

ABSTRACT

Title of Thesis: SOCIOECONOMIC POSITION, GENDER,
AND HPV VACCINE UTILIZATION

Taylor Brianna Rogers, Master of Public Health,
2018

Thesis Directed by: Michel Boudreaux, Ph.D, Assistant Professor,
Department of Health Services Administration

In 2011-2014, the prevalence of HPV was higher in adult males compared to adult females. HPV and its associated health outcomes can be prevented through the completion of the 3-dose HPV vaccine series. Using the 2010 - 2016 National Immunization Survey - Teen, I examined the association of family income and gender with three HPV vaccine utilization outcomes: (1) receipt of provider recommendation; (2) HPV vaccine initiation; and (3) HPV vaccine completion using logistic regressions. Results suggested that family income was negatively correlated with HPV vaccine outcomes regardless of gender and controlling for other covariates. I also found that males had lower vaccine use compared to females, regardless of income. In the second analysis I investigated if the 2011 ACIP guideline increased vaccine utilization outcomes using a difference-in-differences. This analysis suggested that the new guideline increased recommendations by 24 percentage points for males, relative to females ($P < 0.01$), HPV vaccine initiation improved by 23 percentage points ($P < 0.01$), and vaccine completion improved by 10 percentage points ($P < 0.01$).

SOCIOECONOMIC POSITION, GENDER, AND HPV VACCINE UTILIZATION

by

Taylor Brianna Rogers

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Public Health
2018

Advisory Committee:

Assistant Professor Michel Boudreaux, Chair
Professor Stephen B. Thomas, Member
Professor Luisa Franzini, Member
Assistant Professor Neil Sehgal, Member

© Copyright by
Taylor Brianna Rogers
2018

Table of Contents

Table of Contents.....	ii
List of Tables.....	iii
List of Figures.....	iv
List of Abbreviations.....	v
Introduction.....	1
Background.....	2
Fundamental Cause Theory.....	2
Prevalence of Adult HPV.....	5
The Role of Family Income on HPV Vaccine Utilization.....	6
The Role of Healthcare Providers.....	7
HPV Vaccine Effectiveness and Dosage.....	8
Parental Acceptance.....	9
Cultural Barriers to HPV Vaccine Uptake.....	10
Methodology.....	11
Data.....	11
Independent Variables.....	12
Dependent Variables.....	13
Control Variables.....	13
Analytic Approach.....	14
Results.....	15
Descriptive Statistics.....	15
The Association of Family Income and HPV Vaccine Utilization Outcomes.....	17
The Association of Sex & HPV Vaccine Outcomes & Sex Specific Income Gradients...20	
The Association of the ACIP Guideline for Males with HPV Vaccine Outcomes.....	24
Conclusions and Discussion.....	25
Family Income and HPV Vaccine Utilization Outcomes.....	26
Gender and HPV Vaccine Utilization Outcomes.....	27
Effect of 2011 ACIP Recommendation on HPV Vaccine Utilization Outcomes.....	28
Study Limitations.....	29
Study Implications.....	30
Appendices.....	33
Appendix A: Conceptual Framework for Study Aims.....	33
Appendix B: Variable Table for Aim 1.....	35
Appendix C: Variable Table for Aim 2.....	37
Appendix D: Variable Table for Aim 3.....	39
References.....	41

List of Tables

1. Table 1. Selected Descriptive Statistics by Family Income (Aim 1)
2. Table 2. Selected Descriptive Statistics by Gender (Aim 2)
3. Table 3. Regression Results of HPV Vaccine Utilization Outcomes
4. Table 4. Regression Results of HPV Vaccine Utilization Outcomes for Males
5. Table 5. Regression Results of HPV Vaccine Utilization Outcomes for Females
6. Table 6. Difference in Differences Results for HPV Vaccine Utilization Outcomes

List of Figures

1. Figure 1: Provider Recommendation, 2010 – 2016
2. Figure 2: HPV Vaccine Initiation, 2010 – 2016
3. Figure 3: HPV Vaccine Completion, 2010 – 2016

List of Abbreviations

1. ACIP: Advisory Committee on Immunization Practices
2. AOR: Adjusted Odds Ratios
3. APD: Adequate Provider Data
4. CDC: Centers for Disease Control and Prevention
5. FPL: Federal Poverty Line
6. HPV: Human Papillomavirus
7. NIS-Teen: National Immunization Survey – Teen
8. RDD: Random Digit Dialing
9. US: United States

Introduction

According to the Centers for Disease Control and Prevention (CDC) (2016), the human papillomavirus (HPV) is the most common sexually transmitted infection in the United States and it is estimated that approximately 90% of sexually active individuals will be infected at some point in their life. HPV can cause genital warts (from the low-risk HPV strain) and cervical, anal, oropharynx, penile, vaginal, and vulvar cancers (from the high-risk HPV strain). Among adults, low levels of education and higher levels of poverty are associated with increased incidence rates of invasive HPV-associated cancers: cervical, penile, and vaginal (Benard et al., 2008) (Brisson, Drolet, & Malagón, 2013).

HPV and its associated health outcomes can be prevented through the completion of the HPV vaccine, a three-dose series developed in June 2006. The doses are administered over a six month time-period (0, 2, 6 months) (“HPV Vaccine Administration | Human Papillomavirus Vaccination | CDC,” 2017) . Currently, there are three types of HPV vaccines: Cervarix, Gardasil, Gardasil-9. They protect against two, four, and nine types of HPV, respectively. All of them protect against HPV 16 and 18, which are high risk strains and are responsible for most HPV-associated cancers (National Institutes of Health, n.d.). In mid-2006, the Advisory Committee on Immunization Practices (ACIP) announced a recommendation that added the HPV vaccine to the routine immunization schedule for girls aged 9 to 26 years. In 2011, the ACIP included boys aged 9 to 21 years to its routine HPV vaccination recommendation (Centers of Disease Control and Prevention, 2016). Males who identify as gay, bisexual, transgender, have sex with other males, or have an immunocompromising condition are recommended through age 26 (Centers of Disease Control and Prevention, 2016c).

As of 2016, ACIP altered the recommendation a two-dose HPV vaccine for adolescent females and males aged 11 or 12 (Meites, Kempe & Markowitz, 2016). Individuals who initiate prior to their 15th birthday is recommended for two doses. Those initiating on or after their 15th birthday is recommended to receive the full three dose series (Meites, Kempe & Markowitz, 2016).

In 2016, the CDC estimated that 65% and 56% of girls and boys, respectively have initiated the series. However, only 43% of adolescents have completed the entire vaccination series (Centers of Disease Control and Prevention, 2017). Healthy People 2020 objectives aim to increase coverage of at least three doses of the HPV vaccine to 80% for adolescent males and females aged 13 to 15 years. However, as of 2014, 39.7% and 21.6% of adolescent females and males, respectively, received at least three doses of the vaccine series (“Vaccination Coverage | NIS Teen | 2014 Maps by State | CDC,” 2017). Increasing access and use of the HPV vaccine series remains an important public health goal. Full vaccine coverage would substantially reduce disease burden and associated health care costs.

