RESEARCH PAPER

Nativity status and genital HPV infection among adults in the U.S.

Manami Bhattacharya^a, Paul L. Reiter^{b,c}, and Annie-Laurie McRee^{id}

^aDivision of Health Policy and Management, School of Public Health, University of Minnesota, Minneapolis, MN, USA; ^bDivision of Health Behavior and Health Promotion, College of Public Health, The Ohio State University, Columbus, OH, USA; ^cComprehensive Cancer Center, The Ohio State University, Columbus, OH, USA; ^dDivision of General Pediatrics and Adolescent Health, University of Minnesota Medical School, Minneapolis, MN, USA

ABSTRACT

Over 43 million immigrants live in the United States (U.S.). Foreign-born populations experience multiple disparities related to human papillomavirus (HPV), including higher cervical cancer mortality rates, yet little research has examined the prevalence of genital HPV infection among this population. We used data from 1,822 women and 1,622 men ages 20–59 in the U.S. who participated in the 2013–2014 National Health and Nutrition Examination Survey (NHANES). Participants reported their nativity status (foreign- vs. U.S.-born) and provided biospecimens for HPV testing. We assessed nativity differences in the prevalence of three HPV infection outcomes (any HPV type, high-risk HPV type, and vaccine-preventable HPV type) using weighted logistic regression. Overall, 40% of women and 46% of men tested positive for any type of HPV. Compared to women born in the U.S., foreign-born women had a lower prevalence of infection with any HPV type (32% vs. 42%, $p < .01$). Compared to men born in the U.S., foreign-born men had a lower prevalence of all HPV infection outcomes (any type: 39% vs. 48%; high-risk: 22% vs. 34%; vaccine-preventable: 12% vs. 16%; all $p < .05$). Multivariable models attenuated several of these differences, though foreign-born men had lower odds of infection with a high-risk HPV type (OR = 0.75; 95% CI: 0.60–0.93, $p < .01$) after adjusting for covariates. Although lower than among their U.S.-born counterparts, HPV infection is prevalent among foreign-born women and men in the U.S. Findings can help inform strategic communication campaigns and targeted HPV vaccination and cervical cancer screening efforts for immigrant populations.

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Introduction

In the United States (U.S.) alone, human papillomavirus (HPV) causes almost 34,000 new cases of cancer per year,¹ of which a disproportionate burden are experienced by racial and ethnic minority populations.² Worldwide, there are 528,000 new cases of cancer and over 266,000 deaths per year associated with HPV.³ In the U.S., primary and secondary prevention strategies are recommended to help prevent HPV-related disease. HPV vaccination (primary prevention) is currently recommended for all females and males ages 11–12 with catch up through age 26 and, with widespread coverage, has the potential to prevent most cases of cervical and anal cancer as well as many cases of vaginal, vulvar, penile, oropharyngeal and other cancers.^{4,5} In fall 2018, HPV vaccine was also approved for use through age 45,⁶ but there have been no recommendations for administration to date. Current cervical cancer screening guidelines (secondary prevention) recommend women ages 21–29 receive a Pap test every 3 years, and women ages 30–65 receive either a Pap test every 3 years or testing for high-risk HPV every 5 years, alone or in combination with Pap testing (“co-testing”).

Approximately 1 in 7 people living in the U.S. – over 43 million – are born in other countries,⁷ many of whom emigrated from Latin America and Asia,⁷ where the burden of cervical cancer is high. Compared to women born in

the U.S., foreign-born women have lower levels of HPV vaccination^{8,9} and cervical cancer screening.^{10–12} They have also been found to experience later stage diagnosis of cervical cancers,¹³ greater cervical cancer mortality,^{14–16} and some groups such as Korean-American women and Latina women have a higher incidence of cervical cancer.^{17,18} Less is known about HPV-related nativity disparities among men, though research suggests some foreign-born men may have poorer knowledge of HPV infection¹⁹ and lower HPV vaccination coverage⁸ than their U.S.-born counterparts.

Despite these disparities, the burden of infection for HPV in foreign-born populations in the U.S. is unknown. We sought to assess the prevalence of genital HPV infection by nativity status among a population-based sample in the U.S. using data from the National Health and Nutrition Examination Survey (NHANES). Findings provide valuable data that can inform HPV-related cancer prevention efforts, especially vaccination and screening programs.

