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## The Role of Health Information Technology in Improving Awareness of Human Papillomavirus and Human Papillomavirus Vaccine Among U.S. Adults

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### Abstract

**Objective:** Although human papillomavirus (HPV) vaccines prevent cancer-causing HPV infections and cervical pre-cancers, there is suboptimal awareness and limited global accessibility of HPV and HPV vaccine. Emerging evidence suggests that health information technology (HIT) may influence HPV-related awareness and improve vaccine adoption. The objective of this study was to evaluate the link between HIT and HPV-related awareness

**Methods:** Data were obtained from 1,866 U.S. adults aged 18–45 years who completed the 2017 and 2018 Health Information National Trends Survey. We conducted multi-variable logistic regression to analyze the association between HIT utilization and HPV-related awareness.

**Results:** Awareness of HPV and HPV vaccine were 72.7% and 67.5%, respectively. Participants who used electronic means to look up health information (adjusted odds ratio [aOR]=3.05; p=0.001), communicate with health care provider (aOR=1.68; p=0.026), look up test results (aOR=1.94; p=0.005), and track health costs (aOR=1.65; p=0.04) were more likely to report HPV awareness than those who did not. Participants who used an electronic device to look up health information (aOR=3.10; p=0.003), communicate with clinicians (aOR=1.72; p=0.008), look up test results (aOR=1.63; p=0.021), and track health care charges (aOR=1.90; p=0.006) were more likely to report HPV vaccine awareness than those who did not.

**Discussion and Conclusion:** Our findings suggest a positive association between HIT utilization and HPV-related awareness. Given the rapid and exponential increase in mobile technology access globally, these results are encouraging and offer a potential opportunity to leverage digital

technology in primary cancer prevention for HPV-related cancers, especially in low- and middle-income countries with unsophisticated health infrastructures.

**Keywords:** HPV, Health Information Technology, cancer prevention, preventive oncology, HPV vaccine

## Key Point

Use of health information technology (HIT) was positively associated with increased HPV-related awareness.

## Introduction

Globally, human papillomavirus (HPV) infections are present in 11.7% of the female population, with the highest prevalence in the Caribbean, Eastern Africa, and Sub-Saharan Africa where rates are 35.4%, 33.6%, and 24%, respectively.<sup>1</sup> In 2008, of the 12.7 million new cases of cancer worldwide, an estimated 610,000 were attributable to HPV infection.<sup>1</sup> In the United States, HPV is the most common sexually transmitted infection and remains a major cause of cervical, oropharyngeal, and several other cancers.<sup>2,3</sup> According to the Centers for Disease Control and Prevention (CDC), there were 43 million HPV infections in the United States in 2018, of which 13 million were new infections. Despite ongoing efforts to mitigate the transmission of HPV,<sup>4</sup> ~40,000 new HPV infections will cause an HPV-associated cancer in the United States annually.<sup>5</sup>

Although HPV vaccines prevent cancer-causing HPV infections and cervical precancers,<sup>6</sup> there is suboptimal awareness and limited global accessibility of HPV and HPV vaccine. In 2016, 86 countries had implemented HPV vaccination programs as part of the standard vaccine schedule. However, 74 of those countries were high income countries or upper middle income countries, whereas only 12 were lower income countries or lower middle income countries.<sup>7</sup> In the United States, despite increased availability of the HPV vaccination, only 60% of women and 44% of men report awareness of HPV and HPV vaccine.<sup>8</sup> Worldwide, awareness of HPV and HPV vaccines remains suboptimal across several age groups.<sup>9–12</sup> Recent data also suggest that national rates of HPV-related awareness in the United States has declined over time.<sup>13</sup> Hence, innovative population-level interventions aimed at boosting HPV awareness are critically needed globally.