Background

Fundamental Cause Theory

The HPV vaccine is an example of a medical intervention created to reduce HPV associated conditions. For example, the HPV vaccine has reduced cervical cancer incidence and mortality, which in the past was the leading cause of cancer death among women in the United States (National Institutes of Health, n.d.). However, the American Cancer Society estimates that 13,240 women will be newly diagnosed and 4,170 will die from cervical cancer in 2018 (American Cancer Society, 2018). A majority of cervical cancer cases were among minority and/or low socioeconomic status women. Non-Hispanic Black (11.3 per 100,000) and Hispanic (13.8 per 100,000) women have higher incidence rates than non-Hispanic White women (8.5 per 100,000)

(National Cancer Institute, n.d.). Similarly, racial and ethnic minorities are more likely to die from cervical cancer. Non-Hispanic Black women have the highest mortality rate (4.9 per 100,000) compared Hispanic (3.3 per 100,000) and non-Hispanic white women (2.3 per 100,000) (National Cancer Institute, n.d.). These disparities among minority women and/or women of lower socioeconomic status can be attributed to a variety of factors such as lack of healthcare coverage, knowledge, health literacy, access to primary care and/or diverse and culturally competent health care providers.

Though cervical cancer does not affect males, they are equally susceptible to low and high-risk HPV in the form of genital warts and cancers of the oropharynx, anus, mouth, and penis. The prevalence of low and high risk HPV is higher among adult males compared to adult females. More recently, research has shown that oropharyngeal cancer among males has increased nearly 300 percent in the past 40 years; there are approximate 12,638 new cases among males compared to 3,100 new cases among women every year (Sonawane et al., 2017). In fact, the incidence of oropharyngeal cancer has surpassed the incidence of cervical cancer, making oropharyngeal cancer the most common HPV associated cancer in the United States (Sonawane et al., 2017).

According to Phelan, Link, and Tehranifar (2010), the Fundamental Cause Theory was developed to explain health and mortality disparities related to socioeconomic status. Despite modern advancements in disease prevention and risk reduction the association between socioeconomic status, adverse health outcomes, and mortality persists (Link & Phelan, 1995).

The Fundamental Cause Theory consists of four key features: [1] socioeconomic positions influences multiple diseases; [2] socioeconomic position is linked multiple proximate risk factors for these diseases; [3] the accessibility of resources that can reduce risks or can minimize the effects of disease once it occurs; [4] the association between a fundamental cause and health can

be replicated over time through the replacement of intervening mechanisms (Phelan, Link, & Tehranifar, 2010). HPV is a proximate risk factor for genital warts and HPV-associated cancers and the Fundamental Cause Theory predicts the onset of these health conditions and cancers by access to preventative methods, such as the HPV vaccine.

In this study, I will test the Fundamental Cause Theory on adolescent male and female HPV vaccine utilization. The HPV vaccine is a medical intervention that is administered during adolescence and is the potential to reduce risk of genital warts and a variety of cancers affecting adult males and females. It can also produce socioeconomic position and race/ethnicity disparities in the incidence and mortality of HPV-associated conditions and cancers. The HPV vaccine can serve as an empirical test of the Fundamental Cause Theory because it introduces a shift in treatment and knowledge of HPV associated conditions and cancers. Prior to its debut in 2006, there were not any preventative methods for HPV. Second, given that the HPV vaccine is recommended for adolescents, the access and receipt of the vaccine is dependent upon the knowledge, consent, and socioeconomic status of their parents. Third, the vaccine is a one-time intervention (after completion of three dose series within six months) that is capable of preventing genital warts and HPV-associated cancers unlike other screenings such as the pap smear which requires regular adherence (Polonijo & Carpiano, 2013).

It was expected that the HPV vaccination would significantly reduce the incidence of cervical cancer and other HPV associated cancers (“American Cancer Society Guideline for Human Papillomavirus (HPV) Vaccine Use to Prevent Cervical Cancer and Its Precursors - Saslow - 2007 - CA: A Cancer Journal for Clinicians - Wiley Online Library,” n.d.). However, groups with lower socioeconomic position and/or are racial-ethnic minorities are disproportionately affected by HPV and its associated conditions and cancers. It is assumed that they would benefit

the most from the vaccine, however they are the least likely to utilize the vaccine (Downs, Scarinci, Einstein, Collins, & Flowers, 2010).

Polonijo and Carpiano (2013), tested the Fundamental Cause Theory in adolescent HPV vaccination inequalities, by focusing on the impact of socioeconomic position and race/ethnicity on HPV vaccination. They analyzed the association of socioeconomic position and race/ethnicity with parental knowledge of HPV, receipt of healthcare provider recommendation, and vaccination uptake (initiation and completion).

Prevalence of Adult HPV

In 2011-2014, the prevalence of any oral HPV (low risk and high risk) was 7.3% among adults aged 18 to 69 years, with 11.5% prevalence among males and 3.3% among females. In regard to high-risk oral HPV, the prevalence is 4% among all adults and 6.8% among males and 1.2% among females (McQuillan, 2017). Overall, non-Hispanic Asian adults had a lower prevalence of high-risk oral HPV (1.7%) and among males (2.3%) compared to non-Hispanic White adults (4.2% overall and 7.3% males), non-Hispanic Black adults (4.3% overall and 7.5% males), and Hispanic adults (3.4% overall and 5.4% males) (McQuillan, 2017).

Likewise, in 2011-2014, the prevalence of genital HPV was 42.5% among adults 18 to 69 years and males had a higher prevalence (45.2%) than females (39.9%). Non-Hispanic Black adults has the highest prevalence compared to other racial-ethnic groups (64.1%) (McQuillan, 2017).

The prevalence of high-risk genital HPV was 22.7% among adults aged 18 to 69 years. The male prevalence was higher (25.1%) compared to females (20.4%). The prevalence of high-risk HPV is highest among all non-Hispanic Black adults (33.7% overall and 40.3% male) compared to non-Hispanic White adults (21.6% overall and 24.7% males), Hispanic adults (21.7% overall

and 21.8% males), and non-Hispanic Asian adults (11.9% overall and 12.2% males) (McQuillan, 2017).

The Role of Family Income on HPV Vaccine Utilization

Per the Fundamental Cause Theory, it is expected that adolescents with lower family incomes would decreased utilization of the HPV vaccine compared to adolescents with higher family income. Niccolai et al. (2011) findings suggest that adolescents with family incomes below the federal poverty line (FPL) were less likely to initiate the vaccine series compared to adolescent with family incomes greater than \$75,000. This study observed adolescent females aged 13 to 17 years using the 2008 and 2009 National Immunization Survey-Teen (Niccolai, Mehta, & Hadler, 2011). Polonijo and Carpiano, (2013), analyzed the association of household income on HPV vaccine knowledge, receipt of provider recommendation, initiation, and completion of the HPV vaccine series using the same income levels as Niccolai et al. (2011): below poverty level, greater than poverty level but less than or equal to \$75,000, and greater than \$75,000. Using the 2008, 2009, and 2010 National Immunization Survey-Teen, Polonijio and Carpiano also found a positive correlation between household income and HPV vaccine initiation and completion, as well as, HPV vaccine knowledge and receipt of provider recommendation (Niccolai et al., 2011) (Polonijio & Carpiano, 2013).

