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Racial/Ethnic Differences in Adolescent Male HPV Vaccine Initiation and Provider Recommendation

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Abstract

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By Kathryn E. Landis

Over the past decade, vaccination has emerged as a safe, effective way to prevent Human Papillomavirus (HPV) infection and subsequent HPV-related cancers; however, HPV vaccine uptake remains low in the US. Provider recommendations are strongly tied to vaccine uptake, and consistent provision of recommendations is an essential tool for decreasing disparities. After the 2011 Advisory Committee on Immunization Practices (ACIP) recommendation for routine vaccination of males to prevent HPV infection, little is known about specific predictors for initiation. The purpose of this study is to examine racial and ethnic differences for HPV vaccine initiation and provider recommendation in male adolescents. Based on prior National Immunization Survey-Teen (NIS-Teen) publications for males and females, it was hypothesized that minority adolescents would be more likely to initiate HPV vaccines, but less likely to receive a provider recommendation compared to whites. The present study used the 2014 NIS-Teen, which included 10,753 male adolescents with provider verified vaccination data in 50 US states. Multivariate logistic regression models evaluated racial/ethnic differences in initiation, provider recommendation, and if recommendation moderates the relationship between race/ethnicity and initiation. Hispanic adolescents had 76 percent higher odds and non-Hispanic other/multiple race adolescents had 43 percent higher odds of initiation compared to their white counterparts. Rates of provider recommendation were consistent across all racial/ethnic groups, with approximately one-half of parents reporting they received a provider recommendation. There was no significant difference in the odds of receiving a provider recommendation across racial/ethnic groups. These findings suggest that provider recommendations for all males can be improved, and future research should focus on developing culturally appropriate interventions to increase HPV vaccine uptake among all racial/ethnic groups. Future research should also examine HPV vaccine completion patterns in male adolescents.

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INTRODUCTION

Vaccinations are often called one of the greatest public health achievements of the 20th century, and have dramatically reduced mortality around the globe.[1] Over the past decade, vaccination against Human Papillomavirus (HPV) has emerged as a safe, effective way to prevent adolescents from HPV infection, a pervasive sexually transmitted infection, and subsequent HPV-related cancers.[2] HPV infection is a significant problem in the US. Today, approximately 79 million adults are infected with HPV in the United States.[3] HPV infection is unique because it causes outcomes such as ano-genital warts, but also has an established causal link with cervical, anal, vulvar, vaginal, and penile cancers.[2] Because of this link, HPV vaccines are most effective when administered before first sexual contact.[2] Additionally, because racial/ethnic minorities are disproportionately affected by several HPV-related cancers, the vaccine can help reduce HPV-related cancer disparities in minority men and women.[4]

However, HPV vaccine uptake remains low in the US. In fact, current national coverage levels are still significantly below the Healthy People 2020 goal of 80% coverage.[5] Compared to other adolescent vaccines, HPV vaccination is a complex and controversial topic in the US because the vaccine prevents a sexually transmitted infection.[2] As a result, unique barriers for parents and adolescents, such as awareness, acceptance, and lack of provider recommendation, all pose a challenge to vaccine uptake.[6]

Recently, researchers have aimed to understand individual parent and adolescent characteristics that can predict HPV vaccine uptake, with hopes of tailoring patient care and interventions to improve protection from HPV. Furthermore, since the 2011 Advisory Committee on Immunization Practices (ACIP) recommendation to vaccinate

males, socio-demographic predictors of vaccine uptake and the parental decision making process for adolescent males are still not fully understood.[7]

Guided by Andersen's Model of Healthcare Utilization[8], and the Health Belief Model[9], we used the 2014 National Immunization Survey – Teen[10] to examine racial/ethnic differences in HPV vaccine initiation and provider recommendation for adolescent males. We hypothesized that racial/ethnic minority adolescents would be more likely to initiate, but less likely to receive a provider recommendation for HPV vaccines compared to their white counterparts. We also studied HPV provider recommendation as a potential moderator for the association between race/ethnicity and initiation as a method of investigating if minority adolescents and their parents are more likely to adhere to the recommendation. Using multiple logistic regression, we identified key sociodemographic predictors of HPV vaccine initiation in adolescent males with adequate provider vaccination data.

Study results will help identify missed educational opportunities for adolescent males and their providers by identifying key predictors of initiation for males and exploring racial/ethnic differences. Findings will also help guide future interventions targeting male adolescents to increase patient-provider communication and reduce HPV-related cancer disparities.

LITERATURE REVIEW

Human Papillomavirus Background

HPV is the most common sexually transmitted infection in the United States.[3] The Centers for Disease Control and Prevention estimates that approximately 79 million US adults are currently infected with HPV.[3] There are more than 150 HPV genotypes that cause a variety of outcomes, including ano-genital warts and low-grade dysplasia.[2] Genital HPV is spread through sexual contact, and is frequently acquired after sexual debut.[2] Some HPVs can also cause recurrent respiratory papillomatosis (RRP) in infants, which results in papillomas of the upper respiratory tract and is acquired from an HPV-infected mother during labor.[2]

While most people never show symptoms and naturally fight off HPV infections, a small portion develop HPV-related cancers, such as cervical cancer in women and anal, penile, and oropharyngeal cancer in men.[3, 11, 12] These and other HPV-related cancers affect approximately 17,500 women and 9,300 men each year in the US.[3] In addition, there are approximately 360,000 cases of genital warts each year.[3] HPV infections place a significant economic burden on the US healthcare system. For example, one study found that genital wart cases cost the healthcare system more than $220 million annually due to the need for repeat treatments.[13] Because almost one-half of HPV infections occur in adolescents and young adults age 15-24 years [14], this age group is an important target for interventions to prevent HPV-related health consequences.

HPV Vaccine History

HPV vaccines were originally developed to prevent cervical cancer in females.[2] The US Food and Drug Administration (FDA) approved the first quadrivalent HPV vaccine, Gardasil®, first for females age 9 to 26 years in June 2006.[3] Gardasil® is given in three doses over a six month period, and prevents four HPV types (6, 11, 16, 18)

responsible for 70% of HPV-related cervical cancers and 90% of genital warts.[15] The FDA approved an additional bivalent vaccine for females, Cervarix®, in 2009 that prevents cancer-causing strains 16 and 18. In October 2009, the FDA approved the use of Gardasil® to prevent HPV infection Types 6 and 11 in males age 9 to 26 years.[3] The Advisory Committee for Immunization Practices (ACIP), a group of medical and public health experts that provides vaccine recommendations in the US, endorsed widespread use of HPV vaccines in males in 2011.[7] As of March 2015, the new Gardasil-9® protects against nine HPV types responsible for HPV-related cancers and warts, and is available for both females and males age 9 to 26.[16] While the vaccines can be given starting at age 9 or as "catch up" doses to adults, they are currently recommended for routine vaccination at age 11 or 12 years, before sexual debut and potential exposure to HPV infection.[3]

Despite widespread ACIP recommendations, HPV vaccination rates for both females and males remain low. According to the 2014 National Immunization Survey – Teen (NIS-Teen), approximately 60.0% of adolescent girls and 41.7% of adolescent boys sampled had initiated (received at least one dose of the vaccine) in 2014.[17] In addition, only 39.7% of girls and 21.6% of boys had completed all three doses of the vaccine.[17] This gender difference in vaccination rates may be partially explained by the more recent FDA approval of the Gardasil vaccine for males. Low coverage rates for HPV vaccines contrast other adolescent vaccines with high coverage, such as tetanus-diphtheria-pertussis (Tdap) and Meningococcal vaccines. In 2014, the estimated national coverage rates for Tdap and Meningococcal were 87.6% and 79.3%, respectively.[17]

According to published data, the low coverage rates may be explained by specific barriers to HPV vaccination, including lack of provider recommendation, lack of awareness and knowledge, and parent concerns about vaccine safety or effect on adolescent sexual behavior.[6, 18-20] Lack of HPV knowledge is a key barrier to vaccination. For example, Blake et al. analyzed data from the 2013 Health Information National Trends Survey (n=3,185) and found that 68% of adults have heard of HPV or HPV vaccines; this means approximately one-third of the US population remains unaware about HPV outcomes and benefits of HPV vaccines.[21] As a result, research continues to focus on improving awareness of HPV and benefits of vaccination for all populations, particularly on how these barriers or predictors of HPV vaccination may differ between genders or racial and ethnic groups.

Politics of the HPV Vaccine

Unlike other adolescent vaccines, efforts to improve HPV vaccine coverage through legislature and school mandates are politicized and highly controversial in the US, which has a negative impact on uptake for adolescents.[22] Traditionally, US law holds that states are allowed to require vaccinations for children in places such as public schools. These requirements are typically based on ACIP recommendations, and exemptions to these laws include individuals with medical, religious, or philosophical objections.[22] Still, HPV vaccine mandates have created an even more complex and controversial debate in recent years.

At first, HPV vaccines received negative attention due to high costs, which posed significant barriers to patients and providers as well as their insurance companies.[22] However, the vaccines also incited fears of increased sexual promiscuity in adolescents, although several studies have refuted this claim.[18, 23, 24] Some believe that

abstinence-only approaches limit the need for preventive action against HPV infections, but according to the 2013 Youth Risk Behavior Surveillance report, 47% of high school students reported ever having sexual intercourse,[25] More specifically, 30% of 9th-grade and 41.4% of 10th-grade students reported ever having sexual intercourse, respectively.[25]

Several states have attempted to pass legislation surrounding HPV vaccines. In 2006, Michigan became the first state to introduce a mandatory HPV vaccine requirement for sixth-grade girls, but the bill was not enacted.[26] In 2007, Texas Republican governor Rick Perry was criticized after he issued an effective order to mandate HPV vaccines for all sixth-grade girls. Many claimed the order intruded on what should be a parent's personal decision, and promoted early and unsafe sexual activity, and it was later revoked.[22] Since then, 42 states and territories have introduced legislation to require HPV vaccines for school entrance or for vaccine education, and 25 have enacted legislation.[27] As of 2015, only Rhode Island, Virginia, and Washington DC have school-mandated HPV vaccine policies.[27] With mixed acceptance and lack of legislative power to improve uptake, researchers continue to identify new strategies for improving parental education and attitudes surrounding HPV vaccines.

Racial and Ethnic Differences in Vaccine Uptake

Health disparities are defined as differences in which "disadvantaged social groups…systematically experience worse health or greater health risks than more advantaged social groups" and are well documented throughout the healthcare system.[28] Fortunately, racial and ethnic disparities for most childhood and adolescent vaccines declined dramatically over the past two decades.[29] Strategies such as community-wide reminders and the Vaccines for Children program have successfully

targeted racial and ethnic minority populations in the US.[30] Nevertheless, racial/ethnic differences in HPV vaccination coverage still exist. While HPV vaccination rates remain low for both genders, previous research shows several racial/ethnic differences for initiation and completion.[31, 32] For example, previous literature established that African American females are less likely to initiate HPV vaccines compared to whites and other minorities.[33]

On the other hand, some studies show that minority adolescents have higher initiation rates than whites.[34, 35] In the 2013 NIS-Teen, Hispanic adolescents had the highest rates of HPV vaccine initiation. More specifically, 49.6% of Hispanic teen boys sampled had initiated, compared to 42.4% black non-Hispanic and 26.7% white-only non-Hispanic teen boys.[36] However, out of those who initiated, white adolescents most frequently completed the vaccine series (51.1%) compared to minority adolescents (44.8% black only and 47.4% Hispanic).[36] A study in Virginia on adolescent females also found that minorities and those with public insurance were more likely to initiate HPV vaccines compared to their white counterparts.[37]

One possible explanation for these differences is that parents of certain racial and ethnic groups are more accepting of HPV vaccinations and the protection they offer.[38] For example, one study found that Hispanic fathers had low HPV vaccine awareness overall, but 87.5% were willing to vaccinate their adolescent sons.[39] Cui et al. found that minority women had less awareness of HPV vaccines compared to white women, but some minority groups (particularly Latinas and Asian Americans) were more likely to accept the vaccine.[40] In another study, Hispanic mothers showed low knowledge but high willingness to vaccinate their daughters.[41]

Researchers continue to examine racial/ethnic differences in HPV vaccine uptake, as they may have serious implications for rates of HPV-associated cancers that disproportionately affect minority communities. Hispanic women have the highest rates of cervical cancer, but African-American women are more likely to die from cervical cancer compared to whites and other minority groups.[42] Racial and ethnic differences also exist for HPV-related cancers in men. For example, Hispanic men have the highest rates of HPV-related penile cancer.[43] Additionally, white and African-American men are more likely to have HPV-related oropharyngeal cancers compared to Hispanic men.[42]

The Role of Provider Recommendation

Provider recommendation refers to provider encouragement of a health behavior or treatment based on clinical guidelines, often set by the US Preventive Services Task Force.[44] Published data has emphasized the importance of provider-patient communication, especially for increasing positive preventive health behaviors such as colorectal cancer screenings[45], breast cancer screenings[46], and vaccinations.[47] Research focused on preventing barriers to uptake and reducing cancer disparities also highlights provider recommendation as a crucial step in the adolescent vaccination process.[48-51] Not only do provider recommendations help with vaccine uptake[52, 53], but also they impact parental awareness and ultimately acceptance of the vaccine.[54] For example, Rahman et al. found that provider recommendation mediates the association between parental HPV vaccine awareness and uptake.[53]

Despite known importance of provider recommendations and the 2011 ACIP recommendation to vaccinate males, low recommendation rates still prevent many adolescents from receiving HPV vaccines.[49] When asked why their adolescent son did

not receive the HPV vaccine in the 2013 NIS – Teen, the most common response from parents (22.8%) was that it was not recommended.[34] For girls, not receiving a recommendation was the fourth most common reason (13.0%). In a similar study, 56.7% of parents reported lack of provider recommendation as a main reason why they chose not to vaccinate their sons.[55] In other smaller studies, researchers analyzed provider samples from Minnesota[56] (N=575) and Georgia[57] (N=206) and found that providers were more likely to routinely recommended HPV vaccines to girls than boys. Poor quality of provider recommendations can also prevent HPV vaccine uptake. Gilkey et al. recently found that 27% of physicians do not provide strong endorsements for HPV vaccines, and only half tend to recommend same-day vaccination.[58] Another Gilkey et al. study analyzed a national sample of 776 US physicians and found that HPV vaccine discussions typically take twice as long compared to discussions about Tdap, and that 70% of physicians reported discussing HPV vaccination last.[59] These findings suggest that physicians find discussing HPV vaccines difficult and are in need of effective communication strategies.[59] Overall, strong and consistent provider recommendations have the potential to decrease missed opportunities for HPV vaccination.

Racial and Ethnic Differences in Provider Recommendation

While provider recommendations for all vaccinations need improvement, researchers have also identified racial and ethnic differences in patient-provider communication about HPV vaccines. Because provider recommendations are strongly tied to vaccine uptake, they are an essential tool for decreasing racial and ethnic HPV health disparities.[60, 61] Published data report mixed findings for female adolescents and adults. Wong & Do found that among women aware of the vaccine, African Americans were most likely to have a discussion with their healthcare provider[52].