Results

Participant characteristics

Approximately 29% of participants reported being foreign-born (Table 1) and about half (48%) were male. Participants’

average age was 39 years. The majority of participants were married (62%), had more than a high school degree (65%), and had never smoked (59%). Among those aged 35 and younger in the overall sample, 16% (27% of women, <1% of men) reported having received at least one dose of the HPV vaccination series (i.e., series initiation). Foreign-born participants differed from those who were born in the U.S. on all examined demographic and health-related characteristics except for sex ($p < .05$).

HPV infection

Women

Among all women, the prevalence of any HPV type was 40%. About one-quarter (26%) of all women were infected with a high-risk HPV type, and about 12% were infected with

a vaccine-preventable HPV type. In bivariate analyses, the prevalence of any HPV infection was lower among women who were foreign-born compared to those who were born in the U.S. (32% vs. 42%, $p < .05$) (Figure 1(a)). The prevalence of infection with a high-risk or a vaccine-preventable HPV type did not differ by nativity among women (both $p > .05$).

Multivariable analyses attenuated the observed nativity difference in infection with any HPV type (OR = 0.76; 95% CI: 0.53–1.08) (Table 2). There were also no differences by nativity for infection with a high-risk HPV type or a vaccine-preventable HPV type in multivariable analyses. Correlates were similar across outcomes. Women who were older or who reported never having had sex had lower odds of all HPV infection outcomes, while those who were married or living with a partner, current smokers, or who had a greater number of lifetime sexual partners had greater odds.

Table 1. Participant characteristics.

	Overall (n= 3444)		U.S.-born (n= 2441)		Foreign-born (n= 1003)		P
	n	(%)	n	(%)	n	(%)	
Nativity status							–
U.S.-born	2441	(70.9)	–	–	–	–	
Foreign-born	1003	(29.1)	–	–	–	–	
Demographic Characteristics							
Sex							0.26
Male	1622	(48.0)	1165	(48.4)	457	(46.5)	
Female	1822	(52.0)	1276	(51.6)	546	(53.5)	
Age (years)							<.001
20–29	838	(25.3)	677	(26.9)	161	(18.4)	
30–39	883	(24.1)	603	(22.5)	280	(31.0)	
40–49	892	(25.3)	572	(24.2)	320	(30.5)	
50–59	831	(25.3)	589	(26.5)	242	(20.1)	
Race/ethnicity							<.001
Non-Hispanic white	1398	(62.1)	1343	(73.5)	55	(12.7)	
Non-Hispanic black	702	(12.3)	621	(13.5)	81	(7.2)	
Hispanic	805	(17.2)	320	(9.0)	485	(52.9)	
Other	539	(8.4)	157	(4.0)	382	(27.3)	
Relationship/marital status							<.001
Not married	1388	(37.7)	1132	(40.5)	256	(25.8)	
Married/living with a partner	2055	(62.3)	1308	(59.6)	747	(74.2)	
Education							<.001
Less than a high school degree	648	(14.3)	356	(10.9)	292	(29.2)	
High school degree	750	(21.2)	557	(21.6)	193	(19.6)	
More than a high school degree	2045	(64.5)	1527	(67.6)	518	(51.2)	
Income							<.001
Below FPL ^a	790	(16.8)	584	(15.9)	206	(20.5)	
100–250% FPL	986	(25.9)	689	(24.8)	297	(30.6)	
Above 250% FPL	1413	(50.8)	1017	(53.5)	396	(39.0)	
Refused/Missing	255	(6.6)	151	(5.8)	104	(10.0)	
Health Characteristics							
Smoking status							<.001
Never smoker	2035	(58.8)	1309	(55.7)	726	(71.8)	
Former smoker	573	(15.2)	409	(18.6)	164	(16.3)	
Current smoker	836	(23.1)	723	(25.7)	113	(11.9)	
Total number of sexual partners (lifetime)							<.001
5 or fewer	1432	(42.2)	897	(39.6)	535	(53.6)	
6 or more	1556	(47.3)	1294	(51.6)	262	(28.3)	
Never had sex	101	(2.5)	58	(2.1)	43	(4.3)	
Missing/Refused	355	(8.0)	192	(6.7)	163	(13.8)	
HPV Vaccination Series Initiation ^b							0.02
Started series	209	(16.3)	187	(18.1)	22	(6.7)	
Did not start series	1063	(76.8)	798	(75.1)	265	(86.0)	
Missing	92	(6.9)	71	(6.8)	21	(7.3)	

