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Research Article

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Geographic Factors and Human Papillomavirus (HPV) Vaccination Initiation among Adolescent Girls in the United States

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Abstract

Background: This study is among the first to explore geographic factors that may be associated with human papillomavirus (HPV) vaccine uptake in the United States.

Methods: Data from the 2011 and 2012 National Immunization Survey-Teen for 20,565 female adolescents aged 13 to 17 years were analyzed to examine associations of HPV vaccine initiation (receipt of at least one dose) with ZIP code–level geographic factors. Logistic regression including individual and geographic factors was used to estimate the odds of HPV vaccine initiation.

Results: Approximately 53% of girls initiated the HPV vaccine in both years. Girls in high poverty communities had higher HPV vaccine initiation compared with those in low poverty communities [61.1% vs. 52.4%; adjusted OR (AOR), 1.18; 95% confidence intervals (CI), 1.04–1.33]. Initiation was higher among girls in communities where the majority of the population was Hispanic (69.0% vs. 49.9%; AOR, 1.64; 95% CI, 1.43–1.87) or non-Hispanic mixed race (60.4% vs. 49.9%; AOR, 1.30; 95% CI, 1.17–1.44) compared with majority non-Hispanic white communities. Interactions between individual-level race/ethnicity and community racial–ethnic composition indicated significantly higher odds of initiation among Hispanic girls living in Hispanic communities compared with Hispanic girls living in predominantly non-Hispanic White (NHW) (AOR, 2.23; 95% CI, 1.87–2.65) or non-Hispanic Black (NHB) (AOR, 1.90; 95% CI, 1.20–3.04) communities, respectively.

Conclusion: Initiation rates of HPV vaccination among teen girls were highest in the poorest communities and among Hispanics living in communities where the racial–ethnic composition was predominantly Hispanic or mixed race.

Impact: Given low HPV vaccination rates in the United States, these results provide important evidence to inform public health interventions to increase HPV vaccination. *Cancer Epidemiol Biomarkers Prev; 25(2); 309–17. ©2016 AACR.*

Introduction

The human papillomavirus (HPV) represents the most common sexually transmitted infection in the United States (1). HPV infection is associated with cancers in women, including cervical, vulvar, anal, oropharyngeal, and vaginal (2, 3). In the United States, approximately 20,589 HPV-associated cancers are diagnosed each year among females, many of which may be preventable with the current HPV vaccine (2, 4). Cervical cancer is the most common HPV-associated cancer found in women, accounting for about 55.5% (2).

Racial/ethnic and socioeconomic disparities in HPV-associated cancers have been documented in the United States (5–7). Hispanic women have higher rates of cervical cancer compared with non-Hispanic women. White and Black women had higher rates of oropharyngeal cancer compared with women of other races, and rates of vulvar and anal cancers were higher for Whites and non-Hispanics than they were for other racial/ethnic groups. Rates of vaginal cancer were highest among Blacks (3). Furthermore, in the United States, incidence rates of each HPV-associated cancer were highest among women living in neighborhoods where 20% or more of the population is living below the poverty line compared with women living in neighborhoods where <5% of the population is living below poverty line (8).

Since 2006, The Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices (ACIP) has recommended the safe and effective HPV vaccine for girls aged 11 or 12 years, and for females aged 13 through 26 years not previously vaccinated (9). ACIP expanded its recommendation in 2011 to include boys. Receipt of the vaccine at ages 11 and 12 builds an effective immune response before the onset of sexual activity (10, 11). Despite ACIP recommendations, HPV vaccination rates in the United States remain low. The Healthy People's 2020 goal for completing the recommended HPV vaccine three-dose series is 80% for girls (12); yet in 2013, only 57.3% (±1.9) of U.S. teen girls had received at least one dose of HPV vaccine, and only 37.6% (±2.0) had three or more doses of the vaccine.

To date, most HPV vaccination studies have examined individual- and provider-based factors as possible explanations for the low vaccination rates (13). These studies found that higher rates of HPV vaccine initiation were associated with older age, health insurance type, urban residence, physician recommendation for the vaccine, receipt of other childhood vaccines, provider

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reminders, and knowledge of HPV (13). The most recent data from the National Immunization Survey-Teen (NIS-Teen) indicate that girls whose families live below the poverty line had higher rates of both HPV vaccine initiation and receipt of the three-dose series compared with girls whose families live above the poverty line (14). Survey data also indicate that non-Hispanic (NH) Whites and Asians had lower rates of HPV vaccine initiation and receipt of the three-dose series compared with Hispanics, NH Blacks, and American Indian/Alaska Native (3).

In addition to provider- and individual-level factors, it is also possible that geographic or neighborhood factors, like area-based socioeconomic status (SES), could independently influence vaccination uptake. In other areas of cancer prevention research, geographic factors such as area-based SES, racial–ethnic composition, and rural versus urban residence have been shown to influence health status (e.g., cancer stage at diagnosis; refs. 15, 16) and health behaviors (e.g., up-to-date on mammogram) independent of an individual's SES or other individual factors such as health insurance (17–19). Similarly, area-based SES and geographic factors could influence vaccination uptake through pathways linked to the material resources of the neighborhood, availability and ease of access to healthcare facilities, and social capital or networks (e.g., social contagion, similar norms of behavior; refs. 20–22).

Numerous possible outcomes related to HPV vaccination uptake exist, given the different ways geographic factors can influence health service utilization. For example, economic burdens and barriers to care among lower income ethnic minority or rural communities could result in lower HPV vaccination initiation because of fewer health resources and limited financial resources (23–25). Similarly, language barriers (13) and a lack of awareness in ethnic minority communities (26–28) could result in lower uptake (29). In contrast, HPV vaccination initiation could be higher among lower income ethnic minority communities due to social support networks and resource availability associated with living among co-ethnics or with certain groups in segregated communities, similar cultural norms related to vaccination and other health behaviors, or in part to long-term targeted interventions or safety-net services, which provide free or subsidized vaccines (30, 31).

To date, no studies in the United States have examined the potential influence of the racial–ethnic composition of a community on HPV vaccination, and the three U.S. studies that examined the influence of area-based SES were inconsistent (32–34). Furthermore, these studies (32, 34) were limited to specific states or populations (33). To advance research in this area, investigators must explore area-based SES and other relevant geographic factors including the community racial–ethnic composition that could impact HPV vaccination rates using national data representing a wide variety of demographic and economic groups.

In this study, we analyzed data from the NIS-Teen to examine associations between HPV vaccine initiation among female adolescents and community-level factors including area-based poverty, rural/urban residence, and residential racial–ethnic composition. To our knowledge, this is the first study examining associations between geographic factors and HPV vaccine initiation among a nationally representative sample of teen girls in the United States while also accounting for individual-level characteristics.

