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Regional variations in HPV vaccination among 9–17 year old adolescent females from the BRFSS, 2008–2010

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Abbreviations: HPV, human papillomavirus; BRFSS, Behavioral Risk Factor Surveillance System.

Human papillomavirus (HPV) vaccine uptake among 18–26 y old women varies by geographic region in the US. However, little is known about regional variations in vaccination among girls who are in the vaccine's targeted age groups. Regional variation in HPV vaccination among female adolescents (9–17 y old) was examined using cross-sectional data from the Behavioral Risk Factor Surveillance System (BRFSS) between 2008 and 2010. Multivariable logistic regression estimated the association of region of residence (10 states included questions about adolescent HPV vaccination) with uptake and completion of the 3-shot HPV vaccine series. Among 7,849 adolescents, 26.9% initiated, and 55.2% of initiators completed the series. Adolescents from Northeast/Midwest/West states were 1.74 (95% CI: 1.45-2.10) times more likely to have initiated HPV vaccination compared to the South/Southwestern states. Among initiators, vaccine series completion did not vary significantly between the South/Southwestern and Northeast/Midwest/West states. Flu vaccination was associated with increased odds of initiation in both regions and completion of the HPV vaccine series in the South/Southwestern states only. Girls 9–10 and 11–12 y old were less likely to have initiated and 11–12 y olds were less likely to have completed the HPV vaccine series compared to 13–17 y olds. The observed regional variations in vaccination could cause rates of cervical cancer to remain higher in the South/Southwest and widen currently observed regional disparities in cervical cancer rates.

Introduction

A high rate of human papillomavirus (HPV) vaccination across the US is expected to significantly reduce the cases of cervical cancer, precancerous cervical lesions, and other HPV-related cancers.[1] There are currently 2 vaccines approved for use in the US: the bivalent HPV vaccine, which protects against 2 types of high-risk HPV, and the quadrivalent vaccine, which protects against HPV types 6, 11, 16, and 18. HPV types 6 and 11 are responsible for up to 90% of genital warts, and HPV types 16 and 18 are responsible for 70% of cervical cancers and a high proportion of other HPV-related anogenital and oral cancers.[2-5] While both vaccines have been shown to be efficacious, a very high proportion of girls need to receive the vaccine to provide a significant level of herd immunity.[6] To achieve this, Healthy People 2020, which is a program that provides objectives for improving the health of all Americans, adopted a goal of 80% coverage with 3-doses of the HPV vaccine among 13–15 y old females by 2020 (objective IID-11.4).[7] Unfortunately, in the US, there have been low levels of vaccination, particularly in the southern states where a high proportion of cervical cancer cases are expected to occur in 2014.[8]

Regional disparities in HPV vaccination have been observed in the South among 18–26 y old females compared to other regions of the US.[9] Data from the National Immunization Survey-Teen (NIS-Teen) has also indicated that 13–17 y olds in the South have lower rates of HPV vaccination.[10] However, less is known about regional vaccination among younger girls, particularly those who are 11–12 y of age, which is the age range recommended for vaccination. Further, little is known about how characteristics of vaccination differ in southern states compared to the rest of the US. States in the South experience a cervical cancer incidence rate of 10.1 per 100,000 in comparison with 8.9 per 100,000 women in the entire US.[11] Unfortunately, elevated rates of cervical cancer in the South indicate that low vaccination levels may contribute to a continued trend in regional

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cervical cancer disparities. An examination of how characteristics associated with vaccination differ in the South compared to other regions may contribute to understanding why rates of vaccination are low in this region.

It is particularly important to understand whether regional differences in HPV vaccination-both initiation and completion-are apparent among young adolescents because this is the group that has been specifically targeted for vaccination by the Advisory Committee on Immunization Practices (ACIP). The goal of this study was to examine regional variation in HPV vaccination among 9–17 y olds by comparing vaccine initiation and completion rates of Southern states with other states that participated in the child HPV vaccination module for the Behavioral Risk Factor Surveillance System (BRFSS) survey.

