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National, Regional, State, and Selected Local Area Vaccination Coverage Among Adolescents Aged 13–17 Years — United States, 2017

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The Advisory Committee on Immunization Practices (ACIP) recommends routine vaccination of persons aged 11–12 years with human papillomavirus (HPV) vaccine, quadrivalent meningococcal conjugate vaccine (MenACWY), and tetanus and reduced diphtheria toxoids and acellular pertussis vaccine (Tdap). A booster dose of MenACWY is recommended at age 16 years (*1*), and catch-up vaccination is recommended for hepatitis B vaccine (HepB), measles, mumps, and rubella vaccine (MMR), and varicella vaccine (VAR) for adolescents whose childhood vaccinations are not up to date (UTD) (*1*). ACIP also recommends that clinicians may administer a serogroup B meningococcal vaccine (MenB) series to adolescents and young adults aged 16–23 years, with a preferred age of 16–18 years (*2*). To estimate U.S. adolescent vaccination coverage, CDC analyzed data from the 2017 National Immunization Survey–Teen (NIS-Teen) for 20,949 adolescents aged 13–17 years.* During 2016–2017, coverage increased for ≥1 dose of HPV vaccine (from 60.4% to 65.5%), ≥1 dose of MenACWY (82.2% to 85.1%), and ≥2 doses of MenACWY (39.1% to 44.3%). Coverage with Tdap remained stable at 88.7%. In 2017, 48.6% of adolescents were UTD with the HPV vaccine series (HPV UTD) compared with 43.4% in 2016.† On-time vaccination (receipt of ≥2 or ≥3 doses of HPV vaccine by age 13 years) also increased. As in 2016, ≥1-dose HPV vaccination coverage was lower among adolescents living

*Eligible participants were born during January 1999–February 2005. Tdap coverage represents receipt of ≥1 Tdap dose at age ≥10 years. MenACWY coverage represents receipt of the quadrivalent meningococcal conjugate vaccine or meningococcal vaccine of unknown type. MenB coverage represents receipt of at least 1 dose of either a 2-dose or 3-dose series, depending upon the vaccine brand. HPV vaccination coverage includes receipt of any HPV vaccine and does not distinguish between nine-valent (9vHPV), quadrivalent (4vHPV), or bivalent (2vHPV) vaccines. Some adolescents might have received more than the 2 or 3 recommended HPV vaccine doses. Estimates for hepatitis B and MMR vaccines represent coverage based on catch up for adolescents who were 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. Influenza vaccination coverage data are not included in this report but are available online at https://www.cdc.gov/flu/fluvaxview/index.htm.

†Adolescents were considered to be HPV UTD if they had received ≥3 doses, or if all of the following applied: 1) they had received 2 doses; 2) the first dose was received before the 15th birthday; and 3) the interval between the first and second doses was ≥5 months minus 4 days, the absolute minimum interval between the first and second doses. https://www.cdc.gov/vaccines/programs/iis/cdsi.html.

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in nonmetropolitan statistical areas (MSAs) (59.3%) than among those living in MSA principal cities (70.1%).[§] Although HPV vaccination initiation remains lower than coverage with MenACWY and Tdap, HPV vaccination coverage has increased an average of 5.1 percentage points annually since 2013, indicating that continued efforts to target unvaccinated teens and eliminate missed vaccination opportunities might lead to HPV vaccination coverage levels comparable to those of other routinely recommended adolescent vaccines.

NIS-Teen is an annual survey that estimates vaccination coverage among adolescents aged 13–17 years in the 50 states, the District of Columbia (DC), selected local areas, and territories.[¶] NIS-Teen is conducted among parents and guardians of eligible adolescents identified using a random-digit–dialed sample of landline and cellular telephone numbers.[**] Parents and guardians are interviewed by telephone about the sociodemographic characteristics of the adolescent and household. Contact information and consent to contact the teen's vaccination providers are requested. When more than one age-eligible adolescent lives in the household, one is randomly selected for participation. Vaccination providers identified during the interview are mailed a questionnaire requesting the vaccination history from the teen's medical record.[††] Vaccination coverage estimates are based on provider-reported vaccination histories. This report summarizes national vaccination coverage for 20,949 adolescents (9,845 females

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

[¶] The following local areas that received federal Section 317 immunization funds were sampled separately: Chicago, Illinois; New York, New York; Philadelphia County, Pennsylvania; Bexar County, Texas; and Houston, Texas. Three local areas were oversampled (Dallas County, Texas, El Paso County, Texas, and Travis County, Texas). Three territories were sampled separately in 2017 (Guam, Puerto Rico, and the U.S. Virgin Islands). Because of the severity of 2017's hurricane season, survey operations in Puerto Rico and the U.S. Virgin Islands were suspended resulting in insufficient data for estimation of vaccination coverage.

[**] All identified cellular-telephone households were eligible for interview. Sampling weights were adjusted for dual-frame (landline and cellular telephone), nonresponse, noncoverage, and overlapping samples of mixed telephone users. A description of NIS-Teen dual-frame survey methodology and its effect on reported vaccination estimates is available at https://www.cdc.gov/vaccines/imz-managers/coverage/nis/child/dual-frame-sampling.html. Starting in 2018, the landline telephone sample was dropped.

[††] For the telephone samples for the states and local areas, the overall Council of American Survey Research Organizations (CASRO) response rate was 25.7% (51.5% for the landline sample and 23.5% for the cellular-telephone sample). For adolescents with completed interviews, 48.1% had adequate provider data (53.6% landline sample, 47.1% cell sample). Among completed interviews with adequate provider data, 17% (3,572) were from the landline sample, and 83% (17,377) were from the cellular telephone sample. For Guam, the overall CASRO response rate was 31.3%. The CASRO response rate is the product of three other rates: 1) the resolution rate (the proportion of telephone numbers that can be identified as either for 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).

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[47%] and 11,104 males [53%]) aged 13–17 years with adequate provider data.[§§]

Data were weighted and analyzed to account for the complex sampling design of NIS-Teen. NIS-Teen methodology, including methods for weighting and synthesizing provider-reported vaccination histories, has been described previously (*3*). T-tests were used to assess vaccination coverage differences between 2017 and 2016 and between demographic subgroups (i.e., age, health insurance status, MSA status, race/ethnicity, and poverty level). Weighted linear regression by survey year was used to estimate annual percentage point changes in coverage. Trends in HPV vaccination initiation and HPV UTD status by year of birth were assessed using combined data from 2016 and 2017 NIS-Teen; p-values <0.05 were considered statistically significant.

National Vaccination Coverage

In 2017, coverage with ≥1 dose of HPV vaccine was 65.5% among teens, an increase of 5.1 percentage points compared with 2016; 48.6% were HPV UTD with the recommended vaccination series, an increase of 5.2 percentage points from 2016 (Table 1) (Figure). Among adolescents surveyed during 2016–2017, HPV vaccination initiation by age 13 years increased an average of 5.9 percentage points for each birth year, from 19.6% (1998 birth cohort) to 56.3% (2004 birth cohort) (Supplementary Figure 1, https://stacks.cdc.gov/view/cdc/58071). HPV UTD status by age 13 years increased an average of 3.6 percentage points for each birth year, from 7.7% (1998 birth cohort) to 29.8% (2004 birth cohort). Coverage with ≥1 and ≥2 MenACWY doses, ≥2 MMR doses, and ≥2 VAR doses also increased (Table 1). Coverage with ≥1 dose of MenB among persons aged 17 years was 14.5% (95% confidence interval [CI] = 12.3%–17.1%).

Vaccination Coverage by Selected Characteristics

Coverage with ≥1 dose of HPV vaccine and HPV UTD status were higher among adolescents living below the federal poverty level (73.3% and 53.7%, respectively) than among those living at or above the poverty level (62.8% and 46.7%, respectively)[¶¶] (Table 2). Coverage with ≥1 dose of HPV vaccine was 10.8 percentage points lower among adolescents living in non-MSAs and 7.0 percentage points lower among those living in MSA nonprincipal cities compared with those living in MSA principal cities (Table 2). These disparities remained after controlling for poverty level.[***] HPV UTD status was 10.0 percentage points lower among adolescents living in non-MSAs and 5.5 percentage points lower among those living in MSA nonprincipal cities compared with those living in MSA principal cities (Table 2). After adjusting for poverty level, differences in HPV UTD status did not persist among adolescents living in MSA nonprincipal cities, but did among adolescents living in non-MSAs compared with those living in MSA principal cities.[†††] ≥1- and ≥2-dose MenACWY coverage rates among adolescents living in non-MSAs were 7.4 and 12.0 percentage points lower, respectively, than those among adolescents living in MSA principal cities (Table 2). This disparity remained after controlling for poverty level.[§§§] Differences in HPV vaccination coverage by race/ethnicity in 2017 were similar to patterns observed in previous years (Supplementary Table 1, https://stacks.cdc.gov/view/cdc/58073) (*4*). Coverage with ≥1 dose of HPV vaccine and HPV UTD status were 8.8 and 6.6 percentage points higher, respectively, among adolescents enrolled in Medicaid than among those with private insurance only (Supplementary Table 2, https://stacks.cdc.gov/view/cdc/58074). HPV UTD status, ≥1-dose MenACWY, and ≥2-dose MenACWY coverage rates were 12.7, 5.0, and 22.6 percentage points lower, respectively, among uninsured adolescents than among those with private insurance (Supplementary Table 2).

[§§] Adolescents from Guam (n = 382).

[¶¶] Adolescents were classified as below the federal poverty level if their total family income was less than the federal poverty level specified for the applicable family size and number of children aged <18 years. All others were classified as at or above the poverty level. Poverty status was unknown for 779 adolescents. https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html.

[***] Among adolescents living below poverty level, ≥1-dose HPV vaccination coverage estimates stratified by MSA status were 63.7% (95% CI = 58.4%–68.7%) for adolescents living in non-MSAs, 70.4% (CI = 65.8%–74.7%) for adolescents living in MSA nonprincipal cities, and 78.0% (CI = 74.1%–81.5%) for adolescents living in MSA principal cities (reference group). Among adolescents living at or above poverty level, ≥1-dose HPV vaccination coverage estimates were 56.9% (CI = 53.8%–60.0%) for adolescents living in non-MSAs, 61.6% (CI = 59.6%–63.6%) for adolescents living in MSA nonprincipal cities, and 66.0% (CI = 63.7%–68.2%) for adolescents living in MSA principal cities (reference group).

[†††] Among adolescents living below poverty level, HPV UTD status estimates stratified by MSA status were 44.3% (CI = 39.1%–49.6%), 52.8% (CI = 47.8%–57.8%), and 57.0% (CI = 52.4%–61.5%) for adolescents living in non-MSAs, MSA nonprincipal cities, and MSA principal cities (reference group), respectively. Among adolescents living at or above poverty level, HPV UTD status estimates stratified by MSA status were 40.7% (CI = 37.6%–48.3%), 46.1% (CI = 44.0%–48.2%), and 49.3% (CI = 46.9%–51.7%) for adolescents living in non-MSAs, MSA nonprincipal cities, and MSA principal cities (reference group), respectively.

[§§§] Among adolescents living below poverty level, ≥1-dose MenACWY coverage estimates stratified by MSA status were 83.2% (CI = 79.3%–86.5%), 87.7% (CI = 84.0%–90.7%), and 85.1% (CI = 80.9%–88.5%) for adolescents living in non-MSAs, MSA nonprincipal cities, and MSA principal cities (reference group), respectively. Among adolescents living at or above poverty level, ≥1-dose MenACWY coverage estimates were 76.0% (CI = 73.1%–78.7%), 85.7% (CI = 84.0%–87.3%), and 86.0% (CI = 84.3%–87.5%) for adolescents living in non-MSAs, MSA nonprincipal cities, and MSA principal cities (reference group), respectively.

TABLE 1. Estimated vaccination coverage with selected vaccines and doses among adolescents aged 13–17*years, by age at interview — National Immunization Survey–Teen (NIS–Teen), United States, 2017

Vaccine	Age (yrs) % (95% CI)†					Total % (95% CI)†	
	13 (n = 4,283)	14 (n = 4,429)	15 (n = 4,212)	16 (n = 4,218)	17 (n = 3,807)	2017 (n = 20,949)	2016 (n = 20,475)
Tdap§ ≥1 dose	86.4 (84.0–88.4)	89.9 (88.0–91.5)¶	89.4 (87.7–91.0)¶	89.7 (87.7–91.5)¶	88.1 (85.4–90.3)	**88.7 (87.8–89.6)**	**88.0 (87.1–88.9)**
MenACWY**							
≥1 dose	83.6 (81.2–85.8)	85.8 (83.8–87.6)	85.1 (83.1–86.9)	86.6 (84.5–88.4)	84.4 (81.7–86.8)	**85.1 (84.2–86.1)††**	**82.2 (81.2–83.2)**
≥2 doses§§	NA	NA	NA	NA	44.3 (41.4–47.2)	**44.3 (41.4–47.2)††**	**39.1 (36.1–42.1)**
HPV¶¶ vaccine – all adolescents							
≥1 dose	60.7 (57.9–63.5)***	65.1 (62.5–67.6)¶	66.5 (63.8–69.1)¶	67.3 (64.7–69.8)¶	68.1 (65.4–70.7)¶	**65.5 (64.3–66.7)††**	**60.4 (59.2–61.6)**
UTD†††	39.0 (36.2–41.8)***	48.3 (45.5–51.2)¶	50.7 (47.8–53.6)¶	52.7 (49.8–55.5)¶	52.5 (49.5–55.4)¶	**48.6 (47.3–49.9)††**	**43.4 (42.1–44.7)**
HPV¶¶ vaccine – females							
≥1 dose	64.5 (60.5–68.3)***	67.8 (63.8–71.6)	67.2 (63.4–70.9)	71.5 (67.8–75.0)¶	72.0 (68.1–75.6)¶	**68.6 (66.9–70.2)††**	**65.1 (63.3–66.8)**
UTD	43.7 (39.6–47.8)***	52.7 (48.3–57.1)¶	53.3 (49.1–57.5)¶	57.5 (53.3–61.5)¶	58.7 (54.2–63.1)¶	**53.1 (51.2–55.0)††**	**49.5 (47.6–51.4)**
HPV¶¶ vaccine – males							
≥1 dose	57.1 (53.1–61.0)	62.4 (59.1–65.6)¶	65.7 (61.9–69.3)¶	63.4 (59.7–67.0)¶	64.3 (60.6–67.9)¶	**62.6 (60.9–64.2)††**	**56.0 (54.3–57.7)**
UTD	34.4 (30.8–38.2)	44.1 (40.6–47.6)¶	48.1 (44.1–52.2)¶	48.2 (44.3–52.1)¶	46.4 (42.5–50.4)¶	**44.3 (42.6–46.0)††**	**37.5 (35.8–39.2)**
MMR ≥2 doses	93.7 (92.4–94.8)	91.6 (89.6–93.3)	92.1 (90.3–93.5)	91.6 (89.5–93.2)	91.3 (89.4–92.9)¶	**92.1 (91.3–92.8)††**	**90.9 (90.1–91.6)**
Hepatitis B vaccine ≥3 doses	93.0 (91.4–94.3)	92.4 (90.6–93.8)	91.6 (89.8–93.1)	90.9 (88.9–92.6)	91.7 (89.8–93.3)	**91.9 (91.1–92.6)**	**91.4 (90.7–92.1)**
Varicella vaccine							
History of varicella disease§§§	9.8 (8.2–11.7)	11.4 (10.0–13.1)	13.7 (11.6–16.1)¶	14.9 (12.7–17.4)¶	16.5 (14.6–18.6)¶	**13.2 (12.3–14.2)††**	**15.2 (14.3–16.1)**
No history of varicella disease							
≥1 vaccine dose	96.7 (95.6–97.5)	95.7 (93.9–97.1)	95.5 (94.2–96.6)	94.4 (92.2–96.0)¶	94.9 (92.8–96.5)	**95.5 (94.8–96.1)**	**95.0 (94.2–95.6)**
≥2 vaccine doses	92.0 (90.2–93.6)	90.2 (87.9–92.1)	88.8 (86.6–90.7)¶	86.1 (83.7–88.2)¶	85.4 (82.7–87.7)¶	**88.6 (87.6–89.5)††**	**85.6 (84.5–86.6)**
History of varicella disease or receipt of ≥2 varicella vaccine doses	92.8 (91.1–94.2)	91.3 (89.2–93.0)	90.3 (88.4–92.0)¶	88.2 (86.1–90.0)¶	87.8 (85.5–89.7)¶	**90.1 (89.3–90.9)††**	**87.8 (86.9–88.6)**

Abbreviations: CI = confidence interval; HPV = human papillomavirus; MenACWY = quadrivalent meningococcal conjugate vaccine; MMR = measles, mumps, and rubella vaccine; NA = not applicable, Tdap = tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine; UTD = up–to–date.

* Adolescents (N = 20,949) in the 2017 NIS–Teen were born January 1999 through February 2005.

† Estimates with 95% CIs >20 might be unreliable.

§ Includes percentages receiving Tdap vaccine 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 receiving MenACWY or meningococcal vaccine of unknown type.

†† Statistically significant difference (p<0.05) compared with 2016 NIS-Teen estimates.

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

¶¶ HPV vaccine, nine–valent (9vHPV), quadrivalent (4vHPV), or bivalent (2vHPV). For ≥1 dose measures, percentages are reported among females and males combined (N = 20,949) and for females only (N = 9,845) and males only (N = 11,104).

*** Statistically significant difference (p<0.05) in estimated vaccination coverage at age 13 years compared with 2016 NIS-Teen estimates.

††† 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. This update to the HPV recommendation occurred in December of 2016.

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

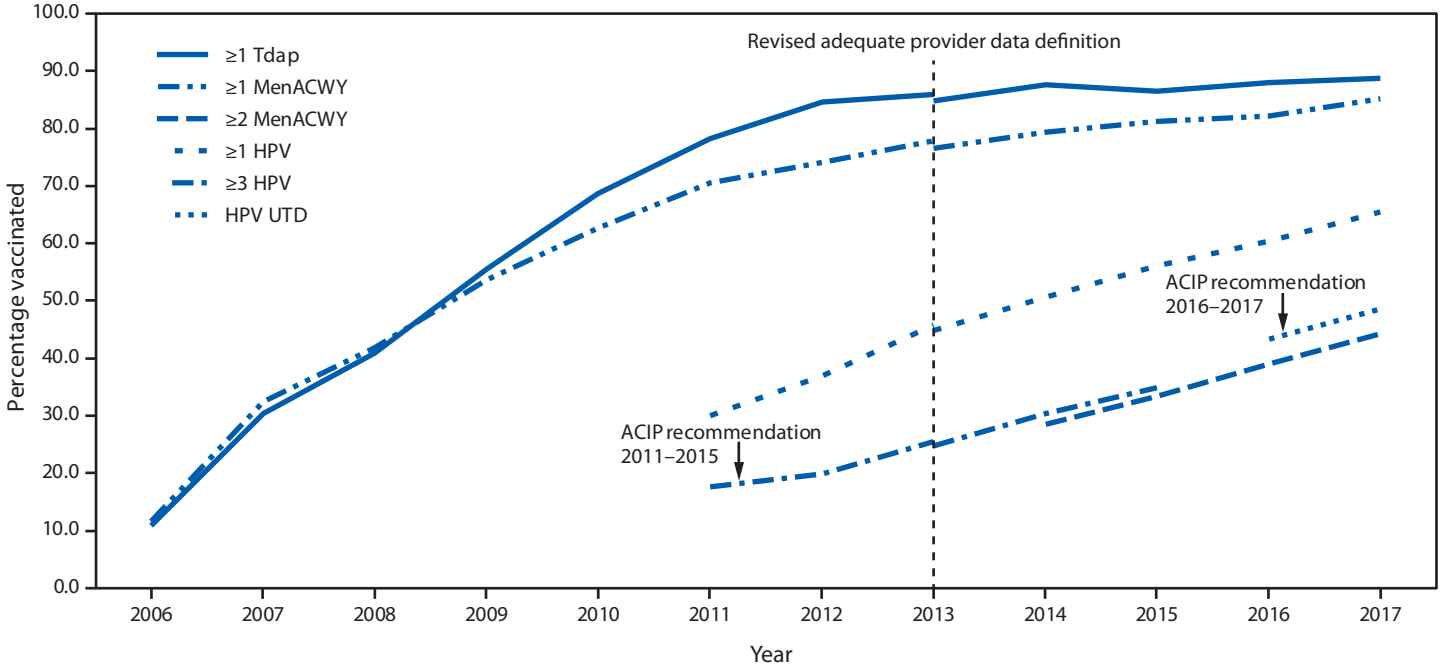
State, Local, and Territorial Vaccination Coverage

Vaccination coverage varied by jurisdiction (Table 3). Coverage with ≥1 dose of Tdap ranged from 78.9% in Alaska to 96.2% in Massachusetts; with ≥1 dose of MenACWY, from 60.7% in Wyoming to 95.3% in Georgia; and with ≥1 dose of HPV vaccine, from 46.9% in Wyoming to 91.9% in DC (Table 3) (Supplementary Figure 2, https://stacks.cdc.gov/view/cdc/58072). HPV UTD status ranged from 28.8% in Mississippi to 78.0% in DC. The largest increases in HPV UTD status from 2016 to 2017 occurred in Virginia (19.8 percentage points), DC (16.0), South Carolina (13.6), Nebraska (12.4), Dallas, Texas (11.8), Louisiana (11.1), North Carolina (10.7), Massachusetts (8.9), Vermont (8.8), and Texas (6.8) (Table 3). During 2013–2017, ≥1-dose HPV vaccination coverage increased an average of 5.1 percentage points per year nationally; the 5-year average annual increase ranged from 2.2 to 8.5 percentage points. The largest average annual increases were in Virginia (8.5 percentage points), DC (7.5), Montana (7.4), and in Arkansas, Iowa, Utah, and El Paso, Texas (7.3 percentage points each) (Supplementary Table 3, https://stacks.cdc.gov/view/cdc/58075).

