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RESEARCH PAPER

Trends in human papillomavirus (HPV) vaccination initiation among adolescents aged 13–17 by metropolitan statistical area (MSA) status, National Immunization Survey – Teen, 2013 – 2017

Tanja Y. Walker[a], Laurie D. Elam-Evans[a], Charnetta L. Williams[a], Benjamin Fredua[b], David Yankey[a], Lauri E. Markowitz[c], and Shannon Stokley[a]

[a]Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases, Immunization Services Division; [b]Leidos Health, Inc., Reston, VA, USA; [c]Centers for Disease Control and Prevention, National Center for Immunization and Respiratory Diseases, Division of Viral Diseases, Atlanta, GA, USA

ABSTRACT

Disparities in HPV vaccination coverage by metropolitan statistical area (MSA) status were observed in the 2016 and 2017 National Immunization Survey – Teen (NIS-Teen). In 2017, HPV vaccination initiation (≥1dose) coverage was 11 percentage points lower for adolescents living in non-MSAs (mostly rural areas) and 7 percentage points lower among those living in MSA, non-principal cities (suburban areas) compared to those living in MSA, principal cities (mostly urban areas). In order to understand how this disparity has changed over time, we examined trends in HPV vaccine initiation by MSA status from 2013 to 2017. Weighted linear regression by survey year was used to estimate annual percentage point changes in HPV vaccination initiation. The five-year average annual percentage point increases in HPV vaccination initiation coverage were 5.2 in mostly urban areas, 4.9 for suburban areas, and 5.2 for mostly rural areas. Despite increases in each MSA area, coverage in mostly rural areas was consistently and significantly lower than coverage in mostly urban areas. Coverage was significantly lower among teens living in mostly rural areas regardless of poverty status, sex, and race/ethnicity except among black, non-Hispanic adolescents. There was no significant change in the magnitude of the disparity between mostly urban areas and mostly rural areas over time (p = .98). A better understanding of the facilitators and barriers to HPV vaccination in mostly rural areas is needed to identify and implement targeted strategies to improve HPV vaccination coverage and reduce these disparities.

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Introduction

Human papillomavirus (HPV) is the most common sexually transmitted infection in the United States. Each year, HPV infections result in the diagnosis of HPV-related cancers for more than 40,000 men and women – HPV is associated with 90% of all anal and cervical cancers; 70% or more of all oropharyngeal and vaginal cancers, and more than 60% of all penile and vulvar cancers.[1,2] To prevent HPV-related infections and cancers, the Advisory Committee on Immunization Practices (ACIP) recommended a three-dose series of HPV vaccine for 11- to 12-year-old girls in 2006 and for boys in 2011.[3,4] In December 2016, the ACIP revised the recommendation to a two-dose series for immunocompetent adolescents beginning the series prior to their 15th birthday, when the two doses are given at least 6 months apart.[5] Persons aged 15–26 years and those with compromised immune systems are recommended to complete a three-dose vaccine series.[5,6]

Since ACIP recommended HPV vaccination for all adolescents, vaccination coverage has increased gradually among females and more rapidly among males. In 2017, coverage with ≥1-dose of HPV vaccine was 65.5% among adolescents aged 13 through 17 years; coverage was 68.6% among females and 62.6% among males.[7] While vaccination coverage with ≥1-dose of HPV vaccine continues to increase, coverage has not reached the level seen for other vaccines recommended for preadolescents aged 11–12 years – tetanus, diphtheria and acellular pertussis vaccine (Tdap) and quadrivalent meningococcal conjugate vaccine (MenACWY). In 2017, coverage with ≥1-dose of HPV vaccine was 23.2 percentage points lower than coverage with ≥1-dose of Tdap and 19.6 percentage points lower than coverage with ≥1-dose of MenACWY.[7] Reasons for the lower coverage with ≥1-dose of HPV vaccine in comparison to coverage with Tdap and MenACWY are not fully understood; however, state requirements of Tdap and MenACWY vaccination for school enrollment may be a factor.[8] Additionally, lack of a strong provider recommendation for HPV vaccination at age 11–12, lack of awareness of the HPV vaccine, low perceived risk of infection, and safety concerns about the vaccine have been reported by parents as major barriers to HPV vaccine initiation.[9–11]

Based on analysis of the 2016 National Immunization Survey – Teen (NIS-Teen) data, urban-rural disparities (as

CONTACT Tanja Y. Walker tywalker@cdc.gov Centers for Disease Control/NCIRD/ISD, 1600 Clifton Rd, Mailstop H24-4, Atlanta, GA 30329-4027, USA
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defined by the MSA status variable) in HPV vaccination initiation (receipt of ≥1dose of HPV vaccine) were observed among adolescents,[12] similar to other previously published studies.[13–16] In 2017, the disparity in HPV vaccination initiation among adolescents living in MSA non-principal cities (suburban areas) compared to those living in MSA, principal cities (mostly urban areas) remained the same.[7] However, the disparity in HPV vaccination initiation among adolescents living in non-MSAs (mostly rural areas) compared to those living in mostly urban areas decreased by 5 percentage points – from a difference of 16 to 11 percentage points.[7,12]