Other studies report that whites and females are more likely to have heard about HPV from their physician.[62] These studies propose that physician characteristics such as race or HPV vaccine awareness may affect patient-provider discussions. More recently, researchers studied the relationship between provider recommendation, vaccine uptake and race/ethnicity for a sample of teen girls using the 2009 NIS-Teen.[63] After controlling for individual characteristics, they found that minorities were less likely to receive a recommendation, but that associations between recommendation and vaccine uptake were strong for all racial/ethnic groups. Another study surveyed New York physicians serving minority populations, and found only 34% of providers routinely recommend HPV vaccines to their patients, citing lack of time for educating patients as a major barrier.[64]

Despite minorities receiving fewer provider recommendations for HPV vaccines, they are more likely to initiate HPV vaccines. One explanation is that there are racial/ethnic differences in adherence to provider recommendation. For example, Reiter et al. found that although Hispanic parents were less likely to receive a provider recommendation and had less knowledge about HPV vaccines, their sons were still more likely to initiate.[65] This suggests that among Hispanic parents who do receive provider recommendations, the likelihood of adherence to that recommendation may be higher. In other words, provider recommendations for minorities may play a stronger role in the parent decision-making process compared to whites. For example, there may be differing cultural norms on whether or not to follow a doctor's orders. Btoush et al. found that female adolescents with non-English speaking parents were 40.9% more likely to initiate HPV vaccines compared to those with English speaking parents.[66] The authors suggest

that questioning a doctor's recommendation may not be as acceptable in other cultures compared to American culture. In another nationally representative online survey of parents of adolescents (n=2521), Hispanic parents reported concerns about HPV vaccine safety, but were also more likely to report generally following their doctor's recommendations for vaccines.[19]

Another possibility is that given higher cancer rates, minority communities may have more experience with HPV related cancer, therefore, increasing awareness and concern for vaccination. From the perspective of the Health Belief Model[9], HPV infections and subsequent cancers may pose a more serious perceived threat. For example, Molokwu et al. observed how Hispanic women with past history of abnormal pap tests were more likely to have heard about HPV vaccines.[41] Overall, improving provider recommendation may help close the gap for racial/ethnic disparities in HPV-related cancer outcomes, and help target educational interventions for parents and providers.

The Importance of Vaccinating Males

The majority of the HPV vaccine literature focuses on female adolescents and specific barriers to vaccine uptake. However, after the FDA approved the use of Gardasil for males age 9-26, the US adopted a gender-neutral vaccination policy with the goal of increasing vaccination rates for both males and females.[67] Although some research questions the cost effectiveness of vaccinating boys[68], immunizing all adolescents is important for several reasons. First, because HPV vaccination rates for girls remain low, herd immunity cannot be established.[67] Herd immunity is a widely accepted vaccination concept where individuals immune to a disease (vaccinated) can provide indirect protection to those who are not immune (unvaccinated), leading to an overall

protected population.[69] Additionally, vaccinating males can help reduce HPV transmission to female sexual partners.[70, 71] Although currently lacking clinical evidence, it is widely accepted that HPV vaccines can prevent oropharyngeal cancer, an increasing HPV-related cancer of the mouth and throat in men.[72, 73] Previously, oropharyngeal cancers were primarily associated with tobacco or alcohol use, but studies have found that incidence for HPV-negative cancers declined by 50% from 1984 to 2004.[74] Moreover, incidence of HPV-positive cancers increased by 225% from 1984 to 2004.[74] Based on these trends, the annual number of HPV-positive oropharyngeal cancers is expected to surpass the annual number of cervical cancers in the next decade.[74] Additionally, incidence of genital warts in men poses a substantial economic burden to the healthcare system, as treatment requires frequent follow-up care. Men account for approximately 50% of the genital wart cases costing the healthcare system more than $220 million annually.[13] Finally, vaccinating males provides protection to groups like men who have sex with men, who do not benefit from a female-only vaccination approach to decrease the spread of HPV.[70, 72]

Since the 2011 ACIP recommendation to vaccinate males, researchers have focused on identifying unique barriers for male HPV vaccination. In addition to barriers that prevent female vaccination such as lack of awareness, parents of adolescent sons may also perceive no direct benefit from vaccinating males[75] or lack social norms surrounding male vaccination.[76] Because of the more recent recommendation, patient-provider conversations about HPV vaccine are important. Donahue et al. reported how provider discussions surrounding HPV vaccination, regardless of recommendation, may

have a stronger effect on adolescent males compared to females.[77] Overall, much is still unknown about the parental decision process for adolescent male HPV vaccination.

Summary

The majority of previous HPV vaccine research focuses on adolescent females, and less is known about the parent decision-making process for vaccination of adolescent sons and predictors of their HPV vaccine initiation.[78] Identifying predictors of male adolescent HPV vaccination is important, because findings can inform educational or legislative strategies to improve uptake. Improving male HPV vaccination coverage will reduce HPV infections in both men and women, and decrease the economic burden of subsequent HPV-related genital warts and cancers. Furthermore, identifying racial/ethnic differences in uptake and provider recommendation is crucial for eliminating cancer disparities in both men and women.

To address this gap in the HPV literature, this study will examine the relationship between race/ethnicity and HPV initiation and provider recommendation for adolescent males. We will also explore provider recommendation as a potential moderator for the relationship between race/ethnicity and initiation. It is important to understand racial/ethnic differences in vaccination because of the implications for HPV-related cancers. In addition to identifying missed educational opportunities for adolescent males and their providers, findings will inform future research focusing on strategies to make patient-provider communication more culturally competent and effective.[79]

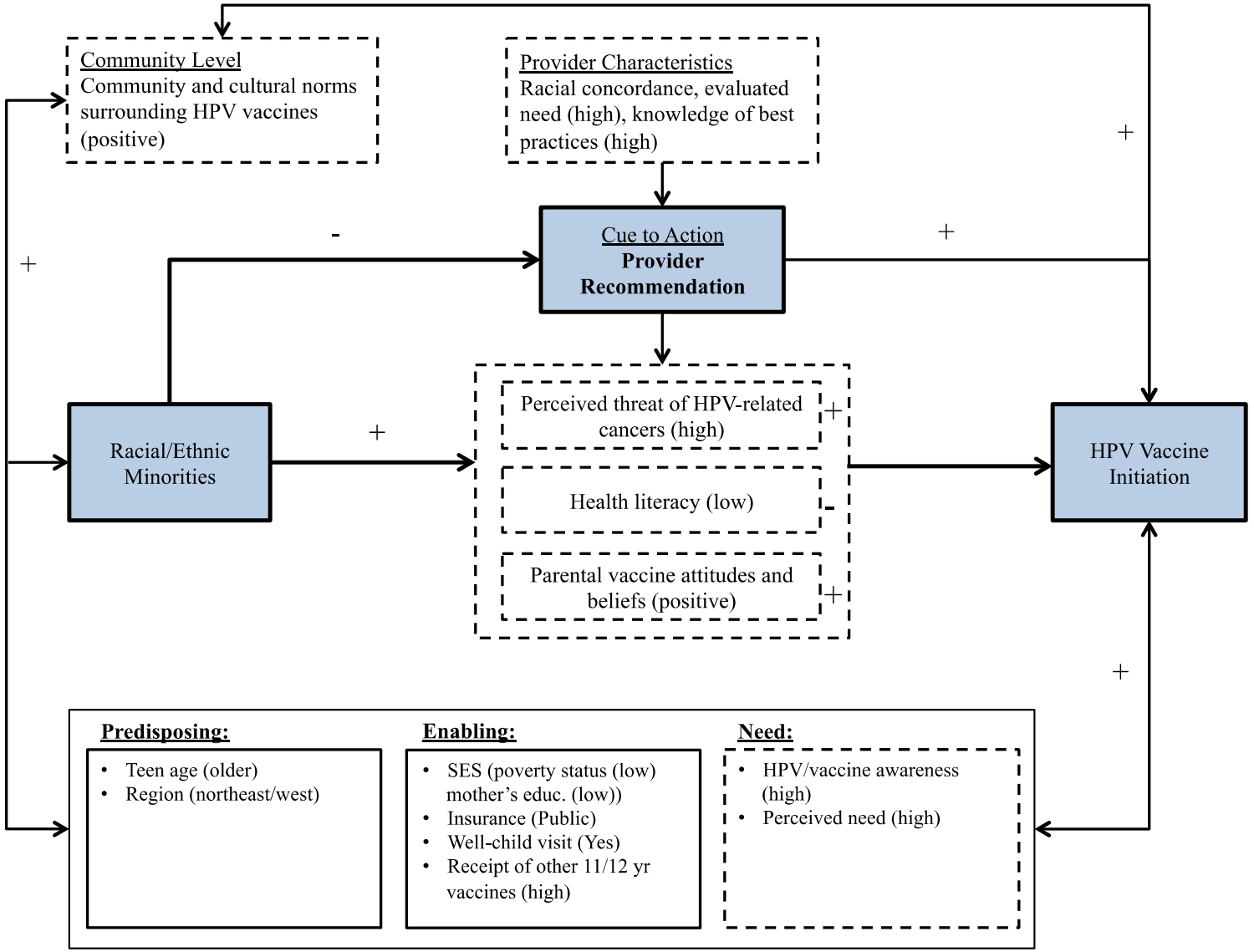
METHODOLOGY

Theoretical Framework

To develop a conceptual framework, the current study draws from the Andersen and Aday Behavioral Model of Healthcare Utilization[8] and the Health Belief Model[9] to establish constructs and mechanisms that link race/ethnicity and HPV vaccination uptake. Andersen and Aday's model provides a well-developed structure for individual-level characteristics that motivate health behaviors.[8] Individual-level predisposing characteristics included in this study are age, mother's education, and geographic region. Individual-level enabling characteristics are socioeconomic status, health insurance, and interaction with the healthcare system. Finally, individual-level need characteristics include clinically evaluated need for HPV vaccines.

The Health Belief Model is used to understand the decision-making process of using preventive services.[9] The model describes how individuals progress through a series of stages before taking action, and how cues to action (such as provider recommendation or media advertisements) can be a catalyst for change. Key constructs include perceived susceptibility and threat of a disease and cues to action. The model demonstrates how these constructs lead to the likelihood of engaging in health promoting behavior. For this study, we considered provider recommendation to be a cue to action, which can influence the likelihood of initiating HPV vaccines.

Figure 1. Conceptual Framework: HPV Vaccine Initiation Process for Male Racial/Ethnic Minority Adolescents



Focal Relationship

Figure 1 illustrates the focal relationship between racial/ethnic minorities and HPV vaccine initiation. The key independent variable is *race/ethnicity*, which can be defined in two parts using a sociological perspective. First, *race,* can be defined as "physical differences, that societies treat as significant and as warranting differential treatment."[80] For example, Freeman also argues "biologic expressions of race result in social interactions, which in turn produce racial and ethnic disparities in morbidity and mortality."[81] On the other hand, *Ethnicity* refers to a "social–political construct and includes shared origin, shared language, and shared cultural traditions."[81] To assess teen race/ethnicity, parent respondents were first asked to identify if they consider the teen Hispanic or Latino. Then, parent respondents were asked to select the teen's race. NIS – Teen combines race and ethnicity into the following categories: Hispanic, Non-Hispanic White, Non-Hispanic Black, and Non-Hispanic Other or Mixed Race.

The first key dependent variable, *HPV vaccine initiation*, refers to receiving the first of three recommended doses of the HPV vaccine.[3] Previous research has identified important racial/ethnic differences in HPV vaccine uptake, with male racial/ethnic minorities being more likely to initiate than their white counterparts.[82] Vaccine initiation was assessed using provider-verified vaccination data. We created a dichotomous variable to measure initiation. If an adolescent's provider verified records state the teen has received one or more HPV shots, then the adolescent has initiated the series.

Provider recommendation was also examined to identify racial/ethnic differences for patient-provider HPV vaccine communication. *Provider recommendation* refers to provider encouragement of a health behavior or treatment based on clinical guidelines

related to HPV vaccination. Parent or caregiver respondents were asked, “Had or has a doctor or other healthcare professional ever recommended that [Teen] receive HPV shots?” Receipt of a provider recommendation for HPV vaccines was measured by this dichotomous parent recall measure of receiving a provider recommendation.

Confounders

Both individual and community-level characteristics are proposed as confounders of the relationship between race/ethnicity and HPV vaccine initiation. First, the framework draws from Andersen’s predisposing, enabling, and need-related characteristics at the individual adolescent and parent level. In addition, the Health Belief Model is used to label provider recommendation for HPV vaccine as a “cue to action” that can encourage a specific health behavior: vaccine initiation.[83]

Individual Level Characteristics

Demographics: Age, Socioeconomic status, and Region

Both adolescent and parental ages have been shown to predict likelihood of HPV vaccine uptake. Adolescents tend to receive HPV vaccines between ages 13-15 years, after the recommended age range of 11-12 years.[84, 85] Previous research also demonstrates that older parents are less likely to vaccinate their children. According to Taylor et al., increased parental age may be associated with less vaccine uptake, and minority parents tend to be younger than their white counterparts.[35] Teen age ranged from 13 to 17 years based on the NIS – Teen sampling strategy, while we categorized mother’s age group into the following levels: less than 35 years, 35 to 45 years, and more than 45 years.

Socioeconomic status (SES) refers to a person’s ability to access financial, social, cultural, and human capital resources.[86] Individuals hold distinct positions

within a larger social system, which provide different levels of access to wealth, power, and prestige.[87] Research has shown that racial/ethnic minorities are more likely to have lower SES, which affects health outcomes.[88] The HPV vaccine literature has mixed findings on how SES impacts vaccine uptake. For example, higher SES is associated with increased awareness and vaccine completion[89], but other studies have reported that parents with higher income and education levels are less likely to vaccinate their children.[90] In addition, Reiter et al. found that Hispanic teens with family income above poverty level and household income above $75,000 were less likely to initiate than those with family income below poverty.[65] We measured socioeconomic status using census poverty level, mother's education status, and mother's marital status. We categorized mother's education into four levels, including less than 12 years, 12 years, more than 12 years (non-college graduate), and college graduate. Mother's marital status was categorized as current married or not currently married. Census poverty level was categorized as below poverty, above poverty with income < $75,000, above poverty with income > $75,000, and unknown. We included unknown or missing poverty status in our analysis to conserve sample size.

Additionally, research has shown how geographic factors such as *region* affect health care outcomes related to HPV. In the U.S., regional minority demographics may affect rates of vaccination and subsequent HPV-related cancers.[43] In one study, adolescents in south/southwest regions were less likely to initiate HPV vaccines compared to west, northeast and Midwest regions.[53] People living in rural areas are also less likely to know that HPV can cause cervical cancer[91], and are

disproportionately affected by HPV related cancers.[92, 93] Teen's geographic region was categorized as Northeast, Midwest, West, or South.

Insurance Status and Coverage

Previous research has established that minorities are more likely to be uninsured or have public insurance[94], and health insurance status may also influence HPV vaccine uptake. For example, boys with private health insurance are less likely to be vaccinated compared to those with public insurance.[35] Uninsured young women are less likely to be vaccinated compared to those with insurance coverage.[89, 95]

Additionally, providers may alter their behavior based on patient insurance type. One study found that difficulty insuring HPV vaccine completion discouraged providers from recommending the vaccine to Medicaid-enrolled adolescents.[96] However, Malo et al. found that Florida Vaccines for Children (VFC) providers were less likely to view cost of stocking HPV vaccines and lack of reimbursement as barriers to vaccinating their patients[97], and Gowda & Dempsey found that participation in more expansive VFC programs was associated with more HPV vaccine coverage in girls.[98] To assess health insurance status, respondents were categorized into four groups, with priority given to employer or union plans. Based on previous studies using NIS-Teen, the four groups included Employer/Union, Any Medicaid or SCHIP, Indian/Military/Other, and uninsured. If respondents did not fall into the first three categories, they were classified as uninsured.

Vaccine awareness and perceived need

Previous studies show that awareness and perceived need increase the likelihood of vaccination[53], and that racial/ethnic differences exist for HPV vaccine

awareness.[31, 63, 99] For example, Reimer et al. found that white parents had more awareness and knowledge of HPV vaccines compared to Hispanic and African-American parents.[62] For this study, the construct is unmeasured and illustrated in Figure 1 with a dotted border.

