Awareness of HPV and Uptake of Vaccination in a High-Risk Population

Jessica Fishman, PhD, a, b Lynne Taylor, PhD, c Ian Frank, MD d

BACKGROUND: Immunization against the human papillomavirus (HPV) is effective at preventing HPV-related cancers, but vaccination rates have remained low. Levels of awareness could conceivably influence vaccination rates, but currently the relationship is unknown. This is the first study to test how strongly levels of awareness among parents and adolescents are related to subsequent HPV vaccination among a high-risk population of adolescents.

METHODS: This longitudinal cohort study measured baseline levels of awareness (about HPV, cervical cancer, HPV vaccination, and news or advertisements about HPV vaccination) among parents of adolescents and also a separate sample of adolescents. Participants resided in predominantly low-income, African American neighborhoods of a large American city. During a 12-month follow-up period, the outcome measures were defined as adolescent receipt of any HPV vaccination, as measured by clinic records.

RESULTS: Within 1 year, <16% of adolescents received vaccination. The relationship between awareness and subsequent vaccination was either not statistically significant or not meaningful in magnitude, with $R^2 = 0.004$ to 0.02. The predicted probability of getting vaccination was <0.50 for all awareness levels and prediction accuracy was poor (area under the curve = 0.56–0.64).

CONCLUSIONS: In this high-risk population, levels of awareness among parents and adolescents were not substantially related to subsequent adolescent HPV vaccination.

WHAT’S KNOWN ON THIS SUBJECT: Immunization against the human papillomavirus (HPV) is effective at preventing HPV-related cancers, but even among some high-risk populations, vaccination rates have remained low. Levels of awareness could conceivably influence vaccination rates, but currently the relationship is unknown.

WHAT THIS STUDY ADDS: In this first study to assess a relationship between awareness and subsequent vaccination, the findings suggest that levels of awareness among parents and adolescents are not related to subsequent adolescent vaccination among a high-risk population.
Human papillomavirus (HPV) is one of the most common sexually transmitted infections, and the majority of cervical cancer is caused by infection with HPV. Vaccination against HPV has the potential to substantially reduce HPV and cervical cancer rates, thereby saving the lives of millions. Despite being characterized as a “product with blockbuster potential in rich countries,” vaccination rates in the United States have been low. A large and growing literature has tried to understand why. As documented by several reviews, studies investigating modifiable determinants of HPV vaccination have focused on measuring psychological factors, like “awareness.” In fact, the majority of studies have been concerned, to some extent, with a population’s awareness of HPV and the vaccine. Awareness has been measured in many populations, where it is sometimes characterized as high and sometimes as low, but studies have yet to test if awareness levels are predictive of subsequent vaccination. Cross-sectional studies cannot establish the direction of a relationship, if one exists, and they typically do not measure actual vaccination. Assuming that awareness does increase uptake, some have “sought to determine factors related to parental awareness of HPV vaccines.” Many merely described variation in awareness. A few longitudinal studies of HPV vaccination have been conducted, but they do not appear to have measured previous awareness levels.

Although the extant literature has yet to test if awareness predicts future vaccination, it is often concluded that interventions should attempt to increase awareness. Higher awareness could conceivably promote immunization, and perhaps much promise has been placed in awareness because it is easily influenced with a simple, quick message. If awareness levels do influence the likelihood of obtaining vaccination, it may be wise for behavioral interventions to target public awareness, as has been common practice.

This study assesses how strongly awareness levels among parents and adolescents are associated with and predictive of future adolescent vaccination. Whether adolescents received vaccination against HPV was tracked over 12 months to assess this outcome prospectively and to establish temporality in any relationship between awareness levels and vaccination. This longitudinal study design has major advantages over cross-sectional designs.

In addition, whereas other studies have enrolled white and relatively affluent populations, this research was conducted among a high-risk population of low-income, African Americans. This population is important to study because it is disproportionately burdened by HPV-related mortality and morbidity. For example, compared with whites, African Americans are ~3 times more likely to die of cervical cancer. Among low-income, African Americans, cervical cancer represents approximately one-quarter of cancer deaths. For this population, prevention of HPV through vaccination is especially important.

**METHODS**

**Study Design**

Using a longitudinal cohort study design, this study assessed baseline awareness among parents of adolescents and also a separate sample of adolescents, making the 2 samples independent. For 12 months, the study tracked adolescents, recording whether they received HPV vaccination.