Materials and Methods

Study data

All individual data were obtained from the restricted-use data files of the 2011 and 2012 NIS-Teen, an annual survey conducted by the CDC to monitor vaccination uptake in the United States. The NIS-Teen includes a nationally representative stratified sample of girls and boys aged 13 to 17 years in all 50 states and the District of Columbia. The survey is based on random-digit dialing of both landline and cellular telephone numbers to identify eligible households. It includes two parts: a survey of parents or guardians of teens 13 to 17 years old to collect information about demographic and socioeconomic characteristics, and a survey mailed to all vaccination providers whom the parents identified and consented to verify their teen's immunization histories. The survey sampling procedures have been described elsewhere (35).

Study participants

The 2011 and 2012 NIS-Teen included 18,573 and 15,137 girls aged 13 to 17 years, respectively, with completed surveys in the United States. Of the total 33,710 girls for 2011 and 2012, 20,565 (61%) had provider-verified vaccination records. The present study was limited to the girls with provider-verified vaccination records and complete records for all the variables included in the analysis.

Individual-level measures

We examined HPV vaccine initiation (receipt of at least one dose of the HPV vaccine, either quadrivalent or bivalent) as the primary outcome variable. The outcome measure was dichotomized as zero doses or one or more doses of the HPV vaccine. We studied several individual-level variables from the survey: (i) the teen's current age in years; (ii) race/ethnicity [non-Hispanic (NH) White, NH Black, NH Other, and Hispanic]; (iii) health insurance type (employer or union, Medicaid, or the State Children's Health Insurance, military or Indian Health Service, and no insurance); (iv) poverty status [categorized as above poverty, high income (annual income > $75,000); above poverty, moderate income (annual income $\leq$ $75,000), below poverty, based on the U.S. Census family poverty thresholds; ref. 36; and unknown]; (v) receipt of a provider recommendation for HPV vaccination (yes, no, or don't know); (vi) mother's age ($\leq$34 years, 35–44, or $\geq$45); (vii) marital status (currently married or not currently married); and (viii) education level (<12 years; 12 years with high school diploma or general equivalency diploma; >12 years without college degree; or college degree or higher). We also included one healthcare system-level factor: facility type where vaccines were administered.

Community-level measures

Using the ZIP codes of participants' current residences, several geographic measures based on U.S. census ZIP Code Tabulation Areas (ZCTAs) were merged with the NIS-Teen at the CDC Research Data Center (RDC). The ZCTAs are generalized areal representations of U.S. Postal Service areas, and in most instances, the ZCTA is the same as the ZIP code (37). Ninety-eight percent of the ZCTAs matched residential ZIP codes from the NIS-Teen participants included in this study.

We developed geographic factors using measures of community disadvantage previously included in health disparities research (38, 39) and research on vaccination uptake and use of cancer screening services (16, 33, 34, 40–42). Using the 2008–2012 U.S. Census American Community Survey, we developed

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the following community-level geographic factors: (i) percentage of a ZCTA's residents living below the federal poverty level (36); (ii) median household income of ZCTA; (iii) population density, and (iv) the racial–ethnic residential composition of the ZCTA. These variables were each divided into quartiles based on the distribution of these measures across ZCTAs. Percent living below poverty was categorized into (i) <5%, (ii) 5%–< 10%, (iii) 10%–< 20%, and (iv) ≥20%.

We operationalized the measure of racial-ethnic residential segregation using census data on racial–ethnic composition because of our focus on the majority racial/ethnic group in each ZIP code (43, 44). Numerous studies have shown that persistent residential racial/ethnic segregation in the United States serves as both a health promoter by facilitating stronger social support networks and as a health barrier by fostering conditions that limit resources (16, 39, 45, 46). Racial–ethnic composition in this study was based on ZCTAs having >50% Hispanic, >50% NHW, >50% NH Asian-Pacific Islander (NHAPI), >50% NHB, >50% NH American Indian/Native Alaskan, or mixed (NHM), if not any of the previous. Because of small numbers after merging the racial–ethnic composition variables with the NIS-Teen, we combined NH American Indian/Native Alaskan with NHAPI into a category called NH-other.

We also included ZCTA measures of rural and urban residence based on the rural-urban commuting area codes (RUCA; ref. 47). The RUCAs provided a definition of rural/urban residences based on criteria that included population density and population work-commuting patterns. We categorized this variable as urban, large rural city/town, small rural town, and isolated small rural town (47).

Statistical analysis

For analysis, we combined the NIS-Teen datasets for 2011 and 2012, using suggested methods (35), and included appropriate sampling weights for calculating the weighted percentages and effect estimates (48). We used weighted frequencies and 95% confidence intervals (CI) to describe the characteristics of the sample. We performed bivariate association tests between HPV vaccination initiation (receipt of one HPV vaccine dose) and individual-level and community-based geographic variables with Wald χ^2 tests.

The study used bivariate logistic regression models to estimate the crude ORs and 95% CIs of vaccination series initiation for each of the individual-level and geographic variables. Multivariable logistic regression models were used to calculate the adjusted odds ratios (AOR) and 95% CIs of vaccination initiation. One multivariable model included only individual and provider factors, and two separate multivariable models were run to examine the independent associations of ZIP code level poverty and racial–ethnic composition with vaccination outcomes. Joint contributions of individual poverty and area poverty and racial segregation were assessed with interaction terms between individual-level race/ethnicity and ZIP code-level poverty and racial–ethnic composition. The surveyed state was included as a random effect to account for dependency by state residence (e.g., state health programs that will influence the girls from that state).

Bivariate associations were analyzed using procedures for complex survey data in SAS statistical software (i.e., PROC SURVEYFREQ; ref. 49). Logistic regression analyses were conducted using SAS GLIMMIX, which implements the Generalized Linear Mixed Model and allows for the incorporation of stratum-specific weighted analysis (50). Statistical tests were two-tailed with a critical α of .05.

Results

Sociodemographic and geographic characteristics of the study population are presented in Table 1. Sixty percent, or 20,565, of girls in the age range of 13 to 17 years had adequate provider data in the 2011 and 2012 NIS-Teen and were included in the study. Overall, 53.5% of girls received more than one dose of HPV vaccine; the proportion was slightly lower in 2011 (53.2%) than in 2012 (53.8%). Most girls were NHW (55.3%) living in urban communities (88.6%) with population densities greater than 651 persons per square mile (quartile 4; 59.5%), and in predominantly NHW (69.5%) ZIP codes. Most mothers were >35 years old (89.3%), without a college degree (33.8%) and had employer- or union-provided health insurance (46.3%).

Table 2 shows the bivariate (unadjusted) ORs and AORs from the multivariable logistic regression models. In the bivariate analysis, all variables were statistically significantly associated with HPV vaccine initiation. Girls living in high density, high poverty, or urban communities had higher odds of vaccine initiation than girls living in low density, low poverty, or rural communities, respectively. Girls living in predominantly minority communities also had higher odds of vaccine initiation compared with those in predominantly NHW communities, regardless of race/ethnicity.