Interaction with the healthcare system and Other Adolescent Vaccines

Interaction with the healthcare system refers to the frequency with which adolescents are visiting their providers for non-urgent care. Previous research has established that racial/ethnic minorities are less likely to have a usual source of care[100], which limits interaction with the system. Donahue et al. found that out of parents who did not vaccinate their children for HPV, 9.4% reported not seeing a doctor in a long time as a main reason.[55] Another study found that for Hispanics, initiation was higher among teens who had visited a healthcare provider in the last year.[65] Increased interaction with the healthcare system may be positively associated with HPV vaccination because it provides an opportunity to improve knowledge and facilitate the three visits required for completion.[101] To assess a teen's level of interaction with the healthcare system, we used receipt of an 11-12 year well-child checkup as a proxy measure. We included an additional category of parents who responded, "Don't know" when asked if their child received an 11-12 year old visit to conserve sample size.

Other adolescent vaccines refers to receipt of vaccines adolescents typically receive at age 11-12 years, such as Tetanus-Diphtheria-Pertussis (Tdap) booster and Meningococcal.[102] Co-administration of HPV, Tdap, and Meningococcal has been well tolerated and is considered a strategy for minimizing the number of required visits.[16, 103] Additionally, researchers found that children with provider

recommendations for any four adolescent vaccines (Tdap, Meningococcal, HPV, and Influenza) were more likely to actually receive Tdap, Meningococcal, and HPV vaccines.[48] As a result, receiving Tdap and Meningococcal vaccines by age 11-12 years may predict HPV vaccine uptake and is included as a covariate.

Community Level Characteristics

Community norms about HPV vaccines

Shared *community values and social norms* may influence a parent's decision to vaccinate their child. Stockwell et al. studied social factors associated with missing vaccination visits for urban children and found that having family members and friends with positive vaccine views was protective.[104] For HPV vaccines, public opinion can result in vaccine uptake or growing hesitation about the vaccine. For example, researchers have found that social norms that support vaccination and positive media influence are both associated with vaccine uptake for girls.[105] Conversely, researchers interviewed parents and found that some associate the HPV vaccine with onset of sexual activity.[106] This construct is unmeasured and illustrated in Figure 1 with a dotted border.

Provider Characteristics Influencing Recommendation

Provider racial concordance

Racial concordance is when a healthcare provider and patient are "racially matched," and is thought to increase communication and trust in the healthcare setting.[107] Previous research found racial concordance was associated with outcomes such as patient satisfaction and continuance of care.[108, 109] As a result, *racial*

concordance may influence how well a patient or their parent adheres to the recommendation for HPV vaccines. This construct is also unmeasured in Figure 1.

Provider evaluated need

To provide recommendations for HPV vaccines, providers must be knowledgeable about current best practices. *Provider evaluated need* refers to the provider's ability to be familiar with current ACIP vaccination guidelines and determine if a patient is eligible for vaccination. Providers who correctly identify need for HPV vaccines may be more likely to engage in a discussion and encourage uptake with their patients. Although the majority of providers are familiar with current guidelines, studies have reported that provider discomfort discussing STIs and HPV-related cancers with adolescent patients and their parents is associated with lack of recommendation.[96, 110] This construct is also unmeasured in Figure 1.

Mechanisms

Parental vaccine attitudes and beliefs: Mediating the focal relationship

Figure 1 shows the proposed mechanism, *parental vaccine attitudes and beliefs*, through which race/ethnicity relates to HPV vaccine uptake. Race and ethnicity shape the cultural views and values parents have, which will ultimately influence their decision to vaccinate their child. For example, Taylor et al. found that parents who discuss sexual health topics with their sons were more likely to vaccinate.[35] Discussion of sexual health topics may vary depending on the cultural background and beliefs of the parents. Because the data do not capture these parental opinions, the construct is unmeasured (Figure 1).

Health literacy: Mediating the focal relationship

Figure 1 also shows the mechanism *health literacy*, through which race/ethnicity relates to HPV vaccine initiation. *Health literacy* is defined as the ability to "obtain, process, and understand basic health information and services to make appropriate health decisions."[111] Previous studies have found that racial/ethnic minorities tend to have lower health literacy compared to whites[111], and that health literacy can help improve HPV vaccine knowledge and uptake.[112]

Perceived threat of HPV and related cancers: Mediating the focal relationship

Parents who believe HPV related health consequences (cancers, genital warts) to be a serious threat are more likely to vaccinate their children. Over 16 studies have examined parental concerns of HPV related diseases and cancers[20] In general, parents with more concerns about HPV infection, genital warts, and cancer are more likely to vaccinate for HPV.[20] *Perceived threat* is also an unmeasured variable in the model.

Provider Recommendation: A potential moderator?

For this framework, *provider recommendation* refers to provider encouragement of a health behavior or treatment based on clinical guidelines related to HPV vaccination. Previous research has reported that provider recommendation supports HPV vaccine uptake[53, 63, 113], but this recommendation may matter less for whites. A 2015 study observed how white adolescent females received more recommendations compared to minorities, but did not have correspondingly higher initiation rates; this implies that parental refusal matters.[113] Drawing from these studies, the research question examines whether provider recommendations carry more weight in the decision to vaccinate for whites compared to racial/ethnic minorities.

Research Questions and Hypotheses

H1: After controlling for adolescent and parent characteristics, racial/ethnic minority adolescents are more likely to initiate the HPV vaccine compared to their white counterparts.

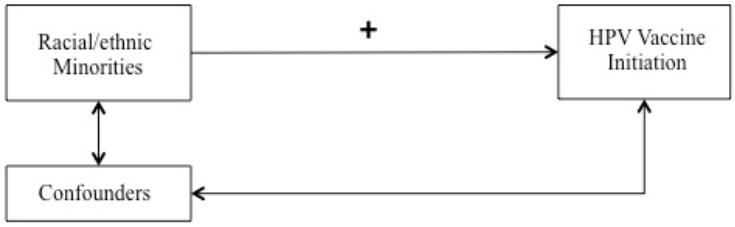


Figure 2. Hypothesis Diagram for the Relationship Between Race/Ethnicity and HPV Initiation

H2: After controlling for adolescent and parent characteristics, racial/ethnic minority adolescents are less likely to receive a provider recommendation for HPV vaccines compared to their white counterparts.

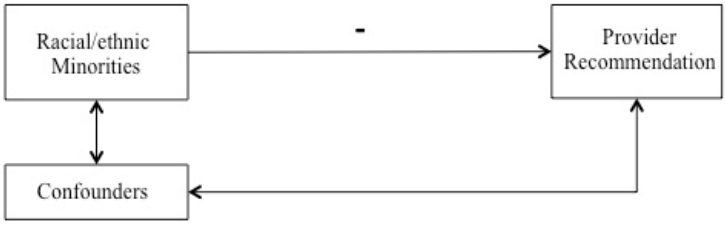


Figure 3. Hypothesis Diagram for the Relationship Between Race/Ethnicity and Provider Recommendation

H3: The positive relationship between minority race/ethnicity and vaccine initiation is strengthened for those who received a provider recommendation to vaccinate, after controlling for adolescent and parent characteristics.

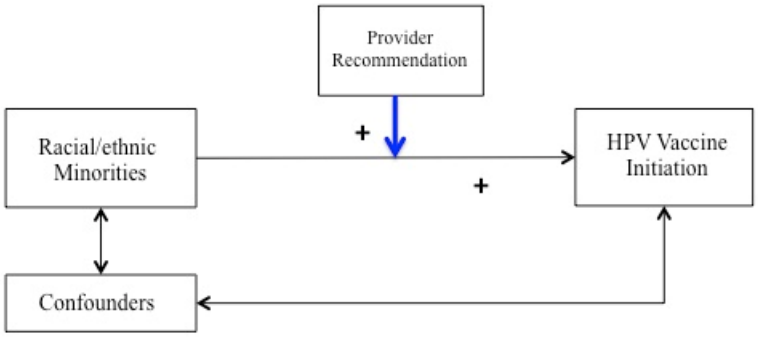


Figure 4. Hypothesis Diagram for Provider Recommendation as a Moderator for the Relationship Between Race/Ethnicity and HPV Initiation

Data Source

The data source for this study is the National Immunization Survey (NIS) - Teen 2014 cross-section. In 2008, the National Center for Immunizations and Respiratory Diseases and the Center for Health Statistics at the CDC expanded the original NIS survey to sample parents or caregivers of adolescents 13-17 years old in all 50 US states, District of Columbia, and Puerto Rico or Virgin Islands.[114] The NIS-Teen contacts participants by using a list-assisted random-digit-dialing telephone survey. In 2012, the CDC also started randomly sampling cell-phone only households. In 2014, response rates of 60.3% and 31.2% were achieved from those contacted via landline and cell phone, respectively.[114] This yielded a total sample of 38,703 adolescents (20,030 landline and 18,673 cell-phone only).[114]

Once interviewers identify parents or caregivers of adolescents, they are asked to self-report demographic characteristics and vaccination history of the adolescents. Interviewers also request permission to contact the adolescent's immunization provider to verify responses. In 2014, 64.4% of landline respondents and 61.2% of cell-phone respondents gave oral consent for NIS to follow up with the teen's providers.[114] Approximately 94.9% of landline sample providers and 94.8% of cell-phone providers

returned vaccine questionnaires.[114] Based on these responses, 11,243 (57.1%) of landline-sample teens were considered to have adequate provider vaccination data. For the cell-phone sample teens, 9,584 (52.3%) had adequate provider data.

NIS-Teen coverage estimates use data from adolescents with adequate provider data, which comes from provider-verified vaccination information. In 2014, the NIS-Teen defined adequate provider data as “any adolescent for whom one or more of the named providers report vaccination history data or who by parental and provider report are completely unvaccinated”.[114] In 2014, adequate provider vaccination data weights were provided for adolescents in all 50 US states, excluding Puerto Rico.

Analytic Sample

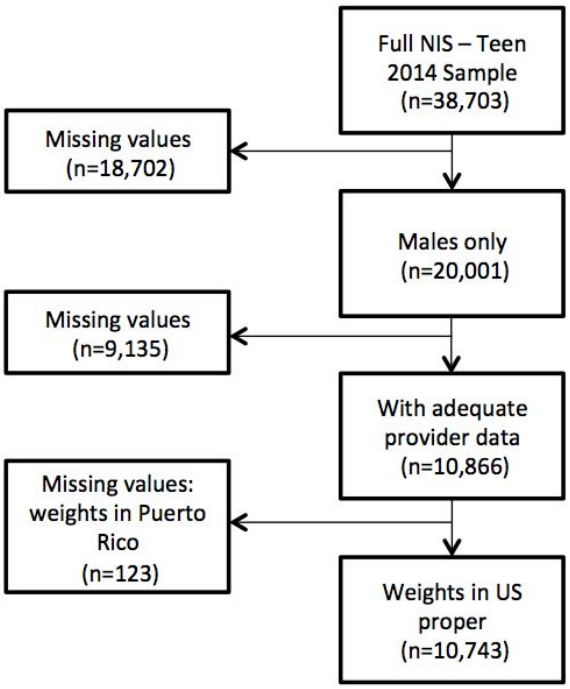


Figure 5. Analytic Sample Flowchart for NIS – Teen 2014

The analytic sample included the 2014 National Immunization Survey – Teen for a cross-sectional design. Only male adolescents with provider verified data and weights for all 50 US states, excluding teens sampled in Puerto Rico, were analyzed. The final sample included 10,743 adolescent males with provider verified vaccination data in the US proper (Figure 5).

Table 1. Key constructs and measurement plans, NIS-Teen 2014			
Construct	**NIS – Teen variable(s)**	**Measure**	**Hypothesized relationship with dependent variable**
Key variables			
HPV Vaccine Initiation	P_NUMHPV	Vaccine initiation will be measured by number of provider verified HPV shots received.	HPV vaccine initiation will be the dependent variable.
Race/ethnicity	RACEETHK	Adolescents will be classified as one of the following racial/ethnic groups: Hispanic Non-Hispanic White Non-Hispanic Black Non-Hispanic Other or Mixed Race	Minority adolescents will be more likely to initiate HPV vaccines compared to whites.
Provider Recommendation	HPVI_RECOM	Using parent recall, a dichotomous variable will categorize respondents based on: "Had or has doctor or other health care professional ever recommended that [Teen] receive HPV shots?" Yes No	Provider recommendation will be a dependent variable. Provider recommendation will also be associated with higher rates of initiation.
Teen characteristics			
Age (time of survey)	AGE	Teen age will be categorized as one of the following: 13 years 14 years 15 years	Older teen age will be associated with increased likelihood of HPV initiation.

		16 years 17 years	
Health Insurance Status	TIS_INS_1 TIS_INS_2 TIS_INS_3 TIS_INS_3A TIS_INS_4_5 TIS_INS_6	Four insurance categories will be created: Employer/Union Any Medicaid or SCHIP Indian/Military/Other Uninsured (none of the above)	Adolescents with public health insurance will have higher rates of initiation.
Interaction with the Healthcare System (proxy)	CKUP_11_12	Interaction with the healthcare system will be estimated based on teen receipt of an 11-12 year old well-child visit. The categories will be as follows: Yes No Don't Know	Adolescents who had well-child visits will be more likely to initiate HPV vaccines.
Receipt of other adolescent vaccines (TDAP, Meningococcal)	P_UTDTDAP P_UTDMEN	Being up-to-date on either Tdap or Meningococcal adolescent vaccines will be measured with "up-to-date" flags (teen must be UTD on at least one shot to be considered UTD.)	Adolescents who are up to date on other adolescent vaccines will be more likely to initiate.
Geographic region	CEN_REG	Geographic region will be measured by reported census region. Regions include: Northwest Midwest South West	Adolescents in regions with higher rates of HPV-related cancers (South and Midwest) will be less likely to initiate HPV vaccines.

Parent Characteristics			
Census poverty level (SES)	INCPOV1	SES will be measured with census poverty level. Poverty levels include: Above poverty >$75K Above poverty <=$75K Below poverty Unknown	Adolescents below poverty will be more likely to initiate compared to those above poverty.
Mother's age group	AGEGRP_M_I	Mother's age categories will include: <= 34 years 35 to 44 years >= 45 years	Adolescents with older mothers will be less likely to vaccinate.
Mother's education level (SES)	EDUC1	Mother's education categories will include: Less than 12 years 12 years More than 12 years, non-college grad College graduate	Adolescents with lower maternal education level will be more likely to initiate.
Mother's marital status (SES)	MARITAL2	Marital status will be categorized as one of the following: Married Not currently married (includes divorced, separated, widowed, deceased)	Adolescents with married mothers will be less likely to initiate.

Statistical Methods

We used complex survey procedures during analysis to account for the survey's dual-frame sampling and weighting techniques.[10] We used SAS 9.4 (SAS Institute, Inc., Cary, NC) for data analysis. We then generated estimates using the PROC SURVEYFREQ and PROC SURVEYLOGISTIC procedures. We clustered standard errors by unique teen identifier (SEQNUMT). Significance levels were set as $p < .05$ and logistic regression results were expressed as odds ratios. The Emory University Institutional Review Board considered this study non-human subjects research and exempted it from review.

Analyses

Descriptive Statistics

First, we generated descriptive statistics for key variables of interest and confounders (Table 1). We used chi-square tests of independence to compare individual characteristics of adolescent HPV vaccine initiators and non-initiators. Chi-square tests of independence were also used to compare individual characteristics of adolescents by race/ethnicity (see Appendix A, Supplemental Table 10).

Main Analysis

To evaluate the effect of race/ethnicity on initiation, we used two logistic regression models and controlled for confounding variables, including health insurance status, well-child visit, poverty status, provider recommendation, teen and maternal age, receipt of Tdap or Meningococcal vaccines, mother's education level, marital status and census region (Table 2, Models 1a and 1b). We then used a third logistic regression model to examine racial/ethnic differences in provider recommendation, controlling for adolescent and parent characteristics (Table 2, Model 2). The fourth logistic regression

model examined the effect of provider recommendation on the association between race/ethnicity and initiation. We created an interaction term between race/ethnicity and provider recommendation; non-Hispanic white adolescents served as the reference group (Table 2, Model 3). We then used the LSMEANS statement in PROC SURVEYLOGISTIC to better compare the role of recommendation in HPV vaccine outcomes across all racial/ethnic groups. We also conducted a sensitivity analysis to examine the separate roles race and ethnicity may have on likelihood of HPV initiation and provider recommendations. These results are included in Appendix A: Race and Ethnicity Sensitivity Analysis.