The decrease in the magnitude of the urban-rural disparity in HPV vaccination initiation observed during 2016–2017 is promising. However, determining whether the disparities in coverage is on the decline requires monitoring over time. The purpose of this analysis was: 1) to examine trends in HPV vaccination initiation coverage by MSA status and 2) to examine trends in disparities in HPV vaccination initiation coverage by MSA status during 2013–2017. The examination of trends in HPV coverage by MSA status will allow us to determine if targeted interventions toward rural populations are needed (e.g., if the disparity between urban and rural populations is increasing or remains the same over time) or if trends should continue to be monitored (e.g., if the disparity between areas is decreasing) without immediate action.

Methods

The survey

The National Immunization Survey – Teen (NIS-Teen) has been conducted annually since 2006.[17] The survey collects data on vaccines received by adolescents aged 13–17 years in the 50 states, the District of Columbia, selected local areas, and selected territories. NIS-Teen is conducted among parents or guardians of age-eligible adolescents identified using a random-digit-dialed sample of landline and cellular telephone numbers. The survey occurs in two phases. In the first phase, parents and guardians of eligible teens are interviewed by telephone. During the telephone interview, information is obtained on the sociodemographic characteristics of the teen and household and contact information and consent to contact the teen's vaccination providers are requested. In the second phase, vaccination providers are mailed a questionnaire requesting the vaccination history from the teen's medical record. Vaccination coverage estimates are based on provider-reported vaccination histories. We used NIS-Teen data from 2013 to 2017 for our analysis.

Measures

We combined 5 years (2013–2017) of NIS-Teen data on adolescents aged 13–17 years in the 50 states and the District of Columbia. The outcome of interest was HPV vaccination initiation (receipt of ≥1-dose of HPV vaccine). We estimated coverage with ≥1-dose of HPV vaccine among adolescents aged 13–17 years for each survey year, by MSA status, and by select demographic subgroups (i.e. sex, race/ethnicity, and poverty level). Additionally, we assessed the trends and variations in initiation of HPV vaccine among adolescents aged 13–17 years by MSA status and survey year. Since ACIP recommends administration of HPV vaccine during the same pre-adolescent visit as Tdap and MenACWY, we also examined the trends in coverage and disparities by MSA status for Tdap and MenACWY to determine whether these variations in coverage by MSA status were unique to the HPV vaccine.

The three-level metropolitan statistical area (MSA) categorization is based on the legal statistical area designation (city, town, village, census-designated places, or townships), county of residence, and the principal city designation, as defined by the US Census Bureau.[18] The U.S. Census Bureau defines an MSA as an area that consists of at least one urban area with a population of at least 50,000 inhabitants.[18] The principal city is the largest city in each metropolitan statistical area. Each county is designated as being either an MSA county or a non-MSA county. When the statistical area was a principal city and in an MSA county, then it was categorized as an MSA principal city. When the statistical area was not a principal city but it was in an MSA county, then it was categorized as an MSA non-principal city. When the statistical area did not belong to an MSA county, the area was categorized as Non-MSA. MSA categories can be interpreted as approximating mostly urban areas (MSA principal city), suburban areas (MSA non-principal city), and mostly rural areas (non-MSA).

Statistical analysis

Data were analyzed using SAS®9.4 Survey Procedures to account for the complex survey design. To adjust for non-response and phoneless households, the data were weighted. Stratifying by MSA status, vaccination coverage estimates for ≥1-dose HPV vaccine, ≥1 MenACWY, and ≥1 Tdap were computed using weighted bivariate analysis. Additionally, for ≥1-dose HPV vaccine, weighted bivariate analysis was conducted to produce vaccination coverage estimates stratifying by MSA and select characteristics (i.e. poverty status, sex, and race/ethnicity). Weighted linear regression[7,12,19] was used to estimate the average annual percentage point change in coverage with ≥1-dose of HPV vaccine, ≥1 MenACWY, and ≥1 Tdap among adolescents aged 13–17 years by MSA status from 2013 to 2017. The weighted linear regression analysis was also used to estimate the average annual percentage point changes in coverage with ≥1-dose of HPV vaccine among adolescents stratifying by MSA status and select characteristics. The reciprocal of the estimated variance of vaccination coverage estimates was used for weighting. We used the estimated slope from the linear regression to measure the change in value each year and tested whether the slope was significantly different from 0 ($p < .05$).[19] T-tests were used for statistical comparison of differences in HPV vaccine initiation coverage by MSA status and survey year. The differences reported were statistically significant at $p < .05$.