Results

Overall, using weighted proportions, 26.9% of adolescents in the BRFSS initiated HPV vaccination and 55.2% of initiators completed the series. Vaccine initiation prevalence for 13–17 y olds was 33.9% in 2008, 35.2% in 2009, and 42.0% in 2010. For the same age group, completion among initiators was 43.9% in 2008, 58.9% in 2009, and 64.8% in 2010. The proportion of female children who initiated the HPV vaccine differed depending on the respondent's: sex, relationship with the child, insurance status, whether they had a primary care doctor, marital status, and employment status (**Table 1**). HPV vaccine initiation differed by age, but not race/ethnicity. Initiation also varied by region and flu vaccination status. Completion of the vaccine series varied by: respondent's employment status, child's age, region, and survey year. Completion of the HPV vaccine series among initiators differed marginally by region.

Three models are presented to show the separate associations of the respondent and child characteristics to initiation, with the final model including all information (**Table 2**). Children in the Northeast/Midwest/West were more likely to have initiated vaccination compared to children in the South/Southwest. Black and Hispanic children were more likely to have initiated compared to white children in Model 1, but the association was attenuated for black children in the full model (Model 3). Younger children were less likely to initiate vaccination compared to 13–17 y old teens. Respondents without a primary care doctor were less likely to report vaccine initiation compared to those with one. Flu vaccination was associated with HPV vaccine initiation.

Similar to the presentation of the analyses for initiation, the associations between respondent and child characteristics are presented separately in the first 2 models before including all information in the final model (**Table 3**). Analyses for HPV vaccine series completion revealed that younger girls in the vaccine age target range (11–12 y of age) were less likely to complete the HPV vaccine series compared to 13–17 y olds(Model 3). Biracial/other were less likely to complete compared to white girls. Girls were more likely to have completed the HPV vaccine in 2009 and 2010 compared to 2008. Flu vaccination was associated with HPV vaccine completion. No regional differences in completion of the HPV vaccine series were detected.

Stratified analyses of vaccine series initiation and completion

In models stratified by region, vaccine initiation varied depending on the respondent's relationship with the child in the South/Southwest (**Table 4**). Not having a primary care doctor in the Northeast/Midwest/Western states was associated with lower odds of initiation. Odds of initiating were similar in the South/Southwest between those who had a primary care doctor and those who did not. Younger children were less likely to have initiated vaccination in both regions compared to 13–17 y olds. Hispanic girls were more likely to have initiated vaccination in the South/Southwest, but no racial/ethnic differences were observed in the other region. Girls were more likely to have initiated in 2009 and 2010 compared to 2008 in the South/Southwestern states. Vaccine initiation did not differ by year in the Northeast/Midwest/Western regions, but odds were higher with each year in the South/Southwest. Flu vaccination was associated with HPV vaccine initiation in the both of the regions observed.

Stratified analyses revealed that female respondents from the Northeast/Midwest/West were almost 3 times more likely to report that their child completed compared to males in the same region, but gender was not associated with report of vaccine series completion in the South/Southwest (**Table 4**). In the Northeast/Midwest/West, respondents without a primary care doctor were less likely to report the child had completed compared to those who had one. Girls 11–12 y of age were less likely to have completed the vaccine series compared to 13–17 y olds in both regions. Completion was similar across race/ethnicity in all regions. Flu vaccination was associated with HPV vaccine series completion in the South/Southwest, but was not significantly associated with completion in the Northeast/Midwest/West.

Discussion

We found regional variations in HPV vaccine initiation among 9–17 y olds. Girls in Northeast/Midwest/West states were more likely to initiate than girls in the South/Southwest. It was encouraging that no regional differences in vaccine completion among initiators were apparent, although completion was low overall. These results mirror geographical HPV vaccination disparities observed among women 18–26 y of age.[9] In both studies, girls in the South/Southwest were less likely to have initiated vaccination than those in the Northeast and Midwest/Western states.[9] One difference between the 2 age groups is that completion was lower in 18–26 y old women from the South/Southwest compared to other regions, while regional differences in completion were not found in this study. It should be noted that we found lower rates of HPV vaccination among 13–17 y olds compared to the NIS-Teen during the time period examined. During 2008–2010, NIS-Teen initiation rates were 37% in 2008, 44% in 2009 and 49% in 2010. [12,13] Completion among

