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Adolescent uptake of human papillomavirus (HPV) vaccine remains low. We evaluated HPV vaccine uptake patterns over 2008–2011 by race/ethnicity, poverty status, and the combination of race/ethnicity and poverty status, utilizing National Immunization Survey–Teen data. Minority and below-poverty adolescents consistently had higher series initiation than white and above-poverty adolescents.

Keywords. HPV vaccines; adolescent; vaccination; healthcare disparities; poverty.

Since 2007, the US Centers for Disease Control and Prevention (CDC) has annually estimated adolescent (ages 13–17) immunization coverage, through the National Immunization Survey–Teen (NIS–Teen). These reports have documented adolescent immunization coverage successes (eg, rapid increases in uptake of new vaccines, such as tetanus and diphtheria toxoids, acellular pertussis vaccine [Tdap], and quadrivalent meningococcal conjugate vaccine [MCV4]) as well as remaining challenges (eg, coverage levels below Healthy People 2020 goals). Compared to more rapid increases in Tdap and MCV4 coverage since 2008, lower HPV vaccine uptake has been an intractable problem [1–4].

In these reports, the CDC has highlighted atypical demographic patterns in HPV vaccine series initiation, with HPV vaccine series initiation higher among Hispanic and black teens compared to white teens, and among girls below the poverty line, compared to those at or above the poverty line (hereafter “above poverty”) [1–4]. However, examining vaccination patterns among these characteristics independently may miss more nuanced health disparities. It has been postulated that “racial disparities should not be analyzed without simultaneously considering the contribution of class disparities... Moreover, this approach suggests that class-based health disparities should never be analyzed without simultaneously considering the contribution of race” [5]. We are not aware of adolescent vaccine uptake analyses taking both of these factors into account simultaneously over multiple years.

Understanding multiyear patterns in these national estimates is important to mitigating barriers to greater HPV vaccine uptake. We conducted this evaluation to (1) assess HPV vaccine uptake by the combination of race/ethnicity and poverty status and (2) conduct a multiyear analysis of HPV vaccine uptake, using 4 years of data (2008 through 2011 NIS–Teen cohorts).

METHODS

Public use data files for the 2008 through 2011 NIS–Teen were available from the CDC [6]. The NIS–Teen utilizes random digit dialing to identify households with 13- to 17-year-old adolescents, for whom routine vaccine coverage is measured and verified with the adolescent’s healthcare provider [6, 7]. We evaluated uptake of Tdap, MCV4, and HPV vaccine among female adolescents, by race/ethnicity, poverty status, and the combination of race/ethnicity and poverty status. Sociodemographic categories were self-reported, and classified as non-Hispanic white, non-Hispanic black, Hispanic, and other non-Hispanic, with poverty status assessed by comparing reported household income to US Census poverty levels [7]. This analysis was conducted only for female adolescents, for all vaccines, to provide the most consistent comparison.

We compared vaccine uptake over the period between 2008 and 2011, and used regression analysis to compute the average annual increase for a 1-year change in vaccine uptake by the sociodemographic characteristics under study. Analyses were conducted in SAS version 9.3 (SAS Institute, Cary, North Carolina), using the survey method–specific procedures PROC SURVEYMEANS and PROC SURVEYREG, with weights as provided in the NIS–Teen datasets. Sex- and sociodemographic-level specific values were computed using domain analysis in the survey procedures.
Because this analysis utilized existing previously collected and freely available public data, this was considered to be non-human subjects research and did not require institutional review board approval.

RESULTS

Overall Coverage
HPV vaccine series initiation increased by approximately 16 percentage points between 2008 and 2011 (from 37.2% to 53%). Over the same period, MCV4 uptake increased by 26.5 percentage points (from 43.1% to 69.6%) and Tdap uptake increased by 37.3 percentage points (from 41.0% to 78.3%).

Coverage by Poverty Status
Since 2008, HPV vaccine series initiation for below-poverty adolescents has been consistently and stably higher than for above-poverty adolescents (Supplementary Figure 1; Table 1). The initial difference by poverty status (10.6% higher in below-poverty adolescents in 2008) persisted over the study period (12.0% higher in below-poverty adolescents in 2011) (Table 1). HPV vaccine is the only routinely recommended adolescent vaccine to exhibit this pattern (Supplementary Figure 1). Series completion was initially low among below poverty adolescents (15% in 2008, compared to 19% for above poverty), but exceeded that of above-poverty adolescents by 2011 (39% vs 33%) (Supplementary Table 1).