Discussion

In 2017, adolescent vaccination coverage with ≥1 dose of HPV vaccine, ≥1 and ≥2 doses of MenACWY, ≥2 doses of MMR, and ≥2 doses of VAR increased, while coverage with ≥1 dose of Tdap and ≥3 doses of HepB remained high. This report includes the first U.S. estimates of ≥1-dose MenB coverage. Unlike MenACWY, MenB is not routinely recommended for all adolescents, and thus, the low vaccination coverage in adolescents aged 17 years (14.5%) is not unexpected.

FIGURE. Estimated coverage with selected vaccines and doses* among adolescents aged 13–17 years, by survey year and ACIP recommendations† — National Immunization Survey-Teen, United States, 2006–2017§



Abbreviations: ACIP = Advisory Committee on Immunization Practices; HPV = human papillomavirus; MenACWY = quadrivalent meningococcal conjugate vaccine; Tdap = tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine; UTD = up to date.

* ≥1 dose Tdap at or after age 10 years; ≥1 dose MenACWY or meningococcal-unknown type vaccine; ≥2 doses MenACWY or meningococcal-unknown type vaccine, calculated only among adolescents aged 17 years at time of interview. Does not include adolescents who received their first and only dose of MenACWY at or after 16 years of age; HPV vaccine, nine-valent (9vHPV), quadrivalent (4vHPV), or bivalent (2vHPV). The routine ACIP recommendation for HPV vaccination was made for females in 2006 and for males in 2011. Because HPV vaccination was not recommended for males until 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 before 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 recommendation changed from a 3-dose to 2-dose series with appropriate spacing between receipt of the first and second dose for immunocompetent adolescents initiating the series before the 15th birthday. Three doses are still recommended for adolescents initiating the series between the ages of 15 and 26 years. Because of the change in recommendation, the graph includes estimates for ≥3 doses HPV from 2011 to 2015 and the HPV UTD estimate for 2016 and 2017. Because HPV vaccination was recommended for boys in 2011, coverage for all adolescents was not measured before that year.

§ NIS-Teen implemented a revised adequate provider data definition (APD) in 2014, and retrospectively applied the revised APD definition to 2013 data. Estimates using different APD definitions may not be directly comparable.

In December 2016, a 2-dose HPV vaccine schedule was recommended for persons starting the series at age <15 years, based on data showing noninferior immunogenicity compared with 3 doses (*5*). This schedule might encourage on-time initiation of the series and facilitate completion; however, it is too early to assess its impact on vaccination coverage. The 5.1 percentage point annual increase in series initiation among all adolescents since 2013 is encouraging. Moreover, on-time vaccination (series completion by age 13 years) has increased approximately four percentage points in each successive birth cohort. Despite these improvements, HPV vaccination initiation remains lower than coverage with Tdap and MenACWY, suggesting ongoing challenges to providing all three vaccines during the same visit. Efforts are under way to promote and improve on-time vaccination, including implementing a new combined Healthcare Effectiveness Data and Information Set measure for adolescent vaccines that assesses receipt of all three routinely recommended adolescent vaccines, including HPV vaccine series completion by age 13 years (*6*).

HPV vaccine and MenACWY coverage in non-MSA areas remains lower than that in MSA areas. Disparities in coverage by MSA status were not observed for Tdap. Unlike persons living in urban settings, rural residents are less likely to have knowledge of HPV or be aware of HPV vaccine and its importance in cancer prevention (*7*,*8*). The overall shortage of health care providers, especially pediatricians, in rural areas might partially explain the lower coverage among rural adolescents (*8*,*9*). Health care providers in rural areas serve a broader population base and might be less familiar with adolescent vaccination recommendations. A study including adolescents and parents in rural Alabama identified provider education, better communication with parents and adolescents about the importance of HPV vaccination for preventing cancer, and a strong provider recommendation as being most influential in

TABLE 2. Estimated vaccination coverage with selected vaccines and doses among adolescents aged 13–17 years,* by poverty level† and metropolitan statistical area§ — National Immunization Survey–Teen (NIS-Teen), United States, 2017

	Poverty status % (95% CI)¶			Metropolitan statistical area (MSA) % (95% CI)¶				
Vaccine	Below poverty level (n = 3,579)	At or above poverty leve (n = 16,591)	Difference (n = 20,170)	Non-MSA (n = 4,123)	MSA nonprincipal city (n = 8,282)	MSA principal city (n = 8,544)	Difference between non-MSA and MSA principal city (n = 12,667)	Difference between MSA nonprincipal city and principal city (n = 16,826)
Tdap ≥1 dose**	88.2 (85.7 to 90.4)	88.8 (87.7 to 89.7)	-0.6 (-3.0 to 2.0)	88.0 (86.0 to 89.8)	88.9 (87.5 to 90.1)	88.8 (87.2 90.1)	-0.8 (-3.1 to 1.6)	0.1 (-1.8 to 2.1)
MenACWY ††								
≥1 dose	85.7 (83.2 to 87.8)	84.8 (83.7 to 85.8)	0.9 (-1.7 to 3.4)	78.6 (76.3 to 80.7)§§	86.1 (84.6 to 87.4)	86.0 (84.4 to 87.4)	-7.4 (-10.0 to 4.7)§§	0.1 (-81.2 to 83.2)
≥2 doses¶¶	46.2 (38.6 to 54.0)	42.8 (39.7 to 45.9)	3.4 (-4.9 to 11.7)	35.0 (29.6 to 40.8)§§	44.3 (40.2 to 48.5)	47.0 (42.2 to 51.9)	-12.0 (-19.5 to 4.6)§§	-2.7 (-9.1 to 3.7)
HPV**								
≥1 dose	73.3 (70.7 to 75.8)§§	62.8 (61.4 to 64.1)	10.5 (7.6 to 13.5)§§	59.3 (56.6 to 61.9)§§	63.1 (61.3 to 64.8)§§	70.1 (68.2 to 71.9)	-10.8 (-14.0 to 7.6)§§	-7.0 (-9.6 to 4.4)§§
UTD†††	53.7 (50.7 to 56.6)§§	46.7 (45.3 to 48.2)	7.0 (3.6 to 10.3)§§	42.4 (39.8 to 45.1)§§	46.9 (45.0 to 48.8)§§	52.4 (50.3 to 54.4)	-10.0 (-13.3 to 6.6)§§	-5.5 (-8.3 to 2.6)§§
≥2 MMR doses	90.6 (88.4 to 92.5)	92.4 (91.5 to 93.1)	-1.8 (-3.9 to 0.5)	92.0 (90.6 to 93.3)	92.1 (90.9 to 93.1)	92.1 (90.7 to 93.3)	0.1 (-1.9 to 1.8)	0.0 (-1.7 to 1.7)
≥3 Hepatitis B doses	89.9 (87.6 to 91.8)§§	92.5 (91.7 to 93.3)	-2.6 (-4.8 to 0.3) §§	91.3 (89.6 to 92.7)	92.0 (90.9 to 93.0)	92.0 (90.6 to 93.1)	-0.7 (-2.7 to 1.3)	0.0 (-1.6 to 1.7)
Varicella								
History of varicella disease§§§	13.8 (12.1 to 15.6)	12.6 (11.6 to 13.6)	1.2 (-0.8 to 3.2)	16.1 (14.2 to 18.2)	12.2 (11.0 to 13.5)	13.6 (12.1 to 15.2)	2.5 (0.0 to 5.1)	-1.4 (-3.4 to 0.6)
No history of varicella disease								
≥1 varicella vaccine dose	94.4 (91.9 to 96.1)	95.7 (95.0 to 96.4)	-1.3 (-3.5 to 0.8)	95.4 (94.1 to 96.5)	95.6 (94.6 to 96.5)	95.4 (94.0 to 96.4)	0.0 (-1.6 to 1.7)	0.2 (-1.3 to 1.8)
≥2 varicella vaccine doses	88.2 (85.5 to 90.4)	88.6 (87.6 to 89.6)	-0.4 (-3.1 to 2.2)	87.3 (85.4 to 89.1)	88.8 (87.4 to 90.1)	88.7 (87.0 to 90.2)	-1.4 (-3.8 to 1.1)	0.1 (-1.9 to 2.3)
History of varicella or receipt of ≥2 doses varicella vaccine	89.8 (87.5 to 91.7)	90.1 (89.1 to 90.9)	-0.3 (-2.6 to 2.0)	89.4 (87.7 to 90.8)	90.2 (88.9 to 91.3)	90.2 (88.7 to 91.5)	-0.8 (-2.9 to 1.3)	0.0 (-1.8 to 1.9)

Abbreviations: CI = confidence interval; HPV = human papillomavirus; MenACWY = quadrivalent meningococcal conjugate vaccine; MMR = measles, mumps, and rubella vaccine; Tdap = tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine; UTD = up-to-date.

* Adolescents (N = 20,949) in the 2017 NIS-Teen were born January 1999 through February 2005.

† Adolescents were classified as below poverty level if their total family income was less than the federal poverty level specified for the applicable family size and number of children aged <18 years. All others were classified as at or above the poverty level. Additional information available at https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html. Poverty status was unknown for 779 adolescents.

§ MSA status was determined based on household-reported county and city of residence, and was grouped into three categories: MSA principal city, MSA nonprincipal city, and non-MSA. MSA and principal city were as defined by the U.S. Census Bureau (https://www.census.gov/geo/reference/gtc/gtc_cbsa.html). Non-MSA areas include urban populations not located within an MSA as well as completely rural areas.

¶ Estimates with 95% CIs >20 might be unreliable.

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

†† Includes percentages receiving MenACWY and meningococcal vaccine of unknown type.

§§ Statistically significant difference (p<0.05) in estimated vaccination coverage by poverty level or metropolitan statistical area; the referent groups were adolescents living at or above poverty level and MSA principal city respectively.

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

*** HPV vaccine, nine-valent (9vHPV), quadrivalent (4vHPV), or bivalent (2vHPV) in females and males combined.

††† 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. This update to the HPV recommendation occurred in December of 2016.

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

initiation of HPV vaccination (*7*). Resources are available to facilitate discussion with adolescents and their parents about the importance of HPV vaccination (https://www.cdc.gov/hpv/). Further evaluation is needed to identify where teens are receiving Tdap in non-MSAs and better understand the barriers to providing HPV vaccine and MenACWY at these sites.

The findings in this report are subject to at least five limitations. First, the overall household response rate was 25.7% (landline = 51.5%; cell phone = 23.5%), and only 53.6% of landline-completed and 47.1% of cell phone–completed interviews included adequate provider data. Second, bias in estimates might remain after adjustment for household and provider nonresponse and phoneless households.¶¶¶ Weights have been adjusted for the increasing number of cell phone–only households over time. Nonresponse bias might change,

¶¶¶ In a sensitivity analysis of 2013 NIS-Teen data, including adjustments for incomplete sample frame, nonresponse bias, and incomplete ascertainment of vaccination status, estimates of Tdap, ≥1 dose MenACWY, and ≥1 dose HPV vaccine coverage, were estimated to be lower than actual values by 1–3 percentage points https://www.cdc.gov/vaccines/imz-managers/nis/downloads/NIS-TEEN-PUF16-DUG.pdf.

TABLE 3. Estimated vaccination coverage with selected vaccines and doses* among adolescents aged 13–17 years,† by HHS region, state, selected local area, or territory — National Immunization Survey–Teen (NIS-Teen), United States, 2017

	All adolescents (N = 20,949) % (95% CI)§			
Region, state, local area	**≥1 Tdap¶**	**≥1 MenACWY****	**≥1 HPV††**	**HPV UTD§§**
United States overall	**88.7 (87.8–89.6)**	**85.1 (84.2–86.1)¶¶**	**65.5 (64.3–66.7)¶¶**	**48.6 (47.3–49.9)¶¶**
Region I	**94.6 (93.1–95.7)**	**92.5 (90.8–93.9)**	**78.2 (75.4–80.8)¶¶**	**63.3 (60.1–66.4)¶¶**
Connecticut	94.9 (91.9–96.8)	94.9 (91.4–97.0)	71.3 (64.9–76.9)¶¶	58.0 (51.4–64.3)
Maine	85.1 (79.8–89.3)	83.9 (78.8–88.0)	75.8 (70.2–80.6)	59.2 (53.2–65.0)
Massachusetts	96.2 (93.4–97.8)	94.0 (90.7–96.2)	81.9 (76.9–85.9)¶¶	65.5 (59.7–70.8)¶¶
New Hampshire	95.1 (91.6–97.2)	87.9 (82.9–91.6)	74.2 (68.5–79.2)	59.9 (53.7–65.8)
Rhode Island	94.6 (91.0–96.8)	94.1 (90.2–96.5)	88.6 (83.3–92.4)	77.7 (71.6–82.8)
Vermont	92.8 (89.2–95.2)	84.2 (78.9–88.3)	78.7 (73.2–83.3)¶¶	64.5 (58.4–70.2)¶¶
Region II	**91.9 (89.7–93.7)**	**90.6 (88.1–92.6)**	**67.6 (64.1–71.0)**	**52.3 (48.5–56.0)**
New Jersey	90.0 (85.3–93.3)	93.3 (89.4–95.9)	65.8 (59.8–71.3)	49.6 (43.4–55.8)
New York	92.9 (90.3–94.8)	89.3 (85.9–91.9)	68.5 (64.0–72.7)	53.6 (48.9–58.2)
New York - New York City	92.9 (89.0–95.5)	88.8 (83.6–92.6)	73.3 (66.9–78.9)	61.0 (54.1–67.5)
New York - rest of state	92.8 (89.1–95.4)	89.5 (84.9–92.9)	65.5 (59.3–71.2)	48.8 (42.6–55.0)
Region III	**89.5 (87.0–91.6)**	**88.8 (86.3–91.0)¶¶**	**70.3 (67.0–73.3)¶¶**	**54.5 (51.0–57.9)¶¶**
Delaware	89.6 (84.5–93.2)	90.5 (85.7–93.7)	75.3 (69.3–80.5)	58.1 (51.6–64.4)
District of Columbia	86.1 (80.2–90.4)	91.3 (85.7–94.9)	91.9 (87.6–94.8)¶¶	78.0 (71.1–83.6)¶¶
Maryland	88.3 (82.2–92.5)	91.8 (86.5–95.1)¶¶	69.2 (62.1–75.6)	52.9 (45.4–60.2)
Pennsylvania	90.6 (86.7–93.5)	93.4 (90.3–95.6)	67.3 (62.2–72.1)	52.5 (47.3–57.7)
Pennsylvania - Philadelphia	91.6 (87.4–94.5)	91.1 (86.8–94.1)	84.9 (80.0–88.7)	69.5 (63.5–75.0)
Pennsylvania - rest of state	90.5 (85.9–93.7)	93.7 (90.1–96.0)	65.0 (59.2–70.4)	50.3 (44.5–56.0)
Virginia	89.3 (83.2–93.4)	80.0 (72.6–85.7)	75.6 (68.4–81.6)¶¶	59.0 (51.1–66.6)¶¶
West Virginia	87.5 (82.8–91.0)	87.9 (83.1–91.5)	60.9 (54.6–66.9)	43.9 (37.7–50.2)
Region IV	**90.9 (89.3–92.2)**	**82.2 (80.0–84.1)¶¶**	**60.0 (57.3–62.6)¶¶**	**43.0 (40.3–45.7)¶¶**
Alabama	88.7 (84.3–92.0)	78.3 (73.0–82.9)	58.0 (52.0–63.9)	40.3 (34.4–46.5)
Florida	91.1 (87.1–94.0)	80.2 (74.3–85.0)	59.8 (53.1–66.1)	42.3 (35.9–49.0)
Georgia	93.3 (89.3–95.9)	95.3 (91.9–97.3)	64.3 (57.5–70.6)	45.7 (39.1–52.5)
Kentucky	86.4 (81.7–90.0)	83.3 (78.3–87.4)	49.6 (43.5–55.6)	37.7 (32.1–43.7)
Mississippi	92.4 (88.6–95.0)¶¶	63.0 (56.9–68.7)	49.6 (43.4–55.9)	28.8 (23.5–34.8)
North Carolina	91.9 (87.8–94.7)	84.8 (79.4–89.0)¶¶	66.8 (60.4–72.6)¶¶	51.9 (45.3–58.4)¶¶
South Carolina	89.4 (84.5–92.8)¶¶	78.6 (72.4–83.7)¶¶	59.6 (52.7–66.0)¶¶	42.7 (36.1–49.5)¶¶
Tennessee	89.4 (84.8–92.8)	75.0 (68.5–80.6)	56.1 (49.3–62.6)	39.2 (32.8–46.1)
Region V	**91.8 (90.4–93.0)**	**89.4 (87.8–90.7)¶¶**	**65.5 (63.2–67.8)¶¶**	**49.0 (46.5–51.4)¶¶**
Illinois	92.4 (89.4–94.6)	89.2 (85.9–91.8)¶¶	66.1 (61.5–70.4)	50.4 (45.8–55.0)
Illinois - Chicago	90.5 (84.9–94.2)	90.9 (83.4–95.2)	81.9 (73.9–87.8)	66.6 (57.7–74.4)
Illinois - rest of state	92.8 (89.2–95.3)	88.9 (85.0–91.8)¶¶	62.7 (57.4–67.7)	46.9 (41.7–52.2)
Indiana	95.1 (92.3–96.9)¶¶	93.1 (89.0–95.8)	59.3 (52.8–65.5)¶¶	40.8 (34.4–47.5)
Michigan	93.4 (89.2–96.0)	93.5 (89.4–96.1)	67.3 (61.1–73.0)	54.3 (47.9–60.6)
Minnesota	87.5 (82.2–91.4)	87.5 (82.4–91.3)	68.1 (61.9–73.7)¶¶	46.9 (40.7–53.3)
Ohio	90.6 (86.9–93.3)	87.3 (83.4–90.4)¶¶	64.1 (58.4–69.3)	47.0 (41.2–52.8)
Wisconsin	90.3 (85.8–93.5)	83.8 (78.4–88.2)	69.2 (63.0–74.8)	52.3 (45.8–58.7)

See table footnotes on the next page.

which could affect comparisons of estimates between survey years. Third, estimates stratified by state/local area might be unreliable because of small sample sizes. Fourth, multiple statistical tests were conducted, and a small number might be significant because of chance alone. Finally, because NIS-Teen includes adolescents aged 13–17 years, data on receipt of MenACWY or MenB vaccine at age ≥18 years could not be collected; thus reported coverage with these vaccines might underestimate the proportion of adolescents receiving them (*1*).