Table 1. Characteristics of adult respondents and 9–17 y olds(N = 7,849)

	Total n	Weighted % initiated HPV vaccine	p-value	n of initiators	Weighted % completed HPV vaccine among initiatiors[a]	p-value
Adult respondent characteristics						
Sex						
Male	2,342	22.0		397	46.5	
Female	5,507	28.9	<0.001	1,357	57.4	0.05
Relationship with child participants						
Parent/ Guardian	7,042	26.3		1,583	55.6	
Grandparent	405	40.7		99	49.7	
Sibling or not related	397	25.4	0.009	71	51.6	0.78
Missing	5	34.9		1		
Insurance status						
Yes	6,453	27.9		1,452	57.0	
No	1,371	23.2	0.03	298	48.5	0.12
Missing	25	20.8		4		
Has primary care doctor						
Yes	6,487	28.4		1,471	57.7	
No	1,345	20.3	<0.001	277	46.2	0.05
Missing	17	75.4		6		
Marital status						
Married/partnered	5,607	24.8		1,189	54.3	
Single	673	30.3		153	53.0	
Separated/divorced/widowed	1,558	33.1	0.001	408	58.7	0.67
Missing	11	18.3		4		
Education						
<High school	771	28.7		185	53	
High school graduate	2,023	28.2		447	53.7	
Some college, college graduate	5,048	25.9	0.45	1,120	56.2	0.85
Missing	7	57.2		2		
Employment						
Employed	5,596	25.9		1,208	56.9	
Not employed	882	34.7		298	44.4	
Student/retired/homemaker	1,365	25.9	0.01	245	62.4	0.04
Missing	15	15.3		3		
Child's characteristics						
Age (years)						
9-10	1,497	5.3		54	42.8	
11-12	1,653	22.4		265	40.9	
13-17	4,699	36.9	<0.001	1,435	59.2	0.02
	Total n	**Weighted % initiated HPV vaccine[a]**	**p-value**	**n**	**Weighted % completed HPV vaccine[a]**	**p-value**
Race						
White	5,585	25.9		1,195	58.1	
Black	566	33.1		119	60.0	
Hispanic	1,299	27.7		352	49.8	
Biracial/ other	334	22.1	0.14	74	30.9	0.10
Missing	65	23.3		14		
Control variables						
BRFSS year						
2008	2,897	24.9		375	42.3	
2009	1,757	27.5		494	57.0	
2010	3,195	28.7	0.19	885	58.7	0.02
Respondent or child received flu vaccine in past 12 months						
Yes	2,842	35.2		804	60.0	
No	4,658	21.7	<0.001	855	51.2	0.05
Missing	349	36.1		95	45.1	
Region						
Northeast/Midwest/West	3,500	32.2		712	61.8	
Connecticut	772	32.4		231	66.5	
New York	478	35.3		-	-	
Pennsylvania	1,322	29.6		190	63.5	

(*continued on next page*)

Table 1. Characteristics of adult respondents and 9–17 y olds(N = 7,849) *(Continued)*

	Total n	Weighted % initiated HPV vaccine	p-value	n of initiators	Weighted % completed HPV vaccine among initiators[a]	p-value
Wisconsin	256	33.6		74	52.1	
Wyoming	672	29.5		217	63.6	
South/Southwest[b]	4,349	23.6	<0.001	1,042	52.5	0.04
Delaware	276	31.9		88	53.6	
Kentucky	427	32.1		116	60.1	
Oklahoma	482	21.3		102	51.2	
Texas	2,736	23.2		634	52.2	
West Virginia	428	25.0		102	50.9	

[a]Weighted proportion of girls who initiated or completed the HPV vaccine series.
[b]p-value reflects comparison between regions.
Abbreviations: Behavioral Risk Factor Surveillance System (BRFSS).

