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National Vaccination Coverage Among Adolescents Aged 13–17 Years — National Immunization Survey-Teen, United States, 2021

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CDC's Advisory Committee on Immunization Practices (ACIP) recommends routine vaccination of persons aged 11–12 years with tetanus, diphtheria, and acellular pertussis vaccine (Tdap), human papillomavirus (HPV) vaccine, and quadrivalent meningococcal conjugate vaccine (MenACWY). A second (booster) dose of MenACWY is recommended at age 16 years. On the basis of shared clinical decision-making, adolescents aged 16–23 years may receive a serogroup B meningococcal vaccine (MenB) series. Catch-up vaccination is recommended for hepatitis A vaccine (HepA); hepatitis B vaccine (HepB); measles, mumps, and rubella vaccine (MMR); and varicella vaccine (VAR) for adolescents whose childhood vaccinations are not up to date (*1*). Although COVID-19 vaccination and influenza vaccination coverage estimates are not presented in this report, vaccination with a COVID-19 vaccine and annual influenza vaccination are also recommended by ACIP for adolescents* (*2*). To estimate vaccination coverage, CDC analyzed data for 18,002 adolescents aged 13–17 years from the 2021 National Immunization Survey-Teen (NIS-Teen).† Coverage with ≥1 dose of Tdap§ (89.6%) and ≥1 dose of MenACWY¶ (89.0%) remained high and stable compared with the previous year. Increases in coverage with the following vaccines occurred from 2020 to 2021: ≥1 dose of HPV** vaccine (from 75.1% to 76.9%); adolescents who were up to date with HPV vaccination (HPV UTD)†† (from

* Influenza vaccination is recommended for all persons aged ≥6 months. Influenza vaccination coverage estimates are available at https://www.cdc.gov/flu/fluvaxview/index.htm. COVID-19 vaccination has been recommended within the scope of the Emergency Use Authorization by ACIP for children and adolescents aged ≥12 years since May 12, 2021. Estimates of COVID-19 vaccination coverage are available at https://covid.cdc.gov/covid-data-tracker/#vaccination-demographics-trends and https://www.cdc.gov/vaccines/imz-managers/coverage/covidvaxview/interactive/children.html.

† Eligible adolescents were born January 2003–January 2009. Estimates in this report include those who might have received on-time or catch-up vaccinations.

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

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

** HPV vaccination coverage includes receipt of any HPV vaccine and does not distinguish between 9-valent, quadrivalent, or bivalent vaccines.

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

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58.6% to 61.7%); and ≥2 MenACWY doses among adolescents aged 17 years (from 54.4% to 60.0%). Coverage with MenACWY, HPV vaccine, and ≥2 HepA doses was lower among adolescents living in nonmetropolitan statistical areas (non-MSAs)[§§] than among those living in MSA principal cities. The potential impact of the COVID-19 pandemic was assessed by comparing vaccination coverage by age and birth year before and during the COVID-19 pandemic. Coverage with ≥1 MenACWY dose by age 13 years was 5.1 percentage points lower among adolescents who reached age 13 years during the pandemic (2021) compared with those who reached age 13 in 2019. Coverage with ≥1 Tdap dose by age 12 years was 4.1 percentage points lower among children who reached age 12 years during the pandemic (2020) compared with those who reached age 12 before the pandemic. Coverage with ≥1 HPV vaccine dose by ages 12 and 13 years among children and adolescents who reached age 12 or 13 during the pandemic did not differ from coverage before the pandemic. Many children and adolescents might have missed routine medical care and recommended vaccinations during the COVID-19 pandemic. Review of patient vaccination records is important for providers to ensure that children and adolescents are up to date with all recommended vaccinations.

NIS-Teen is an annual random-digit–dialed telephone survey[¶¶] that estimates vaccination coverage among adolescents aged 13–17 years in the 50 states, the District of Columbia, selected local areas, and some U.S. territories.[***] Parents and guardians of age-eligible adolescents are interviewed about household sociodemographic characteristics and are asked for permission to contact the adolescent's vaccination providers. Immunization history questionnaires are mailed to vaccination providers with the permission of the parent or guardian to obtain the adolescent's vaccination record. Vaccination coverage estimates are based on provider-reported vaccination histories and include any vaccines administered before the 2021 NIS-Teen interview date. This report presents

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

[¶¶] Persons living in all identified households with a mobile telephone were eligible for interview. Sampling weights were adjusted for single frame (mobile telephone), nonresponse, and noncoverage. A description of NIS-Teen single-frame survey methodology and its effect on reported vaccination estimates is available at https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/pubs-presentations/dual-to-single-frame-teen.html.

[***] Local areas that received federal immunization funds under Section 317 of the Public Health Service Act were sampled separately. Those areas included Chicago, Illinois; New York, New York; Philadelphia County, Pennsylvania; Bexar County, Texas; and Houston, Texas. Three territories were sampled separately in 2021: Guam, Puerto Rico, and U.S. Virgin Islands.

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vaccination coverage estimates for 18,002 adolescents aged 13–17 years.††† The overall Council of American Survey Research Organizations response rate§§§ was 21.0%; 41.2% of adolescents with completed interviews had adequate provider data. Data were weighted and analyzed to account for the complex survey design. T-tests were used to compare differences in vaccination coverage by survey year (2021 versus 2020) and among sociodemographic groups¶¶¶; differences with $p<0.05$ were considered statistically significant. The cumulative percentage of adolescents vaccinated by single year of age milestones was assessed using Kaplan-Meier estimates to account for censoring of vaccination status at ages ≥14 years, stratified by annual birth cohort (2002–2008). To assess potential COVID-19 pandemic effects for ≥1 HPV vaccine, ≥1 MenACWY, and ≥1 Tdap dose, vaccination coverage by age 12 years was compared for children born in 2008 (i.e., those who reached age 12 years in 2020, during the pandemic) to those born in 2007 (i.e., those who reached age 12 years in 2019, before the pandemic); vaccination coverage by age 13 years was compared for adolescents born in 2007 and 2008 (those who reached age 13 years in 2020 and 2021, respectively) to those born in 2006 (those who reached age 13 years in 2019). Analyses were conducted using SAS-callable SUDAAN (version 11; RTI International). This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.****

National Vaccination Coverage

In 2021, 89.6% of adolescents aged 13–17 years had received ≥1 Tdap dose and 89.0% had received ≥1 MenACWY dose (Figure 1) (Table). Coverage with ≥1 HPV vaccine dose in 2021 was 76.9%, an increase of 1.8 percentage points from 2020; 61.7% were HPV UTD, an increase of 3.1 percentage points. Among those aged 17 years, coverage with ≥2 MenACWY doses was 60.0%, an increase of 5.6 percentage points from 2020; coverage with ≥1 MenB dose was 31.4%. Coverage with ≥2 HepA doses was 85.0%, an increase of 2.9 percentage points from 2020. Coverage remained >90% for ≥2 doses of MMR, ≥3 doses of HepB, and both VAR dose among adolescents without a history of varicella disease.††††

Vaccination Coverage by Selected Characteristics

Compared with adolescents living in MSA principal cities, coverage among those in non-MSAs was 9.0 percentage points lower for ≥1 HPV vaccine dose, 8.8 percentage points lower for HPV UTD, 3.0 percentage points lower for ≥1 MenACWY dose, and 6.9 percentage points lower for ≥2 HepA doses. Among adolescents aged 17 years, coverage with ≥2 MenACWY doses was 11.8 percentage points lower for those living in non-MSAs than for those in MSA principal cities. Disparities between non-MSAs and MSA principal cities were statistically significant for adolescents living at or above the poverty level, but not for those living below the poverty level§§§§ (Supplementary Table 1, https://stacks.cdc.gov/view/cdc/120475). Coverage also varied by jurisdiction (Supplementary Table 2, https://stacks.cdc.gov/view/cdc/120476), race and ethnicity,¶¶¶¶ and health insurance status.*****

COVID-19 Pandemic Effects

Coverage with ≥1 HPV vaccine dose was higher at younger ages for adolescents born in more recent years (Figure 2).†††† Coverage with ≥1 HPV vaccine dose by ages 12 and 13 years

††† The 2021 NIS-Teen sample included 8,423 females and 9,579 males. Adolescents from Guam (225), Puerto Rico (350), and U.S. Virgin Islands (245) were excluded from the national estimates.

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

¶¶¶ NIS-Teen methodology for weighting and synthesizing provider-reported vaccination histories has been previously described. https://www.cdc.gov/vaccines/imz-managers/nis/downloads/NIS-TEEN-PUF20-DUG.pdf

**** 45 C.F.R. part 46.102(l)(2); 21 C.F.R. part 56; 42 U.S.C. Sect. 241(d); 5 U.S.C. Sect. 552a; 44 U.S.C. Sect. 3501 et seq.

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

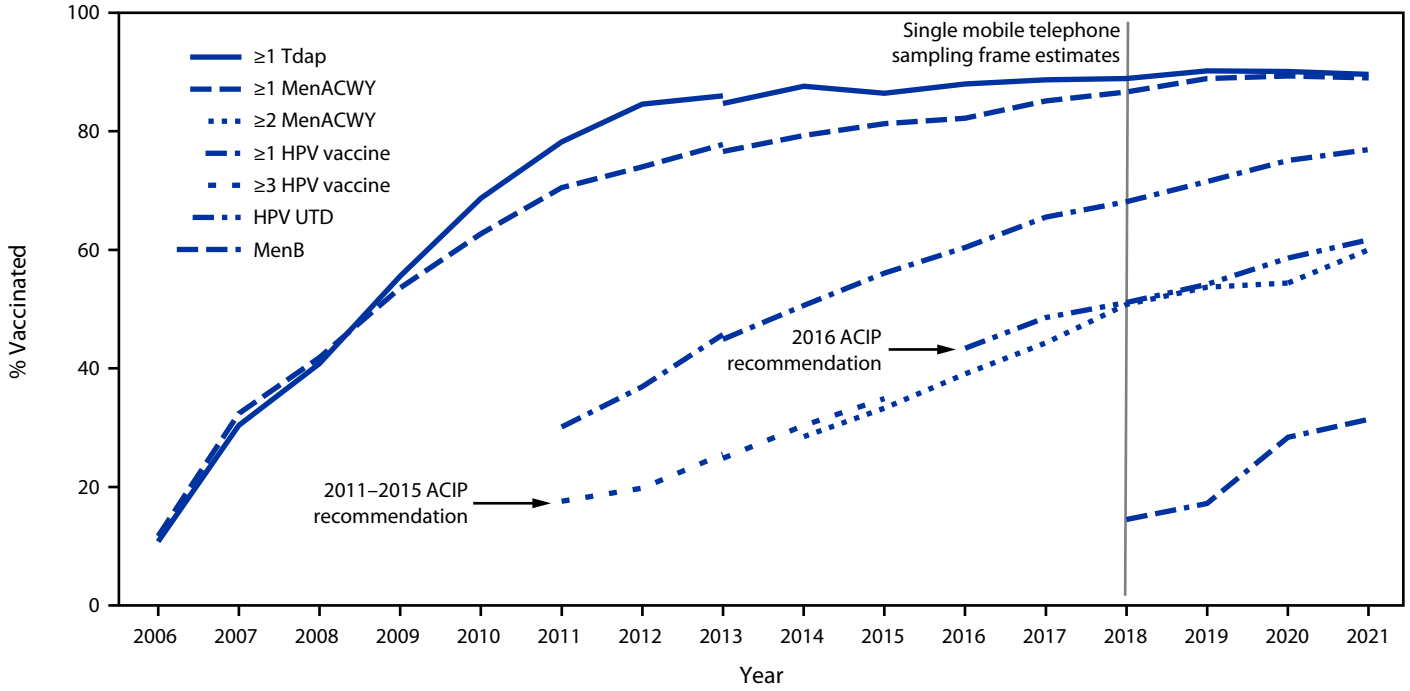
§§§§ Adolescents were classified as being below the federal poverty level if their total family income was less than the level specified for the applicable family size and number of children and adolescents aged <18 years. All others were classified as at or above the poverty level (https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html). Poverty status was unknown for 579 adolescents.

¶¶¶¶ Hispanic or Latino (Hispanic) adolescents had lower coverage with ≥2 MenACWY doses (−10.8 percentage points), and ≥2 MMR doses (−3.6 percentage points) than did non-Hispanic White (White) adolescents. Non-Hispanic Black or African American adolescents had higher coverage with ≥1 HPV vaccine dose (7.1 percentage points) and for proportion HPV UTD (5.0 percentage points) than did White adolescents. Non-Hispanic Asian and non-Hispanic American Indian or Alaska Native (AI/AN) adolescents had higher coverage with most vaccines compared with White adolescents. https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/pubs-presentations/NIS-teen-vac-coverage-estimates-2021-tables.html#table-01

***** Adolescents with any Medicaid insurance had higher coverage with ≥1 HPV vaccine dose (4.6 percentage points) compared with adolescents with private health insurance. Adolescents who were uninsured had lower coverage with ≥1 MenACWY dose, ≥1 HPV vaccine dose, and HPV UTD compared with adolescents with private health insurance. https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/pubs-presentations/NIS-teen-vac-coverage-estimates-2021-tables.html#table-02

††††† NIS-Teen data during 2016–2021 were combined, and Kaplan-Meier methods were used to calculate cumulative vaccination coverage estimates by age in days, stratified by annual birth cohort (2006 = 9,992; 2007 = 5,914; and 2008 = 1,735).

FIGURE 1. Estimated vaccination coverage with selected vaccines and doses*,† among adolescents aged 13–17 years, by survey year — National Immunization Survey-Teen,§,¶ United States, 2006–2021



Abbreviations: ACIP = Advisory Committee on Immunization Practices; APD = adequate provider data definition; HPV = human papillomavirus; HPV UTD = up to date with HPV vaccination; MenACWY = quadrivalent meningococcal conjugate vaccine; MenB = serogroup B meningococcal vaccine; Tdap = tetanus, diphtheria, and acellular pertussis vaccine.

* ≥1 dose Tdap at age ≥10 years; ≥1 dose MenACWY or meningococcal-unknown type vaccine; ≥2 doses MenACWY or meningococcal-unknown type vaccine among adolescents aged 17 years at time of interview. Does not include adolescents who received their first and only dose of MenACWY at age ≥16 years; HPV vaccine includes 9-valent, quadrivalent, or bivalent HPV vaccine. The routine ACIP recommendation for HPV vaccination was made for females in 2006 and for males in 2011. Because HPV vaccination was first recommended for males in 2011, coverage for all adolescents was not measured before that year; HPV UTD includes those with ≥3 doses, and those with 2 doses when the first HPV vaccine dose was initiated at age <15 years and at least 5 months minus 4 days elapsed between the first and second dose.

† ACIP revised the recommended HPV vaccination schedule in late 2016. The schedule changed from a 3-dose to a 2-dose series with appropriate spacing between receipt of the first and second dose for immunocompetent adolescents initiating the series at age <15 years. Three doses are still recommended for persons initiating the series at age ≥15 years. Because of the change in definition, the graph includes estimates for ≥3 doses of HPV vaccine during 2011–2015 and the HPV UTD estimate during 2016–2021. Because HPV vaccination was first recommended for males in 2011, coverage for all adolescents was not measured before that year.

§ NIS-Teen implemented a revised APD in 2014 and retrospectively applied the revised APD to 2013 data. Estimates using different APDs might not be directly comparable.

¶ NIS-Teen moved to a single-sample frame in 2018.

among children and adolescents who reached ages 12 and 13 years during the pandemic was similar to coverage among those who reached these milestone ages before the pandemic (Figure 2). Coverage with ≥1 MenACWY dose by age 13 years among adolescents who reached age 13 years during the pandemic was 5.1 percentage points lower (95% CI = −9.8 to −0.4) than among those who reached age 13 years before the pandemic. Coverage with ≥1 Tdap dose by age 12 years was 4.1 percent points lower (95% CI = −8.1 to −0.1) among children who reached age 12 years during the pandemic than among those who reached age 12 years before the pandemic. Tdap coverage by age 13 years among adolescents who reached age 13 years during the pandemic was not statistically different from coverage among those who reached age 13 years before the pandemic.

Discussion

In 2021, coverage with ≥1 HPV vaccine dose, HPV UTD, and ≥2 HepA doses continued to increase among adolescents aged 13–17 years. Coverage with ≥1 Tdap dose, ≥1 MenACWY dose, ≥2 MMR doses, ≥3 HepB doses, and both doses of VAR among adolescents without a history of varicella disease remained high and stable. Coverage with ≥2 MenACWY doses among adolescents aged 17 years was higher in 2021 than in 2020.

