Parent and Adolescent Knowledge of HPV and Subsequent Vaccination

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human papillomavirus, HPV, vaccination, immunization, knowledge, beliefs, behavior change, prediction, implementation science, theory-based behavioral interventions

ABBREVIATION

HPV—human papillomavirus

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WHAT'S KNOWN ON THIS SUBJECT: Vaccinating youth is among the nation's highest health care priorities. Despite proven health benefits, human papillomavirus vaccination rates remain low.

WHAT THIS STUDY ADDS: This is the first known study to test whether vaccination of high-risk adolescents is related to their or their parents' previous knowledge levels. In the results presented, neither parental nor adolescent knowledge is related to subsequent adolescent vaccination.

abstract

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OBJECTIVE: Human papillomavirus (HPV) vaccination has been shown to have important health benefits, but vaccination rates are low. Parental and adolescent knowledge could possibly promote vaccination, but the relationship between knowledge and subsequent vaccination is unclear. This study examines how strongly HPV vaccination among high-risk adolescents is related to their or their parents' previous knowledge.

METHODS: A longitudinal cohort study enrolled participants from low-income, predominantly African American neighborhoods. Baseline questionnaires measuring knowledge of HPV and HPV vaccination, as well other variables, were completed by 211 adolescents and 149 parents of another adolescent sample. Adolescent vaccination was tracked prospectively for 12 months after baseline by using clinic reporting data. Analyses tested if parent or adolescent knowledge was associated with or predictive of adolescent HPV vaccination.

RESULTS: On average, parents and adolescents answered slightly less than 50% of knowledge items correctly at baseline, with 5% of parents and 10% of adolescents not answering any knowledge items correctly. Within 12 months, 20 of 149 (13.4%) of the parents' daughters received an HPV vaccination and 32 of 211 (15.2%) of the other adolescent sample did so. Neither parental nor adolescent knowledge was associated with or predictive of adolescent vaccination. For example, when testing the relationship between adolescent vaccination and parental knowledge scores, all R^2 values were <0.005. Results were independent of available potential confounders.

CONCLUSIONS: Those with higher levels of knowledge were not more likely to obtain vaccination for themselves or their daughters. Ideally, future interventions will target factors related to vaccination. *Pediatrics* 2014;134:e1049–e1056

Almost all cervical cancer is caused by infection with the human papillomavirus (HPV), a common sexually transmitted disease.[1] Available HPV vaccines have the potential to dramatically reduce cervical cancer rates.[2] For these reasons, national immunization programs in the United States have recommended HPV vaccination for adolescents.[1] However, vaccination rates have been low.[1,3]

In response, there has been much interest in learning which modifiable factors influence vaccination. Conceivably, knowledge of HPV and HPV vaccination could influence vaccination, and nearly all published studies have measured knowledge.[4–8] As one review of the large HPV vaccine literature concluded, knowledge was "by far the most frequently assessed construct."[4]

However, we are not aware of published studies focused on empirically evaluating if knowledge is related to actual future HPV vaccination in the United States. Among studies that used a longitudinal design to track vaccination, it is unclear if or how knowledge was measured.[9,10] Cross-sectional studies have generated mixed reports as to whether knowledge had a relationship with outcomes, which rarely included actual vaccination.[4–8] Moreover, a cross-sectional study can be misleading because it cannot establish the direction of a possible relationship. If knowledge levels do influence the likelihood of obtaining vaccination, clinical trials to increase knowledge would be warranted, and it may be wise for interventions to focus on education, as has been common practice.[11–14]

The current study tests how strongly knowledge of parents and adolescents is associated with and predictive of future adolescent vaccination. This longitudinal study design allowed us to assess the outcome prospectively and to establish temporality in the relationship between knowledge and vaccination. Because a previous vaccination dose could lead to increased knowledge (eg, from a clinic's informational handout describing the vaccine given), this design has major advantages over cross-sectional studies.