Health information technology (HIT) entails various means (e.g., electronic health records, patient portals, messaging apps, e-mails, health websites, telehealth) by which patients

seek and keep track of health information and/or communicate with their health care providers.<sup>14</sup> HIT has emerged as a promising tool for expanding the reach of preventive health services.<sup>15,16</sup> For example, HIT has been positively associated with improved patient education, awareness, adherence, and uptake of pneumococcal and influenza vaccinations.<sup>17–19</sup> Further empirical evidence supporting the role of HIT in preventive oncology includes several recent systematic reviews emphasizing the benefit of HIT interventions in improving immunization coverage rates.<sup>20–23</sup> In the last decade, the usage of HIT has grown and its impact on health has been reported globally.<sup>24–26</sup> For example, HIT utilization in the United States more than doubled from 12.5% in 2011 to 27.4% in 2018.<sup>27</sup> Hence, HIT provides a novel opportunity to leverage technological tools to improve HPV awareness and vaccination uptake.

Although multiple studies have indicated the potential for HIT to bolster HPV, HPV vaccine awareness, as well as HPV vaccine uptake,<sup>13,28,29</sup> prior work has been limited to college students<sup>30,31</sup> and women.<sup>32</sup> Routine HPV vaccine was initially recommended for children (aged 9 years), adolescent, and catch-up vaccinations in some young adults (up to age 26). However, in 2019, the American Committee for Immunization Practices (ACIP) updated its guidelines: catch-up HPV vaccination was recommended for all persons through age 26 and in some eligible adults aged 27–45 years who may be at an elevated risk for new HPV vaccinations.<sup>33</sup> The increased risk of HPV-related diseases and cancers in adults galvanized the ACIP revised guidelines. Hence, more work is needed to improve HPV awareness and vaccine uptake across all life stages starting with children.

Despite evidence suggesting that HIT holds promise for increasing HPV awareness, there is scant information on the relationship between HIT and HPV and HPV vaccine awareness among adults globally using nationally representative samples. Hence, this study uses a U.S. nationally representative sample data to evaluate the relationship between HIT use and HPV and HPV vaccination awareness among U.S. adults aged ≥18–45 years. We hypothesized that use of HIT would be significantly associated with improved awareness of HPV and HPV vaccinations among U.S. adults.

## Methods

### STUDY DESIGN AND SAMPLE

Guided by the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines,<sup>34</sup> we used a cross-sectional design to analyze data from the Health Information National Trends Survey (HINTS), a nationally representative household interview survey of

civilian noninstitutionalized U.S. adults aged  $\geq 18$  years. Administered by the National Cancer Institute (NCI) every few years since 2003, HINTS collects information on health communication systems between providers and patients. HINTS also obtains information on cancer prevention, cancer diagnosis, treatment, and survivorship. Our study data are from the fifth edition of the HINTS, cycles 1 and 2, collected from January through May 2017 (HINTS 5, cycle 1) and January through May 2018 (HINTS 5, cycle 2). Complete information about data collection and methodologies including the sampling and weighting process of both HINTS datasets is described in their corresponding methodology reports.<sup>35</sup>

All HINTS survey respondents are weighted to reflect selection probabilities and the weights are calibrated to provide a nationally representative sample in terms of age, gender, educational attainment, marital status, race, ethnicity, and census region. In addition to the full-sample weight, a set of 50 replicate weights are provided for each adult. These replicate weights are used to calculate standard error of estimates obtained from the HINTS data, using the delete one jackknife (JK1) replication method.<sup>36</sup> Written informed consent was obtained from all HINTS respondents before survey completion. H5C1 and H5C2 were approved by the Westat Institutional Review Board and classified as exempt from review by the U.S. National Institutes of Health Office of Human Subjects Research Protections because the data were deidentified.

## MEASURES

*Primary outcome: awareness of HPV and HPV vaccine.* Awareness of HPV was ascertained based on responses of “yes” or “no” to the survey question—“Have you ever heard of HPV? HPV stands for Human Papillomavirus. It is not HIV, HSV, or herpes.” Awareness of HPV vaccine was determined based on responses of “yes” or “no” to the survey question—“A vaccine to prevent HPV infection is available and is called the cervical cancer vaccine or HPV shot. Before today, have you ever heard of the cervical cancer vaccine or HPV shot?”

