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ORIGINAL PAPER

# Social Determinants of Health and Human Papillomavirus Vaccination Among Young Adults, National Health Interview Survey 2016

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## Abstract

Human papillomavirus (HPV) vaccination has the potential to reduce the burden of anogenital cancers. Vaccine uptake remains suboptimal, especially among young adults. Social determinants of health (SDOH) are societal level conditions that may indirectly influence health behaviors, including HPV vaccination. The purpose of this study was to assess HPV vaccination and SDOH among young adult women and men. The 2016 National Health Interview Survey was restricted to participants ages 18–26 (n = 3593). The Healthy People 2020 SDOH Framework was used to identify variables for economic stability, health and healthcare, education, social and community context, and neighborhood and built environment. Survey-weighted logistic regression models identified SDOH variables significantly associated with HPV vaccination. Reported HPV vaccination occurred for 45.7% of women and 14.5% of men in the sample. Among women, education determinants—highest level of education completed and English language—were significantly associated with HPV vaccination. Men (adjusted OR 0.65, 95% CI 0.54, 0.79) and women (adjusted OR 0.66, 95% CI 0.49, 0.90) who did not use the Internet to look up health information were at lower odds to be vaccinated for HPV. These findings can inform future HPV vaccine uptake efforts by focusing specifically on these SDOH areas—education and health and healthcare. Identifying SDOH leverage points is critical to promoting HPV vaccination and ultimately reducing HPV-associated cancers.

**Keywords** HPV vaccination · Social determinants of health · Young adult · Primary prevention · Cancer

## Introduction

Human papillomavirus (HPV), the most common sexually transmitted infection in the US, is responsible for almost all cervical cancers, 50% of vulvar cancers, 65% of vaginal cancers, 90% of anal cancers, and 35% of penile cancers [4]. As a result, approximately 30,700 cancer cases are attributable to HPV in the US annually [36]. To reduce the health burden of HPV, the Advisory Committee on Immunization Practices recommends routine HPV vaccination, with nine-valent vaccine, for boys and girls aged 11–12 years, catch-up vaccination for boys 13–21 years as well as vaccination of men 22–26 years at high risk, and catch-up vaccination for girls/women 13–26 years [23]. However, only 43% of adolescents—50% of girls and 38% of boys—are up to date on the HPV vaccination series [37], falling short of *Healthy People 2020*'s objective of 80% coverage for girls and boys aged 13–15 years old [34]. While continued efforts are necessary to increase coverage among girls and boys, additional research and interventions are required to improve catch-up vaccination rates among those who have not initiated or completed the vaccination [39].

Currently, the HPV vaccination among young adults (19–26 years of age) with at least one dose ever is 40% for women and 8% for men [39]. Previous studies have cited higher HPV and vaccine knowledge, positive personal

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beliefs about the vaccine, and recommendations from others as leading indicators for receiving the vaccine [12, 29, 31, 32]. However, catch-up rates remain low with marginal signs of improvement. This is especially salient as the prevalence of HPV among adults 18–59 years old was 43%, with the prevalence of high-risk HPV within this age group being 28% [18]. Moreover, girls aged 14–19 had a prevalence of 4% for four HPV high-risk genotypes (6, 11, 16, and 18), but increased to 13% for women aged 20–24 years old [17]. Thus, there is a critical need to examine HPV vaccination catch-up to better understand potential underlying factors related to catch-up vaccination and decrease morbidity and mortality related to HPV-associated cancers.

A novel approach to addressing HPV vaccination catch-up vaccination is to use a Social Determinants of Health (SDOH) approach. SDOH include the conditions in which people are born, grow, live work and age [35]. These conditions are affected by the distribution of resources and affect the health of individuals. An SDOH approach has been used to identify health disparities and populations at risk for a multitude of health behaviors and conditions [7]. Often in public health, an individual or interpersonal approach is taken to health behavior change that does not take into account the community and societal factors that impact health. Social level indicators that impact health may be less immediately obvious due to the often multifaceted routes between social level factors and individual behavior. However, ignoring the social level factors that impact health is to ignore broad scale areas that may hamper or enhance efforts to individual behavior change.