In multivariable analyses that included only individual and provider factors (Table 2, Model 1), all variables associated with vaccine initiation from the bivariate analysis remained statistically significant ($P \leq .05$). Findings were consistent after adjusting for ZIP code poverty and population density (Model 2), except for the individual NHB race/ethnicity, which was no longer significant.

Girls with health insurance through Medicaid or SCHIP had higher odds of HPV vaccine initiation than those with employer- or union-provided insurance (Model 1, AOR, 1.35; 95% CI, 1.24–1.48). Among girls who received a provider recommendation to vaccinate, the odds of vaccination initiation were 3.73 times greater than in girls without such a recommendation. Higher odds of vaccine initiation were also associated with girls whose mothers had <12 years of education compared with those with a college degree (Model 1, AOR, 1.73; 95% CI, 1.53–1.95); among girls with mothers younger than 35 years old compared with girls with mothers 45 years and older (Model 1, AOR, 1.45; 95% CI, 1.29–1.62); and among girls from households with income below the poverty threshold compared to households above the poverty threshold (Model 1, AOR, 1.24; 95% CI, 1.10–1.39).

On the basis of Model 2 results, which included individual and provider factors and ZIP code-level poverty and population density, girls living in communities with the highest poverty levels had higher odds of HPV vaccination initiation compared with girls living in communities with the lowest poverty levels (Model 2, AOR, 1.18; 95% CI, 1.04–1.33). Girls living in communities with the highest population density had higher odds of HPV vaccination initiation compared with girls from the lowest population density categories (Model 2, AOR, 1.49; 95% CI, 1.24–1.80).

Model 3 included individual factors and ZIP code-level racial–ethnic composition and population density. The odds of HPV vaccine initiation was higher among girls from communities

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Table 1. Individual-level and geographic characteristics of HPV vaccine initiation (receipt of at least one dose) among female adolescents aged 13 to 17 years and their families: National Immunization Survey–Teen, 2011–2012

Characteristics	Survey participants, *n* weighted %	Weighted % (95% CI), vaccine initiation (yes)	*P*
Total	20,565	53.5 (52.3–54.7)	
Year			
2011	11,380 (50.1)	53.2 (51.5–54.8)	0.6077
2012	9,185 (49.9)	53.8 (52.0–55.7)	
Age			
13	4,179 (20.3)	44.5 (41.8–47.1)	<0.0001
14	4,158 (19.4)	47.2 (44.5–50.0)	
15	4,242 (20.8)	55.1 (52.4–57.8)	
16	4,152 (21.0)	57.5 (54.6–60.4)	
17	3,834 (18.4)	63.6 (60.9–66.3)	
Insurance coverage			
No insurance	1,246 (7.6)	49.1 (44.4–53.8)	<0.0001
Employer or union	11,629 (46.3)	49.2 (47.6–50.8)	
SCHIP or Medicaid	5,021 (34.0)	60.6 (58.3–63.0)	
IHS, military, other	2,669 (12.1)	52.5 (48.8–56.1)	
Mother's education			
<12 y	2,041 (14.4)	65.9 (62.4–69.4)	
12 y	3,912 (24.3)	54.4 (51.7–57.1)	
>12 y, noncollege graduate	5,717 (27.5)	50.3 (48.0–52.7)	
College graduate	8,895 (33.8)	50.1 (48.3–52.0)	
Mother's marital status			
Married	15,273 (64.8)	51.6 (50.2–53.0)	0.0001
Not married	5,292 (35.1)	57.0 (54.7–59.3)	
Mother's age, y			
≤34	1,531 (10.7)	60.9 (56.7–65.2)	0.0011
35–44	8,394 (45.0)	53.1 (51.2–55.0)	
≥45	10,640 (44.3)	52.0 (50.3–53.8)	
Poverty status[a]			
Above poverty, >$75,000	8,917 (31.9)	52.3 (50.6–54.1)	<0.0001
Above poverty, ≤$75,000	7,692 (39.0)	48.6 (46.6–50.6)	
Below poverty	3,275 (24.7)	63.6 (60.8–66.5)	
Unknown poverty status	681 (4.4)	47.9 (41.7–54.2)	
Race/ethnicity of teen			
Hispanic	2,842 (21.5)	64.3 (61.1–67.4)	<0.0001
Non-Hispanic White	13,822 (55.3)	49.2 (47.8–50.6)	
Non-Hispanic Black	2,072 (14.5)	53.0 (49.4–56.6)	
Non-Hispanic other and multiple race	1,829 (8.8)	54.8 (50.3–59.3)	
Facility types for teen's providers			
All public facilities	3,042 (15.7)	49.2 (45.8–52.5)	0.0046
All hospital facilities	1,703 (7.5)	59.6 (55.3–63.9)	
All private facilities	9,693 (49.5)	53.5 (51.7–55.3)	
Mixed and STD/school/teen clinics or other facilities	4,945 (22)	54.8 (52.3–57.4)	
Unknown	1,182 (5.3)	54.0 (48.8–59.2)	
Provider recommendation to get HPV vaccine			
Yes	12,737 (59.2)	64.1 (62.6–65.5)	<0.0001
No	7,002 (36.4)	36.8 (34.7–39.0)	
Don't know	670 (4.3)	50.8 (43.1–58.6)	
ZIP code geographic measures			
Racial composition (50%+ of that group)			
Hispanic	1,384 (10.1)	69.0 (64.3–73.7)	<0.0001
Mixed	1,884 (13.0)	60.4 (56.2–64.5)	
Non-Hispanic Black	1,266 (6.3)	54.0 (49.2–58.8)	
Non-Hispanic White	15,525 (69.5)	49.9 (48.6–51.2)	
Non-Hispanic other	249 (1.1)	75.7 (60.4–91.1)	
Poverty (% below poverty)[a]			
0%–4.99%	3,117 (12.8)	52.4 (49.6–55.1)	<0.0001
5%–9.9%	5,342 (24.1)	49.9 (47.5–52.3)	
10%–19.9%	7,416 (37.4)	51.6 (49.5–53.7)	
20+%	4,425 (25.7)	61.1 (58.5–63.7)	
Income (quartiles)			
$2,499–$37,750	3,444 (18.6)	58.1 (55.2–61.0)	0.0056
$37,751–$47,292	4,038 (21.9)	54.2 (51.3–57.1)	
$47,293–$60,356	4,857 (23.0)	53.0 (50.4–55.6)	
$60,357–$250,000	7,961 (36.6)	51.7 (49.8–53.6)	

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Table 1. Individual-level and geographic characteristics of HPV vaccine initiation (receipt of at least one dose) among female adolescents aged 13 to 17 years and their families: National Immunization Survey–Teen, 2011–2012 (Cont'd)