Note. HPV, human papillomavirus

Table shows raw frequencies and weighted percentages. Percentages may not total 100 due to rounding. *P*-values represent results of chi-square analyses. Dashes (–) indicate not applicable.

^a Federal Poverty Level (U.S.)

^b Vaccination initiation was calculated for those 35 and under

Table 2. HPV infection among women in the U.S., by nativity status.

	Any HPV type		High-risk HPV type		Vaccine-preventable HPV type	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Nativity status						
U.S.-born	ref		ref		ref	
Foreign-born	0.76	(0.53–1.08)	0.82	(0.55–1.22)	0.75	(0.41–1.38)
Demographic Characteristics						
Age (years)						
20–29	ref		ref		ref	
30–39	0.67	(0.45–1.01)*	0.60	(0.39–0.93)*	0.63	(0.39–1.01)*
40–49	0.64	(0.45–0.91)*	0.50	(0.34–0.73)*	0.46	(0.23–0.92)*
50–59	0.51	(0.34–0.74)*	0.38	(0.27–0.54)*	0.39	(0.25–0.63)*
Race/ethnicity						
Non-Hispanic white	ref		ref		ref	
Non-Hispanic black	2.22	(1.53–3.22)*	1.59	(1.06–2.38)*	1.43	(0.75–2.72)
Hispanic	1.49	(0.91–2.43)	1.45	(0.84–2.50)	1.69	(0.97–2.94)**
Other	1.21	(0.84–1.74)	1.18	(0.79–1.75)	1.45	(0.65–3.23)
Relationship/marital status						
Not married	ref		ref		ref	
Married/living with a partner	2.57	(2.12–3.11)*	1.93	(1.46–2.54)*	1.66	(1.26–2.18)*
Education						
Less than a high school degree	ref		ref		ref	
High school degree	1.12	(0.77–1.65)	1.30	(0.75–2.27)	1.50	(0.90–2.51)
More than a high school degree	0.92	(0.61–1.38)	0.79	(0.47–1.32)	0.77	(0.48–1.24)
Income						
Below FPL ^a	ref		ref		ref	
100–250% FPL	1.00	(0.71–1.41)	1.09	(0.69–1.74)	1.16	(0.71–1.89)
Above 250% FPL	0.75	(0.52–1.08)	0.84	(0.54–1.30)	0.98	(0.59–1.62)
Refused/Missing	0.95	(0.54–1.66)	0.98	(0.57–1.69)	0.84	(0.40–1.75)
Health Characteristics						
Smoking status						
Never smoker	ref		ref		ref	
Former smoker	0.92	(0.58–1.46)	1.04	(0.64–1.68)	1.33	(0.63–2.80)
Current smoker	1.51	(0.92–2.50)**	1.44	(0.93–2.24)**	2.23	(1.44–3.45)*
Total number of sexual partners (lifetime)						
5 or fewer	ref		ref		ref	
6 or more	2.43	(1.80–3.29)*	2.45	(1.69–3.54)*	1.89	(1.09–3.27)*
Never had sex	0.13	(0.05–0.34)*	0.25	(0.09–0.69)*	0.21	(0.06–0.70)*
Missing/Refused	1.77	(1.29–2.42)*	1.60	(1.26–2.02)*	2.08	(1.04–4.16)*

Note. CI, confidence interval; HPV, human papillomavirus; OR, odds ratio; ref, referent group

Tables presents results from multivariable logistic regression analyses including all variables shown.

^a Federal Poverty Level (U.S.)

* $p < .05$

** $p < .01$

Compared to non-Hispanic white women, non-Hispanic black women had greater odds of infection with any HPV type or with a high-risk HPV type.