Results

During 2013–2017, the NIS-Teen national sample included data regarding 103,074 adolescents aged 13–17 years from 50 states and the District of Columbia – 39.9% lived in mostly urban areas 39.2% lived in suburban areas, and 20.9% lived in mostly rural areas (Table 1). Overall, about half of the adolescents in the sample were male (51.1%), white non-Hispanic

Table 1. Characteristics of adolescents 13–17 years by Metropolitan Statistical Area (MSA) Status* and nationally, National Immunization Survey – Teen, United States, 2013–2017.

	United States		MSA Principal City		MSA Non-Principal City		Non-MSA	
	(*N* = 103,074)		(*N* = 41,110)		(*N* = 40,389)		(*N* = 21,575)	
	Sample (*n*)	Weighted % (95% CI)	Sample (*n*)	Weighted % (95% CI)	Sample (*n*)	Weighted % (95% CI)	Sample (n)	Weighted % (95% CI)
Year of Birth	92523	100.0 (– – –)	36857	100.0 (– – –)	36150	100.0 (– – –)	19516	100.0 (– – –)
1996	5360	6.3 (6.0–6.6)	2023	6.2 (5.7–6.7)	2100	6.1 (5.7–6.5)	1237	7.0 (6.2–7.7)
1997	9653	11.1 (10.7–11.4)	3798	10.7 (10.1–11.4)	3753	11.2 (10.7–11.9)	2102	11.3 (10.5–12.2)
1998	13846	15.4 (14.9–15.8)	5462	14.7 (14.0–15.4)	5361	15.7 (15.0–16.4)	3023	16.1 (15.2–17.0)
1999	18229	19.6 (19.2–20.1)	7212	19.8 (19.0–20.6)	7161	19.4 (18.7–20.1)	3856	19.8 (18.9–20.8)
2000	19254	20.5 (20.0–21.0)	7780	21.0 (20.2–21.8)	7491	20.5 (19.8–21.2)	3983	19.3 (18.4–20.3)
2001	15294	16.0 (15.6–16.4)	6124	16.4 (15.6–17.2)	6041	15.7 (15.0–16.3)	3129	15.9 (15.0–16.9)
2002	10887	11.2 (10.8–11.5)	4458	11.1 (10.5–11.7)	4243	11.4 (10.8–12.0)	2186	10.5 (9.8–11.3)
Sex	103074	100.0 (– – –)	41110	100.0 (– – –)	40389	100.0 (– – –)	21575	100.0 (– – –)
Female	49140	48.9 (48.3–49.5)	19739	49.1 (48.2–50.1)	19134	48.8 (47.9–49.7)	10267	48.7 (47.5–49.9)
Male	53934	51.1 (50.5–51.7)	21371	50.9 (49.9–51.8)	21255	51.2 (50.3–52.1)	11308	51.3 (50.1–52.5)
Race/Ethnicity	103074	100.0 (– – –)	41110	100.0 (– – –)	40389	100.0 (– – –)	21575	100.0 (– – –)
White, non-Hispanic	64670	53.6 (53.0–54.2)	20421	41.9 (41.0–42.8)	27989	59.1 (58.2–60.0)	16260	69.7 (68.5–70.8)
Black, non-Hispanic	9648	13.9 (13.5–14.3)	5782	19.1 (18.4–19.8)	2788	10.7 (10.2–11.3)	1078	9.4 (8.7–10.2)
Hispanic	17842	22.8 (22.3–23.4)	10245	28.5 (27.5–29.4)	5525	20.9 (20.0–21.8)	2072	12.5 (11.7–13.4)
American Indian/Alaska -Native, non-Hispanic	1439	0.9 (0.8–1.0)	313	0.5 (0.4–0.6)	355	0.7 (0.6–0.8)	771	2.7 (2.4–3.1)
Asian, non-Hispanic	3781	4.0 (3.7–4.2)	1933	4.9 (4.5–5.4)	1586	4.0 (3.7–4.4)	262	0.9 (0.7–1.2)
Multiracial, non-Hispanic	5242	4.6 (4.3–4.8)	2251	4.9 (4.5–5.3)	1955	4.3 (3.9–4.6)	1036	4.6 (4.2–5.1)
Native Hawaiian, Pacific Islander, non-Hispanic	452	0.3 (0.2–0.4)	165	0.3 (0.2–0.4)	191	0.3 (0.2–0.5)	96	0.2 (0.2–0.3)
Mother's Age	103074	100.0 (– – –)	41110	100.0 (– – –)	40389	100.0 (– – –)	21575	100.0 (– – –)
≤ 34 years	8389	9.1 (8.8–9.5)	3674	10.3 (9.8–10.9)	2675	7.7 (7.2–8.2)	2040	10.7 (10.0–11.4)
35–44 years	42382	43.9 (43.3–44.5)	16604	43.7 (42.7–44.6)	15820	42.3 (41.5–43.2)	9958	50.3 (49.1–51.5)
> 44 years	52303	47.0 (46.4–47.5)	20832	46.0 (45.0–46.9)	21894	50.0 (49.1–50.8)	9577	39.0 (37.9–40.2)
Mother's Education	103074	100.0 (– – –)	41110	100.0 (– – –)	40389	100.0 (– – –)	21575	100.0 (– – –)
< High school	12093	13.5 (13.1–13.9)	6110	16.7 (15.9–17.5)	3555	10.9 (10.3–11.6)	2428	13.0 (12.2–13.9)