On the contrary, Previous research suggests that low-income mothers view the HPV vaccine positively because they have had personal experiences with cervical cancer (Perkins, Pierre-Joseph, Marquez, Iloka, & Clark, 2010) (Gainforth Heather L., Cao Wei, & Latimer-Cheung Amy E., 2012). According to Jeudin et al. (2014), women who are living below the FPL have higher prevalence of HPV (56.5%) compared to women who live above the FPL (39.7%) (Hariri et al., 2011). In addition, women living below the FPL are more likely to be diagnosed with

late-stages of cervical cancer and they are less likely to survive being diagnosed with a metastatic disease (Jeudin, Liveright, del Carmen, & Perkins, 2014). These findings influenced the study's hypotheses.

The Role of Healthcare Providers

Similarly to parents and guardians, healthcare providers also play an integral role in adolescent HPV vaccination uptake as they can present barriers, implicitly or explicitly, that negatively impact the uptake of the HPV vaccine among adolescents. Barriers include inconsistent knowledge of the HPV vaccine among healthcare providers (Perkins & Clark, 2012) (Saraiya, Rosser, & Cooper, 2012), lack of understanding of the association between HPV and genital warts and/or the association between HPV and non-cervical cancers (Perkins & Clark, 2012) (Saraiya et al., 2012).

Previous research has found that collaborative communication between providers and parents of adolescent girls improve the likelihood of HPV vaccination uptake (Moss, Gilkey, Rimer, & Brewer, 2016). Moss et al. (2016), found that 53% of parents who completed the 2010 NIS-Teen survey for their daughters reported having collaborative communications with their providers. This revealed that there were vast disparities in patient-provider collaborative communication. It was less likely to occur in underserved groups which accounted for differential utilization of the vaccine among adolescent girls. Patients who were poor, less-educated, Spanish speaking, southern, lived in rural areas, with non-privately insured parents, and identified as Hispanic reported less collaborative communication (Moss et al., 2016).

The need for increased uptake of the HPV vaccine has generated research centered around immunization quality improvement in regards to adolescent health and cancer prevention (Gilkey et al., 2016). The literature suggests that receipt of provider recommendation is a stronger indicator

of vaccine initiation relative to race/ethnicity, health insurance coverage status, knowledge of the HPV vaccine, and attitudes around the vaccine's safety and effectiveness (Gilkey et al., 2016). In fact, provider recommendation of the vaccine accounts for 70% of adolescent initiation of the series (Dorell, Yankey, Santibanez, & Markowitz, 2011).

Gilkey et al. (2016), investigated the association of provider recommendation quality (no recommendation, low-quality, or high-quality) and found that 48% of parents in the study (N=1495) were not recommended the vaccine. They found that parents who received high-quality recommendations from provider had nine times the odds of initiating the series and three times the odds of completing the series compared to parents who did not receive a recommendation (Gilkey et al., 2016). As expected, they also found that parents who received a low-quality recommendation had four times the odds of initiating compared to parents who did not receive a recommendation, however, the odds of completing the series were not statistically distinguishable (Gilkey et al., 2016).

HPV Vaccine Effectiveness and Dosage

The HPV vaccine is highly effective in preventing HPV types if received prior to exposure to the virus. Given the high prevalence of HPV, vaccines must be delivered prior to the onset of sexual activity, which on occurs at age 17.3 and 17 for females and males, respectively (Chandra, Martinez, Mosher, Abma, & Jones, 2005) ("Fertility, Contraception, and Fatherhood," 2006). Clinical trials for Gardasil and Cervarix found that the vaccines protect against nearly 100% of cervical infections caused by HPV 16 and HPV 18 ("Human Papillomavirus (HPV) Vaccines", n.d.). Similarly, Gardasil-9 is highly effective. Clinical trials found that the vaccine was 97% effective in preventing cervical, vulvar, and vaginal cancer caused by five additional

HPV types 31, 33, 45, 52, and 58 (“Human Papillomavirus (HPV) Vaccines,” n.d.) (Chatterjee, 2014).

Gardasil and Cervarix are known to protect against their target HPV types for 8 (Ferris et al., 2014) and 9 (Naud et al., 2014) years, respectively. However, the duration of Gardasil-9 is unknown (“Human Papillomavirus (HPV) Vaccines,” n.d.). In regards to males, a Gardasil clinical trial found that it can prevent genital warts and anal cell changes caused by HPV infection (Giuliano et al., 2011). Other studies have found that Cervarix is protective against HPV 16 and 18 infections within the anus (Kreimer et al., 2011) and oral cavity (Herrero et al., 2013) among women.

The HPV vaccine was originally recommended to be received in a three dose series over six months. Kreimer et al. (2011), found that the protection against HPV types 16 and 18 among women with one or two doses of Cervarix was comparable to women who received all three doses of the series, the research team also found that this protection persisted throughout four years of follow up (Kreimer et al., 2011). Similar studies have found that young adolescents who receive two doses of Cervarix and Gardasil have an immune response as strong as that of 15 to 25 years old individuals who received all three doses (Dobson et al., 2013) (Romanowski et al., 2011).

Parental Acceptance

Given that target age group for the vaccine is typically under 18, the receipt of the HPV vaccination is often dependent on the willingness and acceptance of their parents or guardians. Previous research has shown that a majority of parents are well aware the HPV vaccine (Joseph et al., 2012) (Tsui et al., 2013) (Litton, Desmond, Gilliland, Huh, & Franklin, 2011), however most parents lack knowledge and preferred more information prior to vaccinating their children; these were barriers to adolescent uptake of the vaccine (Luque et al., 2012; Bastani et al., 2011;

C. G. Dorell, Yankey, Santibanez, & Markowitz, 2011; C. Dorell, Yankey, & Strasser, 2011; Stokley et al., 2011; Gilkey, Moss, McRee, & Brewer, 2012; Joseph et al., 2012b; Kepka, Ulrich, & Coronado, 2012; Laz, Rahman, & Berenson, 2012; Oldach & Katz, 2012; Wilson, Brown, Boothe, & Harris, 2013; Hamlish, Clarke, & Alexander, 2012; Hofstetter & Rosenthal, 2014). Additional reluctance of the vaccine can be attributed to pharmaceutical involvement in ACIP recommendation, marketing of the vaccine, and quickness to incorporate the HPV vaccine into proposed school mandates and national vaccination program (Hofstetter & Rosenthal, 2014).