Coverage by Race/Ethnicity
HPV vaccine series initiation was consistently highest for Hispanic adolescents, followed by black adolescents, with lowest uptake among white adolescents (Supplementary Figure 1; Table 1). Hispanics had both the highest initial coverage (44.4%) and the greatest increase by 2011 (increase of 20.6 percentage points). The average rate of increase for Hispanics was nearly double that for whites (7.0% vs 3.8% average annual increase, respectively) over this period (Table 1). This pattern is similar to that for MCV4 coverage (Supplementary Figure 1). For Tdap, white and Hispanic adolescents had nearly identical vaccine coverage, and black adolescents had slightly, but consistently, lower Tdap coverage (Supplementary Figure 1). More than 40% of Hispanic females completed the 3-dose series by 2011, whereas all other race/ethnicity groups had completion percentages ranging from 32% to 35% (Supplementary Table).

Coverage by Race/Ethnicity and Poverty Status
By 2011, above-poverty non-Hispanic white females had the lowest HPV vaccine series initiation (46.7%), an increase of only 11% from 2008. Below-poverty Hispanics had the highest coverage in 2011 (69.2%), following their high initial coverage

| Table 1. Uptake of at Least 1 Dose of Human Papillomavirus Vaccine Among Adolescent (Aged 13–17) Females, in Aggregate, and by Poverty Status, Race/Ethnicity, and the Combination of Race/Ethnicity and Poverty Status, United States, NIS-Teen, 2008–2011 |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Poverty Status  | 2008 %          | 2008 95% CI     | 2011 %          | 2011 95% CI     | Increase, %, 2008–2011 | Average Annual Increase, %
| Overall         | 37.2            | 35.1–39.3       | 53.0            | 51.4–54.7       | 15.8                        | 5.2
| Poverty         |                 |                 |                 |                 |                             |                             |
| Above poverty   | 35.8            | 33.7–37.9       | 50.1            | 48.2–52.0       | 14.3                        | 4.8
| Below poverty   | 46.4            | 39.7–53.1       | 62.1            | 58.4–65.9       | 15.7                        | 4.9
| Race/ethnicity  |                 |                 |                 |                 |                             |                             |
| NH white        | 35.0            | 32.9–37.1       | 47.5            | 45.6–49.4       | 12.5                        | 3.8
| NH black        | 35.7            | 29.3–42.2       | 56.0            | 51.3–60.7       | 20.3                        | 6.4
| Hispanic        | 44.4            | 37.9–50.8       | 65.0            | 60.9–69.1       | 20.6                        | 7.0
| NH other        | 41.8            | 33.1–50.6       | 54.7            | 48.4–60.9       | 12.9                        | 5.0
| Race/ethnicity/poverty |     |                 |                 |                 |                             |                             |
| NH white, above poverty | 35.7            | 33.4–38.0       | 46.7            | 44.7–48.7       | 11.0                        | 3.7
| NH white, below poverty | 33.6            | 26.6–40.5       | 53.6            | 47.1–60.1       | 20.0                        | 4.6
| NH black, above poverty | 31.2            | 24.9–37.5       | 52.5            | 46.1–58.8       | 21.3                        | 6.8
| NH black, below poverty | 45.9            | 31.3–60.5       | 60.2            | 52.8–67.6       | 14.3                        | 4.7
| Hispanic, above poverty | 39.3            | 31.4–47.2       | 61.9            | 56.2–67.6       | 22.6                        | 8.1
| Hispanic, below poverty | 53.0            | 41.8–64.2       | 69.2            | 63.1–75.4       | 16.2                        | 5.5
| NH other, above poverty | 39.5            | 29.3–49.7       | 50.3            | 43.3–57.2       | 10.8                        | 4.4
| NH other, below poverty | 49.5            | 32.6–66.3       | 65.1            | 52.4–77.8       | 15.6                        | 5.7

Abbreviations: CI, confidence interval; NH, non-Hispanic; NIS-Teen, National Immunization Survey–Teen. * As estimated through PROC SURVEYREG.
in 2008 (53%). For every race/ethnicity group, coverage was higher among below-poverty adolescents by 2011 (Table 1).