*Independent/explanatory variable: HIT.* Our definition of HIT based on prior work is use of computer, smartphone, or other electronic means for health care.<sup>37</sup> In the survey, respondents were asked whether they had used a computer, smartphone, or other electronic means to (1) look up medical information, (2) look up medical test results, (3) purchase medications online, (4) track health care costs and charges, and (5) communicate with a health care provider. Response options were “yes” or “no” and thus they were dichotomized. We then created a composite variable of HIT use from the responses to these questions.

*Participant characteristics.* Informed by prior work,<sup>17</sup> HIT use was stratified by the following key sociodemographic characteristics: age, gender, race, educational level, household income, insurance status, and rural–urban residence, which was defined using the U.S. Department of Agriculture’s (USDA) 2003 Rural-Urban Continuum Codes (i.e., urban [1–3] and rural [4–9]).

## STATISTICAL ANALYSES

Descriptive statistics (e.g., mean) were used to describe the sample. Unweighted frequencies and weighted percentages were presented. Chi-squared tests were used to assess the associations between HIT use and sociodemographic characteristics. Furthermore, HPV and HPV vaccine awareness were estimated after stratifying the study population by key sociodemographic factors. Multivariable logistic regression models adjusting for age, gender, race, educational level, household income, insurance status, and rural–urban residence were used to examine the impact of HIT use on HPV and HPV vaccine awareness. The results of the regression models were presented as crude odds ratios (ORs) and adjusted odds ratios (aORs) with 95% confidence interval. We performed all statistical analyses using the “svy” command in Stata 17.0 statistical software (StataCorp LP, College Station, TX). Final person weights and jackknife replicate weights provided within the H5C1 and H5C2 datasets were used to estimate national level values and standard errors of estimates, respectively. Statistical significance was set at a *p*-value of 0.05.

## Results

### PARTICIPANT CHARACTERISTICS

Of the 27,946 (i.e., 13,360 [H5C1] and 14,586 [H5C2]) surveys mailed, 6,789 (i.e., 3,285 [H5C1] and 3,504 [H5C2]) were returned with response rates of 32.4% (H5C1) and 32.9% (H5C2). Participants with ages greater than 45 years ( $n=4,868$ ) were excluded from our study. In addition, we excluded 2.86% (55/1,921) of participants with missing responses to questions related to HIT usage for communicating with the health care system. Hence, a total of 1,866 participants were included in our analysis. See *Table 1* for full details about participant characteristics by HIT usage. Majority (86.4%) of our cohort reported use of at least one form of HIT to communicate about their health. HPV and HPV vaccine awareness was reported by 72.7% and 67.5%, respectively.

### FACTORS ASSOCIATED WITH HIT USAGE

In bivariate analysis (*Table 1*), individuals who reported at least one form of HIT use in the last year were more likely to

**Table 1. Sample Population Demographic Characteristics: Sample N= 1,866**

DEMOGRAPHIC VARIABLES	TOTAL (N= 1,866), Weighted %	NO USE OF HIT (n= 227), Weighted %	USE OF HIT (n= 1,639), Weighted %	TEST STATISTIC	p
<b>Gender</b>					
Female	50.3	11.2	88.8	2.12	0.148
Male	49.7	15.3	84.7		
<b>Age group, years</b>					
18–34	57.3	14.8	85.2	0.92	0.341
35–45	42.7	11.9	88.1		
<b>Education</b>					
High school or less	24.1	28.0	72.0	23.68	<b>&lt;0.001</b>
Some college	36.8	13.7	86.3		
College graduate or more	39.1	3.2	96.8		
<b>Household income</b>					
<\$20,000	16.3	25.8	74.2	5.46	<b>0.002</b>
\$20,000–\$34,999	12.0	16.6	83.4		
\$35,000–\$49,999	14.9	17.5	82.5		
\$50,000–\$74,999	18.1	11.0	89.0		
\$75,000 or more	38.7	4.4	95.6		
<b>Race</b>					
White	51.7	11.5	88.5	0.15	0.914
Black/African American	9.8	11.7	88.3		
Hispanic	19.6	13.5	86.5		
Others	10.9	11.0	89.0		
<b>Insurance status</b>					
No	11.7	17.4	82.6	17.70	0.195
Yes	88.3	12.9	87.1		
<b>Residence</b>					
Urban	89.2	12.6	87.4	3.53	0.06
Rural	10.8	22.1	77.9		

Bold p-values represent significant results with p-values < 0.05.

