7,955 (13.9)	5,731 (12.8)	12,795 (24.9)	7,798 (10.9)	2,594 (7.3)	1,871 (5.4)
Wyoming	**1,233 (4.0)**	617 (4.1)	613 (3.9)	350 (3.7)	883 (4.2)	322 (3.2)	892 (4.3)	—	—	—	322 (3.2)	801 (6.3)	91 (1.2)

* Defined as receipt of ≥1 dose of Pfizer-BioNTech or Moderna COVID-19 vaccine on or after June 20, 2022.
† Persons with state of residence reported as "unknown" (1,258) were not included in jurisdiction-specific counts.
§ Persons with sex reported as "unknown" (7,215) were not included in male and female counts.
¶ Persons with age reported as zero years at time of vaccination were assumed to be aged ≥6 months.
** Information on the resident's county of residence was not known or was invalid for 88,243 (5.0%) persons.

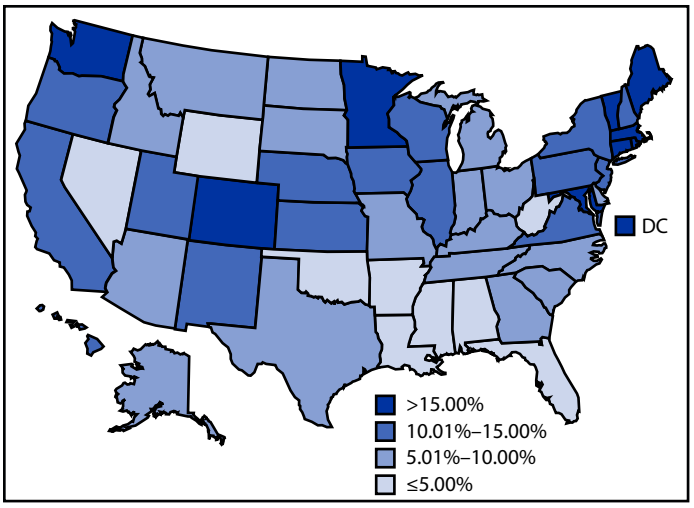
survey which found that 53% of parents of children in rural areas reported that they will "probably or definitely not get their child vaccinated" with COVID-19 vaccines compared with 38% of parents in suburban areas (*7*). However, in Arizona and Wyoming, coverage was higher in rural counties than in urban counties; the reasons for this are not well understood and merit further investigation. Asian and White children were overrepresented among those vaccinated, whereas Black and Hispanic children were underrepresented. Several factors might contribute to these disparities. Black and Hispanic

communities have high rates of poverty (19.5% and 17.0% respectively), compared with White communities (8.2%), which might affect parents' or caregivers' access to vaccination locations, ability to leave work for or travel to vaccination appointments, or access to primary care providers for pediatric vaccination advice (*8*). In a 2022 Kaiser Family Foundation survey published in July 2022, 47% of parents of children aged 6 months–4 years with household incomes ≥$90,000 reported talking to their pediatrician about a COVID-19 vaccine, compared with only 18% of parents with a household income of $40,000–$90,000 and 28% of parents with a household income of <$40,000 (*9*).

In addition, approximately 40% of Hispanic parents reported that they could not get the vaccine from a place they trust, and approximately one third were concerned about having to pay out-of-pocket for their child to get the vaccine compared with only 13% of White parents (*9*). Approximately 40% of Black parents in that survey reported concern about having to take time off from work to take their child to get vaccinated or to take care of them if they had side effects after receiving the vaccine compared with only 18% of White parents (*9*). Having access to a medical home[§§§] and a recommendation from a trusted health care provider can help address parental concerns about COVID-19 vaccine safety and effectiveness and can help improve pediatric COVID-19 vaccination coverage (*5*).

Many factors contribute to vaccine hesitancy among parents of the youngest children, ranging from worries about side effects to confusion about information regarding COVID-19 vaccines from federal health agencies (*9*). According to the Kaiser Family Foundation COVID-19 Vaccine Monitor, parental intention to vaccinate children in this age group has remained low, with more than one half the parents of children aged 2–4 years responding in June 2021 that they will

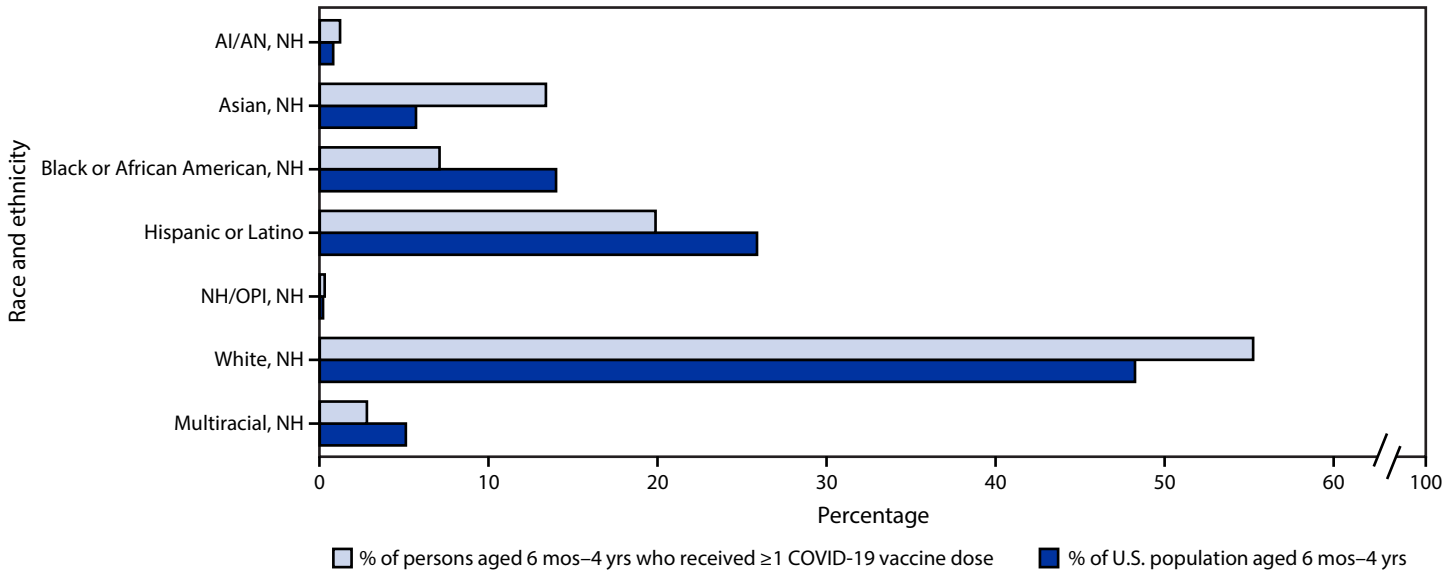
FIGURE 1. Percentage of children aged 6 months–4 years who received ≥1 dose* of a COVID-19 vaccination series, by jurisdiction — United States, June 20–December 31, 2022



Abbreviation: DC = District of Columbia.
* Receipt of ≥1 dose of Pfizer-BioNTech or Moderna COVID-19 vaccine on or after June 20, 2022.

§§§ https://www.aap.org/en/practice-management/medical-home/medical-home-overview/what-is-medical-home

FIGURE 2. Race and ethnicity* of children aged 6 months–4 years who received ≥1 dose of a COVID-19 vaccination series, by racial and ethnic distribution of the U.S. population† aged 6 months–4 years — United States, June 20–December 31, 2022



Abbreviations: AI/AN = American Indian or Alaska Native; NH = non-Hispanic; NH/OPI = Native Hawaiian or other Pacific Islander.
* Race and ethnicity was available for 71.4% of persons.
† The U.S. Census Bureau does not include the category "other" as a race category, although immunization information systems in many jurisdictions might report "other." In this analysis, "other race" was considered unknown, and no comparison with U.S. Census Bureau data was made.

Summary

What is already known about this topic?

Although severe COVID-19 hospitalization and death occur more commonly among adults, young children are also affected.

What is added by this report?

As of December 31, 2022, coverage with ≥1 COVID-19 vaccine dose among young children (those aged 6 months–4 years) was 10.1%, and 5.1% had completed the primary series. Coverage among young children varied by jurisdiction, urbanicity, race, and ethnicity. Five months after the COVID-19 vaccines became available to young children, their vaccination coverage is substantially lower than that in older children.

What are the implications for public health practice?

Enhanced evidence-based practices are needed to decrease barriers to vaccination and increase parental COVID-19 vaccine confidence to improve COVID-19 vaccination coverage among young children to reduce associated morbidity and mortality.

"not vaccinate immediately" (*10*) and more than one half of the parents reporting that they will "definitely not" get their children aged 6 months–4 years vaccinated in September 2022.¶¶¶ Among parents of unvaccinated children aged 6 months–4 years, approximately 80% were concerned about side effects from the vaccine, and 70% were somewhat or very concerned that the vaccine would not keep their child from getting sick (*9*).

The findings in this report are subject to at least five limitations. First, children who received COVID-19 vaccines from different entities that used different methods for submitting data (e.g., if the first dose was given at a pharmacy and the second dose was given at a mass vaccination site) might not have their first and second doses linked, which could have led to underestimation of the percentage of children who completed the vaccination series. Second, if a child inadvertently received a different recipient identification number when receiving their second dose, first and second doses could not be linked. Third, race and ethnicity were unknown for approximately 30% of children aged 6 months–4 years, which could bias the findings. Fourth, the U.S. Census Bureau does not include "other" as a race category; however, many IIS jurisdictions might report race as "other," which could affect the interpretation of proportions for this category. Finally, the CDC's National Center for Health Statistics Urban-Rural Classification was developed in 2013, and counties once classified as rural in 2013 might no longer have been rural in 2022.

