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RESEARCH PAPER

Disparities in collaborative patient-provider communication about human papillomavirus (HPV) vaccination

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ABSTRACT

Background. Healthcare providers may vary their communications with different patients, which could give rise to differences in vaccination coverage. We examined demographic disparities in parental report of collaborative provider communication and implications for human papillomavirus (HPV) vaccination. **Methods.** Participants were 4,124 parents who completed the National Immunization Survey-Teen about daughters ages 13–17. We analyzed disparities in collaborative communication (mutual information exchange, deliberation, and decision) and whether they mediated the relationship between demographic characteristics and HPV vaccine initiation. **Results.** Half of parents (53%) in the survey reported collaborative communication. Poor, less educated, Spanish-speaking, Southern, and rural parents, and parents of non-privately insured and Hispanic adolescents, were least likely to report collaborative communication (all $p < .05$). These disparities in communication accounted for geographic variation in HPV vaccination, specifically, the higher rates of uptake in the Northeast versus the South (mediation $z = 2.31$, $p < .01$) and in urban/suburban vs. rural areas (mediation $z = 2.87$, $p < .01$). These disparities were also associated with vaccination among subgroups with relatively high coverage, minimizing what could have been even higher uptake among Hispanic compared to non-Hispanic white adolescents (mediation $z = -3.04$, $p < .01$) and non-privately versus privately insured adolescents (mediation $z = -3.67$, $p < .001$). Controlling for provider recommendation attenuated some of these associations (but all $p < .10$). **Conclusions.** Collaborative communication showed widespread disparities, being least common among underserved groups. Collaborative communication helped account for differences—and lack of differences—in HPV vaccination among some subgroups of adolescent girls. Leveraging patient-provider communication, especially for underserved demographic groups, could improve HPV vaccination coverage.

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Introduction

National guidelines in the United States recommend that 11- and 12-year-old adolescents routinely receive human papillomavirus (HPV) vaccine,¹ but the nation has failed to meet any of its HPV vaccination goals. As of 2014, completion of the 3-dose series was only 40% among adolescent females and 22% among adolescent males.² Substantial portions of the adolescent population remain at risk for contracting HPV vaccine-preventable diseases, including genital warts, cervical cancer, and other anogenital cancers.³

Healthcare providers play a unique role in encouraging HPV vaccination. One well-developed line of research shows higher HPV vaccination coverage among adolescents whose parents report a recommendation for vaccination from a physician or other healthcare provider. For example, in a study of 2,727 parents, HPV vaccination was 49% among children whose parents had received a recommendation that their child get HPV vaccine compared to 34% among those whose parents had not.⁴ Reasons for the impact of provider recommendation

include that physicians and nurses are among the most trusted professions,⁵ and the availability of the vaccine at most providers' offices minimizes many other barriers.

In addition, how a healthcare provider makes the HPV vaccination recommendation may matter. Indeed, HPV vaccination rates are higher among children of parents who reported higher-quality discussions (i.e., with strong endorsement, encouraging same-day vaccination, and including a cancer prevention message) with their provider about the vaccine compared to patients with lower-quality recommendations.⁶ An understudied area is the extent to which communication about the vaccine is collaborative. In the current study, we use the Charles and Gafni framework^{7–9} to conceptualize collaborative communication as including 3 components: information exchange, deliberation, and decision. *Information exchange* is discussion between patients and providers about healthcare information, attitudes, and priorities. *Deliberation* is having adequate opportunity for patients and providers to talk and think about healthcare options. *Decision* is the joint contribution of both patients and

providers to selecting the course of action. Little is known about how collaborative communication operates in vaccination decisions across demographic groups.

For the current study, we developed 2 hypotheses. First, we hypothesized that traditionally underserved populations would be least likely to receive collaborative communication, based on previous research on disparities in patient-provider communication around other healthcare options.^{11,12} Second, we hypothesized that disparities in collaborative patient-provider communication could help explain differences in HPV vaccination coverage, as shown in Fig. 1. We examined these hypotheses in a large population-based survey of US parents, using clinician-verified data on HPV vaccination for their adolescent daughters.