This study is also unique because it was conducted among a high-risk population. Although other studies have enrolled mostly white and well-educated populations,[4–8] this study was conducted in low-income African American communities because they have low rates of HPV vaccination and are disproportionately affected by HPV-associated cancers, including cervical cancer.[3,15,16] African American women have been twice as likely as white women to be diagnosed with cervical cancer and up to 3 times more likely to die of their disease.[17] Among low-income African American urban populations, cervical cancer has accounted for ~25% of cancer deaths,[18] making prevention especially important.

METHODS

Study Design

By using a longitudinal cohort study design, we assessed baseline knowledge among adolescents and parents of a separate adolescent sample. For 12 months, we followed adolescents to examine if receipt of an HPV vaccine was related to their or their parents' baseline knowledge. The study did not include an intervention but it still measured if knowledge changed substantially over time. Such change was not expected but possible given the existence of multiple mass-media and interpersonal modes of knowledge transmission that were not monitored. (For additional study information, see Supplement 1.)

Study Population

This study was conducted in adolescent females and their parents/guardians (referred to as "parents") because both influence the vaccination decision.[19,20] The study enrolled parents who reported meeting all of the following eligibility criteria: (1) a parent of a girl aged 9 to 18 years old who was not vaccinated against HPV, (2) residents of a targeted low-income African American neighborhood, and (3) able to communicate in English. The study population also included adolescents who met criteria 2 and 3 above and were 13 to 18 years and not vaccinated against HPV and did not report being pregnant or breastfeeding.

Adolescent Vaccination

Because vaccinations are commonly administered during well-visits, which are recommended annually, we tracked adolescents for a total of 1 year. The outcome was defined as receipt of at least 1 HPV vaccine dose during a follow-up period for each adolescent who either responded to the questionnaire measuring knowledge themselves or had a parent who did so. Whether each adolescent received at least 1 HPV vaccine dose during a follow-up period was determined by using clinic records tracked through Philadelphia's Kids Immunization Database/Tracking System (KIDS) and Immunization Information System, which require reporting for all vaccinations to the secure, up-to-date electronic database.[21] To determine vaccination status, a deterministic, hierarchical search was performed by using identifying data (including names, dates of birth, and addresses). The Philadelphia Department of Health provided the HPV vaccination status (yes, with dates of immunizations, or no), and transferred back deidentified data.

Knowledge Measured

Self-administered questionnaires included 18 items measuring knowledge of HPV and the HPV vaccine (Supplement 2). Reflecting the domains examined by published studies, items measured the following: (1) health consequences and symptoms of HPV; (2) HPV and cervical screening; (3) HPV causes, risk factors, and transmission; (4) HPV prevalence; and (5) HPV vaccination and cervical cancer prevention.[4–8] The items included statements such as "HPV causes most cases of cervical cancer," and for each item respondents selected "True," "False," or "Don't Know." Items were worded in a clear and brief manner by using language appropriate for a range of literacy levels.

Face and Content Validity

The knowledge items appeared previously in other studies[4–8] and were also judged by a panel of 8 HPV experts to be relevant (eg, representing various facets and potentially sensitive to differences between persons vaccinated versus those not vaccinated).

Discriminant Validity

Discriminant validity was also reported between knowledge items and those measuring subjective constructs ($r<0.55$).

Reliability

The items had high internal consistency (Cronbach's coefficient α = 0.84 and 0.81 for parents and adolescents, respectively), which supported generating a summary score. Similarly, test-retest reliability was high.

Scoring

Correct responses were scored 1, and other responses were scored 0. When generating the summary score, the number of correct items was summed.

Item Analysis

The range of item difficulty (ie, the percentage getting an item correct) spanned 12% to 63% correct for adults and 11% to 70% correct for adolescents. Given the items' high internal consistency and range of item difficulty, they should provide valid discriminations at all knowledge levels.[22]

Additional Variables

Population characteristics (Table 1) included standard demographic characteristics. The available potential confounders specifically included parent age, income, adolescent age, adolescent sexual debut age, and their number of sexual partners.