N=sample size.

HIT, health information technology.

be college graduates (96.8%), and people with high income (95.6% were from households with annual income ≥\$75,000). Use of HIT to interact with the health care system did not differ by age, gender, race/ethnicity, insurance status, or geographical residence.

Table 2 provides the prevalence of HIT use among the study population. Majority (80.4%) of our cohort reported

usage of smartphones, computers, or other electronic means to look up medical information online. However, less than half reported using these electronic means to look up test results online (33.6%), purchase medications online (22.7%), track health care costs and charges (38.5%), or communicate with a health care provider through e-mails (39.2%).

**Table 2. Proportion of Different Uses of Health Information Technology Among the Study Population**

HEALTH INFORMATION TECHNOLOGY USE	N (WEIGHTED PERCENTAGE)
Look up medical information	1,527 (80.4)
To look up test results online	730 (33.6)
To purchase medications	494 (22.7)
To track health care costs and charges	792 (38.5)
To talk with health care providers	816 (39.2)

**FACTORS ASSOCIATED WITH HPV AND HPV VACCINE AWARENESS**

HPV-related awareness differed according to sociodemographic factors. In bivariate analysis (Table 3), men, individuals with lower annual household incomes, and those of lower educational background were more likely to report non-awareness of HPV or HPV vaccination. In addition, those residing in rural areas (vs. urban) and individuals of racial minorities (Blacks/African Americans and Hispanics vs. Whites) were less likely to be aware of HPV vaccines.

**ASSOCIATION BETWEEN HIT USAGE AND HPV OR HPV VACCINE AWARENESS**

Table 4 provides the crude ORs and aORs of the relationship between the different uses of HIT and HPV and HPV vaccine awareness. In the unadjusted logistic regression analysis, respondents who utilized a smartphone, computer, or electronic means to look up health information (OR=4.03; 95% CI, 2.56–6.34;  $p < 0.001$ ), communicate with health care provider (OR=2.77; 95% CI, 1.44–3.58;  $p = 0.001$ ), look up test results (OR=3.21; 95% CI, 2.12–4.86;  $p < 0.001$ ), and track health care charges (OR=2.06; 95% CI, 1.31–3.24;  $p = 0.002$ ), were more likely to endorse HPV awareness. Similar associations were observed for the unadjusted regressions between HIT utilization and HPV vaccine awareness (Table 4).

In the adjusted analysis, these relationships remained significant. Those who utilized a smartphone, computer, or electronic means to look up health information (aOR=3.05; 95% CI, 1.59–5.88;  $p = 0.001$ ), communicate with health care provider (aOR=1.68; 95% CI, 1.07–2.66;  $p = 0.026$ ), look up test results (aOR=1.94; 95% CI, 1.22–3.07;  $p = 0.005$ ), and track health care charges (aOR=1.65; 95% CI, 1.02–2.65;  $p = 0.040$ ), were more likely to endorse HPV awareness than those who did not.

Similarly, those who utilized an electronic device to look up health information (aOR=3.10; 95% CI, 1.50–6.41;  $p = 0.003$ ),

communicate with health care provider (aOR=1.72; 95% CI, 1.15–2.57;  $p = 0.008$ ), look up test results (aOR=1.63; 95% CI, 1.07–2.46;  $p = 0.021$ ), and track health care charges (aOR=1.90; 95% CI, 1.21–3.00;  $p = 0.006$ ) were more likely to endorse HPV vaccine awareness than their counterparts who did not. However, the adjusted odds of endorsing HPV (aOR=0.79; 95% CI, 0.47–1.34;  $p = 0.384$ ) and HPV vaccine (aOR=0.90; 95% CI, 0.54–1.48;  $p = 0.666$ ) awareness if they use HIT to purchase medications online was not statistically significant after adjusting for sociodemographic factors.