Characteristics	Survey participants, *n* weighted %	Weighted % (95% CI), vaccine initiation (yes)	*P*
Residence type (rural–urban)			
Isolated small rural town	985 (2.4)	44.6 (38.3–50.9)	0.0014
Small rural town	944 (3.0)	47.7 (42.1–53.2)	
Large rural town	1,685 (6.0)	50.5 (46.2–54.8)	
Urban focused	16,694 (88.6)	54.4 (53.0–55.7)	
Population density (quartiles)			<0.0001
1–20 per square mile	1,480 (3.3)	44.6 (39.5–49.7)	
21–71 per square mile	2,463 (9.4)	47.7 (44.3–51.2)	
72–651 per square mile	5,697 (27.7)	51.9 (49.6–54.2)	
>651–203,546 per square mile	10,668 (59.5)	56 (54.3–57.7)	

NOTE: Frequencies (*n*) were not weighted; percents weighted based on sampling weight.
Abbreviations: CI, confidence interval; HPV, human papillomavirus; IHS, Indian Health; SCHIP, State Children's Health Insurance Program.
[a]Poverty status was based on the U.S. Census poverty thresholds for 2011 and 2012, respectively.

where the majority race–ethnic group was Hispanic (AOR, 1.64; 95% CI, 1.43–1.87), mixed race (AOR 1.30; 95% CI, 1.17–1.44), NHB (AOR, 1.16; 95% CI, 1.0–1.34), or other NH race (AOR, 2.63; 95% CI, 1.87–3.71) compared with girls from communities where the majority race–ethnic group was NHW.

The interaction terms—individual race/ethnicity × ZIP code poverty and individual race/ethnicity × ZIP code racial–ethnic composition—were both overall statistically significant (results not shown). The results indicated that Hispanics living in high poverty ZIP codes (poverty ≥ 10%) had higher odds of HPV vaccine initiation compared with Hispanics living in lower poverty ZIP codes (poverty 0%–9.9%; AOR, 1.39; 95% CI, 1.16–1.65). A similar association was found for NH other/multiple races living in high poverty versus low poverty ZIP codes (AOR, 1.43; 95% CI, 1.16–1.76). No other race/ethnicity and ZIP code poverty groups were significant.

Figure 1 shows the model-adjusted percent of girls vaccinated based on race/ethnicity and ZIP code racial–ethnic composition. Initiation rates were lowest for NHW and NHB and highest for Hispanics regardless of the community's racial–ethnic composition. The odds of initiation among Hispanic girls living in Hispanic communities were 2.23 (95% CI, 1.87–2.65) and 1.90 (95% CI, 1.20–3.04) times higher than for those living in predominantly NHW or NHB communities, respectively (results not shown).

Discussion

This study examined the relationship between HPV vaccine initiation and individual- and community-level geographic factors among teen girls in the United States. Overall the odds of initiation were highest among older girls, girls with SCHIP or Medicaid health insurance, girls with younger mothers, and those whose mothers had lower levels of education and incomes below the federal poverty level. Receipt of a provider recommendation was one of the factors most strongly associated with HPV vaccination initiation. These findings are consistent with previous studies that examined survey data (33, 34, 51–53). Also consistent with recent reports (54, 55), we found that the rates of HPV vaccination initiation were highest for Hispanic girls compared with NHW, NHB and other NH race groups. We also found that geographic factors including area-based poverty, residential racial–ethnic composition, and population density were significantly associated with HPV vaccination initiation even after adjusting for individual-level factors.

Our findings indicating higher HPV vaccination initiation among girls living in the poorest communities may seem contrary to conventional beliefs that socioeconomic disadvantage may result in barriers to care and underutilization of health services. However, it is also plausible that the availability of safety-net immunization services for these populations and their access to HPV vaccines through the Vaccine for Children (VFC) program, which is a federally funded program providing free recommended vaccines to eligible children, may be contributing to the higher HPV vaccine uptake (56, 57). Independent of race/ethnicity, the lower HPV vaccine uptake in less disadvantaged or affluent communities could be attributable to barriers related to out-of-pocket expenses for girls who are underinsured, a lack of physician recommendation, and/or infrequent preventive medicine visits. Furthermore, parents in less disadvantaged or affluent communities may be less supportive of the HPV vaccine (58). Future research should consider changes in HPV vaccine initiation in these communities resulting from The Affordable Care Act (ACA), which offers opportunities to improve HPV vaccination coverage among teens. Presently, the ACA requires health insurers to cover the costs of all ACIP-recommended vaccinations at no cost to consumers when provided by in-network providers (59).

Our findings related to community-level poverty were similar to those of one of three previous studies examining area-based SES and HPV vaccination. Pruitt and colleagues (33) reported that girls in poorer counties in six U.S. states were more likely to initiate the vaccine than girls in wealthier counties. In contrast, Chao and colleagues (32) used data from a managed care organization in California and found that girls from high-income neighborhoods were more likely to initiate the vaccine than girls from low-income neighborhoods. The difference in the findings might result from Chao's inclusion of girls within a different age range (9–17) and only those who were members of the managed care organization, therefore not including underinsured and/or unemployed populations, who might have different vaccination rates (32). Our findings were also different from those of Tsui and colleagues' study that included adolescent girls from Los Angeles County. They found that neighborhood factors, including poverty, were not independently associated with vaccine initiation after adjusting for individual factors (34). The lack of a significant association in Tsui's study may be related to the unique, small, and homogeneous sample ($n = 479$) of immigrant, low-income mothers of adolescent girls in the study.

Our findings indicating an independent association of residential racial-ethnic segregation and HPV vaccination initiation

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Table 2. Association between characteristics of female adolescents aged 13 to 17 years and HPV vaccine initiation (receipt of at least one dose): National Immunization Survey–Teen, 2011–2012