Cultural Barriers to HPV Vaccine Uptake

Prior to the introduction of the HPV vaccine, socioeconomic disparities in cervical cancer persisted across countries worldwide (Fisher, Trotter, Audrey, MacDonald-Wallis, & Hickman, 2013). In general, the disadvantaged women experienced higher incidence of cervical cancer compared to women who were more affluent women, this disparity persisted regardless of national cervical screening programs. The introduction of the HPV vaccine has broadened these health disparities (Fisher et al., 2013).

Differential uptake of the HPV vaccine are can partially be attributed to cultural differences that predispose some groups, relative to others, to vaccine use. A small pilot study (n=12) in Georgia found that Hispanic immigrant parents felt their immigration status, distrust in healthcare professionals and facility, as well as cultural factors prevented them from vaccinating their teenagers (Luque, Raychowdhury, & Weaver, 2012). Additionally, Joseph et al (2012), found that 47% of African American and 31% of Haitian daughter have received the vaccine. This difference in uptake can be attributed to the increased awareness of HPV among African Americans compared to Haitian immigrants (Joseph et al., 2012). These finding reinforce the importance of understanding the role of provider recommendation on the uptake of the HPV vaccine.

Methodology

Data

Data was obtained from the National Immunization Survey—Teen (NIS-Teen), a nationally representative survey administered by the National Center for Immunization and Respiratory Diseases of the CDC. It was launched in 2006 and aims to provide estimates of current, population-based, state and local vaccination coverage among adolescents aged 13 to 17 years old (“NIS | About the National Immunization Surveys | Vaccines | CDC,” 2018). The purpose of NIS-Teen data is to monitor vaccination of adolescents at the national, state, and local level, as well as some US territories. In addition, the survey supports the Childhood Immunization Initiative by monitoring vaccine coverage and progress towards HealthyPeople 2020 objectives for adolescent immunizations (“A User’s Guide for the 2016 Public-Use Data File,” 2016). The data includes coverage of the tetanus, diphtheria, acellular pertussis (Tdap), quadrivalent meningococcal vaccine, (MenACWY) HPV, and the seasonal influenza vaccine. The analysis focused on adolescent females and males aged 13 to 17 years in the US, excluding territories.

Telephone numbers are selected using a complex sample design that includes stratification and clustering and is representative at estimation areas of residence (“A User’s Guide for the 2016 Public-Use Data File,” 2016). Oversampling occurred for local areas: El Paso County, Texas and Dallas County, Texas. Currently, NIS-Teen used random digit dialing (RDD) to sample landline and cell-phone numbers. Each year uses independent, quarterly samples of landline or cell-phone numbers within estimation areas (“A User’s Guide for the 2016 Public-Use Data File,” 2016). During this study period (2010 – 2016), NIS-Teen underwent methodological changes which added cell-phones to the sampling frame in 2011. Prior to 2011, the survey only utilized landlines.

The addition of cell-phone accounts for the increase in households that solely use cell-phones (“A User’s Guide for the 2016 Public-Use Data File,” 2016).

Data is collected through computer assisted telephone interviews of parents/guardians. Household with one or more adolescents aged 13 to 17 is selected, then one of the adolescents is randomly selected, and the parent or guardian who is most familiar with the selected adolescent’s immunization history is interviewed (“A User’s Guide for the 2016 Public-Use Data File,” 2016). Interview topics include: household-reported vaccination and health information; demographic/socioeconomic household/teen information, and geographic variables.

During the interview permission is sought from parents/guardians in order to collect data from the teens’ vaccinating healthcare providers. Providers are administered an *Immunization History Questionnaire*, which reports the types of vaccination received, number of doses, and dates of administration of the sampled adolescent. In addition, the *Immunization History Questionnaire* also collects data on the provider’s practice, including the type of healthcare facility. The response rate for the provider interviews ranges from 93.2 to 94.8% (“NIS - Datasets for the National Immunization Survey - Teen,” 2018), depending on the year. The response rate, defined by the Council of American Survey Research Organization, of parents or guardians and is 22.4% to 57.9%, depending on the year (“A User’s Guide for the 2016 Public-Use Data File,” 2016). The proportion of adolescents with adequate provider ranges from 47.4% to 59.4%, depending on the year (“A User’s Guide for the 2016 Public-Use Data File,” 2016).

Independent Variables

The primary independent variables examined in Aims 1 and 2 are family income and sex. The family income was defined using income to poverty ratios, Each year utilized its respective census poverty threshold. Family Income was coded into three levels: less than 200% of the

federal poverty line (FPL), 200-399% of the FPL, and greater than or equal to 400% of the FPL. The gender variable was derived from the NIS-Teen variable describing the sex of the adolescent. The variable includes two categories: male and female. The independent variables of interest for Aim 3 are described in the analytic approach section.

Dependent Variables

The dependent variables include provider recommendation, HPV vaccine initiation, and HPV vaccine completion. Provider recommendation was a binary indicator derived from a NIS-Teen survey question that ask parents: “Provider recommendation comes from a survey question that asks parents: “Had or has doctor or other health care professional ever recommended that teen receive HPV shots?” HPV vaccine initiation and vaccine completion comes from survey question: “Number of human papillomavirus shots / HPV-Gardasil / HPV-Gardasil 9 / HPV-Cervarix / HPV shots of unknown type by age 13 years” determined from provider info, excluding any vaccination after the teen interview date”. Vaccine initiation was coded as a binary indicator of at least one dose versus zero doses. Vaccine completion was coded as a 0/1 variable indicating three or more doses. The measure of the vaccine completion observed adolescents who received at least three doses out of all adolescents.

Prior to 2010, adolescent males were excluded from any HPV vaccine related questions. Initially, I planned to analyze NIS-Teen data from 2008 to 2016. However, due to the lack of data regarding adolescent males, years 2008 and 2009 were dropped and the analyzed was limited to years 2010 to 2016.

Control Variables

All analyses control for the following variables: race/ethnicity (Hispanic, non-Hispanic White, non-Hispanic Black, and non-Hispanic Other and Multiple Race), maternal education (Less

than 12 years, 12 years, more than 12 year but non-college graduate, and college graduate), health care coverage status (uninsured, private, and public), census region (Northeast, Midwest, South, West), marital status (married and non-married), type of healthcare facility (usual place of care) (private, public, hospital, STD/school/teen clinics or others, and mixed) (See Appendix B through D).

Analytic Approach

Aim 1 will measure the relationship between family income and the three HPV vaccine outcomes described above using multiple logistic regression. Control variables include gender, parental education, health insurance type, race/ethnicity, census region, marital status, and type of healthcare facility (see Appendix B). Results are reported as adjusted odds ratios (AOR). All models used survey weights to weight the sample with sufficient provider information to be representative of the U.S. teen population. Variance estimates adjusted for the complex sample design using Taylor series linearized standard errors.