Results

Most households in the sample were in urban/suburban areas (85%) and had incomes at or above the federal poverty level (78%) (Table 1). The majority of girls were non-Hispanic white (61%) and had private health insurance (62%). Overall, 49% of girls (2,096/4,124) had initiated HPV vaccination.

Disparities in collaborative communication

About half of parents (53%) reported that their daughters' providers used collaborative communication when discussing HPV vaccination. Collaborative communication was less common among respondents from traditionally underserved geographic areas than other areas (Table 2). Parents were more likely to report collaborative communication if they did not live in the South, though the difference was statistically significant only when comparing the Northeast to the South (57% vs. 49%, odds ratio [OR]=1.38, 95% confidence interval [CI]=1.06–1.81). In addition, parents were more likely to report collaborative communication if they lived in urban/suburban households compared to rural households (54% vs. 45%, OR=1.44, 95% CI=1.13–1.83).

Collaborative communication was also less common among other traditionally underserved demographic groups (Table 2). For example, reports of collaborative communication were less common for girls who lived in households below the poverty level than at or above (44% vs. 55%, OR=0.66, 95% CI=0.48–0.89) and for girls whose mothers had not attended college than those who had (48% vs. 55%, OR=0.74, 95% CI=0.59–0.94). Collaborative communication was also less common for respondents who took the survey in Spanish than in English, for Hispanic than for non-Hispanic white girls, and for girls

without private health insurance than with private health insurance (all $p < .05$).

In multivariate analysis, census region, urbanicity, and race/ethnicity continued to demonstrate associations with collaborative communication (all $p < .05$) (data not shown). When controlling for provider recommendation, urbanicity and race/ethnicity continued to demonstrate associations with collaborative communication (both $p < .05$) (data not shown).

Collaborative communication as a mediator

We examined whether collaborative communication explained the association between demographic characteristics and HPV vaccination using mediation analysis to fit the model shown in Fig. 1. The first step was to examine the *a* path, the associations between demographic characteristics and collaborative communication. These findings appear in detail in the previous section. The second step was to examine the *b* path, the association between collaborative communication and HPV vaccination. Girls whose parents reported that providers used collaborative vs. non-collaborative communication were much more likely to have initiated HPV vaccination (66% vs. 31%, OR=4.70, 95% CI=4.12–5.36).

The final step was to examine the *c* and *c'* paths, the associations between demographic characteristics and HPV vaccination before and after controlling for collaborative communication. Two general patterns of mediation emerged. The first pattern of mediation, called simple mediation, showed that disparities in collaborative communication contributed to geographic disparities in HPV vaccination. Girls living in the Northeast census region were more likely to receive HPV vaccines than girls living in the South (*c* path estimate=0.37) (Table 3). Controlling for collaborative communication reduced the size of this association (to *c'* path estimate=0.29) by an amount that was statistically significant (mediation $z=2.31$, $p < .01$). Thus, collaborative communication partly explained why living in the Northeast was associated with higher vaccination than living in the South. We found a similar pattern of mediation for urban/suburban versus rural areas, with collaborative communication explaining a portion of this association (mediation $z=2.87$, $p < .01$).