	1 Dose of HPV vaccine			
Characteristics	**Undadjusted[b] OR (95%CI)**	**Model 1[b,c], AOR (95% CI)**	**Model 2[b,c], AOR (95% CI)**	**Model 3[b,c], AOR (95% CI)**
Age				
13	Ref.	Ref.		Ref.
14	1.14 (1.25–1.05)[d]	1.09 (0.97–1.23)	1.13 (1.05–1.25)[d]	1.13 (1.02- 1.24)[d]
15	1.56 (1.70–1.43)[e]	1.57 (1.35–1.82)[e]	1.63 (1.49–1.80)[e]	1.60 (1.46–1.76)[e]
16	1.71 (1.87–1.57)[e]	1.82 (1.56–2.12)[e]	1.88 (1.71–2.07)[e]	1.86 (1.69–2.05)[e]
17	2.22 (2.43–2.02)[e]	2.36 (2.02–2.76)[e]	2.40 (2.17–2.65)[e]	2.38 (2.15–2.63)[e]
Insurance coverage				
No insurance	1.05 (0.94–1.17)	0.92 (0.81–1.05)	0.92 (0.80–1.05)	0.92 (0.81–1.05)
Employer or union	Ref.	Ref.	Ref.	Ref.
SCHIP or Medicaid	1.64 (1.54–1.75)[e]	1.35 (1.24–1.48)[e]	1.34 (1.22–1.47)[e]	1.33 (1.22–1.46)[e]
IHS, military, other	1.14 (1.04–1.25)[d]	1.09 (0.99–1.21)	1.10 (1.00–1.22)	1.08 (0.98–1.20)
Mother's education				
<12 y	1.89 (2.07–1.72)[e]	1.73 (1.53–1.95)[e]	1.70 (1.50–1.92)[e]	1.70 (1.51–1.93)[e]
12 y	1.22 (1.13–1.31)[e]	1.19 (1.09–1.31)[e]	1.19 (1.08–1.30)[d]	1.18 (1.08–1.30)[d]
>12 y, noncollege graduate	1.05 (0.98–1.13)	0.95 (0.87–1.03)	0.96 (0.88–1.04)	0.96 (0.89–1.05)
College graduate	Ref.	Ref.	Ref.	Ref.
Mother's marital status				
Married	Ref.	Ref.	Ref.	Ref.
Not married	1.29 (1.22–1.37)[e]	1.09 (1.01–1.17)[d]	1.07 (1.00–1.14)[d]	1.07 (1.00–1.15)[d]
Mother's age, years				
≤34	1.54 (1.40–1.70)[e]	1.45 (1.29–1.62)[e]	1.43 (1.27–1.60)[d]	1.46 (1.30–1.64)[e]
35 TO 44	1.09 (1.03–1.16)[d]	1.09 (1.02–1.16)[d]	1.09 (1.02–1.16)[d]	1.09 (1.02–1.17)[d]
≥45	Ref.	Ref.		Ref.
Poverty status[a]				
Above poverty, >$75,000	Ref.	Ref.	Ref.	Ref.
Above poverty, ≤$75,000	0.88 (0.82–0.94)[d]	0.73 (0.67–0.79)[e]	0.73 (0.67–0.79)[e]	0.73 (0.67–0.79)[e]
Below poverty	1.68 (1.55–1.81)[e]	1.24 (1.10–1.39)[d]	1.20 (1.07–1.35)[d]	1.19 (1.06–1.34)[d]
Unknown poverty status	0.85 (0.99–0.74)	0.84 (0.71–0.98)[d]	0.83 (0.70–0.97)[d]	0.82 (0.70–0.97)[d]
Race/ethnicity of teen				
Hispanic	1.81 (1.67–1.96)[e]	1.73 (1.57–1.90)[e]	1.63 (1.48–1.80)[e]	1.49 (1.34–1.65)[e]
Non-Hispanic White	Ref.	Ref.	Ref.	Ref.
Non-Hispanic Black	1.28 (1.17–1.39)[e]	1.11 (1.00–1.22)[d]	1.03 (0.93–1.14)	0.99 (0.89–1.11)
Non-Hispanic other and multiple race	1.23 (1.11–1.37)[e]	1.21 (1.08–1.35)[d]	1.15 (1.03–1.29)[d]	1.09 (0.97–1.23)
Provider recommendation to get HPV vaccine				
Yes	3.03 (2.86–3.22)[e]	3.73 (3.49–3.99)[e]	3.72 (3.48–3.98)[e]	3.75 (3.50–4.01)[e]
No	Ref.	Ref.		Ref.
Don't know	1.74 (1.47–2.00)[e]	1.92 (1.65–2.24)[e]	1.81 (1.55–2.10)[e]	1.77 (1.52–2.06)[e]
ZIP code geographic measures				
Racial composition (50%+ of that group)				
Hispanic	2.31 (2.07–2.59)[e]	—	—	1.64 (1.43–1.87)[e]
Mixed	1.55 (1.41–1.70)[e]	—	—	1.30 (1.17–1.44)[e]
Non-Hispanic Black	1.29 (1.15–1.45)[e]	—	—	1.16 (1.00–1.34)[d]
Non-Hispanic White	Ref.	—	—	Ref.
Non-Hispanic other	2.74 (2.0–3.78)[e]	—	—	2.63 (1.87–3.71)[e]
Poverty (% below poverty)[a]				
0–4.99%	Ref.	—	Ref.	—
5–9.9%	0.90 (0.82–1.00)[d]	—	0.92 (0.82–1.01)	—
10–19.9%	1.04 (0.94–1.14)	—	0.98 (0.88–1.09)	—
20+%	1.49 (1.34–1.65)[e]	—	1.18 (1.04–1.33)[d]	—
Population density				
1–20 per square mile	Ref.	—	Ref.	
21–71 per square mile	1.19 (0.99–1.43)	—	1.29 1.06–1.58)[d]	1.05 (0.98–1.14)
72–651 per square mile	1.37 (1.15–1.62)[d]	—	1.37 (1.13–1.65)[d]	1.11 (0.99–1.25)
>651–203,546 per square mile	1.52 (1.29–1,80)[e]		1.49 (1.24–1.80)[e]	1.44 (1.19–1.74)[d]
Residence type				
Isolated small rural town	Ref.			
Small rural town	1.19 (0.93–1.52)	—	—	—
Large rural town	1.31 (1.06–1.63)[d]	—	—	—
Urban focused	1.44 (1.20–1.74)[d]	—	—	—

Abbreviations: CI, confidence interval; HPV, human papillomavirus; IHS, Indian Health; SCHIP, State Children's Health Insurance Program; Ref, reference.

[a]Poverty status was based on the U.S. Census poverty thresholds for 2011 and 2012, respectively.

[b]All models were weighted based on sampling weight and also included state random effects. The sample size was $n = 20{,}308$.

[c]Multivariable models 1–3 include all of the variables without dashes (—) and also include the variables `facility type where vaccines were administered and survey year'.

[d]$P < 0.05$.

[e]$P < 0.0001$.

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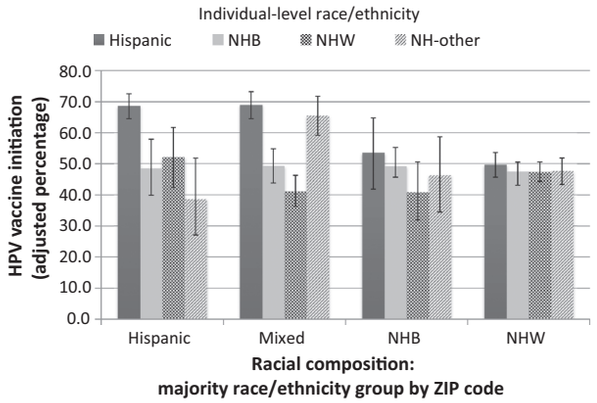

Figure 1.