13–17 y old initiators was also lower in our sample than in the national sample.[12] Reduced rates in the BRFSS are likely due to uneven representation from southern states with lower odds of initiating vaccination. Study year was associated with HPV vaccine initiation and completion, with each subsequent year increasing in vaccination prevalence. This is in agreement with findings from the NIS-Teen across time during the same time period.[12,13] However, it has been found that HPV vaccine completion among insured initiators has been decreasing with each year of initiation.[14] Prevalence rates are slow to reflect trends in incidence, however. Recent data from NIS-Teen suggest that completion of the vaccine series did not increase significantly between 2011 (34.8%) and 2012 (33.4%), but indicate a modest increase in 2013 (37.6%).[10,15]

Hispanic girls in our study were more likely to initiate vaccination compared to white girls. However, the stratified analysis shows that Hispanic girls were more likely than whites to have initiated vaccination in the South/Southwest, but not in the Northeast/Midwest/West. Hispanics have a high prevalence of HPV infection, and are more likely to develop cervical cancer than women of other races or ethnicities.[16,17] Thus, the increased odds of vaccination in Hispanic girls in the South/Southwest may help to reduce some disparities in cervical cancer between different racial/ethnic groups as well as between different regions of the US. A high proportion of Hispanics living in southern states are of Mexican descent and of more recent immigration status, whereas Hispanics in other states represented in this study are more heterogeneous, which may provide some explanation for the observed differences between regions.[18] Although there are several studies that examine acceptability and knowledge of HPV among Hispanics, country of origin is rarely considered as a factor in the choice for vaccination. It is also possible that Hispanics in southern states are more acculturated, and thus more likely to have their children vaccinated.[19] However, studies need to be conducted that focus specifically on how country of origin and acculturation affect the decision to have children vaccinated.

Respondents without a primary care provider had lower odds of reporting that the sampled girl had initiated the HPV vaccine. In models stratified by region, girls in Northeast/Midwest/West states were less likely to initiate and complete HPV vaccination, while girls in the South/Southwest had similar odds of initiating and completing regardless of whether they had a primary care provider. Having a healthcare provider may indicate an important point of contact for health information among those living in Northeast/Midwest/West US states. Healthcare counseling about the HPV vaccine has become an important target in the efforts to get young girls and boys vaccinated.[20] Although it is unknown why these differences exist, it is possible that controversy surrounding proposed laws to require the HPV vaccine, particularly in southern states such as Texas and Virginia, have made the vaccine more prominent in the media, thus increasing awareness in the South.[21] Even though this study shows that girls from southern states are less likely to be vaccinated, widespread media coverage of the issue may have the effect of making it less necessary for a doctor to discuss the HPV vaccine with parents in order for them to request it.

Flu vaccination of the respondent or the child was associated with initiation in both regions and with completion in the South/Southwest. This is consistent with other studies that show flu vaccination is associated with HPV vaccination.[22,23] It is possible that children who receive yearly flu vaccinations have parents with more positive attitudes toward vaccination, and thus have their children HPV vaccinated as well. In addition, flu vaccination may be a marker of children and adults who have regular check-ups, and provided another point of contact with providers to distribute vaccine-related information.

It was revealed that the younger age groups were less likely to have ever initiated the HPV vaccine. Younger initiators were also less likely to complete the series compared to the older (13–17 y old) females. These findings indicate that 11–12 y olds were not being fully vaccinated during the recommended age. Although it could not be determined why, it has been found that 83% of all health provider recommendations to vaccinate were made to parents of 13–17 y old teens.[24] Unfortunately, teens may have been exposed to HPV by the time they reach 17 y of age. Therefore, vaccination efforts in the US would be more effective if children were routinely vaccinated at the recommended age of 11–12 y old, before potential exposure to HPV.