HPV vaccination initiation and completion continue to increase. Postintroduction monitoring studies have found reductions in cervical HPV infection, genital warts, and cervical precancers in the United States (*10*). Protection against HPV-related cancers will continue to increase if adolescents and their parents are educated about the cancer prevention benefits of HPV vaccine and clinicians consistently recommend and simultaneously administer Tdap, MenACWY, and HPV vaccine at age 11–12 years.

TABLE 3. (*Continued*) Estimated vaccination coverage with selected vaccines and doses* among adolescents aged 13–17 years,† by HHS region, state, selected local area, or territory — National Immunization Survey–Teen (NIS-Teen), United States, 2017

	All adolescents (N = 20,949) % (95% CI)§			
Region, state, local area	**≥1 Tdap¶**	**≥1 MenACWY****	**≥1 HPV††**	**HPV UTD§§**
Region VI	**85.0 (83.0–86.8)**	**84.4 (82.4–86.2)**	**59.7 (57.1–62.2)¶¶**	**41.3 (38.9–43.8)¶¶**
Arkansas	92.4 (88.6–94.9)	91.7 (87.4–94.7)	61.1 (54.8–67.0)	35.2 (29.4–41.5)
Louisiana	90.1 (85.5–93.4)	89.0 (84.3–92.5)	69.1 (63.3–74.4)¶¶	52.9 (46.5–59.1)¶¶
New Mexico	85.5 (80.3–89.5)	78.0 (72.4–82.8)	66.9 (60.9–72.4)	48.3 (42.2–54.5)
Oklahoma	86.7 (81.7–90.5)	71.1 (64.9–76.6)	58.5 (52.1–64.6)	41.4 (35.3–47.8)
Texas	83.2 (80.4–85.7)	85.1 (82.4–87.5)	57.8 (54.3–61.2 ¶¶	39.7 (36.5–43.0)¶¶
Texas - Bexar County	83.7 (77.8–88.3)	86.0 (80.3–90.3)	62.9 (56.6–68.8)¶¶	46.4 (40.2–52.7)
Texas - Houston	87.9 (80.2–92.9)	91.4 (85.1–95.2)	73.0 (63.9–80.4)	55.2 (45.9–64.2)
Texas - Dallas County	77.0 (69.8–83.0)	85.1 (78.8–89.7)	54.5 (46.9–62.0)	35.7 (28.8–43.1)¶¶
Texas - El Paso County	89.6 (84.8–93.0)	89.5 (84.4–93.0)	82.8 (77.2–87.2)	60.0 (52.9–66.6)
Texas - Travis County	85.9 (80.9–89.8)	89.1 (84.4–92.4)	69.7 (63.3–75.4)	52.0 (45.4–58.5)
Texas - rest of state	83.1 (79.3–86.3)	84.1 (80.4–87.2)	54.5 (49.9–59.1)¶¶	36.6 (32.4–41.0)
Region VII	**86.8 (84.0–89.2)**	**77.3 (74.2–80.2)¶¶**	**61.5 (58.0–64.8)¶¶**	**44.2 (40.9–47.6)**
Iowa	93.4 (89.8–95.8)	83.6 (78.4–87.7)¶¶	71.4 (65.6–76.5)¶¶	53.7 (47.6–59.8)
Kansas	89.7 (84.9–93.1)	72.1 (65.8–77.6)	52.4 (46.0–58.8)	34.4 (28.6–40.7)
Missouri	80.1 (74.1–85.0)	74.3 (68.3–79.5)	57.8 (51.3–64.0)	39.6 (33.6–45.9)
Nebraska	92.3 (87.5–95.4)	84.8 (79.4–89.0)	71.0 (64.8–76.5)	58.3 (51.9–64.5)¶¶
Region VIII	**89.1 (86.6–91.1)**	**81.4 (78.7–83.8)¶¶**	**65.7 (62.4–68.8)¶¶**	**46.8 (43.4–50.3)¶¶**
Colorado	88.6 (83.6–92.2)	82.4 (77.2–86.6)	72.1 (66.2–77.3)	53.8 (47.4–60.0)
Montana	90.4 (85.8–93.7)	71.2 (64.9–76.8)	65.5 (58.9–71.5)¶¶	49.1 (42.5–55.7)
North Dakota	90.6 (86.8–93.5)	91.9 (88.3–94.4)	72.5 (67.0–77.4)	57.8 (51.9–63.5)
South Dakota	79.5 (73.6–84.4)	74.5 (68.4–79.9)¶¶	63.2 (56.7–69.2)	44.8 (38.5–51.2)
Utah	91.6 (87.7–94.3)¶¶	85.1 (80.3–88.9)¶¶	58.8 (52.6–64.8)	37.4 (31.5–43.7)
Wyoming	86.4 (81.2–90.3)	60.7 (54.5–66.6)	46.9 (40.8–53.1)	30.9 (25.5–36.8)
Region IX	**83.3 (78.5–87.2)**	**82.2 (77.4–86.2)**	**70.4 (65.4–75.0)**	**53.1 (47.5–58.7)**
Arizona	82.4 (76.7–87.0)	83.8 (78.3–88.1)	65.0 (58.4–71.2)	53.0 (46.3–59.6)
California	83.5 (77.2–88.3)	82.2 (75.9–87.1)	71.9 (65.4–77.5)	53.4 (46.3–60.4)
Hawaii	84.8 (79.3–89.1)	85.9 (80.6–90.0)¶¶	69.4 (63.0–75.1)	54.7 (48.2–61.0)
Nevada	82.5 (76.6–87.1)	77.3 (71.0–82.5)	64.9 (58.3–70.9)	49.0 (42.6–55.5)
Region X	**87.2 (84.5–89.5)**	**81.4 (78.2–84.2)¶¶**	**69.9 (66.3–73.3)¶¶**	**52.8 (48.9–56.6)¶¶**
Alaska	78.9 (73.2–83.6)	68.4 (62.5–73.8)	64.5 (58.4–70.1)	42.6 (36.7–48.8)
Idaho	87.3 (82.1–91.1)	90.5 (85.6–93.9)	62.4 (55.7–68.6)	44.1 (37.6–50.7)
Oregon	86.3 (81.6–90.0)	77.0 (71.5–81.8)	71.2 (65.4–76.4)¶¶	54.8 (48.6–60.8)
Washington	88.6 (83.8–92.1)	82.6 (77.2–87.0)	71.9 (65.8–77.3)	55.2 (48.8–61.5)
Range***	**(78.9–96.2)**	**(60.7–95.3)**	**(46.9–91.9)**	**(28.8–78.0)**
Territory				
Guam	77.3 (71.6–82.1)	68.3 (62.2–73.9) †††	67.5 (61.4–73.0)	42.7 (36.9–48.8)

Abbreviations: CI = confidence interval; HHS = U.S. Department of Health and Human Services; HPV = human papillomavirus; MenACWY = quadrivalent meningococcal conjugate vaccine; MMR = measles, mumps, rubella vaccine; Tdap = tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis vaccine; UTD = up-to-date.

* Estimates for additional measures, including MMR, hepatitis B, and varicella vaccines are available at https://www.cdc.gov/vaccines/vaxview/teenvaxview.

† Adolescents (N = 20,949) in the 2017 NIS-Teen were born January 1999 through February 2005.

§ Estimates with 95% CIs >20 might be unreliable.

¶ ≥1 dose Tdap vaccine at age ≥10 years.

** ≥1 dose of MenACWY or meningococcal-unknown type vaccine.

†† HPV vaccine, nine-valent (9vHPV), quadrivalent (4vHPV), or bivalent (2vHPV) in females and males combined.

§§ HPV UTD includes those with ≥3 doses and those with 2 doses when the first HPV vaccine dose was initiated before age 15 years and there was at least 5 months minus 4 days between the first and second dose. This update to the HPV recommendation occurred in December of 2016.

¶¶ Statistically significant (p<0.05) percentage point increase compared to 2016.

*** The calculation for the range was limited to the 50 states and the District of Columbia.

††† Statistically significant (p<0.05) percentage point decrease from 2016.

Summary

What is already known about this topic?

Vaccines to prevent human papillomavirus (HPV)–associated cancers, diphtheria, pertussis, tetanus, and meningococcal diseases are routinely recommended for persons aged 11–12 years.

What is added by this report?

In 2017, coverage among adolescents aged 13–17 years increased for ≥1 dose of HPV vaccine and ≥1 and ≥2 doses of meningococcal vaccines and remained high for ≥1 dose of tetanus and diphtheria toxoids and acellular pertussis vaccine. HPV vaccination initiation has increased an average of 5.1 percentage points annually since 2013.

What are the implications for public health care?

The increase in HPV vaccination coverage indicates that further efforts to address barriers to HPV vaccination initiation and series completion likely will lead to greater protection against HPV-associated cancers.

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Trends in Human Papillomavirus–Associated Cancers — United States, 1999–2015

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Human papillomavirus (HPV) is a known cause of cervical cancer, as well as some oropharyngeal, vulvar, vaginal, penile, and anal cancers. To assess trends, characterized by average annual percent change (AAPC), in HPV-associated cancer incidence during 1999–2015, CDC analyzed data from cancer registries covering 97.8% of the U.S. population. A total of 30,115 new cases of HPV-associated cancers were reported in 1999 and 43,371 in 2015. During 1999–2015, cervical cancer rates decreased 1.6% per year; vaginal squamous cell carcinoma (SCC) rates decreased 0.6% per year; oropharyngeal SCC rates increased among both men (2.7%) and women (0.8%); anal SCC rates also increased among both men (2.1%) and women (2.9%); vulvar SCC rates increased (1.3%); and penile SCC rates remained stable. In 2015 oropharyngeal SCC (15,479 cases among men and 3,438 among women) was the most common HPV-associated cancer. Continued surveillance through high-quality cancer registries is important to monitor cancer incidence and trends in these potentially preventable cancers.

HPV causes cervical cancer and some types of oropharyngeal, vulvar, vaginal, penile, and anal cancer; HPV DNA is found in specific tissue types that include carcinomas of the cervix and SCCs of the vulva, vagina, penis, oropharynx, and anus (*1*,*2*). The natural history from HPV infection to precancerous lesion to invasive cervical cancer is well established. HPV is the most commonly sexually transmitted infection in the United States and is often acquired soon after initiating sexual activity (*3*). Studies indicate that approximately 90% of new cervical HPV infections, including types that cause cancer, clear or become undetectable within 2 years, and those that do not clear take decades to progress to invasive cervical cancer.* Less is known about carcinogenic progression of HPV-associated infection at other anatomic sites (*2*).

CDC analyzed data from population-based cancer registries that participate in the CDC's National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results program that met the criteria for high data quality for all years from 1999 to 2015; these data cover approximately 97.8% of the U.S. population.† Invasive cancers are not tested for HPV in most cancer registries; therefore, an HPV-associated cancer was defined as an invasive malignancy in which HPV DNA was frequently found in special studies, including carcinomas of the cervix (i.e., SCC, adenocarcinomas, and other carcinomas) and SCC of the vulva, vagina, penis, oropharynx, and anus (including rectal SCC) (*2*) and was microscopically confirmed.§ Cases were classified by anatomic site and cell type using the *International Classification of Diseases for Oncology, Third Edition*. Oropharyngeal SCC included squamous cell cancer types at the base of tongue, pharyngeal tonsils, anterior and posterior tonsillar pillars, glossotonsillar sulci, anterior surface of soft palate and uvula, and lateral and posterior pharyngeal walls. Anal SCC also included rectal SCCs because they are biologically similar and might be misclassified. Age-adjusted incidence rates were calculated per 100,000 persons and standardized to the 2000 U.S. standard population. Trends were measured with AAPC in rates calculated using joinpoint regression.¶ Rates were considered to increase if the AAPC was greater than zero ($p<0.05$) and to decrease if the AAPC was less than zero ($p<0.05$); otherwise, rates were considered stable. A maximum of two joinpoints

* Manual for the Surveillance of Vaccine-Preventable Diseases, Chapter 5: Human Papillomavirus (HPV). https://www.cdc.gov/vaccines/pubs/surv-manual/chpt05-hpv.html.

† Cancer registries' incidence data met the following five United States Cancer Statistics criteria: 1) ≤5% of cases ascertained solely on the basis of death certificate; 2) ≤3% of cases missing information on sex; 3) ≤3% of cases missing information on age; 4) ≤5% of cases missing information on race; and 5) ≥97% of registry's records passed a set of single-field and interfield computerized edits that test the validity and logic of data components. https://gis.cdc.gov/Cancer/USCS/DataViz.html.

§ HPV-associated cancers were defined as cancers at specific anatomic sites with specific cell types in which HPV DNA frequently is found. All cancers were microscopically confirmed. Cervical cancers (ICD-O-3 http://codes.iarc.fr/[ICD-O-3] site codes C53.0–C53.9) are limited to carcinomas (ICD-O-3 histology codes 8010–8671, 8940–8941). Vaginal (ICD-O-3 site code C52.9), vulvar (ICD-O-3 site codes C51.0–C51.9), penile (ICD-O-3 site codes C60.0–60.9), anal (including rectal SCC; ICD-O-3 site code C20.9, C21.0–C21.9), and oropharyngeal (ICD-O-3 site codes C01.9, C02.4, C02.8, C05.1, C05.2, C09.0, C09.1, C09.8, C09.9, C10.0, C10.1, C10.2, C10.3, C10.4, C10.8, C10.9, C14.0, C14.2 and C14.8) cancer sites are limited to squamous cell carcinomas (ICD-O-3 histology codes 8050–8084, 8120–8131). Anal and rectal SCC were combined into a single category "anal SCC" because a very small subset of rectal cancers (i.e. the SCCs, around 700 per year) are similar to anal SCC.

¶ https://surveillance.cancer.gov/joinpoint/.

was used. Rates and trends were estimated by sex, age group, race,** ethnicity,†† and region.§§

In the United States, a total of 30,115 new cases of HPV-associated cancer were reported in 1999 and 43,371 in 2015 (Table 1). In 1999, cervical carcinoma (13,125 cases) was the most common HPV-associated cancer: 3,750 more cases of cervical carcinoma than of oropharyngeal SCC were identified. During 1999–2015 cervical carcinoma rates decreased 1.6% per year, and oropharyngeal SCC rates increased 2.7% per year among men and 0.8% per year among women (Figure 1) (Figure 2). In 2015, there were 11,788 reported cases of cervical carcinoma and 18,917 cases of oropharyngeal SCC, including 15,479 (82%) among men and 3,438 (18%) among women.

Rates of oropharyngeal SCC increased among men in all age groups ≥40 years, ranging from 0.8% among men aged 40–49 years to 4.0% among those aged 60–69 years (Table 1). Rates varied by race, with the largest increase occurring among white men (3.3%), and by region, with rates increasing more in the Midwest (3.2%) than in other regions (Table 2).

During 1999–2015 cervical carcinoma rates were stable among women aged 35–39 years and decreased among women aged 20–34 years and aged ≥40 years, decreasing >3% per year among women aged 20–24 years and ≥70 years (Table 1). Cervical carcinoma rates decreased among all racial/ethnic groups, more among Hispanics than among non-Hispanics, and more in the West than in all other regions (Table 2). During 1999–2015 vaginal SCC decreased 0.6% per year.

In contrast, penile SCC rates were stable, and vulvar SCC rates increased 1.3% per year (Table 1) (Figure 2). Specifically, vulvar SCC rates increased during 1999–2015 among women aged 50–69 years, among whites (1.5%), and blacks (1.0%), and in the Northeast (1.5%), Midwestern (1.5%), and Southern (1.3%) regions of the United States.

Anal SCC rates increased among women (2.9% per year) and men (2.1%) during this period. The largest increases in anal SCC rates were among women aged 50–69 years (4.6%–4.8% per year) and men aged 50–59 years (4.0%). Anal SCC rates increased among white women (3.2% per year), black women (2.2%), white men (2.1%), and black men (3.0%). Anal SCC rates increased among both men and women in all regions except among men in the West region; the largest rate increases were among women in the Northeast (4.3% per year) and Midwest (3.6%).

TABLE 1. Annual number and annual age-adjusted rates* and trends† in HPV-associated cancer§ by sex, cancer type, and age group — United States,¶ 1999–2015

Cancer type/ age group (yrs)	Period of diagnosis		
	1999	2015	1999–2015
	No. (rate)*	No. (rate)*	AAPC (95% CI)
Total	**30,115 (11.2)**	**43,371 (12.1)**	**0.5† (0.2–0.9)**
Females			
All HPV-associated cancers	**21,008 (14.6)**	**24,432 (13.6)**	**-0.4† (-0.7 to 0.2)**
Cervical carcinoma	**13,125 (9.3)**	**11,788 (7.2)**	**-1.6† (-2.2 to -1.0)**
15–19	21 (0.2)	—**	—**
20–24	161 (1.8)	74 (0.7)	-4.2† (-5.3 to -3.1)
25–29	677 (7.1)	535 (5.0)	-2.6† (-3.7 to -1.5)
30–34	1,252 (12.5)	1,069 (10.1)	-1.2† (-2.1 to -0.4)
35–39	1,663 (14.8)	1,296 (13.0)	-0.8 (-2.1 to 0.4)
40–44	1,799 (16.4)	1,531 (15.4)	-0.8† (-1.2 to -0.3)
45–49	1,571 (16.1)	1,436 (14.0)	-1.2† (-2.2 to -0.2)
50–54	1,266 (15.0)	1,315 (11.8)	-1.6† (-2.3 to -0.8)
55–59	1,095 (16.6)	1,292 (11.8)	-2.0† (-2.9 to -1.2)
60–64	877 (16.0)	1,053 (10.8)	-2.7† (-3.4 to -1.9)
65–69	772 (15.4)	808 (9.8)	-2.9† (-3.4 to -2.4)
≥70	1,970 (13.2)	1,377 (7.9)	-3.2† (-3.8 to -2.6)
Vulvar SCC	**2,615 (1.7)**	**3,890 (2.0)**	**1.3† (1.1 to 1.6)**
<40	192 (0.2)	154 (0.2)	-0.5 (-1.3 to 0.3)
40–49	354 (1.7)	385 (1.9)	0.3 (-0.6 to 1.2)
50–59	361 (2.4)	778 (3.5)	2.9† (2.4 to 3.4)
60–69	396 (3.8)	905 (5.0)	2.4† (2.0 to 2.9)
≥70	1,312 (8.6)	1,668 (9.1)	0.5 (-0.2 to 1.2)
Vaginal SCC	**730 (0.5)**	**809 (0.4)**	**-0.6† (-1.1 to -0.1)**
<40	28 (0)	20 (0.0)	-2.8† (-4.3 to -1.2)
40–49	84 (0.4)	64 (0.3)	-0.4 (-1.5 to 0.8)
50–59	110 (0.7)	136 (0.6)	-0.2 (-1.0 to 0.6)
60–69	144 (1.4)	219 (1.2)	-0.5 (-1.6 to 0.5)
≥70	364 (2.4)	370 (2.0)	-0.6† (-1.0 to -0.2)
Anal SCC	**2,129 (1.5)**	**4,507 (2.2)**	**2.9† (2.5 to 3.3)**
<40	91 (0.1)	89 (0.1)	-1.2 (-2.5 to 0.1)
40–49	379 (1.8)	377 (1.8)	0.4 (-0.6 to 1.4)
50–59	426 (2.8)	1,347 (6.0)	4.6† (3.7 to 5.6)
60–69	434 (4.1)	1,476 (8.2)	4.8† (4.4 to 5.3)
≥70	799 (5.3)	1,218 (6.9)	2.1† (1.7 to 2.4)
Oropharyngeal SCC	**2,409 (1.6)**	**3,438 (1.7)**	**0.8† (0.5 to 1.1)**
<40	66 (0.1)	71 (0.1)	1 (-0.2 to 2.2)
40–49	262 (1.3)	305 (1.5)	0.4 (-0.8 to 1.6)
50–59	550 (3.6)	1,046 (4.6)	2.1† (1.5 to 2.6)
60–69	653 (6.2)	1,050 (5.8)	0.4 (-0.1 to 1.0)
≥70	878 (5.9)	966 (5.6)	0.3 (-0.3 to 0.8)

See table footnotes on the next page.