Multivariable model adjusted percent of girls that initiated HPV vaccination (receipt of at least one dose) by individual level race/ethnicity and ZIP code racial-ethnic composition. The adjusted percents are based on a multivariable logistic regression that included the following variables: year, child's age, type of insurance coverage, mothers education (years), mother's marital status, mother's age, years, poverty status, race/ethnicity of teen, recommendation to get HPV vaccine, ZIP code population density, ZIP code racial composition (50%+ of that group), state random effects, and an interaction term for racial composition × race/ethnicity. Racial composition includes the majority race by ZIP code: Mixed, no majority race; NHB, non-Hispanic Black; NHW, non-Hispanic White. The racial composition category NH-other was excluded from the figure because of small numbers.

suggest that geographic factors play an important role in HPV vaccinations beyond individual-level characteristics. We found that girls from geographic communities with a majority Hispanic, Black, or mixed-race population had significantly higher odds of vaccination initiation than those from majority NHW communities. Residential racial-ethnic segregation in the United States has been shown both to negatively influence health outcomes through social isolation and lack of access to health and preventative services (60–62) and to positively affect health through strong social support networks and the availability of more health-promoting resources (43, 63, 64). Racial-ethnic minorities are more likely to live in poorer, inner-city urban areas than are NHWs (16, 65) for reasons including racial discrimination, institutional racism, and immigrant settlement patterns (16, 65). In our study, among the girls living in majority Hispanic or NHB communities, 72% and 74% of them, respectively, lived in communities where ≥20% of the population was below the poverty line. In contrast, among the girls living in majority NHW or mixed race/ethnicity communities, only 13% and 35% of them, respectively, lived in similarly impoverished communities. The higher HPV vaccination rates in poor communities with a high concentration of racial-ethnic minorities could therefore be a result of healthcare practice and community-based interventions (e.g., educating key stakeholders influential to the adolescents' vaccination behaviors) and other intervention strategies (66–70) in support of HPV vaccination that have focused efforts on poor Hispanic and Black communities where rates of cervical cancer rates are highest (6).

Our findings also indicated that Hispanic girls living in predominantly Hispanic or mixed race/ethnicity communities had HPV vaccination initiation rates significantly higher than Hispanics living in predominantly NHW or NHB communities. This result could be due to positive or protective factors related to living in communities with a high concentration of ethnic minorities sharing the same health-related values, who provide critical social and instrumental support, and are targeted for public health safety-net services and interventions, (71). These findings are consistent with those of previous studies showing residential racial–ethnic composition can influence health behaviors (43, 45). Higher HPV vaccination initiation rates among Hispanics living in predominantly Hispanic communities could also be a result of low levels of acculturation. Although we did not directly measure acculturation in this study, Hispanic residential segregation in the United States has been shown to be correlated with lower levels of acculturation and low SES (44, 72–74); and, there is evidence from past studies that Hispanics with lower levels of acculturation are more supportive of vaccination for their children than are other demographic groups (75, 76).

For NHB girls, the community's racial–ethnic composition did not substantially change the HPV vaccination initiation rates. Why this study does not show the same protective effect among NHB girls living in poor, predominantly NHB communities as it does for Hispanics girls living in predominantly Hispanic communities is not known; however, it could be related to ease of accessing safety-net services and/or less effective intervention programs. Additional research is needed to better understand why these differences exist and to further understand the independent and/or joint contributions of race, segregation, and poverty on the uptake of HPV vaccination.

Our findings are subject to several limitations. First, the household response rates for 2011 and 2012 were 57.2% and 55.1%, respectively, and the cell phone response rates for the same years were 22.4% and 23.3%, respectively. Although sampling weights are designed to minimize nonresponse and noncoverage bias, some bias remains in the weighted estimates used for analysis. Second, the parents' role in the survey is subject to recall bias. Some parents may have incorrectly recalled whether they had ever received a provider recommendation for the HPV vaccine. Third, the NIS-Teen did not collect certain data potentially important to HPV vaccine initiation, including the parents' health beliefs and uptake of other childhood immunizations. Finally, community geographic measures were based on ZCTA data because these were the smallest geographic units available via NIS-Teen. ZCTA measures have been shown to be more heterogeneous than other preferred geographic units like census tracts and blocks (77). A change in geographic unit (ZIP code to census tract) may result in different conclusions than those that are based on another unit of analysis (often called the modifiable unit problem).

In conclusion, this study found that initiation rates of HPV vaccination among teen girls were highest in the poorest communities and among Hispanics living in communities where the racial–ethnic composition was predominantly Hispanic or mixed race. It also found that regardless of individual race/ethnicity, girls living in predominantly NHW and NHB communities had the lowest initiation rates. The reasons are unknown, but if public health officials wish to increase vaccination coverage in girls in these communities, they should obtain a better understanding of the individual characteristics and geographic or contextual factors that may lead to barriers to HPV vaccination and ineffective public health interventions.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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References