**Study Population and Recruitment**

Because previous literature has suggested that either parents or adolescent daughters may make the vaccination decision, this study included both by recruiting from large, low-income neighborhoods in Philadelphia that are predominantly African-American. For parents, eligibility criteria included being a parent (or guardian) of a girl age 9 to 18 years old who was not vaccinated against HPV. For adolescents, eligibility criteria included being 13 to 18 years, not vaccinated against HPV, and not reporting being pregnant or breastfeeding. Adolescents ages 13+ can self-consent to HPV vaccination in Philadelphia (and elsewhere, as permitted by law).

**Vaccination**

The primary outcome variable is vaccination status at 12 months. Adolescent vaccination was tracked prospectively, as determined by clinic records shared with the Kids Immunization Database/Tracking System. Philadelphia requires reporting for all immunizations administered to children (0–18 years).

**Awareness**

Our exposure variable is baseline awareness level. When measuring awareness, the goal is to measure whether individuals report being exposed to relevant information. In dictionary definitions, awareness means having consciousness or cognizance. Similarly, the psychological definition concerns the perception of an object, condition, or event of interest.

The current study assessed whether individuals report being aware of the following: (1) HPV, (2) cervical cancer, (3) HPV vaccination, and (4) news or advertising about HPV vaccination. The questionnaire items measuring awareness asked: “Before
today, have you ever heard of HPV?"; “Before today, have you ever heard of cervical cancer?”; “Before today, have you ever heard of HPV vaccination, also sometimes called Gardasil?”; and “Have you seen or heard any news or ads about the HPV shot?”

For each item, affirmative responses were coded 1 and other responses were coded 0. To generate a total awareness level, the percentage of questions indicating awareness was determined, with a higher value indicating more awareness.

The awareness measure has sound psychometric properties. In particular, face and content validity was based on a review of awareness measurement in the HPV vaccine literature, where awareness has been frequently examined. As summarized by a review of the literature, awareness is assessed “typically with a single item such as, ‘Have you ever heard of the HPV vaccine?’”5,6 Because the reliance on a single item has been criticized,6,7 the current study includes this and 3 other commonly used items, which have never before been employed in the same study.6,7–10

To further judge the items’ face and content validity, each item was also evaluated by a panel of 8 experts in HPV clinical research. The items were judged to be relevant, representing distinct domains, and potentially sensitive to differences between vaccination status. In reliability testing, the items had moderately high internal consistency (KR-20 = 0.79, 0.72 for parents and adolescents, respectively), which supported generating a summary scale value indicating total awareness.21

As expected, discriminant validity was demonstrated with other constructs, including knowledge. Correlation coefficients indicate that measures share a low percent of their variation (<4%), and do not overlap strongly.24–28 Extensive testing of knowledge and awareness has previously established patterns of discriminant validity, reflecting the conceptual distinction.28–32

### Awareness Versus Knowledge

Awareness concerns the role of information at its most fundamental level by measuring whether attention has been paid, resulting in familiarity.28 Knowledge measures the amount of factually accurate information.22,28,32 Some awareness is needed to acquire knowledge, which is higher in the hierarchical taxonomy of cognition, but they require entirely different measures.28 Those evaluating knowledge ask individuals whether statements are true regarding, for example, HPV risk factor and transmission facts.

Studies testing knowledge effects cannot test whether awareness itself matters.20,28,32 Individuals who have high levels of awareness may not have high levels of knowledge.28 Individuals can be aware of HPV vaccination but have low levels of relevant knowledge if they believe in several misconceptions, were never exposed to many facts, or were once exposed but later fail to recall them. In fact, among parents who had the highest levels of awareness, less than one-quarter had high knowledge levels (ie, scoring between 81% and 100% correct), requiring separate analyses.20

### Additional Variables

The available population characteristics include standard demographic measures (Table 1). Those analyzed as potential confounders were parent age and income, plus adolescent age, sexual debut age, and number of sexual partners.

### Analyses

To assess how strongly awareness items and total levels among parents and adolescents were associated with and predictive of future HPV vaccination among adolescents, analyses calculated the percentage of adolescents vaccinated between baseline and each follow-up period (ie, 3, 6, and 12 months’ postbaseline). Percent vaccination at each follow-up is cumulative; it consists of the number of individuals who were previously vaccinated in the preceding follow-up period(s), plus the new individuals being vaccinated at each time point. We visually examined if there was evidence of a curvilinear association by plotting for each awareness level the percentage of persons vaccinated at 12 months with 95% confidence
To describe awareness level difference between vaccination status at each time point, descriptive summary statistics were computed for the awareness level and each awareness item. The t test and Wilcoxon test assessed awareness level differences between the vaccinated versus the nonvaccinated. The parent and adolescent sample size provided adequate power (80%) to detect a medium effect size difference in awareness between the vaccinated and the unvaccinated group with a 1 tail α of P < .05. A 15- and 20-point difference in mean awareness scores constitutes a medium effect size difference for adolescents (d = 0.50) and parents (d = 0.61), respectively.