Despite overall progress in vaccination coverage among adolescents, coverage disparities remain, particularly by MSA status. Coverage with MenACWY, HPV vaccine, and ≥2 HepA doses was lower among adolescents living in non-MSAs than among adolescents living in MSA principal cities. These geographic disparities were statistically significant only among

TABLE. Estimated vaccination coverage with selected vaccines and doses among adolescents aged 13–17 years,* by age at interview — National Immunization Survey-Teen, United States, 2021

Vaccine	Age at interview, yrs, % (95% CI)†					Total % (95% CI)†	
	13	14	15	16	17	2021	2020
Total no. of recipients	**3,691**	**3,789**	**3,681**	**3,548**	**3,293**	**18,002**	**20,163**
Tdap§ ≥1 dose	87.4 (85.2–89.4)	90.4 (88.2–92.2)	91.4 (89.6–92.9)¶	88.7 (85.8–91.1)	90.0 (87.5–92.1)	**89.6 (88.6–90.5)**	**90.1 (89.2–90.9)**
MenACWY**							
≥1 dose	85.6 (82.8–88.0)	89.4 (86.4–91.8)¶	90.3 (88.4–91.9)¶	88.4 (85.6–90.8)	91.3 (89.2–93.0)¶	**89.0 (87.9–90.0)**	**89.3 (88.4–90.2)**
≥2 doses††	NA	NA	NA	NA	60.0 (56.6–63.3)	**60.0 (56.6–63.3)§§**	**54.4 (51.2–57.5)**
HPV vaccine¶¶							
All adolescents							
≥1 dose	72.5 (69.5–75.2)	74.1 (70.7–77.3)	79.0 (75.9–81.8)¶	78.9 (75.7–81.8)¶	80.4 (77.7–82.8)¶	**76.9 (75.6–78.2)§§**	**75.1 (73.9–76.2)**
HPV UTD***	49.4 (46.0–52.8)	59.4 (55.8–62.9)¶	66.2 (62.7–69.6)¶	65.8 (62.3–69.2)¶	67.9 (64.8–70.9)¶	**61.7 (60.2–63.2)§§**	**58.6 (57.3–60.0)**
Female							
≥1 dose	73.7 (69.4–77.6)	75.6 (70.7–79.9)	82.4 (78.6–85.7)¶	79.2 (73.8–83.6)	82.3 (78.2–85.7)¶	**78.5 (76.6–80.4)**	**77.1 (75.4–78.7)**
HPV UTD	50.1 (45.3–54.9)	61.5 (56.3–66.4)¶	68.6 (63.6–73.1)¶	69.0 (63.7–73.8)¶	70.6 (65.9–74.9)¶	**63.8 (61.5–65.9)**	**61.4 (59.5–63.3)**
Male							
≥1 dose	71.2 (67.1–75.1)	72.7 (67.8–77.1)	76.0 (71.1–80.3)	78.7 (74.8–82.1)¶	78.6 (75.0–81.9)**	**75.4 (73.5–77.2)**	**73.1 (71.5–74.8)**
HPV UTD	48.7 (43.8–53.7)	57.5 (52.5–62.3)¶	64.2 (59.2–68.9)¶	62.5 (57.6–67.2)¶	65.5 (61.2–69.6)¶	**59.8 (57.6–61.8)§§**	**56.0 (54.1–57.8)**
MenB ≥1 dose†††	NA	NA	NA	NA	31.4 (28.2–34.8)¶	**31.4 (28.2–34.8)**	**28.4 (25.5–31.5)**
MMR ≥2 doses	93.5 (91.5–95.0)	92.7 (90.1–94.6)	91.9 (88.7–94.2)	91.8 (89.8–93.5)	91.3 (89.1–93.2)	**92.2 (91.2–93.2)**	**92.4 (91.6–93.2)**
Hepatitis A vaccine ≥2 doses§§§	88.8 (86.5–90.7)	86.0 (83.0–88.6)	85.5 (82.2–88.3)	84.4 (82.1–86.5)¶	79.7 (76.9–82.3)¶	**85.0 (83.8–86.1)§§**	**82.1 (81.1–83.1)**
Hepatitis B vaccine ≥3 doses	92.9 (90.8–94.5)	93.4 (91.7–94.8)	92.9 (90.5–94.8)	91.0 (88.2–93.2)	91.1 (88.6–93.0)	**92.3 (91.3–93.1)**	**92.6 (91.8–93.3)**
Varicella history/Vaccine doses							
No history, ≥1 dose	96.7 (95.3–97.6)	95.8 (94.2–97.0)	93.6 (90.1–95.9)	94.8 (93.1–96.1)	93.8 (91.5–95.4)¶	**94.9 (94.0–95.7)**	**95.6 (94.9–96.2)**
No history, ≥2 doses	93.3 (91.2–94.9)	91.4 (88.6–93.6)	90.6 (87.2–93.1)	91.9 (90.0–93.4)	90.6 (88.1–92.5)	**91.5 (90.5–92.5)**	**91.9 (91.0–92.7)**
History of varicella¶¶¶	5.5 (4.4–6.9)	8.0 (5.6–11.3)	6.5 (5.2–8.2)	7.8 (6.2–9.7)¶	8.9 (6.9–11.3)¶	**7.3 (6.5–8.2)**	**8.4 (7.6–9.2)**
History of varicella or received ≥2 doses vaccine	93.6 (91.7–95.1)	92.1 (89.4–94.1)	91.2 (88.1–93.6)	92.5 (90.8–93.9)	91.4 (89.2–93.2)	**92.2 (91.2–93.1)**	**92.6 (91.7–93.3)**

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

* Adolescents (18,002) surveyed in the 2021 NIS-Teen were born during January 2003–January 2009.

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

§ Includes percentages receiving Tdap at age ≥10 years.

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

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

†† ≥2 doses of MenACWY or meningococcal-unknown type vaccine. Calculated only among adolescents aged 17 years at time of interview. Does not include adolescents who received 1 MenACWY dose at age ≥16 years.

§§ Statistically significant difference (p<0.05) compared with 2020 NIS-Teen estimates.

¶¶ Includes 9-valent HPV, quadrivalent HPV, or bivalent HPV vaccine. For ≥1 HPV vaccine dose measure and HPV UTD measure, percentages reported were among females and males combined (18,002) and for females only (8,423) and males only (9,579).

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

††† ≥1 dose of MenB; calculated only among adolescents aged 17 years at time of interview. Administered on the basis of individual clinical decision.

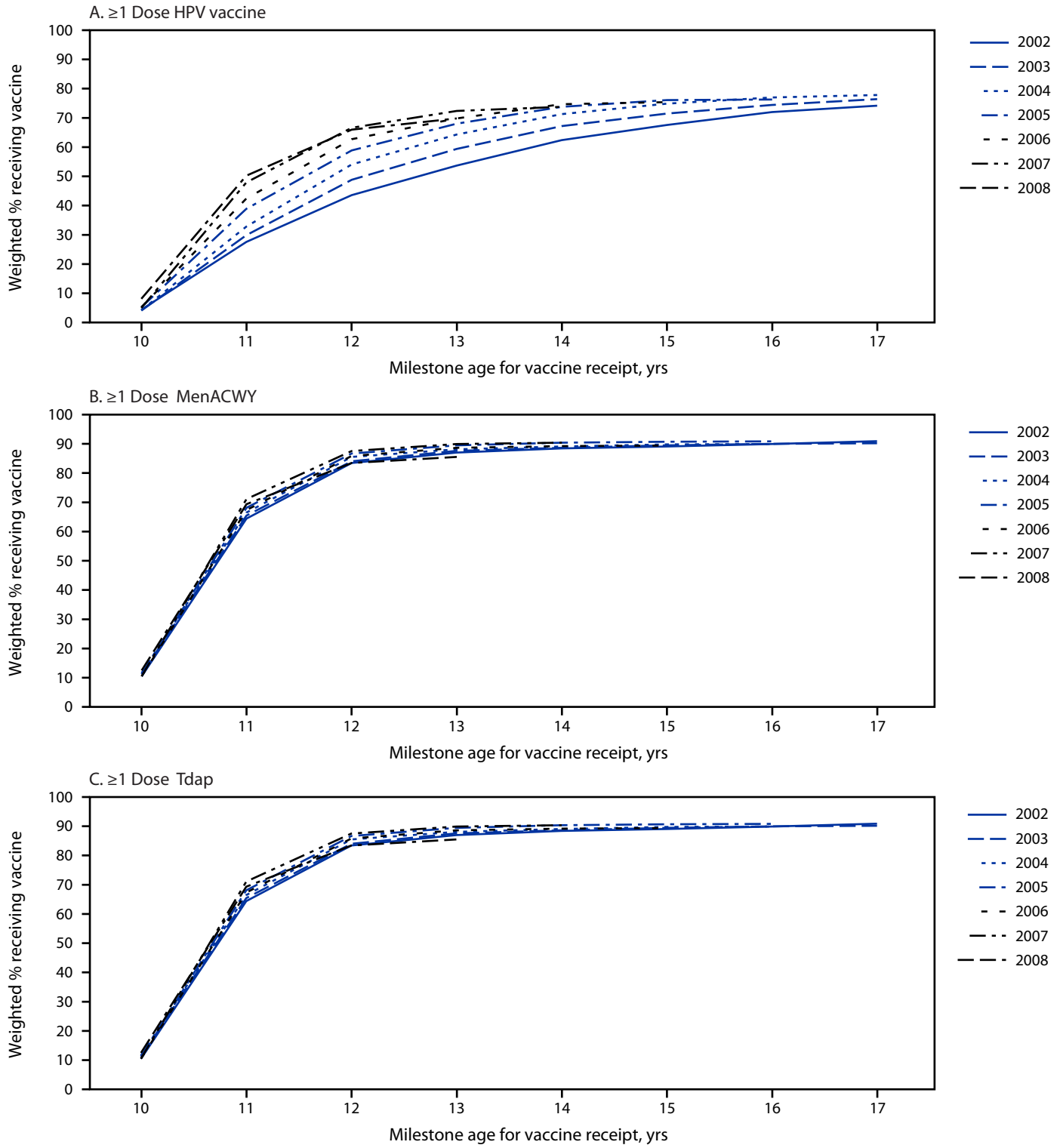
§§§ In July 2020, the Advisory Committee on Immunization Practices revised recommendations for hepatitis A vaccination to include catch-up vaccination for children and adolescents aged 2–18 years who have not previously received hepatitis A vaccine at any age. https://www.cdc.gov/vaccines/hcp/acip-recs/vacc-specific/hepa.html

¶¶¶ Determined by parent or guardian report or provider records.

adolescents living at or above poverty level. Access to the Vaccines for Children (VFC) program§§§§§ might contribute to higher vaccination coverage and lack of a geographic disparity for adolescents living below the poverty level among those in rural and urban areas. During 2016–2017, adolescents in rural areas were less likely than were those in urban areas to have had an age 11–12-year well-child visit (*3*), which might result in fewer opportunities to receive a vaccination and fewer

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

FIGURE 2. Coverage with ≥1 dose of human papillomavirus vaccine (A), ≥1 dose of quadrivalent meningococcal conjugate vaccine (B), and ≥1 dose of tetanus, diphtheria, and acellular pertussis vaccine (C), among adolescents in the 2002–2008 annual birth cohorts, by birth year and milestone age* — National Immunization Survey-Teen, United States, 2015–2021



Abbreviations: HPV = human papillomavirus; MenACWY = quadrivalent meningococcal conjugate vaccine; Tdap = tetanus, diphtheria, and acellular pertussis vaccine.
* Milestone age is the age in years by which the cumulative percent of adolescents vaccinated was assessed and represents vaccination status up to but not including the birthday by which adolescents reached the indicated age.

Summary

What is already known about this topic?

Tetanus, diphtheria, and acellular pertussis vaccine (Tdap), meningococcal conjugate vaccine (MenACWY), and human papillomavirus (HPV) vaccine are routinely recommended for adolescents.

What is added by this report?

Among adolescents aged 13–17 years in 2021, HPV vaccination coverage (≥1 dose and HPV vaccine up to date) increased. Coverage with ≥1-dose Tdap and ≥1-dose MenACWY remained high. Among age-eligible adolescents, MenACWY booster dose coverage increased. Analyses of the potential COVID-19 pandemic effect among adolescents born in 2008 show a concerning decrease in ≥1 MenACWY and ≥1 Tdap dose coverage.

What are the implications for public health?

As more adolescents who were due for routine vaccinations during the pandemic age into the NIS-Teen sample, the full impact of the pandemic can be assessed. Providers should review vaccination records to ensure that adolescents are current with all recommended vaccinations.

opportunities to receive a recommendation for vaccination from a provider. However, differences might also stem from vaccine attitudes and beliefs because coverage was lower among those with incomes above poverty level. Confidence in vaccines has been lower in rural areas than in urban areas for both routine and COVID-19 vaccines (*4*,*5*).

Decreases in coverage with ≥1 MenACWY dose by age 13 years and ≥1 Tdap dose by age 12 years for children and adolescents born in 2008 suggest that disruptions to medical care during the COVID-19 pandemic resulted in lower coverage for these vaccines. Tdap coverage by age 13 years for adolescents born in 2008 was lower than coverage for those born in 2006, but the difference was not statistically significant. Data from eight health systems in the United States evaluating weekly vaccination rates and proportion of children up to date with all age-specific recommended vaccinations also indicated lower coverage during than before the pandemic (*6*). Large decreases in routine vaccination rates were found for children and adolescents aged 11–13 years during March 15–May 16, 2020, and the proportion of adolescents up to date with vaccinations by age 13 years was 3 percentage points lower in September 2020 (56%) than in September 2019 (59%). As more children who were aged 11–12 years when the COVID-19 pandemic was declared age into the NIS-Teen survey sample, the full impact of the COVID-19 pandemic can be better examined.

The findings in this report are subject to at least three limitations. First, the household response rate was 21.0%; 41.4% of completed interviews included adequate provider data. Bias from low response rates might occur if survey participants differ from nonparticipants (*7*). Second, although estimates are adjusted for household and provider nonresponse and households without a telephone, bias in the estimates might remain. A recent survey error assessment indicated that NIS-Teen estimates might underestimate true coverage, with the largest underestimation for Tdap (–6.3 percentage points).¶¶¶¶¶ Little evidence exists for a change in accuracy of NIS-Teen estimates from 2020 to 2021.****** Finally, this report did not assess the possible impact of the COVID-19 pandemic on adolescent vaccination at ages >13 years. An additional analysis of NIS-Teen data indicated no differences in coverage for adolescents aged 14–17 years during the pandemic compared with coverage before the pandemic.††††††

Achieving and maintaining high vaccination coverage levels for adolescents will ensure they have protection from serious and sometimes life-threatening vaccine-preventable diseases. To help adolescents catch up on missed vaccinations, health care providers can identify those who have fallen behind on receiving recommended vaccinations and remind families to schedule an appointment. In addition, during every clinical encounter, including those for COVID-19 vaccination, providers can review patients' vaccination histories and recommend vaccination if needed. Resources to help promote and discuss vaccination with parents and patients can be found at https://www.cdc.gov/vaccines/hcp/patient-ed/index.html.

¶¶¶¶¶ An assessment of validity of the 2020 NIS-Teen estimates has been reported (https://www.cdc.gov/vaccines/imz-managers/nis/downloads/NIS-TEEN-PUF20-DUG.pdf). NIS-Teen vaccination coverage estimates tended to be slightly lower compared with actual values derived after adjusting for noncoverage, nonresponse, and vaccination underascertainment, reaching up to 6.3 percentage points too low for Tdap. This was primarily attributed to underascertainment of vaccinations by NIS provider record check. The validity of estimates did not change from 2019 to 2020.

****** https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/pubs-presentations/NIS-teen-vac-coverage-estimates-2021-tables.html#table-03

†††††† https://www.cdc.gov/vaccines/imz-managers/coverage/teenvaxview/pubs-presentations/NIS-teen-vac-coverage-estimates-2015-2021.html

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Parental Intentions and Perceptions Toward COVID-19 Vaccination Among Children Aged 4 Months to 4 Years — PROTECT Cohort, Four States, July 2021–May 2022

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Approximately 12 million children and adolescents aged ≤18 years in the United States have been infected with SARS-CoV-2, the virus that causes COVID-19, since December 2019,* and COVID-19–associated hospitalization rates increased among children aged <5 years during the B.1.617.2 (Delta) and B.1.1.529 (Omicron) variant peaks (*1*). In June 2022, the Food and Drug Administration amended the Emergency Use Authorization for the BNT162b2 (Pfizer-BioNTech) COVID-19 vaccine to include use of the vaccine in children aged 6 months–4 years and mRNA-1273 (Moderna) for children 6 months–5 years, which CDC recommends all children receive.† Advance reports indicated that fewer than 50% of parents were willing to vaccinate their children aged <5 years (*2*,*3*). Using the Pediatric Research Observing Trends and Exposures in COVID-19 Timelines (PROTECT)§ (*4*) prospective cohort, changes in parental perceptions toward COVID-19 vaccines and vaccination¶ for children aged <5 years were examined during July 2021–May 2022. Among 393 parents who participated in a baseline survey, approximately 64%, 19%, and 10% reported they were likely, were unsure, or were unlikely, respectively, to have their child aged <5 years receive the COVID-19 vaccine. The odds of parents intending to vaccinate their child was lower 3 months after the baseline survey, (adjusted odds ratio [aOR] = 0.84, 95% CI = 0.6–1.0) than at baseline. During the same period, parents also were less likely to perceive that COVID-19 vaccines were effective (aOR = 0.61, 95% CI = 0.4–0.8) and safe (aOR = 0.65, 95% CI = 0.5–0.9) compared with baseline. Intent to vaccinate and perception of safety increased 6 months after the baseline survey in unadjusted models (OR = 1.66, 95% CI = 1.1–2.5; and OR = 1.82, 95% CI = 1.3–2.6, respectively), but were no longer significant after adjusting for the child's receipt of a positive SARS-CoV-2 test result before survey completion, age, sex, race and ethnicity, health insurance, and study site. Enhanced efforts to address parental confidence in childhood vaccination and increase vaccination coverage among children aged <5 years are needed, including reinforcing the effectiveness and safety of vaccination against COVID-19.

PROTECT is an ongoing prospective cohort that includes >2,300 children and adolescents aged 4 months–17 years; the study monitors infections with SARS-CoV-2 in Arizona, Florida, Texas, and Utah (*4*). Children were recruited via community outreach from the public and from families participating in the HEROES-RECOVER longitudinal cohorts of essential and frontline workers (*5*,*6*). Upon enrollment, parents provided sociodemographic information, COVID-19 illness history, vaccination history, and their perceptions about COVID-19 vaccines for children. Participants are surveyed every 3 months. SARS-CoV-2 infections are identified among participant children through midturbinate nasal specimens collected weekly and tested via reverse transcription–polymerase chain reaction. Parents who completed the baseline survey and at least one follow-up survey were included in analysis. One child was randomly selected from households with two or more children aged <5 years to avoid household clustering.

* https://www.aap.org/en/pages/2019-novel-coronavirus-covid-19-infections/children-and-covid-19-state-level-data-report/ (Accessed March 9, 2022).

† https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-fda-authorizes-moderna-and-pfizer-biontech-covid-19-vaccines-children

§ PROTECT is conducted in Phoenix and Tucson, Arizona; Miami, Florida; Temple, Texas; and Salt Lake City, Utah.