The second pattern of mediation, called suppression, showed that disparities in collaborative communication offset differences in HPV vaccination that would have otherwise been larger. Girls living in households below the poverty level were marginally more likely to receive HPV vaccines than girls living in households at or above the poverty level (*c* path estimate=0.31)

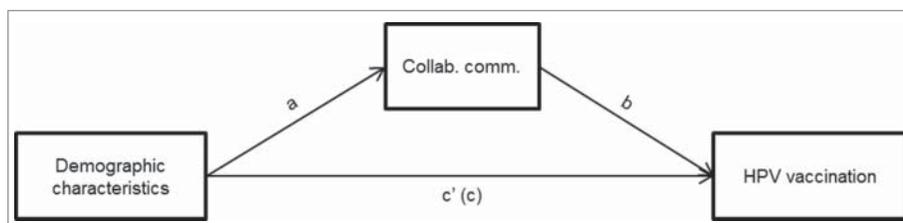


Figure 1. Conceptual model of hypothesized relationships between demographic characteristics, collaborative communication ("Collab. comm."), and HPV vaccination (receipt of first of 3-dose series).

Table 1. Adolescent, parent, and household characteristics of female participants in National Immunization Survey (NIS) - Teen, Parental Attitudes Module, 2010 ($n=4,124$).

	N	%
Household characteristics		
Census region		
South	1,461	36.1
Midwest	922	22.1
Northeast	849	18.2
West	892	23.5
Urbanicity		
Rural	967	15.3
Urban/suburban	3,157	84.7
Poverty level		
At or above	3,387	77.7
Below	576	17.2
Parent characteristics		
Maternal education		
At least some college	2,959	63.7
High school graduate or less	1,165	36.3
Preferred language for survey		
English	3,915	94.2
Spanish	172	5.8
Adolescent characteristics		
Race/ethnicity		
Non-Hispanic white	2,856	61.4
Non-Hispanic black	417	15.0
Hispanic	519	15.9
Other	332	7.7
Age		
13–14 y	1,719	39.1
15–17 y	2,405	60.9
Private insurance		
Yes	2,802	62.4
No	1,322	37.6

Note. Frequencies are unweighted; proportions are weighted.

(Table 3). Controlling for collaborative communication made this association stronger (to c' path estimate=0.53) by an amount that was statistically significant (mediation $z=-2.59$, $p<.01$). In other words, poverty was associated with higher vaccination, but this was partially offset by the deleterious effect of less collaborative communication with poor parents. We found a similar pattern of findings for vaccination by lower vs. higher maternal education (mediation $z=-2.38$, $p<.05$), taking the survey in Spanish versus English (mediation $z=-2.15$, $p<.05$), Hispanic vs. non-Hispanic white race/ethnicity (mediation $z=-3.04$, $p<.01$), and not having versus having private health insurance (mediation $z=-3.67$, $p<.001$).

Controlling for provider recommendation led to similar but, in some cases, weaker findings. Collaborative communication continued to mediate the association of HPV vaccination with Hispanic vs. non-Hispanic white race/ethnicity (mediation $z=-2.94$, $p<.05$) and not having vs. having private health insurance (mediation $z=2.28$, $p<.05$). The mediating effect of collaborative communication became marginally statistically significant for the association of HPV vaccination with living in an urban/suburban area (mediation $z=1.91$, $p<.10$), living in poverty (mediation $z=1.83$, $p<.10$), and taking the survey in Spanish (mediation $z=-1.40$, $p<.10$).

Collaborative communication as a moderator

Two demographic characteristics modified the association of collaborative communication with HPV vaccine initiation.

Table 2. Bivariate associations of demographics with collaborative communication, in National Immunization Survey (NIS) - Teen, Parental Attitudes Module, 2010 ($n=4,124$).