Table 5 provides the crude ORs and aORs for the logistic regression of cumulative HIT use, and awareness of HPV and HPV vaccine. In both the unadjusted and adjusted analyses, there was a statistically significant positive association between cumulative HIT use with HPV and HPV vaccine awareness.

**Discussion**

We used data from a nationally representative survey of U.S. adults to evaluate the relationship between HIT use and HPV and HPV vaccine awareness in the United States. The results showed that U.S. adults aged 18–45 years report a high rate of HIT use, and HIT use is associated with greater odds of awareness of HPV and HPV vaccine. Further, HIT use for interaction with the health care system did not vary by sociodemographic factors like age, race, or ethnicity. Because HPV and HPV vaccine awareness among U.S. adults have declined in recent years,<sup>13</sup> innovative strategies aimed at boosting HPV and HPV vaccine awareness are critically needed. Our findings highlight the potential for HIT, an underutilized resource for primary cancer prevention, to improve awareness of HPV vaccination with the downstream effect of reducing HPV infections that cause HPV-associated cancers.<sup>38–40</sup>

We observed that survey respondents who used HIT to access health care providers, access their medical results, and track health care charges and costs were more likely to endorse HPV and HPV vaccine awareness than those who did not. These findings are consistent with prior work, which indicate that the use of HIT increases both awareness and engagement with preventive health services.<sup>19,23,41</sup> For example, using data from the National Health Interview Survey, Kesiena et al<sup>17</sup> found that among adults aged 40 years and older who had heart disease, the adoption of HIT was associated with greater awareness and a higher pneumococcal vaccine uptake. Similarly, we show that use of HIT may boost HPV-related awareness and potentially HPV vaccine uptake among eligible adults. The high prevalence of HIT engagement as demonstrated in our study is particularly encouraging

**Table 3. Bivariate Association Between Demographic Variables with Awareness of Human Papillomavirus and Human Papillomavirus Vaccine**

Demographic variables	NOT AWARE OF HPV (n= 425), WEIGHTED %	AWARE OF HPV (n= 1,412), WEIGHTED %	<i>p</i>	NOT AWARE OF HPV VACCINE (n= 500), WEIGHTED %	AWARE OF HPV VACCINE (n= 1,323), WEIGHTED %	<i>p</i>
<b>Gender</b>						
Female	17.3	82.7	<b>&lt;0.001</b>	20.0	80.0	<b>&lt;0.001</b>
Male	38.6	61.4		46.0	54.0	
<b>Age group, years</b>						
18–34	29.8	70.2	0.110	31.8	68.2	0.665
35–45	24.8	75.2		33.3	66.7	
<b>Education</b>						
High school or less	44.6	55.4	<b>&lt;0.001</b>	58.1	41.9	<b>&lt;0.001</b>
Some college	28.8	71.2		28.0	72.0	
College graduate or more	15.4	84.6		20.7	79.3	
<b>Household income</b>						
<\$20,000	42.0	58.0	<b>0.001</b>	43.7	56.3	<b>0.004</b>
\$20,000–\$34,999	37.6	62.4		46.2	53.8	
\$35,000–\$49,999	23.6	76.4		30.2	69.8	
\$50,000–\$74,999	25.3	74.7		31.8	68.2	
\$75,000 or more	18.2	81.8		23.9	76.1	
<b>Race</b>						
White	24.8	75.2	0.490	26.0	74.0	<b>&lt;0.001</b>
Black/African American	25.7	74.3		35.8	64.2	
Hispanic	29.3	70.7		44.3	55.7	
Others	31.7	68.3		37.9	62.1	
<b>Insurance status</b>						
No	36.2	63.8	0.097	38.1	61.9	0.339
Yes	26.4	73.6		31.5	68.5	
<b>Residence</b>						
Urban	26.7	73.3	0.082	31.4	68.6	<b>0.034</b>
Rural	35.7	64.3		41.6	58.4	

Bold *p*-values represent significant results with *p*-values < 0.05.  
 HPV, human papillomavirus.

and suggests a potential opportunity to leverage HIT in primary cancer prevention efforts.