This study has some limitations. The BRFSS is a telephone survey, and accuracy of the responses depended on participants'

Table 2. Multivariable logistic regression analysis of HPV vaccine initiation using weighted data

Adult respondent characteristics	Model 1[a]	Model 2[a]	Model 3[a]
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Sex			
Male		Reference	Reference
Female		1.38 (1.11-1.72)*	1.31 (1.05-1.63)*
Relationship with child			
Parent/Guardian		Reference	Reference
Grandparent		1.51 (0.93-2.45)	1.90 (1.05-3.45)*
Sibling or not related		0.87 (0.55-1.39)	0.80 (0.50-1.27)
Insurance status			
Yes		Reference	Reference
No		0.95 (0.71-1.27)	0.90 (0.66-1.24)
Has primary care doctor			
Yes		Reference	Reference
No		0.76 (0.58-0.99)*	0.75 (0.56-1.00)
Marital status			
Married/partnered		Reference	Reference
Single		1.28 (0.88-1.86)	1.20 (0.78-1.83)
Separated/divorced/widowed		1.39 (1.11-1.75)*	1.31 (1.01-1.70)
Education			
<High school		1.29 (0.91-1.83)	0.97 (0.67-1.41)
High school graduate		1.14 (0.92-1.83)	1.06 (0.84-1.33)
Some college, college graduate		Reference	Reference
Employment			
Employed		Reference	Reference
Not employed		1.33 (0.98-1.81)	1.27 (0.92-1.76)
Student/retired/homemaker		0.93 (0.73-1.19)	1.06 (0.84-1.33)
Child's characteristics			
Age (years)			
9-10	0.09 (0.06-0.14)*		0.09 (0.06-0.13)*
11-12	0.46 (0.36-0.58)*		0.46 (0.36-0.59)*
13-17	Reference		Reference
Race			
White	Reference		Reference
Black	1.60 (1.07-2.40)*		1.44 (0.91-2.27)
Hispanic	1.41 (1.10-1.81)*		1.52 (1.14-2.03)*
Biracial/ other	0.81 (0.46-1.45)		0.83 (0.45-1.52)
Control variables			
BRFSS year			
2008	Reference	Reference	Reference
2009	1.21 (0.94-1.54)	1.25 (1.00-1.58)	1.28 (1.00-1.64)
2010	1.33 (1.07-1.64)*	1.26 (1.04-1.54)*	1.40 (1.14-1.73)*
Respondent or child received flu vaccine in past 12 months			
Yes	2.27 (1.87-2.75)*	1.92 (1.60-2.31)*	2.17 (1.79-2.64)*
No	Reference	Reference	Reference
Region			
Northeast/Midwest/West	1.78 (1.48-2.15)*	1.58 (1.32-1.88)*	1.78 (1.47-2.15)*
South/Southwest	Reference	Reference	Reference

[a]Model 1: child variables, Model 2: respondent variables, and Model 3: respondent and child variables.
*Indicates significance at $P < 0.05$.
Abbreviations: Behavioral Risk Factor Surveillance System (BRFSS).

self-report. There appears to be some response bias, as female respondents were more likely to report that the child in their household initiated and completed HPV vaccination. It is possible that the female respondents were more aware of the vaccination status of the girls in their households, or it is possible that they were more likely to respond in a manner that was considered more socially desirable. In addition, only 10 states participated in the child HPV module, and all Northeast/Midwest/West states did not include the number of vaccines received by the children in the 2008 survey. However, the BRFSS is a survey with a rigorous sampling strategy, and is representative of the households in participating states.

This study has important implications for the Southern US, as the states in this region have had low levels of screening with high cervical cancer incidence and mortality.[25] Increasing evidence of low HPV vaccination means that the South/Southwest

Table 3. Multivariable logistic regression to determine odds of characteristics associated with HPV vaccine completion among initiators using weighted data