Aim 2 will measure the association between gender and outcomes using the same logistic regression framework described above. In addition separate stratified models were estimated for males and females separately to examine if income gradients differ by gender.

Aim 3 will measure the impact of the 2011 ACIP recommendation on male HPV vaccine uptake by conducting a multivariable linear probability difference-in-differences analysis. The control group are adolescent females and the treatment group is adolescent males. Given that the new ACIP guideline was implemented in late 2011, the pre period included 2010 and 2011 and the post period included 2012 through 2016. The assumption of the difference-in-differences approach is that the trend for females represents the trend for males had they never been exposed to the ACIP guidelines. The approach controls for any observed or unobserved factors that are

unique to males and any national trends, common to both sexes, that could be confounded with the introduction of the guidelines. Figures 1, 2, and 3 describes the study's conceptual framework for each of the specific aims (See Appendix A).

Results

Descriptive Statistics

Tables 1 and 2 reports the descriptive statistics (N = 263,401). In regards to family income, 41% of the population are less than 200% of the FPL, 52% are within 200% to 399% of the FPL, and 7% is greater than or equal to 400% of the FPL.

The racial and ethnic delineation of the sample included 22% Hispanic, 55% non-Hispanic White, 14% non-Hispanic Black, and 9% identify as non-Hispanic, other and multiple races. Overall, 14% of the sample have mothers with less than 12 years of education, 27% of adolescents' mothers have 12 years of education, 26% have more than 12 years with a bachelor's degree, and 36% are college graduates. 17% of the sample resides in the Northeast, 22% in the Midwest, 37% in the South, and 24% in the West. Lastly, 33% of adolescents within the sample have mothers who are married and 67% have mothers who are not married.

Overall, 52.97% of the population received a provider recommendation for the HPV vaccine, 41.20% initiated the series, and 22.11% completed the HPV vaccine series. Table 1 shows 49.20% of those less than 200% of the FPL, 56.39% of those between 200 and 399% of FPL, and 49.01% of those greater than 400% of the FPL were recommended for the HPV vaccine by a provider. Moreover, 43.67% of those less than 200%, 39.95% of those 200 to 399%, and 36.73% of those greater than 400% of the FPL initiated the HPV vaccine series. Lastly, 21.41% of those less than 200% of FPL, 22.92% of those between 200 and 399% of FPL, and 19.85% of those greater than 400% of the FPL

When stratifying by gender, 38.45% of adolescent males received a recommendation compared to adolescent females (67.94%). Similarly, 28.07% of adolescent males initiated the series compared to adolescent females (54.66%), and 12.81% of adolescent males completed the series compared to 31.65% of adolescent females (Table 2).

Table 1. Selected Descriptive Statistics by Family Income (Aim 1)

	<200% of FPL		200-399% of FPL		>400% of FPL		Total	
	N = 82,382		N = 156,285		N = 24,634		N = 263,401	
	Estimates		Estimates		Estimates		Estimates	
	Rate	SE	Rate	SE	Rate	SE	Rate	SE
Provider Recommendation								
No	50.80	0.45	43.61	0.31	50.99	1.08	47.03	0.25
Yes	49.20	0.45	56.39	0.31	49.01	1.08	52.97	0.25
HPV Vaccine Initiation								
No	56.33	0.46	60.05	0.31	63.27	1.05	58.80	0.25
Yes	43.67	0.46	39.95	0.31	36.73	1.05	41.20	0.25
HPV Vaccine Completion								
No	78.59	0.38	77.08	0.27	80.15	0.84	77.89	0.22
Yes	21.41	0.38	22.92	0.27	19.85	0.84	22.11	0.22
Parental Education (Mother)								
Less than 12 years	26.16	0.40	2.57	0.11	22.22	0.94	13.70	0.20
12 years	34.98	0.41	15.45	0.24	26.50	0.93	26.50	0.93
More than 12 years, non-college grad	27.58	0.37	24.96	0.27	22.96	0.84	25.89	0.21
College Graduate	11.28	0.24	57.02	0.31	28.32	0.84	36.13	0.23
Health Insurance Type								
Uninsured	3.45	0.19	7.48	0.28	4.06	0.51	4.85	0.15
Private	10.55	0.28	66.15	0.53	24.76	1.11	30.25	0.31
Public	86.00	0.33	26.37	0.51	71.18	1.18	64.90	0.33
Race/Ethnicity								
Hispanic	33.66	0.43	11.40	0.25	26.51	1.08	21.65	0.24
Non-Hispanic White	36.69	0.38	70.70	0.31	50.70	1.02	55.27	0.25
Non-Hispanic Black	20.61	0.34	9.04	0.19	14.14	0.70	14.16	0.18
Non-Hispanic Other + Multiple Race	9.05	0.23	8.86	0.19	8.65	0.57	8.92	0.14
Census Region								
Northeast	14.03	0.22	18.83	0.16	19.76	0.67	16.93	0.10
Midwest	20.33	0.26	23.01	0.18	20.41	0.68	21.72	0.11
South	40.45	0.36	34.94	0.23	37.79	0.94	37.41	0.15
West	25.18	0.40	23.21	0.26	22.05	1.10	23.93	0.17
Marital Status								
Non-Married	51.52	0.43	20.68	0.28	32.21	0.97	33.29	0.24
Married	48.48	0.43	79.32	0.28	67.79	0.96	65.81	0.24

Source: National Immunization Survey-Teen, 2010-2016 person files

Note: Standard Errors (SE) are calculated using Taylor Series Linearization with Stata version 14.2.

Note: Table 1 reports the weighted sample size of the study

	Male		Female		Total	
	N = 137,532		N = 125,869		N = 263,401	
	Estimates		Estimates		Estimates	
	Rate	SE	Rate	SE	Rate	SE
Provider Recommendation						
No	61.55	0.34	32.06	0.35	47.03	0.25
Yes	38.45	0.34	67.94	0.35	52.97	0.25
HPV Vaccine Initiation						
No	71.93	0.33	45.34	0.37	58.80	0.25
Yes	28.07	0.33	54.66	0.37	41.20	0.25
HPV Vaccine Completion						
No	87.19	0.25	68.35	0.34	77.89	0.22
Yes	12.81	0.25	31.65	0.34	22.11	0.22
Parental Education (Mother)						
Less than 12 years	13.65	0.28	13.75	0.29	13.70	0.20
12 years	24.66	0.33	23.87	0.32	24.28	0.23
More than 12 years, non-college grad	25.28	0.29	26.53	0.31	25.89	0.21
College Graduate	36.40	0.31	35.85	0.33	36.13	0.22
Health Insurance Type						
Uninsured	4.56	0.19	5.14	0.24	4.85	0.15
Private	30.43	0.43	30.06	0.44	30.25	0.31
Public	65.01	0.45	64.80	0.47	64.90	0.33
Race/Ethnicity						
Hispanic	21.47	0.34	21.83	0.36	21.65	0.24
Non-Hispanic White	55.71	0.35	54.80	0.36	55.27	0.25
Non-Hispanic Black	13.99	0.25	14.34	0.26	14.16	0.18
Non-Hispanic Other + Multiple Race	8.82	0.20	9.03	0.21	8.92	0.14
Census Region						
Northeast	16.94	0.18	16.92	0.19	16.93	0.10
Midwest	21.75	0.20	21.69	0.21	21.72	0.11
South	37.73	0.27	37.45	0.29	37.41	0.15
West	23.93	0.31	23.94	0.33	23.93	0.17
Marital Status						
Non-Married	33.79	0.34	34.61	0.35	34.19	0.24
Married	66.21	0.34	65.39	0.35	65.81	0.24
Family Income						
Less than 200%	40.95	0.35	41.14	0.36	41.04	0.25
200% to 399%	51.70	0.35	51.48	0.36	51.59	0.25
Greater than 400%	7.35	0.20	7.39	0.21	7.37	0.14