We revealed that HIT use was predominantly characterized by looking up medical information online (80.4%) and ~86.4% of survey respondents reported at least one form of HIT use to interact with the health care system. These rates are

likely higher in the context of the COVID-19 (coronavirus disease 2019) pandemic.<sup>42</sup> A plausible explanation for these findings is that HIT use serves as a platform that encourages direct communication and engagement with the health care system as prior work has articulated a relationship between better engagement/communication with health care providers and

**Table 4. Association Between Any Health Information Technology Use with Awareness of Human Papillomavirus and Human Papillomavirus Vaccine**

HIT VARIABLES				
AWARENESS OF HPV	CRUDE OR (95% CI)	<i>p</i>	Adjusted OR (95% CI)	<i>p</i>
No use of HIT (reference)	1.00	–	1.00	–
Look for medical information	4.03 (2.56–6.34)	<0.001	3.05 (1.59–5.88)	<b>0.001</b>
Look up test results	3.21 (2.12–4.86)	<0.001	1.94 (1.22–3.07)	<b>0.005</b>
Purchase medications	1.30 (0.81–2.10)	0.273	0.79 (0.47–1.34)	0.384
Track health care costs and charges	2.06 (1.31–3.24)	0.002	1.65 (1.02–2.65)	<b>0.040</b>
Communicate with health care providers	2.27 (1.44–3.58)	0.001	1.68 (1.07–2.66)	<b>0.026</b>
AWARENESS OF HPV VACCINE	CRUDE OR (95% CI)	<i>p</i>	Adjusted OR (95% CI)	<i>p</i>
No use of HIT (reference)	1.00	–	1.00	–
Look for medical information	4.20 (2.77–6.37)	<0.001	3.10 (1.50–6.41)	<b>0.003</b>
Look up test results	2.94 (2.04–4.22)	<0.001	1.63 (1.07–2.46)	<b>0.021</b>
Purchase medications	1.32 (0.82–2.11)	0.246	0.90 (0.54–1.48)	0.666
Track health care costs and charges	2.50 (1.78–3.51)	<0.001	1.90 (1.21–3.00)	<b>0.006</b>
Communicate with health care providers	2.61 (1.89–3.61)	<0.001	1.72 (1.15–2.57)	<b>0.008</b>

Bold *p*-values represent significant results with *p*-values < 0.05.  
CI, confidence interval; OR, odds ratio.

**Table 5. Association Between Multiple Uses of Health Information Technology with Awareness of Human Papillomavirus and Human Papillomavirus Vaccine**

HIT VARIABLES				
HPV AWARENESS	CRUDE OR (95% CI)	<i>p</i>	ADJUSTED OR (95% CI)	<i>p</i>
No use of HIT (reference)	1.00	–	1.00	–
At least one use of HIT vs. no HIT	3.16 (1.77–5.65)	<0.001	3.03 (1.29–7.15)	<b>0.012</b>
At least two uses of HIT vs. no HIT	5.06 (2.84–9.00)	<0.001	3.23 (1.37–7.60)	<b>0.008</b>
At least three uses of HIT vs. no HIT	5.94 (2.35–15.0)	<0.001	5.77 (2.13–15.6)	<b>0.001</b>
At least four uses of HIT vs. no HIT	8.99 (4.25–19.0)	<0.001	4.44 (1.64–12.08)	<b>0.004</b>
At least five uses of HIT vs. no HIT	7.24 (3.05–17.2)	<0.001	3.58 (1.26–5.53)	<b>0.017</b>
HPV VACCINE AWARENESS	CRUDE OR (95% CI)	<i>p</i>	ADJUSTED OR (95% CI)	<i>p</i>
No use of HIT (reference)	1.00	–	1.00	–
At least one use of HIT vs. no HIT	2.44 (1.36–4.37)	0.003	2.34 (0.89–6.16)	0.084
At least two uses of HIT vs. no HIT	5.14 (2.80–9.44)	<0.001	3.50 (1.36–8.98)	<b>0.010</b>
At least three uses of HIT vs. no HIT	8.46 (4.32–16.60)	<0.001	6.14 (2.18–17.26)	<b>0.001</b>
At least four uses of HIT vs. no HIT	7.17 (3.74–13.74)	<0.001	3.84 (1.30–11.33)	<b>0.015</b>
At least five uses of HIT vs. no HIT	7.34 (3.07–17.56)	<0.001	3.48 (1.06–11.49)	<b>0.041</b>