** Population estimates incorporate bridged single-race estimates derived from the original multiple-race categories in the 2010 U.S. Census. https://seer.cancer.gov/popdata.

†† https://www.census.gov/prod/cen2010/briefs/c2010br-04.pdf.

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

TABLE 1. (*Continued*) Annual number and annual age-adjusted rates* and trends† in HPV-associated cancer§ by sex, cancer type, and age group — United States,¶ 1999–2015

Cancer type/ age group (yrs)	Period of diagnosis		
	1999	2015	1999–2015
	No. (rate)*	No. (rate)*	AAPC (95% CI)
Males			
All HPV-associated cancers	**9,107 (7.4)**	**18,939 (10.5)**	**2.4† (2.2 to 2.6)**
Penile SCC	**973 (0.8)**	**1,224 (0.8)**	**-0.2 (-0.6 to 0.3)**
<40	40 (0.1)	34 (0.0)	-0.7 (-2.1 to 0.8)
40–49	95 (0.5)	99 (0.5)	0.6 (-0.4 to 1.6)
50–59	180 (1.3)	210 (1.0)	-1.4† (-2.4 to -0.5)
60–69	242 (2.6)	287 (1.8)	-2.0† (-2.6 to -1.4)
≥70	416 (4.5)	594 (4.6)	0.8† (0.2 to 1.4)
Anal SCC	**1,168 (1.0)**	**2,236 (1.3)**	**2.1† (1.4 to 2.8)**
<40	129 (0.2)	103 (0.1)	-2.9† (-4.1 to -1.6)
40–49	262 (1.3)	303 (1.5)	0.8 (-0.3 to 1.9)
50–59	246 (1.7)	678 (3.2)	4.0† (3.2 to 4.8)
60–69	214 (2.3)	610 (3.7)	2.7† (1.9 to 3.5)
≥70	317 (3.2)	542 (4.2)	1.5 (-0.7 to 3.8)
Oropharyngeal SCC	**6,966 (5.6)**	**15,479 (8.5)**	**2.7† (2.5 to 2.9)**
<40	147 (0.2)	133 (0.2)	-0.9 (-2.3 to 0.4)
40–49	1,217 (6.0)	1,387 (6.7)	0.8† (0.2 to 1.5)
50–59	2,224 (15.6)	5,106 (23.7)	2.7† (2.2 to 3.2)
60–69	1,891 (20.4)	5,745 (35.2)	4.0† (3.6 to 4.3)
≥70	1,487 (14.9)	3,108 (23.1)	2.8† (2.3 to 3.4)

Sources: CDC's National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results program.
Abbreviations: AAPC = average annual percent change; CI = confidence interval; SCC = squamous cell carcinoma.
* Per 100,000 persons, age-adjusted to the 2000 U.S. standard population.
† Significant at p<0.05. Trends were measured with AAPC in rates and were considered to increase or decrease if p<0.05; otherwise rates were considered stable.
§ HPV-associated cancers were defined as cancers at specific anatomic sites with specific cell types in which HPV DNA frequently is found. All cancers were microscopically confirmed. Cervical cancers (*International Classification of Diseases for Oncology, Third Edition* [ICD-O-3] site codes C53.0–C53.9) are limited to carcinomas (ICD-O-3 histology codes 8010–8671, 8940–8941). Vaginal (ICD-O-3 site code C52.9), vulvar (ICD-O-3 site codes C51.0–C51.9), penile (ICD-O-3 site codes C60.0–60.9), anal (including rectal SCC; ICD-O-3 site code C20.9, C21.0–C21.9), and oropharyngeal (ICD-O-3 site codes C01.9, C02.4, C02.8, C05.1, C05.2, C09.0, C09.1, C09.8, C09.9, C10.0, C10.1, C10.2, C10.3, C10.4, C10.8, C10.9, C14.0, C14.2 and C14.8) cancer sites are limited to squamous cell carcinomas (ICD-O-3 histology codes 8050–8084, 8120–8131).
¶ Cancer incidence compiled from cancer registries that meet the data quality criteria for all invasive cancer sites combined (covering approximately 97.8% of the U.S. population).
** Data suppressed for rates when the number of cases was <6 in a year.

Summary

What is already known about this topic?

Human papillomavirus (HPV) can cause some types of cervical, vulvar, vaginal, penile, anal, and oropharyngeal cancers.

What is added by this report?

Oropharyngeal squamous cell carcinoma is now the most common HPV-associated cancer. During 1999–2015 cervical carcinoma incidence rates decreased 1.6% per year, and oropharyngeal SCC incidence rates increased 2.7% per year among men and 0.8% per year among women.

What are the implications for public health practice?

Population-based screening is recommended for only one HPV-associated cancer (cervical) at this time; however, HPV vaccination can prevent infection with the HPV types most strongly associated with cancer. Ongoing surveillance for HPV-associated cancers using high-quality population-based registries is critical to monitor cancer rates and trends.

Discussion

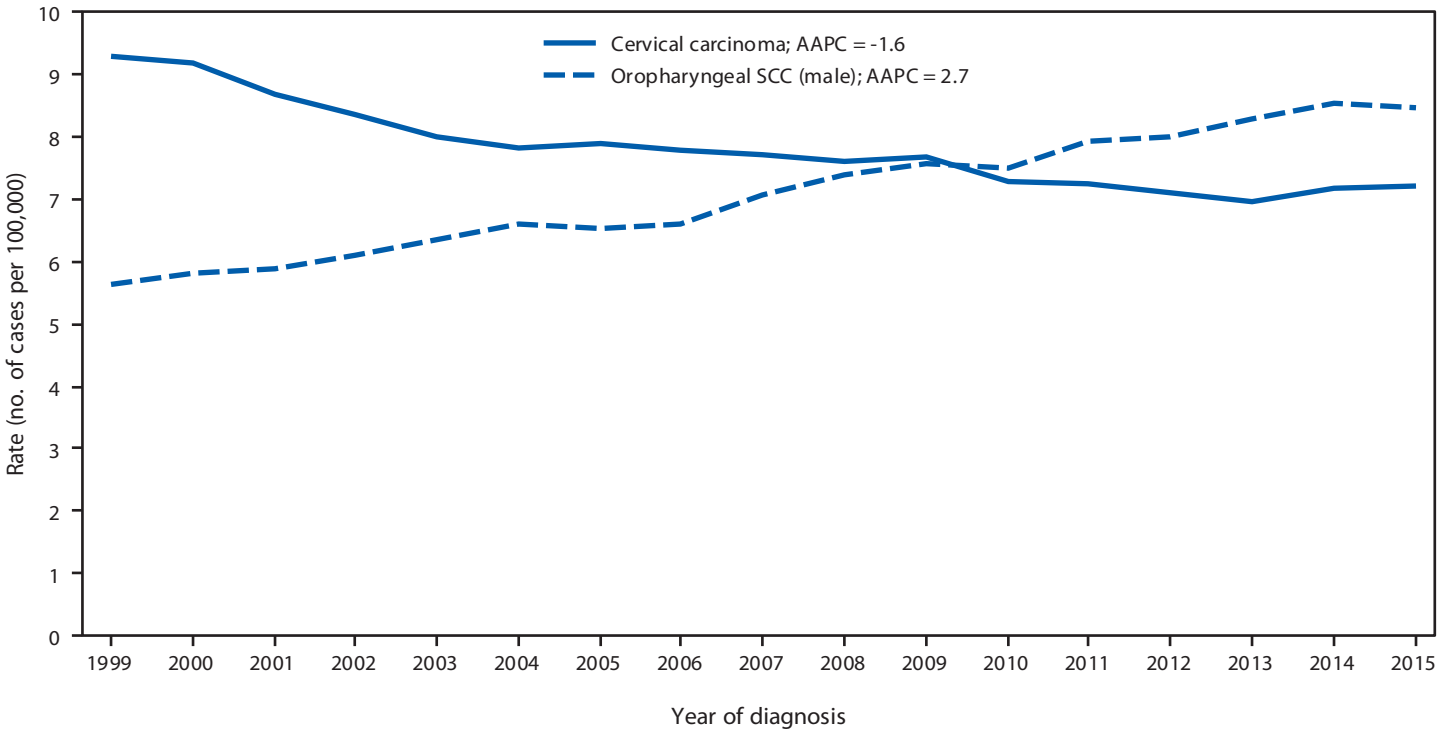
HPV-associated cancer rates changed from 1999 to 2015. Rates increased for oropharyngeal SCC, anal SCC and vulvar SCC, decreased for cervical carcinoma and vaginal SCC, and remained stable for penile SCC.

The decline in cervical cancer from 1999 to 2015 represents a continued trend since the 1950s as a result of cancer screening (*4*). Rates of cervical carcinoma in this report decreased more among Hispanics, American Indian/Alaska Natives, and blacks than other groups; however, incidence rates were still higher among Hispanics and blacks than among whites in 2015. These persistent disparities in incidence suggest that health care delivery needs of some groups are not fully met.

Several factors could contribute to the increase in oropharyngeal and anal cancers including changing sexual behaviors. Unprotected oral sex and receptive anal sex are risk factors for HPV infection (*2*,*5*). White men have the highest number of lifetime oral sex partners and report first performing oral sex at a younger age compared with other racial/ethnic groups; these risk factors could be contributing to a higher rate of oropharyngeal SCC among white men than other racial/ethnic groups (*6*). Although smoking is a risk factor for oropharyngeal cancers, smoking rates have been declining in the United States, and studies have indicated that the increase in oropharyngeal cancer is attributable to HPV (*5*). In contrast to cervical cancer, there currently is no U.S. Preventive Services Task Force recommended screening for other HPV-associated cancers (*7*).

The findings in this report are subject to at least two limitations. First, although population-based cancer registries provide a reliable system for counting invasive cancers, registries do not routinely determine the HPV status of cancers. In the United States, HPV DNA has been determined through special studies and found in 91% of cervical, 91% of anal, 75% of vaginal, 70% of oropharyngeal, 69% of vulvar, and 63% of penile cancers (*1*). Second, reporting of race and ethnicity uses data from medical records, which might be inaccurate in a small proportion of cases. An important strength of this study is the use of high quality population-based surveillance data with 97.8% coverage of the U.S. population, allowing for specific histologic definitions to monitor HPV-associated cancer trends.

FIGURE 1. Trends* in age-adjusted incidence of cervical carcinoma among females and oropharyngeal SCC among men,† — United States,§ 1999–2015



Sources: CDC's National Program of Cancer Registries; National Cancer Institute's Surveillance, Epidemiology, and End Results program.
Abbreviations: AAPC = average annual percent change; SCC = squamous cell carcinoma.
* Trends were measured with AAPC in age-adjusted rates and were considered to increase or decrease if p<0.05; otherwise, trends were considered stable.
† HPV-associated cancers were defined as cancers at specific anatomic sites with specific cell types in which HPV DNA frequently is found. All cancers were microscopically confirmed. Cervical cancers (*International Classification of Diseases for Oncology, Third Edition* [ICD-O-3] site codes C53.0–C53.9) are limited to carcinomas (ICD-O-3 histology codes 8010–8671, 8940–8941). Oropharyngeal (ICD-O-3 site codes C01.9, C02.4, C02.8, C05.1, C05.2, C09.0, C09.1, C09.8, C09.9, C10.0, C10.1, C10.2, C10.3, C10.4, C10.8, C10.9, C14.0, C14.2 and C14.8) cancer sites are limited to squamous cell carcinomas (ICD-O-3 histology codes 8050–8084, 8120–8131).
§ Cancer incidence compiled from cancer registries that meet the data quality criteria for all invasive cancer sites combined for each year during the period 1999–2015 (covering 97.8% of the U.S. population).

Measures to prevent HPV-associated diseases in the United States include both females and males; HPV vaccination was included in the routine immunization program for females in 2006 and for males in 2011. Although it might be too soon for effects on invasive cancers from HPV vaccination in the United States, studies have reported reductions in cervical HPV infection, genital warts, and cervical precancers (*8*). Most cervical cancers are preventable with both HPV vaccination and regular and timely screening among women aged 21–65 years with follow-up for abnormal test results. Routine HPV vaccination is recommended at age 11 or 12 years; currently, the 9-valent HPV vaccine, which targets oncogenic types attributed to 73% of HPV-associated cancers, is being used in the United States (*1*,*9*). Further research to understand the progression from HPV infection to oropharyngeal cancer would be beneficial. Continued surveillance through high-quality registries is important to monitor changes in HPV-associated cancer incidence.

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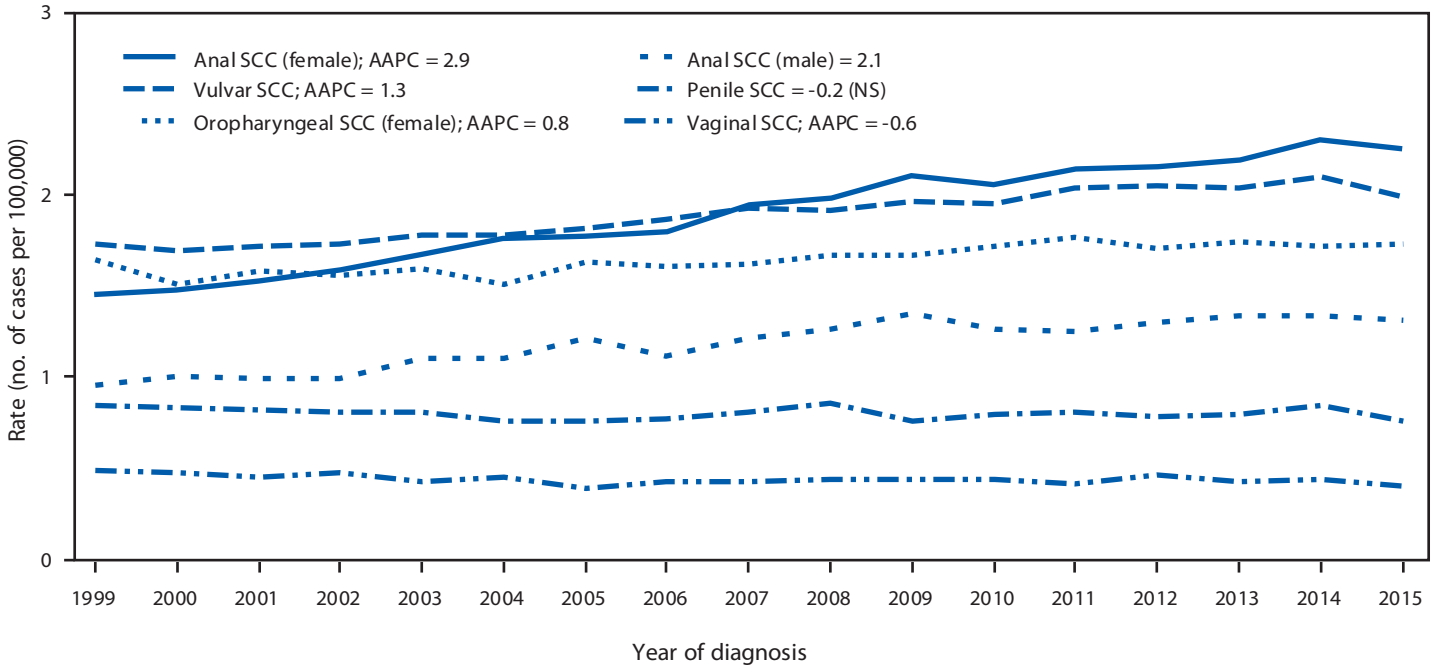
FIGURE 2. Trends* in age-adjusted HPV-associated cancer incidence,† by cancer type and sex — United States,§ 1999–2015



Sources: CDC's National Program of Cancer Registries; National Cancer Institute's Surveillance, Epidemiology, and End Results program.
Abbreviations: AAPC = average annual percent change; HPV = human papillomavirus; SCC = squamous cell carcinoma.
* Trends were measured with AAPC in age-adjusted rates and were considered to increase or decrease if p<0.05; otherwise, trends were considered stable.
† HPV-associated cancers were defined as cancers at specific anatomic sites with specific cell types in which HPV DNA frequently is found. All cancers were microscopically confirmed. Vaginal (*International Classification of Diseases for Oncology, Third Edition* [ICD-O-3] site code C52.9), vulvar (ICD-O-3 site codes C51.0–C51.9), penile (ICD-O-3 site codes C60.0–60.9), anal (including rectal SCC; ICD-O-3 site code C20.9, C21.0–C21.9), and oropharyngeal (ICD-O-3 site codes C01.9, C02.4, C02.8, C05.1, C05.2, C09.0, C09.1, C09.8, C09.9, C10.0, C10.1, C10.2, C10.3, C10.4, C10.8, C10.9, C14.0, C14.2 and C14.8) cancer sites are limited to squamous cell carcinomas (ICD-O-3 histology codes 8050–8084, 8120–8131).
§ Cancer incidence compiled from cancer registries that meet the data quality criteria for all invasive cancer sites combined for each year during the period 1999–2015 (covering 97.8% of the U.S. population).

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TABLE 2. Annual number, annual age-adjusted rate,* and trends† of HPV-associated cancer cases,§ by sex, race, ethnicity,¶ and U.S. census region — United States,†† 1999–2015**

Cancer type/ Characteristic	1999 No. (rate)	2015 No. (rate)	1999–2015 AAPC (95% CI)
Females			
Cervical carcinoma			
Race			
White	10,316 (8.8)	9,079 (7.1)	-1.5† (-2.0 to -1.0)
Black	2,114 (13.4)	1,731 (7.9)	-3.2† (-3.8 to -2.5)
AI/AN	96 (8.8)	117 (5.9)	-1.7† (-2.7 to -0.6)
API	442 (8.7)	616 (5.8)	-2.9† (-3.4 to -2.4)
Ethnicity			
Non-Hispanic	11,293 (8.8)	9,706 (7.0)	-1.5† (-1.9 to -1.0)
Hispanic	1,831 (15.2)	2,082 (8.9)	-3.4† (-3.9 to -2.9)
Region			
Northeast	2,571 (8.8)	2,140 (6.9)	-1.7† (-2.0 to -1.4)
Midwest	2,901 (8.9)	2,498 (7.3)	-1.7† (-2.3 to -1.0)
South	4,935 (10.1)	4,601 (7.7)	-1.7† (-2.1 to -1.3)
West	2,718 (8.8)	2,549 (6.6)	-2.0† (-2.6 to -1.4)
Vulvar SCC			
Race			
White	2,394 (1.8)	3,485 (2.2)	1.5† (1.3 to 1.7)
Black	186 (1.2)	289 (1.3)	1.0† (0.2 to 1.8)
AI/AN	7 (0.7)	20 (1.1)	—§§
API	20 (0.5)	46 (0.5)	0.5 (-1.3 to 2.3)
Ethnicity			
Non-Hispanic	2,510 (1.8)	3,679 (2.1)	1.6† (1.3 to 1.8)
Hispanic	105 (1.2)	211 (1.1)	-0.1 (-0.8 to 0.6)
Region			
Northeast	618 (1.9)	847 (2.2)	1.5† (1.1 to 2.0)
Midwest	687 (1.9)	1,024 (2.4)	1.5† (0.5 to 2.5)
South	855 (1.7)	1,366 (2.0)	1.3† (1.0 to 1.7)
West	455 (1.5)	653 (1.5)	0.3 (-0.2 to 0.9)
Vaginal SCC			
Race			
White	583 (0.4)	638 (0.4)	-0.3 (-0.9 to 0.3)
Black	125 (0.9)	124 (0.6)	-2.7† (-4.0 to -1.4)
AI/AN	—§§	—§§	—§§
API	14 (0.4)	29 (0.3)	-2.1 (-4.6 to 0.4)
Ethnicity			
Non-Hispanic	682 (0.5)	724 (0.4)	-0.5 (-1.0 to 0.1)
Hispanic	48 (0.5)	85 (0.4)	-1.7† (-2.8 to -0.6)
Region			
Northeast	148 (0.5)	154 (0.4)	-0.7 (-1.6 to 0.3)
Midwest	165 (0.5)	161 (0.4)	-0.1 (-1.1 to 1.0)
South	297 (0.6)	327 (0.5)	-0.9† (-1.7 to -0.1)
West	120 (0.4)	167 (0.4)	-0.5 (-1.4 to 0.3)
Anal SCC			
Race			
White	1,904 (1.5)	4,010 (2.4)	3.2† (2.8 to 3.6)
Black	175 (1.2)	378 (1.6)	2.2† (1.4 to 2.9)
AI/AN	8 (1.0)	22 (1.1)	—§§
API	21 (0.5)	47 (0.4)	-0.9 (-3.5 to 1.8)
Ethnicity			
Non-Hispanic	2,001 (1.5)	4,192 (2.4)	3.2† (2.8 to 3.6)
Hispanic	128 (1.4)	315 (1.5)	0.5 (-0.1 to 1.2)
Region			
Northeast	374 (1.2)	855 (2.2)	4.3† (2.7 to 6.0)
Midwest	465 (1.3)	979 (2.3)	3.6† (3.0 to 4.1)
South	815 (1.6)	1,689 (2.3)	2.6† (2.1 to 3.0)
West	475 (1.6)	984 (2.1)	2.2† (1.6 to 2.8)
Oropharyngeal SCC			
Race			
White	2,090 (1.7)	3,022 (1.9)	1.2† (0.9 to 1.5)
Black	282 (1.9)	303 (1.3)	-1.7† (-2.3 to -1.2)
AI/AN	7 (0.8)	15 (0.9)	—§§
API	22 (0.5)	56 (0.5)	0.9 (-0.8 to 2.6)
Ethnicity			
Non-Hispanic	2,306 (1.7)	3,251 (1.8)	1.0† (0.7 to 1.2)
Hispanic	103 (1.1)	187 (0.9)	0.1 (-1.1 to 1.3)
Region			
Northeast	524 (1.7)	659 (1.8)	1.1† (0.6 to 1.7)
Midwest	536 (1.6)	813 (1.9)	1.5† (1.0 to 2.0)
South	887 (1.8)	1,348 (1.9)	0.7† (0.4 to 1.0)
West	462 (1.5)	618 (1.4)	-0.2 (-0.5 to 0.1)
Males			
Penile SCC			
Race			
White	864 (0.9)	1,045 (0.8)	-0.1 (-0.7 to 0.4)
Black	71 (0.7)	124 (0.8)	-0.2 (-1.3 to 0.9)
AI/AN	10 (2.1)	8 (0.5)	—§§
API	15 (0.5)	27 (0.3)	-0.9 (-3.3 to 1.5)
Ethnicity			
Non-Hispanic	865 (0.8)	1,029 (0.7)	-0.3 (-0.8 to 0.2)
Hispanic	108 (1.4)	195 (1.1)	-0.9 (-2.0 to 0.2)
Region			
Northeast	180 (0.8)	222 (0.8)	0 (-1.0 to 0.9)
Midwest	240 (0.9)	267 (0.8)	-0.5 (-2.0 to 0.9)
South	387 (1.0)	486 (0.8)	-0.8 (-1.9 to 0.3)
West	166 (0.7)	249 (0.7)	0.2 (-0.6 to 0.9)

See table footnotes on the next page.