Logistic regression (with maximum likelihood estimates to compute the odds ratio [OR] and Wald’s 95% confidence interval [CI], R², and the C statistic) was used to assess the magnitude of the relationship between awareness levels (total) and vaccination behavior. The OR describes the odds of getting a vaccination on the basis of awareness level, whereas the R² denotes the percentage of variance in vaccination behavior that can be explained by awareness levels. We compute the predicted probability of getting vaccinated at each awareness level, and the area under the curve (AUC), as captured by the C statistic, assessed the model’s prediction accuracy. C values between 0.9 and 1 were considered excellent, between 0.8 and 0.9 good, between 0.7 and 0.8 fair, between 0.6 and 0.7 poor, and between 0.5 and 0.6 useless.34 To describe the association between each awareness item and getting vaccinated, we computed the awareness item percentage along with their 95% CI, Fisher’s exact test, and Φ correlation along with its r². The available potential confounders were examined by their bivariate correlation with vaccination behavior and awareness level. If the potential confounder was related to both, it would be adjusted for in the logistic regression model. All analyses used SAS version 9.3 (SAS Institute, Inc, Cary, NC).

RESULTS

Sample Characteristics
At baseline, 211 adolescents and 149 parents (of other adolescents) responded to a questionnaire measuring awareness and sociodemographic variables. Study participants were low income, with median household incomes in their neighborhoods ranging from $13,900 to $37,700 and more than one-third of the sample reporting their household incomes <$10,000. The sample was mostly African American, with 194 adolescents (91.9%) and 140 parents (95.2%) identifying as such. Few reported Hispanic/Latino ethnicity (<6%). The adolescents were 13 to 18 years, and parents (including older guardians) were 23 to 71 years old, with means of 15.3 (SD = 1.5) and 41.7 years (SD = 9.2), respectively. Forty-four percent (n = 92) of the adolescents reported being sexually active. Before the study, all adolescents received a vaccination of some kind, and the vast majority (76.2% [99/211]) had since age 10. Table 1 reveals additional characteristics.

Description of Vaccination Prevalence and Awareness
During the 3-, 6-, and 12-month follow-up periods, HPV vaccination status was tracked for each adolescent of interest. Among the 149 parents enrolled in the study, 5.4% (n = 8), 10.1% (n = 15), and 13% (n = 20) of their daughters received an HPV vaccination, respectively, during the 3, 6, and 12 months’ postbaseline. The parents’ baseline awareness levels were negatively skewed, ranging from 0% to 100%; mean = 76%, median = 100%, with only 6 parents (4.0%) not reporting awareness of any terms, and 85 (57.1%) reporting awareness for all terms. Parents were most likely to be aware of cervical cancer (94%) and least likely to be aware of any news or ads about HPV vaccination (66%). Among the sample of adolescents reporting baseline awareness levels, 7/211 (3.3%), 18/211 (8.5%), and 32/211 (15%) received an HPV vaccination during the 3-, 6-, and 12-month follow-up period, respectively. The adolescent awareness levels were negatively skewed, ranging from 0% to 100%, mean = 60%, median = 75%, with 29 (13.7%) adolescents not reporting any awareness, and 68 (32.2%) reporting awareness for all questions. Adolescents, like parents, were most likely to be aware of cervical cancer (73%) and least likely to be aware of any news about HPV vaccination (51%).

The Relationship Between Parents’ Awareness Levels and Their Daughters’ Vaccination
Based on visual inspection of the percent vaccinated at each awareness level, for each follow-up period, parents’ awareness was not curvilinearly related to their daughters’ subsequent vaccination status. The baseline mean awareness levels of parents with adolescents who received an HPV vaccine during each follow-up period was not statistically significantly different from mean awareness levels of parents with adolescents who did not receive an HPV vaccine (P = .44, P = .42, P = .44; Table 2). At 3 months, the small number of immunizations precluded obtaining a stable OR for being vaccinated on the basis of awareness. At 6 and 12 months, the odds of getting vaccinated on the basis of awareness were not statistically significant. As shown in Fig 1, the predicted probability of getting vaccinated was <0.12 for each awareness level and prediction...
Accuracy was poor (AUC = 0.56–0.57). Similarly, when separately analyzing each awareness item, the percentage of parents reporting awareness for each was slightly higher in the vaccinated group versus the nonvaccinated group, but the magnitude of the associations was negligible. Because none of the potential confounders were related to both awareness and vaccination behavior, they were not adjusted for in the logistic regression models.