¶¶¶ https://www.kff.org/coronavirus-covid-19/dashboard/kff-covid-19-vaccine-monitor-dashboard/; https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-september-2022/

An estimated 3 million COVID-19 cases and more than 500 associated deaths have been reported among children aged <5 years since the start of the COVID-19 pandemic (*1*). Children aged 6 months–4 years are now eligible for COVID-19 vaccination; public health practitioners, health care professionals, child care facility and school administrators, and state and local governments can employ evidence-based practices**** to decrease barriers to vaccination and increase confidence in COVID-19 vaccines, which can help reduce COVID-19–associated morbidity and mortality among the nation's youngest children.

**** https://www.cdc.gov/vaccines/covid-19/planning/children.html

Acknowledgments

COVID-19 Vaccine Task Force; U.S. Department of Defense; immunization program managers, immunization information system managers, and other staff members of the immunization programs in the 64 jurisdictions and five federal entities who provided these data.

Corresponding author: Bhavini Patel Murthy, bmurthy@cdc.gov.

[1]Immunization Services Division, National Center for Immunization and Respiratory Diseases, CDC; [2]CDC COVID-19 Emergency Response Team; [3]Stat-Epi Associates, Inc., Ponte Vedra Beach, Florida; [4]Division of Human Development and Disability, National Center for Birth Defects and Developmental Disabilities, CDC.

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

References

1. Marks KJ, Whitaker M, Agathis NT, et al.; COVID-NET Surveillance Team. Hospitalization of infants and children aged 0–4 years with laboratory-confirmed COVID-19—COVID-NET, 14 states, March 2020–February 2022. MMWR Morb Mortal Wkly Rep 2022;71:429–36. PMID:35298458 https://doi.org/10.15585/mmwr.mm7111e2
2. CDC. COVID data tracker. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. Accessed October 6, 2022. https://covid.cdc.gov/covid-data-tracker/#demographics
3. Miller AD, Zambrano LD, Yousaf AR, et al.; MIS-C Surveillance Authorship Group. Multisystem inflammatory syndrome in children—United States, February 2020–July 2021. Clin Infect Dis 2022;75:e1165–75. PMID:34864955 https://doi.org/10.1093/cid/ciab1007
4. US Census Bureau. Population and housing unit estimates. Washington, DC: US Department of Commerce, US Census Bureau; 2021. Accessed April 7, 2021. https://www.census.gov/programs-surveys/popest.html
5. Murthy NC, Zell E, Fast HE, et al. Disparities in first dose COVID-19 vaccination coverage among children 5–11 years of age, United States. Emerg Infect Dis 2022;28:986–9. PMID:35226801 https://doi.org/10.3201/eid2805.220166
6. Ingram DD, Franco SJ. 2013 NCHS urban–rural classification scheme for counties. Hyattsville, MD: US Department of Health and Human Services, CDC, National Center for Health Statistics; 2014. https://www.cdc.gov/nchs/data/series/sr_02/sr02_166.pdf
7. CDC. For immunization managers: COVID-19 vaccination coverage and vaccine confidence among children. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. https://www.cdc.gov/vaccines/imz-managers/coverage/covidvaxview/interactive/children.html

8. US Census Bureau. Income and poverty in the United States: 2020. Washington, DC: US Department of Commerce, US Census Bureau; 2021. Accessed January 12, 2023. https://www.census.gov/library/publications/2021/demo/p60-273.html
9. Lopes L, Hamel L, Sparks G, Montero A, Presiado M, Brody M. KFF COVID-19 vaccine monitor: July 2022. San Francisco, CA: Kaiser Family Foundation; 2022. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-july-2022/
10. Rane MS, Robertson MM, Westmoreland DA, Teasdale CA, Grov C, Nash D. Intention to vaccinate children against COVID-19 among vaccinated and unvaccinated US parents. JAMA Pediatr 2022;176:201–3. PMID:34870702 https://doi.org/10.1001/jamapediatrics.2021.5153

COVID-19 Bivalent Booster Vaccination Coverage and Intent to Receive Booster Vaccination Among Adolescents and Adults — United States, November–December 2022

Peng-jun Lu, MD, PhD[1]; Tianyi Zhou, MPH[1,2]; Tammy A. Santibanez, PhD[1]; Anurag Jain, MS[1,2]; Carla L. Black, PhD[1]; Anup Srivastav, PhD[1,2]; Mei-Chuan Hung, PhD[1,2]; Jennifer L. Kriss, PhD[1]; Susanne Schorpp, PhD[1,3]; David Yankey, PhD[1]; Natalie Sterrett, MPH[1,4]; Hannah E. Fast, MPH[1]; Hilda Razzaghi, PhD[1]; Laurie D. Elam-Evans, PhD[1]; James A. Singleton, PhD[1]

COVID-19 vaccine booster doses are safe and maintain protection after receipt of a primary vaccination series and reduce the risk for serious COVID-19–related outcomes, including emergency department visits, hospitalization, and death (*1,2*). CDC recommended an updated (bivalent) booster for adolescents aged 12–17 years and adults aged ≥18 years on September 1, 2022 (*3*). The bivalent booster is formulated to protect against the Omicron BA.4 and BA.5 subvariants of SARS-CoV-2 as well as the original (ancestral) strain (*3*). Based on data collected during October 30–December 31, 2022, from the National Immunization Survey–Child COVID Module (NIS-CCM) (*4*), among all adolescents aged 12–17 years who completed a primary series, 18.5% had received a bivalent booster dose, 52.0% had not yet received a bivalent booster but had parents open to booster vaccination for their child, 15.1% had not received a bivalent booster and had parents who were unsure about getting a booster vaccination for their child, and 14.4% had parents who were reluctant to seek booster vaccination for their child. Based on data collected during October 30–December 31, 2022, from the National Immunization Survey–Adult COVID Module (NIS-ACM) (*4*), 27.1% of adults who had completed a COVID-19 primary series had received a bivalent booster, 39.4% had not yet received a bivalent booster but were open to receiving booster vaccination, 12.4% had not yet received a bivalent booster and were unsure about getting a booster vaccination, and 21.1% were reluctant to receive a booster. Adolescents and adults in rural areas had a much lower primary series completion rate and up-to-date vaccination coverage. Bivalent booster coverage was lower among non-Hispanic Black or African American (Black) and Hispanic or Latino (Hispanic) adolescents and adults compared with non-Hispanic White (White) adolescents and adults. Among adults who were open to receiving booster vaccination, 58.9% reported not having received a provider recommendation for booster vaccination, 16.9% had safety concerns, and 4.4% reported difficulty getting a booster vaccine. Among adolescents with parents who were open to getting a booster vaccination for their child, 32.4% had not received a provider recommendation for any COVID-19 vaccination, and 11.8% had parents who reported safety concerns. Although bivalent booster vaccination coverage among adults differed by factors such as income, health insurance status, and social vulnerability index (SVI), these factors were not associated with differences in reluctance to seek booster vaccination. Health care provider recommendations for COVID-19 vaccination; dissemination of information by trusted messengers about the continued risk for COVID-19–related illness and the benefits and safety of bivalent booster vaccination; and reducing barriers to vaccination could improve COVID-19 bivalent booster coverage among adolescents and adults.

NIS-CCM and NIS-ACM data were collected by telephone interview in English, Spanish, or other languages using a random-digit–dialed sample of cellular telephone numbers. Data collected during October 30–December 31, 2022,* were analyzed to assess demographic, behavioral, and social factors associated with COVID-19 primary series vaccination,†,§,¶ bivalent booster receipt,**,††,§§ up-to-date COVID-19 vaccination status,¶¶ and, among adults or their children who had

* Approximates coverage as of November 30, 2022.

† COVID-19 vaccination status was based on responses to the questions, "Have you received at least one dose of a COVID-19 vaccine?," "Which brand of COVID-19 vaccine did you receive for your first dose?," "How many doses of a COVID-19 vaccine have you received?," and "During what month and year did you receive your most recent COVID-19 vaccine?"

§ For adolescents aged 12–17 years, primary series completion was defined as completion of a 2-dose primary COVID-19 vaccine series.

¶ For adults, primary series completion was defined as receipt of a 2-dose primary mRNA or Novavax COVID-19 vaccine series for adults who are not immunocompromised or receipt of a 3-dose mRNA or Novavax COVID-19 vaccine series for adults who reported being immunocompromised. For respondents whose initial vaccine was Janssen (Johnson & Johnson) vaccine, primary series completion was defined as receipt of a single dose primary vaccine for adults who are not immunocompromised or receipt of 2-dose series for adults who reported being immunocompromised.

** For adolescents aged 12–17 years, bivalent booster dose was defined as, since September 1, 2022, the receipt of at least a third dose of COVID-19 vaccine after completion of a 2-dose primary series.

†† For adults, bivalent booster dose was defined as receipt of at least a third dose of COVID-19 vaccine since September 1, 2022, after completion of 2-dose primary mRNA or Novavax vaccine series for adults who are not immunocompromised or at least a fourth dose of the vaccine after completion of a 3-dose mRNA or Novavax vaccine series for adults who reported being immunocompromised.

§§ For adults whose initial vaccine was a Janssen vaccine, bivalent booster dose was defined as the receipt of at least a second dose of COVID-19 vaccine since September 1, 2022, for adults who are not immunocompromised or at least a third dose for adults who reported being immunocompromised.

¶¶ Up-to-date COVID-19 vaccination status was defined as receipt of a primary COVID-19 vaccination series and ≥1 bivalent booster dose or, among those who had not received a bivalent booster, completion of the most recent COVID-19 vaccine dose (the most recent dose could be a primary dose or a monovalent booster dose) <2 months earlier.

not received a bivalent booster dose, intent to receive booster vaccination or to get their child a booster vaccination. Receipt of an updated bivalent booster was not explicitly asked of respondents; however, only bivalent boosters were authorized after September 1, 2022 (*3*). Thus, a booster vaccination received after September 1, 2022, was assumed to be a bivalent booster. The cumulative NIS-CCM and NIS-ACM response rates as of December 2022 were 18.2% and 23.2%, respectively. Bivalent booster dose receipt and intention to receive (or have child receive) a booster dose were assessed among the subset of respondents who had completed the primary COVID-19 vaccination series (*5*) (2,900 [NIS-CCM]; 83,462 [NIS-ACM]). Primary series completion and up-to-date COVID-19 vaccination status were assessed among all adolescents (4,383 [NIS-CCM]) and adults (99,056 [NIS-ACM]).