Source: National Immunization Survey-Teen, 2010-2016 person files

Note: Standard Errors (SE) are calculated using Taylor Series Linearization with Stata version 14.2.

Note: Table 2 reports the weighted sample size of the study

The Association of Family Income and HPV Vaccine Utilization Outcomes

Table 3 shows the results of the logistic regression of the HPV utilization outcomes: (1) provider recommendation, (2) HPV Vaccine Initiation, and (3) HPV Vaccine Completion. The data is

pooled across all years in the study period. In regards to receipt of provider recommendation, adolescents with family incomes between 200 and 399% of the FPL have increased odds of receiving a provider recommendation compared to adolescents who have a family income greater than 400% of the FPL (AOR = 1.16, P=0.04). Additionally, adolescents with the 200 to 399% (AOR = 1.23, P=0.01) and less than 200% of the FPL (AOR = 1.30, P<0.01) have increased odds of initiating the vaccine. Adolescents within the 200 to 399% of the FPL (AOR = 1.27, P=0.01) and less than 200% of the FPL (AOR=1.21, P=0.02) have increased odds of completing the series compared to those greater than 400% of the FPL. Vaccine completion is defined as adolescents who received at least three doses out of all adolescents.

Hispanic adolescents have an increased odds of receiving a provider recommendation (AOR=1.16, P<0.01), HPV vaccine initiation (AOR=1.45, P<0.01), and vaccine completion (AOR=1.22, P<0.01) compared to non-Hispanic White adolescents. Moreover, Table 3 shows that non-Hispanic Black have increased odds of initiating the series (AOR=1.12, P=0.01) and significantly reduced odds of completing the vaccine series (AOR=0.08, P=0.02) compared to non-Hispanic White adolescents. In regards to education of the adolescents' mothers, mothers with less than 12 years, 12 years of education, and mothers with more than 12 years but without a college degree have significantly reduced odds of receiving a provider recommendation, initiating and completing the vaccination series compared to adolescents with mothers who graduated from college.

I also found that publicly insured (AOR=0.77, P<0.01) and uninsured (AOR=0.61, P<0.01) adolescents have significantly reduced odds of receiving a provider recommendation compared to privately insured adolescents. Similarly, uninsured adolescents also have reduced odds of initiating (AOR=0.72, P<0.01) and completing (AOR=0.65, P<0.01) the HPV vaccine

series when compared to privately insured adolescents. The logistic regression also shows that adolescents that seek care from public facility (AOR=0.67, P<0.01) and STD/school/teen clinics or others (AOR=0.69, P<0.01) facilities have significantly reduced odds of receiving a provider recommendation compared to adolescents who seek care at private facilities. In addition, adolescents who seek care at public facilities (AOR=0.79, P<0.01) have reduced odds and adolescents who seek care at hospitals have increased odds (AOR=1.20, P<0.01) of initiating the series compared to adolescents that use private facilities. Lastly, adolescents who seek care at public facilities (AOR=0.77, P<0.01) and STD/School/Teen Clinics or Others (AOR=0.73, P<0.01) have reduced odds of completing the series compared to adolescents who seek care at private facilities.

Lastly, adolescents who reside in the Midwest, South, and Western regions of the United States have reduced odds of receiving a provider recommendation and completing the HPV vaccine series compared to adolescents residing in the Northeast region of the United States. Similarly, adolescents in the Midwest and South have reduced odds of HPV vaccine initiation and completion compared to the Northeast. When observing the association between marital status and the three HPV vaccine utilization outcomes, I found that adolescents with non-married mothers had significant increased odds of receiving a provider recommendation (AOR=1.14, P<0.01), initiating (AOR=1.23, P<0.01), and completing the HPV vaccine series (AOR=1.11, P=0.01) compared to adolescents with married mothers.

Table 3. Regression Results of HPV Utilization Outcomes

	Provider Recommendation			HPV Initiation			HPV Completion		
	AOR	SE	P-Value	AOR	SE	P-Value	AOR	SE	P-Value
Gender									
Female	1	1	1	1	1	1	1	1	1
Male	0.35**	0.01	0.00	0.37**	0.01	0.00	0.38**	0.01	0.00
Family Income									
Greater than 400%	1	1	1	1	1	1	1	1	1
200% to 399%	1.16*	0.08	0.04	1.23**	0.09	0.01	1.27**	0.11	0.01
Less than 200%	1.10	0.08	0.17	1.30**	0.10	0.00	1.21*	0.10	0.02
Race/Ethnicity									
Non-Hispanic White	1	1	1	1	1	1	1	1	1
Non-Hispanic Black	1.02	0.05	0.65	1.12**	0.05	0.01	0.88*	0.05	0.02
Non-Hispanic Other + Multiple Race	0.96	0.05	0.43	1.08	0.06	0.15	0.96	0.06	0.50
Hispanic	1.16**	0.05	0.00	1.45**	0.07	0.00	1.22**	0.06	0.00
Parental Education (Mother)									
College Graduate	1	1	1	1	1	1	1	1	1
Less than 12 years	0.51**	0.03	0.00	0.82**	0.05	0.00	0.75**	0.05	0.00
12 years	0.64**	0.03	0.00	0.81**	0.04	0.00	0.78**	0.04	0.00
More than 12 years, non-college gra	0.80**	0.04	0.00	0.87**	0.04	0.00	0.84**	0.04	0.00
Health Insurance Type									
Private	1	1	1	1	1	1	1	1	1
Public	0.77**	0.03	0.00	0.95	0.04	0.26	0.93	0.05	0.12
Uninsured	0.61**	0.05	0.00	0.72**	0.07	0.00	0.65**	0.07	0.00
Usual Place of Care									
Private	1	1	1	1	1	1	1	1	1
Public	0.67**	0.03	0.00	0.79**	0.04	0.00	0.77**	0.05	0.00
Hospital	1.05	0.06	0.43	1.20**	0.07	0.00	1.08	0.07	0.20
STD/School/Teen Clinics or Others	0.69**	0.06	0.00	0.86	0.07	0.08	0.73**	0.07	0.00
Mixed	0.97	0.04	0.49	1.03	0.04	0.41	1.04	0.05	0.44
Census Region									
Northeast	1	1	1	1	1	1	1	1	1
Midwest	0.82**	0.04	0.00	0.85**	0.04	0.00	0.87**	0.04	0.00
South	0.69**	0.03	0.00	0.76**	0.03	0.00	0.81**	0.04	0.00
West	0.79**	0.04	0.00	0.93	0.05	0.10	0.87*	0.05	0.02
Marital Status									
Married	1	1	1	1	1	1	1	1	1
Non-Married	1.14**	0.04	0.00	1.23**	0.05	0.00	1.11**	0.05	0.01