Men

Among all men, the prevalence of any HPV type was 46%. About one-third (31%) of all men were infected with a high-risk HPV type, and about 15% were infected with a vaccine-preventable HPV type. In bivariate analyses, the prevalence of all HPV infection outcomes was significantly lower among men who were foreign-born compared to those who were born in the U.S. (any HPV: 39% vs. 48%, $p < .05$; high-risk HPV: 22% vs. 34%, $p < .001$; vaccine-preventable HPV: 12% vs. 16%, $p < .05$) (Figure 1(b)).

In multivariable models, foreign-born men had lower odds of high-risk HPV infection compared to men born in the U.S. (OR = 0.75; 95% CI: 0.60–0.93) (Table 3). Differences for any HPV type and for vaccine-preventable HPV infection outcomes were no longer statistically significant in multivariable models. Correlates were similar across outcomes. Men who were older or who reported never having had sex had lower odds of all HPV infection outcomes, while those who were married or living with

Figure 1. Human papillomavirus (HPV) infection by nativity status among women (Panel A) and men (Panel B) in the U.S. Bars indicate standard errors.

Table 3. HPV infection among men in the U.S., by nativity status.

	Any HPV type		High-risk HPV type		Vaccine-preventable HPV type	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
Nativity status						
U.S.-born	ref		ref		ref	
Foreign-born	0.88	(0.55–1.40)	0.75	(0.60–0.93)*	1.02	(0.58–1.79)
Demographic Characteristics						
Age (years)						
20–29	ref		ref		ref	
30–39	1.05	(0.79–1.41)	0.96	(0.73–1.25)	0.97	(0.61–1.54)
40–49	1.09	(0.79–1.50)	0.83	(0.59–1.18)	0.78	(0.49–1.24)
50–59	1.28	(0.84–1.95)	0.85	(0.59–1.24)	1.01	(0.61–1.67)
Race/ethnicity						
Non-Hispanic white	ref		ref		ref	
Non-Hispanic black	1.96	(1.59–2.42)*	1.50	(1.11–2.02)*	1.29	(0.83–2.00)
Hispanic	1.25	(0.92–1.69)	1.04	(0.74–1.45)	0.78	(0.45–1.37)
Other	0.72	(0.43–1.19)	0.55	(0.34–0.88)*	0.94	(0.53–1.69)
Relationship/marital status						
Not married	ref		ref		ref	
Married/living with a partner	1.38	(1.04–1.82)*	1.38	(1.01–1.89)*	1.67	(1.23–2.29)*
Education						
Less than a high school degree	ref		ref		ref	
High school degree	1.51	(1.01–2.25)*	1.56	(0.90–2.70)	1.09	(0.62–1.93)
More than a high school degree	0.96	(0.69–1.33)	0.95	(0.65–1.39)	0.49	(0.32–0.75)*
Income						
Below FPL ^a	ref		ref		ref	
100–250% FPL	0.86	(0.58–1.27)	0.74	(0.44–1.26)	1.07	(0.68–1.68)
Above 250% FPL	0.90	(0.56–1.42)	0.78	(0.45–1.34)	1.12	(0.67–1.89)
Refused/Missing	0.62	(0.30–1.28)	0.50	(0.25–0.99)*	0.61	(0.30–1.22)
Health Characteristics						
Smoking status						
Never smoker	ref		ref		ref	
Former smoker	1.29	(0.92–1.82)	1.30	(0.90–1.88)	0.64	(0.41–1.01)*
Current smoker	1.69	(1.06–2.67)*	1.23	(0.90–1.68)	1.17	(0.78–1.77)
Total number of sexual partners (lifetime)						
5 or fewer	ref		ref		ref	
6 or more	3.48	(2.49–4.88)*	3.80	(2.77–5.23)*	4.80	(2.89–7.95)*
Never had sex	0.12	(0.03–0.47)*	0.09	(0.01–0.85)*	0.11	(0.01–1.04)**
Missing/Refused	3.06	(1.74–5.38)*	3.90	(2.27–6.70)*	3.97	(1.71–9.25)*

Note. CI, confidence interval; HPV, human papillomavirus; OR, odds ratio; ref, referent group

^aFederal Poverty Level (U.S.)