¶ Parental perceptions toward COVID-19 vaccines were assessed with the following questions and response options: 1) "How much do you know about COVID-19 vaccines in children? Would you say…? Nothing at all, a little, some, a lot, a great deal, don't know, decline to answer"; 2) "How safe do you think the COVID-19 vaccine is in children? Extremely safe, very safe, somewhat safe, not too safe, not at all safe, don't know, decline to answer"; 3) "How effective do you think the COVID-19 vaccine is in preventing children from getting sick with COVID-19? Extremely effective, very effective, somewhat effective, not too effective, not at all effective, don't know, decline to answer"; 4) "I trust what the government says about the COVID-19 vaccine. Strongly disagree, mildly disagree, neutral, mildly agree, strongly agree, don't know, decline to answer"; 5) "What are the chances that [participant name] will get a COVID-19 vaccination? almost zero chance, very small chance, small, moderate, large, very large chance, almost certain, don't know, decline to answer"; and 6) "If [participant name] is unable to or doesn't get a COVID-19 vaccination, what do you think [participant name]'s chance of getting sick with COVID-19 this year will be? Almost zero chance, very small chance, small, moderate, large, very large chance, almost certain, don't know, decline to answer."

This study was restricted to 393 children aged <5 years who were enrolled in the PROTECT study during July 2021–May 2022. Vaccine intention was ascertained using baseline parental responses to the question, "What are the chances that [child] will get a COVID-19 vaccination?" Responses were grouped into three categories: unlikely (almost zero chance, very small chance); unsure (small chance, do not know, moderate chance); and likely (large chance, very large chance, almost certain).

A generalized estimating equation (GEE) model was used for each question to evaluate whether within-parent responses changed from a neutral or negative response (unsure or unlikely) to a positive response 3 and 6 months after the baseline enrollment survey. All available surveys from participants in the analytic group were included in the GEE models. The survey time point was added as a categorical predictor to calculate the OR for vaccine intention and vaccine perceptions. In addition, ORs describe the likelihood of all participants providing more positive responses at the 3-month and 6-month surveys compared with the baseline survey. Both unadjusted and adjusted models were calculated; the adjusted model included a positive test for SARS-CoV-2 infection in the child between surveys, sociodemographic characteristics, and study site. For vaccination intention outcomes, GEE models with multinomial distributions and cumulative logit links were used; the other models assessing perception outcomes used binomial distributions and logit links. All statistical analyses were completed using SAS (version 9.4; SAS Institute); statistical significance was defined as $p<0.05$ for chi-square tests and nonoverlapping 95% CIs for GEE models. PROTECT was reviewed by CDC and approved by the Institutional Review Boards at University of Arizona and Abt Associates under reliance agreements; the study was conducted consistent with applicable federal law and CDC policy.**

During July 2021–May 2022, parents provided information on 393 children aged <5 years enrolled in the PROTECT study (Table 1). The majority of children (227; 58%) resided in Arizona, and 92 (23%) had parents in the HEROES-RECOVER cohort (*5*,*6*). Median age was 2.8 years (SD = 1.3 year); 189 (48%) were male, 183 (47%) were non-Hispanic White persons, and 110 (28%) were Hispanic persons; 132 (34%) children received a positive SARS-CoV-2 test result during the study. At baseline, 253 (64.4%) parents reported that they were likely to get their child vaccinated; 76 (19.3%) were unsure, and 39 (9.9%) reported that they were unlikely to vaccinate their child (Table 1). There were statistically significant differences in vaccine intention identified by study site ($p<0.001$), positive SARS-CoV-2 test result during the study ($p = 0.006$), percent of household members vaccinated ($p = 0.011$), and household income ($p = 0.003$).

Approximately two thirds of participants (270; 68.7%) completed a 3-month survey and 137 (34.9%) completed a 6-month survey (Table 2) (Figure). Among parents who completed a 3-month survey, 11 (4.1%) changed their vaccination intent from a neutral or negative to positive response after 3 months, although parents overall were 24% less likely to vaccinate (aOR = 0.76) than they were at baseline. Also at 3 months, 30 (11.2%) parents changed their perception of vaccine effectiveness from neutral or negative to positive, although overall, they were 39% less likely to perceive the vaccine as effective (aOR = 0.61). At 3 months after the baseline survey, perception of vaccine safety changed from neutral or negative to positive for 29 (10.9%) parents; however, overall parents were 35% less likely to perceive the vaccine as safe (aOR = 0.65). When asked about perceived trust in government, 28 (10.7%) of parents changed from a negative or neutral to a positive response after 3 months, although they were 51% less likely to report trust in the government compared with baseline (aOR = 0.49).

Among 137 parents who completed a 6-month survey, 11 (8.1%) changed their perception of vaccine effectiveness from neutral or negative to positive (Table 2); overall parents were 62% less likely to have a positive response (aOR = 0.38) regarding vaccine effectiveness. Eleven (8.4%) parents changed their level of trust in government from negative or neutral to positive, although overall, parents were 49% less likely to have a positive response (aOR = 0.51). In unadjusted models only, vaccination intent and perceptions of vaccine safety were less likely to be neutral or negative at 6 months (OR = 1.66 and OR = 1.82, respectively); after adjusting for receipt of a positive SARS-CoV-2 test result before 6-month survey completion, age, sex, race and ethnicity, health insurance, and site, these were no longer statistically significant.

Discussion

Among parents of 393 children aged <5 years in this analysis, 64% indicated at baseline that they were likely to have their child vaccinated with the COVID-19 vaccine. During a 3-month observation period, however, parents indicated decreased intention to vaccinate and decreased confidence in COVID-19 vaccine safety and effectiveness as well as less trust in the government. Among the subset of participants who were in the study for 6 months, perceptions of vaccine safety, vaccine knowledge, and intent to vaccinate increased, but only in models that were not adjusted for potential confounders including SARS-CoV-2 infection during the study period.

** 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.

TABLE 1. Baseline parental COVID-19 vaccination intent for children aged <5 years, by selected characteristics — Pediatric Research Observing Trends and Exposures in COVID-19 Timelines, four states, July 2021–May 2022

Characteristic	Participants, no. (column % or SD)	Vaccination intent, no. (row %* or SD)			p-value†
		Unlikely	Unsure	Likely	
All children	393 (100)	39 (9.9)	76 (19.3)	253 (64.4)	—
Median age, yrs	2.8 (1.3)	2.9 (1.3)	2.9 (1.3)	3.0 (1.1)	0.865
Sex					
Male	189 (48.1)	22 (11.6)	37 (19.6)	127 (67.7)	0.198
Female	186 (47.3)	16 (8.6)	38 (20.4)	126 (67.2)	
Missing	18 (4.6)	1 (5.6)	1 (5.6)	0 (—)	
Race and ethnicity					
White, non-Hispanic	183 (46.6)	18 (9.8)	34 (18.6)	130 (71.0)	0.400
Black, non-Hispanic	12 (3.1)	2 (16.7)	5 (41.7)	5 (41.7)	
Asian, non-Hispanic	13 (3.3)	1 (7.7)	4 (30.8)	8 (61.5)	
Hispanic	110 (28.0)	11 (10.0)	25 (22.7)	71 (64.5)	
Other	36 (9.1)	2 (5.6)	5 (13.9)	29 (80.6)	
Site					
Tucson, Arizona	156 (39.7)	8 (5.1)	15 (9.6)	126 (80.8)	<0.001
Phoenix, Arizona	41 (10.4)	2 (4.9)	7 (17.1)	29 (70.7)	
Other areas in Arizona	30 (7.6)	4 (13.3)	7 (23.3)	19 (63.3)	
Temple, Texas	42 (10.7)	10 (23.8)	10 (23.8)	20 (47.6)	
Salt Lake City, Utah	56 (14.3)	6 (10.7)	14 (25.0)	35 (62.5)	
Miami, Florida	68 (17.3)	9 (13.2)	23 (33.8)	24 (35.3)	
Positive SARS-CoV-2 test result before study	48 (12.2)	3 (6.3)	14 (29.2)	29 (60.4)	0.173
Positive SARS-CoV-2 test result during study	132 (33.6)	21 (15.9)	18 (13.6)	89 (67.4)	0.006
% of household members aged >5 years vaccinated					
0	6 (1.5)	3 (50.0)	1 (16.7)	2 (33.3)	0.011
<50	21 (5.3)	2 (9.5)	4 (19.0)	5 (23.8)	
≥50	366 (93.1)	34 (9.3)	71 (19.4)	246 (67.2)	
Parents enrolled in adult study	92 (23.4)	10 (10.9)	16 (17.4)	66 (71.7)	0.628
Parent insured					
Yes	351 (89.3)	39 (11.1)	66 (18.8)	242 (68.9)	0.026
No	23 (5.9)	0 (—)	9 (39.1)	10 (43.5)	
Missing	19 (4.8)	0 (—)	1 (5.3)	1 (5.3)	
Household income					
$0–$49,999	54 (13.7)	6 (11.1)	17 (31.5)	28 (51.9)	0.003
$50,000–$99,999	101 (25.7)	15 (14.9)	25 (24.8)	61 (60.4)	
$100,000–$149,999	77 (19.6)	5 (6.5)	11 (14.3)	60 (77.9)	
≥$150,000	112 (28.5)	8 (7.1)	13 (11.6)	90 (80.4)	
Responses to vaccine questions,§ mean (SD)					
Vaccination intent¶	5.7 (0.10)	1.5 (0.08)	3.7 (0.07)	6.7 (0.04)	<0.001
Chance of getting sick	4.2 (0.08)	2.6 (0.20)	3.7 (0.12)	4.6 (0.09)	<0.001
Vaccine knowledge	3.1 (0.06)	2.6 (0.14)	2.5 (0.13)	3.4 (0.07)	<0.001
Vaccine safety	3.9 (0.05)	2.5 (0.20)	3.1 (0.10)	4.2 (0.05)	<0.001
Vaccine effectiveness	3.9 (0.05)	2.6 (0.19)	3.5 (0.10)	4.2 (0.05)	<0.001
Trust in government	3.9 (0.07)	2.5 (0.21)	3.5 (0.11)	4.2 (0.08)	<0.001

* Might not sum to 100% because of rounding or missing intention category for some persons. Likely included "large chance," "very large chance," and "almost certain"; unsure included "small chance," "do not know," and "moderate chance"; and unlikely included "almost zero chance" and "very small chance."

† Chi-square tests performed to test if the distribution of each characteristic differed by intention group. An analysis of variance was used to test if the median age of children and vaccine belief questions differed between intention groups.

§ For all responses, a higher value means a more positive response. Parental perceptions toward COVID-19 vaccines were assessed with the following questions and response options: 1) "How much do you know about COVID-19 vaccines in children? Would you say…? Nothing at all, a little, some, a lot, a great deal, don't know, decline to answer"; 2) "How safe do you think the COVID-19 vaccine is in children? Extremely safe, very safe, somewhat safe, not too safe, not at all safe, don't know, decline to answer"; 3) "How effective do you think the COVID-19 vaccine is in preventing children from getting sick with COVID-19? Extremely effective, very effective, somewhat effective, not too effective, not at all effective, don't know, decline to answer"; 4) "I trust what the government says about the COVID-19 vaccine. Strongly disagree, mildly disagree, neutral, mildly agree, strongly agree, don't know, decline to answer"; 5) "What are the chances that [participant name] will get a COVID-19 vaccination? Almost zero chance, very small chance, small, moderate, large, very large chance, almost certain, don't know, decline to answer"; and 6) "If [participant] is unable to or doesn't get a COVID-19 vaccination, what do you think [participant]'s chance of getting sick with COVID-19 this year will be? Almost zero chance, very small chance, small, moderate, large, very large chance, almost certain, don't know, decline to answer."

¶ This question is used to identify the vaccination intent columns.

TABLE 2. Change in knowledge, attitude, and practice responses of parents of children aged <5 years from baseline to 3- and 6-month surveys — Pediatric Research Observing Trends and Exposures in COVID-19 Timelines, four states, July 2021–May 2022

Survey questions*/Time after baseline survey, mos.	Participant responses, no.	No. (%)		Odds ratio† (95% CI)	
		Response change to neutral or negative	Response change to positive	Unadjusted	Adjusted§
Intention to vaccinate					
3	269	24¶ (8.9)	11 (4.1)	0.84 (0.68–1.04)	0.76¶ (0.59–0.99)
6	137	11 (8.0)	7 (5.1)	1.66¶ (1.10–2.50)	1.10 (0.73–1.67)
Chance of getting sick					
3	270	39 (14.4)	29 (10.7)	1.16 (0.89–1.52)	1.12 (0.83–1.51)
6	135	16 (11.9)	15 (11.1)	1.40 (0.98–2.00)	1.12 (0.76–1.65)
Vaccine knowledge					
3	270	21 (7.8)	33 (12.2)	1.30* (1.03–1.64)	1.21 (0.93–1.58)
6	136	15 (11.0)	20 (14.7)	1.45* (1.05–2.00)	1.29 (0.88–1.88)
Vaccine safety					
3	266	54¶ (20.3)	29 (10.9)	0.82 (0.63–1.08)	0.65¶ (0.47–0.90)
6	134	7 (5.2)	17 (12.7)	1.82¶ (1.29–2.57)	1.06 (0.71–1.58)
Vaccine effectiveness					
3	269	60¶ (22.3)	30 (11.2)	0.80 (0.61–1.06)	0.61¶ (0.44–0.84)
6	136	38¶ (27.9)	11 (8.1)	0.76 (0.54–1.07)	0.38¶ (0.25–0.57)
Trust in government					
3	262	65¶ (24.8)	28 (10.7)	0.67¶ (0.50–0.89)	0.49¶ (0.34–0.71)
6	131	31¶ (23.7)	11 (8.4)	1.01 (0.70–1.46)	0.51¶ (0.32–0.81)

* For all vaccine perception questions except intention: odds of moving from a negative/neutral response at baseline to a positive response at follow-up. For intention: odds of being more likely to vaccinate at follow-up compared with at baseline (odds of changing from unlikely to vaccinate to being unsure of vaccinating, or unsure of vaccinating to likely to vaccinate). Odds ratio below 1 indicates less likely to go from negative/neutral to positive, and an odds ratio above 1 indicates more likely to go from negative/neutral to positive from baseline to follow-up; chance of getting sick: positive defined as "large chance," "very large chance," or "almost certain"; neutral defined as "small chance," "do not know," or "moderate chance"; and negative defined as "almost zero chance" and "very small chance"; vaccine knowledge positive defined as "a lot" or "a great deal"; neutral defined as "a little," "some," or "do not know"; and negative defined as "nothing at all"; vaccine safety positive defined as "very safe" or "extremely safe"; neutral defined as "somewhat safe," "not too safe," or "do not know"; and negative defined as "not at all safe; vaccine effectiveness positive defined as "very effective" or "extremely effective"; neutral defined as "not too effective," "somewhat effective," or "do not know"; and negative defined as "not at all effective"; trust in government positive defined as "strongly agree" or "agree"; neutral defined as "neutral" or "do not know"; and negative defined as "strongly disagree" or "disagree."

† Odds ratios for both time points are compared with baseline responses.

§ Adjusted for receiving a positive SARS-CoV-2 test result before survey completion, age, sex, race and ethnicity, health insurance, and site.

¶ Indicates statistically significant result.

Perceptions of vaccine effectiveness and trust in government remained neutral or negative after 6 months.

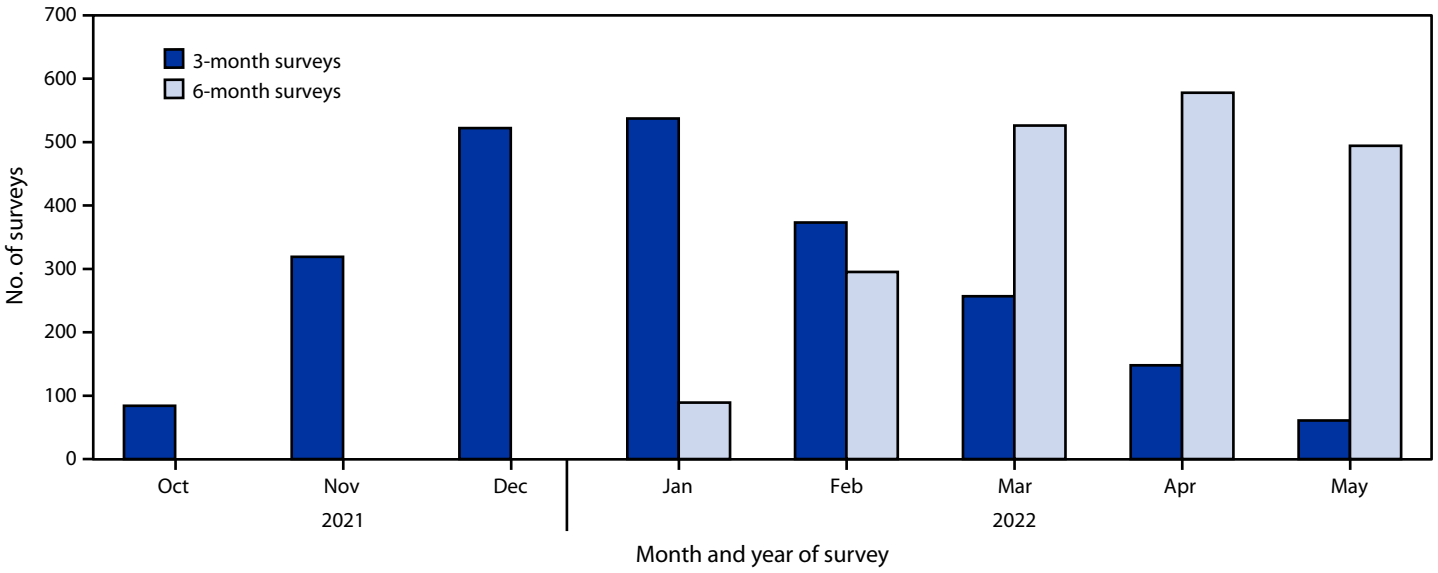
The PROTECT cohort demonstrated a higher parental intent to vaccinate their young children than did other earlier surveys (*2*,*7*). Participants in COVID-19 research might be more likely than nonparticipants to comply with CDC recommendations. However, intention to vaccinate and vaccine confidence decreased over time, even though the vaccines were demonstrated to be safe and effective in older children (*8*). The decline in confidence is likely the result of multiple factors. For example, the follow-up period occurred at the time of pandemic-related events that might have affected perceptions about COVID-19 vaccines, including conflicting news reports of vaccine availability for this age group (*3*). In addition, one third of participants received positive SARS-CoV-2 test results during the observation period, which might have reduced parents' confidence in or perceived need for the COVID-19 vaccine†† or reinforced assumptions of mild illness in children. Finally, news of lower estimates of vaccine effectiveness in older children potentially influenced the decline in vaccine confidence (*9*) in early 2022.