Source: National Immunization-Teen, 2010-2016 person files

Note: Standard Errors (SE) are calculated using Taylor Series Linearization with Stata version 14.2

Note: * for P-Value ≤ 0.05 , ** for P-Value ≤ 0.01

Note: N = 263,401

Note: AOR (Adjusted Odds Ratio)

The Association of Sex and HPV Vaccine Outcomes and Sex Specific Income Gradients

Table 3 also demonstrates that adolescent males have statistically significant reduced odds of receiving a provider recommendation (AOR = 0.35, P<0.01), HPV vaccination initiation (AOR =0.37, P = 0.00), and HPV vaccination completion (AOR = 0.38, P<0.01) compared to adolescent females.

Tables 4 and 5 shows the results of gender specific regressions. Table 4 shows that among adolescent males, there is not statistical difference in provider recommendation or HPV vaccine completion by family income. However, male adolescents with less than 200% (AOR=1.22, P=0.05) of the FPL have increased odds of initiating the series compared to adolescents who are greater than 400% of the FPL.

A similar phenomenon occurs among adolescent females (Table 5). Female adolescents within 200 to 399% had increased odds of receiving a provider recommendation (AOR=1.32,

Table 4. Regression Results of HPV Utilization Outcomes for Males									
	Provider Recommendation			HPV Initiation			HPV Completion		
	OR	SE	P-Value	OR	SE	P-Value	OR	SE	P-Value
Family Income									
Greater than 400%	1	1	1	1	1	1	1	1	1
200% to 399%	1.03	0.10	0.74	1.07	0.11	0.49	1.16	0.15	0.24
Less than 200%	1.07	0.10	0.46	1.22*	0.12	0.05	1.13	0.14	0.34
Race/Ethnicity									
Non-Hispanic White	1	1	1	1	1	1	1	1	1
Non-Hispanic Black	1.14*	0.07	0.04	1.23**	0.08	0.00	1.01	0.09	0.87
Non-Hispanic Other + Multiple Race	1.08	0.08	0.33	1.17*	0.09	0.04	0.94	0.09	0.53
Hispanic	1.31**	0.08	0.00	1.53**	0.10	0.00	1.29**	0.10	0.00
Parental Education (Mother)									
College Graduate	1	1	1	1	1	1	1	1	1
Less than 12 years	0.63**	0.05	0.00	0.84*	0.07	0.05	0.89	0.10	0.28
12 years	0.64**	0.04	0.00	0.76**	0.05	0.00	0.73**	0.06	0.00
More than 12 years, non-college grad	0.77**	0.05	0.00	0.82**	0.05	0.00	0.73**	0.05	0.00
Health Insurance Type									
Private	1	1	1	1	1	1	1	1	1
Public	0.70**	0.05	0.00	0.85**	0.05	0.01	0.80**	0.06	0.00
Uninsured	0.48**	0.05	0.00	0.52**	0.07	0.00	0.45**	0.10	0.00
Usual Place of Care									
Private	1	1	1	1	1	1	1	1	1
Public	0.69**	0.05	0.00	0.80**	0.06	0.00	0.86**	0.09	0.15
Hospital	1.09	0.08	0.29	1.24**	0.10	0.01	1.00	0.10	0.96
STD/School/Teen Clinics or Others	0.68**	0.08	0.00	0.85	0.11	0.22	0.61**	0.10	0.00
Mixed	0.93	0.05	0.18	1.02	0.06	0.75	1.12	0.09	0.15
Census Region									
Northeast	1	1	1	1	1	1	1	1	1
Midwest	0.86**	0.05	0.01	0.86*	0.05	0.02	0.85*	0.07	0.03
South	0.72**	0.04	0.00	0.77**	0.04	0.00	0.77**	0.05	0.00
West	0.81**	0.06	0.01	0.92	0.07	0.26	0.80*	0.08	0.02
Marital Status									
Married	1	1	1	1	1	1	1	1	1
Non-Married	1.10	0.06	0.07	1.18**	0.06	0.00	1.14	0.08	0.06
Source: National Immunization-Teen, 2010-2016 person files									
Note: Standard Errors (SE) are calculated using Taylor Series Linearization with Stata version 14.2									
Note: * for P-Value ≤ 0.05 , ** for P-Value ≤ 0.01									
Note: N = 263,401									
Note: AOR (Adjusted Odds Ratio)									