* $p < .05$

** $p < .01$

a partner, current smokers, or who had a greater number of sexual partners had greater odds. Compared to non-Hispanic white men, non-Hispanic black men had higher odds of any HPV infection or high-risk HPV type and men categorized as another race/ethnicity had lower odds of high-risk HPV.

Discussion

By the year 2060, half of the U.S. population is projected to be part of a minority group, and 1 in 5 foreign-born.²⁰ Thus, to better target prevention efforts, it is crucial to gain a deeper understanding of the disease burden and health risks among these populations. To our knowledge, this is the first study to examine the prevalence of genital HPV infection by nativity status. Among this population-based sample, we found that about 1 in 3 foreign-born women and men are infected with any type of HPV, and over 1 in 5 is infected with a high-risk type. While the prevalence of HPV infection was lower among foreign-born adults than among those born in the U.S., this is nonetheless a substantial burden. Although nativity differences were attenuated for most HPV outcomes in multivariate models, we believe these findings are noteworthy for a number of reasons.

First, the lower prevalence of HPV among men and women who were foreign-born indicates that disparities related to HPV and nativity, such as higher levels of cervical cancer mortality among foreign-born women, are not likely due to higher rates of infection or high-risk infection. Rather, other known disparities, such as lower vaccination, lower screening participation, delayed diagnosis, and poorer access to care,^{8–13} may explain the discrepancy between this population's lower prevalence of HPV infection but increased risk of negative HPV-related outcomes. Indeed, our findings suggest low coverage of HPV vaccination among foreign-born women and men. Similar to other studies showing lower rates of HPV vaccine initiation among foreign-born than among U.S.-born populations in those 20 to 25 years old (10% vs. 20%),^{8,9} we found that fewer than 1 in 10 foreign-born adults ages 35 and younger had received any doses of the vaccine. If left unaddressed, disparities in utilization of these health services will likely lead to continued HPV-related cancer disparities in the long term.

Second, findings from this study can inform future HPV prevention programs and policies. The novel data on HPV infection prevalence reported here is important for strategically communicating with foreign-born women and men about their risk of HPV infection, which may, in turn, affect their perceived risk (or

likelihood) of getting an HPV-related disease. Perceived risk is a construct in several health behavior theories^{21–23} that has been correlated with prevention behaviors and has the potential to affect uptake of HPV vaccination and cervical cancer screening. These prevalence data may also be useful for educating healthcare providers about HPV infection among foreign-born women and men and, thus, the importance of recommending HPV vaccine and appropriate screening to this population. These prevention efforts have the potential to reach a large population. For example, over 10% of the more than 43 million immigrants living in the U.S. are between the ages of 10 and 25²⁴ and, thus, eligible for HPV vaccination; the proportion that could potentially receive the vaccine grows to almost half (49%) when considering the age-group eligible with the new approval of the vaccine through age 45.²⁴ Our findings can also help inform vaccination policy. Although there are policies for other vaccinations that are specific to immigrant populations,²⁵ HPV vaccination is not currently required for immigration. While the lack of requirement is congruent with policies directed at U.S.-born populations, unlike national guidelines, it is also not a *recommended* vaccination for immigration.²⁵ With a median age at immigration of 28 years,²⁶ many foreign-born men and women are eligible for HPV vaccination upon immigration, making this an important target for immigration immunization policy.

Strengths and limitations

Strengths of this study include the use of data from a large, nationally-representative sample and assessment of genital HPV infection derived from DNA testing of biological specimens. Although biospecimens for the NHANES are self-collected, this method has result concordance with clinician-collected samples.²⁷ Limitations of this study include the use of a dichotomous measure for nativity status, classifying participants as either U.S.- or foreign-born, due to sample size. This aggregated approach likely obscures differences within the foreign-born group, as the prevalence of HPV varies dramatically across countries.²⁸ Future research should examine HPV infection using a more granular approach to assessing nativity status, for example examining country of origin or including measures of acculturation among foreign-born participants, including age at the time of immigration. Additional limitations include self-reported data, which for some variables (e.g., sexual behavior), may be prone to social desirability and recall biases, and a cross-sectional design which provides a strong indicator of current HPV infection but does not capture lifetime exposure to HPV, as some infections may clear from the body.²⁹ Our study also did not control for some characteristics and behaviors (e.g., specific sexual practices) that may be relevant to HPV transmission between sexual partners or for sexual experience at the time of immigration. Further, we were not able to account for HPV vaccination status in our analyses due to small sample sizes.