High School	16916	23.0 (22.5–23.6)	6566	22.3 (21.5–23.2)	5878	21.7 (20.9–22.5)	4472	30.0 (28.9–31.2)
> High school, some college	27218	25.3 (24.8–25.8)	9798	23.7 (22.8–24.5)	10623	25.5 (24.7–26.2)	6797	29.6 (28.6–30.6)
College graduate	46847	38.2 (37.7–38.7)	18636	37.4 (36.5–38.2)	20333	41.9 (41.1–42.8)	7878	27.4 (26.3–28.4)
Income to Poverty Ratio†	103074	100.0 (– – –)	41110	100.0 (– – –)	40389	100.0 (– – –)	21575	100.0 (– – –)
< 133% of federal poverty	19373	23.8 (23.3–24.3)	9598	29.0 (28.1–29.9)	5478	18.0 (17.3–18.8)	4297	28.8 (27.6–29.9)
133% to < 322% of federal poverty level	36246	37.3 (36.8–37.9)	13574	36.3 (35.4–37.2)	13121	36.0 (35.2–36.9)	9551	45.1 (44.0–46.3)
322% to < 503% of federal poverty level	21748	18.1 (17.7–18.6)	7705	15.4 (14.8–16.1)	9706	21.2 (20.5–21.8)	4337	15.5 (14.7–16.4)
≥ 503% of federal poverty level	25707	20.7 (20.3–21.2)	10233	19.3 (18.6–20.0)	12084	24.8 (24.1–25.5)	3390	10.6 (9.9–11.2)
Poverty Level (2 level)	99648	100.0 (– – –)	39616	100.0 (– – –)	39106	100.0 (– – –)	20926	100.0 (– – –)
Below poverty level	18486	23.4 (22.9–23.9)	9133	28.5 (27.5–29.4)	5199	17.5 (16.8–18.3)	4154	29.0 (27.9–30.2)
At/Above poverty level	81162	76.6 (76.1–77.1)	30483	71.5 (70.6–72.5)	33907	82.5 (81.7–83.2)	16772	71.0 (69.8–72.1)
Insurance Status	103074	100.0 (– – –)	41110	100.0 (– – –)	40389	100.0 (– – –)	21575	100.0 (– – –)
Private Insurance	59798	51.6 (51.1–52.2)	22273	46.4 (45.5–47.4)	26352	58.7 (57.9–59.6)	11173	42.0 (40.8–43.2)
Any Medicaid	30411	35.5 (34.9–36.1)	13428	40.2 (39.2–41.1)	9483	29.2 (28.4–30.1)	7500	44.0 (42.8–45.2)
Other Insurance	8599	7.9 (7.6–8.2)	3433	7.7 (7.2–8.2)	3214	7.8 (7.4–8.3)	1952	8.6 (7.9–9.2)
No Insurance	4266	5.0 (4.7–5.2)	1976	5.7 (5.3–6.2)	1340	4.2 (3.8–4.6)	950	5.5 (4.9–6.2)
Had 11- to 12-year preventive care visit	103074	100.0 (– – –)	41110	100.0 (– – –)	40389	100.0 (– – –)	21575	100.0 (– – –)
Yes	48095	44.9 (44.3–45.5)	19193	43.7 (42.7–44.6)	21044	48.8 (47.9–49.7)	7858	34.8 (33.7–36.0)
No	25271	23.3 (22.8–23.7)	8715	21.9 (21.1–22.7)	8173	20.2 (19.5–20.9)	8383	38.3 (37.2–39.5)
Don't know	29708	31.8 (31.3–32.4)	13202	34.4 (33.5–35.4)	11172	31.0 (30.2–31.8)	5334	26.8 (25.8–27.9)
Received provider recommendation for HPV vaccine	94406	100.0 (– – –)	37514	100.0 (– – –)	37224	100.0 (– – –)	19668	100.0 (– – –)
Yes	65718	67.1 (66.6–67.7)	26718	68.2 (67.3–69.2)	26573	68.1 (67.2–68.9)	12427	60.4 (59.2–61.6)
No	28688	32.9 (32.3–33.4)	10796	31.8 (30.8–32.7)	10651	31.9 (31.1–32.8)	7241	39.6 (38.4–40.8)
Provider Facility Type	102445	100.0 (– – –)	40858	100.0 (– – –)	40181	100.0 (– – –)	21406	100.0 (– – –)
All Public Facilities	15013	15.1 (14.7–15.6)	5041	15.2 (14.4–15.9)	3748	11.0 (10.4–11.7)	6224	29.6 (28.5–30.8)
All Hospital Facilities	11493	9.6 (9.3–10.0)	5154	10.8 (10.3–11.4)	3931	8.7 (8.2–9.2)	2408	9.3 (8.6–10.0)
All Private Facilities	50041	52.4 (51.8–53.0)	21138	52.3 (51.3–53.3)	23504	59.4 (58.5–60.3)	5399	27.4 (26.3–28.4)
All School/Other	1680	1.8 (1.7–2.0)	745	2.0 (1.7–2.3)	593	1.8 (1.5–2.1)	342	1.6 (1.4–2.0)
Mixed	22732	19.7 (19.3–20.2)	8094	18.5 (17.8–19.2)	7764	17.6 (16.9–18.2)	6874	31.3 (30.2–32.4)
All Military/All WIC Clinic Facilities, All Pharmacies	1486	1.3 (1.2–1.5)	686	1.3 (1.1–1.5)	641	1.5 (1.3–1.7)	159	0.8 (0.6–1.0)