Statistical Analyses

The analytic goal was to examine how strongly knowledge among independent samples of adolescents and parents was related to future HPV vaccination among adolescents. The primary outcome variables were receipt of a vaccination dose during 3, 6, 9, and 12 months postbaseline follow-up periods. Summary statistics were computed for the primary outcome variables and the baseline knowledge score. For each follow-up period, stratifying by vaccination status, boxplots were used for visually comparing the distribution of knowledge for the vaccinated group versus the nonvaccinated group. To visually examine if knowledge and vaccination had a curvilinear relationship, we plotted for each knowledge level (0–1, 2–3, 4–5, etc) the percentage of persons vaccinated, with 95% confidence limits. We then computed and compared the η correlation coefficient to the Pearson correlation coefficient, and obvious negligible differences would support a noncurvilinear relationship.[23]

To assess the relationship between knowledge scores and vaccination behavior, we used a *t* test, and a logistic regression model (binary logit link) with maximum likelihood estimates, Wald's 95% confidence interval, R^2 statistic, and the C-statistic. The *t* Tests assessed mean differences in the number of correct knowledge items between persons vaccinated and those not vaccinated. From the regression model, an odds ratio was used to describe the magnitude of the likelihood

TABLE 1 Population Characteristics

	Value
Parent/guardian (self-reported by parent), *n*	149
Female gender, *n* (%)	134 (90.5)
African American, *n* (%)	140 (95.2)
Hispanic/Latino, *n* (%)	4 (2.7)
Age, mean ± SD, y	41.7 ± 9.2
Household income, *n* (%)	
<$10 000	48 (36.6)
$10 000–20 000	23 (17.6)
$20 001–30 000	28 (21.4)
$>30 000	32 (24.4)
Household income for neighborhoods, median range, $[a]	13 906–37 714
Daughter received any (non-HPV) vaccine shots since she was 10 y, *n* (%)	99 (76.2)
Adolescent females (self-reported by adolescent), *n*	211
African American, *n* (%)	194 (91.9)
Hispanic/Latino, *n* (%)	11 (5.3)
Age, mean ± SD, y	15.3 ± 1.5
Have had vaginal, anal, or oral sex, *n* (%)	92 (44.0)
Age when first had sex, *n* (%)	
≤13 years	17 (20.5)
14 years	16 (19.3)
15 years	26 (31.3)
≥16 years	24 (28.9)
Number of sex partners, *n* (%)	
1–3	70 (76.9)
4–6	17 (18.7)
>6	4 (4.4)
Currently smokes cigarettes, *n* (%)	10 (4.8)

[a] Reported by the US Census.

of getting a vaccination on the basis of knowledge level, whereas the R^2 statistic describes the percentage of variance in vaccination behavior that can be explained by knowledge level. The area under the receiver operating characteristic curve, or C-statistic, assessed the model's overall prediction accuracy.

We tested all available potential confounders (specified above) by correlating each with the knowledge score and vaccination behavior. Variables related to both knowledge and vaccination would be adjusted for when examining the relationship between knowledge and vaccination. In secondary analyses, we examined (1) if knowledge changed between baseline and follow-up periods by using paired *t* tests and (2) the percentage correct for each knowledge item and the relationship between getting a specific item correct and being vaccinated.

RESULTS

Those who responded to the baseline knowledge questionnaire included 211 adolescents and 149 parents of other adolescents. The adolescents ranged in age from 13 to 18 years, with a mean age of 15 years (SD = 1.5 years). Parents, who were mostly female, ranged in age from 23 to 71 years (mean age = 42 years; SD = 9.2 years) due to older guardian caretakers. All adolescents had received vaccination of some kind in their lifetime, and 76% had received a vaccination since age 10. The sample was characterized as low income and predominantly African American. Table 1 summarizes additional characteristics, including adolescent sexual experience, and other risk factors for HPV.

Knowledge

Among parents, the baseline knowledge scores ranged from 0 to 16, with 5% of parents not answering any questions correctly, with a mean of 7.6 correct answers (SD = 4.4). The adolescents' baseline knowledge scores ranged from 0 to 18, with 10% of adolescents not answering any questions correctly and a mean of 6.4 correct answers (SD = 4.1). For groups of adolescents who did and did not receive an HPV vaccine, the distribution of the parents' knowledge scores was similarly uniform. However, the adolescents' knowledge score distribution of those vaccinated versus not vaccinated varied slightly. During this study, there were no known historical events (eg, new vaccination campaigns or news coverage shifts) that would be expected to change knowledge. Given this, knowledge was not expected to change substantially during follow-up, which was confirmed at 3-month intervals by tracking a subsample of ∼60% of the baseline respondents.