1. Dunne EF, Unger ER, Sternberg M, McQuillan G, Swan DC, Patel SS, et al. Prevalence of HPV infection among females in the United States. JAMA 2007;297:813–9.
2. Centers for Disease Control and Prevention. HPV-Associated Cancers Statistics. Accessed September 5, 2015. Available from: http://www.cdc.gov/cancer/hpv/statistics/index.htm.
3. Centers for Disease C, Prevention. Human papillomavirus-associated cancers - United States, 2004–2008. MMWR Morb Mortal Wkly Rep 2012;61:258–61.
4. Dunne EF, Markowitz LE, Saraiya M, Stokley S, Middleman A, Unger ER, et al. CDC grand rounds: Reducing the burden of HPV-associated cancer and disease. MMWR Morb Mortal Wkly Rep 2014;63:69–72.
5. Jemal A, Simard EP, Dorell C, Noone AM, Markowitz LE, Kohler B, et al. Annual Report to the Nation on the Status of Cancer, 1975–2009, featuring the burden and trends in human papillomavirus(HPV)-associated cancers and HPV vaccination coverage levels. J Natl Cancer Inst 2013;105:175–201.
6. Jeudin P, Liveright E, Del Carmen MG, Perkins RB. Race, ethnicity, and income factors impacting human papillomavirus vaccination rates. Clin Ther 2014;36:24–37.
7. Niccolai LM, Mehta NR, Hadler JL. Racial/Ethnic and poverty disparities in human papillomavirus vaccination completion. Am J Prev Med 2011;41:428–33.
8. Boscoe FP, Johnson CJ, Sherman RL, Stinchcomb DG, Lin G, Henry KA. The relationship between area poverty rate and site-specific cancer incidence in the United States. Cancer 2014;120:2191–8.
9. Kuehn BM. CDC panel backs routine HPV vaccination. JAMA 2006;296:640–1.
10. Centers for Disease Control and Prevention. Teen Vacciantion Coverage 2013 National Immunization Survey (NIS)-Teen. 2013; Available from: http://www.cdc.gov/vaccines/imz-managers/coverage/nis/teen/tables/13/tab01_iap_2013.pdf.
11. Elam-Evans LD, Yankey D, Jeyarajah J, Singleton JA, Curtis RC, MacNeil J, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years–United States, 2013. MMWR Morb Mortal Wkly Rep 2014;63:625–33.
12. U.S. Department of Health and Human Services. Healthy People 2020 Summary of Objectives.
13. Holman DM, Benard V, Roland KB, Watson M, Liddon N, Stokley S. Barriers to human papillomavirus vaccination among US adolescents: a systematic review of the literature. JAMA Pediatr 2014;168:76–82.
14. Elam-Evans LD, Yankey D, Singleton JA, Kolasa MCenters for Disease C, Prevention. National, state, and selected local area vaccination coverage among children aged 19–35 months - United States, 2013. MMWR Morb Mortal Wkly Rep 2014;63:741–8.
15. Merkin SS, Stevenson L, Powe N. Geographic socioeconomic status, race, and advanced-stage breast cancer in New York City. Am J Public Health 2002;92:64–70.
16. Warner ET, Gomez SL. Impact of neighborhood racial composition and metropolitan residential segregation on disparities in breast cancer stage at diagnosis and survival between black and white women in California. J Community Health 2010;35:398–408.
17. Shariff-Marco S, Yang J, John EM, Sangaramoorthy M, Hertz A, Koo J, et al. Impact of neighborhood and individual socioeconomic status on survival after breast cancer varies by race/ethnicity: the Neighborhood and Breast Cancer Study. Cancer Epidemiol Biomarkers Prev 2014;23:793–811.
18. Lantz PM, Mujahid M, Schwartz K, Janz NK, Fagerlin A, Salem B, et al. The influence of race, ethnicity, and individual socioeconomic factors on breast cancer stage at diagnosis. Am J Public Health 2006;96:2173–8.
19. Henry KA, McDonald K, Sherman R, Kinney AY, Stroup AM. Association between individual and geographic factors and nonadherence to mammography screening guidelines. J Womens Health (Larchmt) 2014;23:664–74.
20. Adler NE, Newman K. Socioeconomic disparities in health: pathways and policies. Health Affairs 2002;21:60–76.
21. Diez Roux AV. Investigating neighborhood and area effects on health. Am J Public Health 2001;91:1783–9.
22. Robert SA. Socioeconomic position and health: the independent contribution of community socioeconomic context. Annu Rev Sociol 1999;25:489–516.
23. Arcury TA, Gesler WM, Preisser JS, Sherman J, Spencer J, Perin J. The effects of geography and spatial behavior on health care utilization among the residents of a rural region. Health Serv Res 2005;40:135–55.
24. Field K. Measuring the need for primary health care: an index of relative disadvantage. Appl Geogr 2000;20:305–32.
25. Freeman HE, Corey CR. Insurance status and access to health services among poor persons. Health Serv Res 1993;28:531–41.
26. Jain N, Euler GL, Shefer A, Lu P, Yankey D, Markowitz L. Human papillomavirus (HPV) awareness and vaccination initiation among women in the United States, National Immunization Survey-Adult 2007. Prev Med 2009;48:426–31.
27. Marlow LA, Wardle J, Forster AS, Waller J. Ethnic differences in human papillomavirus awareness and vaccine acceptability. J Epidemiol Community Health 2009;63:1010–5.
28. Cui Y, Baldwin SB, Wiley DJ, Fielding JE. Human papillomavirus vaccine among adult women: disparities in awareness and acceptance. Am J Prev Med 2010;39:559–63.
29. Glenn BA, Tsui J, Singhal R, Sanchez L, Nonzee NJ, Chang LC, et al. Factors associated with HPV awareness among mothers of low-income ethnic minority adolescent girls in Los Angeles. Vaccine 2015;33:289–93.
30. Malo TL, Hassani D, Staras SA, Shenkman EA, Giuliano AR, Vadaparampil ST. Do Florida Medicaid providers' barriers to HPV vaccination vary based on VFC program participation? Matern Child Health J 2013;17:609–15.
31. Walker AT, Smith PJ, Kolasa M. Reduction of racial/ethnic disparities in vaccination coverage, 1995–2011. MMWR Surveill Summ 2014;63 Suppl 1:7–12.