One approach to assessing SDOH is through the use of the Healthy People 2020 SDOH Framework [35]. This framework was developed to divide social determinants into five categories: social and community context, education, economic stability, neighborhood and built environment, and health and health care. Each of the five categories are then broken down into key areas. For example, economic stability includes items such as food insecurity and employment and social and community context examines areas such as social cohesion and civic participation (Table 1). The framework

**Table 1** Description of social determinants of health applied to HPV vaccination

| |
|---|
| What is the relationship between HPV vaccination among young adults and *economic stability*? |
| Key areas: |
| Employment |
| Food insecurity |
| Housing instability |
| Poverty |
| What is the relationship between HPV vaccination among young adults and *education*? |
| Key areas: |
| Early childhood education and development |
| Enrollment in higher education |
| High school graduation |
| Language and literacy |
| What is the relationship between HPV vaccination among young adults and the *social and community context*? |
| Key areas: |
| Civic participation |
| Discrimination |
| Incarceration |
| Social cohesion |
| What is the relationship between HPV vaccination among young adults and *health and healthcare*? |
| Key areas: |
| Access to health care |
| Access to primary care |
| Health literacy |
| What is the relationship between HPV vaccination among young adults and *neighborhood and built environment*? |
| Key areas: |
| Access to foods that support healthy eating patterns |
| Crime and violence |
| Environmental conditions |
| Quality of housing |

allows for an assessment of a broad range of social factors within a single study. Elements of SDOH have often been included in HPV vaccination studies as part of demographic information or along with other outcome variables [1, 3, 10]. While there is support for significant variations in HPV vaccination by gender, race/ethnicity, and socioeconomic status [13, 24, 28, 33], studies have rarely used a framework as a basis for examining a wide range of social factors and potential associations with HPV vaccination [3]. In addition, most of this research has been conducted with parents and/or adolescents rather than young adults [3, 24]. The use of the Healthy People 2020 SDOH Framework to approach social determinants of HPV vaccination is unique and useful for two reasons. First, utilizing a social determinants framework extends beyond the typical assessment of sociodemographics by providing a supporting structure to guide what is and is not included as a social determinant of health. For example, the framework includes areas of healthcare and community context such as access to primary care and social cohesion that may not typically be included as covariates. Second, this framework provides context to SDOH in that all constructs remain at a social level rather than intertwining individual and interpersonal factors that may confound social determinants if analyzed concurrently.

There is currently a paucity of research assessing multiple elements of SDOH and HPV vaccination catch-up among young adults. With low rates of HPV vaccination among young adults, there is a need to understand which areas of SDOH are associated with HPV vaccination to target specific social factors for allocation of resources for research and intervention. A SDOH approach indicates which groups to prioritize vaccine uptake efforts and illuminate areas of need. The purpose of this study was to utilize the Healthy People 2020 SDOH Framework to assess HPV vaccination and SDOH among young adult women and men using the 2016 National Health Interview Survey.

## Materials and Methods

### Overview

The National Center for Health Statistics (NCHS), National Health Interview Survey (NHIS) is an annual survey to assess the health, on a broad range of topic areas, among noninstitutionalized, civilian adults in the United States [19]. Cross-sectional household interview surveys were conducted using a multistage area probability design. The sampling procedures consider the US population distribution based on census data, and also oversampled Black, Hispanic, and Asian persons. Data were collected with in-person interviews using computer-assisted personal interviewing. Details on the sample procedures have been described by NCHS [21]. The analysis for this study was considered exempt by the Institutional Review Board.

### Study Sample

This study utilized the National Health Interview Survey 2016, and utilized the sample adult from the survey, a randomly selected adult per household interviewed. In the publicly available NHIS dataset, 33,028 adults were included. The conditional response rate was 80.9% [21]. For this analysis, the sample was restricted to 18–26 year old adults, due to the age range for HPV vaccination in the United States. Persons with missing or refused data for responses included in this analysis were removed. Overall, there were 1714 men and 1879 women in the sample.

### Measures

The outcome for this analysis was *HPV vaccination*. Participants were asked, "Have you ever received an HPV shot or vaccine?" and responded yes, no, doctor refused when asked, and refused. This variable was self-reported and operationalized as Yes and No (no, doctor refused, and refused).

SDOH variables were identified in the NHIS dataset as eligible predictor variables for analysis. These variables were classified based on the five SDOH categories, with the exception of neighborhood and built environment [35]. Proxy measures were selected for Healthy People 2020 SDOH Framework key areas based on availability of measures in the NHIS dataset. Due to the secondary nature of the study, not all key areas of the framework are represented in analyses.