	n/N	%	OR	95% CI
Household characteristics				
Census region				
South	768/1,461	49.2	(ref)	
Midwest	485/922	52.0	1.12	(0.88–1.43)
Northeast	505/849	57.2	1.38	(1.06–1.81)*
West	462/892	55.3	1.28	(0.89–1.85)
Urbanicity				
Rural	450/967	45.0	(ref)	
Urban/suburban	1,770/3,157	54.1	1.44	(1.13–1.83)**
Poverty level				
At or above	1,853/3,387	54.6	(ref)	
Below	282/576	44.1	0.66	(0.48–0.89)**
Parent characteristics				
Maternal education				
At least some college	1,653/2,959	55.4	(ref)	
High school graduate or less	567/1,165	48.0	0.74	(0.59–0.94)*
Preferred language for survey				
English	2,123/3,915	54.0	(ref)	
Spanish	82/172	36.5	0.49	(0.26–0.93)*
Adolescent characteristics				
Race/ethnicity				
Non-Hispanic white	1,595/2,856	56.8	(ref)	
Non-Hispanic black	208/417	50.2	0.77	(0.55–1.07)
Hispanic	246/519	41.5	0.54	(0.37–0.79)**
Other	171/332	47.8	0.70	(0.45–1.07)
Age				
13–14 y	909/1,719	51.7	(ref)	
15–17 y	1,311/2,405	53.3	1.07	(0.85–1.35)
Private insurance				
Yes	1,592/2,802	57.1	(ref)	
No	628/1,322	45.4	0.63	(0.49–0.79)***

Note. OR=odds ratio; CI=confidence interval; ref=reference group. Frequencies are unweighted; proportions and odds ratios are weighted.

* $p<.05$; ** $p<.01$; *** $p<.001$

First, the relationship between collaborative communication and HPV vaccination differed by urbanicity ($p=.02$), such that the absolute difference in HPV vaccination associated with collaborative communication was larger for girls living in rural areas (46%, 95% CI=39–55%) than for girls living in urban/suburban areas (33%, 95% CI=27–39%) (Fig. 2A). Second, the relationship between collaborative communication and HPV vaccination differed by race/ethnicity ($p=.01$), such that the absolute difference in HPV vaccination associated with collaborative communication was larger for non-Hispanic white girls (44%, 95% CI=38–49%) than for non-Hispanic black girls (16%, 95% CI=1–31%), and the difference for the remaining 2 groups did not differ from either (Hispanic: 40%, 95% CI=21–58%; other: 18%, 95% CI=-4–39%) (Fig. 2B).

Discussion

We found stark disparities in reports of collaborative patient-provider communication about HPV vaccination among a national sample of parents of adolescents. These disparities were present for almost every indicator of being underserved that we assessed: living in the South and in rural areas, and being poor, less educated, Spanish-speaking, Hispanic, and publicly insured. Furthermore, these disparities in communication either contributed to geographic differences in vaccination or weakened what would have otherwise been more positive trends in vaccination among disadvantaged groups. In

Table 3. Effects of controlling for collaborative communication as a mediator of the relationship between demographics and HPV vaccine initiation, in National Immunization Survey (NIS) - Teen, Parental Attitudes Module, 2010 ($n=4,124$).

	c path (Total effect)	c' path (Direct effect)	Mediation
	est (SE)	est (SE)	z
Household characteristics			
Census region (ref: South)			
Midwest	0.14 (0.13)	0.11 (0.13)	0.89
Northeast	0.37 (0.14)**	0.29 (0.15)*	2.31**
West	0.42 (0.19)*	0.38 (0.23)	1.30
Urbanicity (ref: rural)	0.18 (0.12)	0.08 (0.12)	2.87**
Poverty level (ref: at or above)	0.31 (0.16)	0.53 (0.18)**	-2.59**
Parent characteristics			
Maternal education (ref: at least some college)		0.31 (0.14)*	-2.38*
Preferred language (ref: English)	0.90 (0.33)**	1.33 (0.37)**	-2.15*
Adolescent characteristics			
Race/ethnicity (ref: non-Hispanic white)			
Non-Hispanic black	-0.13 (0.17)	-0.04 (0.19)	-1.56
Hispanic	0.26 (0.20)	0.56 (0.24)*	-3.04**
Other	0.03 (0.22)	0.19 (0.29)	-1.63
Age (ref: 13-14)	0.39 (0.12)**	0.47 (0.13)**	0.58
Private insurance (ref: yes)	0.10 (0.12)	0.30 (0.14)*	-3.67***

Note. est=coefficient estimate; SE=standard error; ref=reference group.