Primary series completion, up-to-date COVID-19 vaccination status, bivalent booster vaccination status, and intention to receive (or have one's child receive) a booster were stratified by race and ethnicity,*** metropolitan statistical area (MSA),††† SVI,§§§ other demographic characteristics, and behavioral and social drivers of vaccination (*6*). Persons considered open to booster vaccination included those who reported they definitely or probably would get booster vaccination for themselves or their child. Persons considered reluctant to receive booster vaccination included those who reported they probably or definitely would not get a booster for themselves or their child. Data were analyzed using SAS (version 9.4; SAS Institute) and SUDAAN (version 11.0.1; Research Triangle Institute). All percentages were weighted to represent the noninstitutionalized U.S. adolescent or adult population.¶¶¶ T-tests were used to determine differences between groups with $p<0.05$ considered statistically significant. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.****

From interviews conducted during November–December 2022, 58.3% of all adolescents aged 12–17 years had completed a COVID-19 vaccine primary series, and 10.7% were up to date with COVID-19 vaccination (Table 1). Among adolescents who had completed a COVID-19 primary series, 18.5% had received a bivalent booster since September 1, 2022; 52.0% had not received a bivalent booster but had parents who were open to booster vaccination for their child (31.0% definitely would and 21.0% probably would), 15.1% had parents who were unsure about getting a booster vaccination for their child, and 14.4% of adolescents had parents who were reluctant to get a booster vaccination for their child. Up-to-date COVID-19 vaccination status among all adolescents, and bivalent booster coverage among those who had completed the primary series, increased from November (9.2% and 15.7%, respectively) to December (12.3% and 21.3%, respectively). COVID-19 primary series completion was similar among Black and White adolescents and higher among Hispanic and non-Hispanic Asian (Asian) adolescents compared with White adolescents, while bivalent booster coverage was lower among Black (10.2%), Hispanic (14.6%), and non-Hispanic other or multiracial adolescents (14.0%) than among White (22.9%) adolescents. Adolescents who were uninsured and those living in a high SVI county had lower bivalent booster coverage compared with those who were insured and living in lower SVI counties. Reluctance to seek child's booster vaccination was lower among Hispanic compared with White adolescents' parents; however, reluctance to seek booster vaccination did not differ by insurance or SVI status. Adolescents in rural (non-MSA) areas had lower COVID-19 vaccine primary series completion rate and up-to-date coverage than those in MSA principal city areas.

Among adults aged ≥18 years interviewed during November–December 2022, 84.2% had completed a COVID-19 primary series, and 23.2% were up to date with COVID-19 vaccination (Table 2). Among adults who had completed a primary COVID-19 vaccination series, 27.1% had received a bivalent booster, 39.4% had not yet received the bivalent booster but reported being open to booster vaccination (23.1% definitely would and 16.3% probably would), 12.4% were unsure about getting a booster, and 21.1% were reluctant to get a booster. Up-to-date COVID-19 vaccination status among all adults, and bivalent booster coverage among those who had completed a primary series increased from November (21.0% and 24.4%, respectively) to December (25.4% and 29.7%, respectively). Primary COVID-19 vaccination series completion was similar among White, Black, and Hispanic adults and higher among Asian adults than among those of all other races and ethnicities. Bivalent booster dose coverage was lower among Black (21.2%), Hispanic (15.0%), and Asian (25.1%) adults compared with White adults (32.1%). Bivalent booster coverage was higher among adults who had received a provider

*** Those who reported Hispanic ethnicity were classified as Hispanic and could be of any race. For adults, "non-Hispanic other/multiple races" included non-Hispanic adults who reported "other" race or more than one race. For adolescents, "non-Hispanic other/multiple races" included non-Hispanic American Indian or Alaska Native, non-Hispanic Native Hawaiian or other Pacific Islander, and non-Hispanic other or multiple races.

††† Urbanicity status was derived based on the centroid of the zip code of residence, categorized as MSA principal city, MSA nonprincipal city, or non-MSA.

§§§ Categorization into an SVI level was based on respondent-reported zip code of residence. https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

¶¶¶ Survey weights were also calibrated by age and sex to state-level vaccine administration data reported to CDC by jurisdictions as of the middle of the monthly data collection period. https://covid.cdc.gov/covid-data-tracker/ (Accessed November 29, 2022).

**** 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.

recommendation for booster vaccination (34.9%) than among those without a provider recommendation (22.2%). Bivalent booster dose coverage among adults who lived below the poverty level, were uninsured, and who lived in a moderate or high SVI county was lower than coverage among their less economically disadvantaged and lower SVI counterparts, although reluctance to seek bivalent booster vaccination generally did not differ by poverty, insurance, or SVI status. Adults in rural (non-MSA) areas had lower COVID-19 vaccine primary series completion rate and up-to-date coverage than those in MSA principal city areas.

Among all adults who had completed a COVID-19 primary series, 5.2% reported difficulty getting a booster vaccine, with a higher percentage of those open to booster vaccination (4.4%) and unsure about booster vaccination (6.6%) reporting difficulty than did those who were already vaccinated (3.6%) (Table 3). The most common barrier reported was difficulty getting an appointment (5.5% of adults). Overall, among all adults who had completed a COVID-19 vaccine primary series, Black, Hispanic, and non-Hispanic American Indian or Alaska Native adults were more likely to report difficulty getting a booster vaccine, and Black and Hispanic adults were less likely to report confidence about COVID-19 vaccination safety and receipt of provider recommendation for booster vaccination compared with White adults (Supplementary Table 1, https://stacks.cdc.gov/view/cdc/124394). Among adults who were open to or unsure about booster vaccination, 41.1% and 28.7%, respectively, received a provider recommendation for booster vaccination (58.9% and 71.3%, respectively, did not receive a provider recommendation), and 83.1% and 54.5% of adults, respectively, were confident about COVID-19 vaccination safety (16.9% and 45.5%, respectively, had safety concerns) (Table 3). Among adolescents with parents who were open to or unsure about booster vaccination for their children, 67.6% and 54.8% of these parents, respectively, received a provider recommendation for any COVID-19 vaccine for their child (32.4% and 45.2% did not receive a provider recommendation), and 88.2% and 54.4% of these adolescents, respectively, had parents who were confident about COVID-19 vaccination safety for their child (11.8% and 45.6%, respectively, had parents with safety concerns). Adults and parents of adolescents overwhelmingly reported that a COVID-19 vaccine is important (54%–98% across bivalent booster vaccination and booster vaccination intent

TABLE 1. COVID-19 primary vaccine series completion and up-to-date COVID-19 vaccination status* among all adolescents aged 12–17 years and bivalent booster vaccination coverage among those who had completed the primary COVID-19 vaccination series, by demographic and behavioral characteristics — National Immunization Survey–Child COVID Module, United States, October 30–December 31, 2022

		%† (95% CI)		Adolescents who completed primary series of COVID-19 vaccine				
					%† (95% CI)			
						Parental intent to get booster dose for child		
Characteristic	Total no.	Adolescents who completed primary COVID-19 vaccination series	Up to date with COVID-19 vaccination*	No.	Bivalent booster coverage among those with completed primary series	Definitely or probably will	Unsure	Definitely or probably will not
Total	**4,383**	**58.3 (55.7–60.8)**	**10.7 (9.5–12.2)**	**2,900**	**18.5 (16.3–20.9)**	**52.0 (48.8–55.2)**	**15.1 (12.9–17.6)**	**14.4 (12.2–16.9)**
Month of interview								
Nov§	**1,992**	58.2 (54.3–62.0)	9.2 (7.5–11.1)	1,328	15.7 (12.9–19.1)	54.6 (49.6–59.5)	15.4 (12.1–19.4)	14.2 (10.9–18.4)
Dec	**2,391**	58.3 (54.9–61.7)	12.3 (10.4–14.5)¶	1,572	21.3 (18.2–24.8)¶	49.3 (45.3–53.4)	14.9 (12.1–18.1)	14.5 (11.8–17.8)
Age group, yrs								
12–14§	**2,656**	51.8 (48.2–55.4)	10.3 (8.6–12.2)	1,654	19.3 (16.1–22.8)	54.1 (49.4–58.7)	14.3 (11.0–18.4)	12.4 (9.8–15.4)
15–17	**1,727**	64.8 (61.1–68.4)¶	11.2 (9.4–13.4)	1,246	17.9 (14.9–21.2)	50.3 (45.9–54.7)	15.8 (13.0–19.1)	16.1 (12.7–20.1)
Sex								
Female	**2,063**	60.3 (56.6–63.9)	10.9 (9.1–13.1)	1,372	19.2 (16.0–22.8)	50.5 (45.7–55.3)	15.2 (12.0–19.1)	15.1 (11.7–19.1)
Male§	**2,290**	56.3 (52.7–59.8)	10.5 (8.7–12.5)	1,508	17.6 (14.7–20.9)	53.4 (49.1–57.6)	15.2 (12.3–18.6)	13.8 (11.0–17.3)
Race and ethnicity								
Asian, non-Hispanic	**232**	88.3 (79.4–93.7)¶	15.5 (9.5–24.3)	195	18.2 (11.0–28.6)	57.1 (42.5–70.5)	10.7 (5.5–19.9)**	14.0 (6.6–27.3)**
Black or African American, non-Hispanic	**407**	54.2 (46.8–61.6)	5.6 (3.1–10.0)¶	261	10.2 (5.5–18.2)¶,**	52.3 (43.1–61.3)	20.4 (14.2–28.4)	17.1 (11.3–25.0)
Hispanic or Latino	**858**	64.3 (58.1–70.0)¶	8.7 (6.2–12.1)¶	568	14.6 (10.4–20.0)¶	57.3 (50.2–64.1)¶	18.1 (13.5–23.9)	10.0 (6.7–14.7)¶
White,§ non-Hispanic	**2,500**	54.5 (51.2–57.7)	12.4 (10.7–14.5)	1,630	22.9 (19.8–26.4)	47.9 (43.9–51.9)	13.5 (10.9–16.6)	15.7 (12.5–19.6)
Other (including AI/AN) and multiple races, non-Hispanic	**338**	57.4 (47.3–67.0)	10.4 (6.3–16.7)	220	14.0 (8.3–22.6)¶	58.9 (44.3–72.1)	14.8 (5.3–34.8)**	12.3 (6.2–22.8)**
Urbanicity								
MSA, principal city§	**1,319**	63.7 (58.8–68.3)	11.9 (9.5–14.8)	928	18.9 (15.1–23.3)	53.4 (47.6–59.1)	17.0 (13.4–21.3)	10.7 (7.9–14.5)
MSA, nonprincipal city	**2,219**	59.9 (56.3–63.4)	11.1 (9.4–13.1)	1,479	18.8 (16.0–22.1)	51.3 (47.0–55.6)	12.6 (9.8–16.1)	17.3 (13.9–21.3)¶
Non-MSA	**676**	37.4 (31.8–43.4)¶	6.9 (4.4–10.7)¶	347	16.9 (10.9–25.5)	50.8 (41.4–60.2)	23.0 (15.5–32.9)	9.2 (5.6–14.8)

See table footnotes on the next page.