Table 2. Logistic Regression Models

Model 1a and 1b:
$\ln\left(\frac{Initiation}{1-Initiation}\right) = \beta_0 + \beta_1 RaceEthnicity + \beta_2 Rec + \beta_3 TeenAge + \beta_4 Insurance + \beta_5 Wellchild + \beta_6 OtherVaccines + \beta_7 Region + \beta_8 Poverty + \beta_9 Educ + \beta_{10} Marital + \beta_{11} MotherAge + \varepsilon$
Model 2:
$\ln\left(\frac{Rec}{1-Rec}\right) = \beta_0 + \beta_1 RaceEthnicity + \beta_2 TeenAge + \beta_3 Insurance + \beta_4 Wellchild + \beta_5 OtherVaccines + \beta_6 Region + \beta_7 Poverty + \beta_8 Educ + \beta_9 Marital + \beta_{10} MotherAge + \varepsilon$
Model 3:
$\ln\left(\frac{Initiation}{1-Initiation}\right) = \beta_0 + \beta_1 RaceEthnicity + \beta_2 Rec + \beta_3 TeenAge + \beta_4 Insurance + \beta_5 Wellchild + \beta_6 OtherVaccines + \beta_7 Region + \beta_8 Poverty + \beta_9 Educ + \beta_{10} Marital + \beta_{11} MotherAge + \beta_{12} RaceEthnicity * Rec + \varepsilon$

RESULTS

Descriptive Statistics

Table 3 describes weighted individual characteristics for adolescent male initiators and non-initiators of HPV vaccines. The final sample size was 10,743 male adolescents with adequate provider data. Of those, 4,436 adolescents (41.3%) initiated the HPV vaccine, while 6,307 adolescents (58.7%) did not initiate the vaccine. The mean age at time of survey was 15.0 years. The majority of male adolescents were non-Hispanic white (55.9%), had 11-12 year well-child visits (90.4%), had insurance coverage through an employer or union (57.1%), lived in the South (37.8%), and were up-to-date on Tdap or Meningococcal vaccines (75.3%). Overall, 53.7% of parents self-reported receiving a recommendation for HPV vaccines from a healthcare provider. The largest percentage of adolescents came from families with reported incomes above poverty and making > $75K (36.4%). The majority of mothers were college graduates (37.1%), age 45 years or older (46.1%), and were currently married (67.5%). The sample significantly differed on several adolescent and parental characteristics by initiation status, including race/ethnicity, health insurance, region, being up-to-date on Tdap or Meningococcal, HPV recommendation, maternal education level, maternal marital status and poverty status (Chi-squared tests, $p<.05$). For example, 54.2% of Hispanic adolescents initiated the HPV vaccine series, compared to only 36.4% of non-Hispanic white adolescents. The majority of adolescents with employer/union insurance (61.5%) and adolescents in the South (62.1%) and Midwest (62.2%) did not initiate, respectively.

Table 3. Weighted Adolescent Male and Parent Characteristics by HPV Vaccine Initiation Status, NIS Teen 2014

	Total (N=10743)	Initiated (N=4436)	Did not initiate (N=6307)	P-value
Adolescent Characteristics				
US weighted sample size	10,659,765	4,450,370	6,209,395	
Proportion of sample (%)	100	41.3	58.7	
Mean age of teen at survey (years)	15.0	15.0	14.9	
Race/ethnicity (%)				<.0001
Hispanic	22.0	54.2	45.8	
Non-Hispanic white	55.9	36.4	63.6	
Non-Hispanic black	13.2	42.1	57.9	
Non-Hispanic other + mixed race	8.9	44.0	56.0	
Had 11-12 year well-child visit (%)				.3051
Yes	90.4	44.4	55.6	
No	5.6	36.0	64.0	
Don't know	4.0	43.6	56.4	
Health insurance (%)				.0008
Employer/Union	57.1	38.5	61.5	
Any Medicaid/SCHIP	31.4	47.3	52.7	
Indian/Military/Other	4.8	40.1	59.9	
Uninsured	6.7	40.5	59.5	
Region of country (%)				<.0001
Northeast	16.7	48.0	52.0	
Midwest	21.7	37.8	62.2	
South	37.8	37.9	62.1	
West	23.9	47.0	53.0	
UTD Tdap or Meningococcal (%)				<.0001
Yes	91.3	45.4	54.6	
No	8.7	3.4	96.6	
Parent Characteristics				
Received provider recommendation for HPV vaccine (%)				<.0001
Yes	53.7	63.4	36.6	
No	46.3	19.2	80.8	
Maternal education level (%)				<.0001
Less than 12 years	13.4	55.8	44.2	
12 years	23.8	42.4	57.6	
12 + years, non college grad	25.7	36.4	63.6	
College graduate	37.1	40.0	60.0	

Maternal age group (%)				.0672
<= 34 years	8.3	48.9	51.1	
35-44 years	45.6	41.2	58.8	
>= 45 years	46.1	41.0	59.0	
Marital status (%)				.0207
Married	67.5	40.2	59.8	
Not currently married	32.5	45.0	55.0	
Poverty status (%)				<.0001
Below poverty	22.4	51.6	48.4	
Above poverty <= $75,000	35.8	39.4	60.6	
Above poverty > $75,000	36.5	39.6	60.4	
Unknown	5.3	30.7	69.3	

Source: CDC, NCRID and NCHS (2015), 2014 National Immunization Survey.
NIS Teen = National Immunization Survey - Teen; HPV = human papillomavirus; initiation = 1 or more shots; UTD = up-to-date; Tdap = diphtheria, tetanus, and pertussis; Completion = 3 or more shots

Note: Row percents shown for Initiated and Did not initiate categories

Main Analysis

Weighted logistic regression results are shown in Table 4. The first research question addressed whether race/ethnicity predicts the likelihood of adolescent male HPV vaccine initiation (Model 1a). After controlling for various individual adolescent and parental characteristics (excluding provider recommendation), we found that male adolescent race/ethnicity significantly predicted likelihood of initiation. More specifically, Hispanic adolescents had 76 percent higher odds of initiating HPV vaccines compared to non-Hispanic whites (p=.0001). Non-Hispanic other and multiple race adolescents had 43 percent higher odds of initiation (p= .0252). Finally, non-Hispanic black adolescents were no more likely to initiate than their non-Hispanic white counterparts (OR: 1.27; 95% CI: 0.96-1.68).

Several adolescent and parental covariates had a significant association with HPV vaccine initiation. For example, adolescents covered by Indian/Military/Other insurance had 44 percent higher odds of initiating compared to adolescents with Employer/Union insurance (p=.0475). Male adolescents living the Midwest and South had 29 and 31 percent smaller odds respectively of initiating compared to their counterparts in the Northeast. Being up-to-date on either Tdap or Meningococcal was a strong predictor of initiation, with up-to-date adolescents having almost 1,981% higher odds of initiating compared with non-up-to-date adolescents. Maternal age group and maternal education level were significant predictors as well. Mothers aged 35-44 years had 31 percent higher odds of having sons that initiated the vaccine compared to mothers aged <= 34 years. Mothers with less than 12 years of education had 62 percent greater odds of having sons that initiated compared to those with 12 years of education.

We also analyzed Model 1 including provider recommendation as a control variable (Table 4, Model 1b). Our results are fairly consistent with Model 1a, and indicated that male Hispanic adolescents had significantly greater odds of initiation compared to their non-Hispanic white counterparts (OR: 1.91; 95% CI: 1.41-2.57). Similar to Model 1a, non-Hispanic other and multiple race adolescents had 59 percent higher odds of initiating compared to non-Hispanic whites (OR: 1.59; 95% CI: 1.11-2.29).

Similar to Model 1a, significant covariate predictors for increased initiation in Model 1b included being up-to-date on Tdap or Meningococcal (OR: 18.59; 95% CI: 11.17-30.94), and maternal education level of less than 12 years (OR: 1.92; 95% CI: 1.32-2.80). Above poverty <= $75 K (OR: 0.70; 95% CI: 0.51-0.95) and unknown poverty status (OR: 0.43; 95% CI: 0.25-0.73) were also associated with lower odds of initiation, respectively.

In contrast to Model 1a, maternal age 35 to 44 years was not significant predictor of adolescent initiation (OR: 0.64; 95% CI: 0.41-1.02). Indian/Military/Other insurance status was also not significantly associated with greater odds of initiation compared to Employer/Union adolescents (OR: 1.27; 95% CI: 0.88-1.84). Additionally, there were no significant regional predictors for initiation in this model. However, adolescents who had a well-child visit had 35 percent lower odds of initiation compared to adolescents who did not have a visit (OR: 0.65; 95% CI: 0.43-0.98).

Receiving a provider recommendation for HPV vaccines was a strong predictor of initiation for male adolescents. In particular, adolescents with parents who reported receiving a provider recommendation had 892% higher odds of initiation compared with

their counterparts who did not receive a recommendation (OR: 8.92; 95% CI: 7.22-11.02).

Model 2 examined the relationship between adolescent race/ethnicity and receipt of a provider recommendation for HPV vaccines (Table 4). After controlling for individual-level covariates, our results indicate there were no significant racial/ethnic differences for provider recommendation in male adolescents. For example, Hispanic and Non-Hispanic black adolescents had 16 percent (95% CI: 0.87-1.55) and 22 percent (95% CI: 0.93-1.61) higher odds of receiving a recommendation compared to white counterparts, respectively. Non-Hispanic other and multiple race adolescents had 2 percent lower odds of receiving a recommendation in comparison to whites (95% CI: 0.71-1.34). Similar to previous models, several adolescent and parent covariates in Model 2 had significant associations with provider recommendation. For example, adolescents who received an 11-12 year well-child visit had 249% higher odds of initiating compared to those who did not (OR: 2.49; 95% CI: 1.56-3.99). In addition, adolescents up-to-date on Tdap or Meningococcal vaccines had approximately 320% higher odds of receiving a provider recommendation for HPV vaccines (OR: 3.20; 95% CI: 2.35-4.37).

There were also several significant geographical differences for receiving provider recommendations. For example, adolescents living in the Midwest (OR: 0.65; 95% CI: 0.52-0.82) and South (OR: 0.59; 95% CI: 0.47-0.74) were less likely to have received provider recommendations compared to those living in the Northeast, respectively.

Table 4. Weighted logistic regressions for racial/ethnic differences in adolescent male HPV vaccine initiation and provider recommendation, NIS Teen 2014

	Initiation	Initiation (with Recommendation)	Provider Recommendation
	Model 1a, OR (95% CI)	Model 1b, OR (95% CI)	Model 2, OR (95% CI)
Adolescent Characteristics			
Race/ethnicity			
Non-Hispanic white	Ref	Ref	Ref
Hispanic	1.76 (1.32-2.34)	1.91 (1.41-2.57)	1.16 (0.87-1.55)
Non-Hispanic black	1.27 (0.96-1.68)	1.20 (0.86-1.68)	1.22 (0.93-1.61)
Non-Hispanic other + multiple race	1.43 (1.05-1.96)	1.59 (1.11-2.29)	0.98 (0.71-1.34)
Age of teen at survey (y)			
13	Ref	Ref	Ref
14	1.11 (0.82-1.49)	1.15 (0.82-1.62)	1.01 (0.74-1.39)
15	1.27 (0.96-1.70)	1.20 (0.86-1.67)	1.23 (0.91-1.66)
16	0.98 (0.73-1.32)	1.03 (0.75-1.42)	0.95 (0.69-1.29)
17	1.15 (0.86-1.55)	1.29 (0.92-1.81)	0.91 (0.67-1.24)
Did teen have an 11-12 year well-child visit?			
No	Ref	Ref	Ref
Yes	1.08 (0.75-1.57)	0.65 (0.43-0.98)	2.49 (1.56-3.99)
Don't know	1.22 (0.64-2.32)	0.99 (0.52-1.90)	1.67 (0.81-3.43)
Health insurance			
Employer/Union	Ref	Ref	Ref
Any Medicaid/SCHIP	1.10 (0.83-1.44)	1.24 (0.93-1.64)	0.89 (0.68-1.17)
Indian/Military/Other	1.44 (1.00-2.05)	1.27 (0.88-1.84)	1.38 (0.97-1.98)
Uninsured	0.86 (0.54-1.37)	1.01 (0.64-1.59)	0.70 (0.46-1.07)
Region of country			
Northeast	Ref	Ref	Ref
Midwest	0.73 (0.59-0.92)	0.86 (0.67-1.10)	0.65 (0.52-0.82)
South	0.69 (0.55-0.86)	0.85 (0.66-1.09)	0.59 (0.47-0.74)
West	1.04 (0.78-1.39)	1.12 (0.82-1.54)	0.87 (0.65-1.16)
UTD Tdap or Meningococcal			
No	Ref	Ref	Ref
Yes	19.81 (12.19-32.19)	18.59 (11.17-30.94)	3.20 (2.35-4.37)
Parent Characteristics			
Received provider recommendation for HPV vaccine			

No	Ref	Ref	Ref
Yes	N/A	8.92 (7.22-11.02)	N/A
Maternal age group			
<= 34 years	Ref	Ref	Ref
35-44 years	0.69 (0.49-0.97)	0.64 (0.41-1.02)	0.99 (0.70-1.42)
>= 45 years	0.75 (0.53-1.06)	0.68 (0.43-1.09)	1.11 (0.77-1.60)
Maternal education level			
12 years	Ref	Ref	Ref
Less than 12 years	1.62 (1.15-2.30)	1.92 (1.32-2.80)	0.96 (0.67-1.38)
12 + years, non college grad	0.86 (0.66-1.11)	0.80 (0.61-1.06)	1.05 (0.82-1.35)
College graduate	1.02 (0.78-1.34)	0.99 (0.74-1.32)	1.07 (0.81-1.41)
Marital status			
Not currently married	Ref	Ref	Ref
Married	0.90 (0.72-1.12)	0.88 (0.69-1.12)	1.01 (0.80-1.26)
Poverty status			
Below poverty	Ref	Ref	Ref
Above poverty <= $75 K	0.74 (0.55-0.98)	0.70 (0.51-0.95)	0.91 (0.68-1.22)
Above poverty > $75 K	0.88 (0.61-1.25)	0.76 (0.53-1.09)	1.18 (0.83-1.69)
Unknown	0.48 (0.30-0.77)	0.43 (0.25-0.73)	0.85 (0.53-1.36)

Source: CDC, NCRID and NCHS (2015), 2014 National Immunization Survey.
NIS Teen = National Immunization Survey - Teen; HPV = human papillomavirus; initiation = 1 or more shots; UTD = up-to-date; Tdap = diphtheria, tetanus, and pertussis; N/A = Model did not include provider recommendation as a covariate

Note: Model 1a N = 9099; Model 1b N = 8268; Model 2 N = 8268

Interaction Effects

To assess the effect of provider recommendation on the relationship between race/ethnicity and HPV vaccine initiation, we included an interaction term between race/ethnicity and provider recommendation in Model 3. Overall, the interaction term race/ethnicity*provider recommendation was significant (p=.0318) when controlling for the same set of individual adolescent and parent characteristics. Next, we used the LSMEANS statement to run comparisons between each racial/ethnic group and recommendation status (see Appendix B, Table 11).