For *economic stability*, two variables were selected. Income, or total earnings last year, was based on a person's estimate of their earnings for the last year. Due to the amount of missing responses for this variable, NCHS produces imputed data [20]. The earnings were then categorized as: less than or equal to $5000, between $5001 and $14,000, between $14,001 and $28,000, and greater than $28,000. These categorizes were selected based on the quartiles for the data. Employment was the second economic stability variable. This was measured as the person's work status in the last year, and was also imputed for missing values [20]. This was coded as either had a job, or did not have a job.

For *education*, this included two variables for higher education and language. Participants reported their highest level of education at the time of the survey. This was operationalized as less than a high school degree, high school graduate or GED, and some college or college degree. Next, participants reported how well they spoke English on a scale of very well to not at all. This was operationalized as very well, and well, not well, not at all.

For *social and community context*, four variables were included. Participants responded to the following stems: (1) people in the neighborhood help each other, (2) people I count on in the neighborhood, (3) people in neighborhood can be trusted, and (4) close-knit neighborhood. Response options included definitely agree, somewhat agree, somewhat disagree, and definitely disagree.

For *health and healthcare*, four variables were included. Insurance coverage was operationalized as insured, and not insured/don't know. Participants also responded to if they had a place they usually go to when sick or need health advice, which was measured as yes, there is no place, and there is more than one place. This was then operationalized as yes (yes, and more than one place) or no. Participants reported the time since last seen a healthcare provider, which was operationalized as less than 6 months ago, between 6 and 12 months ago, and more than a year ago. Finally, a measure of health literacy was derived from the question, looked up health information on Internet in the past 12 months, which was categorized as yes or no. Health literacy represents how people find, understand, evaluate, and use information; thus, information-seeking using a web-based source falls under this definition.

### Analysis

All analyses utilized survey-weighting procedures in SAS software Version 9.4 using domain analyses, to account for the sub-population analysis, and survey-weighting, to account for the complex sample. Additionally, stratified analyses were conducted based on sex due to the differences in the HPV vaccine recommendation timeline in the United States [23]. First, survey-weighted percentages for each SDOH variable by HPV vaccination status were estimated, with corresponding Rao-Scott chi square tests. Next, survey-weighted crude odds ratios for each SDOH modeling HPV vaccination were estimated. Note, that multiple imputation procedures (n = 5) were used for the employment and income variables. If a SDOH variable was statistically significant for at least one level of the predicator variable, then the SDOH variable was included in the final model for each sex stratification, respectively. For men, income, employment, place of usual care, time since seen healthcare provider, and looked up health information were included in the final model. For women, education, language, trusted people in neighborhood, insurance coverage, time since seen healthcare provider, and looked up health information were included in the final model. The adjusted models also controlled for sexual orientation, region, race/ethnicity, and age. Survey-weighted adjusted odds ratios and 95% confidence intervals modeling HPV vaccination for each sex were estimated. A p-value less than 0.05 was considered statistically significant for this analysis.

## Results

The NHIS sample adults, ages 18–26 years in this analysis included 1714 men and 1879 women. Among men, 14.5% were vaccinated for HPV (Table 2). Among women, 45.7% were HPV vaccinated. The mean age of the sample was approximately 22 years for both men and women. More than half the sample identified as Non-Hispanic White, followed by Hispanic, Black, Asian, and Other. A majority identified their sexual orientation as heterosexual (94% of men and 91% of women). Approximately one-third of respondents were from the South in the US, followed by about a quarter in the West and Midwest, respectively.

### Social Determinants of Health Among Men

In the unadjusted models, economic (income, employment) and health and healthcare (usual place for care, time since seen healthcare provider, health literacy) factors were significantly associated with HPV vaccination among men (Table 3). Education and social and community factors were not significantly associated with HPV vaccination among men. Specifically, for economic factors, men with lower incomes (< $14,000) had higher odds of vaccination compared to men with incomes greater than $28,000. In contrast,