The findings in this report are subject to at least four limitations. First, follow-up surveys were distributed over 3-month periods, making discerning specific causes of changes in vaccine perception difficult. Second, because the study population is participating in a surveillance and vaccine-effectiveness study and includes frontline workers, vaccine intention might be inflated. Third, the majority of participants are from Arizona, which might not be representative of other states. Finally, not all participants in this ongoing longitudinal cohort study have been enrolled long enough to complete follow-up surveys.

This study is the first longitudinal analysis of vaccine intention and perceptions among parents of children aged <5 years. During a 3-month observation period, parents reported

†† https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-april-2022

FIGURE. Distribution of 3-month and 6-month surveys, by study month — Pediatric Research Observing Trends and Exposures in COVID-19 Timelines cohort, four states, October 2021–May 2022



Summary

What is already known on this topic?

In June 2022, COVID-19 vaccines were authorized for use in children aged 6 months–5 years. Intent to vaccinate and vaccination rates in children have been low.

What is added by this report?

During July 2021–May 2022, in a longitudinal cohort of 393 children aged <5 years in four states, parental intent to vaccinate children against COVID-19 and perception of COVID-19 vaccine safety and effectiveness declined over a 3-month period, but intent to vaccinate and perceptions of vaccine safety returned to baseline after 6 months.

What are the implications for public health practice?

Identifying and addressing barriers to COVID-19 vaccination in children aged <5 years and educating parents about COVID-19 vaccine effectiveness and safety in young children are critical to increasing pediatric COVID-19 vaccination coverage.

reduced confidence and intent to vaccinate their child when the vaccine becomes available, although their overall intent is higher than other national published rates (*2*,*7*,*10*). Enhanced efforts to identify and address parental barriers to and increase confidence in COVID-19 vaccination in children aged <5 years are needed, including educating parents about the effectiveness and safety of COVID-19 vaccination in this population.

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COVID-19 mRNA Vaccine Safety Among Children Aged 6 Months–5 Years — United States, June 18, 2022–August 21, 2022

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On June 17, 2022, the Food and Drug Administration (FDA) amended the Emergency Use Authorization (EUA) for mRNA COVID-19 vaccines to include children aged 6 months–4 years for receipt of BNT162b2 (Pfizer-BioNTech) (administered as 3 doses, 3 μg [0.2 mL] each) and children aged 6 months–5 years for receipt of mRNA-1273 (Moderna) (administered as 2 doses, 25 μg [0.25 mL] each) (*1*,*2*). In preauthorization clinical trials, the Pfizer-BioNTech vaccine was administered to 3,013 children aged 6 months–4 years (*3*) and the Moderna vaccine was administered to 5,011 children aged 6 months–5 years (*4*). Most adverse events reported in these trials were mild to moderate in severity and no serious vaccine-related adverse events were reported. To characterize postauthorization safety of COVID-19 vaccine primary series among young children, CDC reviewed adverse events and health impacts after receipt of Pfizer-BioNTech and Moderna vaccines that were reported to v-safe, a voluntary smartphone-based U.S. safety surveillance system established by CDC to monitor adverse events after COVID-19 vaccination (https://vsafe.cdc.gov/en/), and the Vaccine Adverse Event Reporting System (VAERS), a U.S. passive vaccine safety surveillance system managed by CDC and FDA. During June 18–August 21, 2022, approximately 599,457children aged 6 months–4 years received the Pfizer-BioNTech vaccine and 440,773 aged 6 months–5 years received the Moderna vaccine*; approximately 23,266 children were enrolled in v-safe after mRNA COVID-19 vaccination. The most frequent systemic reactions reported to v-safe after receipt of Pfizer-BioNTech or Moderna vaccines were irritability or crying among approximately one half of children aged 6 months–2 years. Among children aged ≥3 years, systemic reactions after vaccination were less frequently reported; injection site pain was the most frequently reported reaction among these older children. VAERS received a total of 1,017 reports of adverse events after Pfizer-BioNTech or Moderna vaccination among children aged 6 months–4 years and children aged 6 months–5 years; 998 (98.1%) events were classified as nonserious and 19 (1.9%) as serious. No reports of myocarditis after vaccination were reported. These initial safety findings are similar to those from preauthorization clinical trials (*3*,*4*). Health care providers and parents of young children should be aware that local and systemic reactions are expected after vaccination with Pfizer-BioNTech or Moderna vaccine and that serious adverse events are rare.

On June 20, 2022, v-safe was modified to allow parents and guardians to enroll children aged 6 months–4 years after any mRNA COVID-19 vaccine dose. Text message reminders are sent to parents or guardians to complete online health surveys for their child.† Health surveys sent in the first postvaccination week include questions about local injection site and systemic reactions (i.e., mild, moderate, or severe) and health impacts.§ Specific questions were included for children aged 6 months–2 years who might not be able to describe reactions or who might experience reactions that are different from those experienced by children aged ≥3 years.¶ CDC's v-safe call center contacts registrants who indicate that medical care was received after vaccination and encourages completion of a VAERS report.

VAERS is a national passive vaccine safety surveillance system managed by CDC and FDA that monitors adverse events after vaccination (*5*). VAERS accepts reports of postvaccination adverse events from health care providers, vaccine manufacturers, and members of the public.** Signs, symptoms, and

* The Pfizer-BioNTech COVID-19 vaccine for use in children aged 6 months–4 years was administered as 3 doses (3 μg [0.2 mL] each), at intervals of 3 weeks between doses 1 and 2 and ≥8 weeks between doses 2 and 3; the Moderna COVID-19 vaccine for use in children aged 6 months–5 years was administered as 2 doses (25 μg [0.25 mL] each), 4 weeks apart. Data for Moderna COVID-19 doses administered to children aged 5 years were unavailable. https://covid.cdc.gov/covid-data-tracker/#vaccination-demographic (Accessed August 16, 2022).

† Children and adolescents aged ≤15 years cannot self-enroll and must be enrolled by a parent or guardian. Health check-ins are sent via text messages that link to web-based surveys on days 0–7 after vaccination; then weekly through 6 weeks after vaccination; and then 3, 6, and 12 months after vaccination.

§ Parents and guardians describe the severity of the child's symptoms as mild, moderate, or severe. Severity of symptoms for registrants aged ≥3 years is defined as mild (noticeable, but not problematic), moderate (limit normal daily activities), or severe (make daily activities difficult or impossible). The definition of severity of symptoms among registrants aged ≤2 years is unique to each local injection site and systemic reaction. Health impacts among children include inability to perform normal daily activities, missed child care or school, or received care from a medical professional because of new symptoms or conditions.

¶ These reactions were based on data collected in clinical trials and include groin or underarm swelling or tenderness, diarrhea, rash, vomiting, irritability or crying, loss of appetite, and sleepiness.

** Health care providers are required by COVID-19 vaccine EUAs to report certain adverse events after vaccination to VAERS, including death (https://vaers.hhs.gov/faq.html). A VAERS form includes patient information, vaccine information, vaccine administration information, and information regarding the adverse event (https://vaers.hhs.gov/docs/VAERS%202.0_Checklist.pdf).

diagnostic findings in VAERS reports are assigned Medical Dictionary for Regulatory Activities preferred terms (MedDRA PTs) by VAERS staff.†† Reports of serious events to VAERS§§ were reviewed by CDC and FDA physicians to form a consensus clinical impression based on available data. Using selected MedDRA PTs, a search was performed to identify possible cases of myocarditis, a rare adverse event that has been associated with mRNA COVID-19 vaccines (*6*).

Local and systemic reactions and health impacts reported to v-safe during the week after vaccination were described for children aged 6 months–4 years who received Pfizer-BioNTech vaccine and children aged 6 months–5 years who received Moderna vaccine during June 18–August 21, 2022. VAERS reports were described by serious and nonserious status, demographic characteristics, and MedDRA PTs. Analyses were conducted using SAS software (version 9.4; SAS Institute); p-values <0.05 were considered statistically significant. These surveillance activities were reviewed by CDC and conducted consistent with applicable federal law and CDC policy.¶¶

Review of v-safe Data

During June 18–August 21, 2022, v-safe enrolled 4,749 children aged 6 months–2 years and 3,792 aged 3–4 years who had received Pfizer-BioNTech vaccine and 8,338 children aged 6 months–2 years and 6,387 aged 3–5 years who had received Moderna vaccine (Table 1). Most children (22,695; 97.6%) did not receive any other vaccine at the time of receipt of the first COVID-19 dose. Local and systemic reactions reported during the week after receipt of either Pfizer-BioNTech or Moderna vaccines were most frequently reported on the day after vaccination. Local reactions were reported for 900 (19.0%) children aged 6 months–2 years and 1,078 (28.4%) aged 3–4 years after the first Pfizer-BioNTech vaccine dose and for 1,601 (19.2%) aged 6 months–2 years and 2,072 (32.4%) aged 3–5 years after the first Moderna dose. Systemic reactions were reported for 2,649 (55.8%) children aged 6 months–2 years and for 1,220 (32.2%) children aged 3–4 years after receipt of the first Pfizer-BioNTech vaccine dose and for 4,647 (55.7%) children aged 6 months–2 years and for 2,204 (34.5%) children aged 3–5 years after the first Moderna vaccine dose. The most frequently reported reactions after receipt of either Pfizer-BioNTech and Moderna vaccines among children aged 6 months–2 years were irritability or crying, sleepiness, and fever; among children aged 3–5 years, the most frequently reported reactions were injection site pain, fatigue, and fever. Most reports described reactions as mild to moderate in severity (Table 2).

Parents of approximately 1,323 (5.7%) and 803 (6.5%) of children aged 6 months–5 years reported that their child was unable to perform normal daily activities in the week after dose 1 and dose 2, respectively of either vaccine. Approximately 741 (2%) reported seeking medical care in the week after either dose; most medical care was received via a clinic appointment (450; 1.3%). Four children received care at a hospital after vaccination; two respondents indicated the hospitalization was unrelated to vaccination, one was unwilling to provide further information, and one completed a VAERS report (Table 3).

Review of VAERS Data

During June 18–August 21, 2022, VAERS received and processed 496 reports of adverse events among children aged 6 months–4 years who had received Pfizer-BioNTech vaccine and 521 reports for children aged 6 months–5 years who had received Moderna vaccine (Table 3).*** Among Pfizer-BioNTech vaccine recipients for whom a VAERS report was submitted, the median age was 3 years, and 249 (50.2%) reports were for events among males. Among Moderna vaccine recipients, the median age was 2 years, and 272 (52.2%) reports were for events among males. Most children (978; 96.2%) for whom reports were submitted received Pfizer-BioNTech or Moderna vaccine as the sole vaccine administered.

Overall, 998 (98.1%) VAERS reports were for nonserious events, including 486 (98.0%) after Pfizer-BioNTech and 512 (98.3%) after Moderna vaccination. The most commonly reported events (455; 44.7%) were related to vaccination errors (e.g., incorrect dose administered, product administered to patient of inappropriate age, or product or preparation issue); among 278 reports of vaccination errors after receipt of Pfizer-BioNTech and 177 reports after receipt of Moderna vaccines, 45 (9.9%) reports indicated that an adverse health event had occurred. Nonserious adverse events most commonly reported were fever (197; 19.8%), rash (95; 9.5%), vomiting (79; 7.9%), urticaria (66; 6.6%), and fatigue (60; 6.0%).

Nineteen serious events were reported to VAERS. Eight reports were for seizure, six of which were reports among children who were afebrile on medical evaluation; one child had a recorded temperature of 102.7°F (39.3°C) and temperature

†† Each VAERS report might be assigned at least one MedDRA PT. A MedDRA coded event does not indicate a medically confirmed diagnosis. https://www.meddra.org/how-to-use/basics/hierarchy

§§ VAERS reports are classified as serious (based on FDA Code of Federal Regulations Title 21) if any of the following are reported: hospitalization, prolongation of hospitalization, life-threatening illness, permanent disability, congenital anomaly or birth defect, or death. https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr

¶¶ 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.

*** Processed VAERS reports are those that have been coded using MedDRA, deduplicated, and undergone standard quality assurance and quality control review.

TABLE 1. Adverse reactions and health impacts reported for children aged 6 months–5 years* (N = 23,266) who received Pfizer-BioNTech or Moderna COVID-19 vaccine — United States, June 18–August 21, 2022

	Vaccine, age group, % reporting reaction or health impacts after vaccination†							
	Pfizer-BioNTech (N = 8,541)				Moderna (N = 14,725)			
	6 mos–2 yrs (n = 4,749)		3–4 yrs (n = 3,792)		6 mos–2 yrs (n = 8,338)		3–5 yrs (n = 6,387)	
Event	Dose 1 (4,749)	Dose 2 (2,467)	Dose 1 (3,792)	Dose 2 (2,060)	Dose 1 (8,338)	Dose 2 (4,288)	Dose 1 (6,387)	Dose 2 (3,549)
Any injection site reaction	**19.0**	**18.3**	**28.4**	**26.5**	**19.2**	**26.7**	**32.4**	**47.1**
Itching	NA	NA	1.9	1.5	NA	NA	1.5	1.7
Pain	13.7	13.3	24.7	23.4	14.2	19.9	29.1	43.5
Redness	5.6	6.3	4.9	5.3	6.1	8.8	4.5	8.1
Swelling or hardness	2.8	1.9	2.2	2.0	2.8	5.7	2.3	4.9
Groin or underarm swelling/ tenderness	0.3	0.2	NA	NA	0.4	0.3	NA	NA
Any systemic reaction	**55.8**	**47.1**	**32.2**	**29.2**	**55.7**	**58.2**	**34.5**	**49.9**
Abdominal pain	NA	NA	3.5	3.4	NA	NA	4.4	6.3
Myalgia	NA	NA	4.8	3.6	NA	NA	5.0	9.7
Chills	NA	NA	4.0	2.8	NA	NA	3.6	7.7
Fatigue	NA	NA	20.1	19.6	NA	NA	22.9	33.2
Fever	18.7	13.8	12.1	10.9	19.7	27.2	13.5	30.6
Headache	NA	NA	5.0	4.0	NA	NA	5.2	8.7
Joint pain	NA	NA	1.6	0.8	NA	NA	1.0	1.5
Nausea	NA	NA	3.0	2.2	NA	NA	3.0	4.9
Diarrhea	6.7	5.3	4.4	4.0	6.3	5.9	4.3	3.8
Rash	4.9	3.2	2.4	1.4	4.4	3.6	2.2	1.9
Vomiting	3.8	2.8	2.9	2.3	3.6	3.8	3.1	4.1
Irritability/Crying	39.6	33.5	NA	NA	39.4	42.7	NA	NA
Loss of appetite	11.7	8.7	NA	NA	10.2	12.9	NA	NA
Sleepiness	25.8	20.9	NA	NA	25.9	28.5	NA	NA
Any health impact	**10.3**	**7.5**	**9.3**	**7.4**	**9.8**	**11.6**	**10.8**	**15.9**
Unable to perform normal daily activities	5.3	3.3	5.7	4.1	5.2	6.1	6.6	10.6
Unable to attend child care or school	5.9	4.4	5.6	4.4	5.7	6.5	6.2	7.8
Needed medical care	2.8	2.2	1.7	1.2	2.7	2.4	1.5	1.2
Telehealth	0.8	0.4	0.5	0.3	0.7	0.7	0.5	0.5
Clinic appointment	1.6	1.3	1.0	0.7	1.8	1.5	0.9	0.6
Emergency visit	0.4	0.2	0.2	0.0	0.2	0.1	0.2	0.1
Hospitalization	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0

Abbreviation: NA = not applicable.

* On June 17, 2022, the Food and Drug Administration amended the Emergency Use Authorizations for BNT162b2 (Pfizer-BioNTech) vaccine to include children aged 6 months–4 years and mRNA-1273 (Moderna) vaccine to include children aged 6 months–5 years. Safety findings for children aged ≥60 months (5 years) who received Pfizer-BioNTech vaccine have been previously described and were not included in this study.

† Percentage of children whose parents reported a reaction or health impact at least once during days 0–7 post-vaccination. Health check-in surveys were unique for each age group (6 months–2 years and ≥3 years).

was not reported for the other child. Two children with preexisting diagnoses of structural brain abnormalities experienced seizures in the days after vaccination. One child experienced signs and symptoms consistent with anaphylaxis several hours after vaccination; this child received a partial vaccine dose accompanied by a needle malfunction followed by revaccination with an appropriate dose. No reports of myocarditis after vaccination were reported.

Discussion

Approximately, one million young children have received an mRNA COVID-19 vaccine. The findings in this report are consistent with those from safety data from preauthorization clinical trials for young children (*3*,*4*). Trial participants aged 6 months–4 years who received Pfizer-BioNTech vaccine and 6 months–5 years who received Moderna vaccine most frequently reported mild or moderate local and systemic reactions; no serious adverse events judged to be related to vaccination were reported in the trial data (*3*,*4*). Initial postauthorization safety monitoring of 19 serious reports identified one report of febrile seizure plausibly associated with vaccination.

Systemic reactions were more frequently reported after COVID-19 vaccination for children aged 6 months–2 years than for children aged 3–5 years. The most frequent reactions reported to v-safe for children aged 6 months–2 years included irritability or crying, sleepiness, and loss of appetite. These reactions are consistent with the clinical trial findings (*3*,*4*) and are common after childhood vaccination (*7*).