Figures 6 and 7 illustrate how provider recommendation affects the association between race/ethnicity and initiation. Figure 1 is stratified by provider recommendation status (yes/no), and compares minority racial/ethnic groups to non-Hispanic whites (reference group) for each recommendation status. For those who received a provider recommendation, Hispanic adolescents had by far the highest odds of initiating HPV vaccines compared to whites. For those who did not receive a provider recommendation, Hispanics, non-Hispanic blacks, and Non-Hispanic other/multiple race adolescents had odds of initiation twice as high compared to whites. We then stratified Figure 7 by race/ethnicity, and compared adolescents who received provider recommendations to those who did not for each racial/ethnic group. Using no recommendation as the reference group, we found that non-Hispanic white adolescents had nearly 110% higher odds of initiation when they had received a provider recommendation. The odds of Hispanic adolescents initiating after receiving a recommendation were nearly 900% higher, while the odds of non-Hispanic black and other/multiple race adolescents were nearly 500% higher and 700% higher, respectively. Overall, the relationship between recommendation and initiation was strong for all racial/ethnic groups.

Figure 6. Interaction between Race/Ethnicity and Provider Recommendation on Male HPV Vaccine Initiation, NIS-Teen 2014

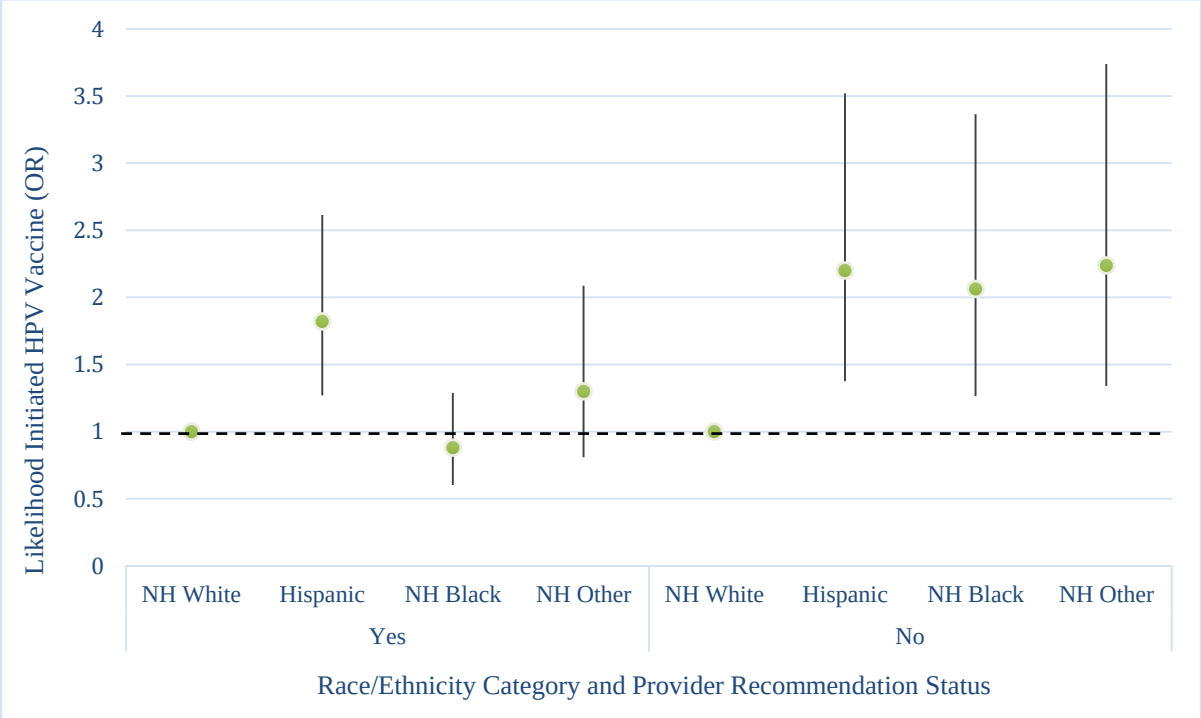
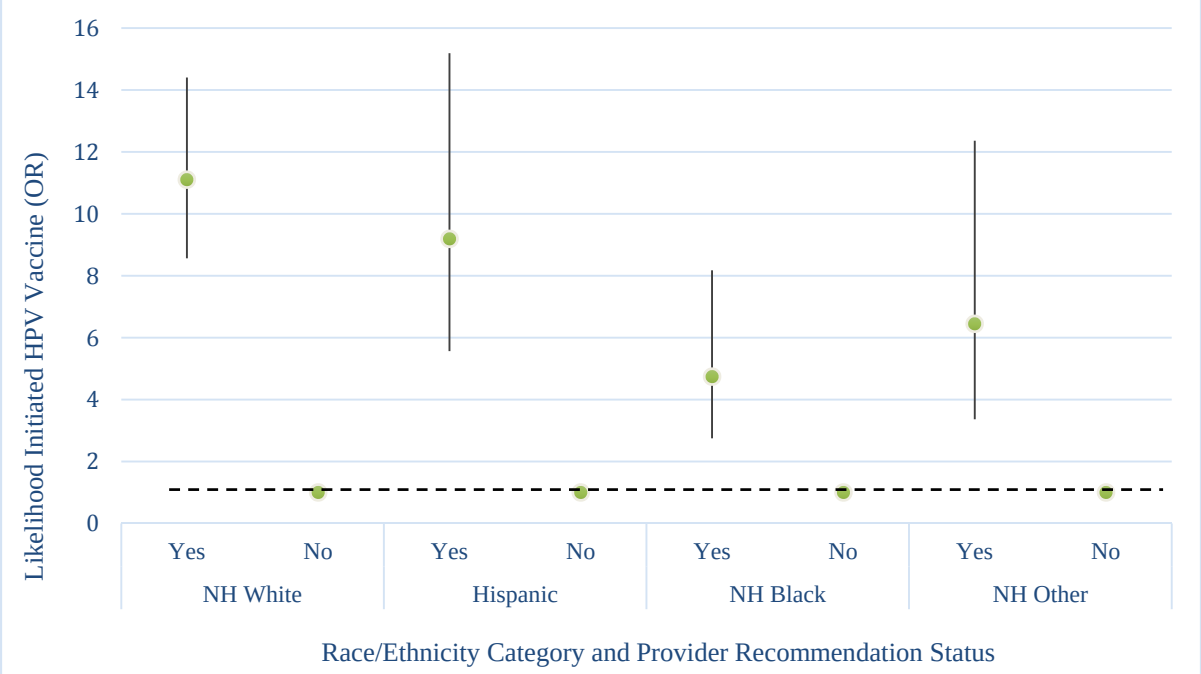


Figure 7. Interaction between Race/Ethnicity and Provider Recommendation on Male HPV Vaccine Initiation, NIS-Teen 2014



DISCUSSION

Summary

Overall, male adolescent HPV vaccination remains low. Compared to initiation rates from the NIS-Teen 2013 survey (34.6%), however, HPV vaccine uptake for teen boys continued to increase in 2014 (41.7%).[17] After multivariate logistic regression, we found that Hispanic male adolescents had 76% higher odds of initiating HPV vaccines compared to their non-Hispanic white counterparts. Other or multiple race adolescents also had 43% higher odds of initiating compared to whites. Contrary to our initial hypothesis, the odds of male adolescents receiving a provider recommendation for HPV vaccines did not differ by race/ethnicity. This suggests that minority male adolescents are receiving similar opportunities for patient-provider discussion on HPV vaccines compared to their white counterparts, but recommendations rates should be improved for all adolescents to reduce HPV-related cancer outcomes. For all racial/ethnic groups, approximately 53% of parents reported receiving provider recommendations. We also examined the interaction between race/ethnicity and provider recommendation, and found that recommendation greatly increases the odds of initiation for all racial/ethnic groups. However, recommendation may be a more important factor in the decision-making process for parents of non-Hispanic white adolescents compared to parents of minority adolescents.

Predictors of Initiation

Table 3 shows how initiators and non-initiators significantly differed on provider recommendation rates, with 63.4% of initiators and 36.6% of non-initiators reporting that they received a recommendation. Additionally, 90.7% of initiators were up-to-date on either Tdap or Meningococcal vaccines. As expected, these variables were significant predictors of initiation in our logistic regression models (Table 4). We found that

adolescents up-to-date on other adolescent vaccines were had significantly higher odds of both initiation and provider recommendation compared to those who were not up-to-date or did not report receiving a provider recommendation (Table 4). This suggests that receipt of other adolescent vaccines plays an important role in the HPV vaccination process, and supports previous research on the benefit of presenting HPV, Tdap, and Meningococcal vaccines as a "bundle" during provider visits.[115] It is also possible that adolescents who were up-to-date on one or both 11-12 year vaccines may be more likely to have a usual source of healthcare and, therefore, have more consistent opportunities to discuss HPV vaccination with their provider.

Similar to previous studies, we found that Hispanic male adolescents had higher odds of initiating HPV vaccines compared to whites.[34, 35] HPV vaccination is unique because racial/ethnic minorities have higher initiation rates compared to whites. While this is promising for Hispanic populations who still disproportionately suffer from the majority of HPV-related cancers[43], all men will benefit from the protection HPV vaccines provide. For example, even though Hispanic men have the highest rates of HPV-related penile cancer[43] and are more likely to be diagnosed with anal cancer[116], white and African-American men are more likely to have HPV-related oropharyngeal cancers.[42] It is possible that Hispanic parents are more likely to adhere to provider recommendations, or have a more positive view of vaccines. Additional research should aim to explain these racial/ethnic differences by examining sociocultural views on HPV vaccination.

Having a well-child visit did not significantly predict HPV vaccine initiation in Model 1a, but became significant with provider recommendation included as a covariate

in Model 1b (Table 4). However, this was a significant predictor of receiving a provider recommendation, suggesting that providers are using well-child visits as an opportunity to recommend vaccination. Mother's education level was also associated with an increased likelihood of HPV vaccine initiation. Adolescents with mothers who had less than 12 years of education had higher odds of initiation compared to adolescents with mothers who had completed high school. This finding is consistent with previous research found that parents with higher education levels were actually less likely to report vaccinating their children against HPV[90]. It is possible that parents with higher education levels may be more aware of HPV vaccination in the media, which may result in more exposure to anti-vaccine rhetoric. Additionally, we found that 40.0% of Hispanic mothers had less than 12 years of education, compared with only 3.9% of Non-Hispanic white mothers (Appendix B: Supplemental Table 10). As a result, education levels of Hispanic mothers may be associated with less exposure to anti-vaccine rhetoric, or perhaps language barriers that may facilitate provider recommendation adherence.

Provider Recommendation is a Strong Predictor of Initiation

Overall, provider recommendation was a strong predictor of HPV vaccination for our sample of adolescent males. We found that adolescents who reported receiving a recommendation had almost eight times the odds of initiating the HPV vaccine series compared to those who did not report receiving a recommendation (Table 4). The importance of provider recommendations for HPV vaccines has been previously established in the literature.[48-50] A previous study that examined HPV vaccine initiation and provider recommendation in teen girls found that minorities were less likely to report receiving a provider recommendation for HPV vaccines compared to whites.[63] However, we found no significant racial/ethnic differences in provider

recommendation for teen boys. This could be the result of provider hesitancy to discuss HPV vaccination with female minorities compared to male minorities, possibly due to perceived cultural norms about female adolescent sexual education or activity.

We also found interesting regional differences in provider recommendations, which may be a reflection of differing social norms surrounding discussion of preventing sexually transmitted infections like HPV. More specifically, parents in the Midwest and South were significantly less likely to report receiving provider recommendations for HPV vaccines compared to their counterparts in the Northeast. Improving uptake in these regions is important, particularly in the South due to lack of preventive HPV screenings and existing cancer disparities.[116] For example, previous research has shown higher rates of invasive anal cancer for men and women in the South.[116]

Our interaction results also have interesting implications for male HPV vaccination. We observed how the relationship between race/ethnicity and HPV vaccine initiation might be moderated by provider recommendation status. In fact, Figures 6 and 7 illustrated how receiving a provider recommendation may be more important for parents of non-Hispanic white adolescents. For adolescents who did not receive recommendations, all three minority groups had significantly higher odds of HPV initiation compared to whites (Figure 6). In Figure 7, we also observed how the magnitude of increased likelihood of initiation was smallest for non-Hispanic blacks. This suggests that recommendation may not be as important in the decision-making process, and other educational tools may be needed to improve uptake for non-Hispanic black adolescents. Overall, we found that provider recommendation is a strong cue to

action for all racial/ethnic groups (Figure 7), but that recommendations are not the only driving force behind minority adolescent vaccination.

Policy Implications for Improving HPV Vaccine Uptake

One positive finding was that provider recommendation rates were consistent across all racial/ethnic groups. However, provider recommendation rates should be improved for all male adolescents, as the HPV literature shows that recommendations for males still substantially lag behind their female counterparts.[56, 57] Policymakers and clinical decision makers should support continued education for healthcare providers in order to increase recommendation rates and enable providers to send effective messages to their patients. States can also promote policies to fund research and implementation of evidence-based communication strategies to improve uptake for all adolescent males.

After passage of the Affordable Care Act (ACA) in 2010, preventive services such as vaccinations no longer required cost sharing. This eliminated the significant financial barrier for HPV vaccines, which previously cost up to $500 for all three doses. Researchers have attributed the passage of the ACA with an uptake of HPV vaccination for women.[117] Therefore, it is likely that male HPV vaccine uptake will benefit from less cost sharing, especially those 18 years and older who can still receive catch-up doses by remaining on their parents' insurance plan.

In addition, introducing more school-based vaccination mandates for HPV vaccines could help address established regional differences in HPV vaccination and related cancers. Currently, only Virginia, Rhode Island, and the District of Columbia have implemented policies to require HPV vaccination for school entry.[27] Another promising approach is school-located HPV vaccination clinics, which could remove the logistical challenges of getting young adolescents to see their provider three times within

six months.[118] Mandates and school-based programs for HPV vaccines, however, still remain politically controversial and implementation may be challenging with low levels of vaccine acceptance. Changing the culture around HPV vaccination may improve acceptability levels, especially in the Southeast and Midwest.

Strengths and Limitations

This study has several limitations. First, causality cannot be established because the data are cross-sectional. Second, the dataset does not allow for examination of mechanisms such as parent cultural beliefs about HPV vaccines and adolescent sexual activity, community cultural norms surrounding adolescent vaccination, or racial concordance between patient and provider. These proposed confounders may provide more thorough insight into racial/ethnic differences in initiation and should be examined when new datasets become available. Third, the landline response rate for the National Immunization Survey – Teen is traditionally around 68%.[114] This is similar to other national telephone-based surveys, but may bias results because parents who are more knowledgeable about their teen's vaccination status or more active in health-seeking behaviors may be more likely to participate. In recent years, the cell phone response rate is approximately 23%[114], which may also bias results. Fourth, the self-reported nature of the provider recommendation variable makes the study vulnerable to parent recall bias. Parents may have incorrectly remembered a provider discussion on HPV vaccines. Additionally, the NIS-Teen does not provide a standard definition to parents or guardians of what constitutes a provider recommendation; some survey participants may have incorrectly classified themselves by reporting a recommendation, therefore inflating our results. Also, the NIS-Teen race/ethnicity categories are limited (Hispanic, Non-Hispanic white, Non-Hispanic black, Other), and we may have overlooked important racial or

ethnic differences in HPV vaccination. As more nationally representative surveys being to include HPV vaccine measures for boys, future research can examine race and ethnicity separately, or include additional minority groups in their analyses. Finally, because the 2014 NIS-Teen recently changed the definition of adequate provider data, these estimates will not be directly comparable to estimates previously published using previous years of NIS-Teen data.