Conclusion

In this national study, we found that genital HPV infection is common among both native- and foreign-born populations in the U.S., and many men and women are infected with an HPV

type that vaccination could protect against. Our results can inform future HPV and cervical cancer prevention efforts that target foreign-born populations; future research should also seek to understand their barriers and facilitators to vaccination and screening. Taken together, such efforts may help reduce existing HPV-related disparities among these populations.

Materials and methods

We conducted a secondary analysis of publicly available data from NHANES which is described in detail elsewhere.³⁰ Briefly, the NHANES is a series of cross-sectional surveys administered by the Centers for Disease Control and Prevention with the goal of assessing health status, nutritional status, the prevalence of major diseases, and risk factors for those diseases.³⁰ NHANES employs a complex, multistage, probability sampling design to obtain a nationally-representative sample of the non-institutionalized civilian population in the U.S. The NHANES collects data through in-person interviews and physical examinations from individuals who provide informed consent. Interviews are conducted at participant's homes using audio computer-assisted self-interviewing software (ACASI) for potentially sensitive questions, and can be in multiple languages.³⁰ Physical examinations are administered by trained personnel in a mobile examination center.³⁰

The present study includes data from the 2013–2014 survey cycle, as this is the first cycle for which NHANES examinations included collection of biospecimens for genital HPV testing for *both* female and male participants ages 14–59 years. We analyzed data from 1,822 women and 1,622 men ages 20–59 who provided samples adequate for HPV testing. Our sample excludes participants 60 years and older as they were not tested for HPV infection, and those under 20 years due to variable restrictions for this age group (e.g., all HPV-related data are restricted for those under 18; marital status is not publicly available for those under 20). The Institutional Review Board at the University of Minnesota deemed the present secondary data analysis exempt from review.

Measures

HPV infection outcomes

Participants self-collected vaginal (females) or penile (males) biospecimens using sterile swabs. Samples were assessed using the Research Use Only Linear Array Assay genotyping test (Roche Diagnostics) to detect DNA evidence of HPV infection for 37 HPV types (6, 11, 16, 18, 26, 31, 33, 35, 39, 40, 42, 45, 51, 52, 53, 54, 55, 56, 58, 59, 61, 62, 64, 66, 67, 68, 69, 70, 71, 72, 73, 81, 82, 83, 84, 89, and IS39).³⁰ We defined three HPV infection outcomes for analyses (yes or no for each): (a) any HPV infection; (b) high-risk HPV infection (types 16, 18, 26, 31, 33, 35, 39, 45, 51, 52, 53, 56, 58, 59, 64, 66, 67, 68, 69, 70, 73, 82, or IS39); and (c) vaccine-preventable HPV infection (types 6, 11, 16, 18, 31, 33, 45, 52, or 58). We classified high-risk HPV types based on a scheme consistent with past analyses of NHANES data.²⁹

Nativity

The NHANES questionnaire assessed nativity with the question “In what country were you born?” Responses were

categorized as foreign-born vs. U.S.-born (born in 50 U.S. states or Washington, DC).³⁰

Covariates

The NHANES questionnaire assessed various demographic and health-related characteristics that we included as covariates (Table 1). Demographic characteristics included sex, age, race/ethnicity, relationship/marital status, education level, and poverty level. Health-related characteristics included smoking status, number of sexual partners, and self-reported HPV vaccination (at least 1 dose). We categorized the total number of sexual partners using a cutoff based on the median number of sexual partners reported by participants. We report HPV vaccination status only for respondents ages 35 and under based on the year of initial HPV vaccine approval in the U.S. (2006) and current guidelines for administration (ages 9–26 years).

Analysis

We used chi-squared analyses to compare HPV infection outcomes and demographic and health characteristics between foreign- and U.S.-born participants. We constructed multivariable logistic regression models, stratified by sex, to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for each of our three HPV infection outcomes separately, controlling for demographic and health-related characteristics. HPV vaccination status was not included in multivariable models due to low vaccination coverage in this population. All analyses were conducted in Stata 14 (Statacorp, College Station, TX) and adjusted for the complex sampling design of NHANES. Statistical tests were two-tailed, with a critical α of 0.05.