* $p<.05$, ** $p<.01$, *** $p<.001$

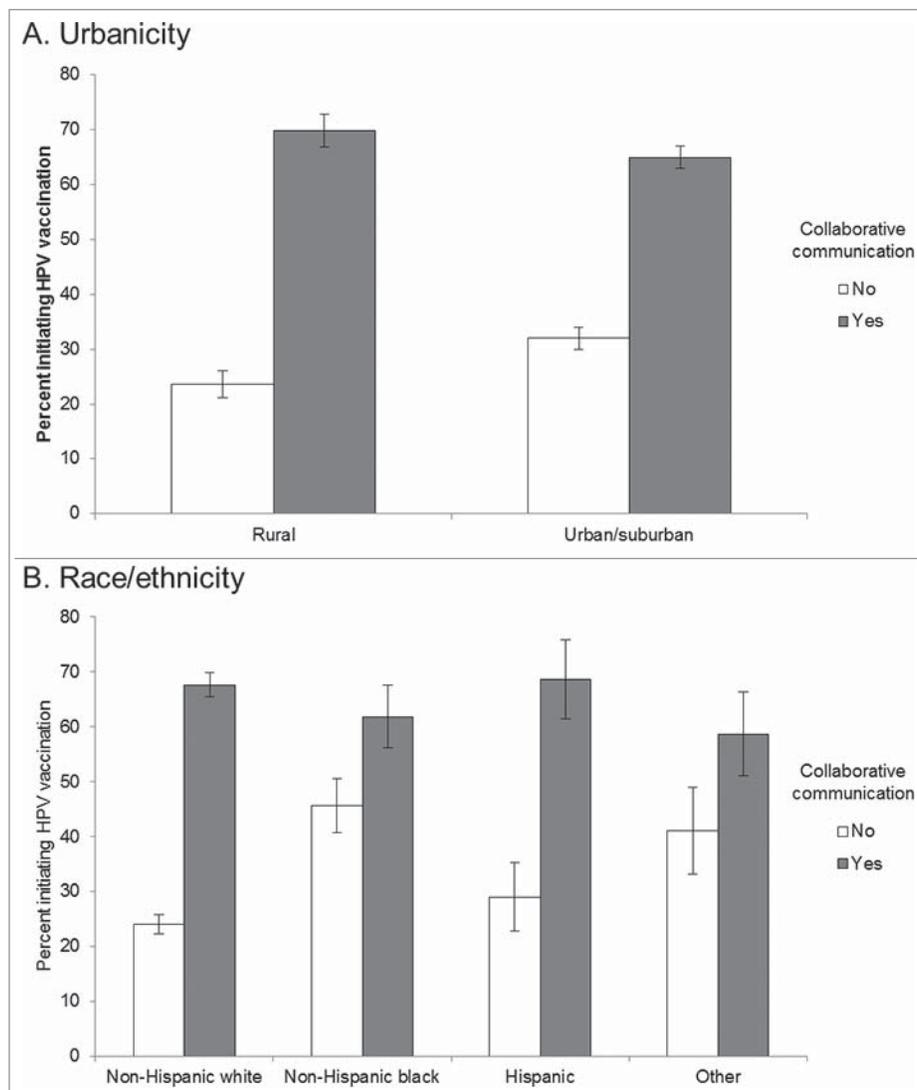


Figure 2. Relationships between (A) urbanicity and (B) race/ethnicity and HPV vaccine initiation, depending on whether parents report collaborative communication with healthcare providers. Error bars show 95% confidence intervals.

addition, we found that the strength of the effect of collaborative communication was particularly high for non-Hispanic white girls and girls living in rural areas, reinforcing the potential power of collaborative communication to overcome other barriers to vaccination faced by girls in these groups. Overall, collaborative communication was positively associated with HPV vaccination.