TABLE 1. (*Continued*) COVID-19 primary vaccine series completion and up-to-date COVID-19 vaccination status* among all adolescents aged 12–17 years and bivalent booster vaccination coverage among those who had completed the primary COVID-19 vaccination series, by demographic and behavioral characteristics — National Immunization Survey–Child COVID Module, United States, October 30–December 31, 2022

Characteristic	Total no.	%† (95% CI)		Adolescents who completed primary series of COVID-19 vaccine				
		Adolescents who completed primary COVID-19 vaccination series	Up to date with COVID-19 vaccination*	No.	%† (95% CI)			
					Bivalent booster coverage among those with completed primary series	Parental intent to get booster dose for child		
						Definitely or probably will	Unsure	Definitely or probably will not
SVI of county of residence††								
Low§	**1,589**	61.7 (57.5–65.7)	14.4 (12.0–17.1)	1,101	23.3 (19.6–27.5)	49.5 (44.8–54.2)	12.5 (9.6–16.1)	14.7 (11.4–18.7)
Moderate	**1,477**	59.0 (54.6–63.2)	11.5 (9.3–14.0)	969	19.4 (15.8–23.6)	54.7 (49.4–60.0)	13.1 (10.1–16.8)	12.8 (9.5–17.1)
High	**1,077**	53.8 (48.7–58.8)¶	7.0 (5.1–9.6)¶	653	13.2 (9.5–18.0)¶	51.4 (44.6–58.2)	20.8 (15.6–27.1)¶	14.6 (10.1–20.6)
Household income								
Below poverty level§	**438**	45.6 (37.8–53.6)	8.1 (4.9–13.2)	249	17.6 (10.7–27.7)	48.6 (37.9–59.5)	19.5 (13.1–28.0)	14.2 (6.9–27.0)**
Above poverty level, <$75,000	**953**	47.0 (41.9–52.1)	7.8 (5.5–10.9)	539	14.8 (10.3–20.7)	53.0 (46.0–59.9)	17.5 (13.1–23.1)	14.7 (10.4–20.5)
Above poverty level, ≥$75,000	**2,150**	67.2 (63.5–70.6)¶	14.7 (12.6–17.1)¶	1,551	22.7 (19.5–26.2)	53.2 (48.8–57.6)	10.7 (8.4–13.5)¶	13.4 (10.6–16.8)
Unknown	**842**	62.1 (56.3–67.5)¶	7.2 (5.2–9.9)	561	12.0 (8.6–16.5)	49.7 (42.2–57.2)	21.6 (15.0–30.0)	16.7 (11.8–23.2)
Mother's education level								
High school diploma or less§	**906**	49.0 (43.6–54.4)	7.2 (5.0–10.1)	499	13.9 (9.7–19.5)	53.9 (46.6–61.1)	16.9 (12.5–22.5)	15.3 (10.4–22.0)
Some college	**1,071**	46.7 (42.1–51.4)	6.9 (5.0–9.5)	597	13.4 (9.6–18.5)	52.5 (45.7–59.3)	19.5 (14.1–26.3)	14.6 (10.6–19.8)
College degree or more	**2,327**	73.1 (69.6–76.5)¶	16.2 (14.0–18.6)¶	1,765	23.4 (20.3–26.8)¶	50.8 (46.6–55.0)	12.2 (9.7–15.1)	13.6 (10.8–17.0)
Health insurance								
Medicaid	**1,174**	47.9 (43.2–52.6)	7.5 (5.5–10.1)¶	657	15.2 (11.1–20.5)¶	50.1 (43.5–56.7)	19.8 (14.9–26.0)	14.8 (10.5–20.5)
Other	**2,988**	65.6 (62.5–68.6)¶	13.5 (11.8–15.4)¶	2,120	20.8 (18.2–23.6)¶	52.5 (48.7–56.2)	12.4 (10.2–14.9)	14.4 (11.8–17.4)
Not insured§	**134**	46.2 (33.2–59.9)	0.4 (0.1–1.1)	68	1.0 (0.3–2.8)**	55.0 (34.6–73.9)**	29.8 (14.0–52.5)**	14.3 (5.3–33.1)**
HHS region§§								
Region 1§	**438**	80.1 (73.0–85.6)	23.7 (18.0–30.5)	340	32.1 (24.6–40.6)	44.1 (36.0–52.4)	13.9 (8.6–21.6)	10.0 (5.9–16.3)
Region 2	**414**	66.1 (57.4–73.9)¶	7.0 (4.3–11.3)¶	308	11.9 (7.3–18.7)¶	48.7 (39.7–57.8)	16.1 (10.6–23.9)	23.2 (16.3–32.1)¶
Region 3	**757**	65.2 (60.0–70.1)¶	13.0 (10.2–16.5)¶	543	20.3 (16.1–25.4)¶	56.2 (50.3–61.9)¶	13.0 (9.6–17.4)	10.5 (7.4–14.6)
Region 4	**520**	46.7 (40.8–52.8)¶	6.8 (4.5–10.3)¶	307	13.7 (8.9–20.5)¶	52.2 (44.0–60.2)	16.3 (11.0–23.5)	17.9 (12.2–25.4)
Region 5	**582**	48.0 (42.1–53.9)¶	12.4 (9.3–16.3)¶	385	26.0 (20.0–33.2)	51.1 (43.9–58.3)	13.4 (9.1–19.3)	9.5 (6.3–13.9)
Region 6	**504**	63.8 (58.1–69.2)¶	11.0 (7.6–15.8)¶	284	16.2 (10.9–23.4)¶	52.0 (43.9–60.0)	18.6 (12.9–26.0)	13.2 (8.6–19.7)
Region 7	**210**	48.2 (38.9–57.7)¶	11.7 (7.6–17.7)¶	138	23.8 (15.5–34.6)	55.6 (43.5–67.1)	9.4 (4.6–18.2)**	11.3 (5.0–23.5)**
Region 8	**431**	56.1 (48.7–63.3)¶	15.5 (10.9–21.6)	248	28.5 (20.6–38.0)	49.2 (40.1–58.4)	13.0 (7.6–21.3)	9.3 (5.4–15.5)
Region 9	**347**	66.6 (56.7–75.2)¶	9.9 (6.4–15.2)¶	228	14.6 (9.2–22.5)¶	54.8 (43.2–66.0)	15.1 (8.5–25.3)	15.5 (8.4–26.6)
Region 10	**180**	63.7 (52.5–73.6)¶	9.7 (5.0–18.1)¶,**	119	16.9 (8.7–30.2)¶,**	49.2 (35.6–62.9)	15.1 (7.5–28.1)**	18.8 (10.1–32.4)
Interview language								
English	**4,208**	58.1 (55.5–60.6)	11.0 (9.7–12.5)	2,785	18.9 (16.7–21.4)	51.5 (48.2–54.8)	14.6 (12.3–17.2)	14.9 (12.6–17.6)¶
Other language§	**175**	60.8 (45.0–74.6)**	6.8 (2.9–15.3)**	115	12.3 (5.4–25.7)**	58.4 (44.5–71.2)	22.8 (13.7–35.4)	6.4 (2.5–15.6)**
Received influenza vaccination since July 1, 2022								
Yes	**1,776**	77.0 (72.4–81.0)¶	26.8 (23.6–30.4)¶	1,421	35.4 (31.4–39.5)¶	44.0 (39.8–48.2)¶	11.5 (9.0–14.6)¶	9.2 (6.8–12.3)¶
No§	**2,539**	47.9 (44.7–51.2)	1.8 (1.3–2.5)	1,441	3.5 (2.5–5.0)	59.3 (54.5–63.9)	18.6 (15.2–22.7)	18.6 (15.1–22.7)
Monovalent booster status among adolescents who completed primary series								
Received ≥1 monovalent booster dose	**1,070**	100	26.0 (21.9–30.5)¶	985	27.9 (23.5–32.7)¶	59.0 (53.7–64.1)¶	8.0 (5.7–11.3)¶	5.1 (3.4–7.6)¶
Did not receive any monovalent booster§	**2,002**	100	14.4 (12.1–17.2)	1,915	13.5 (11.2–16.2)	48.3 (44.3–52.3)	18.9 (15.9–22.4)	19.3 (16.2–22.9)

Abbreviations: AI/AN = American Indian or Alaska Native; HHS = U.S. Department of Health and Human Services; MSA = metropolitan statistical area; SVI = social vulnerability index.

* Up-to-date COVID-19 vaccination status was defined as receipt of a primary COVID-19 vaccination series and ≥1 bivalent booster dose or, among those who had not received a bivalent booster, completion of the most recent COVID-19 vaccine dose (the most recent dose could be a primary dose or a monovalent booster dose) <2 months earlier.