Despite these limitations, the current study has several strengths. The NIS-Teen is a nationally representative sample; therefore, the study findings can be generalizable to all male adolescents between the ages of 13 and 17 years living in all 50 US states. More importantly, this survey includes questions about HPV vaccination in males; many other national surveys still only gather information on HPV vaccines from females even though the US has a gender-neutral vaccination policy. This dataset also includes important control variables that have been linked to HPV vaccine uptake, such as insurance type and receipt of other adolescent vaccines such as Tdap and Meningococcal. In addition, the NIS – Teen addresses parent self-report bias by including provided-verified vaccine data for the majority of adolescents. Provider-verified information strengthens the internal validity of parent-reported vaccine coverage. Finally, beginning in 2012, the NIS – Teen samples include respondents from both landline households and cell phone only households. Because cell phone only households may differ from the general population (i.e. low income, no established residence), this recent inclusion of cell phone numbers may increase generalizability of results and help account for nonresponse bias.[10]

Recommendations for Future Research

Because the current study only examined HPV vaccine initiation, future research should analyze HPV initiation and series completion patterns as more nationally

representative datasets begin to include male HPV vaccination measures. Additionally, researchers should further examine geographical predictors of male HPV vaccine uptake, paying close attention to regional and state policy differences and school-mandated vaccination programs when larger sample sizes are available. Future studies should also attempt to study the important differences in HPV vaccination outcomes by measuring race and ethnicity with two separate constructs. In the current study, sample size restrictions prohibited more detailed analysis on the three-way interactions between teen race, ethnicity, and provider recommendation on vaccine initiation. Additionally, we do not know what type of provider NIS-Teen adolescents see when they receive HPV vaccines, and provider type may be an important indicator for successful vaccine initiation. Because the NIS-Teen does not include a measure of provider race or ethnicity, we could not measure patient-provider racial concordance. Researchers should use provider surveys to further explore this topic, as racial concordance may also have implications for the messaging included in HPV vaccine recommendations.

While quantitative analysis is useful for identifying predictors of vaccination, qualitative studies may help explain the vaccination decision-making process for adolescent males and their parents, and whether or not cultural norms play an important role. For example, in 2015, Merck and Co., Inc. released Gardasil 9®, an HPV vaccine that protects against nine different HPV strains known to cause cancer and genital warts.[119] Researchers conducted online focus groups with 87 parents of daughters to examine parent perceptions of this new vaccine.[120] They found that parents remained hesitant of the “newness” of such vaccines, while others proposed delaying vaccination so their children would receive a “superior” vaccine. Parental concerns about vaccine

safety continue to challenge HPV vaccine uptake. As a result, parents believe providers should exhibit more confidence when recommending HPV vaccines.[120] Identifying specific parental concerns and perspectives through focus groups and in-depth interviews, particularly for minorities, will help shape provider messaging around new versions of HPV vaccines in the future.

Qualitative research would also help understand the unique barriers and facilitators of HPV vaccination for different racial/ethnic groups. In this study, the interaction results suggest certain racial/ethnic groups may value provider recommendations more than others. For example, provider recommendation may matter less for African Americans. This may reflect a general theme of hesitancy or distrust of providers and medical advice for these parents, stemming from a history of racial discrimination and ethical misconduct in the US.[121] Research has also shown that higher-income, Non-Hispanic white parents are more likely to refuse vaccines.[122] Perhaps this population is more likely to have exposure to anti-vaccine media online or through word of mouth, and qualitative research could help understand how these messages appeal to a group that typically has higher education levels and ultimately influence parental decision-making.[123, 124]

Researchers can also explore how healthcare organizations and providers can better target educational messages for male adolescents about the benefits of HPV vaccination. For example, researchers in North Carolina have studied how middle school students prefer certain styles of HPV vaccine messaging via text message.[125] The authors found that emphasizing positive outcomes related to vaccination may be a good strategy to increase uptake. Additionally, researchers in Georgia conducted a randomized

controlled trial to determine the impact of various educational interventions for parents to increase adolescent vaccination coverage; however, they found that parents in the intervention arms were less likely to report their child initiated the HPV vaccine compared to parents in the control group.[126] This further emphasizes that parental attitudes and beliefs are important for HPV vaccination acceptance and future success of educational interventions.[126] In general, evidence-based communication strategies for providers can engage adolescents and their parents, leading to a decision to vaccinate.

CONCLUSION

HPV vaccination for all adolescents, especially males, remains low in the US. Strong provider recommendations for all adolescents can help improve vaccine uptake, and protect individuals from costly HPV-related health consequences such as genital warts and ano-genital cancers. This study found that male Hispanic adolescents and non-Hispanic other or multiple race adolescents had higher odds of HPV vaccine initiation than their white counterparts. However, we found no significant racial/ethnic differences in the likelihood of receiving a provider recommendation, suggesting that recommendations serve as a strong “cue to action” for all male adolescents. Our results indicate that there is still much room for improvement in male HPV vaccination uptake, and that more research is needed to determine reasons behind racial/ethnic differences in facilitators of vaccination. Given the relative newness of HPV vaccination for males, there is a prime opportunity to expand vaccine uptake and promote policy action such as school-mandated education and social marketing targeted to male adolescents and their parents. Future research should also examine racial/ethnic differences and characteristics that predict male HPV vaccine completion.

REFERENCES

1. *Ten great public health achievements--United States, 1900-1999.* MMWR Morb Mortal Wkly Rep, 1999. **48**(12): p. 241-3.
2. Plotkin, S.A., W.A. Orenstein, and P.A. Offit, *Vaccines*. Sixth edition. ed. 2013, Philadelphia, Pa.: Elsevier Saunders. xix, 1550 pages.
3. *HPV Vaccine - Questions & Answers*. 2013; Available from: http://www.cdc.gov/vaccines/vpd-vac/hpv/vac-faqs.htm - about.
4. *Accelerating HPV Vaccine Uptake: Urgency for Action to Prevent Cancer. A Report to the President of the United States from the President's Cancer Panel*, in *Bethesda, MD: National Cancer Institute*. 2014.
5. *Healthy People 2020*. Washington, DC: US Department of Health and Human Services 2012 Ocober 24, 2015]; Available from: http://www.healthypeople.gov/2020/topicsobjectives2020/objectiveslist.aspx?topicId=23.
6. Berenson, A.B., *An update on barriers to adolescent human papillomavirus vaccination in the USA.* Expert Rev Vaccines, 2015: p. 1-8.
7. Dunne, E.F., et al., *Recommendations on the Use of Quadrivalent Human Papillomavirus Vaccine in Males-Advisory Committee on Immunization Practices (ACIP), 2011 (Reprinted from MMWR, vol 60, pg 1705, 2011).* Jama-Journal of the American Medical Association, 2012. **307**(6): p. 557-559.
8. Aday, L.A. and R. Andersen, *A framework for the study of access to medical care.* Health Serv Res, 1974. **9**(3): p. 208-20.
9. Janz, N.K. and M.H. Becker, *The Health Belief Model: a decade later.* Health Educ Q, 1984. **11**(1): p. 1-47.
10. *National Immunization Survey-Teen: A User's Guide for the 2014 Public-Use Data File*. 2014, National Center for Immunization and Respiratory Diseases National Center for Health Statistics Hyattsville, MD.
11. Wierzbicka, M., et al., *HPV vaccination in head and neck HPV-related pathologies.* Otolaryngol Pol, 2014. **68**(4): p. 157-73.
12. Dalianis, T., *Human papillomavirus (HPV) and oropharyngeal squamous cell carcinoma.* Presse Med, 2014. **43**(12p2): p. e429-e434.
13. Hoy, T., et al., *Assessing incidence and economic burden of genital warts with data from a US commercially insured population.* Current medical research and opinion, 2009. **25**(10): p. 2343-2351.
14. Satterwhite, C.L., et al., *Sexually transmitted infections among US women and men: prevalence and incidence estimates, 2008.* Sex Transm Dis, 2013. **40**(3): p. 187-93.
15. *HPV Vaccine Information for Clinicians - Fact Sheet*. 2012 2012 [cited 2015; Available from: http://www.cdc.gov/std/HPV/STDFact-HPV-vaccine-hcp.htm.
16. Petrosky, E., et al., *Use of 9-valent human papillomavirus (HPV) vaccine: updated HPV vaccination recommendations of the advisory committee on immunization practices.* MMWR Morb Mortal Wkly Rep, 2015. **64**(11): p. 300-4.
17. Reagan-Steiner, S., et al., *National, Regional, State, and Selected Local Area Vaccination Coverage Among Adolescents Aged 13-17 Years--United States, 2014.* MMWR Morb Mortal Wkly Rep, 2015. **64**(29): p. 784-92.

18. Bednarczyk, R.A., et al., *Sexual activity-related outcomes after human papillomavirus vaccination of 11- to 12-year-olds.* Pediatrics, 2012. **130**(5): p. 798-805.
19. Freed, G.L., et al., *Parental vaccine safety concerns in 2009.* Pediatrics, 2010. **125**(4): p. 654-9.
20. Trim, K., et al., *Parental Knowledge, Attitudes, and Behaviours towards Human Papillomavirus Vaccination for Their Children: A Systematic Review from 2001 to 2011.* Obstet Gynecol Int, 2012. **2012**: p. 921236.
21. Blake, K.D., et al., *Predictors of human papillomavirus awareness and knowledge in 2013: gaps and opportunities for targeted communication strategies.* Am J Prev Med, 2015. **48**(4): p. 402-10.
22. Charo, R.A., *Politics, parents, and prophylaxis--mandating HPV vaccination in the United States.* N Engl J Med, 2007. **356**(19): p. 1905-8.
23. Jena, A.B., D.P. Goldman, and S.A. Seabury, *Incidence of sexually transmitted infections after human papillomavirus vaccination among adolescent females.* JAMA Intern Med, 2015. **175**(4): p. 617-23.
24. Smith, L.M., et al., *Effect of human papillomavirus (HPV) vaccination on clinical indicators of sexual behaviour among adolescent girls: the Ontario Grade 8 HPV Vaccine Cohort Study.* Cmaj, 2015. **187**(2): p. E74-81.
25. Kann, L., et al., *Youth risk behavior surveillance--United States, 2013.* MMWR Surveill Summ, 2014. **63 Suppl 4**: p. 1-168.
26. Colgrove, J., *The ethics and politics of compulsory HPV vaccination.* N Engl J Med, 2006. **355**(23): p. 2389-91.
27. *HPV Vaccine Policies* National Conference of State Legislatures [cited 2015; Available from: http://www.ncsl.org/research/health/hpv-vaccine-state-legislation-and-statutes.aspx.
28. Braveman, P., *Health disparities and health equity: concepts and measurement.* Annu Rev Public Health, 2006. **27**: p. 167-94.
29. Walker, A.T., et al., *Reduction of racial/ethnic disparities in vaccination coverage, 1995-2011.* MMWR Surveill Summ, 2014. **63 Suppl 1**: p. 7-12.
30. Hutchins, S.S., R. Jiles, and R. Bernier, *Elimination of measles and of disparities in measles childhood vaccine coverage among racial and ethnic minority populations in the United States.* J Infect Dis, 2004. **189 Suppl 1**: p. S146-52.
31. Jeudin, P., et al., *Race, ethnicity, and income factors impacting human papillomavirus vaccination rates.* Clin Ther, 2014. **36**(1): p. 24-37.
32. Bednarczyk, R.A., et al., *Human papillomavirus vaccine uptake and barriers: association with perceived risk, actual risk and race/ethnicity among female students at a New York State university, 2010.* Vaccine, 2011. **29**(17): p. 3138-43.
33. Kessels, S.J., et al., *Factors associated with HPV vaccine uptake in teenage girls: a systematic review.* Vaccine, 2012. **30**(24): p. 3546-56.
34. Stokley, S., et al., *Human Papillomavirus Vaccination Coverage Among Adolescents, 2007-2013, and Postlicensure Vaccine Safety Monitoring, 2006-2014-United States.* Mmwr-Morbidity and Mortality Weekly Report, 2014. **63**(29): p. 620-624.
35. Taylor, J.L., et al., *Vaccinating Sons against HPV: Results from a US National Survey of Parents.* Plos One, 2014. **9**(12).

36. CDC, *National Immunization Survey - Teen subset Table Race/ethnicity and vaccines - HPV doses and completion.*
37. Pierce, J.Y., et al., *Post Approval Human Papillomavirus Vaccine Uptake Is Higher in Minorities Compared to Whites in Girls Presenting for Well-Child Care.* Vaccines (Basel), 2013. **1**(3): p. 250-61.
38. Perkins, R.B., et al., *Factors Affecting Human Papillomavirus Vaccine Use Among White, Black and Latino Parents of Sons.* Pediatric Infectious Disease Journal, 2013. **32**(1): p. E38-E44.
39. Kornfeld, J., et al., *HPV knowledge and vaccine acceptability among Hispanic fathers.* J Prim Prev, 2013. **34**(1-2): p. 59-69.
40. Cui, Y., et al., *Human Papillomavirus Vaccine Among Adult Women Disparities in Awareness and Acceptance.* American Journal of Preventive Medicine, 2010. **39**(6): p. 559-563.
41. Molokwu, J., N.P. Fernandez, and C. Martin, *HPV awareness and vaccine acceptability in hispanic women living along the US-Mexico border.* J Immigr Minor Health, 2014. **16**(3): p. 540-5.
42. *HPV in Communities of Color*. May 11, 2015 [cited 2015; Available from: http://www.cdc.gov/Features/PreventHPV/.
43. *Minority Health and HPV*. Diseases & Conditions 2014 Available from: http://www.cdc.gov/features/PreventHPV/.
44. *About the USPSTF*. U.S. Preventive Services Task Force 2014; Available from: http://www.uspreventiveservicestaskforce.org/Page/Name/about-the-uspstf.
45. Ye, J., Z. Xu, and O. Aladesanmi, *Provider recommendation for colorectal cancer screening: examining the role of patients' socioeconomic status and health insurance.* Cancer Epidemiol, 2009. **33**(3-4): p. 207-11.
46. Kiely, D. and S. Schwartz, *Assessing breast cancer risk in a primary care setting.* Nurse Pract, 2014. **39**(10): p. 49-53.
47. Nichol, K.L., R. Mac Donald, and M. Hauge, *Factors associated with influenza and pneumococcal vaccination behavior among high-risk adults.* J Gen Intern Med, 1996. **11**(11): p. 673-7.
48. Gargano, L.M., et al., *Impact of a physician recommendation and parental immunization attitudes on receipt or intention to receive adolescent vaccines.* Human Vaccines & Immunotherapeutics, 2013. **9**(12): p. 2627-2633.
49. Dorell, C., D. Yankey, and S. Strasser, *Parent-reported reasons for nonreceipt of recommended adolescent vaccinations, national immunization survey: teen, 2009.* Clin Pediatr (Phila), 2011. **50**(12): p. 1116-24.
50. Rosenthal, S.L., et al., *Predictors of HPV vaccine uptake among women aged 19-26: importance of a physician's recommendation.* Vaccine, 2011. **29**(5): p. 890-5.
51. Vadaparampil, S.T., et al., *Missed clinical opportunities: provider recommendations for HPV vaccination for 11-12 year old girls are limited.* Vaccine, 2011. **29**(47): p. 8634-41.
52. Wong, K.Y. and Y.K. Do, *Are there socioeconomic disparities in women having discussions on human papillomavirus vaccine with health care providers?* BMC women's health, 2012. **12**(1): p. 33.