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32. Chao C, Velicer C, Slezak JM, Jacobsen SJ. Correlates for human papillomavirus vaccination of adolescent girls and young women in a managed care organization. Am J Epidemiol 2010;171:357–67.
33. Pruitt SL, Schootman M. Geographic disparity, area poverty, and human papillomavirus vaccination. Am J Prev Med 2010;38:525–33.
34. Tsui J, Gee GC, Rodriguez HP, Kominski GF, Glenn BA, Singhal R, et al. Exploring the role of neighborhood socio-demographic factors on HPV vaccine initiation among low-income, ethnic minority girls. J Immigr Minor Health 2013;15:732–40.
35. Centers for Disease Control and Prevention. The 2011 National Immunization Survey- Teen Data User's Guide. Atlanta, GA: Centers for Disease Control and Prevention; 2010. Accessed January 26, 2015.Available at from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NIS/NISTEENPUF12_DUG.pdf.
36. U.S. Census Bureau. Poverty Thresholds by Size of Family and Number of Related Children Under 18 Years, 2011–2012. Available from: https://www.census.gov/hhes/www/poverty/data/threshld/.
37. US Census Bureau. ZIP Code Tabulation Areas (ZCTAs). Available from: https://www.census.gov/geo/reference/zctas.html.
38. Krieger N, Waterman PD, Chen JT, Soobader MJ, Subramanian SV. Monitoring socioeconomic inequalities in sexually transmitted infections, tuberculosis, and violence: geocoding and choice of area-based socioeconomic measures–the public health disparities geocoding project (US). Public Health Rep 2003;118:240–60.
39. Li K, Wen M, Henry KA. Residential racial composition and black-white obesity risks: differential effects of neighborhood social and built environment. Int J Environ Res Public Health 2014;11:626–42.
40. Anderson AE, Henry KA, Samadder NJ, Merrill RM, Kinney AY. Rural vs urban residence affects risk-appropriate colorectal cancer screening. Clin Gastroenterol Hepatol 2013;11:526–33.
41. Flores YN, Davidson PL, Nakazono TT, Carreon DC, Mojica CM, Bastani R. Neighborhood socio-economic disadvantage and race/ethnicity as predictors of breast cancer stage at diagnosis. BMC Public Health 2013;13:1061.
42. Tsui J, Singhal R, Rodriguez HP, Gee GC, Glenn BA, Bastani R. Proximity to safety-net clinics and HPV vaccine uptake among low-income, ethnic minority girls. Vaccine 2013;31:2028–34.
43. White K, Borrell LN. Racial/ethnic residential segregation: framing the context of health risk and health disparities. Health Place 2011;17:438–48.
44. Massey DS, Denton NA. The dimensions of residential segregation. Soc Forces 1988;67:281–315.
45. Russell E, Kramer MR, Cooper HL, Thompson WW, Arriola KR. Residential racial composition, spatial access to care, and breast cancer mortality among women in Georgia. J Urban Health 2011;88:1117–29.
46. Russell EF, Kramer MR, Cooper HL, Gabram-Mendola S, Senior-Crosby D, Jacob Arriola KR. Metropolitan area racial residential segregation, neighborhood racial composition, and breast cancer mortality. Cancer Causes Control 2012;23:1519–27.
47. Rural Health Research Center University of Washington. Rural-Urban Commuting Areas (RUCAs). (2007). University of Washington, Retrieved 3 March 2010 from University of Washington: Available from: http://depts.washington.edu/uwruca/ruca-rural.php.
48. Jain N, Singleton JA, Montgomery M, Skalland B. Determining accurate vaccination coverage rates for adolescents: the National Immunization Survey-Teen 2006. Public Health Rep 2009;124:642–51.
49. SAS Institute Inc. SAS for Windows, Version 9.3. SAS Institute; Cary, NC, USA.
50. Institute S. The GLIMMIX procedure. SAS Institute; Cary, NC; 2005.
51. Dorell CG, Yankey D, Santibanez TA, Markowitz LE. Human papillomavirus vaccination series initiation and completion, 2008–2009. Pediatrics 2011;128:830–9.
52. Rahman M, McGrath CJ, Berenson AB. Geographic variation in human papillomavirus vaccination uptake among 13–17 year old adolescent girls in the United States. Vaccine 2014;32:2394–8.
53. Ylitalo KR, Lee H, Mehta NK. Health care provider recommendation, human papillomavirus vaccination, and race/ethnicity in the US National Immunization Survey. Am J Public Health 2013;103:164–9.
54. Curtis CR, Dorell C, Yankey D, Jeyarajah J, Chesson H, Saraiya M, et al. National human papillomavirus vaccination coverage among adolescents aged 13–17 years-National Immunization Survey–teen, United States, 2011. MMWR Surveill Summ 2014;63 Suppl 2:61–70.
55. Stokley S, Jeyarajah J, Yankey D, Cano M, Gee J, Roark J, et al. Human papillomavirus vaccination coverage among adolescents, 2007–2013, and postlicensure vaccine safety monitoring, 2006–2014–United States. MMWR Morb Mortal Wkly Rep 2014;63:620–4.
56. Walker AT, Smith PJ, Kolasa MCenters for Disease C, Prevention. Reduction of racial/ethnic disparities in vaccination coverage, 1995–2011. MMWR Surveill Summ 2014;63 Suppl 1:7–12.
57. Lindley MC, Smith PJ, Rodewald LE. Vaccination coverage among U.S. adolescents aged 13–17 years eligible for the Vaccines for Children program, 2009. Public Health Rep 2011;126 Suppl 2:124–34.
58. Reich JA. Neoliberal Mothering and Vaccine Refusal: Imagined Gated Communities and the Privilege of Choice. Gender & Society 2014;28:679–704.
59. The Affordable Care Act and Immunization. (n.d.). Retrieved June 8, 2015. Available from: http://www.hhs.gov/healthcare/facts/factsheets/2010/09/The-Affordable-Care-Act-and-Immunization.html.
60. Schulz A, Israel B, Williams D, Parker E, Becker A, James S. Social inequalities, stressors and self reported health status among African American and white women in the Detroit metropolitan area. Soc Sci Med 2000;51:1639–53.
61. Williams DR, Collins C. Racial residential segregation: a fundamental cause of racial disparities in health. Public Health Rep 2001;116:404–16.
62. Pruitt SL, Lee SJ, Tiro JA, Xuan L, Ruiz JM, Inrig S. Residential racial segregation and mortality among black, white, and Hispanic urban breast cancer patients in Texas, 1995 to 2009. Cancer 2015;121:1845–55.
63. Landrine H, Corral I. Separate and unequal: residential segregation and black health disparities. Ethn Dis 2009;19:179–84.
64. Walton E. Residential segregation and birth weight among racial and ethnic minorities in the United States. J Health Soc Behav 2009;50:427–42.
65. Jones C. The impact of racism on health. Ethn Dis 2002;12:S2-10-3.
66. Berenson AB, Rahman M, Hirth JM, Rupp RE, Sarpong KO. A brief educational intervention increases providers' human papillomavirus vaccine knowledge. Hum Vaccin Immunother 2015;11:1331–6.
67. Community Preventive Services Task Force. The guide to community preventive services. Increasingappropriate vaccination [Internet]. Atlanta (GA): the Task Force. Available from: http://www.thecommunityguide.org/vaccines/index.html.
68. Moss JL, Reiter PL, Dayton A, Brewer NT. Increasing adolescent immunization by webinar: a brief provider intervention at federally qualified health centers. Vaccine 2012;30:4960–3.
69. Perkins RB, Zisblatt L, Legler A, Trucks E, Hanchate A, Gorin SS. Effectiveness of a provider-focused intervention to improve HPV vaccination rates in boys and girls. Vaccine 2015;33:1223–9.
70. Reiter PL, Stubbs B, Panozzo CA, Whitesell D, Brewer NT. HPV and HPV vaccine education intervention: effects on parents, healthcare staff, and school staff. Cancer Epidemiol Biomarkers Prev 2011;20:2354–61.
71. Kawachi I, Berkman L. Social Cohesion, Social Capital, and Health. Social Epidemiology. New York: Oxford University Press; 2000. p. 174–90.
72. Logan J, Alba R, McNulty T, Fisher B. Making a place in the metropolis: locational attainment in cities and suburbs. Demography 1996;33:443–53.
73. Martin ME. Residential segregation patterns of Latinos in the United States, 1990–2000: testing the ethnic enclave and inequality theories. New York: Routledge; 2007.
74. Massey DS, Fischer MJ. How segregation concentrates poverty. Ethnic Racial Stud 2000;23:670–91.
75. Anderson LM, Wood DL, Sherbourne CD. Maternal acculturation and childhood immunization levels among children in Latino families in Los Angeles. Am J Public Health 1997;87:2018–21.
76. Crawford ND, Blaney S, Amesty S, Rivera AV, Turner AK, Ompad DC, et al. Individual- and neighborhood-level characteristics associated with support of in-pharmacy vaccination among ESAP-registered pharmacies: pharmacists' role in reducing racial/ethnic disparities in influenza vaccinations in New York City. J Urban Health 2011;88:176–85.
77. Krieger N, Waterman P, Chen JT, Soobader MJ, Subramanian SV, Carson R. Zip code caveat: bias due to spatiotemporal mismatches between zip codes and US census-defined geographic areas–the Public Health Disparities Geocoding Project. Am J Public Health 2002;92:1100–2.

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