Disclosure of potential conflicts of interest

No potential conflict of interest was reported by the authors.

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ORCID

Annie-Laurie McRee <http://orcid.org/0000-0001-6588-5995>

References

- Centers for Disease Control and Prevention. How many cancers are linked with HPV each year? 2018 Aug 22 [accessed 2018 Sep 8]. <https://www.cdc.gov/cancer/hpv/statistics/cases.htm>.
- Centers for Disease Control and Prevention (CDC). HPV-associated cancers rates by race and ethnicity; 2018 Aug 27 [accessed 2018 Sep 8]. <https://www.cdc.gov/cancer/hpv/statistics/race.htm>.
- World Health Organization (WHO). Human papillomavirus (HPV). WHO; 2018 [accessed 2017 Oct 30]. <http://www.who.int/immunization/diseases/hpv/en/>.
- Huh WK, Joura EA, Giuliano AR, Iversen O-E, de Andrade RP, Ault KA, Bartholomew D, Cestero RM, Fedrizzi EN, Hirschberg AL, et al. Final efficacy, immunogenicity, and safety analyses of a nine-valent human papillomavirus vaccine in women aged 16–26 years: a randomised, double-blind trial. *Lancet*. 2017;390(10108):2143–59. doi:10.1016/S0140-6736(17)31821-4.
- Garland SM, Kjaer SK, Muñoz N, Block SL, Brown DR, DiNubile MJ, Lindsay BR, Kuter BJ, Perez G, Dominiak-Felden G, et al. Impact and effectiveness of the quadrivalent human papillomavirus vaccine: A systematic review of 10 years of real-world experience. *Clin Infect Dis*. 2016;63(4):519–27. doi:10.1093/cid/ciw354.
- U.S. Preventive Task Force. Final recommendation statement: cervical cancer: screening. 2018 Aug. [accessed 2018 Nov 3]. <https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/cervical-cancer-screening2>.
- López G, Radford J Facts on U.S. immigrants, 2015. Pew Research Center's Hispanic Trends Project; 2017 [accessed 2018 Sep 8]. <http://www.pewhispanic.org/2017/05/03/facts-on-u-s-immigrants/>.
- Pérez AE, Agénor M, Gamarel KE, Operario D. Nativity disparities in human papillomavirus vaccination among U.S. adults. *Am J Prev Med*. 2018;54(2):248–58. doi:10.1016/j.amepre.2017.10.019.
- Agénor M, Abboud S, Delgadillo JG, Pérez AE, Peitzmeier SM, Borrero S. Intersectional nativity and racial/ethnic disparities in human papillomavirus vaccination initiation among US women: a national population-based study. *Cancer Causes Control*. 2018;29(10):927–36. doi:10.1007/s10552-018-1069-1.
- Shoemaker ML, White MC. Breast and cervical cancer screening among Asian subgroups in the USA: estimates from the National Health Interview Survey, 2008, 2010, and 2013. *Cancer Causes Control*. 2016;27(6):825–29. doi:10.1007/s10552-016-0750-5.
- Johnson CE, Mues KE, Mayne SL, Kiblawi AN. Cervical cancer screening among immigrants and ethnic minorities: A systematic review using the Health Belief Model. *J Low Genit Tract Dis*. 2008;12(3):232. doi:10.1097/LGT.0b013e31815d8d88.
- Tsui J, Saraiya M, Thompson T, Dey A, Richardson L. Cervical cancer screening among foreign-born women by birthplace and duration in the United States. *J Womens Health*. 2007;16(10):1447–57. doi:10.1089/jwh.2006.0279.
- Montealegre JR, Zhou R, Amirian ES, Follen M, Scheurer ME. Nativity disparities in late-stage diagnosis and cause-specific survival among Hispanic women with invasive cervical cancer: an analysis of Surveillance, Epidemiology, and End Results data. *Cancer Causes Control*. 2013;24(11):1985–94. doi:10.1007/s10552-013-0274-1.
- Seeff LC, McKenna MT. Cervical cancer mortality among foreign-born women living in the United States, 1985 to 1996. *Cancer Detect Prev*. 2003;27(3):203–08. doi:10.1016/S0361-090X(03)00062-X.
- Centers for Disease Control and Prevention (CDC). Cervical cancer rates by race and ethnicity; 2016 [accessed 2018 Oct 25]. <https://www.cdc.gov/cancer/cervical/statistics/race.htm>.
- Schleicher E. Immigrant women and cervical cancer prevention in the United States. Baltimore, Maryland: Women's and Children's Health Policy Center, Johns Hopkins Bloomberg School of Public Health; 2007.
- McCracken M, Olsen M, Chen MS, Jemal A, Thun M, Cokkinides V, Deapen D, Ward E. Cancer incidence, mortality, and associated risk factors among Asian Americans of Chinese, Filipino, Vietnamese, Korean, and Japanese ethnicities. *CA Cancer J Clin*. 2007;57(4):190–205. doi:10.3322/canjclin.57.4.190.
- Siegel R, Naishadham D, Jemal A. Cancer statistics for hispanics/latinos, 2012. *CA Cancer J Clin*. 2012;62(5):283–98. doi:10.3322/caac.21153.
- Schiffner TA, Buki LP, Sabet RF. Mexican American college men's (mis)understandings about HPV and cervical cancer. *Fam Community Health*. 2017;40(2):150–59. doi:10.1097/FCH.0000000000000140.