* MSA categories can be interpreted as approximating mostly urban areas (MSA principal city), suburban areas (MSA non-principal city), and mostly rural areas (non-MSA).

† Imputed Poverty-to-Income ratio variable.

(53.6%), with private insurance (51.6%). The majority were living in households at/above poverty level (76.6%). A large percentage of mothers of adolescents in the survey were older than 44 years (47.0%) and were college graduates (38.2%). During 2013–2017, 23.3% of all adolescents did not have an 11–12-year preventive care visit. One-third (32.9%) of all parents reported not receiving a provider recommendation for vaccination with HPV vaccine for their adolescent (Table 1).

HPV vaccination initiation increased both nationally and by MSA status area; the slopes were significantly different from 0 ($p < .05$). Nationally, coverage with ≥1-dose of HPV vaccine increased from 44.9% to 65.5% from 2013 to 2017; the average annual increase was 5.1 percentage points. In mostly

urban areas, coverage with ≥1-dose of HPV vaccine ranged from 49.0% to 70.1% over the five-year period for an average annual increase of 5.2 percentage points. In suburban areas, coverage with ≥1-dose of HPV vaccine ranged from 43.8% to 63.1% for an average annual increase of 4.9 percentage points. HPV vaccination initiation among adolescents living in mostly rural areas ranged from 36.5% to 59.3% over the five-year period for an average annual increase of 5.2 percentage points (Figure 1).

HPV vaccination coverage increased each year in all MSA areas. However, disparities in vaccination coverage between MSA areas were observed; these differences did not significantly change over time – the slopes of the differences did not significantly differ from zero (Figure 2(a-c)). HPV vaccination initiation was 11–16 percentage points lower for adolescents living in mostly rural areas compared to those living in mostly urban areas (Figure 2(a)), 5–9 percentage points lower for adolescents living in suburban areas compared to those living in mostly urban areas (Figure 2(b)), and 4–8 percentage points lower for adolescents living in mostly rural areas compared to those living in suburban areas (Figure 2(c)).

To determine whether these disparities by MSA status were unique to the HPV vaccine, we examined trends in coverage and disparities by MSA status for Tdap and MenACWY – other vaccines routinely recommended for preadolescents aged 11–12 years. Compared with adolescents living in mostly urban and suburban areas, those living in mostly rural areas had significantly lower coverage with ≥1-dose MenACWY (Figure 3(a)). Over the five-year period, coverage with meningococcal vaccine was similar between suburban and mostly urban areas whereas the difference in coverage with ≥1-dose MenACWY between mostly urban and mostly rural areas ranged from 7.4 to 16.9 percentage points (Figure 3(b)). During 2013–2017, there was a significant decrease ($p < .01$) in the disparity in coverage between mostly urban and mostly rural areas for MenACWY vaccine (Figure 3(b)). Coverage with ≥1-dose of Tdap vaccine was significantly lower among adolescents living in mostly rural areas compared with those living in mostly urban and suburban areas from 2013 to 2015. However, in 2016 and 2017, there were no disparities in ≥1-dose of Tdap vaccination coverage by MSA area (Figure 4).

Additional analyses were conducted to examine the trends in coverage with ≥-1dose of HPV vaccine among subgroups of adolescents by MSA status and whether similar trends in urban-rural disparities exist among these subgroups. From 2013 to 2017, significant increases in coverage with ≥1-dose of HPV vaccine were observed among adolescents in each MSA regardless of sex, race/ethnicity, and poverty level (Supplementary Figure 1a – 3b). Despite significant increases in HPV vaccination initiation observed over the five-year period, urban-rural disparities among subgroups of adolescents persisted over time. The five-year average annual percentage point change in the difference in HPV vaccine initiation between mostly urban and mostly rural areas did not change significantly among females ($p = .19$) (Supplementary Figure 1a.) or among males ($p = .38$) (Supplementary Figure 1b.). Additionally, the average annual percentage point change in the difference in HPV vaccination initiation between mostly urban and mostly rural areas did not change among white, non-Hispanic ($p = .65$) (Supplementary Figure 2a.) or Hispanic adolescents ($p = .92$) (Supplementary Figure 2c). While there was no change in the difference in HPV vaccination initiation between black non-Hispanic adolescents by geographic area ($p = .55$), there was also no disparity in coverage with ≥1-dose of HPV vaccine as seen in other racial/ethnic groups (Supplementary Figure 2b). During the five-year period, there was no significant change in the difference in coverage with ≥1-dose of HPV vaccine among adolescents living below the poverty level ($p = .91$) (Supplementary Figure 3a) or at/above the poverty level ($p = .96$) (Supplementary Figure 3b).