† Weighted.

§ Reference level.

¶ p<0.05 by T-test for comparisons of vaccination coverage within each variable with the indicated reference level.

** Proportion was based on sample size of >30 but did not meet National Center for Health Statistics' reliability criteria (sample size [n<30] and/or CI half-width >15 and/or the relative CI width >130%).

†† The CDC and the Agency for Toxic Substances and Disease Registry SVI uses 15 U.S. Census Bureau variables to help officials identify communities that might need support before, during, or after disasters. https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

§§ *Region 1*: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; *Region 2*: New Jersey, New York, and Puerto Rico; *Region 3*: Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and 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*: Arizona, California, Hawaii, and Nevada; *Region 10*: Alaska, Idaho, Oregon, and Washington.

TABLE 2. COVID-19 primary vaccination series completion and up-to-date COVID-19 vaccination status* and bivalent booster vaccination coverage among adults aged ≥18 years who had completed the primary COVID-19 vaccination series, by demographic and behavioral characteristics — National Immunization Survey–Adult COVID Module, United States, October 30–December 31, 2022

		%† (95% CI)		Adults who completed primary series				
					%† (95% CI)			
						Intention to get a booster		
Characteristic	Total no.	Completed primary COVID-19 vaccination series	Up to date with COVID-19 vaccination*	No.	Bivalent booster coverage among those with completed primary series	Definitely or probably will	Unsure	Definitely or probably will not
Total	**99,056**	**84.2 (83.7–84.7)**	**23.2 (22.6–23.8)**	**83,462**	**27.1 (26.4–27.7)**	**39.4 (38.7–40.2)**	**12.4 (11.9–13.0)**	**21.1 (20.4–21.7)**
Month of interview								
Nov§	**40,495**	84.3 (83.6–85.1)	21.0 (20.2–21.9)	34,227	24.4 (23.4–25.4)	41.9 (40.7–43.1)	12.7 (11.9–13.5)	21.0 (20.0–22.0)
Dec	**58,561**	84.1 (83.4–84.8)	25.4 (24.6–26.2)¶	49,235	29.7 (28.8–30.6)¶	36.9 (36.0–37.9)¶	12.2 (11.5–12.9)	21.2 (20.3–22.0)
Age group, yrs								
18–49§	**44,936**	77.5 (76.6–78.3)	14.1 (13.5–14.8)	35,973	17.7 (17.0–18.5)	42.7 (41.6–43.8)	14.1 (13.4–14.9)	25.4 (24.4–26.4)
50–64	**26,919**	88.9 (88.0–89.7)¶	27.2 (26.0–28.5)¶	22,998	30.1 (28.8–31.6)¶	38.5 (37.0–40.1)¶	11.9 (10.9–13.1)¶	19.4 (18.2–20.7)¶
≥65	**25,572**	96.4 (95.7–96.9)¶	42.1 (40.5–43.6)¶	23,276	43.3 (41.7–44.9)¶	34.0 (32.5–35.6)¶	9.0 (8.1–10.0)¶	13.8 (12.7–14.9)¶
Sex								
Female	**51,060**	86.5 (85.8–87.2)¶	25.7 (24.8–26.5)¶	43,914	29.1 (28.2–30.1)¶	39.4 (38.3–40.5)	12.5 (11.8–13.3)	19.0 (18.1–19.8)¶
Male§	**47,031**	82.0 (81.2–82.8)	20.8 (20.0–21.6)	38,869	24.9 (24.0–25.9)	39.5 (38.4–40.6)	12.1 (11.4–12.9)	23.5 (22.5–24.5)
Race and ethnicity								
AI/AN, non-Hispanic	**1,070**	72.2 (65.8–77.9)¶	16.5 (11.8–22.6)¶	748	22.4 (16.2–30.3)¶	39.4 (32.2–47.1)	11.9 (8.2–17.0)	26.2 (20.3–33.1)
Asian, non-Hispanic	**4,871**	97.4 (96.4–98.1)¶	24.8 (21.9–27.9)	4,674	25.1 (22.1–28.2)¶	46.6 (43.1–50.1)¶	14.4 (12.0–17.2)¶	13.9 (11.7–16.4)¶
Black or African American, non-Hispanic	**10,558**	84.7 (83.1–86.2)	18.7 (17.0–20.5)¶	8,954	21.2 (19.2–23.3)¶	44.0 (41.5–46.5)¶	15.2 (13.5–16.9)¶	19.7 (17.7–21.8)
Hispanic or Latino	**12,574**	84.1 (82.7–85.5)	13.2 (12.0–14.5)¶	10,576	15.0 (13.6–16.5)¶	47.5 (45.3–49.7)¶	17.7 (16.0–19.5)¶	19.8 (18.1–21.6)¶
Native Hawaiian or other Pacific Islander, non-Hispanic	**520**	83.2 (74.4–89.4)	17.1 (10.6–26.4)¶	423	20.4 (12.4–31.5)¶	38.9 (27.7–51.5)	21.8 (13.0–34.2)¶	18.9 (7.7–39.5)**
White,§ non-Hispanic	**63,157**	83.8 (83.1–84.5)	27.3 (26.5–28.1)	53,341	32.1 (31.3–33.0)	36.1 (35.2–37.1)	10.0 (9.4–10.6)	21.7 (20.9–22.5)
Other and multiple races, non-Hispanic	**3,396**	77.3 (73.4–80.8)¶	18.5 (15.7–21.7)¶	2,580	23.7 (20.2–27.7)¶	38.2 (33.7–42.9)	11.7 (9.3–14.5)	26.4 (22.5–30.6)¶
Urbanicity								
MSA, principal city§	**36,639**	86.3 (85.4–87.1)	23.9 (22.9–24.9)	31,887	27.0 (25.9–28.2)	40.6 (39.2–42.0)	12.7 (11.7–13.7)	19.7 (18.6–20.9)
MSA, nonprincipal city	**46,994**	85.5 (84.8–86.2)	23.8 (23.0–24.6)	39,884	27.4 (26.5–28.3)	39.5 (38.4–40.5)	12.1 (11.4–12.9)	21.0 (20.2–21.9)
Non-MSA	**15,423**	74.2 (72.6–75.8)¶	19.4 (18.0–20.9)¶	11,691	25.7 (23.9–27.6)	36.1 (34.1–38.1)¶	13.1 (11.7–14.6)	25.2 (23.4–27.0)¶
SVI of county of residence††								
Low§	**29,005**	85.8 (84.8–86.7)	27.5 (26.5–28.6)	25,032	31.6 (30.5–32.8)	37.6 (36.4–38.9)	10.9 (10.0–11.9)	19.8 (18.8–20.9)
Moderate	**32,669**	85.5 (84.7–86.3)	24.6 (23.5–25.6)¶	27,643	28.3 (27.1–29.5)¶	40.1 (38.7–41.4)¶	11.3 (10.4–12.2)	20.4 (19.4–21.6)
High	**27,206**	82.4 (81.4–83.4)¶	20.1 (19.0–21.2)¶	22,756	23.9 (22.7–25.3)¶	41.3 (39.8–42.9)¶	13.1 (12.0–14.2)¶	21.7 (20.4–23.0)¶
Household income								
Below poverty level§	**8,615**	79.1 (77.2–80.9)	14.3 (12.8–16.0)	6,492	16.5 (14.7–18.5)	45.8 (43.1–48.5)	18.4 (16.4–20.5)	19.4 (17.3–21.6)
Above poverty level, <$75,000	**29,539**	83.3 (82.3–84.2)¶	21.7 (20.6–22.8)¶	24,507	25.6 (24.3–26.8)¶	41.7 (40.3–43.1)¶	11.5 (10.6–12.5)¶	21.2 (20.1–22.4)
Above poverty level, ≥$75,000	**40,320**	88.0 (87.2–88.7)¶	28.7 (27.7–29.7)¶	35,913	32.4 (31.3–33.5)¶	37.5 (36.4–38.7)¶	9.6 (8.8–10.5)¶	20.4 (19.5–21.5)
Unknown	**20,582**	81.7 (80.5–82.9)¶	20.6 (19.4–21.8)¶	16,550	24.5 (23.1–26.0)¶	36.7 (35.0–38.4)¶	16.1 (14.9–17.4)	22.7 (21.3–24.2)¶
Education level								
High school diploma or less§	**23,239**	77.2 (76.1–78.3)	15.6 (14.7–16.6)	17,134	19.5 (18.3–20.7)	40.6 (39.1–42.1)	16.4 (15.2–17.5)	23.6 (22.3–24.9)
Some college	**26,185**	84.3 (83.4–85.1)¶	22.2 (21.1–23.4)¶	21,065	26.0 (24.7–27.3)¶	39.7 (38.3–41.2)	11.7 (10.7–12.6)¶	22.6 (21.4–23.8)
College graduate	**46,772**	93.3 (92.8–93.8)¶	34.3 (33.3–35.3)¶	43,121	36.4 (35.3–37.4)¶	38.4 (37.3–39.5)¶	8.4 (7.7–9.0)¶	16.9 (16.1–17.8)¶
Health insurance								
Insured	**89,787**	86.1 (85.6–86.7)¶	25.1 (24.4–25.7)¶	77,084	28.6 (27.9–29.4)¶	39.0 (38.2–39.8)¶	11.7 (11.1–12.2)¶	20.7 (20.1–21.4)
Not insured§	**6,498**	67.2 (64.8–69.5)	7.7 (6.4–9.3)	4,334	10.5 (8.7–12.7)	47.2 (44.1–50.4)	18.9 (16.6–21.4)	23.4 (20.9–26.1)
U.S.-born status								
Non–U.S.-born	**12,947**	90.7 (89.5–91.8)¶	17.8 (16.3–19.3)¶	11,703	19.2 (17.6–20.9)¶	43.9 (41.8–46.1)¶	19.1 (17.4–20.9)¶	17.8 (16.2–19.5)¶
U.S.-born§	**81,491**	83.3 (82.7–83.9)	24.5 (23.8–25.1)	68,273	28.9 (28.2–29.7)	38.8 (37.9–39.6)	10.8 (10.2–11.4)	21.5 (20.8–22.3)

See table footnotes on page 196.