53. Hirth, J.M., et al., *Regional variations in HPV vaccination among 9-17 year old adolescent females from the BRFSS, 2008-2010.* Hum Vaccin Immunother, 2014. **10**(12): p. 3475-83.
54. Perkins, R.B., et al., *Effectiveness of a provider-focused intervention to improve HPV vaccination rates in boys and girls.* Vaccine, 2014.
55. Donahue, K.L., et al., *Acceptability of the human papillomavirus vaccine and reasons for non-vaccination among parents of adolescent sons.* Vaccine, 2014. **32**(31): p. 3883-5.
56. McRee, A.L., M.B. Gilkey, and A.F. Dempsey, *HPV vaccine hesitancy: findings from a statewide survey of health care providers.* J Pediatr Health Care, 2014. **28**(6): p. 541-9.
57. Luque, J.S., et al., *Recommendations and administration of the HPV vaccine to 11- to 12-year-old girls and boys: a statewide survey of Georgia vaccines for children provider practices.* J Low Genit Tract Dis, 2014. **18**(4): p. 298-303.
58. Gilkey, M.B., et al., *Quality of Physician Communication about Human Papillomavirus Vaccine: Findings from a National Survey.* Cancer Epidemiology Biomarkers & Prevention, 2015.
59. Gilkey, M.B., et al., *Physician communication about adolescent vaccination: How is human papillomavirus vaccine different?* Prev Med, 2015. **77**: p. 181-5.
60. Reimer, R.A., et al., *Ethnic and gender differences in HPV knowledge, awareness, and vaccine acceptability among White and Hispanic men and women.* J Community Health, 2014. **39**(2): p. 274-84.
61. Rahman, M., T.H. Laz, and A.B. Berenson, *Racial Disparity in Receiving a Physician Recommendation for Human Papillomavirus Vaccine among US Adolescent Girls: Trend from 2008 to 2012.* Cancer Epidemiol Biomarkers Prev, 2015. **24**(4): p. 764.
62. Reimer, R.A., et al., *Ethnic and Gender Differences in HPV Knowledge, Awareness, and Vaccine Acceptability Among White and Hispanic Men and Women.* Journal of Community Health, 2014. **39**(2): p. 274-284.
63. Ylitalo, K.R., H. Lee, and N.K. Mehta, *Health Care Provider Recommendation, Human Papillomavirus Vaccination, and Race/Ethnicity in the US National Immunization Survey.* American Journal of Public Health, 2013. **103**(1): p. 164-169.
64. Bruno, D.M., et al., *Identifying human papillomavirus vaccination practices among primary care providers of minority, low-income and immigrant patient populations.* Vaccine, 2014. **32**(33): p. 4149-54.
65. Reiter, P.L., et al., *Early adoption of the human papillomavirus vaccine among Hispanic adolescent males in the United States.* Cancer, 2014. **120**(20): p. 3200-7.
66. Btoush, R.M., et al., *Initiation of Human Papillomavirus Vaccination Among Predominantly Minority Female and Male Adolescents at Inner-City Community Health Centers.* Am J Public Health, 2015: p. e1-e9.
67. Elbasha, E.H. and E.J. Dasbach, *Impact of vaccinating boys and men against HPV in the United States.* Vaccine, 2010. **28**(42): p. 6858-67.
68. Laprise, J.F., et al., *Comparing the cost-effectiveness of two- and three-dose schedules of human papillomavirus vaccination: a transmission-dynamic modelling study.* Vaccine, 2014. **32**(44): p. 5845-53.

69. Fine, P.E., *Herd immunity: history, theory, practice.* Epidemiol Rev, 1993. **15**(2): p. 265-302.
70. Sadlier, C., et al., *Prevalence of human papillomavirus in men who have sex with men in the era of an effective vaccine; a call to act.* HIV Med, 2014. **15**(8): p. 499-504.
71. Luyten, J., B. Engelen, and P. Beutels, *The sexual ethics of HPV vaccination for boys.* HEC Forum, 2014. **26**(1): p. 27-42.
72. Stanley, M., *HPV vaccination in boys and men.* Hum Vaccin Immunother, 2014. **10**(7): p. 2109-11.
73. *Human papillomavirus (HPV) and Oropharyngeal Cancer - Fact Sheet* 2013; Available from: http://www.cdc.gov/std/hpv/stdfact-hpvandoralcancer.htm.
74. Chaturvedi, A.K., et al., *Human papillomavirus and rising oropharyngeal cancer incidence in the United States.* J Clin Oncol, 2011. **29**(32): p. 4294-301.
75. Holman, D.M., et al., *Barriers to Human Papillomavirus Vaccination Among US Adolescents A Systematic Review of the Literature.* Jama Pediatrics, 2014. **168**(1): p. 76-82.
76. Schuler, C.L. and T. Coyne-Beasley, *Has Their Son Been Vaccinated? Beliefs About Other Parents Matter for Human Papillomavirus Vaccine.* Am J Mens Health, 2015.
77. Donahue, K.L., et al., *Human Papillomavirus Vaccine Initiation among 9–13-Year-Olds in the United States.* Preventive Medicine Reports, 2015.
78. Alexander, A.B., et al., *Parent-son decision-making about human papillomavirus vaccination: a qualitative analysis.* BMC Pediatr, 2012. **12**: p. 192.
79. Saha, S., et al., *Patient-physician racial concordance and the perceived quality and use of health care.* Arch Intern Med, 1999. **159**(9): p. 997-1004.
80. Monnier, C. *Basic Concepts (Race and Ethnicity).* Global Sociology August 29, 2010 [cited 2015; Available from: https://globalsociology.pbworks.com/w/page/14711160/Basic%20Concepts%20%28Race%20and%20Ethnicity%29.
81. Ford, M.E. and P.A. Kelly, *Conceptualizing and categorizing race and ethnicity in health services research.* Health Serv Res, 2005. **40**(5 Pt 2): p. 1658-75.
82. Elam-Evans, L.D., et al., *National, regional, state, and selected local area vaccination coverage among adolescents aged 13-17 years--United States, 2013.* MMWR Morb Mortal Wkly Rep, 2014. **63**(29): p. 625-33.
83. Mehta, P., M. Sharma, and R.C. Lee, *Designing and evaluating a health belief model-based intervention to increase intent of HPV vaccination among college males.* Int Q Community Health Educ, 2013. **34**(1): p. 101-17.
84. Gilkey, M.B., et al., *Do correlates of HPV vaccine initiation differ between adolescent boys and girls?* Vaccine, 2012. **30**(41): p. 5928-34.
85. *National and state vaccination coverage among adolescents aged 13-17 years--United States, 2012.* MMWR Morb Mortal Wkly Rep, 2013. **62**(34): p. 685-93.
86. *Improving the Measurement of Socioeconomic Status for the National Assessment of Educational Progress: A Theoretical Foundation.* 2012.
87. Dickinson, E. and L. Jill, *Exploring the Limitations of Measures of Students' Socioeconomic Status (SES).* Practical Assessment, Research & Evaluation, 2014. **19**(1).

88. *Ethnic and Racial Minorities & Socioeconomic Status*. [cited 2015 Available from: http://www.apa.org/pi/ses/resources/publications/factsheet-erm.pdf.
89. Wisk, L.E., D. Allchin, and W.P. Witt, *Disparities in human papillomavirus vaccine awareness among US parents of preadolescents and adolescents.* Sexually Transmitted Diseases 2014. **41**(2): p. 117-122.
90. Ogilvie, G., et al., *A population-based evaluation of a publicly funded, school-based HPV vaccine program in British Columbia, Canada: parental factors associated with HPV vaccine receipt.* PLoS Med, 2010. **7**(5): p. e1000270.
91. Blake, K.D., et al., *Predictors of Human Papillomavirus Awareness and Knowledge in 2013: Gaps and Opportunities for Targeted Communication Strategies.* Am J Prev Med, 2015.
92. Brewer, N.T., et al., *Longitudinal Predictors of HPV Vaccine Initiation among Adolescent Girls in a High-Risk Geographic Area.* Sexually Transmitted Diseases, 2011. **38**(3): p. 197-204.
93. Mills, L.A., K.J. Head, and R.C. Vanderpool, *HPV vaccination among young adult women: a perspective from appalachian kentucky.* Prev Chronic Dis, 2013. **10**.
94. Monheit, A.C. and J.P. Vistnes, *Race/ethnicity and health insurance status: 1987 and 1996.* Med Care Res Rev, 2000. **57 Suppl 1**: p. 11-35.
95. Fisher, H., et al., *Inequalities in the uptake of human papillomavirus vaccination: a systematic review and meta-analysis.* Int J Epidemiol, 2013. **42**(3): p. 896-908.
96. Bynum, S.A., et al., *Factors associated With Medicaid providers' recommendation of the HPV vaccine to low-income adolescent girls.* J Adolesc Health, 2014. **54**(2): p. 190-6.
97. Malo, T.L., et al., *Do Florida Medicaid Providers' Barriers to HPV Vaccination Vary Based on VFC Program Participation?* Maternal and Child Health Journal, 2013. **17**(4): p. 609-615.
98. Gowda, C. and A.F. Dempsey, *Medicaid reimbursement and the uptake of adolescent vaccines.* Vaccine, 2012. **30**(9): p. 1682-1689.
99. Pierre-Victor, D., et al., *Human papillomavirus vaccine uptake among males 11-26 years in United States: findings from the National Health and Nutrition Examination Survey, 2011-2012.* Vaccine, 2014. **32**(49): p. 6655-8.
100. Gaskin, D.J., et al., *Examining racial and ethnic disparities in site of usual source of care.* Journal of the National Medical Association, 2007. **99**(1): p. 22-30.
101. Perkins, R.B., et al., *Correlates of human papillomavirus vaccination rates in low-income, minority adolescents: a multicenter study.* J Womens Health (Larchmt), 2012. **21**(8): p. 813-20.
102. *Well-Child Visits and Immunizations*. GroupHealth.gov [cited 2015 Available from: https://http://www.ghc.org/healthAndWellness/?item=/common/healthAndWellness/children/childVisits/overview.html.
103. Schilling, A., et al., *Coadministration of a 9-Valent Human Papillomavirus Vaccine With Meningococcal and Tdap Vaccines.* Pediatrics, 2015. **136**(3): p. e563-72.

104. Stockwell, M.S., et al., *Failure to return: parental, practice, and social factors affecting missed immunization visits for urban children.* Clin Pediatr (Phila), 2014. **53**(5): p. 420-7.
105. Krawczyk, A., et al., *Parents' decision-making about the human papillomavirus vaccine for their daughters: I. Quantitative results.* Hum Vaccin Immunother, 2015: p. 0.
106. Hansen, C.E., et al., *"It All Depends": A Qualitative Study of Parents' Views of Human Papillomavirus Vaccine for their Adolescents at Ages 11-12 years.* J Cancer Educ, 2015.
107. Fryer, C.S., et al., *The Symbolic Value and Limitations of Racial Concordance in Minority Research Engagement.* Qual Health Res, 2015.
108. Thornton, R.L., et al., *Patient-physician social concordance, medical visit communication and patients' perceptions of health care quality.* Patient Educ Couns, 2011. **85**(3): p. e201-8.
109. Alegria, M., et al., *Patient-clinician ethnic concordance and communication in mental health intake visits.* Patient Educ Couns, 2013. **93**(2): p. 188-96.
110. Alexander, A.B., et al., *A model of health care provider decision making about HPV vaccination in adolescent males.* Vaccine, 2015. **33**(33): p. 4081-4086.
111. *America's Health Literacy: Why We Need Accessible Health Information*, in *Health Communication Activities*. 2008, U.S. Department of Health and Human Services
112. Strohl, A.E., et al., *Barriers to prevention: knowledge of HPV, cervical cancer, and HPV vaccinations among African American women.* Am J Obstet Gynecol, 2015. **212**(1): p. 65.e1-5.
113. Perkins, R.B., et al., *Why are U.S. girls getting meningococcal but not human papilloma virus vaccines? Comparison of factors associated with human papilloma virus and meningococcal vaccination among adolescent girls 2008 to 2012.* Womens Health Issues, 2015. **25**(2): p. 97-104.
114. *National Immunization Survey - Teen 2014 Data User's Guide*. 2015
115. Ogunbajo, A., et al., *"I think they're all basically the same": parents' perceptions of human papilloma virus (HPV) vaccine compared with other adolescent vaccines.* Child Care Health Dev, 2016.
116. Joseph, D.A., et al., *Understanding the burden of human papillomavirus-associated anal cancers in the US.* Cancer, 2008. **113**(10 Suppl): p. 2892-900.
117. Lipton, B.J. and S.L. Decker, *ACA Provisions Associated With Increase In Percentage Of Young Adult Women Initiating And Completing The HPV Vaccine.* Health Aff (Millwood), 2015. **34**(5): p. 757-64.
118. Stubbs, B.W., et al., *Evaluation of an intervention providing HPV vaccine in schools.* Am J Health Behav, 2014. **38**(1): p. 92-102.
119. Petrosky, E., et al., *Use of 9-Valent Human Papillomavirus (HPV) Vaccine: Updated HPV Vaccination Recommendations of the Advisory Committee on Immunization Practices.* Mmwr-Morbidity and Mortality Weekly Report, 2015. **64**(11): p. 300-304.
120. Fontenot, H.B., V. Domush, and G.D. Zimet, *Parental Attitudes and Beliefs Regarding the Nine-Valent Human Papillomavirus Vaccine.* Journal of Adolescent Health, 2015. **57**(6): p. 595-600.

121. Corbie-Smith, G., S.B. Thomas, and D.M. St George, *Distrust, race, and research.* Arch Intern Med, 2002. **162**(21): p. 2458-63.
122. Siddiqui, M., D.A. Salmon, and S.B. Omer, *Epidemiology of vaccine hesitancy in the United States.* Hum Vaccin Immunother, 2013. **9**(12): p. 2643-8.
123. Dube, E., M. Vivion, and N.E. MacDonald, *Vaccine hesitancy, vaccine refusal and the anti-vaccine movement: influence, impact and implications.* Expert Rev Vaccines, 2015. **14**(1): p. 99-117.
124. Moran, M.B., et al., *Information scanning and vaccine safety concerns among African American, Mexican American, and non-Hispanic White women.* Patient Educ Couns, 2016. **99**(1): p. 147-53.
125. Cates, J.R. and T. Coyne-Beasley, *Social marketing to promote HPV vaccination in pre-teenage children: talk about a sexually transmitted infection.* Hum Vaccin Immunother, 2015. **11**(2): p. 347-9.
126. Underwood, N.L., et al., *Human papillomavirus vaccination among adolescents in Georgia.* Hum Vaccin Immunother, 2015. **11**(7): p. 1703-8.
127. Mays, V.M., et al., *Classification of race and ethnicity: implications for public health.* Annu Rev Public Health, 2003. **24**: p. 83-110.

APPENDIX A. RACE AND ETHNICITY SENSITIVITY ANALYSIS

Sensitivity Analysis to Examine Race and Ethnicity Constructs

Health services research literature has previously debated how to classify race and ethnicity when examining questions of racial and ethnic differences and disparities.[127] Many researchers argue that combining race and ethnicity fails to elicit subtle differences between the biological and social constructs.[127] Because many current nationally representative surveys, including NIS-Teen, measure combined race/ethnicity, researchers frequently combine the two measures during analysis and interpretation. To better understand these distinctions in relation to male HPV vaccine initiation, we carried out a preliminary sensitivity analysis to compare initiation and provider recommendation models using separate race and ethnicity measures. As a result, the three sensitivity logistic regression models included race (white, black, other or multiple race) and Hispanic/Latino ethnicity as separate confounders. Due to small sample size for Hispanic blacks, we considered the results to be preliminary and offer direction for future research on socio-cultural determinants of HPV vaccination.

Table 5. Logistic Regression Models (Sensitivity Analysis)

Model 4a:
$\ln\left(\frac{Initiation}{1-Initiation}\right) = \beta_0 + \beta_1 Race + \beta_2 Ethnicity + \beta_3 Rec + \beta_4 TeenAge + \beta_5 Insurance + \beta_6 Wellchild + \beta_7 OtherVaccines + \beta_8 Region + \beta_9 Poverty + \beta_{10} Educ + \beta_{11} Marital + \beta_{12} MotherAge + \varepsilon$
Model 4b:
$\ln\left(\frac{Rec}{1-Rec}\right) = \beta_0 + \beta_1 Race + \beta_2 Ethnicity + \beta_3 TeenAge + \beta_4 Insurance + \beta_5 Wellchild + \beta_6 OtherVaccines + \beta_7 Region + \beta_8 Poverty + \beta_9 Educ + \beta_{10} Marital + \beta_{11} MotherAge + \varepsilon$
Model 5:
$\ln\left(\frac{Initiation}{1-Initiation}\right) = \beta_0 + \beta_1 Race + \beta_2 Ethnicity + \beta_3 Rec + \beta_4 TeenAge + \beta_5 Insurance + \beta_6 Wellchild + \beta_7 OtherVaccines + \beta_8 Region + \beta_9 Poverty + \beta_{10} Educ + \beta_{11} Marital + \beta_{12} MotherAge + \beta_{13} Race * Rec + \beta_{14} Ethnicity * Rec + \varepsilon$

Sensitivity Analysis Results

Table 6. Adolescent Male Race and Ethnicity Frequencies, NIS-Teen 2014

Race of Teen	Is Teen Hispanic or Latino?		Total
	Yes	No	
White	1407	7071	8478
Black	96	989	1085
Other/Multiple Race	174	1006	1180
Total	1677	9066	10743

Source: CDC, NCRID and NCHS (2015), 2014 National Immunization Survey.