Vaccination

Vaccination status was determined for all adolescents. Among the parents enrolled, 20 of 149 (13.4%) of their daughters received at least 1 HPV vaccination within 12 months. Among the separate sample of adolescents, 32 of 211 (15.2%) received an HPV vaccination within 12 months (Table 2).

Relationship Between Parents' Knowledge and Daughters' Vaccination

Parents' knowledge scores were not curvilinearly related to their daughters' subsequent vaccination status at any time points. None of the potential confounders were significantly related to parent knowledge scores and vaccination for daughters and were therefore not adjusted for in the remaining analyses.

Logistic regression results show that the likelihood of daughters receiving a vaccination was not related to parents' baseline knowledge (Table 3). All R^2 values were negligible, indicating that the variance in knowledge did not explain vaccination behavior. By using *t* tests, the difference between the mean baseline knowledge score of parents whose daughters obtained vaccination and those parents whose daughters did not, during each follow-up period, was not statistically significant (Table 3). Furthermore, vaccination during each follow-up period had very low and often negative correlations with aspects of knowledge and single knowledge items (ranging from $r = -0.11$ to $r = 0.09$).

Relationship Between Adolescents' Knowledge and Vaccination

Adolescent knowledge was not curvilinearly related to vaccination during any follow-up periods. None of the available potential confounder variables were significantly related to adolescent knowledge and HPV vaccination and were therefore not adjusted for in the remaining analysis. The proportion of variance in knowledge related to receiving an HPV vaccination was negligible for each follow-up period (Table 4).

TABLE 2 Number of Individuals Receiving 0 to 3 Shots During Each Follow-up Period

Follow-up period	0 shots	1 shot	2 shots	3 shots
Parents' adolescent daughters (*n* = 149)				
3 mo	141 (94.63)	8 (5.37)	0	0
6 mo	134 (89.93)	13 (8.72)	2 (1.34)	0
9 mo	131 (87.92)	15 (10.07)	3 (2.01)	0
12 mo	129 (86.58)	15 (10.07)	4 (2.68)	1 (0.67)
Additional adolescents (*n* = 211)				
3 mo	204 (96.68)	7 (3.32)	0	0
6 mo	193 (91.47)	17 (8.06)	1 (0.47)	0
9 mo	186 (88.15)	22 (10.43)	3 (1.42)	0
12 mo	179 (84.83)	25 (11.85)	7 (3.32)	0

Data are presented as *n* (%).

TABLE 3 Relationship Between HPV Vaccination Status at 3, 6, 9, and 12 Months and Parents' Baseline Knowledge

Follow-up Time Points	Adolescent Vaccinated at Least Once, *n* (%)	Adolescent Not Vaccinated at Least Once, *n* (%)	Mean (95% CI) Knowledge Scores		*t* Test	*P* value	R^2	Exact Log Reg OR (95% CI)	C-statistic[a]
			Among Those Vaccinated	Among Those Not Vaccinated					
Three-month	8 (5.37)	141 (94.63)	7.13 (2.92–11.33)	7.66 (6.93–0.39)	.33	.74	0.0008	0.97 (0.83–1.15)	0.54
Six-month	15 (10.07)	134 (89.93)	6.80 (4.01–9.59)	7.72 (6.98–8.47)	.77	.44	0.004	0.95 (0.84–1.08)	0.56
Nine-month	18 (12.08)	131 (87.92)	7.28 (4.80–9.75)	7.68 (6.93–8.43)	.36	.72	0.0009	0.979 (0.88–1.10)	0.52
Twelve-month	20 (13.42)	129 (86.58)	7.70 (5.35–10.05)	7.62 (6.87–8.37)	−.08	.94	0.0000	1.004 (0.90–1.12)	0.51

N = 149 parents. "Vaccinated" refers to whether the adolescent had received at least 1 HPV vaccination dose during the follow-up period. CI, confidence interval; Exact Log Reg OR, exact logistic regression odds ratio;.
None of the potential confounder variables were significantly related to knowledge and vaccination behavior and were therefore not adjusted for.
[a] Association between predicted probabilities and observed response. The concordance index (C-statistic) is comparable to the area under the receiver operating characteristic curve.