Our finding that traditionally underserved demographic groups experienced less collaborative communication mirrors previous findings of similar disparities in provider communication.^{11,12} Explanations for these inequities include providers' assumptions about the most effective mode of communication,¹³ difficulties with cross-cultural communication,¹⁴ and, in some cases, patient preferences.^{9,15} In promoting health equity, the ideal outcome would be increasing and equalizing opportunities for vaccination across subgroups, regardless of communication style.¹⁶ Yet the research literature is not yet settled on the benefits and drawbacks of collaborative patient-provider communication about vaccines. Some research studies have suggested that a presumptive approach, treating vaccination as routine and something that will happen as a matter of course during the healthcare visit, is best at encouraging vaccination.^{17,18} Other correlational studies report evidence of the benefits of a shared approach for vaccination,^{10,19} though a recent randomized trial found that a shared approach did not improve vaccination attitudes.²⁰ Similarly, in this study, we found that collaborative (or shared) communication style was associated with the highest rates of HPV vaccination, with particularly strong positive associations for rural and non-Hispanic white girls. A synthesis of the 2 seemingly opposing approaches could be this: a presumptive approach may be the best way to open vaccination discussions, and providers can shift to a shared approach with parents who ask for more information. Clearly, more research is needed to understand the relationship between patient-provider communication and vaccination, especially in different contexts.

Our mediation analyses found that collaborative communication helped to explain geographic variation in HPV vaccination rates, specifically across census regions and by urbanicity. Notably, previous research has shown that vaccination is least common in areas, such as the South, where HPV-attributable cancer rates are highest,²¹ which could indicate the potential for widening geographic cancer disparities in the coming decades. Differences in patient-provider communication by census region and urbanicity could reflect differences in provider training²² or cultural or class differences between providers and their patients.^{12,14} However, national programs training healthcare providers in how to discuss HPV vaccination (e.g., ref. 23) should minimize these regional differences in communication, so additional studies are needed to understand why the patterns we observed in the current study emerged. However, more collaborative patient-provider interactions could help overcome these disparities in vaccination and vaccine-preventable outcomes, but future studies are needed to evaluate the promise of interventions that aim to change communication style.

In addition, we found that collaborative communication had a suppressive effect on the relationships between demographic groups that traditionally have been medically underserved^{24,25} and HPV vaccination. For example, Hispanic girls and girls

whose parents completed NIS-Teen in Spanish were more likely to initiate HPV vaccination than their counterparts, despite their being less likely to receive collaborative communication. Controlling for communication made their vaccination advantage even stronger. Similarly, girls who lived in poorer households, with lower maternal educational achievement, and without private insurance were more likely to be vaccinated than their counterparts, and controlling for communication made their advantage even stronger. The implications of these findings are 2-fold. First, providers' more frequent use of collaborative communication with other groups (those that are not underserved) could have helped to overcome some of their other barriers to vaccination, such as higher levels of vaccine hesitancy.^{26,27} Second, employing collaborative communication with underserved groups when discussing HPV vaccines could confer even more benefit to them, thereby potentially leading to even higher uptake and greater protection from cancers that disproportionately affect them.²⁸⁻³²

These findings have implications for both public health and clinical practice. Based on the current findings, we can hypothesize that if providers used the same communication styles for all demographic groups, the differences in vaccination by indicators of being medically underserved would be even more dramatic. Previous studies have reported parity or minimal differences in HPV vaccination along traditional disparity axes (e.g., race, socioeconomic status), including in the dataset from which the current study drew.^{33,34} Public health researchers should investigate further how patient-provider communication can reduce or preempt disparities in health behaviors, and how these patterns vary across groups, including with randomized controlled trials and longitudinal studies. In addition, these findings point to the potential benefit of greater training for healthcare providers and trainees in the most effective ways to discuss vaccination with adolescents and their parents. For example, as discussed above, a 2-step approach to vaccination communication (beginning with a presumptive approach and then, moving to a collaborative approach as needed) could be particularly effective in establishing HPV vaccination as normative and meeting the informational needs of parents. Although replication and experimental support are needed, the current analysis suggests that communication style can help improve both overall levels of vaccination and levels of uptake within vulnerable populations.