Table 7. Weighted Adolescent Male Race and Ethnicity Frequencies, NIS Teen 2014

		Total (N=10743)	**Initiated** (N=4436)	**Did not initiate** (N=6307)	**P-value**
Adolescent Characteristics					
US weighted sample size		10,659,765	4,450,370	6,209,395	
Proportion of sample (%)		100	41.3	58.7	
Race/ethnicity (%)					<.0001
	Hispanic	22.0	28.5	17.3	
	Non-Hispanic white	55.9	48.7	61.0	
	Non-Hispanic black	13.2	13.3	13.2	
	Non-Hispanic other + multiple race	8.9	9.4	8.6	
Race category (%)					0.2640
	White only	74.6	73.1	75.7	
	Black only	14.5	15.0	14.1	
	Other + multiple race	10.9	11.9	10.1	
Is teen Hispanic or Latino? (%)					<.0001
	Yes	22.0	28.6	17.3	
	No	78.0	71.5	82.7	

Source: CDC, NCRID and NCHS (2015), 2014 National Immunization Survey.
NIS Teen = National Immunization Survey - Teen subset; HPV = human papillomavirus; initiation = 1 or more shots; Note: Row percents shown for Initiated and Did not initiate categories.

Table 8 provides the results of a sensitivity analysis using separate race and ethnicity variables to predict likelihood of adolescent male HPV vaccine initiation and receipt of a provider recommendation. While adolescent race was not significantly associated with initiation, Hispanic or Latino ethnicity alone remained a strong predictor of adolescent male vaccine uptake. Similar to the main analysis, neither race nor ethnicity was associated with the likelihood of receiving a provider recommendation for HPV vaccines (Table 3).

Table 8. Weighted logistic regressions for racial and ethnic sensitivity analysis in adolescent male HPV vaccine initiation and provider recommendation, NIS Teen 2014

	Initiation Model 4a, OR (95% CI)	**Initiation (with Provider Recommendation)** Model 4b, OR (95% CI)	**Provider Recommendation** Model 5, OR (95% CI)
Adolescent Characteristics			
Race			
White only	Ref	Ref	Ref
Black only	1.149 (0.848-1.555)	1.124 (0.814-1.552)	1.132 (0.836-1.533)
Other or multiple race	1.219 (0.923-1.610)	1.273 (0.930-1.744)	1.031 (0.772-1.376)
Is teen Hispanic or Latino?			
No	Ref	Ref	Ref
Yes	1.621 (1.208-2.176)	1.728 (1.280-2.334)	1.115 (0.835-1.490)
Age of teen at survey (y)			
13	Ref	Ref	Ref
14	1.081 (0.797-1.467)	1.135 (0.807-1.596)	0.999 (0.728-1.373)
15	1.334 (0.994-1.792	1.274 (0.914-1.776)	1.259 (0.930-1.704)
16	1.006 (0.744-1.360)	1.046 (0.760-1.439)	0.963 (0.706-1.314)
17	1.167 (0.865-1.573)	1.313 (0.933-1.848)	0.914 (0.669-1.249)
Did teen have an 11-12 year well-child visit?			
No	Ref	Ref	Ref
Yes	1.13 (0.776-1.644)	0.67 (0.446-1.007)	2.561 (1.591-4.122)
Don't know	1.764 (0.857-3.631)	1.362 (0.697-2.659)	2.003 (0.938-4.277)
Health insurance			
Employer/Union	Ref	Ref	Ref
Any Medicaid/SCHIP	1.112 (0.844-1.464)	1.238 (0.932-1.644)	0.899 (0.684-1.181)
Indian/Military/Other	1.375 (0.931-2.031)	1.228 (0.830-1.818)	1.355 (0.937-1.959)
Uninsured	0.911 (0.559-1.484)	1.091 (0.698-1.707)	0.728 (0.471-1.126)
Region of country			
Northeast	Ref	Ref	Ref
Midwest	0.793 (0.632-0.996)	0.909 (0.705-1.172)	0.687 (0.547-0.862)
South	0.725 (0.580-0.907)	0.881 (0.687-1.129)	0.615 (0.492-0.769)
West	1.194 (0.888-1.605)	1.305 (0.947-1.800)	0.928 (0.685-1.256)
UTD Tdap/Meningococcal			
No	Ref	Ref	Ref
Yes	5.921 (4.495-7.798)	5.164 (3.870-6.891)	2.721 (2.204-3.360)
Parent Characteristics			

Received provider recommendation for HPV vaccine?			
No	.	Ref	Ref
Yes	.	8.402 (6.804-10.376)	.
Maternal age group			
<= 34 years	Ref	Ref	Ref
35-44 years	0.69 (0.493-0.967)	0.632 (0.404-0.987)	1.004 (0.697-1.446)
>= 45 years	0.766 (0.545-1.078)	0.687 (0.439-1.075)	1.134 (0.778-1.652)
Maternal education level			
12 years	Ref	Ref	Ref
Less than 12 years	1.561 (1.095-2.225)	1.87 (1.279-2.736)	0.922 (0.646-1.317)
12 + years, non-college grad	0.822 (0.634-1.065)	0.795 (0.599-1.056)	1.03 (0.801-1.323)
College graduate	0.943 (0.709-1.255)	0.931 (0.685-1.265)	1.021 (0.770-1.354)
Marital status			
Not currently married	Ref	Ref	Ref
Married	0.936 (0.750-1.167)	0.921 (0.725-1.169)	1.036 (0.831-1.293)
Poverty status			
Below poverty	Ref	Ref	Ref
Above poverty <= $75 K	0.783 (0.588-1.044)	0.756 (0.555-1.032)	0.951 (0.709-1.276)
Above poverty > $75 K	0.832 (0.573-1.210)	0.738 (0.508-1.071)	1.15 (0.798-1.658)
Unknown	0.446 (0.276-0.721)***	0.407 (0.233-0.710)***	0.813 (0.505-1.309)

Source: CDC, NCRID and NCHS (2015), 2014 National Immunization Survey.
NIS Teen = National Immunization Survey - Teen; HPV = human papillomavirus; initiation = 1 or more shots; CI = Confidence interval; UTD = up to date; Tdap = diphtheria, tetanus, and pertussis
Note: Model 1 N = 9099 ; Model 2 N = 8268; Model 3 N = 8268

APPENDIX B. SUPPLEMENTAL TABLES

Table 9. Weighted Adolescent Male and Parent Characteristics by HPV Vaccine Initiation Status, NIS Teen 2014

	Total (N=10,743)	Initiated (N=4,436)	Did not initiate (N=6,307)	P-value
Adolescent Characteristics				
US weighted sample size	10,659,765	4,450,370	6,209,395	
Proportion of sample (%)	100	41.3	58.7	
Mean age of teen at survey (years)	15.0	15.0	14.9	
Race/ethnicity (%)				<.0001
Hispanic	22.0	28.5	17.3	
Non-Hispanic white	55.9	48.7	61.0	
Non-Hispanic black	13.2	13.3	13.2	
Non-Hispanic other + multiple race	8.9	9.4	8.6	
Had 11-12 year well-child visit (%)				0.3051
Yes	90.4	91.4	89.5	
No	5.6	4.6	6.4	
Don't know	4.0	4.0	4.0	
Health insurance (%)				0.0008
Employer/Union	57.1	53.0	60.0	
Any Medicaid/SCHIP	31.4	35.8	28.3	
Indian/Military/Other	4.8	4.6	4.9	
Uninsured	6.7	6.5	6.8	
Region of country (%)				<.0001
Northeast	16.7	19.2	14.9	
Midwest	21.7	19.6	23.1	
South	37.8	34.3	40.2	
West	23.9	26.9	21.7	
UTD Tdap/Meningococcal (%)				<.0001
Yes	75.3	90.7	64.2	
No	24.7	9.3	35.8	
Parent Characteristics				
Received provider recommendation for HPV vaccine (%)				<.0001
Yes	53.7	79.3	34.5	
No	46.3	20.7	65.5	
Maternal education level (%)				<.0001
Less than 12 years	13.4	17.9	10.1	

	12 years	23.8	24.2	23.5	
	12 + years, non-college grad	25.7	22.4	28.1	
	College graduate	37.1	35.5	38.3	
Maternal age group (%)					0.0672
	<= 34 years	8.3	9.8	7.3	
	35-44 years	45.6	45.0	46.1	
	>= 45 years	46.1	45.3	46.6	
Marital status (%)					0.0207
	Married	67.5	65.0	69.3	
	Not currently married	32.5	35.0	30.7	
Poverty status (%)					<.0001
	Below poverty	22.4	27.7	18.6	
	Above poverty <= $75K	35.8	33.8	37.2	
	Above poverty > $75K	36.5	34.6	37.8	
	Unknown	5.3	3.9	6.4	

Source: CDC, NCRID and NCHS (2015), 2014 National Immunization Survey.
NIS Teen = National Immunization Survey - Teen; HPV = human papillomavirus; initiation = 1 or more shots; UTD = up to date; Tdap = diphtheria, tetanus, and pertussis;
Note: Column percents shown for Initiated and Did not initiate categories.

Table 10. Weighted Adolescent Male and Parent Characteristics by Race/Ethnicity, NIS Teen 2014

	Total (N=10743)	Hispanic (N=1677)	NH White (N=7071)	NH Black (N=989)	NH Other + Multiple Race (N=1006)	P-value
Adolescent Characteristics						
US weighted sample size	10,659,765	2,344,966	5,954,731	1,411,105	948,962	
Proportion of sample (%)	100	22.0	55.9	13.2	8.9	
Age of teen at survey (y) (%)						0.356
13	20.2	23.6	19.1	19.0	20.9	
14	20.4	20.6	20.0	22.7	19.7	
15	19.2	19.6	19.6	17.6	18.5	
16	21.4	21.6	20.9	21.2	23.5	
17	18.7	14.6	20.4	19.4	17.5	
Had 11-12 year well-child visit (%)						
Yes	90.4	89.8	92.0	92.2	78.9	0.0006
No	5.6	6.4	4.6	4.3	12.6	
Don't know	4.0	3.9	3.5	3.6	8.5	
Health insurance (%)						<.0001
Employer/Union	57.1	34.7	70.5	39.1	54.1	
Any Medicaid/SCHIP	31.4	49.5	19.4	51.7	32.9	
Military/Indian/Other	4.8	2.4	5.8	2.8	7.5	
Uninsured	6.7	13.4	4.3	6.4	5.5	
Region of country (%)						<.0001
Northeast	16.7	14.0	18.3	15.6	15.2	
Midwest	21.7	10.4	27.2	19.1	18.5	
South	37.8	34.0	35.3	60.4	29.0	
West	23.9	41.6	19.2	4.9	37.3	
UTD Tdap/Meningococcal (%)						0.6864
Yes	75.3	76.9	75.3	73.8	73.0	
No	24.7	23.1	24.7	26.2	27.0	
Initiated HPV vaccine series (%)						<.0001
Yes	41.7	54.2	36.4	42.1	44.0	
No	58.3	45.8	63.6	57.9	56.0	
Parent Characteristics						
Received provider recommendation for HPV vaccine (%)						0.8225
Yes	53.7	53.3	54.5	53.3	50.8	

No	46.3	46.7	45.5	46.7	49.2	
Maternal education level (%)						<.0001
Less than 12 years	13.4	40.0	3.9	11.1	10.7	
12 years	23.8	26.0	21.2	32.1	22.1	
12 + years, non-college grad	25.7	16.7	28.1	30.4	26.3	
College graduate	37.1	17.3	46.9	26.4	40.9	
Maternal age group (%)						<.0001
<= 34 years	8.3	11.8	5.8	14.2	6.8	
35-44 years	45.6	56.9	40.2	48.1	47.8	
>= 45 years	46.1	31.3	54.0	37.7	45.4	
Marital status (%)						<.0001
Married	67.5	61.5	75.6	43.3	67.7	
Not currently married	32.5	38.5	24.4	56.7	32.3	
Poverty status (%)						<.0001
Below poverty	22.4	42.4	11.7	35.0	21.3	
Above poverty <= $75 K	35.8	36.5	34.6	43.2	30.9	
Above poverty > $75 K	36.5	14.8	49.5	15.4	39.3	
Unknown	5.3	6.2	4.2	6.3	8.5	

Source: CDC, NCRID and NCHS (2015), 2014 National Immunization Survey.
NIS Teen = National Immunization Survey; HPV = human papillomavirus; NH = Non-Hispanic; initiation = 1 or more shots; UTD = up to date; Tdap = diphtheria, tetanus, and pertussis; Completion = 3 or more shots
Note: Row percents shown for race/ethnicity categories.

Table 11. Interaction Comparisons between Race/Ethnicity and Provider Recommendation on HPV Vaccine Initiation Status, NIS Teen 2014*

Race/Ethnicity	Recommendation Status	Race/Ethnicity	Recommendation Status	P-value	Odds Ratio
Hispanic	Yes	Hispanic	No	<.0001	8.7746
Hispanic	Yes	NH Black only	Yes	0.0065	1.9664
Hispanic	Yes	NH Black only	No	<.0001	9.1244
Hispanic	Yes	NH Other + MR	Yes	0.1946	1.4095
Hispanic	Yes	NH Other + MR	No	<.0001	9.2488
Hispanic	Yes	NH White only	Yes	0.0025	1.7788
Hispanic	Yes	NH White only	No	<.0001	18.4327
Hispanic	No	NH Black only	Yes	<.0001	0.2241
Hispanic	No	NH Black only	No	0.8936	1.0399
Hispanic	No	NH Other + MR	Yes	<.0001	0.1606
Hispanic	No	NH Other + MR	No	0.8627	1.0540
Hispanic	No	NH White only	Yes	<.0001	0.2027
Hispanic	No	NH White only	No	0.0016	2.1007
NH Black only	Yes	NH Black only	No	<.0001	4.6401
NH Black only	Yes	NH Other + MR	Yes	0.2199	0.7168
NH Black only	Yes	NH Other + MR	No	<.0001	4.7034
NH Black only	Yes	NH White only	Yes	0.6046	0.9046
NH Black only	Yes	NH White only	No	<.0001	9.3738
NH Black only	No	NH Other + MR	Yes	<.0001	0.1545
NH Black only	No	NH Other + MR	No	0.9652	1.0136
NH Black only	No	NH White only	Yes	<.0001	0.1950
NH Black only	No	NH White only	No	0.0049	2.0202
NH Other + MR	Yes	NH Other + MR	No	<.0001	6.5618
NH Other + MR	Yes	NH White only	Yes	0.2815	1.2620
NH Other + MR	Yes	NH White only	No	<.0001	13.0776
NH Other + MR	No	NH White only	Yes	<.0001	0.1923
NH Other + MR	No	NH White only	No	0.0075	1.9930
NH White only	Yes	NH White only	No	<.0001	10.3623

Source: CDC, NCRID and NCHS (2015), 2014 National Immunization Survey.
*Odds ratios generated with LSMEANS statement.
MR = Multiple race.