TABLE 2. (*Continued*) Annual number, annual age-adjusted rate,* and trends† of HPV-associated cancer cases,§ by sex, race, ethnicity,¶ and U.S. census region — United States,†† 1999–2015**

Cancer type/ Characteristic	1999 No. (rate)	2015 No. (rate)	1999–2015 AAPC (95% CI)
Anal SCC			
Race			
White	1,008 (0.9)	1,870 (1.3)	2.1† (1.6 to 2.5)
Black	136 (1.1)	315 (1.7)	3.0† (1.2 to 4.7)
AI/AN	—§§	12 (0.6)	—§§
API	7 (0.2)	16 (0.2)	1.0 (-1.5 to 3.5)
Ethnicity			
Non-Hispanic	1,093 (1.0)	2,072 (1.4)	2.3† (1.6 to 3.1)
Hispanic	75 (0.8)	164 (0.8)	-0.1 (-1.1 to 1.0)
Region			
Northeast	246 (1.0)	485 (1.6)	2.7† (2.0 to 3.4)
Midwest	230 (0.8)	400 (1.1)	2.7† (1.9 to 3.4)
South	431 (1.0)	884 (1.4)	2.3† (1.6 to 3.0)
West	261 (1.0)	467 (1.2)	0.8 (-0.1 to 1.6)
Oropharyngeal SCC			
Race			
White	5,871 (5.5)	13,979 (9.2)	3.3† (3.1 to 3.6)
Black	944 (8.3)	1,135 (6.1)	-1.6† (-2.0 to -1.2)
AI/AN	36 (4.7)	82 (4.4)	2.5† (0.9 to 4.1)
API	78 (2.0)	166 (1.9)	1.1† (0.1 to 2.1)
Ethnicity			
Non-Hispanic	6,635 (5.8)	14,728 (9.1)	3.0† (2.8 to 3.2)
Hispanic	330 (4.2)	751 (4.1)	0.1 (-0.5 to 0.7)
Region			
Northeast	1,367 (5.5)	2,710 (8.0)	2.6† (2.4 to 2.9)
Midwest	1,569 (5.4)	3,423 (8.5)	3.2† (2.9 to 3.6)
South	2,677 (6.3)	6,183 (9.4)	2.5† (2.3 to 2.8)
West	1,353 (5.1)	3,163 (7.4)	2.6† (2.3 to 2.9)

Sources: CDC's National Program of Cancer Registries and the National Cancer Institute's Surveillance, Epidemiology, and End Results program.

Abbreviations: AAPC = average annual percent change; AI/AN = American Indian/Alaska Native; API = Asian or Pacific Islander; CI = confidence interval; SCC = squamous cell carcinoma.

* Per 100,000 persons, age-adjusted to the 2000 U.S. standard population.

† Significant at $p<0.05$. Trends were measured with AAPC in rates and were considered to increase or decrease if $p<0.05$; otherwise rates were considered stable.

§ HPV-associated cancers were defined as cancers at specific anatomic sites with specific cell types in which HPV DNA frequently is found. All cancers were microscopically confirmed. Cervical cancers (*International Classification of Diseases for Oncology, Third Edition* [ICD-O-3] site codes C53.0–C53.9) are limited to carcinomas (ICD-O-3 histology codes 8010–8671, 8940–8941). Vaginal (ICD-O-3 site code C52.9), vulvar (ICD-O-3 site codes C51.0–C51.9), penile (ICD-O-3 site codes C60.0–60.9), anal (including rectal SCC; ICD-O-3 site code C20.9, C21.0–C21.9), and oropharyngeal (ICD-O-3 site codes C01.9, C02.4, C02.8, C05.1, C05.2, C09.0, C09.1, C09.8, C09.9, C10.0, C10.1, C10.2, C10.3, C10.4, C10.8, C10.9, C14.0, C14.2 and C14.8) cancer sites are limited to squamous cell carcinomas (ICD-O-3 histology codes 8050–8084, 8120–8131).

¶ Racial categories are not mutually exclusive from Hispanic ethnicity. Rates are not presented for cases with unknown or other race or unknown ethnicity.

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

†† Cancer incidence compiled from cancer registries that meet the data quality criteria for all invasive cancer sites combined (covering approximately 97.8% of the U.S. population).

§§ Data suppressed for rates when the number of cases was <6 in a year.

Occupational Patterns in Unintentional and Undetermined Drug-Involved and Opioid-Involved Overdose Deaths — United States, 2007–2012

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The opioid epidemic affects multiple segments of the U.S. population (*1*). Occupational patterns might be critical to understanding the epidemic. Opioids are often prescribed for specific types of work-related injuries, which vary by occupation* (*2*). CDC used mortality data from the National Occupational Mortality Surveillance (NOMS) system to examine unintentional or undetermined drug overdose mortality within 26 occupation groups. This study included data from the 21 U.S. states participating in NOMS during 2007–2012.† Drug overdose mortality was compared with total mortality using proportional mortality ratios (PMRs) indirectly standardized for age, sex, race, year, and state. Mortality patterns specific to opioid-related overdose deaths were also assessed. Construction occupations had the highest PMRs for drug overdose deaths and for both heroin-related and prescription opioid–related overdose deaths. The occupation groups with the highest PMRs from methadone, natural and semisynthetic opioids, and synthetic opioids other than methadone were construction, extraction (e.g., mining, oil and gas extraction), and health care practitioners. The workplace is an integral part of life for the majority of the adult U.S. population; incorporating workplace research and interventions likely will benefit the opioid epidemic response.

NOMS is a population-based surveillance system and a collaborative effort between state vital statistics offices and CDC's National Institute for Occupational Safety and Health (NIOSH) and National Center for Health Statistics (NCHS). Through data sharing agreements with NIOSH, all participating states, or NCHS under states' direction, share selected data from their death certificates, including the decedent's usual industry and occupation, coded to the U.S. Census industry and occupation codes. This analysis includes 4,024,086 deaths that occurred in persons aged ≥18 years, from the 21 states that contributed ≥1 year of data† to NOMS during 2007–2012.§

International Classification of Disease, Tenth Revision (ICD-10) codes for underlying cause of death were used to identify unintentional (X40–X44) and undetermined (Y10–Y14) drug overdose deaths. Among drug overdose deaths, the specific type of opioid was indicated by the following ICD-10 multiple cause of deaths codes: T40.1 (heroin) and T40.2–T40.4 (prescription opioids [i.e., T40.2, natural and semisynthetic opioids; T40.3, methadone; and T40.4, synthetic opioids other than methadone]).¶ Deaths that involved multiple opioid types were included in multiple categories.

Usual occupation, recorded as free-text on the death certificate, was coded to 1990 or 2000 U.S. Census occupation codes** by NIOSH or by the state. A crosswalk based on U.S. Census data was used to convert the 1990 U.S. Census occupation codes to the 2000 U.S. Census occupation codes.†† Occupation codes were binned into 26 groups based on job duties.§§ For each outcome, the proportion of deaths among each occupation group was compared with the proportion of deaths among all occupations combined using PMRs indirectly standardized by age, sex, race, calendar year, and state of occurrence. A PMR >1.00 indicated that the proportion of deaths within that occupation group is higher than the proportion of deaths among all occupation groups combined. Corresponding 95% confidence intervals were calculated.

* The Bureau of Labor Statistics provides work-related injury, illness, and fatality data by industry and occupation. https://www.bls.gov/iif/.

† Participating states (participation years): Florida (2012), Georgia (2011, 2012), Hawaii (2007–2012), Idaho (2007–2012), Indiana (2007–2010), Kansas (2007–2012), Kentucky (2010–2012), Louisiana (2008–2010), Michigan (2007–2012), Nebraska (2007–2011), Nevada (2007–2012), New Hampshire (2007–2012), New Jersey (2007–2012), New Mexico (2007–2012), North Dakota (2008–2012), Ohio (2007–2012), Texas (2007–2010), Utah (2007–2012), Vermont (2012), Washington (2007–2012), and West Virginia (2007–2012)

§ 2012 is the most recent year for which NOMS data are available. NOMS is the largest source of U.S. population-level mortality data that contains occupation and industry information. Only 21 states contributed data to NOMS during the study period.

¶ From 2013 to 2014, a large increase in illicitly manufactured fentanyl occurred. Within the study period, this category is mostly recording information about pharmaceutical synthetic opioids.

** https://www2.census.gov/programs-surveys/demo/guidance/industry-occupation/occ2000t.pdf. The 1990 census occupation codes are available upon request from the NOMS program (https://www.cdc.gov/niosh/topics/noms/).

†† The crosswalk is based on data in Table 2 of U.S. Census Bureau Technical Paper #65. https://www.census.gov/content/dam/Census/library/working-papers/2003/demo/techpaper2000.pdf.

§§ https://usa.ipums.org/usa/volii/occ2000.shtml.

The analysis identified 57,810 drug overdose deaths within the study population (1.4% of the 4,024,086 deaths). The majority of drug overdose deaths were among persons who were male (61.8%), white (89.8%), and aged 45–54 years (30.1%) or 35–44 years (24.1%).[¶¶] PMRs from drug overdose were significantly above 1.00 for the following six occupation groups: 1) construction (1.25); 2) extraction (1.16); 3) food preparation and serving (1.11); 4) health care practitioners and technical (1.16); 5) health care support (1.18); and 6) personal care and service (1.10) (Table 1). PMRs from drug overdose were also significantly elevated among deaths where the usual occupation was unpaid/unemployed (1.10)[***] or unknown (1.31).[†††] For each specific opioid type, significantly elevated PMRs were generally observed only for those occupation groups that also had a significantly elevated PMR for drug overdose overall (Table 1) (Table 2). The only two exceptions were the arts, design, entertainment, sports, and media occupation group and the building and grounds cleaning and maintenance occupation group. For these groups, the proportion of drug overdose deaths among the two occupation groups was similar to the proportion of drug overdose deaths overall (i.e., PMR approximately = 1.00), whereas the proportional distribution of specific drugs involved in an overdose was different,[§§§] with heroin-involved overdose deaths higher than expected (Table 1). The highest PMRs for methadone, natural and semisynthetic opioids, and synthetic opioids were in the construction (1.34), extraction (1.39), and healthcare practitioner (1.81) occupation groups, respectively.

Because the PMRs for all opioid types within the construction occupation group were elevated, a subanalysis further examined opioid-related deaths in this group. The analysis identified 7,402 drug overdose deaths among persons aged ≥18 years within the construction occupation group. The majority of decedents were male (96.7%), white (92.6%), and aged 45–54 years (30.4%) or 35–44 years (26.9%).[¶¶¶] These deaths were examined by the following occupation subgroups[****]: first-line supervisors and managers,[††††] construction trade workers (e.g., carpenters, electricians, painters, iron and steel workers, operating engineers, and construction equipment operators), construction trade helpers, and other construction and related workers (e.g., building inspectors, hazardous waste workers, and highway maintenance workers). PMRs were significantly elevated for all types of opioids within the occupation subgroup construction trade workers (Table 3).

Discussion

In this study, unintentional and undetermined overdose deaths varied by occupation group, with the construction group having elevated PMRs for all drug types. Although few related studies have been conducted, similar results have been observed. In Kentucky (2011) (*3*) and Ohio (2016) (*4*), for example, overdose deaths varied by industry and occupation and were highest among construction workers. Multiyear studies conducted in two Massachusetts jurisdictions (Barnstable County and Mystic Valley Public Health Coalition communities) found trade workers (e.g., construction, building/grounds maintenance, and mechanics) had the largest proportion of opioid overdose deaths (37% and 42%, respectively) (*5*,*6*). Variation was expected because work-related injuries and illnesses vary by occupation and industry. In addition, other factors that might affect opioid use, such as psychosocial work-related stress (e.g., job insecurity or high demand/low control jobs), socioeconomic standing, and education level, also vary by occupation and industry (*7*–*9*).

The specific drugs influencing higher than expected proportions of overdose deaths also varied by occupation group. In this study, heroin PMRs were highest for the construction; food preparation and serving; and arts, design, entertainment, sports, and media occupation groups. Among the drug types evaluated, heroin is illicit, whereas among the other types, usage is both licit (i.e., prescribed and used as directed) and illicit. Data from the National Survey on Drug Use and Health illustrate that self-reported illicit drug use varies by

[¶¶] Opioid overdose decedent median age = 43 years.

[***] Homemaker (not working on a farm), volunteer, or student.

[†††] This category includes deaths with insufficient information available on the death certificate to apply a U.S. Census occupation code or for which the usual occupation field was left blank.

[§§§] The proportional distribution of drugs (i.e., the proportion of total drug overdoses deaths for each drug type) involved in drug overdose deaths include opioids and nonopioids (e.g., cocaine). PMRs are mutually dependent and a higher proportion for one cause (e.g., a specific drug) results in a lower proportion for another cause. In this analysis, cause-specific outcomes (e.g., heroin-related overdose or prescription opioid–related overdose) are not independent and are partially overlapping. Decedents might have multiple drug types within their system at time of death and therefore counted in more than one cause-specific outcome category.

[¶¶¶] Construction occupation group.

[****] Construction first-line supervisors and managers = census 2000 occupation code 620; construction trade workers = census 2000 occupation codes 621–653; construction trade helpers = census 2000 occupation code 660; other construction and related workers = census 2000 occupation codes 666–676. https://www.cdc.gov/niosh/topics/coding/pdfs/2000_Census_Occupation.pdf.

[††††] This occupation group includes supervisors/managers for both construction and extraction. A subcode to separate construction supervisors/managers from extraction supervisors/managers is not available.

TABLE 1. Usual occupation group and mortality from unintentional or undetermined drug overdoses* and drug overdoses involving heroin† or opioid analgesics§ — National Occupational Mortality Surveillance, United States, 2007–2012

U.S. Census 2000 occupation group¶	Total no. of deaths observed	Drug overdose*			Heroin†			Prescription opioid§		
		Deaths			Deaths			Deaths		
		No. observed	No. expected	Standardized PMR (95% CI)**	No. observed	No. expected	Standardized PMR (95% CI)**	No. observed	No. expected	Standardized PMR (95% CI)**
Total	**4,024,086**	**57,810**	—††	—††	**7,463**	—††	—††	**25,058**	—††	—††
Management	325,123	2,458	3,324.2	0.74 (0.71–0.77)	232	383.2	0.61 (0.53–0.69)	1,106	1,446.7	0.76 (0.72–0.81)
Business operations	38,740	349	496.2	0.70 (0.63–0.78)	31	51.2	0.61 (0.41–0.86)	155	213.2	0.73 (0.62–0.85)
Financial	51,795	390	575.2	0.68 (0.61–0.75)	31	57.5	0.54 (0.37–0.77)	181	254.6	0.71 (0.61–0.82)
Computer and mathematical	21,425	422	585.2	0.72 (0.65–0.79)	57	85.5	0.67 (0.5–0.86)	187	255.6	0.73 (0.63–0.84)
Architecture and engineering	88,825	580	839.3	0.69 (0.64–0.75)	62	116.5	0.53 (0.41–0.68)	265	354.1	0.75 (0.66–0.84)
Life, physical, and social science	24,332	257	301.8	0.85 (0.75–0.96)	20	37.9	0.53 (0.32–0.81)	124	133.8	0.93 (0.77–1.11)
Community and social services	39,046	381	449.3	0.85 (0.77–0.94)	35	48.6	0.72 (0.50–1.00)	160	190.4	0.84 (0.72–0.98)
Legal	17,677	208	254.3	0.82 (0.71–0.94)	15	24.1	0.62 (0.35–1.03)	98	116.1	0.84 (0.69–1.03)
Education, training, and library	146,334	701	1,187.8	0.59 (0.55–0.64)	46	109.1	0.42 (0.31–0.56)	289	514.8	0.56 (0.50–0.63)
Arts, design, entertainment, sports, and media	48,331	929	898.7	1.03 (0.97–1.10)	144	119.4	1.21 (1.02–1.42)	412	401.0	1.03 (0.93–1.13)
Health care practitioners and technical††	126,901	1,839	1,592.0	1.16 (1.10–1.21)	109	139.3	0.78 (0.64–0.94)	876	709.2	1.24 (1.15–1.32)
Health care support§§	57,196	1,363	1,153.1	1.18 (1.12–1.25)	116	106.7	1.09 (0.90–1.30)	626	518.9	1.21 (1.11–1.30)
Protective service	57,986	653	909.7	0.72 (0.66–0.78)	64	125.6	0.51 (0.39–0.65)	299	382.7	0.78 (0.7–0.88)
Food preparation and serving§§	109,961	2,885	2,595.3	1.11 (1.07–1.15)	486	345.6	1.41 (1.28–1.54)	1,207	1,142.6	1.06 (1.00–1.12)
Building and grounds cleaning and maintenance	121,966	2,025	2,090.4	0.97 (0.93–1.01)	344	294.7	1.17 (1.05–1.30)	811	888.9	0.91 (0.85–0.98)
Personal care and service§§	67,288	1,333	1,207.3	1.10 (1.05–1.17)	144	125.4	1.15 (0.97–1.35)	612	540.3	1.13 (1.04–1.23)
Sales	287,191	3,413	3,795.9	0.90 (0.87–0.93)	405	460.4	0.88 (0.80–0.97)	1,515	1,684.7	0.90 (0.85–0.95)
Office and administrative support	345,607	2,861	3,523.8	0.81 (0.78–0.84)	261	346.8	0.75 (0.66–0.85)	1,341	1,564.7	0.86 (0.81–0.90)
Farming, fishing, and forestry	27,421	354	482.4	0.73 (0.66–0.81)	49	66.1	0.74 (0.55–0.98)	158	222.1	0.71 (0.60–0.83)
Construction§§	244,534	7,402	5,902.5	1.25 (1.23–1.28)	1,345	922.9	1.46 (1.38–1.54)	3,122	2,573.0	1.21 (1.17–1.26)
Extraction§§	19,536	431	370.8	1.16 (1.06–1.28)	35	43.9	0.80 (0.55–1.11)	263	201.7	1.30 (1.15–1.47)
Installation, maintenance, and repair	124,578	2,179	2,201.1	0.99 (0.95–1.03)	319	339.5	0.94 (0.84–1.05)	950	945.6	1.00 (0.94–1.07)
Production	370,855	3,662	3,871.5	0.95 (0.92–0.98)	514	571.6	0.90 (0.82–0.98)	1,544	1,580.7	0.98 (0.93–1.03)
Transportation and material moving	276,558	4,370	4,656.7	0.94 (0.91–0.97)	710	721.1	0.98 (0.91–1.06)	1,680	1,869.1	0.90 (0.86–0.94)
Military specific	37,616	352	425.3	0.83 (0.74–0.92)	41	60.9	0.67 (0.48–0.91)	142	188.5	0.75 (0.63–0.89)
Nonpaid workers§§	856,256	13,001	11,819.2	1.10 (1.08–1.12)	1,324	1,380.0	0.96 (0.91–1.01)	5,783	5,250.3	1.10 (1.07–1.13)
Unknown§§	91,008	3,012	2,301.4	1.31 (1.26–1.36)	524	379.7	1.38 (1.26–1.50)	1,152	914.8	1.26 (1.19–1.33)

Abbreviations: CI = confidence interval; NOMS = National Occupational Mortality Surveillance; PMR = proportionate mortality ratio.