TABLE 2. (*Continued*) COVID-19 primary vaccination series completion and up-to-date COVID-19 vaccination status* and bivalent booster vaccination coverage among adults aged ≥18 years who had completed the primary COVID-19 vaccination series, by demographic and behavioral characteristics — National Immunization Survey–Adult COVID Module, United States, October 30–December 31, 2022

		%† (95% CI)		Adults who completed primary series				
					%† (95% CI)			
						Intention to get a booster		
Characteristic	Total no.	Completed primary COVID-19 vaccination series	Up to date with COVID-19 vaccination*	No.	Bivalent booster coverage among those with completed primary series	Definitely or probably will	Unsure	Definitely or probably will not
HHS region§§								
Region 1§	**9,433**	96.8 (96.1–97.3)	34.8 (33.0–36.7)	8,529	35.4 (33.6–37.3)	36.8 (34.8–38.7)	11.0 (9.7–12.4)	16.8 (15.4–18.5)
Region 2	**9,305**	95.9 (95.2–96.5)	25.0 (23.4–26.7)¶	8,410	25.6 (23.9–27.3)¶	38.1 (36.2–40.1)	13.2 (12.0–14.6)¶	23.1 (21.5–24.8)¶
Region 3	**19,392**	90.5 (89.5–91.3)¶	27.9 (26.6–29.2)¶	16,973	30.2 (28.8–31.6)¶	39.1 (37.5–40.6)	11.4 (10.4–12.5)	19.3 (18.1–20.6)¶
Region 4	**9,440**	79.5 (78.0–81.0)¶	17.3 (15.9–18.9)¶	7,438	21.1 (19.4–23.0)¶	40.5 (38.3–42.7)¶	13.2 (11.8–14.8)¶	25.1 (23.2–27.1)¶
Region 5	**14,124**	76.7 (75.0–78.2)¶	24.9 (23.4–26.4)¶	11,795	32.0 (30.2–34.0)¶	36.7 (34.8–38.6)	12.2 (10.8–13.8)	19.0 (17.5–20.7)
Region 6	**13,313**	78.3 (76.7–79.8)¶	16.7 (15.4–18.0)¶	10,716	20.6 (19.0–22.3)¶	43.3 (41.2–45.5)¶	14.1 (12.7–15.7)¶	21.9 (20.2–23.7)¶
Region 7	**4,221**	77.3 (75.0–79.4)¶	23.7 (21.5–25.9)¶	3,385	29.5 (27.0–32.2)¶	38.7 (36.0–41.4)	10.2 (8.6–12.2)	21.5 (19.4–23.8)¶
Region 8	**6,921**	82.7 (80.9–84.3)¶	23.8 (21.9–25.9)¶	5,340	28.3 (26.0–30.7)¶	38.6 (36.0–41.3)	11.1 (9.5–13.0)	21.9 (19.8–24.2)¶
Region 9	**9,895**	89.8 (88.6–90.9)¶	25.8 (23.9–27.7)¶	8,362	28.5 (26.5–30.6)¶	40.3 (37.9–42.7)¶	12.4 (10.9–14.1)	18.8 (17.0–20.8)
Region 10	**3,012**	85.8 (83.2–88.0)¶	27.0 (24.0–30.2)¶	2,514	31.4 (28.0–35.0)	39.1 (35.5–42.8)	10.4 (8.2–13.2)	19.1 (16.2–22.3)
Interview language								
English	**96,741**	84.3 (83.7–84.8)	23.8 (23.2–24.4)¶	81,638	27.8 (27.1–28.5)¶	39.0 (38.2–39.8)¶	11.7 (11.2–12.3)¶	21.5 (20.8–22.2)¶
Other language§	**2,315**	83.2 (80.1–85.9)	10.2 (8.0–12.9)	1,824	11.0 (8.6–14.0)	49.0 (44.6–53.5)	28.2 (24.3–32.5)	11.8 (9.2–15.0)
Frontline and essential workers aged 18–64 yrs¶¶								
Essential health care	**8,756**	90.3 (88.7–91.6)¶	23.5 (21.7–25.5)¶	7,929	25.4 (23.4–27.5)¶	37.3 (34.8–39.8)	12.0 (10.4–13.8)¶	25.4 (23.2–27.7)¶
School and child care	**2,904**	88.3 (85.0–91.0)¶	24.6 (21.3–28.3)¶	2,624	27.3 (23.7–31.3)¶	44.8 (40.4–49.2)¶	9.9 (8.0–12.2)¶	18.0 (14.9–21.6)¶
Other frontline worker	**4,461**	75.0 (72.4–77.5)	11.8 (10.0–13.7)	3,342	14.7 (12.5–17.1)	40.7 (37.4–44.0)	16.3 (13.6–19.4)	28.3 (25.4–31.5)
Other essential worker§	**8,726**	74.5 (72.6–76.4)	12.6 (11.2–14.1)	6,519	16.6 (14.8–18.6)	38.7 (36.2–41.3)	15.5 (13.7–17.6)	29.1 (26.8–31.6)
Persons who are not essential workers	**46,662**	81.3 (80.5–82.1)¶	18.9 (18.2–19.7)¶	38,363	22.8 (21.9–23.7)¶	42.4 (41.3–43.6)¶	13.1 (12.3–14.0)¶	21.7 (20.7–22.6)¶
Disability* **								
Yes (any)	**10,191**	86.4 (85.0–87.8)¶	23.8 (21.9–25.7)	8,434	26.7 (24.6–28.9)	40.7 (38.4–43.1)	13.6 (11.9–15.4)	19.0 (17.1–21.0)¶
No§	**88,644**	84.0 (83.4–84.5)	23.1 (22.5–23.8)	74,876	27.1 (26.4–27.8)	39.3 (38.5–40.1)	12.3 (11.7–12.9)	21.3 (20.6–22.0)
Received influenza vaccination since July 1, 2022								
Yes	**46,760**	96.2 (95.7–96.6)¶	44.3 (43.3–45.4)¶	44,954	45.7 (44.6–46.8)¶	34.1 (33.1–35.2)¶	8.2 (7.5–8.8)¶	12.0 (11.3–12.8)¶
No§	**51,931**	75.2 (74.4–76.1)	7.4 (6.9–7.9)	38,217	9.2 (8.5–9.8)	44.5 (43.4–45.6)	16.6 (15.7–17.5)	29.8 (28.7–30.8)
Reported medical conditions								
Yes	**32,096**	90.1 (89.3–90.8)¶	32.7 (31.5–33.9)¶	28,645	35.8 (34.5–37.1)¶	40.4 (39.0–41.8)	9.7 (8.8–10.6)¶	14.1 (13.2–15.2)¶
No§	**65,830**	81.6 (80.9–82.3)	18.9 (18.3–19.6)	53,991	22.7 (21.9–23.5)	39.1 (38.1–40.0)	13.6 (13.0–14.3)	24.6 (23.8–25.4)
Provider recommendation of the COVID-19 booster vaccine								
Yes	**35,463**	97.0 (96.5–97.5)¶	34.4 (33.2–35.5)¶	34,627	34.9 (33.8–36.1)¶	42.3 (41.1–43.5)¶	9.3 (8.6–10.1)¶	13.5 (12.7–14.4)¶
No§	**63,593**	77.8 (77.1–78.6)	17.7 (17.0–18.3)	48,835	22.2 (21.4–23.0)	37.7 (36.7–38.6)	14.4 (13.7–15.2)	25.8 (24.9–26.7)

See table footnotes on the next page.

categories). Over one half of adults and parents of adolescents reported that vaccination is important, even among those who were reluctance to seek a booster vaccine.

Discussion

From interviews conducted during November–December 2022, approximately 20% of adolescents aged 12–17 years and approximately 30% of adults who had completed a primary COVID-19 vaccination series had received a bivalent booster dose since it was recommended on September 1, 2022. However, a large percentage of adults and parents of adolescents reported intent to receive booster vaccination for themselves or their children, indicating that booster vaccination coverage could substantially increase with appropriate interventions tailored to these reachable populations.

Reduction in disparities in completion of primary COVID-19 vaccination by race and ethnicity likely contributed to a reduction in the disparities in COVID-19 age-adjusted mortality rates that were observed early in the pandemic (*7*). However, bivalent booster coverage was lower among Black and Hispanic adolescents and adults compared with White adolescents and adults. Tailored and community-led interventions that helped reduce racial and ethnic inequities in primary COVID-19 vaccination could help address reported racial and ethnic differences in barriers to and attitudes toward booster vaccination. These strategies include creating and training a network of local community-trusted messengers to address

TABLE 2. (*Continued*) COVID-19 primary vaccination series completion and up-to-date COVID-19 vaccination status* and bivalent booster vaccination coverage among adults aged ≥18 years who had completed the primary COVID-19 vaccination series, by demographic and behavioral characteristics — National Immunization Survey–Adult COVID Module, United States, October 30–December 31, 2022

		%† (95% CI)		Adults who completed primary series				
					%† (95% CI)			
						Intention to get a booster		
Characteristic	Total no.	Completed primary COVID-19 vaccination series	Up to date with COVID-19 vaccination*	No.	Bivalent booster coverage among those with completed primary series	Definitely or probably will	Unsure	Definitely or probably will not
Monovalent booster status among adults aged 18–49 years who completed primary series								
Received ≥1 monovalent booster dose	**20,699**	100	26.2 (25.0–27.5)¶	20,647	26.3 (25.1–27.6)¶	49.6 (48.0–51.1)¶	11.6 (10.5–12.7)¶	12.6 (11.6–13.6)¶
Received no monovalent booster§	**15,384**	100	9.7 (8.8–10.7)	15,326	8.5 (7.7–9.5)	35.4 (33.8–37.0)	16.9 (15.7–18.1)	39.2 (37.6–40.8)
Monovalent booster status among adults aged ≥50 years who completed primary series								
Received ≥2 monovalent booster doses	**13,036**	100	51.4 (49.2–53.6)¶	13,003	51.5 (49.2–53.7)¶	41.1 (38.9–43.4)¶	4.6 (3.7–5.6)¶	2.9 (2.2–3.7)¶
Received 1 monovalent booster dose	**19,489**	100	40.0 (38.3–41.7)¶	19,420	40.2 (38.5–41.9)¶	37.0 (35.4–38.8)¶	9.7 (8.7–10.8)¶	13.0 (11.8–14.3)¶
Received no monovalent booster§	**13,970**	100	21.9 (20.3–23.7)	13,851	20.2 (18.6–21.9)	31.7 (29.9–33.6)	16.1 (14.6–17.8)	31.9 (30.1–33.8)

Abbreviations: AI/AN = American Indian or Alaska Native; HHS = U.S. Department of Health and Human Services MSA = metropolitan statistical area; SVI = social vulnerability index.