**Table 2** Demographic characteristics frequencies and survey-weighted percentages of sample of young adults (ages 18–26 years) from National Health Interview Survey, 2016

| | Men (n = 1714) | Women (n = 1879) |
|---|---|---|
| Age (mean, SE) | 21.98 (0.09) | 21.91 (0.08) |
| Race/ethnicity | | |
| Hispanic | 281 (21.6%) | 296 (19.9%) |
| Non-Hispanic, White | 1119 (58.6%) | 1148 (57.8%) |
| Non-Hispanic, Black | 162 (13.8%) | 294 (16.0%) |
| Non-Hispanic, Asian | 113 (4.8%) | 106 (5.0%) |
| Non-Hispanic, Other | 39 (1.2%) | 35 (1.2%) |
| Region | | |
| Northeast | 264 (16.0%) | 268 (15.1%) |
| Midwest | 406 (22.6%) | 426 (23.9%) |
| South | 560 (36.4%) | 654 (35.1%) |
| West | 484 (25.1%) | 531 (25.9%) |
| Sexual orientation | | |
| Heterosexual | 616 (93.9%) | 1708 (91.2%) |
| Gay/lesbian | 39 (2.0%) | 32 (2.0%) |
| Bisexual | 29 (1.8%) | 91 (4.1%) |
| Other | 30 (2.3%) | 48 (2.8%) |
| HPV vaccination | | |
| Yes | 288 (14.5%) | 873 (45.7%) |
| No | 1426 (85.5%) | 1006 (54.3%) |

**Table 3** Survey-weighted proportions and odds ratios for HPV vaccination among men 18–26 years—National Health Interview Survey 2016. Data from NCHS, National Health Interview Survey

| Variable | Vaccinated | | Unvaccinated | | Crude odds ratio | Adjusted odds ratio[b] |
|---|---|---|---|---|---|---|
| | N | %[a] | N | %[a] | | |
| HPV vaccination | 288 | 14.52% | 1426 | 85.48% | | |
| SDOH 1: income last year[c] | % | SE | % | SE | | |
| ≤$5000 | 54.06 | 4.30 | 36.72 | 1.78 | **1.72 (1.31, 2.25)** | 1.06 (0.74, 1.52) |
| $5001–$14,000 | 20.67 | 3.54 | 16.11 | 1.47 | **1.50 (1.04, 2.15)** | 1.40 (0.94, 2.09) |
| $14,001–$28,000 | 11.76 | 2.29 | 22.10 | 1.82 | **0.62 (0.42, 0.92)** | 0.81 (0.52, 1.24) |
| $28,000+ | 13.51 | 3.03 | 25.06 | 1.87 | (Referent) | (Referent) |
| SDOH 2: employment[c] | | | | | | |
| Had a job | 66.86 | 4.55 | 78.67 | 1.52 | (Referent) | (Referent) |
| Did not have a job | 33.14 | 4.55 | 21.33 | 1.52 | **1.35 (1.08, 1.69)** | 1.13 (0.85, 1.49) |
| SDOH 3: highest level of education | | | | | | |
| Less than high school | 15.85 | 3.40 | 11.67 | 1.14 | 1.46 (0.82, 2.59) | |
| High school or GED | 28.14 | 3.80 | 28.40 | 1.64 | 1.06 (0.70, 1.62) | |
| Some college or degree | 56.01 | 4.54 | 59.94 | 2.00 | (Referent) | |
| SDOH 4: how well spoke English | | | | | | |
| Very well | 97.02 | 1.27 | 93.35 | 1.02 | 2.32 (0.92, 5.89) | |
| Well, not well, not at all | 2.98 | 1.27 | 6.65 | 1.02 | (Referent) | |
| SDOH 5: people in neighborhood help each other | | | | | | |
| Definitely agree | 36.03 | 3.65 | 28.80 | 1.58 | (Referent) | |
| Somewhat agree | 47.10 | 4.12 | 51.63 | 1.97 | 0.73 (0.51, 1.05) | |
| Somewhat disagree | 10.89 | 2.69 | 12.62 | 1.45 | 0.69 (0.38, 1.25) | |
| Definitely disagree | 5.99 | 2.01 | 6.96 | 0.96 | 0.69 (0.31, 1.55) | |
| SDOH 6: people I count on in neighborhood | | | | | | |
| Definitely agree | 47.28 | 4.33 | 39.08 | 1.89 | (Referent) | |
| Somewhat agree | 34.60 | 3.94 | 40.07 | 1.92 | 0.71 (0.48, 1.07) | |
| Somewhat disagree | 8.94 | 1.87 | 11.92 | 1.22 | 0.62 (0.37, 1.06) | |
| Definitely disagree | 9.18 | 2.68 | 8.94 | 1.10 | 0.85 (0.40, 1.79) | |
| SDOH 7: people in neighborhood can be trusted | | | | | | |
| Definitely agree | 41.96 | 3.94 | 33.67 | 1.86 | (Referent) | |
| Somewhat agree | 41.39 | 3.91 | 44.12 | 1.90 | 0.75 (0.53, 1.08) | |
| Somewhat disagree | 8.90 | 2.17 | 13.15 | 1.57 | 0.54 (0.29, 1.00) | |
| Definitely disagree | 7.75 | 2.67 | 9.06 | 1.19 | 0.69 (0.30, 1.55) | |
| SDOH 8: close-knit neighborhood | | | | | | |
| Definitely agree | 25.97 | 3.49 | 22.70 | 1.56 | (Referent) | |
| Somewhat agree | 36.64 | 3.79 | 35.79 | 1.66 | 0.90 (0.57, 1.40) | |
| Somewhat disagree | 21.33 | 3.30 | 26.20 | 1.63 | 0.71 (0.43, 1.17) | |
| Definitely disagree | 16.05 | 3.11 | 15.32 | 1.36 | 0.92 (0.51, 1.63) | |
| SDOH 9: insurance coverage in US | | | | | | |
| Insured | 87.95 | 3.54 | 85.50 | 1.18 | 1.24 (0.63, 2.44) | |
| Not insured/don't know | 12.05 | 3.54 | 14.50 | 1.18 | (Referent) | |
| SDOH 10: place for usual health care | | | | | | |
| Yes | 80.12 | 3.05 | 72.25 | 1.90 | (Referent) | (Referent) |
| No | 19.88 | 3.05 | 27.75 | 1.90 | **0.65 (0.43, 0.98)** | 0.87 (0.71, 1.08) |
| SDOH 11: time since last seen healthcare provider | | | | | | |
| Less than 6 months ago | 57.30 | 3.94 | 45.65 | 2.28 | **2.24 (1.36, 3.67)** | 1.09 (0.85, 1.41) |
| Between 6 and 12 months ago | 24.87 | 3.62 | 22.58 | 1.72 | **1.96 (1.11, 3.48)** | 1.21 (0.89, 1.64) |
| More than a year ago or never | 17.83 | 3.29 | 31.77 | 1.90 | (Referent) | (Referent) |
| SDOH 12: looked up health information on internet, past 12 months | | | | | | |
| Yes | 64.35 | 3.93 | 47.62 | 1.95 | (Referent) | (Referent) |
| No | 35.65 | 3.93 | 52.38 | 1.95 | **0.50 (0.35, 0.72)** | **0.65 (0.54, 0.79)** |