There was less variability in series completion by the combination of race/ethnicity and poverty status; below-poverty Hispanics again had the highest overall coverage (45%). HPV vaccine series completion was higher for below-poverty adolescents in the non-Hispanic black, non-Hispanic other, and Hispanic groups compared to their above-poverty peers. Series completion was the same (33%) for both above- and below-poverty white adolescents (Supplementary Table 1), following a larger increase in series completion among below-poverty whites (from 12% to 33%) compared to above-poverty whites (from 20% to 33%) (Supplementary Table 1).

**DISCUSSION**

We found that national estimates of HPV vaccine series initiation by adolescent girls demonstrate a consistent pattern of higher HPV vaccine uptake among adolescents below the federal poverty level, compared to those above the poverty level. This finding is unique to the HPV vaccine, and persisted across racial and ethnic categories.

The finding of lowest HPV vaccination among above-poverty white adolescents needs further evaluation. This may be related to findings of greater active refusal of all childhood vaccines among mothers who were white, were college educated, and had higher incomes [8]. It is possible that HPV vaccine is more often refused by above-poverty whites because of greater access to routine cervical screening, leading to a lowered perceived need for the HPV vaccine.

Medically underserved populations with less access to routine care, especially racial and ethnic minorities, have higher rates of cervical cancer [9, 10]. Maternal experiences with HPV-related disease have been associated with greater willingness to vaccinate daughters against HPV [11]. A recent study identified increasing safety concerns about the HPV vaccine, relative to those of Tdap and MCV4, as a contributor to lower HPV vaccine uptake [12]; it is possible that greater awareness of HPV-related diseases in some populations may overcome vaccine safety concerns. Continued research is needed on sociocultural impacts of disease awareness within the context of sociodemographic information, including more in-depth qualitative assessments on the interactions of these factors.

Given the high cost of the HPV vaccine, it has been hypothesized that the Vaccines for Children program may have a greater impact on HPV vaccine uptake among traditionally underserved populations [1–4]. However, health insurance plans provide first-dollar coverage and/or have no annual deductible requirements for HPV vaccine at levels consistent with other routinely recommended adolescent vaccines [13], indicating little difference in cost-sharing for adolescent vaccines among privately insured adolescents.

Whereas there are few states with HPV vaccine middle school entry requirements, 30 states have middle school Tdap requirements and 22 states have MCV4 requirements [14]. However, even with more states having middle school entry vaccination requirements for Tdap than for MCV4, Tdap coverage exceeded that of MCV4 by only 8% by 2011.

This evaluation is subject to some limitations. First, because of relatively small samples of some racial groups (eg, American Indian/Alaska Native and Asian), we used a 4-level race/ethnicity classification (non-Hispanic white, non-Hispanic black, Hispanic, non-Hispanic other), which may overlook differences in other racial groups by poverty status. Future studies specifically addressing poverty-level disparities among these groups are needed. This study was focused on the effects of race/ethnicity and poverty on adolescent vaccination, and did not address other factors that can affect HPV vaccination, including provider recommendation [15, 16]. Additional studies are needed to address the relationship between provider recommendation and sociodemographic factors. The lack of a SAS procedure for generalized linear models for complex survey data necessitated the use of the SURVEYREG procedure to evaluate the average per-year increase in vaccine coverage, using linear regression. Although not optimal, this approach will not provide estimates biased in the same way as logistic regression estimates. Finally, the available data only spanned 4 years; the 2012 NIS-Teen public use files were not available at the time of this analysis.

Generally high coverage of Tdap and MCV4 indicates the potential for high HPV vaccine uptake. Expanded use of detailed surveillance efforts to reach more granular subpopulations of adolescents and greater utilization of multiple years of data to evaluate consistent disparity patterns are needed to develop and implement interventions to address disparities in adolescent immunization coverage.

**Supplementary Data**

Supplementary materials are available at Clinical Infectious Diseases online (http://cid.oxfordjournals.org/). Supplementary materials consist of data provided by the author that are published to benefit the reader. The posted materials are not copyrighted. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

**Notes**

**Disclaimer.** All analyses, interpretations, or conclusions reached are attributed to the authors and not to the National Center for Health Statistics, which is responsible only for the initial data.

**Potential conflicts of interest.** All authors: No potential conflicts.

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