TABLE 2. Most frequent adverse reactions reported to v-safe for children aged 6 months–5 years (N = 23,266)* who received Pfizer-BioNTech or Moderna COVID-19 vaccine, by severity and dose — United States, June 18–August 21, 2022

	Age, vaccine, % reporting reaction or health impact after vaccination†							
	6 mos–2 yrs (N = 13,087)				3–5 yrs (N = 10,179)			
	Pfizer-BioNTech (n = 4,749)		Moderna (n = 8,338)		Pfizer-BioNTech (n = 3,792)		Moderna (n = 6,387)	
Event	Dose 1 (4,749)	Dose 2 (2,467)	Dose 1 (8,338)	Dose 2 (4,288)	Dose 1 (3,792)	Dose 2 (2,060)	Dose 1 (6,387)	Dose 2 (3,549)
Irritability/Crying	**39.6**	**33.5**	**39.4**	**42.7**	**NA**	**NA**	**NA**	**NA**
Mild	24.4	22.2	25.9	27.9	NA	NA	NA	NA
Moderate	14.5	10.9	12.7	14.1	NA	NA	NA	NA
Severe	0.6	0.5	0.8	0.8	NA	NA	NA	NA
Sleepiness	**25.8**	**20.9**	**25.9**	**28.5**	**NA**	**NA**	**NA**	**NA**
Mild	21.2	18.0	21.7	24.5	NA	NA	NA	NA
Moderate	4.4	2.6	3.9	3.9	NA	NA	NA	NA
Severe	0.3	0.2	0.2	0.1	NA	NA	NA	NA
Injection site pain	**NA**	**NA**	**NA**	**NA**	**24.7**	**23.4**	**29.1**	**43.5**
Mild	NA	NA	NA	NA	21.4	20.2	25.1	33.1
Moderate	NA	NA	NA	NA	3.0	3.1	3.8	9.8
Severe	NA	NA	NA	NA	0.2	0.1	0.2	0.5
Fatigue	**NA**	**NA**	**NA**	**NA**	**20.1**	**19.6**	**22.9**	**33.2**
Mild	NA	NA	NA	NA	11.6	13.2	14.4	19.2
Moderate	NA	NA	NA	NA	7.6	6.2	7.5	12.9
Severe	NA	NA	NA	NA	0.9	0.2	1.0	1.1
Fever§	**18.7**	**13.8**	**19.7**	**27.2**	**12.1**	**10.9**	**13.5**	**30.6**
Temperature not documented	6.2	5.1	6.6	7.4	2.7	3.4	2.7	7.2
Temperature documented	12.5	8.8	13.1	19.9	9.4	7.5	10.8	23.4
Normal temperature	4.8	3.9	5.4	7.7	3.5	3.6	3.5	8.6
Documented fever	7.7	4.9	7.7	12.2	5.9	3.9	7.3	14.8
Mild	2.8	1.9	3.0	5.6	2.0	2.0	2.7	7.2
Moderate	2.4	1.8	2.4	3.9	2.0	0.9	2.4	4.3
Severe	2.2	1.0	1.9	2.2	1.6	0.8	1.9	2.9
Very severe	0.3	0.2	0.4	0.5	0.4	0.2	0.3	0.4
Pain	**13.7**	**13.3**	**14.2**	**19.9**	**NA**	**NA**	**NA**	**NA**
Mild	12.1	11.9	12.0	16.3	NA	NA	NA	NA
Moderate	1.6	1.3	2.1	3.4	NA	NA	NA	NA
Severe	0.1	0.0	0.1	0.3	NA	NA	NA	NA
Myalgia	**NA**	**NA**	**NA**	**NA**	**4.8**	**3.6**	**5.0**	**9.7**
Mild	NA	NA	NA	NA	2.5	2.0	2.7	5.2
Moderate	NA	NA	NA	NA	2.1	1.5	2.1	4.4
Severe	NA	NA	NA	NA	0.2	0.1	0.2	0.2
Loss of appetite	**11.7**	**8.7**	**10.2**	**12.9**	**NA**	**NA**	**NA**	**NA**
Mild	6.7	5.4	6.4	8.7	NA	NA	NA	NA
Moderate	4.4	3.0	3.3	3.6	NA	NA	NA	NA
Severe	0.7	0.3	0.5	0.5	NA	NA	NA	NA
Headache	**NA**	**NA**	**NA**	**NA**	**5.0**	**4.0**	**5.2**	**8.7**
Mild	NA	NA	NA	NA	3.1	2.9	3.2	5.4
Moderate	NA	NA	NA	NA	1.6	0.9	1.8	3.1
Severe	NA	NA	NA	NA	0.3	0.2	0.3	0.2

Abbreviation: NA = not applicable.

* On June 17, 2022, the Food and Drug Administration amended the Emergency Use Authorizations for BNT162b2 (Pfizer-BioNTech) vaccine to include children aged 6 months–4 years and mRNA-1273 (Moderna) vaccine to include children aged 6 months–5 years. Safety findings for children aged ≥60 months (5 years) who received Pfizer-BioNTech vaccine have been previously described and were not included in this study.

† Percentage of registrants for whom a parent or guardian reported a reaction or health impact at least once during days 0–7 after vaccination. Includes the most severe event reported during the 0–7-day window. Parents and guardians who participate in v-safe use the following definitions to describe the severity of a child's symptoms: mild (noticeable, but not problematic), moderate (limit normal daily activities), or severe (make daily activities difficult or impossible).

§ Fever is self-reported and registrants are not required to record a temperature. Among children who had a reported temperature and met the definition for fever (≥100.4°F [≥38°C]) during days 0–3, fever was classified as mild (100.4°F–101.1°F [38°C–38.4°C]), moderate (101.2°F–102.0°F [38.4°C–38.9°C]), severe (102.1°F–104.0°F [38.9°C–40.0°C]), or very severe (>104.0°F [>40°C]).

Among VAERS reports for Pfizer-BioNTech recipients aged 6 months–4 years and Moderna recipients aged 6 months–5 years, 98% or more were nonserious. Vaccination errors were among the most common events reported to VAERS in this age group. No adverse event was associated with vaccination errors in 92% of these reports. Children in

TABLE 3. Events* reported to the Vaccine Adverse Event Reporting System for children aged 6 months–5 years† after receipt of Pfizer-BioNTech or Moderna COVID-19 vaccine — United States, June 18–August 21, 2022

Adverse events	Vaccine, no. reporting (%)		
	Pfizer-BioNTech	Moderna	Total
Total	**496**	**521**	**1,017**
Vaccination errors	**278 (56.0)**	**177 (34.0)**	**455 (44.7)**
Error without adverse health event	248 (89.2)	162 (91.5)	**410 (90.1)**
Error with adverse health event§	30 (10.8)	15 (8.5)	**45 (9.9)**
Error with nonserious health event¶	30 (10.8)	14 (7.9)	**44 (9.7)**
Error with serious health event	0 (—)	1 (0.6)	**1 (0.2)**
Nonserious reports (excluding vaccination error MedDRA PTs)**	**486 (98.0)**	**512 (98.3)**	**998 (98.1)**
Fever	84 (17.3)	113 (22.1)	**197 (19.7)**
Rash	52 (10.7)	43 (8.4)	**95 (9.5)**
Vomiting	37 (7.6)	42 (8.2)	**79 (7.9)**
Urticaria	23 (4.7)	43 (8.4)	**66 (6.6)**
Fatigue	29 (6.0)	31 (6.1)	**60 (6.0)**
SARS-CoV-2 negative test result	24 (4.9)	33 (6.5)	**57 (5.7)**
Cough	17 (3.5)	34 (6.6)	**51 (5.1)**
Irritability	16 (3.3)	33 (6.5)	**49 (4.9)**
Decreased appetite	17 (3.5)	29 (5.7)	**46 (4.6)**
Diarrhea	19 (3.9)	26 (5.1)	**45 (4.5)**
Erythematous rash	13 (2.7)	28 (5.5)	**41 (4.1)**
COVID-19	19 (3.9)	18 (3.5)	**37 (3.7)**
SARS-CoV-2 positive test result	18 (3.7)	17 (3.3)	**35 (3.5)**
Serious reports††	**10 (2.0)**	**9 (1.7)**	**19 (1.9)**
Seizure§§	4	3	**7**
Acute left basal ganglia infarction	1	0 (—)	**1**
Acute flaccid myelitis¶¶	0 (—)	1	**1**
Anaphylaxis***	0 (—)	1	**1**
Atypical Kawasaki disease	0 (—)	1	**1**
Breath holding	1	0 (—)	**1**
Brief resolved unexplained event	0 (—)	1	**1**
Eye infection with neutropenia	1	0 (—)	**1**
Febrile seizure	1	0 (—)	**1**
Immune thrombocytopenic purpura	1	0 (—)	**1**
Pancreatitis	1	0 (—)	**1**
Tachycardia	0 (—)	1	**1**
Upper respiratory infection with wheezing	0 (—)	1	**1**

Abbreviations: MedDRA PT = Medical Dictionary for Regulatory Activities preferred term; VAERS = Vaccine Adverse Event Reporting System.

* Signs and symptoms in VAERS reports are assigned MedDRA PTs by VAERS staff members. Each VAERS report was coded for one or more MedDRA PTs. A MedDRA PT does not represent a medically confirmed diagnosis and might represent a normal finding or a diagnostic test result. Vaccine administration errors that are MedDRA coded are listed separately in this table.

† On June 17, 2022, the Food and Drug Administration amended the Emergency Use Authorizations for BNT162b2 (Pfizer-BioNTech) vaccine to include children aged 6 months–4 years and mRNA-1273 (Moderna) vaccine to include children aged 6 months–5 years. Safety findings for children aged ≥60 months (5 years) who received Pfizer-BioNTech vaccine have been previously described and were not included in this study.

§ The most common MedDRA PTs among reports of vaccination error included incorrect dose administered, product administered to patient of inappropriate age, product preparation issue, wrong product administered, expired product administered, product storage error, and underdose.

¶ Adverse health events coded for reports with nonserious vaccination errors included decreased appetite, diarrhea, fatigue, fever, rash, scratch, and vomiting.

** Includes the top 13 most frequently coded MedDRA PTs among nonserious reports.

†† Because of the small number of serious reports, percentages are not provided for serious report events. VAERS reports are classified as "serious" only if one of the following events are reported: hospitalization, prolongation of hospitalization, life-threatening illness, permanent disability, congenital anomaly or birth defect, or death. All other reports are classified as "nonserious" (https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm?fr). Serious reports to VAERS were reviewed by CDC physicians to form a clinical impression, based on available information. In the table, the clinical impression for each report is listed. https://www.meddra.org/how-to-use/basics/hierarchy

§§ Six of the seven seizure reports were for afebrile children; temperature was not reported for the other child. Two of the seven reports represented children with preexisting structural brain abnormalities. Three reports of seizures occurring within 24 hours of vaccination were made; one was of an afebrile child with a history of febrile seizures. Two additional reports of seizures were made, occurring 9 days and 18 days after vaccination.

¶¶ The acute flaccid myelitis report represented a child recently diagnosed with hand, foot, and mouth disease and human rhinovirus B infection.

*** The anaphylaxis report was for a child who received two vaccinations after a part of the first dose was not injected. Approximately 8 hours after vaccination, the child developed signs and symptoms consistent with anaphylaxis and was treated in an emergency department and discharged.

these age groups are authorized to receive a smaller amount of mRNA COVID-19 vaccine than are older children (*8*); incorrect dosing by vaccine administrators in different childhood age groups might lead to vaccination errors. Continued education of vaccine providers might help reduce administration errors, including incorrect dosing, among children. Of the

eight seizures reported to VAERS, only one was associated with a fever (39.3°C [102.7°F]) occurring after COVID-19 vaccination and two were in children with structural brain abnormalities. Myocarditis is a rare adverse event that has been associated with mRNA COVID-19 vaccines; the risk appears highest among adolescents and decreases with decreasing age in childhood (*6*). No events of myocarditis were reported to VAERS after vaccination in children aged 6 months–5 years.

The findings in this report are subject to at least four limitations. First, v-safe is a voluntary program; as a result, v-safe data might not be representative of the vaccinated population. For example, although more doses of Pfizer-BioNTech vaccine than Moderna vaccine were administered to young children in the United States during the surveillance period of this report, more v-safe reports were received for children who received Moderna vaccine. Second, VAERS is a passive reporting system and is subject to reporting biases and underreporting, especially of nonserious events (*5*). Third, Pfizer-BioNTech dose 3 data were not available at the time of this analysis. Finally, these data are limited by the short surveillance period and might change as safety monitoring continues and more doses are administered to children aged 6 months–5 years.

The Advisory Committee on Immunization Practices recommends that all persons aged ≥6 months receive a COVID-19 vaccine (*8*). Initial vaccine safety monitoring in children aged 6 months–5 years are usually similar to those described in clinical trials, and no unexpected safety concerns were detected (*3*,*4*). Health care providers and parents of young children should be advised that local and systemic reactions are expected after vaccination with COVID-19 mRNA vaccines, and serious adverse events are rare. CDC and FDA will continue to monitor vaccine safety and will provide updates as needed to guide COVID-19 vaccination recommendations.

Summary

What is already known about this topic?

COVID-19 vaccines have been recommended for children aged 6 months–5 years since June 2022; approximately one million doses were administered to persons in this age group during June–August 2022.

What is added by this report?

Local and systemic reactions after vaccination with either BNT162b2 (Pfizer-BioNTech) or mRNA-1273 (Moderna) COVID-19 vaccines were reported for children aged 6 months–4 years and 6 months–5 years, respectively, to v-safe and VAERS safety monitoring systems. Serious adverse events were rarely reported.

What are the implications for public health practice?

Initial vaccine safety data indicate that among young children, local and systemic reactions are expected after COVID-19 vaccination and serious adverse events are rare.

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Booster COVID-19 Vaccinations Among Persons Aged ≥5 Years and Second Booster COVID-19 Vaccinations Among Persons Aged ≥50 Years — United States, August 13, 2021–August 5, 2022

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COVID-19 vaccine booster doses provide enhanced protection against SARS-CoV-2 infection, emergency department visits, hospitalization, and death (*1*–*3*). As of May 19, 2022, all fully vaccinated persons aged ≥5 years are recommended to receive a booster dose when eligible; selected populations, as determined by age and immunocompromise status, are also eligible for a second booster or an additional dose to complete a primary COVID-19 vaccination series (*4*). Data on COVID-19 vaccine doses administered during August 13, 2021–August 5, 2022, and submitted to CDC from 50 states and the District of Columbia (DC) were analyzed to assess booster and second booster vaccination coverage among eligible populations, by age group, sex, race and ethnicity, urban-rural classification, and the primary series vaccine product received. For this analysis, primary series completion was defined as receipt of 2 mRNA (i.e., mRNA-1273 [Moderna] or BNT162b2 [Pfizer-BioNTech]) COVID-19 vaccine doses or 1 Ad26.COV.S (Janssen [Johnson & Johnson]) COVID-19 vaccine dose because data were not available to identify immunocompromised persons who might have received an additional primary dose. Among 214.4 million eligible persons aged ≥5 years, 106.3 million (49.6%) received a booster dose, and booster dose coverage increased with age. Booster dose coverage was lowest for children, adolescents, and adults aged 18–39 years; males; non-Hispanic Black or African American (Black), Hispanic or Latino (Hispanic), and multiracial persons; residents of rural counties; and Janssen primary series recipients. Among 58.8 million eligible first booster dose recipients aged ≥50 years, 20.0 million (34.0%) received a second booster dose. Second booster dose coverage was lowest among persons aged 50–64 years; males; Hispanic, Black, and multiracial persons; residents of rural counties; and Janssen primary series recipients. Interventions focused on improving public health communication and outreach to populations with low booster and second booster dose vaccination coverage should be developed to increase access to COVID-19 vaccines and ensure that all persons can benefit from the increased protection conferred by COVID-19 vaccine booster doses.

On August 13, 2021, CDC's Advisory Committee on Immunization Practices (ACIP) recommended that moderately or severely immunocompromised persons receive an additional dose to complete a primary series of Moderna (persons aged ≥18 years) or Pfizer-BioNTech (persons aged ≥12 years) COVID-19 vaccine (Supplementary Table, https://stacks.cdc.gov/view/cdc/120701). On September 24, and October 21, 2021, a COVID-19 booster dose was recommended for selected populations aged ≥18 years,* and then recommended for all persons aged ≥18 years on November 19, 2021. On December 9, 2021, January 5, 2022, and May 19, 2022, booster dose recommendations were expanded to Pfizer-BioNTech recipients aged 16–17, 12–15, and 5–11 years, respectively. In addition, selected populations, including all persons aged ≥50 years and moderately or severely immunocompromised persons aged ≥12 years, became eligible to receive a second COVID-19 booster dose on March 29, 2022.

Data on COVID-19 vaccine administration in the United States are reported to CDC by jurisdictions, pharmacies, and federal entities.† COVID-19 vaccine doses administered during August 13, 2021–August 5, 2022, among persons aged ≥5 years in 50 states (excluding persons aged <18 years in Idaho)§ and DC, were analyzed to assess booster and second booster dose vaccination coverage by age group, sex, race and ethnicity, urban-rural classification,¶ and the primary series vaccine product received. Booster dose vaccination coverage was calculated among persons who completed a primary series** of

* The September 24, 2021, booster dose recommendations included selected Pfizer-BioNTech primary series recipients aged ≥18 years. The October 21, 2021, booster dose recommendations included selected Moderna primary series recipients aged ≥18 years and all Janssen primary series recipients aged ≥18 years.

† Data were regularly reported to CDC via immunization information systems (IISs), the Vaccine Administration System, or direct data submission. Timely reporting from COVID-19 vaccine providers to jurisdictional data systems is required. The IIS jurisdictions included in this analysis comprise the 50 U.S. states and six local jurisdictions (Chicago, Illinois; Houston, Texas; San Antonio, Texas; Philadelphia, Pennsylvania; New York, New York; and DC).

§ Aggregate data are submitted for vaccine doses administered in Idaho to persons aged <18 years. These data could not be included in the analysis because linkage between primary series and booster doses was not possible.

¶ The vaccine recipient's county of residence was classified using the 2013 National Center for Health Statistics Urban-Rural Classification Scheme for Counties. Urban counties include counties assigned to four metropolitan levels (large central metropolitan, large fringe metropolitan, medium metropolitan, and small metropolitan), whereas rural counties are those assigned to two nonmetropolitan levels (micropolitan and noncore). Additional information is online. https://www.cdc.gov/nchs/data_access/urban_rural.htm

Moderna, Pfizer-BioNTech, or Janssen COVID-19 vaccine and were eligible to receive a booster dose by the end of the analysis period.[††] Persons who received 2 mRNA COVID-19 doses or 1 Janssen COVID-19 dose were defined as having completed a primary series because data to identify persons who might have received an additional primary dose were not available. A booster dose was defined as a homologous or heterologous dose of COVID-19 vaccine administered ≥4 weeks[§§] after completion of a primary series. A second booster dose was defined as a homologous or heterologous dose of COVID-19 vaccine administered ≥3 months (mRNA primary series recipients) or ≥2 months (Janssen recipients) after receipt of the first booster dose.