The Relationship Between Adolescents’ Awareness Level and Their Vaccination

Visual inspection of the percent of adolescents vaccinated at each awareness level, for each of the 3 follow-up periods, did not reveal signs of a curvilinear relationship. The awareness level means were statistically significantly higher for the vaccinated group versus the unvaccinated group at 6 months (75% vs 59%; \( P = .048 \)), and 12 months (73% vs 58%; \( P = .044 \); Table 2). However, the magnitude of the relationship is weak at 6 months (OR = 4.82, 95% CI = 0.98–24.62, \( R^2 = 0.02 \)) and 12 months (OR = 3.42, 95% CI = 1.05–11.25, \( R^2 = 0.008 \)). The predicted probability of vaccination was <0.50 for all awareness levels. For example, as indicated by Fig. 2, an awareness level of 0, 25%, 50%, 75%, and 100% has a 0.07, 0.10, 0.13, 0.17, and 0.21 predicted probability of getting vaccinated within the year. Overall, prediction accuracy was poor (AUC = 0.61–0.64). Because none of the potential confounders were significantly related to awareness and vaccination, they were not adjusted for in the logistic regression models, a procedure that is often recommended for analyzing each awareness item separately.

### Table 2: Relationship Between HPV Vaccination and Previous Awareness Levels (0%–100% correct)

<table>
<thead>
<tr>
<th></th>
<th>Not Vaccinated, ( N ) (%)</th>
<th>Vaccinated, ( N ) (%)</th>
<th>Not Vaccinated Mean (SD); Median [95% CI for Mean]</th>
<th>Vaccinated Mean (SD); Median [95% CI for Mean]</th>
<th>Wilcoxon ( P ) value*a</th>
<th>( t ) Test ( P ) value</th>
<th>Exact OR (95% CI)</th>
<th>( R^2 )</th>
<th>AUC (C)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parents</strong></td>
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<tr>
<td>Baseline awareness: 3 mo vaccination</td>
<td>141 (94.63)</td>
<td>8 (5.37)</td>
<td>75% (33%); 100% [88%–90%]</td>
<td>88% (19%); 100% [72%–103%]</td>
<td>.44</td>
<td>.29</td>
<td>4.52 (0.31–25.42)^c</td>
<td>0.0088</td>
<td>0.57</td>
</tr>
<tr>
<td>Baseline awareness: 6 mo vaccination</td>
<td>134 (89.93)</td>
<td>15 (10.07)</td>
<td>75% (33%); 100% [89%–90%]</td>
<td>82% (32%); 100% [94%–99%]</td>
<td>.42</td>
<td>.45</td>
<td>2.02 (0.34–16.74)</td>
<td>0.004</td>
<td>0.56</td>
</tr>
<tr>
<td>Baseline awareness: 12 mo vaccination</td>
<td>129 (87)</td>
<td>20 (13)</td>
<td>74% (33%); 100% [89%–90%]</td>
<td>83% (32) 100% [68%–97%]</td>
<td>.25</td>
<td>.31</td>
<td>2.31 (0.47–14.80)</td>
<td>0.008</td>
<td>0.57</td>
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<tr>
<td><strong>Adolescents</strong></td>
<td></td>
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<tr>
<td>Baseline awareness: 3 mo vaccination</td>
<td>204 (96.68)</td>
<td>7 (3.32)</td>
<td>60% (56%); 75% [55%–65%]</td>
<td>85% (20%); 100% [88%–104%]</td>
<td>.06</td>
<td>.06</td>
<td>17.28 (0.87–999.99)^c</td>
<td>0.02</td>
<td>0.70</td>
</tr>
<tr>
<td>Baseline awareness: 6 mo vaccination</td>
<td>193 (91.47)</td>
<td>18 (8.53)</td>
<td>59% (56%); 75% [54%–94%]</td>
<td>78% (23%); 88% [82%–93%]</td>
<td>.05</td>
<td>.05</td>
<td>4.81 (0.98–30.00)</td>
<td>0.02</td>
<td>0.64</td>
</tr>
<tr>
<td>Baseline awareness: 12 mo vaccination</td>
<td>179 (84.83)</td>
<td>32 (15.17)</td>
<td>58% (35%); 75% [53%–64%]</td>
<td>73% (29%); 75% [62%–93%]</td>
<td>.04</td>
<td>.04</td>
<td>3.42 (1.05–12.25)</td>
<td>0.02</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Vaccinated denotes if adolescent had received at least 1 HPV vaccination after baseline. None of the potential confounder variables were significantly related to awareness and vaccination and were therefore not adjusted for in the model.