Respondent characteristics	Model 1[a]	Model 2[a]	Model 3[a]
Sex			
Male		Reference	Reference
Female		2.22 (1.41-3.49)*	2.22 (1.41-3.49)*
Relationship with child			
Parent/Guardian		Reference	Reference
Grandparent		1.10 (0.44-2.78)	1.10 (0.44-2.78)
Sibling or not related		0.83 (0.32-2.19)	0.58 (0.27-1.24)
Insurance status			
Yes		Reference	Reference
No		0.92 (0.50-1.69)	0.92 (0.50-1.69)
Has primary care doctor			
Yes		Reference	Reference
No		0.66 (0.38-1.15)	0.66 (0.38-1.15)
Marital status			
Married/partnered		Reference	Reference
Single		0.58 (0.27-1.24)	0.58 (0.27-1.24)
Separated/divorced/widowed		0.89 (0.55-1.44)	0.89 (0.55-1.44)
Education			
<High school		1.29 (0.66-2.50)	1.24 (0.64-2.42)
High school graduate		1.06 (0.71-1.58)	1.06 (0.71-1.58)
Some college, college graduate		Reference	Reference
Employment			
Employed		Reference	Reference
Not employed		1.36 (0.72-2.54)	1.35 (0.72-2.56)
Student/retired/homemaker		0.65 (0.41-1.04)	0.69 (0.43-1.00)
Child's characteristics			
Age (years)			
9-10	0.63 (0.26-1.55)		0.68 (0.27-1.70)
11-12	0.43 (0.25-0.71)*		0.39 (0.23-0.65)*
13-17	Reference		Reference
Race			
White	Reference		Reference
Black	1.26 (0.58-2.73)		1.18 (0.50-2.80)
Hispanic	0.78 (0.50-1.22)		0.87 (0.52-1.47)
Biracial/ other	0.35 (0.15-0.80)*		0.32 (0.14-0.76)*
Control variables			
BRFSS year			
2008	Reference	Reference	Reference
2009	1.59 (0.89-2.84)	1.88 (1.06-3.34)*	1.92 (1.08-3.40)*
2010	1.69 (1.01-2.83)*	1.85 (1.11-3.06)*	1.86 (1.12-3.07)*
Respondent or child received flu vaccine in past 12 months			
Yes	1.45 (1.01-2.09)*	1.57 (1.09-2.26)*	1.55 (1.08-2.22)*
No	Reference	Reference	Reference
Region			
Northeast/Midwest/West	1.22 (0.80-1.87)	1.18 (0.78-1.78)	1.18 (0.78-1.78)
South/Southwest	Reference	Reference	Reference

[a] Model 1:child variables, Model 2: respondent variables, and Model 3: respondent and child variables.
*Significance at $P < 0.05$.
Abbreviations: Behavioral Risk Factor Surveillance System (BRFSS).

could continue to experience a high burden of HPV-related cancers, and even serve as a reservoir for vaccine-type HPV as decreases in HPV-related disease incidence becomes more apparent in other states over the next several decades. Further, this study demonstrates that simply controlling for region may obscure regional variations in characteristics associated with vaccination. To better understand geographical disparities in vaccination, more detailed research examining the effect of state legislation, marketing, funding for free vaccines and regional cultural influences on HPV vaccination are needed.

Methods

Data and study selection

Individual-level data were obtained from the public-use data files of the 2008–2010 BRFSS.[26] The survey was a random digit dial telephone survey of non-institutionalized adults in the US. Children were selected randomly for every household with at least 1 child under the age of 18 y. All child data was provided by an adult proxy, referred to in this study as the respondent. The methods and response rates for the BRFSS are

Table 4. Multivariable logistic regression to determine odds of characteristics associated with HPV vaccine series initiation and completion among initiators using weighted data, by region