In each case, the difference between the mean knowledge score in the vaccinated group and the nonvaccinated group was not statistically significant. In terms of the likelihood of obtaining a vaccination on the basis of knowledge scores, results revealed no statistically significant association between knowledge and vaccination during each follow-up period (Table 4). Additionally, vaccination during each follow-up period had low, and often negligible, correlations with aspects of knowledge and single knowledge items (r = −0.09 to 0.16).

Prediction Accuracy

From the observed area under the receiver operating characteristic curve, the ability to predict adolescent vaccination on the basis of parents' knowledge was low (C = 0.53–0.56). The ability to predict adolescents' vaccination status on the basis of their knowledge was also low (C = 0.51–0.63).

DISCUSSION

In this high-risk population, few adolescents received HPV vaccination, highlighting the need to understand which modifiable factors explain why some patients obtain recommended vaccinations, whereas others do not. Although it is conceivable that knowledge is a prerequisite of healthy choices, it has been unclear if knowledge is indeed related to vaccination. In turn, this longitudinal study examined how strongly knowledge is associated with and predictive of subsequent vaccination.

This study found that neither parental nor adolescent knowledge was related to adolescent vaccination, as measured objectively at prospective time points. Some with low knowledge did get vaccinated and others with high knowledge did not get vaccinated, suggesting that, for many, knowledge was neither necessary nor sufficient. Visual inspection of the data did not reveal any relationships, and the measures of association between vaccination and knowledge scores, as well as single knowledge items, were very low. Additionally, knowledge did not predict vaccination. Prediction accuracy, based on the association between the predicted probability of vaccination and the observed response, was very near 0.50, indicating an essentially random chance (eg, by coin flip) of predicting future vaccination on the basis of knowledge levels.

The current findings need not be viewed as negating data from surveys, such as the National Immunization Survey–Teen, in which knowledge levels were not actually measured.[24] Respondents who report, for example, wanting more information,[24] cannot be assumed to have low knowledge levels, because these are distinct constructs. (Individuals with low knowledge levels can lack interest in learning more. Those with higher levels can express interest in learning even more.) Neither the National Immunization Survey study nor ours tested whether increasing knowledge levels will improve vaccine acceptance, but several other studies testing this possibility have not shown an effect.[8,25–31] Collectively, these results do not suggest that knowledge is a primary determinant of vaccination.

More generally, the current findings are consistent with the causal pathways of the most extensively validated behavioral prediction models, such as the Theory of Reasoned Action and Theory of Planned Behavior. In these models, correct factual information plays no direct role and is considered generally immaterial to behavioral prediction.[32] Many studies of several health behaviors also find knowledge to be unrelated.[32] For example, given small effect sizes relating HIV/AIDS knowledge and condom use, meta-analyses have reasoned that knowledge does not influence safe sex behavior and

TABLE 4 Relationship Between HPV Vaccination Status at 3, 6, 9, and 12 Months and Adolescents' Baseline Knowledge

Follow-up Time Points	Adolescent Vaccinated at Least Once, *n* (%)	Adolescent Not Vaccinated at Least Once, *n* (%)	Mean (95% CI) Knowledge Scores		*t* Test	*P*	R^2	Exact Log Reg OR (95% CI)	C-statistic[a]
			Among Those Vaccinated	Among Those Not Vaccinated					
Three-month	7 (3.32)	204 (96.68)	8.14 (5.10–11.18)	6.33 (5.77–6.89)	−1.17	.25	0.006	1.12 (0.92–1.36)	0.63
Six-month	18 (8.53)	193 (91.47)	6.56 (4.86–8.26)	6.37 (5.79–6.96)	−.18	.86	0.0001	1.01 (0.90–1.14)	0.51
Nine-month	25 (11.85)	186 (88.15)	7.20 (5.74–8.66)	6.28 (5.68–6.87)	−1.07	.29	0.0054	1.057 (0.95–1.18)	0.56
Twelve-month	32 (15.17)	179 (84.83)	7.03 (5.81–8.24)	6.27 (5.66–6.89)	−.97	.33	0.0045	1.047 (0.954–1.149)	0.55