* Up-to-date COVID-19 vaccination status was defined as receipt of a primary COVID-19 vaccination series and ≥1 bivalent booster dose or, among those who had not received a bivalent booster, completion of the most recent COVID-19 vaccine dose (the most recent dose could be a primary dose or a monovalent booster dose) <2 months earlier.

† Weighted.

§ Reference level.

¶ p<0.05 by T-test for comparisons of vaccination coverage within each variable with the indicated reference level.

** Proportion was based on sample size of >30 but did not meet National Center for Health Statistics' reliability criteria (sample size [n<30] and/or CI half-width >15 and/or the relative CI width >130%).

†† The CDC and the Agency for Toxic Substances and Disease Registry SVI uses 15 U.S. Census Bureau variables to help officials identify communities that might need support before, during, or after disasters. https://www.atsdr.cdc.gov/placeandhealth/svi/index.html

§§ *Region 1*: Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont; *Region 2*: New Jersey, New York, and Puerto Rico; *Region 3*: Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and 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*: Arizona, California, Hawaii, and Nevada; *Region 10*: Alaska, Idaho, Oregon, and Washington.

¶¶ Essential worker groups were categorized as essential healthcare personnel (including health care, social service, and death care workers), school and child care (including preschool or child care, K–12 school, and other schools and instructional settings), other frontline (including first response [e.g., police or fire protection], correctional facility, food and beverage store, agriculture, forestry, fishing, or hunting, food manufacturing facility, nonfood manufacturing facility, public transit, and United States Postal Service), other essential (including other essential that are not listed above), and "not a frontline or essential worker" (including those who were not employed).

*** Disability was defined as an affirmative response to the following survey question: "Do you have serious difficulty seeing, hearing, walking, remembering, making decisions, or communicating?"

misinformation and promote accurate, culturally appropriate vaccine messaging; providing vaccination in additional settings such as churches, barbershops, mass vaccination sites, or community sites; and working with culturally competent health care providers to provide a recommendation for bivalent booster vaccination.[††††,§§§§]

Although bivalent booster vaccination coverage among adults differed by factors such as income, health insurance status, and SVI, these factors were not associated with differences in reluctance to seek booster vaccination. This finding suggests the presence of unmeasured structural or access barriers to vaccination, even though only a small percentage of adults who had not received a booster since September 1, 2022, reported difficulties associated with cost of getting a booster vaccine or getting to a vaccination site. Patterns among adolescents were similar, with those who were uninsured and living in high SVI areas having lower booster vaccination coverage, but similar parental reluctance to vaccinate their children compared with those with higher incomes and living in less vulnerable areas. Specific barriers to booster vaccination, such as financial barriers, were not assessed in parents of adolescents.

Findings from this study suggest that provider recommendation for a COVID-19 booster dose has a positive impact on receipt of bivalent booster vaccination. However, among adults who were open to vaccination or adolescents with parents open

†††† COVID-19 vaccine equity for racial and ethnic minority groups. https://www.cdc.gov/coronavirus/2019-ncov/community/health-equity/vaccine-equity.html

§§§§ Partnering for vaccine equity. https://www.cdc.gov/vaccines/health-equity/index.html

TABLE 3. Barriers to receiving COVID-19 booster vaccination among adults and attitudinal and social factors regarding COVID-19 vaccination among adults and adolescents, by bivalent booster vaccination and booster vaccination intent* among those who completed a COVID-19 vaccine primary series — National Immunization Survey–Adult COVID Module and National Immunization Survey–Child COVID Module, United States, October 30–December 31, 2022

Characteristic	%† (95% CI)				
	Overall	Received COVID-19 bivalent booster vaccination	Definitely or probably will get booster	Unsure will get booster	Definitely or probably will not get booster
Adults who completed primary COVID-19 vaccination series					
Total no.	**83,462**	**27,340**	**31,240**	**8,944**	**15,938**
Reported barriers in getting a booster vaccination among adults aged ≥18 years					
Difficulty getting a booster vaccine (very or somewhat difficult)§	**5.2 (4.9–5.6)**	3.6 (3.1–4.2)	4.4 (3.9–4.9)¶	6.6 (5.6–7.8)¶,**	8.2 (7.2–9.2)¶,**
Difficulty getting an appointment	**5.5 (5.1–5.8)**	6.2 (5.5–6.9)	5.7 (5.2–6.3)	6.1 (5.0–7.3)	3.8 (3.1–4.6)¶,**
Difficulty knowing where to get vaccinated	**3.8 (3.5–4.1)**	2.5 (2.1–3.0)	4.0 (3.5–4.4)¶	5.7 (4.7–6.9)¶,**	4.1 (3.4–4.9)¶
Difficulty getting to vaccination sites	**3.0 (2.7–3.3)**	1.8 (1.5–2.2)	3.1 (2.7–3.6)¶	4.4 (3.5–5.5)¶,**	3.4 (2.7–4.4)¶
Vaccination sites not open at convenient times	**3.8 (3.5–4.2)**	2.6 (2.2–3.1)	3.9 (3.5–4.5)¶	5.2 (4.3–6.3)¶,**	4.4 (3.6–5.2)¶
Did not know whether eligible for a booster vaccine	**3.1 (2.8–3.4)**	2.5 (2.1–3.0)	3.5 (3.1–4.0)¶	3.4 (2.7–4.2)	2.8 (2.3–3.5)
Had a reaction to a previous dose of the COVID-19 vaccine	**3.1 (2.9–3.4)**	1.5 (1.2–1.8)	2.1 (1.8–2.4)¶	5.6 (4.5–6.9)¶,**	5.9 (5.0–6.8)¶,**
Difficulty with cost of getting a booster vaccine	**2.8 (2.6–3.1)**	0.8 (0.6–1.1)	3.1 (2.7–3.6)¶	4.3 (3.6–5.2)¶,**	4.0 (3.3–4.8)¶,**
Attitudinal and social factors regarding COVID-19 vaccination among adults aged ≥18 years					
Concerned about getting COVID-19 (very or moderately)††	**42.1 (41.3–42.9)**	56.4 (55.0–57.8)	47.1 (45.9–48.4)¶	34.1 (31.9–36.4)¶,**	19.0 (17.6–20.4)¶,**
Thinks a COVID-19 vaccine is important (very or somewhat)††	**86.7 (86.1–87.2)**	97.6 (97.1–98.0)	96.4 (95.9–96.9)¶	85.4 (83.7–86.9)¶,**	54.4 (52.6–56.1)¶,**
Thinks COVID-19 vaccine is safe (completely or very)††	**71.0 (70.2–71.7)**	87.4 (86.4–88.4)	83.1 (82.1–84.0)¶	54.5 (52.0–56.9)¶,**	33.5 (31.8–35.2)¶,**
Friends and family vaccinated (almost all or many)††	**83.2 (82.6–83.8)**	89.6 (88.6–90.5)	87.2 (86.3–88.0)¶	80.4 (78.5–82.2)¶,**	69.0 (67.3–70.7)¶,**
Provider recommendation of the COVID-19 booster vaccine	**38.4 (37.6–39.1)**	49.5 (48.0–50.9)	41.1 (39.9–42.4)¶	28.7 (26.6–30.8)¶,**	24.6 (23.1–26.1)¶,**
Attitudinal and social factors regarding COVID-19 vaccination among parents of adolescents aged 12–17 years					
Total no.	**2,900**	**591**	**1,536**	**392**	**381**
Concerned about getting COVID-19 vaccine for child (very or moderately)††	**39.5 (36.4–42.7)**	49.7 (43.1–56.3)	43.2 (38.8–47.8)	32.1 (25.3–39.9)¶,**	20.7 (14.6–28.5)¶,**
Thinks a COVID-19 vaccine is important for child (very or somewhat)††	**90.0 (87.9–91.8)**	97.6 (94.2–99.0)	97.2 (95.6–98.2)	83.9 (77.0–88.9)¶,**	60.5 (51.4–68.9)¶,**
Thinks COVID-19 vaccine is safe for child (completely or very)††	**76.7 (73.9–79.2)**	87.1 (82.1–90.9)	88.2 (85.3–90.6)	54.4 (46.4–62.2)¶,**	41.5 (32.5–51.0)¶,**
Friends and family had similar-aged children vaccinated (almost all or many)††	**73.3 (70.3–76.1)**	82.1 (76.1–86.8)	79.0 (75.2–82.3)	61.6 (53.2–69.4)¶,**	53.5 (44.2–62.6)¶,**
Received provider recommendation for the COVID-19 vaccine††	**65.6 (62.4–68.7)**	76.3 (70.2–81.4)	67.6 (63.3–71.7)¶	54.8 (46.0–63.3)¶,**	55.9 (46.6–64.9)¶,**

* For adolescents, booster vaccination intent represents reported parental intent to get a booster vaccine for their child.
† Weighted percentage.
§ Respondents who had received a booster dose were asked, "How difficult was it for you to get a COVID-19 booster vaccine?" Respondents who had not received a booster dose were asked, "How difficult would it be for you to get a COVID-19 vaccine booster?"
¶ p<0.05 by T-test for comparisons with those who received bivalent booster vaccination as the reference level.
** p<0.05 by T-test for comparisons with those who have not received bivalent booster but will definitely or probably get bivalent booster as the reference level.
†† Questions were asked about COVID-19 vaccination generally and not specifically about COVID-19 booster dose vaccination.

to vaccination, more than one half of adults and one in three parents of adolescents did not receive a provider recommendation. Those who were unsure about booster vaccination for themselves or their children, and thus also potentially reachable to be vaccinated, were even less likely to have received a provider recommendation. Safety concerns about vaccination were also prevalent among those open to or unsure about booster vaccination. Provider recommendations to all patients that include culturally appropriate communication about the benefits and safety of booster vaccination and dissemination of information about the safety of vaccine by other trusted messengers could improve COVID-19 vaccination coverage (*8*).