	Northeast/Midwest/West		South/Southwest	
	Initiation	**Completion**	**Initiation**	**Completion**
Adult respondent characteristics				
Sex				
Male	Reference	Reference	Reference	Reference
Female	1.05 (0.79-1.40)	2.87 (1.63-5.07)*	1.57 (1.14-2.18)*	1.83 (1.00-3.36)
Relationship with child				
Parent/Guardian	Reference	Reference	Reference	Reference
Grandparent	1.03 (0.52-2.07)	0.55 (0.15-2.07)	2.30 (1.13-4.69)*	2.08 (0.66-6.57)
Sibling or not related	1.01 (0.54-1.88)	1.08 (0.22-5.32)	0.50 (0.25-0.99)*	0.84 (0.28-2.48)
Insurance status				
Yes	Reference	Reference	Reference	Reference
No	0.81 (0.45-1.45)	1.64 (0.51-5.30)	0.92 (0.63-1.34)	0.79 (0.40-1.57)
Has primary care doctor				
Yes	Reference	Reference	Reference	Reference
No	0.53 (0.32-0.87)*	0.21 (0.07-0.63)*	0.84 (0.59-1.19)	0.77 (0.42-1.40)
Marital status				
Married/partnered	Reference	Reference	Reference	Reference
Single	0.81 (0.57-1.14)	0.49 (0.22-1.08)	0.76 (0.54-1.09)	1.01 (0.38-2.72)
Separated/divorced/widowed	1.24 (0.71-2.17)	0.21 (0.07-0.63)*	0.80 (0.42-1.52)	1.01 (0.56-1.80)
Education				
<High school	1.40 (0.73-2.69)	0.46 (0.12-1.73)	0.85 (0.53-1.36)	1.53 (0.73-3.22)
High school graduate	0.95 (0.69-1.56)	1.05 (0.60-1.83)	1.18 (0.86-1.62)	1.15 (0.69-1.92)
Some college, college graduate	Reference	Reference	Reference	Reference
Employment				
Employed	Reference	Reference	Reference	Reference
Not employed	1.04 (0.70-1.56)	1.47 (0.63-3.42)	1.45 (0.91-2.32)	1.36 (0.63-2.94)
Student/retired/homemaker	0.98 (0.69-1.39)	0.52 (0.27-1.02)	1.06 (0.75-1.50)	0.76 (0.43-1.34)
Control variables				
BRFSS year				
2008	Reference		Reference	0.57 (0.34-0.97)*
2009	1.06 (0.77-1.47)	0.92 (0.54-1.57)	1.59 (1.12-2.24)*	1.10 (0.64-1.89)
2010	0.84 (0.63-1.13)	Reference	1.96 (1.46-2.64)*	Reference
Respondent or child received flu vaccine in past 12 months				
Yes	1.95 (1.49-2.54)*	1.12 (0.67-1.81)	2.43 (1.85-3.20)*	1.68 (1.08-2.64)*
No	Reference	Reference	Reference	Reference
Child's characteristics				
Age (years)				
9-10	0.06 (0.03-0.10)*	1.05 (0.23-4.80)	0.10 (0.06-0.17)*	0.61 (0.22-1.71)
11-12	0.34 (0.24-0.46)*	0.31 (0.16-0.60)*	0.61 (0.44-0.85)*	0.38 (0.21-0.71)*
13-17	Reference	Reference	Reference	Reference
Race				
White	Reference	Reference	Reference	Reference
Black	1.00 (0.61-1.64)	0.47 (0.17-1.30)	1.59 (0.85-2.96)	1.74 (0.64-4.74)
Hispanic	1.11 (0.62-1.98)	1.93 (0.62-6.05)	1.57 (1.13-2.18)*	0.81 (0.45-1.47)
Biracial/ other	0.66 (0.29-1.51)	0.33 (0.07-1.48)	0.95 (0.39-2.33)	0.30 (0.11-0.83)
	Northeast/Midwest/West Initiation	South/Southwest Completion	Initiation	Completion
Received flu vaccine in past 12 months				
Yes	1.95 (1.49-2.54)*	1.12 (0.67-1.81)	2.43 (1.85-3.20)*	1.68 (1.08-2.64)*
No	Reference	Reference	Reference	Reference

*Significance at $P < 0.05$.
Abbreviations: Behavioral Risk Factor Surveillance System (BRFSS).

available in greater detail on the BRFSS documentation website.[26]

Girls 9–17 y of age were eligible to be included. Respondents must have answered "yes" or "no" to the vaccine initiation question for the selected female child. Of 8,872 eligible females, 798 of the survey respondents did not know or refused to answer whether the child had been vaccinated. Also, children without age data were excluded from the study (n = 225). Total sample size was 7,849 girls after applying the exclusion criteria.