Information on recipient race and ethnicity was available for 73.6% of the eligible population. Analyses were conducted using SQL Server Management Studio (version 18; Microsoft) and SAS software (version 9.4; SAS Institute). Tests for statistical significance were not conducted because these data are reflective of the U.S. population aged ≥5 years[¶¶] and were not based on probability population samples. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.[***]

As of August 5, 2022, 214.4 million persons aged ≥5 years (68.6% of the U.S. population aged ≥5 years)[†††] were eligible to receive a booster dose. Among this population, 106.3 million (49.6%) received a booster dose (Table 1). Booster coverage increased with age, ranging from 15.6% among children aged 5–11 years to 69.5% among adults aged ≥65 years. Booster coverage was lower among males (47.3%) than among females (51.9%), and the coverage difference between males and females was largest among persons aged 18–39 years (6 percentage points). Overall, booster coverage varied by race and ethnicity, ranging from 37.3% among Hispanic persons to 58.5% among non-Hispanic Asian persons. When stratified by age group, the lowest booster dose coverage among persons aged 5–39 years was among Black persons (range = 9.8%–27.9%), and among those aged ≥40 years, coverage was lowest among Hispanic (range = 45.4%–64.0%) and multiracial (range = 45.7%–62.7%) persons. Booster dose coverage was lower in persons living in rural counties (micropolitan and noncore) (48.5%) than among urban residents (50.3%), although coverage differences by urban-rural classification were smaller among older adults. Among persons aged ≥18 years, booster coverage among Janssen, Moderna, and Pfizer-BioNTech primary series recipients was 34.8%, 56.3%, and 51.9%, respectively.

Among 58.8 million persons aged ≥50 years who were eligible to receive a second booster dose, 20.0 million (34.0%) received a second booster by August 5, 2022 (Table 2). Second booster dose coverage increased with age, ranging from 26.1% among persons aged 50–64 years to 41.4% among those aged ≥75 years. Second booster dose coverage was lowest among males, Hispanic and Black persons, persons living in rural counties, and Janssen primary series recipients.

Discussion

By August 5, 2022, approximately one half of the eligible population aged ≥5 years had received a COVID-19 vaccine booster dose, representing approximately one third (34.0%) of the U.S. population aged ≥5 years. Booster and second booster dose vaccination coverage rates were lowest among the youngest age groups; males; Black, Hispanic, and multiracial persons; residents of rural counties; and Janssen primary series recipients. Some similarities existed between booster dose coverage and primary series coverage trends as of August 21, 2022, with children, adolescents, younger adults aged 18–24 years, males, and Black persons being underrepresented among fully vaccinated persons (*5*).

Booster dose coverage was highest among adults aged ≥65 years (69.5%), with smaller coverage differences across sex, race and ethnicity, and urban-rural classification compared with that in adults aged 18–64 years. Among age groups, the lowest booster dose coverage was among children aged 5–11 years (15.6%), followed by that among adolescents aged 12–17 years (33.4%). Children aged 5–11 years were recommended to receive a booster dose most recently, which might partially explain the low coverage in this group. Racial and ethnic disparities in booster dose coverage were largest (≥26 percentage points) among persons aged 12–39 years. Understanding the factors contributing to low booster and second booster dose coverage among Black, Hispanic, and multiracial populations, and designing interventions to

[**] During the analysis period, the Food and Drug Administration–approved or authorized COVID-19 vaccines with a booster dose recommendation were Moderna (persons aged ≥18 years), Pfizer-BioNTech (persons aged ≥5 years), and Janssen (persons aged ≥18 years). To be considered to have completed a primary series, persons must have received 2 primary series doses of mRNA vaccine on different days or received 1 dose of Janssen primary series vaccine; 2-dose mRNA primary series recipients were categorized by the vaccine product received for the second dose of the primary series.

[††] Eligibility was determined by age at time of primary series completion and date of primary series completion. To be considered part of the eligible population, persons must have received the second dose of a primary series of mRNA vaccine ≥5 months before the end of the analysis period (by March 5, 2022) or received 1 primary series dose of Janssen vaccine ≥2 months before the end of the analysis period (by June 10, 2022).

[§§] A 4-day grace period was subtracted from all interval calculations to allow for doses received ≤4 days earlier than recommended.

[¶¶] Excluding persons in Idaho aged <18 years.

[***] 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.

[†††] U.S. population estimates for persons aged ≥5 years came from the U.S. Census Bureau's 2021 Population Estimates Program and excluded persons in Idaho aged <18 years to reflect the population under analysis.

TABLE 1. Characteristics of COVID-19 booster dose vaccination recipients aged ≥5 years as a percentage of the eligible population* aged ≥5 years, by age group, sex,† race and ethnicity,§,¶ urban-rural classification, and primary series vaccine product†† — United States, August 13, 2021–August 5, 2022**

Characteristic	No. (% of eligible population) vaccinated, by age group, yrs					
	Total	5–11	12–17	18–39	40–64	≥65
No. of eligible persons	**214,371,606**	**7,579,057**	**14,373,389**	**63,832,354**	**80,437,874**	**48,148,932**
Total vaccinated	**106,252,812 (49.6)**	1,181,821 (15.6)	4,795,396 (33.4)	23,971,719 (37.6)	42,827,799 (53.2)	33,476,077 (69.5)
Sex						
Female	**57,838,625 (51.9)**	584,423 (15.6)	2,514,377 (34.6)	13,254,320 (40.5)	23,022,647 (55.4)	18,462,858 (70.3)
Male	**47,968,126 (47.3)**	595,704 (15.6)	2,270,715 (32.1)	10,589,555 (34.6)	19,598,577 (51.3)	14,913,575 (68.8)
Race and ethnicity						
AI/AN	**653,776 (45.2)**	10,277 (13.4)	50,881 (34.0)	166,569 (36.0)	273,904 (52.4)	152,145 (65.0)
Asian	**6,790,145 (58.5)**	152,571 (20.6)	489,722 (51.2)	2,312,672 (54.2)	2,657,574 (65.2)	1,177,606 (75.5)
Black or African American	**7,361,157 (42.9)**	55,840 (9.8)	323,974 (24.1)	1,389,409 (27.6)	3,475,085 (49.2)	2,116,849 (67.3)
Hispanic or Latino	**11,530,086 (37.3)**	156,334 (10.4)	892,558 (25.4)	3,446,614 (29.4)	4,966,386 (45.4)	2,068,194 (64.0)
NH/OPI	**226,574 (46.7)**	3,380 (15.7)	14,587 (33.9)	63,345 (36.2)	99,454 (55.7)	45,808 (68.8)
White	**50,903,937 (54.7)**	528,485 (17.7)	2,078,786 (37.8)	9,926,219 (41.5)	19,457,448 (56.8)	18,912,999 (71.8)
Two or more races	**1,269,279 (40.5)**	36,180 (17.9)	109,183 (33.0)	337,384 (31.6)	470,782 (45.7)	315,750 (62.7)
Unknown or other race	**27,517,858 (48.6)**	238,754 (16.2)	835,705 (32.9)	6,329,507 (36.9)	11,427,166 (51.0)	8,686,726 (66.5)
Urban-rural classification, two-level						
Urban	**91,471,674 (50.3)**	1,072,472 (16.0)	4,356,807 (34.3)	21,467,699 (38.8)	37,002,405 (54.4)	27,572,291 (70.6)
Rural	**11,237,723 (48.5)**	50,278 (10.2)	308,437 (25.7)	1,630,043 (30.2)	4,351,229 (49.2)	4,897,736 (67.7)
Urban-rural classification, six-level						
Large central metro	**34,904,526 (50.4)**	473,646 (17.7)	1,705,095 (34.6)	9,549,773 (40.8)	14,158,318 (55.2)	9,017,694 (71.3)
Large fringe metro	**27,729,051 (51.6)**	344,640 (16.1)	1,467,727 (37.0)	6,023,947 (39.8)	11,580,198 (55.6)	8,312,539 (71.1)
Medium metro	**20,741,562 (49.1)**	194,202 (13.6)	896,992 (31.3)	4,334,684 (35.6)	8,175,484 (52.7)	7,140,200 (69.6)
Small metro	**8,096,535 (49.2)**	59,984 (13.5)	286,993 (30.0)	1,559,295 (34.0)	3,088,405 (51.6)	3,101,858 (69.4)
Micropolitan	**6,802,071 (48.2)**	34,556 (10.6)	205,991 (26.6)	1,072,177 (30.8)	2,654,387 (49.6)	2,834,960 (67.9)
Noncore	**4,435,652 (49.1)**	15,722 (9.6)	102,446 (24.0)	557,866 (29.3)	1,696,842 (48.7)	2,062,776 (67.5)
Primary series vaccine product						
Janssen (Johnson & Johnson)	**5,858,549 (34.8)**	NA	NA	1,698,326 (26.2)	3,091,323 (38.6)	1,068,900 (45.7)
Moderna	**42,029,340 (56.3)**	NA	NA	8,546,104 (40.6)	17,190,419 (56.1)	16,292,817 (70.9)
Pfizer-BioNTech	**58,364,923 (47.5)**	1,181,821 (15.6)	4,795,396 (33.4)	13,727,289 (37.8)	22,546,057 (54.0)	16,114,360 (70.6)

Abbreviations: AI/AN = American Indian or Alaska Native; NA = not applicable; NH/OPI = Native Hawaiian or other Pacific Islander.

* The eligible population is defined as persons aged ≥5 years who completed a primary COVID-19 vaccination series and were eligible to receive a booster dose by the end of the analysis period. For Pfizer-BioNTech and Moderna primary series recipients, 2 primary series doses must have been received by March 5, 2022 (≥5 months earlier); for Janssen recipients, 1 primary series dose must have been received by June 10, 2022 (≥2 months earlier).

† Information on the recipient's sex was not available for 0.7% (1,476,563) of the population with a completed primary series. Among these, 446,061 persons received a booster dose.

§ AI/AN, Asian, Black or African American, NH/OPI, and White persons, and persons of one or more races were non-Hispanic or Latino; Hispanic or Latino persons could be of any race.

¶ Information on the recipient's race or ethnicity was not available for 26.4% (56,637,652) of the population with a completed primary series. Among these, 27,517,858 persons received a booster dose.

** Information on the recipient's county of residence was not available for 4.4% (9,459,737) of the population with a completed primary series. Among these, 3,543,415 persons received a first booster dose.

†† For Pfizer-BioNTech primary series recipients, the total booster coverage was calculated among persons aged ≥5 years, whereas the total booster coverage for Moderna and Janssen primary series recipients was calculated among persons aged ≥18 years. The total booster coverage for Pfizer-BioNTech primary series recipients aged ≥18 years is 51.9%.

address these factors, is crucial to ensuring equitable access to COVID-19 vaccination.

Booster and second booster dose coverage rates among Janssen primary series recipients were lower than those among mRNA vaccine recipients. One possible reason for this is the Janssen 1-dose primary series might have been preferred by persons less likely to receive multiple doses, such as transient populations (e.g., persons experiencing homelessness), persons with limited access to health care, and persons with needle aversion. Booster and second booster dose coverage was lower among residents of rural counties than that among urban residents; lower COVID-19 vaccine acceptance has been observed in rural areas, and rural residents might also experience more barriers to accessing health care than do urban residents (*6*). Persons living in rural areas were previously found to be less likely to engage in COVID-19 preventive behaviors such as mask wearing (*7*), which would likely increase the potential benefit provided by a booster dose in this population.

The findings in this report are subject to at least five limitations. First, COVID-19 vaccine booster dose recommendations were released during a 10-month period, and some populations had less time than others to receive a booster dose. Further,

TABLE 2. Characteristics of COVID-19 second booster dose vaccination recipients aged ≥50 years as a percentage of the eligible population aged ≥50 years with a first booster dose,* by age group, sex,† race and ethnicity,§,¶ and urban-rural classification — United States, January 13–August 5, 2022**

Characteristic	No. (% eligible population), by age group, yrs			
	Total	50–64	65–74	≥75
No. of eligible persons with a first booster dose	**58,816,621**	**27,276,149**	**18,943,334**	**12,597,138**
Total vaccinated	**19,974,129 (34.0)**	7,108,294 (26.1)	7,650,363 (40.4)	5,215,472 (41.4)
Sex				
Female	**11,047,047 (34.6)**	3,902,233 (26.7)	4,171,696 (41.1)	2,973,118 (41.1)
Male	**8,875,045 (33.3)**	3,182,593 (25.4)	3,461,044 (39.6)	2,231,408 (41.9)
Race and ethnicity				
AI/AN	**97,664 (31.7)**	45,041 (27.0)	34,100 (36.9)	18,523 (38.2)
Asian	**906,530 (36.1)**	399,363 (28.2)	307,002 (44.5)	200,165 (49.5)
Black or African American	**1,182,553 (28.1)**	494,591 (22.0)	452,565 (34.7)	235,397 (36.0)
Hispanic or Latino	**1,137,781 (24.4)**	541,812 (19.6)	383,202 (31.3)	212,767 (31.5)
NH/OPI	**32,196 (32.6)**	15,085 (27.0)	11,112 (39.6)	5,999 (40.9)
White	**11,359,753 (36.6)**	3,678,835 (28.1)	4,519,386 (42.7)	3,161,532 (43.0)
Two or more races	**191,434 (33.7)**	74,772 (27.0)	70,809 (40.2)	45,853 (39.9)
Unknown or other race	**5,066,218 (32.8)**	1,858,795 (25.6)	1,872,187 (38.7)	1,335,236 (40.0)
Urban-rural classification, two-level				
Urban	**17,110,072 (34.7)**	6,228,966 (26.7)	6,500,217 (41.6)	4,380,889 (42.5)
Rural	**2,326,717 (30.1)**	671,880 (22.0)	953,884 (34.8)	700,953 (36.3)
Urban-rural classification, six-level				
Large central metro	**6,015,482 (35.5)**	2,385,983 (27.9)	2,187,784 (42.6)	1,441,715 (43.8)
Large fringe metro	**5,311,941 (34.9)**	1,963,815 (26.6)	2,002,077 (42.3)	1,346,049 (43.3)
Medium metro	**4,137,088 (34.3)**	1,376,505 (25.9)	1,641,235 (40.7)	1,119,348 (41.4)
Small metro	**1,645,561 (32.8)**	502,663 (24.3)	669,121 (38.5)	473,777 (39.4)
Micropolitan	**1,393,949 (30.8)**	412,877 (22.5)	571,693 (35.9)	409,379 (37.1)
Noncore	**932,768 (29.3)**	259,003 (21.3)	382,191 (33.4)	291,574 (35.3)
Primary series vaccine product				
Janssen (Johnson & Johnson)	**645,707 (20.7)**	410,836 (19.8)	162,852 (23.0)	72,019 (21.1)
Moderna	**9,187,651 (34.6)**	2,903,685 (26.0)	3,730,327 (40.6)	2,553,639 (41.3)
Pfizer-BioNTech	**10,140,771 (34.8)**	3,793,773 (27.1)	3,757,184 (41.5)	2,589,814 (42.7)

Abbreviations: AI/AN = American Indian or Alaska Native; NH/OPI = Native Hawaiian or other Pacific Islander.

* The eligible population is defined as persons aged ≥50 years at time of primary series completion who received a first booster dose and were eligible to receive a second booster dose by the end of the analysis period.

† Information on the recipient's sex was not available for 0.4% (223,377) of the population with a first booster dose. Among these, 52,037 persons received a second booster dose.

§ AI/AN, Asian, Black or African American, NH/OPI, and White persons, and persons of one or more races were non-Hispanic or Latino; Hispanic or Latino persons could be of any race.

¶ Information on the recipient's race or ethnicity was not available for 26.3% (15,446,958) of the population with a first booster dose. Among these, 5,066,218 persons received a second booster dose.

** Information on the recipient's county of residence was not available for 3.2% (1,859,993) of the population with a first booster dose. Among these, 537,340 persons received a second booster dose.

changes in COVID-19 variant predominance and case prevalence during this period likely affected booster and second booster dose acceptance among different populations. Second, misclassification of vaccination status might have occurred if linkage among vaccination records in jurisdiction-specific data systems was not possible, if, for example, persons received doses in different jurisdictions. Third, eligibility was determined by age at primary series completion, and a small number of persons who met the minimum eligible age requirement after primary series completion might have been excluded. Fourth, a small proportion of booster and second booster doses might have been misclassified because information on immunocompromise status was not available to identify immunocompromised persons who might have received an additional primary series dose. In addition, misclassification might have occurred due to the definitions for booster and second booster doses, which were designed to include doses administered to immunocompromised persons. However, after receipt of a primary series, approximately 99.0% of persons who received 1 subsequent dose received this dose after the minimum recommended interval for a booster dose; 99.6% of persons who received 2 subsequent doses received

Summary

What is already known about this topic?

A COVID-19 vaccine booster dose provides enhanced protection against SARS-CoV-2 infection, COVID-19–associated emergency department visits, hospitalization, and death.

What is added by this report?

Among 214 million eligible persons aged ≥5 years, approximately one half received a booster dose. Among 55 million eligible persons aged ≥50 years, approximately one third received a second booster dose. Booster and second booster dose coverage rates were lower among the youngest age groups; males; non-Hispanic Black or African American, Hispanic or Latino, and multiracial persons; residents of rural counties; and Janssen (Johnson & Johnson) primary series recipients.

What are the implications for public health practice?

Focused interventions to improve vaccine equity and effectiveness of outreach to populations with low booster and second booster dose coverage should be developed and implemented.

the second postprimary series dose after the minimum recommended interval for a second booster dose.[§§§] Finally, race or ethnicity was unknown, unable to be reported, or invalid for approximately one quarter of the population, which could bias results. In May 2022, the National Immunization Survey Adult COVID Module (NIS-ACM) found no substantial racial and ethnic disparities among fully vaccinated adults (*8*); however, disparities across race and ethnicity were present in booster dose coverage based on NIS-ACM.

All fully vaccinated eligible persons aged ≥5 years are recommended to receive a COVID-19 booster vaccine dose, and certain populations, including adults aged ≥50 years, are recommended to receive a second booster dose when eligible (*4*). Booster doses increase the primary series vaccine effectiveness and strengthen the immune response in children, adolescents, and adults (*1*–*3*). Health care providers can educate and encourage all persons to receive a booster dose when they are eligible. Focused interventions should be developed and implemented to improve access to COVID-19 vaccines and ensure the effectiveness of public health communication and outreach to populations with low coverage, which might reduce health disparities.