* Deaths were classified using the *International Classification of Diseases, Tenth Revision* (ICD–10). Drug overdose deaths were identified using underlying cause-of death codes X40–X44 (unintentional) and Y10–Y14 (unknown intent).

† Drug overdose deaths, as defined, that have heroin (T40.1) as a contributing cause.

§ Drug overdose deaths, as defined, that have prescription opioids (T40.2-T40.4) as a contributing cause.

¶ Occupation groups presented in ascending 2000 census code order (e.g., Management = 001–043); https://usa.ipums.org/usa/volii/occ2000.shtml.

** Indirectly standardized to the standard population of all NOMS deaths with occupation information by age, sex, race (white, black, other), calendar year (2007–2012), and state.

†† Not applicable.

§§ PMR significantly above 1.00 for drug overdose deaths in these categories.

industry.[§§§§] The top three industries among persons aged 18–64 years who reported using illicit drugs in the past month were accommodations and food services; arts, entertainment, and recreation; and construction (*10*).

The variation by occupation group in this study leads to speculation about opioid initiation or use and the work environment. A single on-the-job injury (e.g., fracture or dislocation) or chronic work-related pain (e.g., caused by repetitive motion or lifting) might result in a prescription for pain medication (*2*,*8*). Workers' compensation data from

[§§§§] Within "Industry," jobs are organized into categories by type of establishment/business whereas within "Occupation," jobs are organized into categories with similar job duties. For instance, within the 2016 construction industry, 62.4% were construction and extraction occupations, 9.7% were office and administrative support occupations, 6.2% were management occupations, and 3.2% were transportation and material moving occupations. (https://www.bls.gov/emp/ep_table_109.htm).

TABLE 2. Usual occupation group and mortality from unintentional and undetermined drug overdoses* involving natural and semisynthetic opioids†, methadone§, or synthetic opioids other than methadone¶ — National Occupational Mortality Surveillance, United States, 2007–2012

U.S. Census 2000 occupation group**	Total no. of deaths observed	Natural and semisynthetic opioids*			Methadone†			Synthetic opioids other than methadone§		
		Deaths			Deaths			Deaths		
		No. observed	No. expected	Standardized PMR (95% CI)††	No. observed	No. expected	Standardized PMR (95% CI)††	No. observed	No. expected	Standardized PMR (95% CI)††
Total	**4,024,086**	**16,603**	—§§	—§§	**7,504**	—§§	—§§	**3,966**	—§§	—§§
Management	325,123	747	965.5	0.77 (0.72–0.83)	326	433.0	0.75 (0.67–0.84)	177	223.7	0.79 (0.68–0.92)
Business operations	38,740	111	139.8	0.79 (0.65–0.96)	34	63.8	0.53 (0.37–0.74)	29	36.2	0.80 (0.54–1.15)
Financial	51,795	132	170.6	0.77 (0.65–0.92)	40	74.3	0.54 (0.38–0.73)	28	41.9	0.67 (0.44–0.97)
Computer and mathematical	21,425	120	167.1	0.72 (0.60–0.86)	51	81.2	0.63 (0.47–0.83)	35	37.4	0.94 (0.65–1.30)
Architecture and engineering	88,825	178	230.3	0.77 (0.66–0.90)	75	114.0	0.66 (0.52–0.82)	32	51.6	0.62 (0.42–0.88)
Life, physical, and social science	24,332	85	88.0	0.97 (0.77–1.19)	31	43.1	0.72 (0.49–1.02)	22	18.7	1.18 (0.74–1.78)
Community and social services	39,046	100	126.8	0.79 (0.64–0.96)	46	55.7	0.83 (0.60–1.10)	34	31.3	1.09 (0.75–1.52)
Legal	17,677	73	78.2	0.93 (0.73–1.17)	18	34.2	0.53 (0.31–0.83)	18	18.4	0.98 (0.58–1.54)
Education, training, and library	146,334	215	346.4	0.62 (0.54–0.71)	50	143.6	0.35 (0.26–0.46)	65	89.0	0.73 (0.56–0.93)
Arts, design, entertainment, sports, and media	48,331	268	264.8	1.01 (0.89–1.14)	125	124.5	1.00 (0.84–1.20)	60	57.9	1.04 (0.79–1.33)
Health care practitioners and technical	126,901	565	474.5	1.19 (1.09–1.29)	199	198.1	1.00 (0.87–1.15)	229	126.3	1.81 (1.59–2.06)
Health care support	57,196	396	339.5	1.17 (1.05–1.29)	197	152.4	1.29 (1.12–1.49)	106	93.4	1.13 (0.93–1.37)
Protective service	57,986	216	257.0	0.84 (0.73–0.96)	76	115.9	0.66 (0.52–0.82)	49	55.0	0.89 (0.66–1.18)
Food preparation and serving	109,961	765	744.9	1.03 (0.96–1.10)	400	357.3	1.12 (1.01–1.23)	180	176.3	1.02 (0.88–1.18)
Building and grounds cleaning and maintenance	121,966	544	591.7	0.92 (0.84–1.00)	249	265.4	0.94 (0.83–1.06)	119	137.3	0.87 (0.72–1.04)
Personal care and service	67,288	411	361.1	1.14 (1.03–1.25)	205	159.0	1.29 (1.12–1.48)	89	87.5	1.02 (0.82–1.25)
Sales	287,191	1,039	1,118.5	0.93 (0.87–0.99)	422	507.2	0.83 (0.75–0.92)	229	261.5	0.88 (0.77–1.00)
Office and administrative support	345,607	908	1,042.3	0.87 (0.82–0.93)	366	450.2	0.81 (0.73–0.90)	233	269.0	0.87 (0.76–0.98)
Farming, fishing, and forestry	27,421	103	140.0	0.74 (0.60–0.89)	54	80.5	0.67 (0.50–0.87)	23	28.4	0.81 (0.51–1.22)
Construction	244,534	2,013	1,696.2	1.19 (1.14–1.24)	1,075	805.2	1.34 (1.26–1.42)	416	366.3	1.14 (1.03–1.25)
Extraction	19,536	208	149.7	1.39 (1.21–1.59)	42	45.8	0.92 (0.66–1.24)	41	33.2	1.23 (0.89–1.67)
Installation, maintenance, and repair	124,578	631	625.8	1.01 (0.93–1.09)	304	293.2	1.04 (0.92–1.16)	132	135.0	0.98 (0.82–1.16)
Production	370,855	1,018	1,034.0	0.98 (0.93–1.05)	470	477.7	0.98 (0.90–1.08)	237	256.6	0.92 (0.81–1.05)
Transportation and material moving	276,558	1,084	1,227.8	0.88 (0.83–0.94)	548	572.6	0.96 (0.88–1.04)	235	283.2	0.83 (0.73–0.94)
Military specific	37,616	87	122.3	0.71 (0.57–0.88)	41	62.8	0.65 (0.47–0.89)	28	23.5	1.19 (0.79–1.72)
Nonpaid workers	856,256	3,841	3,485.7	1.10 (1.07–1.14)	1,705	1,527.7	1.12 (1.06–1.17)	946	887.7	1.07 (1.00–1.14)
Unknown	91,008	745	614.6	1.21 (1.13–1.30)	355	265.7	1.34 (1.20–1.48)	174	139.7	1.25 (1.07–1.44)

Abbreviations: CI = confidence interval; NOMS = National Occupational Mortality Surveillance; PMR = proportionate mortality ratio.

* Deaths were classified using the *International Classification of Diseases, Tenth Revision* (ICD–10). Drug overdose deaths were identified using underlying cause-of death codes X40–X44 (unintentional) and Y10–Y14 (unknown intent).

† Drug overdose deaths, as defined, with natural and semisynthetic opioids (T40.2) as a contributing cause.

§ Drug overdose deaths, as defined, with methadone (T40.3) as a contributing cause.

¶ Drug overdose deaths, as defined, with synthetic opioids other than methadone (T40.4) as a contributing cause. This category includes legal and illegal fentanyl along with other synthetic opioids.

** Occupation groups presented in ascending 2000 census code order (e.g., Management = 001–043); https://usa.ipums.org/usa/volii/occ2000.shtml.

†† Indirectly standardized to the standard population of all NOMS deaths with occupation information by age, sex, race (white, black, other), calendar year (2007–2012), and state.

§§ Not applicable.

26 states (2013–2015) indicated that opioids were prescribed for 52%–80% of injured workers who received pain medications (*2*). Persons might also self-medicate or work in an environment with normative support for illicit drug use (*9*). An estimated 64.2% of self-reported illicit opioid¶¶¶¶ users were employed full-time or part-time in 2016.***** As licit and illicit opioid users participate in the workforce, occupation might be an important factor in understanding and responding to the opioid epidemic.

¶¶¶¶ Illicit opioid means heroin or the use of prescription pain relievers in any way not directed by a doctor (does not include over-the-counter medications).

***** https://www.samhsa.gov/data/sites/default/files/NSDUH-DetTabs-2016/NSDUH-DetTabs-2016.pdf.

TABLE 3. Construction occupation subgroup* and mortality from unintentional and undetermined drug overdoses† by drug type — National Occupational Mortality Surveillance, United States, 2007–2012

Opioid type	First-line supervisors/managers		Construction trades workers		Helpers, construction		Other construction and related workers	
	No. observed	PMR (95% CI)§	No. observed	PMR (95% CI)§	No. observed	PMR (95% CI)§	No. observed	PMR (95% CI)§
Total	**24,306**	—¶	**213,029**	—¶	**419**	—¶	**6,780**	—¶
Overdose	338	0.94 (0.84–1.05)	6,901	1.28 (1.25–1.31)	26	1.31 (0.85–1.91)	137	1.15 (0.97–1.36)
Heroin**	44	0.88 (0.64–1.18)	1,282	1.51 (1.42–1.59)	—††	—††	15	0.84 (0.47–1.38)
Prescription opioids§§	148	0.96 (0.81–1.12)	2,911	1.23 (1.19–1.28)	12	1.42 (0.73–2.48)	51	1.00 (0.74–1.31)
Natural semisynthetic¶¶	92	0.9 (0.72–1.10)	1,876	1.21 (1.15–1.26)	6	1.07 (0.39–2.32)	39	1.16 (0.82–1.58)
Methadone***	49	1.01 (0.75–1.33)	1,007	1.36 (1.28–1.45)	—††	—††	15	0.93 (0.52–1.53)
Synthetic†††	27	1.26 (0.83–1.83)	383	1.14 (1.03–1.26)	—††	—††	—††	—††

Abbreviations: CI = confidence interval; NOMS = National Occupational Mortality Surveillance; PMR = proportionate mortality ratio.

* Construction first-line supervisors and managers = census 2000 occupation code 620; construction trade workers = census 2000 occupation codes 621–653; construction trade helpers = census 2000 occupation code 660; other construction and related workers = census 2000 occupation codes 666–676.

† Deaths were classified using *International Classification of Diseases, Tenth Revision* (ICD–10*)*. Drug overdose deaths were identified using underlying cause-of death codes X40–X44 (unintentional) and Y10–Y14 (unknown intent).

§ Indirectly standardized to the standard population of all NOMS deaths with occupation information by age, sex, race (white, black, other), calendar year (2007–2012), and state.

¶ Not applicable.

** Drug overdose deaths, as defined, that have heroin (T40.1) as a contributing cause.

†† Observations <5 are not shown. PMRs were not calculated.

§§ Drug overdose deaths, as defined, that have prescription opioids (T40.2-T40.4) as a contributing cause.

¶¶ Drug overdose deaths, as defined, that have natural and semisynthetic opioids (T40.2) as a contributing cause.

*** Drug overdose deaths, as defined, that have methadone (T40.3) as a contributing cause.

††† Drug overdose death, as defined, that have synthetic opioids other than methadone (T40.4) as a contributing cause. This category includes legal and illegal fentanyl along with other synthetic opioids.

The findings in this report are subject to at least six limitations. First, data were analyzed in aggregate, but occupational patterns for each drug type might have differed by year. Second, NOMS has limited information on the specific circumstances of death. It is not known, for example, whether the death occurred at work. Death certificates do not state whether decedents were employed at their usual job (listed on the death certificate), another job, or unemployed at the time of death; if the drug use was legal or illegal; or if drug use was initiated while decedents were employed at their usual job, another job, or before employment. Third, the specific drug involved in the drug overdose death might have been misclassified (e.g., heroin deaths misclassified as morphine deaths because of similar metabolites) or given nonspecific codes (*1*). Within this study, the only drug code listed for one fourth of overdose deaths was "other and unspecified drugs" (T50.9 excluding T36–T50.8). Outcome misclassification might vary by state and year. Fourth, intentional overdose deaths were excluded; however, an unknown proportion of undetermined deaths might have included homicides or suicides and might therefore have resulted in overestimates. In this study, 9.6% of drug overdose deaths were of undetermined intent. The distribution of overdose deaths by intent and occupation group need to be explored. Fifth, PMRs are mutually dependent and cannot distinguish whether occupation was associated with increasing a specific cause of death, preventing the occurrence of other causes of death, or some combination of these effects. Finally, only 21 states participated in NOMS during the study period, which limits generalizability of the findings.

This study identified occupation groups with a higher proportion of drug and opioid-specific overdose mortality but was unable to identify specific factors that might have led to the observed results. The surveillance data presented in this study generated many questions; future studies are needed to identify potential work-related factors along the causal pathway from drug initiation to overdose mortality and to investigate ways of tailoring prevention measures to specific occupations. Workplace-specific programs and policies to reduce the impact of the opioid epidemic can be implemented. Since 2009, a decline in opioid use among nonsurgical workers' compensation claims in 26 states has occurred, which is associated with changes to workers' compensation laws and regulations regarding pain management and the prescribing and distribution of opioids, in addition to corresponding national and state-level legislative and regulatory changes (*2*). Examples of programs††††† that might address both licit and illicit opioids include comprehensive drug-free workplace programs, employee assistance programs, peer-support networks, and education targeted to employees

††††† The Substance Abuse and Mental Health Services Administration (SAMHSA) provides detailed information on drug-free workplace programs, related laws and regulations, and a toolkit for employers (https://www.samhsa.gov/workplace).

Summary

What is already known about this topic?

A majority of the U.S. population participates in the workforce. A person's job affects both physical and psychological well-being. The opioid epidemic negatively affects workers, workplaces, and employers.

What is added by this report?

During 2007–2012 proportional mortality ratios (PMR) for heroin-related overdose deaths (1.46) and methadone-related overdose deaths (1.34) were highest for the construction occupation group. PMRs for natural and semisynthetic opioids were highest for the extraction (1.39) and health care practitioner (1.81) occupation groups.

What are the implications for public health practice?

Identification of occupations associated with drug overdose deaths further characterizes the opioid epidemic. Incorporating workplace research and targeted interventions might benefit the opioid epidemic response.

and employers (*3*,*5*,*6*). Continued evaluation of the effectiveness and impact of these programs and interventions are needed to prevent opioid misuse and abuse and to reduce opioid-related morbidity and mortality.

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Coccidioidomycosis Outbreak Among Workers Constructing a Solar Power Farm — Monterey County, California, 2016–2017

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In January 2017, two local health departments notified the California Department of Public Health (CDPH) of three cases of coccidioidomycosis among workers constructing a solar power installation (solar farm) in southeastern Monterey County. Coccidioidomycosis, or Valley fever, is an infection caused by inhalation of the soil-dwelling fungus *Coccidioides*, which is endemic in the southwestern United States, including California. After a 1–3 week incubation period, coccidioidomycosis most often causes influenza-like symptoms or pneumonia, but rarely can lead to severe disseminated disease or death (*1*). Persons living, working, or traveling in areas where *Coccidioides* is endemic can inhale fungal spores; workers who are performing soil-disturbing activities are particularly at risk. CDPH previously investigated one outbreak among solar farm construction workers that started in 2011 and made recommendations for reducing risk for infection, including worker education, dust suppression, and use of personal protective equipment (*2*,*3*). For the current outbreak, the CDPH, in collaboration with Monterey County and San Luis Obispo County public health departments, conducted an investigation that identified nine laboratory-confirmed cases of coccidioidomycosis among 2,410 solar farm employees and calculated a worksite-specific incidence rate that was substantially higher than background county rates, suggesting that illness was work-related. The investigation assessed risk factors for potential occupational exposures to identify methods to prevent further workplace illness.

Investigation and Results

Preconstruction preparations at the approximately 3,000-acre solar farm in Monterey County began in February 2016, and construction started in June 2016 in two phases; the first was completed in August 2017, and the second is expected to continue through the end of 2018. A confirmed case of coccidioidomycosis was defined by the Council of State and Territorial Epidemiologists as a diagnosed illness that met clinical criteria for coccidioidomycosis and was laboratory confirmed (*4*); CDPH further required that illness occurred in a solar farm construction employee, with symptom onset ≥1 week after beginning work and <1 month after the final workday at the solar farm. Employee rosters for February 2016–April 2017 provided by the solar farm owner were matched with the statewide CDPH coccidioidomycosis surveillance database to aid in case-finding. Patients identified through this matching process were interviewed using a structured questionnaire to obtain information on clinical signs and symptoms, occupational exposures, and use of dust control measures at the workplace. Medical records were requested from health care providers, and data were abstracted to confirm that patients met clinical and laboratory criteria. Employee rosters and interviews were used to confirm timing of illness onset associated with solar farm employment. The incidence rate among solar farm workers was calculated by dividing the number of confirmed cases by total person-years spent on the worksite among all employees during the period covered by owner-provided rosters. To calculate person-years, the total number of days between first and last day onsite for each employee was obtained from rosters; total person-days was then converted to person-years by dividing by 365. The annualized incidence among employees at this worksite was compared with background 2016 rates for Monterey and other counties surrounding the worksite by calculating a rate ratio with 95% confidence interval (CI) for each comparison county.