Discussion

This study examined the trends in HPV vaccination initiation and disparities in ≥1-dose HPV vaccine coverage by MSA

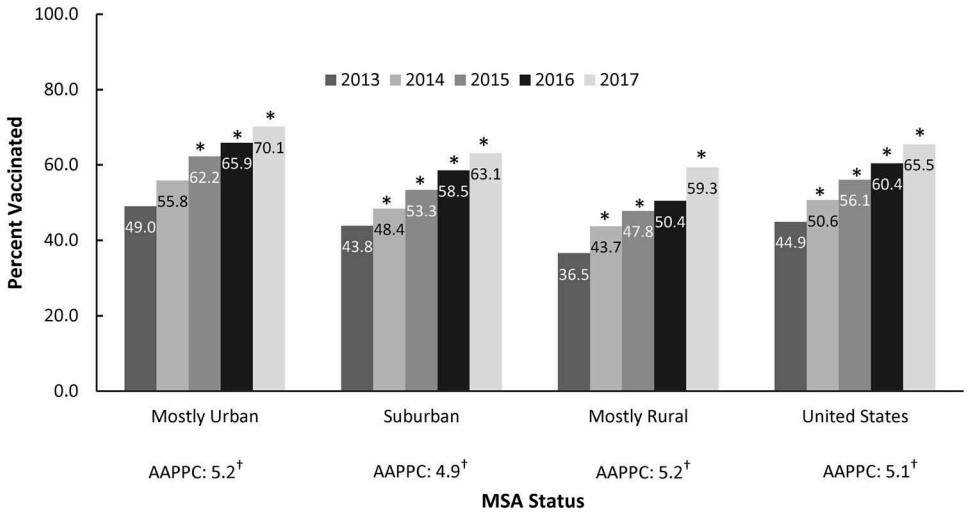

Figure 1. Coverage with ≥1 HPV vaccine among adolescents aged 13–17 years by MSA status and nationally, NIS-teen, 2013–2017.

Footnotes:AAPPC = Average annual percentage point change. *Statistically significant ($p < .05$) percent point increase compared to the previous year.† Statistically significant average annual increase/decrease