[§§§] Calculations of the interval between primary series completion and postprimary series doses were available for 91.8% of booster dose recipients and 94.5% of second booster dose recipients (excluding data received via direct data submission). In these calculations, the minimum recommended interval for a booster dose was defined as 5 months between primary series completion and administration of the first postprimary dose; the minimum recommended interval for a second booster dose was defined as 4 months between administration of the first postprimary series dose and the second postprimary series dose.

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Strategies Adopted by Gay, Bisexual, and Other Men Who Have Sex with Men to Prevent *Monkeypox virus* Transmission — United States, August 2022

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The first U.S. case of monkeypox during the current outbreak was confirmed on May 17, 2022 (*1*); on August 4, the U.S. Department of Health and Human Services declared the outbreak to be a public health emergency.* To date, most reported monkeypox cases in the United States and globally have occurred among men who reported sexual or close intimate contact with another man during the 3 weeks before symptom onset (*2*). The multipronged response to monkeypox has included expanding access to monkeypox vaccine and developing messaging† for gay, bisexual, and other men who have sex with men (MSM) seeking to reduce their chances for acquiring monkeypox. During August 5–15, 2022, a monkeypox-specific follow-up survey was completed by a convenience sample of 824 MSM who responded to the annual American Men's Internet Survey (AMIS).§ Overall, 48% of respondents reported reducing their number of sex partners, 50% reported reducing one-time sexual encounters, and 50% reported reducing sex with partners met on dating apps or at sex venues since learning about the monkeypox outbreak. Nearly one in five respondents reported receiving ≥1 dose of vaccine to prevent monkeypox. Receipt of vaccine was highest among Hispanic or Latino (Hispanic) men (27.1%) and lowest among non-Hispanic Black or African American (Black) men (11.5%); 17.7% of non-Hispanic White (White) men and 24.2% of men of other race or ethnicity received vaccine. Receipt of vaccine was higher in urban (27.8%) and suburban (14.5%) areas than in other areas (5.7%–7.0%). These data suggest that MSM are taking steps to protect themselves and their partners from monkeypox. It is important that federal, state, and local public health programs continue to deliver tailored, respectful harm reduction messages that do not create stigma to diverse communities of MSM. Vaccine programs should prioritize efforts to maximize equitable access to vaccines to prevent monkeypox.

AMIS is an annual, cross-sectional, online behavioral survey of a convenience sample of cisgender men in the United States who report sex with another man during the 12 months preceding the survey (*3*). During August 5–15, 2022, AMIS 2021 survey participants who agreed to be recontacted were invited to complete a follow-up survey assessing knowledge of and experiences with monkeypox. After providing research consent, participants answered questions about general knowledge, awareness, and concern about monkeypox; personal behavior changes during the past 3 months because of the monkeypox outbreak; and receipt of vaccine to prevent monkeypox infection. The Emory University Institutional Review Board reviewed and approved procedures for the AMIS survey. This activity was also reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.¶

Overall, 2,999 AMIS 2021 participants were invited to participate in the monkeypox survey, and 824 (27.5%) responded and completed all questionnaire sections. Among these respondents, 70.5% were White, and 50.9% were aged <45 years. Most men (90.0%) reported sex with a man during the preceding 3 months (i.e., during the current monkeypox outbreak); 238 (28.9%) reported two or more sex partners during the preceding 14 days. Respondents were from all regions of the United States; (47.8%) lived in urban areas.

Respondents reported changing sexual behaviors since they learned about the monkeypox outbreak (Table 1). Overall, 47.8% reported reducing their number of sex partners, 49.8% reported reducing one-time sexual encounters, and 49.6% reported reducing sex with partners met on dating apps or at sex venues. In addition, 50.4% reported reducing group sex participation, and 41.9% reported reducing attendance at sex venues or social events with close contact because of the monkeypox outbreak.

A total of 151 respondents (18.6%) reported receiving ≥1 dose of vaccine to prevent monkeypox (Table 2). Receipt of vaccine was highest among Hispanic men (27.1%) and lowest among Black men (11.5%); 17.7% of White men and 24.2% of men of another race and ethnicity received vaccine. Receipt of vaccine was higher in urban (27.8%) and suburban (14.5%) areas than in medium or small metropolitan (7.0%) or rural (5.7%) areas and was higher in the Northeast (27.8%) and West (21.5%) than in the Midwest (14.9%) or South (13.0%) U.S. Census Regions.

* https://www.hhs.gov/about/news/2022/08/04/biden-harris-administration-bolsters-monkeypox-response-hhs-secretary-becerra-declares-public-health-emergency.html (Accessed August 25, 2022).

† This messaging was first published online June 7, 2022, and was updated as of August 5, 2022. https://www.cdc.gov/poxvirus/monkeypox/sexualhealth/index.html (Accessed August 25, 2022).

§ https://emoryamis.org (Accessed August 25, 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 et seq.

TABLE 1. Strategies for monkeypox prevention adopted by men who have sex with men since they learned about the monkeypox outbreak (N = 797) — American Men's Internet Survey, United States, August 2022

Characteristic (no. who answered not applicable)	No. (%)*		
	Decreased/Less	No change	Increased/More
No. of sex partners (108)	329 (47.8)	358 (52.0)	1 (0.1)
One-time sexual encounters (176)	309 (49.8)	305 (49.2)	6 (1.0)
Sex with a partner met on a dating app or at a sex venue (199)	294 (49.6)	294 (49.6)	5 (0.8)
Having group sex (331)	234 (50.4)	229 (49.4)	1 (0.2)
Going to sex venues or events (407)	162 (41.9)	222 (57.4)	3 (0.8)
Going to social events with close contact, such as dance parties or raves (347)	156 (34.9)	288 (64.4)	3 (0.7)
Use of condoms (275)	6 (1.2)	471 (90.8)	42 (8.1)

* Row percentages calculated after subtracting the number of respondents who reported that the individual behavior was not applicable to them, which is included in parentheses. Row totals including those who felt the item was not applicable might not sum to 797 because of missing data for individual items.

Receipt of vaccine was more common among respondents reporting two or more partners during the preceding 14 days (30.1%) than among those reporting no partners or one partner (13.9%) and among those reporting engaging in group sex with male partners during the preceding 3 months (31.5%) than among those not engaging in group sex during that time (12.8%). Among 662 persons who had not received monkeypox vaccine, 180 (28.5%) indicated that they had tried to get vaccinated.

Frequency of receipt of vaccine was similar for persons who reported having received a diagnosis of HIV infection (22.3%) and those whose most recent HIV test was negative (19.0%). Among those who reported not having HIV, a higher proportion of persons taking HIV preexposure prophylaxis (PrEP) (31.4%) than those not taking HIV PrEP (7.0%) were vaccinated. When limited to 188 men with two or more partners during the preceding 14 days, vaccination was even more prevalent among those taking HIV PrEP: 46 (38.0%) of 121 respondents taking HIV PrEP reported having received vaccine, compared with nine (13.4%) of 67 who were not taking HIV PrEP. Receipt of vaccine was also more prevalent among men who received testing for another sexually transmitted infection during the preceding 3 months.

Three (1.7%) participants reported having received a diagnosis of monkeypox, and 91 (11.4%) of 798 who responded to the question reported knowing someone who had received a diagnosis of monkeypox. Although 53.1% reported they were "somewhat concerned" or "very concerned" about monkeypox, 82.3% reported feeling confident that they could protect themselves from monkeypox.

Discussion

These findings among a convenience sample of men who reported male sexual contact provide early information about the actions that MSM are taking to reduce their risk for acquiring and transmitting *Monkeypox virus*. These data highlight the importance of health communication in the context of strong community leadership in response to the U.S. monkeypox outbreak. The adoption of prevention strategies reported here aligns with specific harm reduction strategies developed for monkeypox and with broader sexual health information and recommendations for MSM.** A modeling study that assessed the potential effects of reductions in one-time sexual partnerships found that these changes might substantially slow transmission and ultimately reduce the percentage of MSM who acquire monkeypox (*4*). It is important that federal, state, and local public health programs continue to deliver tailored harm reduction messages to diverse communities of MSM. These messages should be designed to reduce the potential for stigma (*5*) and build strength and resiliency (*6*).

These data also suggest racial and ethnic disparities in vaccination, with particularly low reported vaccination among Black men, who are disproportionately affected by monkeypox (*2*). In addition, men who were not taking HIV PrEP or who had not received STI testing were less likely to have received vaccine, suggesting opportunities to improve access for persons who are less engaged with routine health care and sexual health services. Equitable vaccine program implementation involves community engagement in program planning and implementation, engaging diverse partners already working with special populations, delivering vaccines through mobile outreach and pop-up events, and diversifying times and locations for vaccine administration.††

These survey data suggest important geographic differences in vaccination, with lower reported vaccination receipt in less urban areas and among men in the South and Midwest. This is particularly concerning because the highest number of cases reported to date have been from southern states.§§ Expanding vaccine availability geographically, including diversifying vaccination locations to include nonurban areas, can help ensure that those who need vaccination have access to it. This will be especially important as vaccine availability increases and vaccine

** https://www.cdc.gov/msmhealth/for-your-health.htm (Accessed August 25, 2022).
†† https://www.cdc.gov/poxvirus/monkeypox/interim-considerations/overview.html#equity (Accessed August 25, 2022).
§§ https://www.cdc.gov/poxvirus/monkeypox/response/2022/us-map.html (Accessed August 25, 2022).

TABLE 2. Characteristics of men who have sex with men, by receipt of vaccine to protect against monkeypox — American Men's Internet Survey, United States, August 2022

Characteristic	All participants	Received ≥1 vaccine dose
	No. (column %)	No. (row %)
Total	**824 (100.0)**	**151 (18.6)**
Age group, yrs		
15–24	46 (5.6)	10 (21.7)
25–34	227 (27.5)	50 (22.6)
35–44	147 (17.8)	35 (24.1)
45–54	128 (15.5)	23 (18.3)
≥55	276 (26.7)	33 (12.0)
Race and ethnicity*		
Black, non-Hispanic	87 (10.6)	10 (11.5)
White, non-Hispanic	581 (70.5)	102 (17.7)
Hispanic or Latino	88 (10.7)	23 (27.1)
Other	68 (8.3)	16 (24.2)
Health insurance		
None	24 (2.9)	3 (12.5)
Private only	564 (68.6)	107 (19.2)
Public only	164 (20.0)	25 (15.5)
Other or multiple insurance	70 (8.5)	16 (23.2)
Population density		
Urban	394 (47.8)	108 (27.8)
Suburban	188 (22.8)	27 (14.5)
Small/Medium metropolitan	188 (22.8)	13 (7.0)
Rural	54 (6.6)	3 (5.7)
U.S. Census Bureau region		
Northeast	174 (21.1)	48 (27.8)
Midwest	141 (17.1)	21 (14.9)
South	305 (37.0)	39 (13.0)
West	204 (24.8)	43 (21.5)
No. of partners during past 14 days		
0–1	586 (71.1)	80 (13.9)
2 or more	238 (28.9)	71 (30.1)
Had group sex with male partners during past 3 months		
No	580 (70.9)	73 (12.8)
Yes	238 (29.1)	74 (31.5)
Self-reported HIV status		
Positive	104 (12.6)	23 (22.3)
Negative	656 (79.6)	123 (19.0)
Unknown	64 (7.8)	5 (7.9)
Currently taking HIV PrEP[§]		
No	397 (57.5)	27 (7.0)
Yes	320 (44.6)	98 (31.4)
Tested for an STI during past 3 months		
No	410 (50.1)	37 (9.1)
Yes	409 (49.9)	114 (28.2)
Concerned about getting monkeypox		
Not concerned or a little concerned	382 (46.9)	47 (12.5)
Somewhat or very concerned	433 (53.1)	104 (24.4)
Feel confident that they can protect themselves from monkeypox		
Strongly or mostly disagree	132 (17.7)	13 (10.0)
Strongly or mostly agree	612 (82.3)	136 (22.6)

Abbreviations: PrEP = preexposure prophylaxis; STI = sexually transmitted infection.

* The Other category includes non-Hispanic persons of multiple races and Native Hawaiian or other Pacific Islander, American Indian or Alaska Native, and Asian persons.

† Self-reported HIV status was determined from responses to questions about having ever had an HIV test, results of the most recent HIV test, and having ever received a positive HIV test result. Participants' self-reported HIV status was categorized as positive, negative, or unknown.

§ PrEP percentage calculated only among those who reported negative or unknown HIV status (N = 720).

Summary

What is already known about this topic?

A global monkeypox outbreak is currently primarily affecting gay, bisexual, and other men who have sex with men.

What is added by this report?

In a recent survey of gay, bisexual, and other men who have sex with men, approximately one half reported reducing their number of sex partners, one-time sexual encounters, and use of dating apps because of the monkeypox outbreak. Receipt of vaccine to protect against monkeypox varied by race, ethnicity, and geography.

What are the implications for public health practice?

It is essential that public health programs continue to deliver tailored, respectful harm reduction messages that do not create stigma to diverse communities of men who have sex with men. Vaccine programs should prioritize efforts to maximize equitable access.

strategies expand beyond postexposure prophylaxis to include preexposure vaccination.

The findings in this report are subject to at least four limitations. First, this survey represents a convenience sample of Internet-using cisgender MSM who chose to participate in a survey about monkeypox. This subset of men is older and less racially diverse than the full AMIS sample (*7*), and persons who were more concerned about monkeypox might have been more likely to complete the survey, which could lead to overestimates of behavior modifications and receipt of vaccine. Additional efforts to collect information from populations disproportionately affected by the current monkeypox outbreak are underway. Second, these data are self-reported and might be subject to social desirability bias. Third, the reported number of partners during the preceding two weeks might not reflect sexual behaviors throughout the entire outbreak (and thus eligibility for expanded postexposure prophylaxis with vaccine), particularly if behaviors changed because of the outbreak or receiving vaccine; ongoing monitoring will be needed to understand persistence or changes in these findings over time. Finally, because the survey did not ask whether respondents had seen harm reduction messaging, these changes cannot be ascribed directly to messaging efforts.

Addressing inequities in vaccine availability and coverage is an urgent public health priority. However, vaccination alone will not be sufficient to end the current monkeypox outbreak. These findings suggest that MSM are already taking actions to protect their sexual health and making decisions to reduce risk to themselves and their partners. These changes are important to protect MSM from exposure before access to vaccine is possible and after vaccination.[¶¶] CDC will continue to work with state and local partners to develop and provide tailored, respectful harm reduction messaging to diverse communities affected by the monkeypox outbreak and to monitor the impact of messaging and prevention strategies, including vaccination.

[¶¶] The current vaccine regimen for JYNNEOS vaccine consists of 2 doses, 28 days apart, with maximal immune protection achieved 2 weeks after the second dose: https://www.cdc.gov/poxvirus/monkeypox/vaccines.html. Persons who are vaccinated should continue to take steps to protect themselves from monkeypox as knowledge of vaccine efficacy during the current outbreak continues to evolve: https://www.cdc.gov/poxvirus/monkeypox/considerations-for-monkeypox-vaccination.html (Accessed August 25, 2022).

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Modeling the Impact of Sexual Networks in the Transmission of *Monkeypox virus* Among Gay, Bisexual, and Other Men Who Have Sex With Men — United States, 2022

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Transmission of *Monkeypox virus* (MPXV) during the 2022 multinational monkeypox outbreak has been associated with close contact, primarily sexual behavior, between men (*1*). Survey data suggest that gay, bisexual, and other men who have sex with men (MSM) have taken steps to protect themselves and their partners from monkeypox, including reducing one-time sexual partnerships (*2*). CDC simulated dynamic network models representing the sexual behavior between MSM. Men with more than one partner in the preceding 3 weeks had 1.8–6.9 times the risk for acquiring monkeypox as did men with only one partner. Although one-time partnerships represented <3% of the total daily partnerships and 16% of the sex between men on any given day, they accounted for approximately 50% of MPXV transmission. In this model, a 40% decrease in one-time partnerships yielded a 20%–31% reduction in the percentage of MSM infected and a delay in the spread of the outbreak. A decrease in one-time partnerships not only decreased the final percentage of MSM infected, but it also increased the number of days needed to reach a given level of infection in the population, allowing more time for vaccination efforts to reach susceptible persons. If decreasing one-time partnerships were combined with additional mitigation measures such as vaccination or shorter time from symptom onset to testing and treatment, this effect would be higher. Reductions in one-time partnerships, a change in behavior already being reported by MSM, might significantly reduce MPXV transmission.

CDC adapted previously developed models of sexual infection transmission used to study HIV and gonorrhea transmission in the United States* (*3*,*4*); this framework has also been used to study MPXV spread in Belgium (*5*) (Supplementary Box 1; https://stacks.cdc.gov/view/cdc/120605). In this dynamic network modeling framework, men may have zero or one main partnership at a time, assumed to last 477 days on average, as well as zero, one, or two casual partnerships at a time, assumed to last 166 days on average. Men may also form one-time partnerships that last 1 day, meant to mimic a single sexual encounter that is not repeated. A man could possibly have main, casual, and one-time partnerships concurrently. The model includes six strata of sexual activity, which differ in their rate of one-time partnership formation (Supplementary Box 2; https://stacks.cdc.gov/view/cdc/120606). These partnership strata were informed by data collected during 2016–2019 from MSM in Atlanta, Georgia, who reported the number, type, and duration of their current sexual partnerships (*3*,*4*,*6*).

MPXV natural history and MSM care-seeking behaviors were based on previous publications, and metrics observed during the current outbreak response when available (*7*) (Supplementary Box 2; https://stacks.cdc.gov/view/cdc/120606). Because of uncertainty about how widely MPXV might spread among MSM, two scenarios in which 10 highly active cases were introduced to a population of 10,000 MSM were simulated, representing lower and higher transmission, by adjusting the transmission probability per act, so that MPXV would eventually infect approximately 15% (lower transmission) and 25% (higher transmission) of MSM. Within each transmission scenario, the model estimated the final individual risk for acquiring monkeypox within each of the six sexual activity strata. The model also summarized the proportion of MPXV transmission that occurred via each partnership type. Finally, the reduction in the final proportion of MSM infected was estimated at baseline and under a scenario in which MSM decreased their one-time partnering by 40% 2.5 months after MPXV entered the population, which is similar to recent survey results (*2*). All simulations were conducted in R (version 4.2.0; R Foundation) using the EpiModel package (*8*).