Bold values indicate statistical significance

[a]Survey-weighted

[b]Adjusted for other variables in column, sexual orientation, region, race/ethnicity, and age

[c]Derived from multiple imputation (n = 5)

men with incomes of $14,001–$28,000 were less odds to be vaccinated than men with income greater than $28,000. Men who did not have a job were at higher odds to be vaccinated compared to men with a job (OR 1.35, 95% CI 1.08, 1.69). As for health and healthcare, men who did not have a place for usual healthcare were at lower odds to be vaccinated for HPV. Men who have seen a healthcare provider in the last year, and men who have used the Internet to look up health information were more likely to be vaccinated.

In the adjusted model, the effects for income, employment, place of usual care, and time since seen a healthcare provider were attenuated and no longer statistically significant. The adjusted model controlled for sexual orientation, region, race/ethnicity, and age. Men who did not use the Internet to look up health information were at lower odds to be vaccinated for HPV, while controlling for other variables (aOR 0.65, 95% CI 0.54, 0.79).

### Social Determinants of Health Among Women

In the unadjusted models, education (highest level of education completed, English language), social and community (people in neighborhood to trust), and health and healthcare (insurance coverage, time since seen healthcare provider, health literacy) factors were significantly associated with HPV vaccination among women (Table 4). Economic factors were not significantly associated with HPV vaccination. Specifically, for education factors, women who completed up to a high school degree were at lower odds to be vaccinated compared to women who had some college or a college degree. Women who spoke English very well were more than three times the odds to be vaccinated compared to women who did not speak English very well (OR 4.86, 95% CI 2.49, 9.51). For social and community context, persons who definitely disagreed with the statement, people in the neighborhood I can trust, were at lower odds to be vaccinated compared to people who definitely agreed. For health and healthcare, women who were insured and women who have seen a healthcare provider in the last 6 months (compared to women who have not seen a provider in more than a year) were at higher odds to be vaccinated. Women who did not look up health information in the last year on the internet were at lower odds to be vaccinated (OR 0.55, 95% CI 0.41, 0.73).