A total of 10 states participated in the child HPV vaccination survey at least one time during the 3 survey years. These states were divided into 2 regions to examine variation in vaccine

initiation and completion. Regions included: Northeast/Midwest/West (CT, NY, PA, WI, WY), and South/Southwest (DE, KY, OK, TX, WV). States were combined into 2 regions in order to achieve adequate power for analyses. In 2008, DE, NY, OK, PA, TX, and WV included the child HPV questions, in 2009, CT, TX, WI, and WY included these questions, and in 2010 CT, KY, PA, TX, WV, and WY included child HPV vaccine questions in their state survey. States in the Northeast/Midwest/West region did not include questions about the number of HPV vaccinations received in the 2008 survey. This study was exempt from full review by the University of Texas Medical Branch and the University of North Carolina at Chapel Hill Institutional Review Boards.

Measures

Dichotomous dependent variables included: HPV vaccine initiation and completion. Initiation was determined using the question: "A vaccine to prevent the human papillomavirus or HPV infection is available and is called cervical cancer vaccine, HPV shot, GARDASIL, or Cervarix. Has this child EVER had the HPV vaccination?" Initiation was determined to have occurred if respondents answered "yes" and then indicated that the selected child received one vaccine dose. Responses were binary, with children who received $\geq$1 dose assigned a value of 1, and those who reported no vaccination assigned a value of 0. For completion, children who had initiated and received 3 doses of the HPV vaccine were assigned 1 and those with fewer than 3 doses were assigned 0.

Characteristics of both respondent and the child were included in the analyses. Characteristics for the respondent included: sex (male or female), relationship to the child (parent/guardian, grandparent, sibling or unrelated to child), insurance coverage, whether they had a primary care doctor, marital status (married/ partnered, single-never married, separated/ divorced/ widowed), and education level (<high school, graduated high school, attended some college or college graduate). For relationship, respondents were asked, "How are you related to the child?" Possible responses included: parent (biologic, step, or adoptive), foster parent or guardian, grandparent, sibling (biologic, step, or adoptive), other relative, and not related in any way. Responses were collapsed into 3 categories, with parent/guardian including parents and foster parents or guardians, grandparents in a separate category, and sibling/other included the remainder of the possible responses.

Child characteristics included: age (9–10, 11–12, and 13–17 y of age) and race/ ethnicity (white, black, Hispanic, biracial/other). Age was categorized to reflect current guidelines for vaccination, which include the recommendation that children be vaccinated at 11–12 y of age, but can be vaccinated as young as 9 y old with catch-up vaccination up to 26 y of age. Children were categorized Hispanic if the adult respondent answered "yes" to the question, "Is the child Hispanic or Latino?" To determine race, the adult respondent was asked, "Which one or more of the following would you say is the race of the child?" Children who were white but not Hispanic were categorized as white. Children who were black or African American but not Hispanic were categorized as black. Children who were Native Hawaiian or other Pacific Islander, American Indian, Alaska Native, other, or who were biracial were included into the biracial/other category. We also included other variables in the model such as: region, the year the BRFSS was conducted (2008, 2009, 2010), and whether the child or respondent received the flu vaccine (injection or nasal spray) in the past year.

Statistical analyses

Data was weighted using child weights to calculate proportions in order to make the results more generalizable to children in the US. Rao-Scott Ratio Chi-Square Tests were used to examine differences between categorical variables in the descriptive analyses and to test for interaction effects. Multivariable logistic regression models estimated the odds for initiating and completing HPV vaccination among initiators. For these analyses, 3 models were used to examine regional differences in initiation and completion of the HPV vaccine series. The first model included the child's characteristics, and shared characteristics, which consisted of: region of the household, the survey year, and receipt of the flu vaccine. The second model included the respondent characteristics and shared characteristics. The third model included all variables. These models were used to determine whether inclusion of child or respondent characteristics changed the association between region and vaccination substantially. A model with main effects and interaction terms for region and all other characteristics was tried. Since several interaction terms were significant, 2 region-specific models were built by stratifying the final analyses by region. Stratification by region allowed the observation of differences in associations between characteristics and vaccination between regions. All analyses were conducted using SAS software version 9.3 (Cary, NC).

Disclosure of Potential Conflicts of Interest

Jennifer S. Smith has received research grants, served on paid advisory boards, and/or been a paid speaker for GlaxoSmithKline and Merck Corporation over the past five years. Drs. Hirth, Rahman, and Berenson report no conflicts of interest.

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