MSM with more than one partner in the previous 3 weeks had 1.8–6.9 times the risk for acquiring monkeypox compared with those who only had one partner in the past 3 weeks, depending on the transmission scenario (Table). The higher transmission scenario resulted in larger differences in risk between men in higher and lower activity strata. For example, in the lower transmission scenario the men in the highest activity stratum had 3.6 times the risk for acquiring monkeypox compared with men who only had one partner in the past 3 weeks; in the higher transmission scenario these men had nearly seven times the risk for acquiring monkeypox. Activity strata with an average of fewer than one partner in the past 3 weeks led to decreased risk for acquiring monkeypox.

*Modeling code is available for download. https://github.com/CDCgov/mpx_networkmodel_mmwr

Modeled one-time partnerships had a disproportionate effect on transmission (Figure 1). Although one-time partnerships represented 3% of the total daily partnerships and 16% of the sexual contacts on any given day in the models, these partnerships accounted for 46%–54% of MPXV transmission, depending on the transmission scenario. In the lower transmission scenario, 54.0% of transmission occurred through one-time, 33.2% through casual, and 12.9% through main partnerships over the course of the outbreak. In the higher transmission scenario, 45.6% of transmission occurred through one-time, 38.8% through casual, and 15.6% through main partnerships over the course of the outbreak. In both lower and higher transmission scenarios, casual partnerships played a larger role in transmission than did main partnerships.

The model predicted that a 40% decrease in one-time partnerships would result in a 20%–31% reduction in the final percentage of MSM infected, depending on the transmission scenario (Figure 2), with larger impact in the lower transmission scenario. This impact could be stronger if combined with additional mitigation measures including vaccination or shorter time from symptom onset to testing and treatment. A decrease in one-time partnerships not only decreased the final percentage of MSM infected, but it also increased the number of days needed to reach a given level of infection in the population, allowing more time for vaccination efforts to reach susceptible persons. For example, reductions in one-time partnerships delayed the timing of 10% cumulative infection by approximately 150 days. Decreased one-time partnerships also led to fewer MSM being infected at any given time.

Discussion

This analysis illustrates that risk for MPXV acquisition varies widely among MSM according to the number of sexual partners a person has. In addition, one-time sexual partnerships are important contributors to the spread of MPXV through a sexual network. The model predicts that reductions in the number of one-time partnerships at a level already reported by MSM (*2*) might result in reductions in the final proportion of MSM infected and a slower-developing outbreak that would ultimately lead to fewer MSM infected at any given time. These changes might allow for additional time for other prevention measures, such as vaccination, to be more widely implemented and disseminated and reduce the impact on health care systems.

Although the importance of number of partners has been well established previously (*9*), the importance of one-time partnerships isn't as widely understood. Having a large number of partners, as is facilitated by having many one-time partnerships, results in broad connectivity in a sexual network. This increases transmission of all sexually transmitted infections but is particularly important for an infection like monkeypox, which has a short, symptomatic contagious period.

The findings show that changes already being reported by MSM (*2*) can have important implications for the trajectory of the monkeypox outbreak. Current vaccination efforts are challenged by the speed with which the outbreak is spreading: the quicker the outbreak spreads, the faster persons become infected, resulting in insufficient time for many men who are susceptible and at risk to receive a vaccine. Because current vaccine supply is limited, measures that might delay the spread of MPXV, such as reduction in one-time partnerships, could be critical for broadening vaccine coverage and lowering the cumulative infection rate.

The findings in this report are subject to at least five limitations. First, data on MPXV transmission needed to develop these types of models are currently limited. The model included scenarios reflecting a lower and higher transmission potential of MPXV; however, the actual transmission potential of this outbreak might be outside the bounds considered. If MPXV

TABLE. Modeled mean number of partners, population size, and risk ratio for acquiring monkeypox among gay, bisexual, and other men who have sex with men, by level of sexual activity — United States, 2022*

	Mean no. and types[§] of partners during time interval					
	Past yr	Past 3 wks			RR (by transmission scenario)	
Sexual activity stratum[†]	All types	All types	One-time only	% of population	Lower	Higher
1 (lowest)	1.8	0.8	0.0	19	0.6	0.5
2	1.8	0.8	0.0	19	0.7	0.5
3	4.0	0.9	0.1	19	0.9	0.9
4	4.0	1.0	0.2	19	1.0[¶]	1.0[¶]
5	14.7	1.5	0.7	19	1.8	2.3
6 (highest)	124.7	6.6	5.8	5	3.6	6.9

Abbreviation: RR = risk ratio.

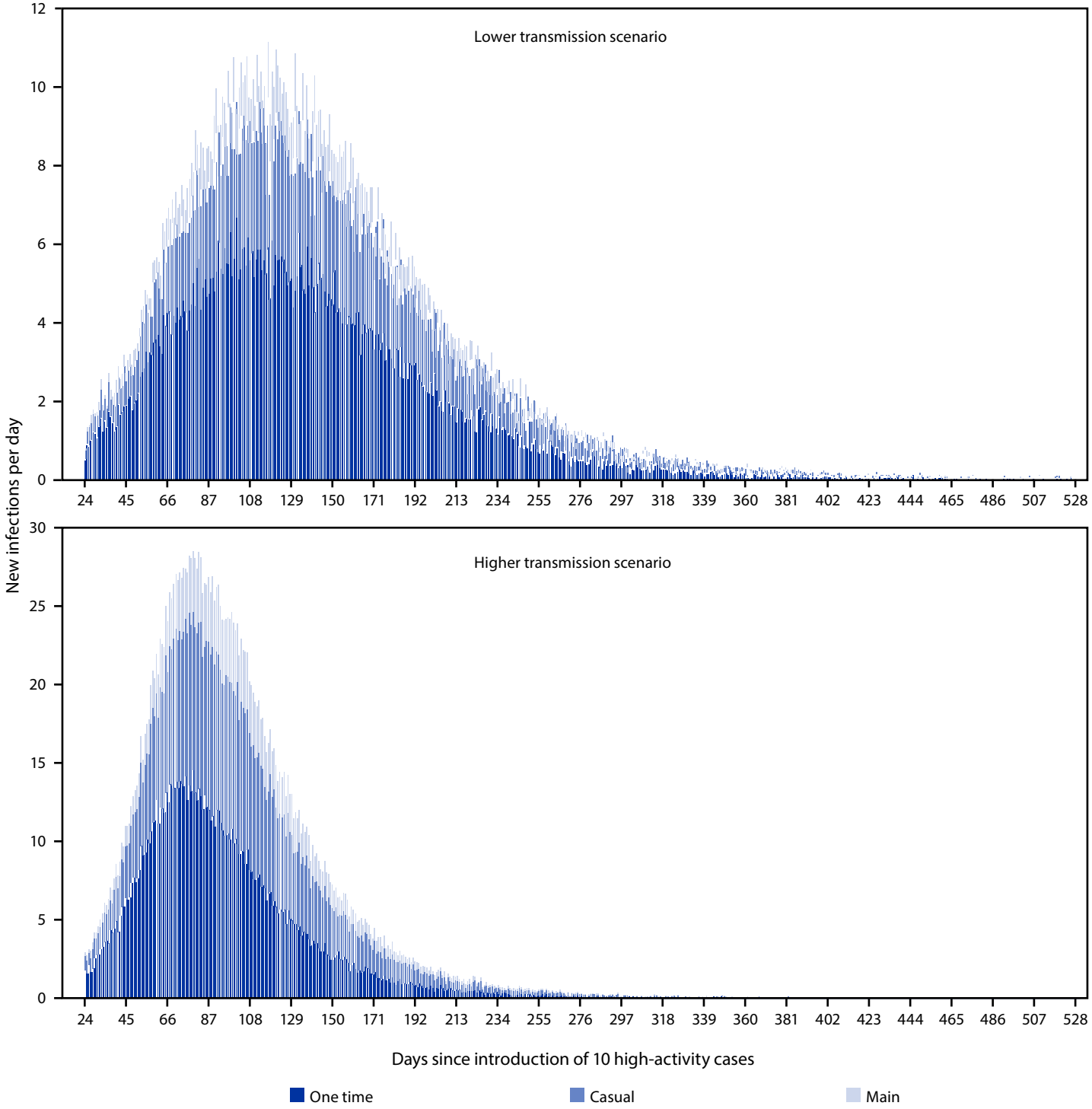
* Contact data sources: https://doi.org/10.1016/j.epidem.2020.100386; https://doi.org/10.1093/infdis/jiw223; https://doi.org/10.1093/infdis/jiw223

† Based on rate of one-time partnership formation. MSM in stratum 1 have a 0.000 probability of having a one-time sexual partner on any given day, and MSM in stratum 6 have a 0.286 probability of having a one time-time sexual partner on any given day. Strata 2–5 have one-time partnership probabilities between these two endpoints on any given day.

§ Partnerships include main (assumed to last an average of 477 days), casual (assumed to last an average of 166 days), and one-time (assumed to last 1 day).

¶ Comparison group for RR calculation.

FIGURE 1. Modeled number* of new infections each day by lower† and higher§ transmission scenarios and type of partnership over the course of a monkeypox outbreak among men who have sex with men, by time since importation of 10 high activity cases — United States, 2022



* Numbers presented are the mean number of infections across 60 stochastic trials in which no premature extinction occurred.
† In the lower transmission scenario, it was assumed that there was a 60% probability of *Monkeypox virus* transmission per sex act: 54.0% of transmission occurred through one time, 33.2% through casual, and 12.9% through main partnerships over the course of the outbreak.
§ In the higher transmission scenario, it was assumed that there was a 90% probability of *Monkeypox virus* transmission per sex act: 45.6% of transmission occurred through one time, 38.8% through casual, and 15.6% through main partnerships over the course of the outbreak.

were less intensely transmitted, a larger difference in infection risk between the highest and lowest activity strata and a larger impact of behavioral change would be anticipated. If MPXV were more intensely transmitted, a smaller difference in infection risk between the highest and lowest activity strata and a smaller impact of behavioral change would be anticipated. Second, superspreading events are not explicitly modeled. However, because persons in the highest activity stratum have approximately 100 partners per year, some of these one-time partnerships are occurring on the same day, which might adequately approximate a superspreading event. However, the model does not include specific events on a given date. Third, contact tracing is not modeled. Although contact tracing could help reduce infection levels, the exclusion of this mechanism is unlikely to change inferences related to number of partners or one-time partnerships. Fourth, regular reintroductions of MPXV infections are also not modeled. Ignoring regular importation (or exportation) of infections is also unlikely to affect inferences. Finally, the data used to characterize the sexual partnering behavior of MSM were collected among MSM aged <40 years at venues such as bars, bookstores, and other lesbian, gay, bisexual, and transgender–friendly places, and the data might not be representative of all MSM and might have oversampled MSM with more frequent sexual activity.

In the current outbreak, MPXV has been transmitted predominantly through close contact associated with sexual activity. Therefore, identifying factors that put persons at increased risk for acquiring and transmitting infection is critical to understanding transmission and tailoring mitigation strategies and control measures. These models show that personal decisions and public health interventions around one-time partnerships can have a substantial impact on reducing MPXV transmission. Changes in number of sex partners, and particularly changes in one-time partnerships, which are already being reported by MSM (*2*), have the potential to delay the spread of the outbreak. This could allow vaccination and implementation of other mitigation efforts to reach populations at high risk before they have been exposed to MPXV, and ultimately reduce MPXV transmission.

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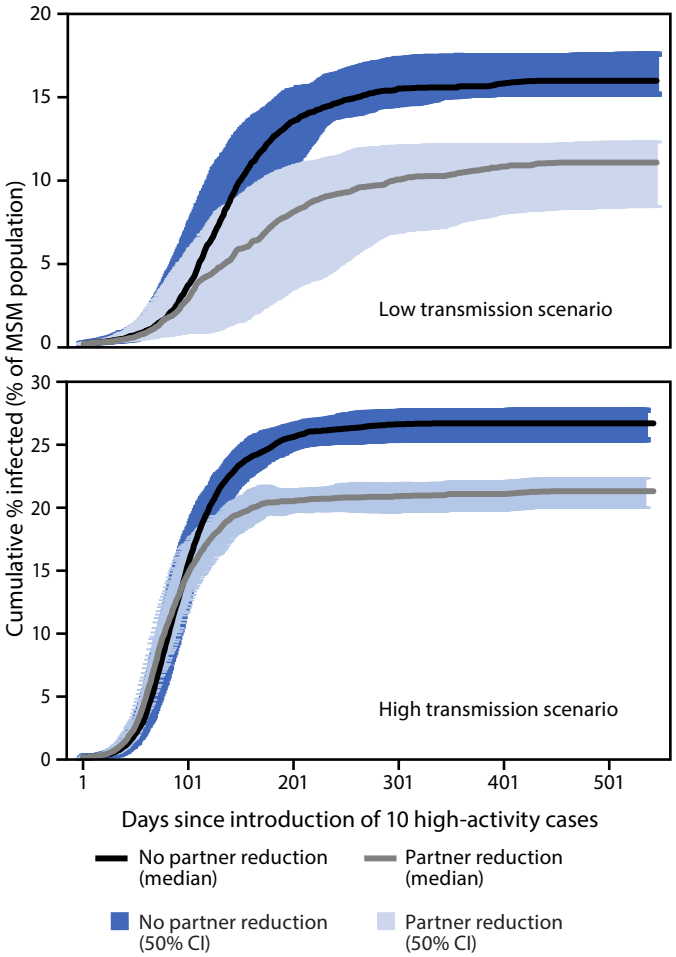
FIGURE 2. Modeled impact* of reduction in one-time sexual partners† in a monkeypox outbreak among men who have sex with men with lower§ and higher¶ transmission scenarios, by days since importation of 10 high activity cases — United States, 2022



Abbreviations: CI = credibility interval; MSM = men who have sex with men.
* The 50% CI were calculated from 60 stochastic trials in which no premature extinction occurred.
† Represents a behavior change that assumes a 40% reduction in one-time partnership formation at day 75 of the outbreak.
§ In the lower transmission scenario, behavior change caused a 31% proportionate reduction in the final percentage infected.
¶ In the higher transmission scenario, behavior changed caused a 20% proportionate reduction in the final percentage infected.

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Summary

What is already known about this topic?

The 2022 monkeypox outbreak is associated with sexual and intimate contact. Survey data suggest that gay, bisexual, and other men who have sex with men (MSM), who have been disproportionately affected, are reducing one-time partnerships.

What is added by this report?

Modeling of sexual infection transmission between men indicates that one-time partnerships, which account for 3% of daily sexual partnerships and 16% of daily sex acts, account for approximately 50% of daily *Monkeypox virus* (MPXV) transmission. A 40% reduction in one-time partnerships might delay the spread of monkeypox and reduce the percentage of persons infected by 20% to 31%.

What are the implications for public health practice?

Reductions in one-time partnerships, already being reported by MSM, might significantly reduce MPXV transmission.

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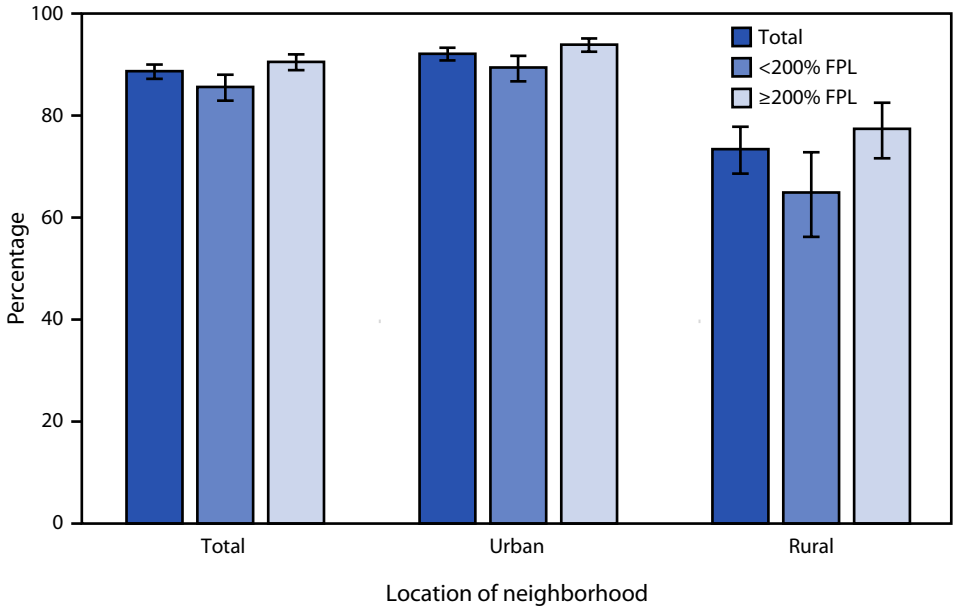
QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Percentage* of Children and Adolescents Aged 6–17 Years Who Have Roads, Sidewalks, Paths, or Trails Where They Can Walk or Ride a Bicycle,† by Urban-Rural Status§ and Family Income¶ — National Health Interview Survey, United States, 2020**



Abbreviations: FPL = federal poverty level; MSA = metropolitan statistical area.
* With 95% CIs indicated by error bars.
† Based on a positive response to the question, "Where the child lives, are there roads, sidewalks, paths or trails where they can walk or ride a bicycle?"
§ Urban-rural status is determined by the Office of Management and Budget's February 2013 delineation of MSAs, in which each MSA must have at least one urban area of ≥50,000 inhabitants. Areas with <50,000 inhabitants are grouped into the rural category.
¶ 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.

During 2020, 88.7% of children and adolescents aged 6–17 years had roads, sidewalks, paths, or trails in their neighborhood or near their home where they could walk or ride a bicycle. Availability of these spaces was less common among children and adolescents who lived in families with incomes <200% of FPL (85.6%) than among those in families with incomes ≥200% of FPL (90.5%) and was consistent among children and adolescents in both urban (89.4% versus 93.9%) and rural (64.9% versus 77.4%) areas. Regardless of income, availability of spaces to walk or ride a bicycle was lower among children and adolescents living in rural areas (73.4%) than among those in urban areas (92.1%).

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

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