Study strengths include that we used data from a nationally-representative sample with provider verification of vaccination.³⁵ Our analytic sample was relatively large, allowing us to conduct complex mediation and moderation analyses. Study limitations include that data collection occurred in 2010; since that time, HPV vaccination coverage nationally has increased somewhat,² and national guidelines have begun recommending routine vaccination in adolescent males.³⁶ Thus, the context in which vaccination takes place has changed, although similar differences in HPV vaccination by adolescent age, race/ethnicity, and poverty persist.² Additionally, our operationalization of non-collaborative communication likely includes distinct communication styles (e.g., directive communication, poor collaborative communication) that could obscure the study findings. Future studies should use qualitative and observational methods, as well as experimental designs, to clarify different

communication styles and their unique relationships with adolescent vaccination. In our examination of communication about HPV vaccination, we focused on healthcare providers and parents, without incorporating the experiences of adolescent patients; future studies should examine the triadic influences of providers, parents, and patients. Finally, our study was cross-sectional, limiting our ability to make causal inferences and suggesting caution when interpreting the mediational analyses.

In conclusion, we found extensive disparities in parental reports of collaborative patient-provider communication about HPV vaccines, and these disparities helped to explain the small differences in HPV vaccine initiation seen across some demographic groups. Specifically, the relatively higher rates of HPV vaccination among Hispanic and low socioeconomic status girls compared to non-Hispanic white and high socioeconomic status girls could have been even larger if they had equally received collaborative communication from their providers. Additional studies are needed to clarify these relationships in order to make causal inferences about these associations in advance of the development of training programs for providers. In this way, public health researchers and clinicians may be able to use patient-provider communication style to improve vaccination coverage and protect more adolescents from developing HPV vaccine-preventable diseases.

Materials and methods

Data source

The National Immunization Survey (NIS)-Teen is an annual, population-based survey that estimates national coverage of adolescent vaccination.³⁵ The survey has 2 steps: (1) phone interviews with caregivers (hereafter called “parents”) of 13- to 17-year-old children (administered in English or in Spanish), and (2) written questionnaires sent to adolescents’ primary care providers. In the final 2 quarters of 2010, the NIS-Teen phone interview included the Parental Attitudes Module (PAM), a supplementary set of items assessing parents’ attitudes and experiences around vaccination, including patient-provider communication. Because data collection occurred in 2010, before the introduction of a national recommendation for routine HPV vaccination among males,³⁶ we limited our analysis to adolescent females. We excluded from analysis any participant with missing data on all items about patient-provider communication about HPV vaccines ($n=8$), for a final analytic sample of 4,124 parents of adolescent girls.

The National Center for Health Statistics (NCHS) Research Ethics Review Board (ERB) approved data collection for NIS-Teen. Analysis of de-identified data from the survey is exempt from federal regulations for the protection of human research participants. Analysis of restricted data through the NCHS Research Data Center is also approved by the NCHS ERB. The Institutional Review Board at the University of North Carolina exempted this study from review.

Measures

Predictors. NIS-Teen has reported that HPV vaccination is higher among adolescents who are Hispanic (compared to

non-Hispanic white) and who live below the poverty level (compared to at or above the poverty level).³³ Other studies have also reported differences by demographic characteristics.^{34,37–41} Using data from the main NIS-Teen phone interview,³⁵ we focused our analysis on predictor variables that included household (census region, urbanicity, and poverty [compared to 100% of the federal poverty level]), parent (maternal education and preferred language to complete the survey), and adolescent characteristics (race/ethnicity, age at the time of the interview, and private health insurance status).