Among 2,410 employees who had worked at the solar farm for ≥1 day, 16 matches between employee rosters and the CDPH coccidioidomycosis surveillance database were identified; medical records were obtained for all 16, and 11 persons were interviewed by telephone. Overall, nine confirmed cases of coccidioidomycosis were identified among the 16 patients; three persons did not meet clinical criteria, and four did not meet work-related illness onset criteria. Eight of nine patients with confirmed coccidioidomycosis were interviewed; one could not be reached after multiple attempts and was confirmed by review of medical records and employment rosters only. Among the nine confirmed cases, median patient age was 42 years (interquartile range = 31–46 years), and seven were male (Table 1). Patients resided in four California counties (Fresno, Madera, Monterey, and San Luis Obispo). Six received diagnoses of coccidioidomycosis pneumonia; five had visited emergency departments from one to four times; one was hospitalized; and none died. Among the eight interviewed patients, seven reported missing work because of illness (median: 14 days; range = 1–320 days).

TABLE 1. Demographic and clinical characteristics of patients with confirmed coccidioidomycosis (N = 9) among workers constructing a solar power farm — California, 2016–2017

Characteristic	Patients, No. (%)
Age (yrs), Median IQR	42 (31–46)
Sex	
Male	7 (78)
Female	2 (22)
Received pneumonia diagnosis	6 (67)
Visited emergency department	5 (56)
Hospitalized	1 (11)
Died	0 (0)

Abbreviation: IQR = interquartile range.

Illness onset for the nine patients occurred during August–December 2016 (Figure). Seasonal rains, which suppressed dust, began in late December 2016 and continued through mid-April 2017; most of the first phase of construction was completed by May 2017. All patients reported working outdoors at the solar farm and had job titles that included biologist, paleontologist, electrician, truck driver, iron worker, and general laborer. All eight patients interviewed reported high dust levels frequently (every day or once a week); seven reported that water trucks were frequently unable to control dust levels; five reported frequently working in or near a ditch or trench; no patient was assigned to another work location or sent home because of high dust levels. Seven reported both infrequent (sometimes, rarely, or never) use of respiratory protection and no respirator fit-testing. Although seven reported receiving safety training about Valley fever, only three patients knew what to do if they had symptoms; subsequent review of training materials identified deficiencies (e.g., not emphasizing the potential for Valley fever to be a severe illness, not describing prevention strategies, and not indicating where employees should seek clinical care). No patients reported exposure to a dust cloud or other source of dust or dirt outside of work during the 4 weeks before illness onset.

The annualized coccidioidomycosis incidence among solar farm workers at this worksite was 1,095 per 100,000 persons/year; whereas the 2016 incidence in Monterey County was 17.5 per 100,000 population, corresponding to a rate ratio of 62.6 (95% CI = 31.4–124.8). Rate ratios for the five counties surrounding the worksite (Fresno, Kern, Kings, San Benito, and San Luis Obispo) ranged from 4.4 to 210.6 (Table 2). These findings indicate that the coccidioidomycosis incidence among employees was significantly higher than the background incidence rates in surrounding counties.

Summary

What is already known about this topic?

Workers performing soil-disturbing activities are at risk for coccidioidomycosis, an infection caused by inhaling the soil-dwelling fungus *Coccidioides*.

What is added by this report?

Nine confirmed coccidioidomycosis cases were identified among 2,410 solar farm workers in California. The incidence among workers (1,095 per 100,000 persons/year) was 4.4 to 210.6 times higher than background county rates, providing evidence that illness was work-related.

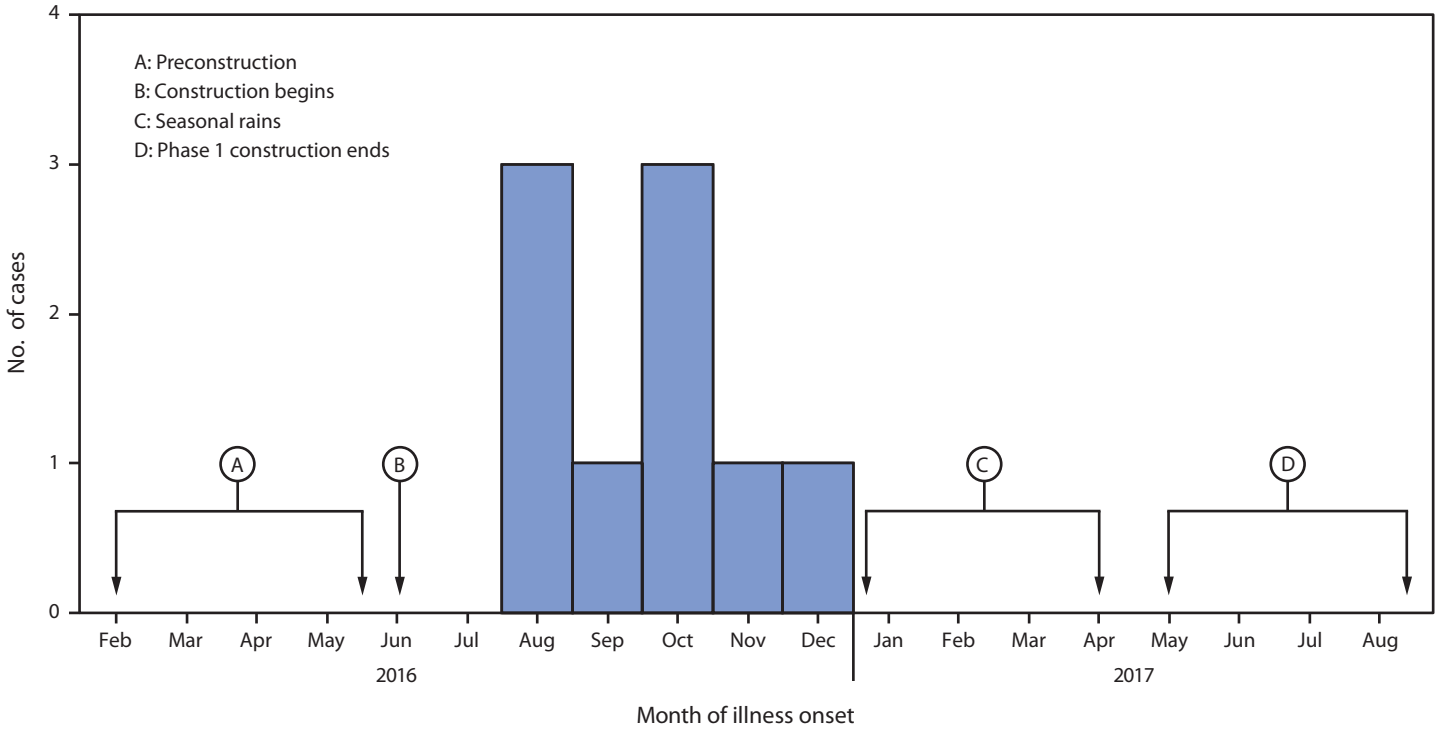
What are the implications for public health practice?

Employers should take measures to protect workers from dust exposure in areas where *Coccidioides* is endemic, involvement of public health practitioners is needed in the review of proposed construction that might expose workers to coccidioidomycosis, and clinicians should suspect coccidioidomycosis in patients with a clinically compatible illness who work outdoors.

Public Health Response

On July 26, 2017, CDPH provided interim recommendations for prevention of illness to the solar farm owner and all employers and union representatives associated with the worksite. On August 8, 2017, CDPH and San Luis Obispo Public Health Department conducted a site visit to the solar farm to observe and interview current workers and employers about work practices, dust control, and use of protective equipment; review training materials; and discuss prevention strategies. The visit confirmed dust control issues, serious lapses in use of respiratory protection, insufficient coccidioidomycosis employee training, and no system for tracking or reporting illness. In November 2017, CDPH issued formal investigation findings and prevention recommendations before the start of the second construction phase, which is scheduled to continue through the end of 2018. Recommendations for employers included 1) reducing dust exposure by ensuring ample and efficient water truck capacity to wet soil; 2) using only heavy equipment with enclosed cabs and temperature-controlled, high efficiency particulate air–filtered air; 3) providing clean coveralls daily to employees who disturb soil; 4) implementing a mandatory respiratory protection program (8 CCR §5144, Respiratory Protection: https://www.dir.ca.gov/title8/5144.html) that specifically requires National Institute for Occupational Safety and Health–approved respirators be worn while performing or in the near vicinity of job activities that create airborne dust; 5) developing effective Valley fever training for all employees, including ways to reduce exposure,

FIGURE. Construction schedule and illness onset of coccidioidomycosis among workers constructing a solar power farm (N = 9) — Monterey County, California, 2016–2017



how to recognize symptoms, and where to seek care; and 6) tracking and reporting of all suspected Valley fever illnesses that occur at the worksite to the Monterey County Health Department. The California Division of Occupational Safety and Health cited six solar farm employers for not protecting workers from coccidioidomycosis; violations included failure to control employee exposure to dust and failure to provide and ensure use of respiratory protection (*5*).

Discussion

Coccidioidomycosis is a reportable disease in 22 states including California, where a substantial increase in incidence has been observed since 2014 (*6*). Underrecognition, misdiagnosis, and substantial delays between seeking health care and accurate diagnosis are common (*7*). Outdoor workers performing soil-disturbing activities in areas where *Coccidioides* is endemic are particularly at risk for infection, and approximately half of all reported outbreaks have involved occupational exposures (*8*), including outbreaks among workers constructing two solar farms in San Luis Obispo County, California, during 2011–2014 (*2*,*3*).

TABLE 2. Coccidioidomycosis incidence* and rate ratios among solar farm workers and counties surrounding the solar farm worksite

Population	Incidence (cases per 100,000 population)	RR (95% CI)
Solar farm workers	1,095	—
Monterey County	17.5	62.6 (31.4–124.8)
Kern County	251.7	4.4 (2.3–8.4)
Kings County	157.3	7.0 (3.6–13.5)
San Luis Obispo County	82.8	13.2 (6.8–25.7)
Fresno County	60.8	18.0 (9.3–34.8)
San Benito County	5.2	210.6 (57.0–777.8)

Abbreviations: CI = confidence interval; RR = rate ratio.
* Incidence for solar farm workers is annualized. Incidence in surrounding counties is for 2016.

The high incidence among these solar farm workers provides evidence that coccidioidomycosis was likely acquired at work rather than in the community. Employers in areas with endemic *Coccidioides* should implement infection prevention measures and protect workers who are at risk for exposure to *Coccidioides*; risk for infection can be decreased by using dust-control measures and appropriate personal protective equipment at work (*3*). In California, numerous large-scale energy projects are in the planning or construction phases,

and many are in the Central Valley and Central Coast regions where *Coccidioides* is endemic (*9*). Despite previous outbreak investigations and subsequent recommendations (*2*,*3*), this report of another coccidioidomycosis outbreak among solar farm workers indicates that prevention methods need to be better incorporated into the planning and monitoring of construction projects in areas with endemic *Coccidioides* (e.g., by involving public health practitioners in preproject reviews). Outdoor workers in these areas should be trained by employers about the potential for infection, how to limit dust exposure, how to recognize symptoms, where to seek care, and how to ask a health care provider to assess them for coccidioidomycosis. Clinicians should inquire about occupational history and should suspect coccidioidomycosis in patients who are outdoor workers in areas with endemic *Coccidioides* and who have a clinically compatible illness.

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All authors have completed and submitted the ICMJE form for disclosure of potential conflicts of interest. No potential conflicts of interest were disclosed.

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Assessment of Epidemiology Capacity in State Health Departments — United States, 2017

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In 2017, the Council of State and Territorial Epidemiologists performed its sixth periodic Epidemiology Capacity Assessment, a national assessment that evaluates trends in workforce size, funding, and epidemiology capacity among state health departments. A standardized web-based questionnaire was sent to the state epidemiologist in the 50 states, the District of Columbia (DC), and the U.S. territories and the Federated States of Micronesia inquiring about the number of current and optimal epidemiologist positions; sources of epidemiology activity and personnel funding; and each department's self-perceived capacity to lead activities, provide subject matter expertise, and obtain and manage resources for the four Essential Public Health Services (EPHS)* most closely linked to epidemiology. From 2013 to 2017, the number of state health department epidemiologists† increased 22%, from 2,752 to 3,369, the greatest number of workers since the first full Epidemiology Capacity Assessment enumeration in 2004. The federal government provided most (77%) of the funding for epidemiologic activities and personnel. Substantial to full capacity (50%–100%) was highest for investigating health problems (92% of health departments) and monitoring health status (84%), whereas capacity for evaluating effectiveness (39%) and applied research (29%) was considerably lower. An estimated additional 1,200 epidemiologists are needed to reach full capacity to conduct the four EPHS. Additional resources might be needed to ensure that state health department epidemiologists possess the specialized skills to deliver EPHS, particularly in evaluation and applied epidemiologic research.

Epidemiology Capacity Assessments were conducted in 2001, 2004, 2006, 2009, and 2013, with supplementary workforce enumeration conducted in 2010. Since 2004, 100% of the states and DC have responded to the assessment. The Epidemiology Capacity Assessment was updated in 2017 to reflect expansion of health department programs into genomics, informatics, and vital statistics. A core set of questions has remained essentially unchanged and permits the monitoring of trends in the epidemiology workforce employed by the 50 states, DC, and U.S. territories; current funding sources for epidemiology activities and personnel; capacity in the four EPHS relevant to epidemiology (*1*); and issues in hiring, training, and retaining skilled epidemiologists to meet current needs and changing priorities.

After the council piloted the instrument, the 2017 Epidemiology Capacity Assessment was disseminated electronically to state and territorial epidemiologists using Qualtrics,§ an online survey tool. Data collection began April 28, 2017, and was completed August 11, 2017. Virtual technical assistance was provided to support completion of the Epidemiology Capacity Assessment. All 50 states, DC, and three territories responded to the assessment; this analysis includes responses from U.S. states and DC. The number of full-time equivalent (FTE) epidemiologist positions (to the nearest 0.1 FTE) was collected by program area and source of funding. Respondents subjectively evaluated their capacity for each EPHS as none (0%), minimal (1%–24%), partial (25%–49%), substantial (50%–74%), almost full (75%–99%), and full (100%). For each program area, jurisdictions were asked to provide an overall judgement of capacity¶ to meet all four EPHS.

A total of 3,369 FTE epidemiologist positions were enumerated in 2017, a 22% increase over the 2,752 reported in 2013. Overall, the number of epidemiologists per 100,000 population was 1.04 (range = 0.2–5.6), 20% higher than the 0.87 per 100,000 calculated in 2013. The size of the epidemiology workforce in each state ranged from five to 208.

The federal government provided 77% of funding for epidemiologic activities and personnel in 2017, a slight decrease

* The four EPHS capacities evaluated in the assessment included 1) monitoring health status to identify and solve community health problems (EPHS #1); 2) diagnosing and investigating health problems and health hazards in the community (EPHS #2); 3) evaluating effectiveness, accessibility, and quality of personal and population-based health services (EPHS #9); and 4) researching new insights and innovative solutions to health problems (EPHS #10).

† Epidemiologists were defined as "all those employed by the state; all those working at the state level who are either federal assignees (e.g., [Epidemic Intelligence Services officer], [Career Epidemiology Field officer], [Public Health Associate Program associate]) or contract employees (e.g., [Council of State and Territorial Epidemiologists] trainee, contracted from school of public health to work at or for the State Health Department); and state employees assigned to work at a local or regional level (e.g., to conduct investigations for a region of the state)" who should focus on the functions performed by the individual rather than the job title, using as guidance the Applied Epidemiology Competencies.

§ https://www.qualtrics.com/.

¶ For purposes of the Epidemiology Capacity Assessment, capacity was defined as "the state health department's ability to lead activities, provide subject matter expertise, and apply for, receive, and manage resources to conduct key activities."

from 79% in 2013. State governments provided an additional 19%, an amount unchanged since 2013, and the remaining 4% came from other sources. CDC was the source of 89% of the 2017 federal funding for epidemiology personnel.

Among program areas, infectious diseases accounted for 1,838 (55%) of the 3,369 epidemiology positions, followed by maternal and child health (MCH) (10%) and chronic diseases (9%) (Table) (Figure 1). Program areas with the fewest epidemiologists included substance abuse, occupational health, oral health, mental health, and genomics. The number of infectious disease positions has increased steadily since program area positions were first measured in 2004; infectious disease positions experienced the largest absolute increase from 2013 to 2017, with the addition of 487 positions (Figure 1). In contrast, the number of epidemiologists in preparedness (formerly bioterrorism and emergency response) positions has been declining since 2004, and the decline was steeper (-55%) during 2013–2017. The number of MCH epidemiologists has gradually increased, and the number of injury epidemiologists, after experiencing a gradual decline, is higher than any time in the past. The number of chronic disease, and environmental, occupational, and oral health program epidemiologists has remained stable or declined since 2004.

Participating state epidemiologists expressed the need for nearly 1,200 additional epidemiologists to reach full capacity to provide the four EPHS, a 36% increase over current levels (Table). Nearly 600 of these additional needed epidemiologists are in the areas of infectious diseases, MCH, and chronic diseases, areas which already represent 75% of the epidemiology workforce. Although jurisdictions reported the need for additional positions in programs for substance abuse (64), mental health (42), and genomics (20), these program areas accounted for only 4% of the optimal total positions (those currently filled plus those needed). At the time of the assessment, among 353 vacancies nationwide, 314 (89%) positions were being actively recruited, including 141 (45%) in infectious disease program areas.

In 2017, 84% and 92% of jurisdictions perceived that they had substantial-to-full capacity for monitoring health status (EPHS #1) and investigating health problems and hazards (EPHS #2), respectively, similar to responses in 2013 (82% and 90%, respectively). In contrast, 39% of the 51 reporting jurisdictions reported substantial-to-full capacity for evaluation of effectiveness (EPHS #9), up from 35% in 2017, and 22% reported similar capacity for research (EPHS #10), compared with 29% in 2013.

When overall capacity was examined by program area, substantial-to-full capacity was highest for infectious diseases, chronic diseases, and MCH and was lowest for genomics, mental health, and substance abuse (Figure 2). From 2013 to 2017, substantial-to-full capacity changed by <5 percentage points for all program areas, with the exception of chronic diseases (increase from 66% to 78%), environmental health (decline from 49% to 43%), and mental health (decline from 8% to 2%). Preparedness, which experienced a 55% decrease in the number of epidemiologists, reported a decline in capacity of two percentage points, from 69% to 67%.