*a Wilcoxon = 2-sample test (2 sided) \( P \) value.

*b The C statistics = the AUC.

^c The small vaccination number precludes obtaining accurate OR estimates as indicated by the large 95% CI.
FIGURE 1
Relationship between the predicted probability of vaccination and parents’ awareness.
FIGURE 2
Relationship between the predicted probability of vaccination and adolescents' level of awareness.
groups’ percentage correct, 95% CI, Fisher’s exact tests, Φ correlations, and \( r^2 \); Table 3).

**DISCUSSION**

In this high-risk population, HPV vaccination was unlikely, which demonstrates the need to understand which modifiable factors should be targeted by future interventions. Awareness is modifiable and widely considered a promising target. In response to recent studies suggesting that knowledge may not increase HPV vaccination, it has been argued that it is at least important to increase awareness. But is awareness linked to vaccination?

The adolescents’ awareness levels means were statistically higher for the vaccinated groups than the nonvaccinated group, whereas the parents’ awareness levels means were statistically higher for the vaccinated groups than the nonvaccinated group.
were not significantly different. Regarding magnitude of the relationship, however, this study revealed that neither parental nor adolescent awareness levels were meaningfully related to adolescent vaccination. When analyzing total awareness levels and also each item, the percent of variance in awareness related to vaccination is minimal. In addition, awareness levels did not predict vaccination. The predicted probability of getting vaccinated at each awareness level is low (<0.50), and prediction accuracy was poor for both samples at all time points.

These findings can be considered consistent with several empirically supported causal pathways of behavioral prediction models where there is no necessary relationship between behavior and knowledge or awareness levels.\textsuperscript{32,43–46} Theoretically, vaccination behavior is predicted by whether individuals hold beliefs that promote vaccination, regardless of how much awareness or veracity those beliefs reflect.\textsuperscript{52–45}

It is also worth considering whether provider communication during the clinical encounter may be more important than the patients’ previous level of awareness or knowledge. In other words, regardless of whether patients had low levels of awareness previously, they may be likely to vaccinate when immunization is strongly recommended during a clinic visit and made immediately available. An emergent literature has been raising this possibility\textsuperscript{47–52} and interventions that improve clinician communication may be useful.

Studies using vaccination as the outcome are rare, and almost all of them rely on self-reporting.\textsuperscript{6–10} which is subject to recall bias and shown in other studies to be inaccurate.\textsuperscript{13,53–55} In the current study, many were not able to recall vaccination status accurately (data not shown). It is therefore a strength of this study that outcomes were assessed by using objective vaccination records. Although they may include some inaccuracy, this is unlikely to be a source of bias. It was also judged to be a strength of this study that vaccination was tracked over the course of an entire year, because vaccination frequently occurs during an annual well-child visit.

Although this study uses objective measures of vaccination and a rigorous study design, we do not wish to overstate our findings. Possibly, a different measure of awareness may be associated with vaccination, although this study used the most comprehensive measure of awareness to date. There is potential for unmeasured confounders and results may not be generalizable to other populations. During this study, there were no known historical events (eg, new vaccination campaigns) that would be expected to significantly increase awareness among the study population, but such change is still possible. However, if relatively low baseline levels did increase over time, this change would restrict the range, making the actual relationship with vaccination even smaller.\textsuperscript{26}

CONCLUSIONS
This study investigated the potential influence of awareness because, although there has been widespread interest in its role, its relationship with vaccination has been unclear.\textsuperscript{6–10} In this study, which was powered to detect a meaningful difference, the tests fail to detect substantial relationships. Although the awareness level means are sometimes higher for the vaccinated group than the unvaccinated group, but sometimes similar, the strength of the relationship remains consistently weak, with very little variance explained. Furthermore, awareness did not predict vaccination. The data do not suggest a promising relationship, although one is possible. For this high-risk population where vaccination is rare, evidence-based behavioral interventions are urgently needed. Ideally, interventions will target variables associated with vaccination. Interventions that do not target actual determinants can have no effect or even a “boomerang” effect that increases unhealthy behavior.\textsuperscript{56–59}

ACKNOWLEDGMENTS
We thank David Mandell for his strong support. We also thank anonymous reviewers and Warren Bilker for his advice on the analyses. In addition, we thank the Philadelphia Department of Public Health, Division of Disease Control, for assistance with data collection, and study participants for the data they have provided.

ABBREVIATIONS
AUC: area under the curve
CI: confidence interval
HPV: human papillomavirus
OR: odds ratio
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*Pediatrics* 2016;138;
DOI: 10.1542/peds.2015-2048 originally published online July 20, 2016;
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