In the adjusted model, education (highest level of education completed, English language), and health and healthcare (health literacy) factors were significantly associated with HPV vaccination among women. The adjusted model controlled for sexual orientation, region, race/ethnicity, and age. Other healthcare factors were no longer statistically significant with adjustment for other factors. Women who completed up to a high school degree were at lower odds to be vaccinated compared to women who had some college or a college degree. Women who spoke English very well were at three times the odds to be vaccinated compared to women who did not speak English very well (aOR 3.44, 95% CI 1.64, 7.22). Women who did not look up health information in the last year on the Internet were at lower odds to be vaccinated (aOR 0.66, 95% CI 0.49, 0.90).

## Discussion

Given the public health importance of reducing HPV and HPV-associated diseases, understanding factors that contribute to HPV vaccine uptake is critical. While previous research has examined individual- and social-level predictors of HPV vaccine uptake, this study utilized a SDOH Framework to assess which factors are associated with HPV vaccination among young adult women and men in the United States. In this assessment of SDOH and HPV vaccination, we found variation in significant determinants by sex. For women, education and language were significantly associated with HPV vaccination. For both sexes, searching for health information on the Internet was significantly associated with HPV vaccination.

This study utilized the Healthy People 2020 SDOH Framework. However, it should be acknowledged that proxy measures were not available for all areas of the framework. The five areas of the framework and expanded key areas (Table 1) were the basis for the study. In economic stability, income and employment were measured, but no variables assessed food or housing instability. For the area of education, higher education and language were measured, but not early childhood education and development or literacy. In social and community context four items assessed one key area of social cohesion, but civic participation, discrimination, and incarceration were not measured. Only health and healthcare assessed all key areas, with measures for insurance coverage, primary care, and health literacy. No variables assessed any key areas of neighborhood and built environment. The lack of variables available using secondary data indicate a need for a comprehensive range of SDOH to be measured in large, public datasets in addition to demographic data.

Among women, language was a strong determinant associated with HPV vaccine uptake, specifically, women who reported speaking English very well were more likely to be vaccinated. This may be attributed to HPV vaccine interventions and awareness campaigns focused on English speaking populations. Additionally, there is evidence that parents from different ethnic groups encounter different vaccination barriers and require intervention strategies tailored to these barriers [11, 38]. As a result, more vulnerable populations where English is not the primary language may be less likely to receive the HPV vaccine. Previous research found that

**Table 4** Survey-weighted proportions and odds ratios for HPV vaccination among women 18–26 years—National Health Interview Survey 2016. Data from NCHS, National Health Interview Survey 2016