20. United States Census Bureau. Projections of the size and composition of the U.S: 2014–2060. 2018 [accessed 2018 Sep 8]. <https://www.census.gov/library/publications/2015/demo/p25-1143.html>.
21. Rogers RW. A protection motivation theory of fear appeals and attitude change. *J Psychol*. 1975;91(1):93–114. doi:10.1080/00223980.1975.9915803.
22. Becker MH. The health belief model and sick role behavior. *Health Educ Monogr*. 1974;2(4):409–19. doi:10.1177/109019817400200407.
23. Ferrer RA, Klein WM. Risk perceptions and health behavior. *Curr Opin Psychol*. 2015;5:85–89. doi:10.1016/j.copsyc.2015.03.012.
24. Migration Policy Institute. Frequently requested statistics on immigrants and immigration in the United States; 2017. <https://www.migrationpolicy.org/article/frequently-requested-statistics-immigrants-and-immigration-united-states>.
25. Centers for Disease Control and Prevention (CDC). Recommended vaccines for immigrants and refugees; 2018 Sep 4 [accessed 2018 Sep 27]. <https://www.cdc.gov/vaccines/adults/rec-vac/immigrants-refugees.html>.
26. Camarota S Immigrants in the United States: a profile of the foreign-born using 2014 and 2015 census bureau data. Center for Immigration Studies; 2016. <https://cis.org/sites/cis.org/files/immigrant-profile.pdf>.
27. Winer RL, Feng Q, Hughes JP, Yu M, Kiviat NB, O'Reilly S, Koutsky LA. Concordance of self-collected and clinician-collected swab samples for detecting human papillomavirus DNA in women 18 to 32 years of age. *SexTransm Dis*. 2007;34(6):371–77. doi:10.1097/01.olq.0000240315.19652.59.
28. Forman D, de Martel C, Lacey CJ, Soerjomataram I, Lortet-Tieulent J, Bruni L, Vignat J, Ferlay J, Bray F, Plummer M, et al. Global burden of human papillomavirus and related diseases. *Vaccine*. 2012;30:F12–F23. doi:10.1016/j.vaccine.2012.07.055.
29. Hariri S, Unger ER, Sternberg M, Dunne EF, Swan D, Patel S, Markowitz LE. Prevalence of genital human papillomavirus among females in the United States, the National Health and Nutrition Examination Survey, 2003–2006. *J Infect Dis*. 2011;204(4):566–73. doi:10.1093/infdis/jir34.1.
30. Centers for Disease Control and Prevention (CDC). NHANES - National Health and Nutrition Examination Survey; 2018 Jul 26 [accessed 2018 Aug 20]. <https://www.cdc.gov/nchs/nhanes/index.htm>.