Mediator. In the PAM of NIS-Teen, parents answered items mapping on to the 3 constructs described in the Charles and Gafni framework.^{7–9} Items began with “At visits made for [teen name]’s vaccinations, did [his/her] healthcare provider...” and concluded with “...talk to you about HPV shot?” (information exchange); “...give you enough time to discuss the HPV shot?” (deliberation); and “...play a role in your decision to get [teen name] vaccinated or not to get [teen name] vaccinated with the HPV shot?” (decision).³⁵ We created an indicator variable reflecting whether parents reported collaborative communication, coding communication as 1 if they responded yes to all 3 items (*collaborative communication*) and as 0 if they responded with any other option (no, don’t know, or refused) to any item (*non-collaborative communication*). We examined other coding options which yielded similar findings (data not shown).

Outcome. The NIS-Teen³⁵ included written questionnaires sent to adolescents’ healthcare providers, who reported on HPV vaccine initiation (receipt of the first dose of the 3-dose HPV vaccine series).

Control variable. Because previous research studies have highlighted the singular influence of a provider recommendation for HPV vaccination,^{37,42,43} our final analyses controlled for this variable. Parents reported provider recommendation in the PAM of NIS-Teen³⁵ with one item: “At visits made for [teen name]’s vaccinations, did [his/her] healthcare provider recommend the HPV shot?” We coded provider recommendation as 1 if parents responded yes, and 0 if they responded with any other option (no, don’t know, or refused).

Analytic strategy

First, we examined differences in collaborative patient-provider communication by conducting bivariate logistic regressions for the association between each demographic characteristic and collaborative communication. We conducted 2 additional analyses to supplement the findings of our bivariate models: (1) a multivariate logistic regression model to examine the simultaneous association between all demographic characteristics and collaborative communication, and (2) a multivariate logistic regression model to examine these associations, controlling for provider recommendation.

Next, we conducted analysis of collaborative communication as a mediator, which involves fitting 3 regression models for each pathway of interest.⁴⁴ In the first model, we examined the association between demographic characteristics and collaborative communication (that is, the bivariate logistic regressions described above) (*a* path in Fig. 1). In the second model, we examined the total association between each demographic characteristic and HPV vaccination (*c* path in Fig. 1). In the

third model, we examined the direct association between each demographic characteristic and HPV vaccination (c' path in Fig. 1), controlling for collaborative communication. This model also involves the estimation of the b path in Fig. 1, or the association between collaborative communication and HPV vaccination. We evaluated the change between the total and direct associations (the $c - c'$ paths) by using a z test for mediation analysis with categorical variables, using the approach of Iacobucci.⁴⁵ Then, we repeated these analyses controlling for provider recommendation.

Finally, as an exploratory analysis, we examined collaborative communication as a moderator of the association between demographic characteristics and HPV vaccination. We ran separate models that included each demographic characteristic, the indicator for collaborative communication, and a multiplicative interaction term. For each model, we examined the Wald chi-square statistic for the interaction term, and if it indicated statistical evidence for a moderated effect ($p < .05$), we probed the interaction.

We implemented analyses in SAS version 9.2 (Cary, NC). We used a 2-tailed critical p value of .05. Analyses incorporated sampling weights developed by NIS-Teen staff; we report unweighted frequencies and weighted proportions and odds ratios.

Disclosure of potential conflicts of interest

JLM, MBG, and BKR have no conflicts of interest to disclose. NTB has served on paid advisory boards or received research grants from Merck and GlaxoSmithKline. These entities had no role in the study design, data analysis, or reporting of the results.

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Notes on contributors

The research in this article was conducted while JLM was a Special Sworn Status researcher of the US Census Bureau at the Center for Economic Studies. All results have been reviewed by the National Center for Health Statistics to ensure that no confidential information is disclosed. Research results and conclusions expressed are those of the authors and do not necessarily reflect the views of the National Cancer Institute or the National Center for Health Statistics.

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