| Variable | Vaccinated | | Unvaccinated | | Crude odds ratio | Adjusted odds ratio[b] |
|---|---|---|---|---|---|---|
| | N | %[a] | N | %[a] | | |
| HPV vaccination | 873 | 45.75% | 1006 | 54.25% | | |
| SDOH 1: income last year[c] | % | SE | % | SE | | |
| ≤$5000 | 44.14 | 2.32 | 47.63 | 2.52 | 0.90 (0.73, 1.11) | |
| $5001–$14,000 | 22.02 | 2.00 | 18.72 | 1.81 | 1.14 (0.88, 1.48) | |
| $14,001–$28,000 | 18.46 | 2.04 | 19.55 | 1.94 | 0.92 (0.70, 1.20) | |
| $28,000+ | 15.38 | 1.75 | 14.11 | 1.61 | (Referent) | |
| SDOH 2: employment[c] | | | | | | |
| Had a job | 75.18 | 2.21 | 69.59 | 2.24 | (Referent) | |
| Did not have a job | 24.82 | 2.21 | 30.41 | 2.24 | 0.87 (0.75, 1.01) | |
| SDOH 3: highest level of education | | | | | | |
| Less than high school | 6.50 | 1.31 | 12.75 | 1.60 | **0.40 (0.24, 0.67)** | **0.46 (0.26, 0.79)** |
| High school or GED | 21.74 | 2.13 | 31.44 | 2.16 | **0.54 (0.40, 0.73)** | **0.62 (0.45, 0.85)** |
| Some college or degree | 71.75 | 2.27 | 55.81 | 2.41 | (Referent) | (Referent) |
| SDOH 4: how well spoke english | | | | | | |
| Very well | 98.19 | 0.50 | 91.78 | 1.34 | **4.86 (2.49, 9.51)** | **3.44 (1.64, 7.22)** |
| Well, not well, not at all | 1.81 | 0.50 | 8.22 | 1.34 | (Referent) | (Referent) |
| SDOH 5: people in neighborhood help each other | | | | | | |
| Definitely agree | 33.50 | 2.29 | 30.36 | 1.95 | (Referent) | |
| Somewhat agree | 44.82 | 2.34 | 46.28 | 2.12 | 0.88 (0.66, 1.17) | |
| Somewhat disagree | 12.89 | 1.59 | 14.71 | 1.51 | 0.79 (0.52, 1.22) | |
| Definitely disagree | 8.79 | 1.28 | 8.65 | 1.25 | 0.92 (0.58, 1.47) | |
| SDOH 6: people I count on in neighborhood | | | | | | |
| Definitely agree | 44.02 | 2.34 | 39.62 | 2.14 | (Referent) | |
| Somewhat agree | 33.06 | 2.09 | 33.80 | 1.99 | 0.88 (0.67, 1.15) | |
| Somewhat disagree | 14.03 | 1.71 | 14.35 | 1.90 | 0.88 (0.57, 1.36) | |
| Definitely disagree | 8.89 | 1.28 | 12.23 | 1.38 | 0.65 (0.42, 1.02) | |
| SDOH 7: people in neighborhood can be trusted | | | | | | |
| Definitely agree | 39.18 | 2.39 | 34.08 | 2.04 | (Referent) | (Referent) |
| Somewhat agree | 38.96 | 2.23 | 40.37 | 2.20 | 0.84 (0.63, 1.12) | 0.93 (0.69, 1.25) |
| Somewhat disagree | 12.65 | 1.59 | 12.85 | 1.42 | 0.86 (0.57, 1.28) | 0.91 (0.60, 1.39) |
| Definitely disagree | 9.22 | 1.33 | 12.70 | 1.52 | **0.63 (0.41, 0.98)** | 0.89 (0.55, 1.42) |
| SDOH 8: close-knit neighborhood | | | | | | |
| Definitely agree | 26.28 | 2.22 | 23.89 | 1.80 | (Referent) | |
| Somewhat agree | 32.92 | 2.24 | 34.59 | 2.04 | 0.87 (0.62, 1.21) | |
| Somewhat disagree | 22.75 | 1.86 | 25.66 | 1.86 | 0.81 (0.57, 1.15) | |
| Definitely disagree | 18.06 | 1.68 | 15.85 | 1.81 | 1.04 (0.68, 1.57) | |
| SDOH 9: insurance coverage in US | | | | | | |
| Insured | 92.32 | 1.23 | 87.41 | 1.45 | **1.73 (1.15, 2.61)** | 1.25 (0.82, 1.91) |
| Not insured/don't know | 7.68 | 1.23 | 12.59 | 1.45 | (Referent) | (Referent) |
| SDOH 10: place for usual health care | | | | | | |
| Yes | 83.48 | 1.80 | 80.54 | 1.70 | (Referent) | |
| No | 16.52 | 1.80 | 19.46 | 1.70 | 0.82 (0.59, 1.14) | |
| SDOH 11: time since last seen healthcare provider | | | | | | |
| Less than 6 months ago | 72.59 | 2.17 | 64.10 | 2.08 | **1.49 (1.03, 2.15)** | 1.21 (0.83, 1.75) |
| Between 6 and 12 months ago | 15.97 | 1.78 | 20.90 | 1.95 | 1.00 (0.63, 1.60) | 0.85 (0.54, 1.34) |
| More than a year ago or never | 11.44 | 1.61 | 15.01 | 1.36 | (Referent) | (Referent) |
| SDOH 12: looked up health information on internet, past 12 months | | | | | | |
| Yes | 69.25 | 2.38 | 55.20 | 2.24 | (Referent) | (Referent) |
| No | 30.75 | 2.38 | 44.80 | 2.24 | **0.55 (0.41, 0.73)** | **0.66 (0.49, 0.90)** |

Bold values indicate statistical significance

[a]Survey-weighted

[b]Adjusted for other variables in column, sexual orientation, region, race/ethnicity, and age

[c]Derived from multiple imputation (n = 5)

while vaccine uptake did not differ by parents' preferred language among adolescent girls, intent for vaccination was higher among Spanish-speaking parents. Yet, these same parents were more likely to report they did not receive a provider recommendation for the vaccine [27]. Given that speaking English was one of the strongest factors for HPV vaccine uptake among women in this study, tailoring existing HPV vaccine interventions to non-English speaking populations is warranted.