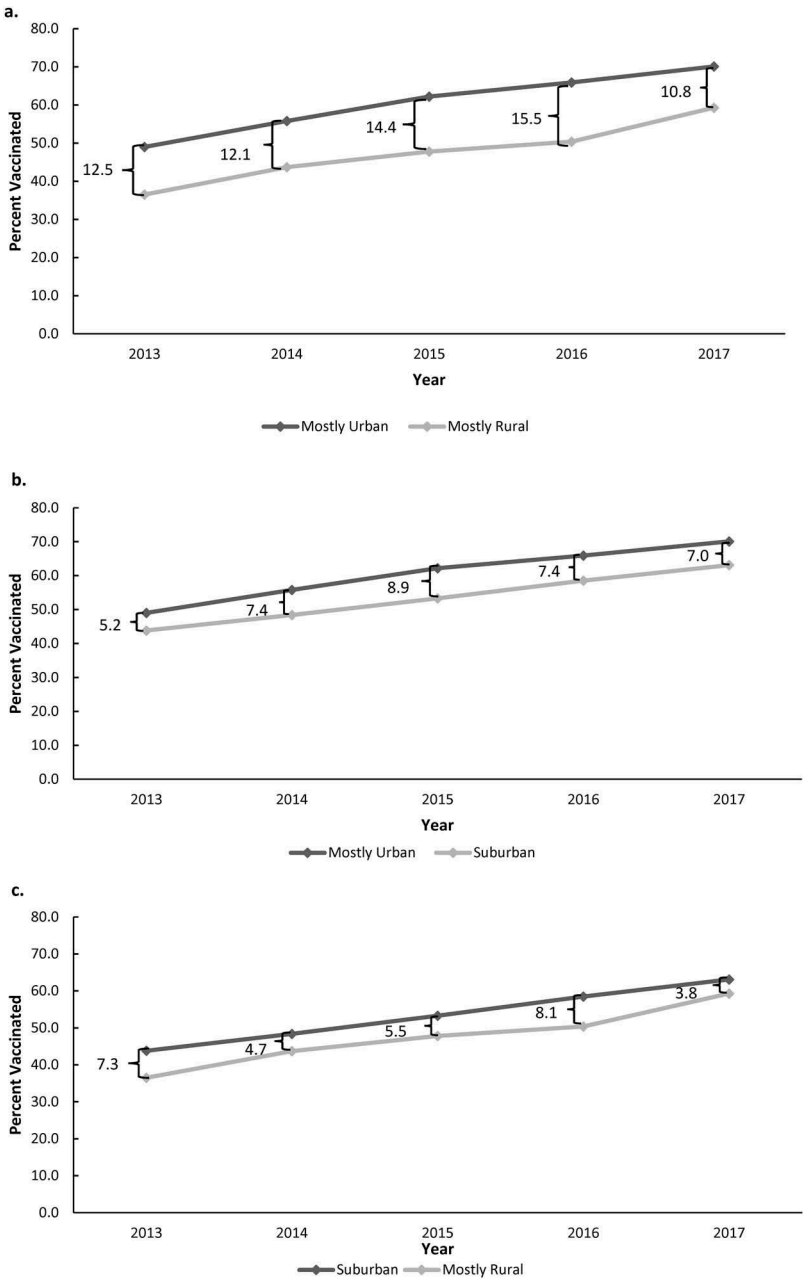

Figure 2. (a). Disparities in HPV vaccination initiation among adolescents aged 13–17 years living in mostly urban vs. mostly rural areas, NIS-teen 2013–2017. Between 2013 and 2017, the estimated average annual percentage point change in the difference in coverage between mostly urban and mostly rural areas: 0.0, p = .98. (b). Disparities in HPV vaccination initiation among adolescents aged 13–17 years living in mostly urban vs. suburban areas, NIS-teen 2013–2017. Between 2013 and 2017, the estimated average annual percentage point change in the difference in coverage between mostly urban and suburban areas: 0.3, p = .50. (c). Disparities in HPV vaccination initiation among adolescents aged 13–17 years living in suburban vs. mostly rural areas, NIS-teen 2013–2017. Between 2013 and 2017, the estimated average annual percentage point change in the difference in coverage between suburban and mostly rural areas: −0.3, p = .59.

status over a five-year period. From 2013 to 2017, we observed that coverage with ≥1-dose of HPV vaccine increased an average of about 5 percentage points each year among adolescents living in urban, suburban, and rural areas. We also observed that HPV vaccination initiation in mostly rural and suburban areas were significantly lower than coverage in mostly urban areas, and these differences persisted over time. These findings were consistent with previous studies that examined differences by urbanicity[7,12–16].

The disparity in coverage with ≥1-dose of HPV vaccine observed between adolescents living within urban areas and outside of urban areas is not well understood. Previous studies have identified several reasons likely responsible for the disparity in coverage observed between geographical areas. Among these reasons are lack of awareness of the HPV vaccine and knowledge on its role in protecting against certain cancers among residents of rural areas.[20,21] Also, there may be a lack of knowledge of HPV vaccination recommendations among rural health-care providers who are likely family and/or general practitioners serving entire rural communities.[20–22] Vaccination providers in rural areas are not likely to strongly recommend the HPV vaccine for reducing the risk of cancer if they are not themselves educated on the importance of vaccination of children ages 11–12 and prior to exposure to HPV virus. Parents and guardians from a study in