Discussion

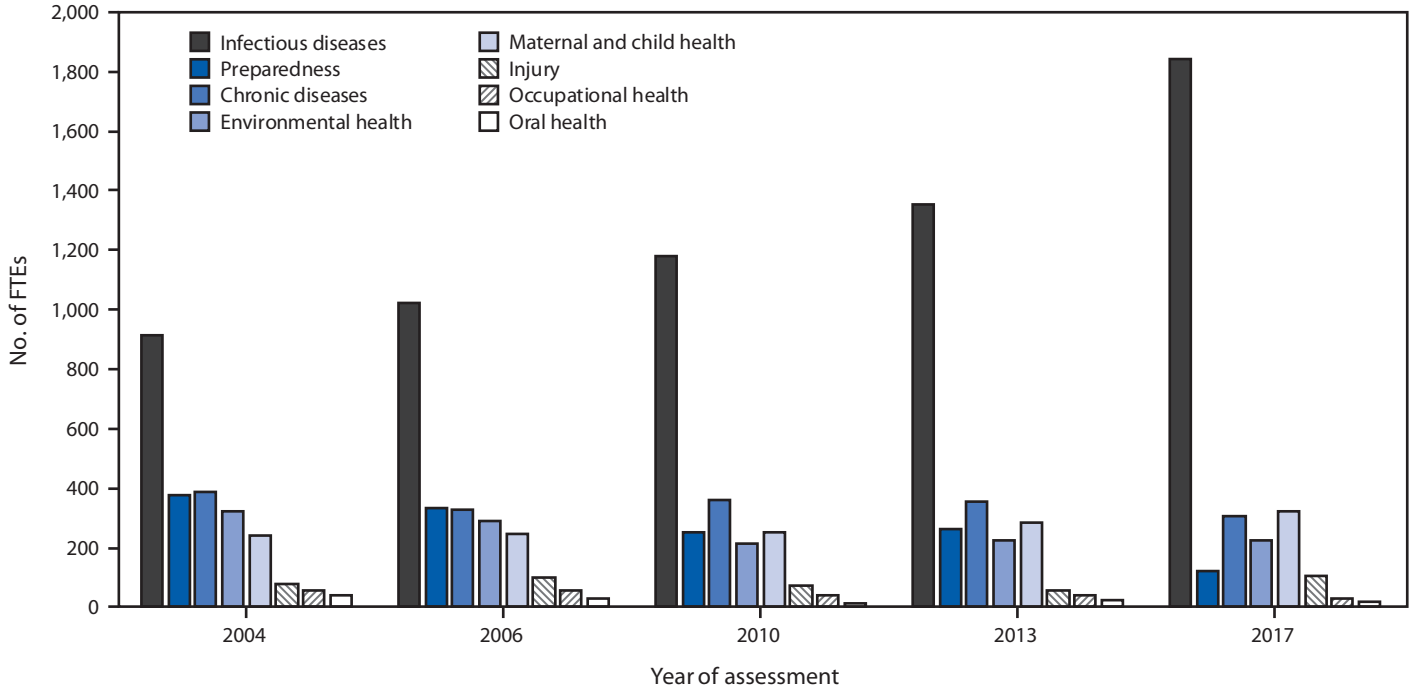
Overall, the 2017 Epidemiology Capacity Assessment documented that, although the epidemiology workforce continues to grow, there is an ongoing unmet need for additional

TABLE. Epidemiology full-time equivalents (FTEs), by program area — Council of State and Territorial Epidemiologists Epidemiology Capacity Assessment, 50 states and the District of Columbia, 2017

Program area	FTEs currently filled (% of total)	Additional FTEs needed	Optimal* (% of ideal FTEs currently met)†	Vacant positions§	Positions actively being recruited¶
Infectious disease	1,838.2 (54.6)	338.4	2,176.6 (84.4)	158.6	140.6
Maternal and child health	321.2 (9.5)	122.0	443.2 (72.4)	44.7	37.7
Chronic disease	304.4 (9.0)	136.6	441.0 (69.0)	41.7	36.7
Environmental health	221.7 (6.6)	121.9	343.6 (64.5)	23.3	18.3
Informatics	95.7 (2.8)	91.2	186.9 (51.2)	15.0	14.0
Vital statistics	110.7 (3.3)	62.0	172.7 (64.1)	13.2	13.2
Injury	102.5 (3.0)	56.9	159.4 (64.3)	11.2	13.2
Preparedness	117.6 (3.5)	35.7	153.3 (76.7)	9.5	10.5
Substance abuse	58.6 (1.7)	63.7	122.3 (47.9)	8.8	6.3
Occupational health	28.4 (0.8)	38.1	66.5 (42.7)	7.5	5.5
Mental health	4.0 (0.1)	42.3	46.3 (8.6)	6.0	6.0
Oral health	18.0 (0.5)	25.0	43.0 (41.9)	3.0	2.0
Genomics	4.4 (0.1)	20.2	24.6 (17.9)	1.3	3.3
Other	143.4 (4.3)	45.1	188.5 (76.1)	9.6	6.6
Total	**3,368.8 (100.0)**	**1,199.1**	**4,567.9 (73.7)**	**353.4**	**313.9**

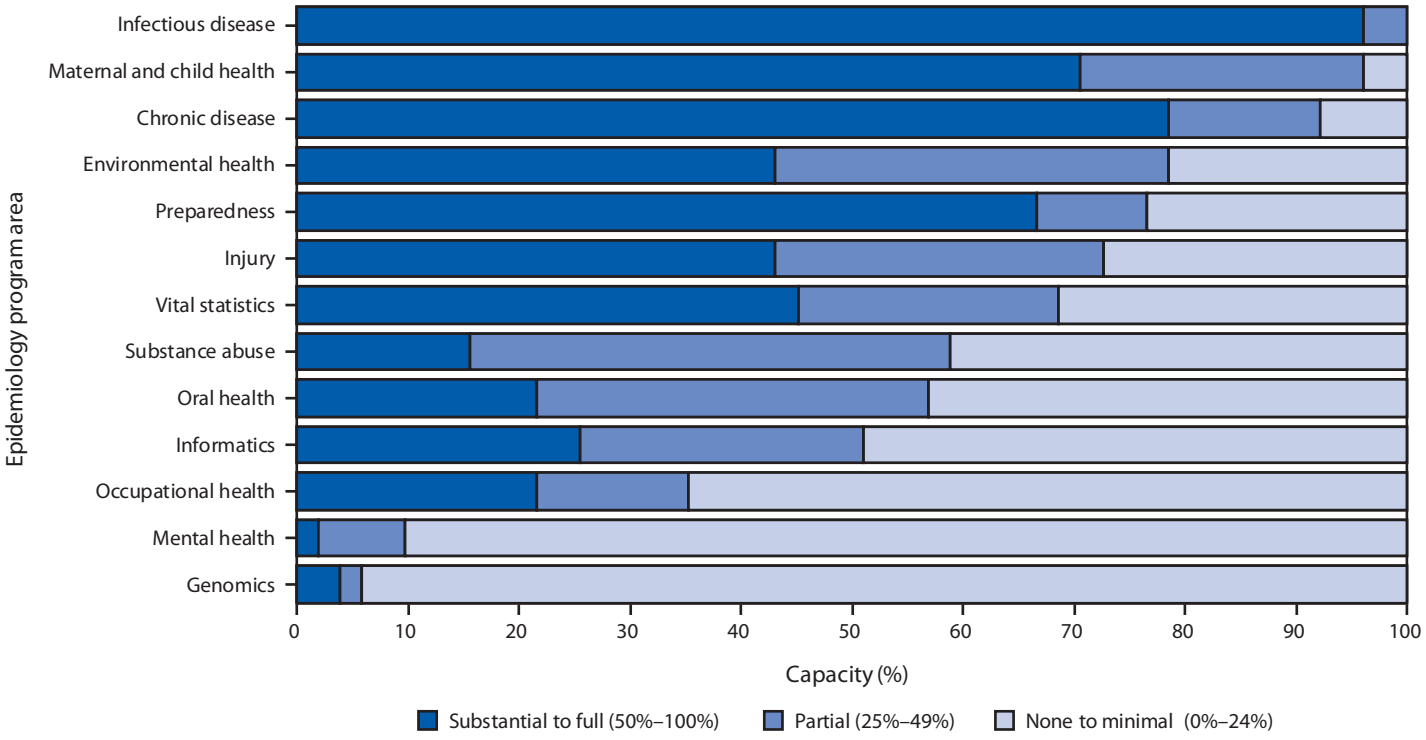
* Currently filled plus additional needed.
† Currently filled/ideal x 100.
§ Positions to be filled at a state health department for which work is available and the job could start within 30 days.
¶ Vacant positions human resources working actively to fill.

FIGURE 1. Epidemiology full-time equivalents (FTEs), by program area* — Council of State and Territorial Epidemiologists Epidemiology Capacity Assessment, United States, 2004–2017



* Preparedness was formerly bioterrorism.

FIGURE 2. Overall current epidemiologic capacity to provide four Essential Public Health Services* — Council of State and Territorial Epidemiologists Epidemiology Capacity Assessment, United States, 2017



* The four Essential Public Health Services (EPHS) capacities evaluated included 1) monitoring health status to identify and solve community health problems (EPHS #1); 2) diagnosing and investigating health problems and health hazards in the community (EPHS #2); 3) evaluating effectiveness, accessibility, and quality of personal and population-based health services (EPHS #9); and 4) researching new insights and innovative solutions to health problems (EPHS #10).

epidemiologist positions in well-established areas, such as infectious diseases, and in emerging areas, including substance abuse, mental health, and informatics. Whereas capacity is high in monitoring health status and in diagnosing public health problems, capacity in evaluation and research lags behind, and no strict correlation exists between growth in workforce size and EPHS capacity. Program area capacity is high in well-established areas but is lower for newer areas such as genomics and informatics and for areas with low and waning numbers of epidemiologists, such as oral health and environmental health.

The recent increase in infectious disease and injury positions and decrease in preparedness positions might reflect changes in funding sources and priorities. In the past 2 decades, the Epidemiology and Laboratory Capacity and Public Health Emergency Preparedness cooperative agreements have provided funding to health departments for many infectious disease and preparedness epidemiology positions (*2*,*3*) in response to emerging and reemerging threats (*4*,*5*). However, funding recently has decreased for preparedness (*6*) and increased for infectious diseases, and some epidemiologists previously working in preparedness might have shifted to infectious disease positions. Such a shift might explain why capacity in preparedness has not decreased substantially in the face of the 55% decrease in preparedness positions. Recently, CDC has also increased funding to injury programs in response to the U.S. opioid epidemic through cooperative agreements for the Prevention for States program (*7*), Data-Driven Prevention Initiative (*8*), and Enhanced State Opioid Overdose Surveillance (*9*).

The findings in this report are subject to at least two limitations. First, the number of epidemiology positions is measured only for state health departments and does not include epidemiologists working in other state agencies such as occupational health epidemiologists working in state departments of labor. Second, the data on public health capacity are subjective, although when the analyses were limited to those jurisdictions with the same state epidemiologist in 2013 and 2017, EPHS capacity findings were essentially unchanged.

Despite the increase in the number of epidemiologists since 2013, only infectious diseases, preparedness, chronic diseases, and MCH have substantial-to-full capacity to conduct EPHS. Serious capacity deficits remain, especially in areas of substance abuse, mental health, occupational health, environmental health, and informatics at a time when these areas are assuming increasing importance.** Capacity in evaluation and research is particularly low. The increase in program area capacity that accompanied the increase in epidemiologists from 2009 to 2013 did not continue from 2013 to 2017. The findings suggest that hiring alone, without considering the specialized skills needed to improve the current perceived gaps in capacity, might no longer result in capacity improvements. Gaps in capacity affect the ability of public health agencies to respond and leave them vulnerable to emerging threats such as the current opioid epidemic. Hiring epidemiologists with evaluation and research skills or retraining existing staff members and prioritizing these skills in state health departments might help achieve full EPHS capacity.

Summary

What is already known about this topic?

Overall, the state health department epidemiology workforce has increased over time, but an unmet need remains high. Evaluation and research capacity has improved but remains low. Most funding has come from the federal government.

What is added by this report?

From 2013 to 2017, the number of state epidemiologists increased by 22%. Several emerging program areas remain seriously understaffed. The federal government continues to fund most (77%) state epidemiology activities and personnel. Capacity in four assessed Essential Public Health Services has remained stable or has declined in all areas except evaluation.

What are the implications for public health practice?

More epidemiologists and greater expertise in evaluation and applied research are needed to achieve comprehensive health department capacity.

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Notes from the Field

Mumps Outbreak — Alaska, May 2017–July 2018

Amanda Tiffany, PhD[1,2]; Drew Shannon[3]; Willy Mamtchueng[3]; Louisa Castrodale, DVM[2]; Joseph McLaughlin, MD[2]

In May 2017, the Alaska Section of Epidemiology (SOE) was notified of an Anchorage resident with laboratory-confirmed mumps who reported exposure to an out-of-state visitor with mumps-like symptoms. Another seven laboratory-confirmed cases were reported in late July and August; all were in Anchorage residents, mostly in persons who self-identified as Native Hawaiian or other Pacific Islander (NH/PI). In response, SOE disseminated educational materials and recommended that all Alaskans ensure that they were up to date on their measles-mumps-rubella (MMR) vaccinations. Cases were classified as suspected, probable, or confirmed according to the Council of State and Territorial Epidemiologists case definition (*1*).

On November 15, with 56 confirmed and probable mumps cases identified (including 82% among NH/PI, who represent 4.8% of the Anchorage population), SOE recommended a third dose of MMR vaccine (MMR3) for persons at increased risk for acquiring mumps, such as persons participating in group settings (e.g., school, daycare, church) where mumps cases were identified or any persons who self-identified as NH/PI, if at least 5 years had passed since their second MMR dose (*2*). Despite this recommendation, cases continued to occur among persons at increased risk and among persons without documented epidemiologic links to other cases. Consequently, on December 28, 2017, when 138 cases had been reported, the MMR3 recommendation was expanded to all Anchorage residents. On February 22, 2018, with 247 cases reported, and cases continuing and occurring statewide among persons with indeterminate epidemiologic links and no history of in-state or out-of-state travel, the recommendation was extended to all 737,080 Alaska residents.

Concurrently, SOE and the Anchorage Department of Health and Human Services coordinated community outreach in collaboration with local partners to offer targeted vaccination clinics, presentations, and media campaigns to raise awareness about the outbreak and the importance of vaccination. Since November 15, 2017, when the first MMR3 recommendation was made, through July 31, 2018, the average number of MMR doses administered in Anchorage (where most of the outreach was focused) increased by 136% to 461 per month, from 195 per month before the recommendation (November 1, 2016–November 15, 2017) (p = 0.001) (Figure).

As of July 31, 2018, the outbreak is ongoing, with 391 confirmed and probable cases reported; 94% of cases have been in Anchorage residents. The median age of patients was 25 years (range = 3 months–79 years) and 193 (49%) self-identified as NH/PI. Overall, 162 (41%) patients had received ≥2 MMR doses before symptom onset, 51 (13%) received 1 dose, and 15 (4%) had not received MMR; vaccination status was unknown for 163 (42%) patients.

Compared with mumps outbreaks in discrete populations such as universities where the population at risk is well defined, community outbreaks pose unique challenges. Following updated Advisory Committee on Immunization Practice recommendations (*3*), a third MMR dose was recommended for persons at increased risk for acquiring mumps as defined by the epidemiologic data. However, as the outbreak evolved, it became more difficult to determine who was at increased risk. Group-specific MMR3 recommendations were challenging for clinicians to implement when faced with uncertainty about whether their patients participated in group settings where mumps was circulating. In response, SOE implemented a stepwise expansion of its MMR3 recommendation that eventually included all Alaskans. Evaluation of Alaska's response to the mumps outbreak, including the impact of MMR3 recommendations on MMR uptake, is ongoing. Disseminating information through social media, working with community groups, and vaccination clinics have been important in raising awareness and increasing vaccine uptake.

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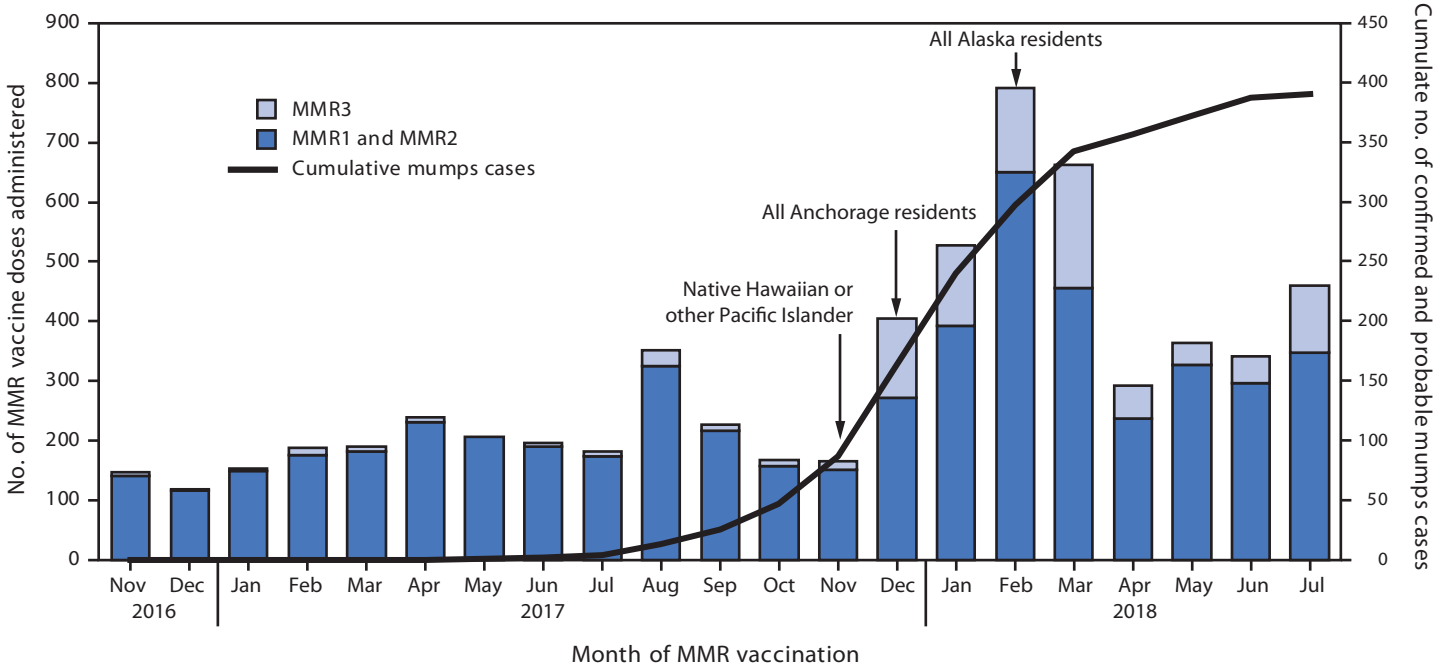
FIGURE. Cumulative number of confirmed and probable mumps cases and MMR vaccine doses administered,* by dose number and month of vaccination — Anchorage, Alaska, November 2016–July 2018



Abbreviations: MMR = measles-mumps-rubella vaccine; MMR1 = first MMR dose; MMR2 = second MMR dose; MMR3 = third MMR dose.
* Arrows indicate the month during which MMR3 recommendation was made for specific populations.

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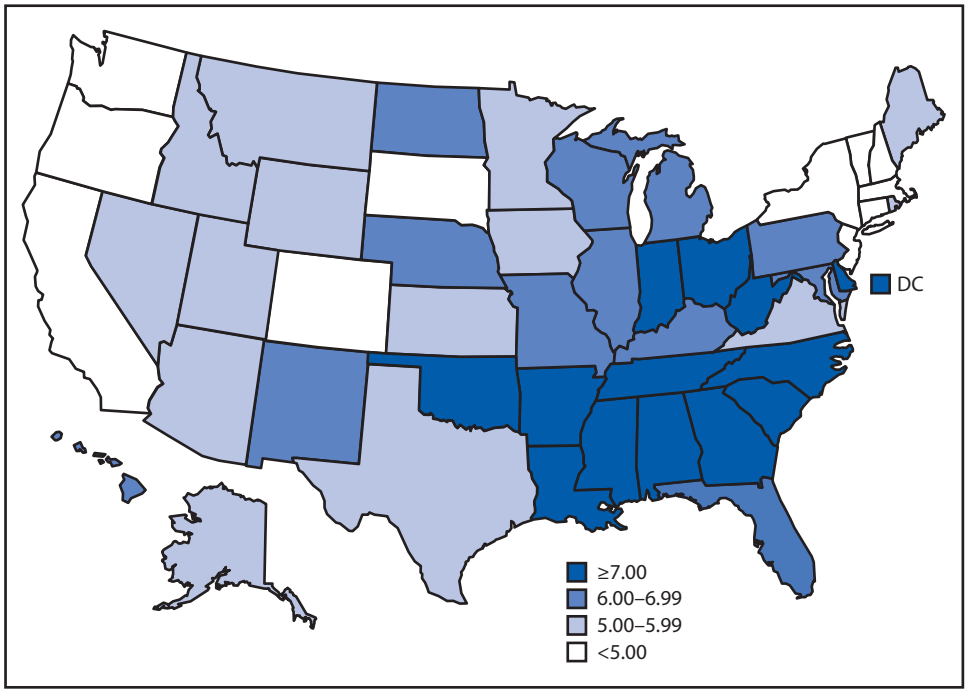
QuickStats

FROM THE NATIONAL CENTER FOR HEALTH STATISTICS

Infant Mortality Rate,* by State — United States, 2016



* The infant mortality rate is the number of infant (aged <1 year) deaths per 1,000 live births.

In 2016, the infant mortality rate in the United States was 5.87 infant deaths per 1,000 live births. The rate ranged from 3.47 in Vermont to 9.03 in Alabama. Rates in two other states were <4.00 (New Hampshire [3.67] and Massachusetts [3.94]). Higher rates were primarily in the southern states. In addition to Alabama, two other states had rates >8.00 (Arkansas [8.20] and Mississippi [8.67]).

Source: National Vital Statistics System. Linked birth/infant death period files, 2016. https://www.cdc.gov/nchs/nvss/linked-birth.htm.

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