Women with lower educational attainment were also less likely to receive the HPV vaccine compared to women with at least some college. This may be attributed to differentials in knowledge about the vaccine, but also differences in access to services, such as health resources in college settings. Previous research found that primary reasons for non-vaccination among young adult women in the United States included report of not needing the vaccine and not knowing enough about the vaccine [29]. Other research has also identified HPV vaccine awareness and uptake being lower among women with lower educational attainment [8, 26]. While much of the population appears to have heard of HPV, various studies show a smaller proportion of participants understood the consequences of HPV, knew there was a vaccine to prevent the disease and had not received a recommendation from a healthcare provider to receive the vaccine [2, 8, 25]. To counter these deficiencies in knowledge and increase vaccination rates in underserved populations, interventions must provide information regarding the health consequences of HPV, HPV vaccine and prevention, coupled with strong and consistent healthcare provider recommendations.

For men and women, information-seeking on the Internet was significantly associated with HPV vaccination. This finding is consistent with research reporting the effects on health information seeking behavior and HPV vaccination knowledge and intentions [22]. However, evidence in current literature shows higher education level is strongly associated with information-seeking on Internet and often information located on the Internet is not adequate for low literacy populations with high reading levels and complex information [5]. Also, there is research highlighting disparities for those with lower income and educational level do not use the Internet as a first source for health information [14]. Our results add to the literature regarding communication inequalities with a heavy focus on Internet direct to consumer advertising as the main source of vaccine information leading to disparities in HPV knowledge and vaccination rates [15]. Solutions to this widening gap include establishing and ensuring access to digital literacy centers [6], as well as developing and implementing off-line strategies to provide information such as patient-provider communication [15].

One interesting finding is that access to usual care and insurance coverage were not associated with HPV vaccination. Previous research has demonstrated that healthcare provider recommendation is one of the strongest predictors of HPV vaccine uptake [9]. Additionally, women without a regular healthcare provider or no recent visit to a healthcare provider were less likely to be vaccinated [40]. While this was not a key social determinant for HPV vaccination in this study, expanding access to other types of providers or health venues, such as pharmacies or dental offices, may help promote HPV vaccination [30].

In this study, use of the Healthy People 2020 SDOH framework allowed the analysis of areas as broad as education, economic stability, health and healthcare, and social and community context to be analyzed concurrently to move forward research and interventions targeted to specific areas of need. Results of this study allow a pathway for researchers to consider the most prudent ways to initiate research in areas that may further alleviate low vaccine uptake including information-seeking on the Internet, and women with lower educational attainment or those for whom English is not a primary language.

These findings should be considered in the context of limitations. First, this was a cross-sectional study, and temporality between the SDOH and vaccine uptake cannot be established. This study was also limited in the social determinants variables available in this dataset. While this dataset has more variables related to SDOH compared to other national datasets [16], there were no variables available on neighborhood and built environment. One limitation with these measures is the use of personal income for young adults, since these persons may still rely on familial support for income. Finally, data were self-reported for HPV vaccination status and SDOH indicators. Persons who received the HPV vaccine as an adolescent may have more difficulty recalling their vaccination status.

## Conclusions

Identifying these significant social determinants for HPV vaccination among young men and women, including education and health and health care factors, may contribute to interventions aimed at promoting health equity in the prevention of HPV and HPV-associated disease. This study is based on nationally representative data, making it generalizable to the U.S. population of young adults. In addition, the study uses a SDOH framework to identify vulnerable populations for HPV vaccination among young adults. This framework-based approach indicates prioritized areas of barriers to vaccine uptake and has the potential to drive future intervention research to increase young adult HPV vaccine catch-up.

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## Compliance with Ethical Standards

**Conflict of interest** The authors have no conflict of interest to disclose.

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