The findings in this report are subject to at least four limitations. First, response rates of the NIS-CCM and NIS-ACM were low (18% and 23%, respectively). Although survey weights were calibrated to COVID-19 vaccine administration data to mitigate possible bias from incomplete sampling frame, nonresponse, and misclassification of vaccination status, bias in estimates might remain after weighting. Second, COVID-19 vaccination was self-reported and might be subject to recall or social desirability bias. Third, respondents were not specifically asked about bivalent boosters, and all boosters received after September 1, 2022, were assumed to be bivalent boosters, which might have overestimated bivalent booster coverage if some persons had received a monovalent booster after September 1, 2022. Finally, the survey sampled noninstitutionalized U.S. adults via mobile telephone; therefore, adults who were incarcerated or nursing home residents might not be represented in the sample.

Summary

What is already known about this topic?

COVID-19 bivalent booster vaccination has been recommended for persons aged ≥12 years since September 1, 2022.

What is added by this report?

Based on interviews conducted during November–December 2022, only 27.1% of adults and 18.5% of adolescents who had completed a COVID-19 primary series received a bivalent booster, and coverage was lower among Black and Hispanic persons. An additional 39.4% of adults were open to booster vaccination, and an additional 52.0% of adolescents had parents who were open to booster vaccination for their children. Those in rural areas had much lower primary series completion rate and up-to-date vaccination coverage.

What are the implications for public health practice?

Health care provider recommendations for booster vaccination, dissemination of information about the safety of vaccine by trusted messengers, and reducing barriers to vaccination could improve COVID-19 booster vaccination coverage.

A large proportion of persons who have completed a primary COVID-19 vaccination series have not received the bivalent booster but are open to vaccination or have parents who are open to getting a booster vaccination for their child. Ongoing monitoring of intent to receive a booster vaccination (or to have one's child vaccinated with the booster vaccine), barriers to vaccination, and differences in bivalent booster vaccination coverage by demographic factors will be helpful for improving and expanding tailored strategies to improve vaccination coverage. To improve coverage, communities should partner with medical providers, schools, and community organizations to administer bivalent booster vaccination onsite or provide a referral for vaccination, reduce barriers to receipt of vaccination, employ trusted messengers to discuss vaccine safety and effectiveness with adults or parents and guardians of adolescents, and emphasize the importance of staying up to date with their COVID-19 vaccination (*9,10*).

Corresponding author: Peng-jun Lu, lhp8@cdc.gov.

[1]Immunization Services Division, National Center for Immunization and Respiratory Diseases, CDC; [2]Leidos Inc., Atlanta, Georgia; [3]Goldbelt C6, Chesapeake, Virginia; [4]Oak Ridge Institute for Science and Education, Oak Ridge, Tennessee.

All authors have completed and submitted the International Committee of Medical Journal Editors form for disclosure of potential conflicts of interest. Laurie D. Elam-Evans is chair of the Epidemiology Section of the American Public Health Association. No other potential conflicts of interest were disclosed.

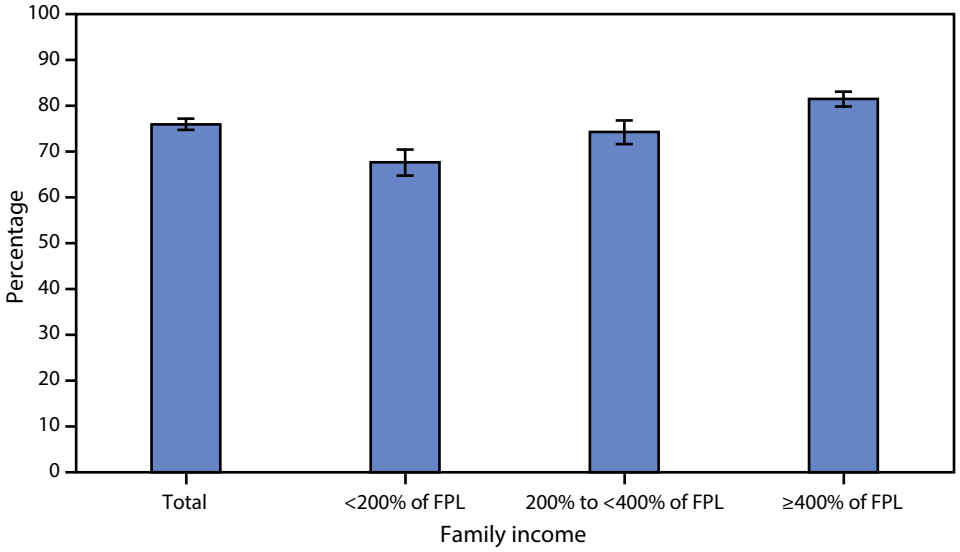
References

1. Thompson MG, Natarajan K, Irving SA, et al. Effectiveness of a third dose of mRNA vaccines against COVID-19–associated emergency department and urgent care encounters and hospitalizations among adults during periods of Delta and Omicron variant predominance—VISION Network, 10 states, August 2021–January 2022. MMWR Morb Mortal Wkly Rep 2022;71:139–45. PMID:35085224 https://doi.org/10.15585/mmwr.mm7104e3
2. Hause AM, Marquez P, Zhang B, et al. Safety monitoring of bivalent COVID-19 mRNA vaccine booster doses among persons aged ≥12 years—United States, August 31–October 23, 2022. MMWR Morb Mortal Wkly Rep 2022;71:1401–06. PMID:36327162 https://doi.org/10.15585/mmwr.mm7144a3
3. CDC. CDC recommends the first updated COVID-19 booster. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. Accessed November 21, 2022. https://www.cdc.gov/media/releases/2022/s0901-covid-19-booster.html
4 CDC. National Immunization Surveys. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. Accessed November 28, 2022. https://www.cdc.gov/vaccines/imz-managers/nis/about.html#current-surveys
5. Mbaeyi S, Oliver SE, Collins JP, et al. The Advisory Committee on Immunization Practices' interim recommendations for additional primary and booster doses of COVID-19 vaccines—United States, 2021. MMWR Morb Mortal Wkly Rep 2021;70:1545–52. PMID:34735422 https://doi.org/10.15585/mmwr.mm7044e2
6. Brewer NT, Chapman GB, Rothman AJ, Leask J, Kempe A. Increasing vaccination: putting psychological science into action. Psychol Sci Public Interest 2017;18:149–207. PMID:29611455 https://doi.org/10.1177/1529100618760521
7. Truman BI, Chang MH, Moonesinghe R. Provisional COVID-19 age-adjusted death rates, by race and ethnicity—United States, 2020–2021. MMWR Morb Mortal Wkly Rep 2022;71:601–5. PMID:35482556 https://doi.org/10.15585/mmwr.mm7117e2
8. Nguyen KH, Yankey D, Lu PJ, et al. Report of health care provider recommendation for COVID-19 vaccination among adults, by recipient COVID-19 vaccination status and attitudes—United States, April–September 2021. MMWR Morb Mortal Wkly Rep 2021;70:1723–30. PMID:34914669 https://doi.org/10.15585/mmwr.mm7050a1
9. CDC. COVID-19 vaccination field guide: 12 strategies for your community. Atlanta, GA: US Department of Health and Human Services, CDC; 2022. Accessed November 10, 2022. https://www.cdc.gov/vaccines/covid-19/vaccinate-with-confidence/community.html
10. Reitsma MB, Goldhaber-Fiebert JD, Salomon JA. Quantifying and benchmarking disparities in COVID-19 vaccination rates by race and ethnicity. JAMA Netw Open 2021;4:e2130343. PMID:34668949 https://doi.org/10.1001/jamanetworkopen.2021.30343

QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Women Aged 50–74 Years Who Had a Mammogram Within the Preceding 2 Years,† by Family Income§ — National Health Interview Survey, United States, 2021¶



Abbreviation: FPL = federal poverty level.
* With 95% CIs indicated by error bars.
† Based on an affirmative response to the question, "Have you ever had a mammogram?" Those who answered "yes" were asked, "About how long has it been since your most recent mammogram?" This question was asked of all women, regardless of history of breast cancer.
§ As a percentage of FPL, which is based on family income and family size, using the U.S. Census Bureau's poverty thresholds. Family income was imputed when missing.
¶ Estimates are based on household interviews of a sample of the civilian, noninstitutionalized U.S. population.

In 2021, 76.0% of women aged 50–74 years reported that they had a mammogram within the preceding 2 years. The percentage of women who had a mammogram within the preceding 2 years increased with family income, from 67.7% of women with family income <200% of FPL, to 74.3% of women with income 200% to <400% of FPL, and 81.5% of those with income ≥400% of FPL.

Source: National Center for Health Statistics, National Health Interview Survey, 2021. https://www.cdc.gov/nchs/nhis/index.htm

Reported by: Nazik Elgaddal, MS, nelgaddal@cdc.gov; Cynthia Reuben, MA.

For more information on this topic, CDC recommends the following link:
https://www.cdc.gov/cancer/dcpc/resources/features/breastcancerawareness/

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

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

ISSN: 0149-2195 (Print)