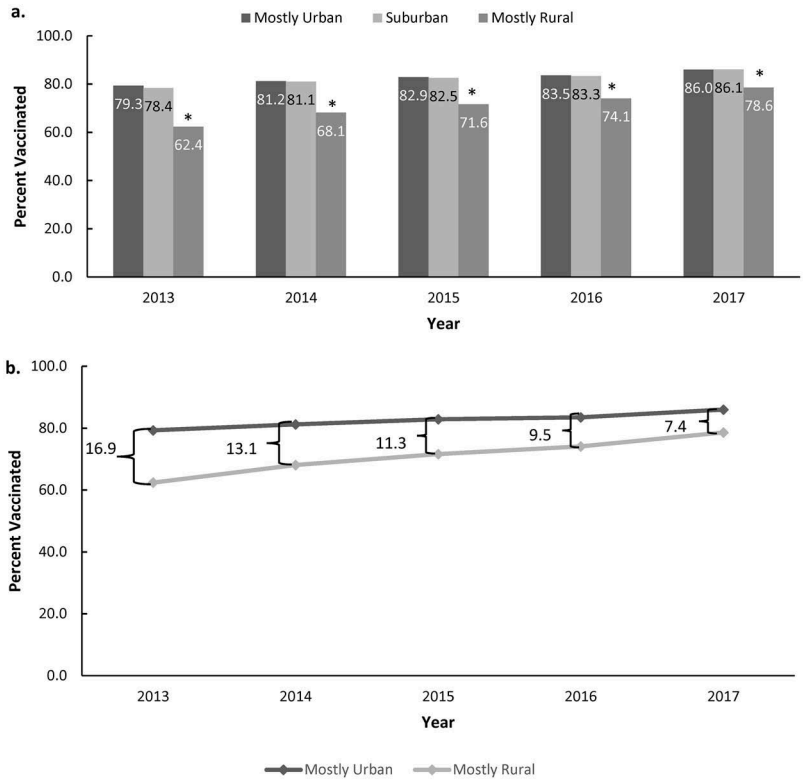

Figure 3. (a). Disparities in ≥1 MenACWY vaccination coverage among adolescents aged 13–17 Years by MSA, NIS-teen, 2013–2017. Footnotes: * Statistically different from adolescents living in both mostly urban and suburban areas ($p < .05$). (b). Disparities in ≥1 MenACWY vaccination coverage among adolescents aged 13–17 years living in mostly urban vs. mostly rural areas, NIS-teen 2013–2017. Between 2013 and 2017, the estimated average annual percentage point change in the difference in coverage between mostly urban and mostly rural areas: −2.2, $p < .01$.

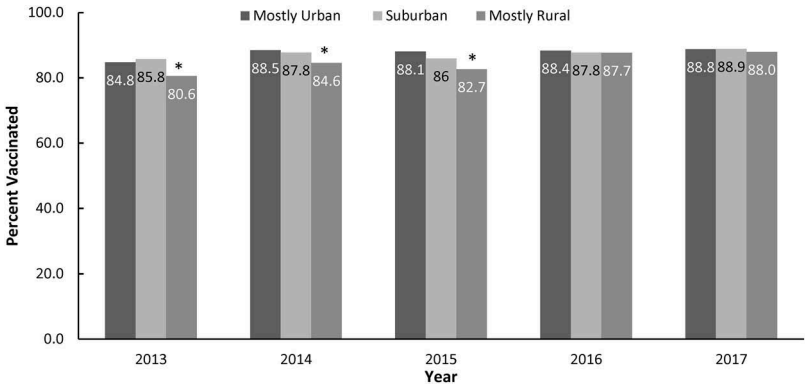

Figure 4. Disparities in ≥1 Tdap vaccination coverage among adolescents aged 13–17 Years by MSA, NIS-teen, 2013–2017. Footnotes:* Statistically different from adolescents living in both mostly urban and suburban areas ($p < .05$).

rural Alabama stated that a strong provider recommendation would be most influential in initiation of the HPV vaccine series.[20] This is consistent with other findings that the quality of the recommendation from the health-care provider continues to be a major predictor of HPV vaccination.[23–27] Provider recommendation for HPV vaccination, at each age-eligible visit, even if parents choose initially not to have their children vaccinated, has been shown to improve vaccine acceptance.[27]

The differences in coverage with ≥1-dose of HPV vaccine by MSA status have remained over time. When MSA status was stratified by select characteristics (e.g. sex, race/ethnicity, and poverty level), the urban-rural disparity persisted over time for all groups except among black, non-Hispanic adolescents. In comparing the trends in coverage and disparities by MSA status for Tdap and MenACWY vaccines, we found similar trends of urban-rural disparities for coverage with ≥1 MenACWY. Urban-Rural disparities for coverage with ≥1 MenACWY are still present but appear to be diminishing. During 2013–2017, an increasing number of states required MenACWY vaccination for school enrollment (pre-2013: 19 states vs. post-2013: 30 states) which likely contributed to increased coverage with MenACWY in rural areas.[28] Over the five-year period, the disparity in coverage with ≥1Tdap disappeared; however, it should be

noted that the urban-rural disparities were observed for coverage with Tdap vaccine from 2013 to 2015. The Tdap vaccine is required for enrollment in secondary schools in the District of Columbia and all states except Hawaii and may partially explain the vanishing urban-rural disparity observed for coverage with the Tdap vaccine.[29] Other factors associated with the decrease in the urban-rural disparity for MenACWY and Tdap vaccination should be investigated to determine if similar interventions could be targeted toward rural populations to improve vaccination coverage and reduce differences in HPV vaccination coverage by geographical area.

There are at least four limitations in this study. First, biases in estimates may remain after adjustments to minimize nonresponse bias and incomplete representation of the sampling frame due to phoneless households. Second, trends in coverage by survey year could be biased if residual bias remaining after weighting adjustments varied by survey year.[17] Third, the three-level MSA status categorization lacks granularity to detect differences that might exist within MSA areas. For example, are there differences in vaccination coverage among adolescents living in larger versus smaller urban areas or more or less remote rural areas as suggested in other studies.[14,15] Finally, an assumption of linearity was applied in estimating the average annual percentage point increase by year; if the trend is non-linear, this average may not reflect variations in the rate of increase from year to year.

A better understanding of the underlying factors behind lower HPV vaccine coverage in more rural areas when compared with more urban areas is needed in order to develop targeted interventions appropriate for rural populations. However, one place to start is for health-care providers to incorporate recommendation for and administration of HPV and MenACWY vaccines during the same visit they administer Tdap vaccine.

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No conflicts of interest were reported by any of the authors. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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