N = 211 adolescents. "Vaccinated" refers to whether the adolescent had received at least 1 HPV vaccination dose during the follow-up period. CI, confidence interval; Exact Log Reg OR, exact logistic regression odds ratio.
None of the potential confounder variables were significantly related to knowledge and vaccination behavior and were therefore not adjusted for.
[a] Association between predicted probabilities and observed response. The concordance index (C-statistic) is comparable to the area under the receiver operating characteristic curve.

that knowledge is not the most appropriate focus for safer sex interventions.[33] Instead, beliefs, whether factually accurate or not, are viewed as influencing behavior. For example, normative beliefs about who approves/disapproves of HPV vaccination may be more influential than knowledge levels.[6,20,34] Fortunately, beliefs are modifiable and, in turn, theory-based interventions can successfully change behavior by targeting specific beliefs of import that underlie perceived norms, self-efficacy, or attitudes.[35]

The current findings also provide an opportunity to consider how it can be logically problematic to assume a direct relationship between knowledge and behavior. As a case in point, consider individuals agreeing with the factually incorrect statement that "women will never need Pap tests if they get the HPV shot." Agreement, although factually incorrect, reflects a belief that promotes vaccination. At the same time, individuals can agree with a factually correct statement (about vaccination cost or side effects, for example) that may discourage vaccination. Instead of evaluating factual accuracy, it is more relevant to behavioral prediction to consider whether agreement or disagreement with a statement encourages or discourages a behavior.[32] Beliefs that predict vaccination (and are ethical to disseminate) can be promoted by interventions.

Determining which specific facts can support a belief of import is also an empirical matter that can be considered. A particular fact does not necessarily strengthen a belief that influences a healthy behavior; it can actually weaken the belief or have no relationship.[32] Future research can determine if some facts help strengthen beliefs influencing HPV vaccination, and these findings can inform public health messages.

In this study, the outcome, actual vaccination, was objectively measured rather than self-reported. Most studies have not measured vaccination, and almost all that did have measured self-reported vaccination,[4–8] which is subject to recall bias and shown in other vaccine studies to be inaccurate.[10,36–38] Clinic records were also preferable because many in this study were not able to accurately report their vaccination status (data not shown). Despite the official records, some inaccuracy is possible, although it is not likely to be a source of bias. In addition, the relationship between knowledge and vaccination intention should be considered when developing interventions, because intentions are necessary (although not sufficient) for voluntary immunization.

Future studies can address several other current limitations. For example, although this study focuses on a population disproportionately affected by HPV-related disease burden, the findings may not be generalizable to others (eg, male adolescents). This study used an extensive measure of knowledge that displayed sound measurement characteristics and included items commonly used in studies,[4–8] but it is possible that if additional knowledge items were included, an association may have been detected. Future studies can also evaluate additional potential confounders. The study design tracked adolescents over 12 months because vaccinations are common during annual well-visits, but future studies can also include longer follow-up periods.

CONCLUSIONS

In summary, this longitudinal study tested if knowledge levels were related to subsequent HPV vaccination. Among a high-priority population, knowledge was neither associated with nor predictive of adolescent vaccination. Due to the limitations of a single study, additional research should consider various study designs and populations. Future studies should identify which modifiable factors discriminate between those who do and do not vaccinate so that interventions can target them. Given that public health campaigns and other communication interventions can relay only a limited set of messages, it is important to determine the extent to which they should continue to focus resources on knowledge transmission. Fortunately, numerous studies about other health behaviors have documented the positive impact of evidence-based communication interventions.[35,39,40]

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