Bold *p*-values represent significant results with *p*-values < 0.05.

vaccines uptake.<sup>17,18</sup> Because HIT also allows clinicians to send educational information, updates and reminders to patients outside the traditional office settings, interventions utilizing communication technologies in practice-based settings may represent an alternative mode for HPV vaccination intervention delivery.<sup>43,44</sup>

We observed disparities in HIT use—survey respondents with less education and overall lower socioeconomic background reported less usage. However, HIT use to interact with the health care system did not differ by sociodemographic factors such as age, gender, race/ethnicity, insurance status, or geographical residence. Survey respondents residing in rural areas (vs. urban) and individuals of racial minorities (Blacks/African Americans and Hispanics vs. Whites) were less likely to be aware of HPV and HPV vaccine. These data are consistent with prior studies, which showed African Americans were less likely to initiate HPV vaccinations than whites after adjusting for sociodemographic and health care access variables.<sup>45</sup> Because our findings underscore the potential impact of HIT in targeted cancer prevention measures for underserved communities (i.e., in the United States and globally) with well-established disparities in cancer outcomes, more research is also needed to reduce barriers to HIT access in these vulnerable populations globally.

Reassuringly, mobile health technologies have emerged and are increasingly used to address gaps in health care access, coverage, and equity in low- and middle-income settings.<sup>46,47</sup> Thus, although our results are limited to the U.S. population, the exponential increase in mobile phone and technology penetration in low- and middle-income countries indicates that these results could be extended to more global contexts, especially in low-resource settings with fragile health systems.<sup>48</sup> This is further supported by the growing body of work showing that digital technology interventions could be integrated in preventive oncology programs in low resource settings, especially as literacy in technology utilization becomes more common and more cost-effective technology tools become readily available.<sup>49,50</sup>

There are several limitations of our study that warrant discussion. First, considering that the survey uses self-reported information, the data are subject to misrepresentation and recall bias by survey respondents. Second, the low response rate (33%) for both iterations of HINTS data suggests the potential for selection bias where individuals with high HIT use likely completed the survey. Third, because the survey is administered primarily in English, our findings may not be generalizable to individuals who have limited English proficiency or health literacy. Furthermore, all study participants were adults residing in the United States, which pre-

cludes the generalizability of our results to global contexts, especially considering global variations in technology penetration and access. Fourth, we could not infer causality from the association between HIT use and awareness of HPV and HPV vaccine with the use of cross-sectional data. Fifth, we lacked data to assess factors such as history of HPV infection and HPV immunization record that could explain the observed relationships.

Hence, future studies should evaluate other potential confounders and moderators on the link between HIT and HPV and HPV vaccine awareness. Furthermore, qualitative studies may provide further insights regarding facilitators and barriers to HIT use that should be considered in interventions for primary cancer prevention are needed.

## Conclusions

Our findings indicate a high prevalence of engagement with HIT among those aged 18–45 years as well as a positive association between HIT use and HPV-related awareness. These results suggest a potential opportunity to leverage digital technology in preventive oncology services. However, disparities in HIT use may limit scalability and integration of HIT into routine HPV preventive services as those with lower education and lower socioeconomic status (SES) are not entirely digitally connected. Thus, more research is needed to examine how to effectively incorporate HIT utilization in primary cancer prevention for HPV-related cancers, especially those pertaining to vaccination uptake and adoption.

## Disclosure Statement

No competing financial interests exist.

## Funding Information

Time for study and article preparation was supported by the National Cancer Institute through Grant No. K08CA251654 to H.L.A.

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*Received: September 7, 2022*

*Revised: September 17, 2022*

*Accepted: September 22, 2022*

*Online Publication Date: November 17, 2022*