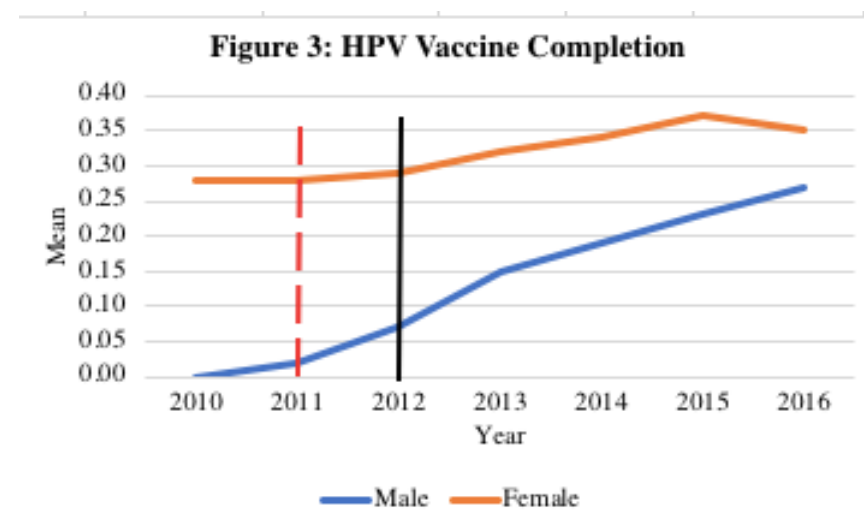
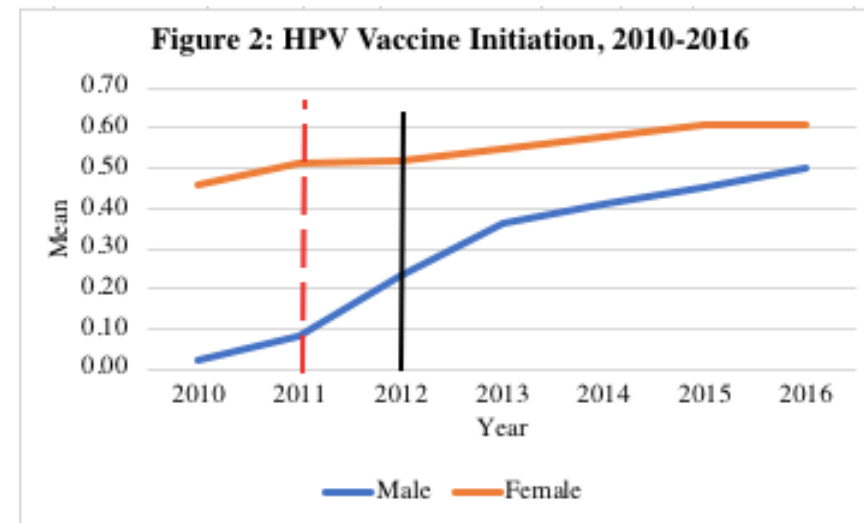
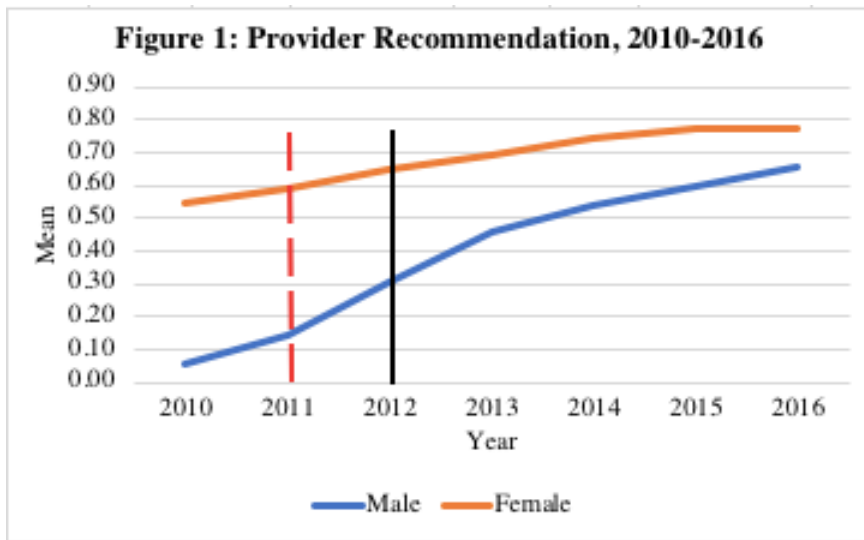
P=0.01), initiating (AOR=1.36, P<0.01), and completing (AOR=1.32, P<0.01) the series compared to female adolescents who have a family income greater than 400% of the FPL. Similarly, female adolescents with a family income less than 200% of the FPL have increased odds of initiating (AOR=1.36, P<0.01) and completing (AOR=1.25, P<0.05) the vaccination series compared to those greater than 400% of the FPL. Further, female adolescents within 200 to 399% of the FPL have increased odds of completing the series (AOR=1.23, P=0.01) compared

to those above 400% of the FPL. The results presented in Tables 4 and 5 regarding the socioeconomic gradients suggest that the odds of receiving a provider recommendation, initiating, and completing the vaccine series is consistent regardless of gender.

Table 5. Regression Results of HPV Utilization Outcomes for Females

	Provider Recommendation			HPV Initiation			HPV Completion		
	AOR	SE	P-Value	AOR	SE	P-Value	AOR	SE	P-Value
Family Income									
Greater than 400%	1	1	1	1	1	1	1	1	1
200% to 399%	1.32**	0.14	0.01	1.36**	0.15	0.00	1.32**	0.15	0.01
Less than 200%	1.11	0.12	0.32	1.36**	0.14	0.00	1.25*	0.14	0.04
Race/Ethnicity									
Non-Hispanic White	1	1	1	1	1	1	1	1	1
Non-Hispanic Black	0.90	0.06	0.11	1.03	0.06	0.65	0.81**	0.05	0.00
Non-Hispanic Other + Multiple Race	0.83*	0.05	0.02	1.02	0.08	0.84	0.97	0.08	0.67
Hispanic	1.00	0.07	0.97	1.38**	0.09	0.00	1.17*	0.08	0.02
Parental Education (Mother)									
College Graduate	1	1	1	1	1	1	1	1	1
Less than 12 years	0.41**	0.04	0.00	0.80**	0.07	0.01	0.68**	0.06	0.00
12 years	0.62**	0.04	0.00	0.87*	0.06	0.04	0.81**	0.05	0.00
More than 12 years, non-college gra	0.83**	0.06	0.01	0.93	0.06	0.23	0.90	0.06	0.11
Health Insurance Type									
Private	1	1	1	1	1	1	1	1	1
Public	0.87*	0.06	0.03	1.06	0.07	0.36	1.02	0.06	0.74
Uninsured	0.77*	0.09	0.02	0.90	0.10	0.33	0.78*	0.10	0.04
Usual Place of Care									
Private	1	1	1	1	1	1	1	1	1
Public	0.65**	0.04	0.00	0.77**	0.05	0.00	0.71**	0.05	0.00
Hospital	1.00	0.09	1.00	1.16	0.10	0.09	1.13	0.09	0.14
STD/School/Teen Clinics or Others	0.70**	0.09	0.00	0.86	0.10	0.20	0.80	0.10	0.07
Mixed	1.02	0.06	0.70	1.04	0.06	0.45	0.99	0.06	0.84
Census Region									
Northeast	1	1	1	1	1	1	1	1	1
Midwest	0.78**	0.05	0.00	0.84**	0.05	0.01	0.88*	0.06	0.05
South	0.66**	0.04	0.00	0.75**	0.04	0.00	0.84**	0.05	0.00
West	0.75**	0.06	0.00	0.91	0.07	0.24	0.92	0.07	0.28
Marital Status									
Married	1	1	1	1	1	1	1	1	1
Non-Married	1.19**	0.06	0.00	1.28**	0.06	0.00	1.10	0.06	0.07
Source: National Immunization-Teen, 2010-2016 person files									
Note: Standard Errors (SE) are calculated using Taylor Series Linearization with Stata version 14.2									
Note: * for P-Value ≤ 0.05 , ** for P-Value ≤ 0.01									
Note: N = 263,401									
Note: AOR (Adjusted Odds Ratio)									

The Association of the ACIP Guideline for Males with HPV Vaccine Outcomes



Figures 1, 2, and 3 display a time series of the HPV vaccine utilization variables stratified by gender. The red dashed line represents the 2011 ACIP recommendation and the black line represents the beginning of the post-period of the difference in differences analysis.

Table 6 shows the effect of the 2011 ACIP recommendation on adolescent male receipt of provider recommendation, HPV vaccine initiation, and HPV vaccine completion. Adolescent male receipt of provider recommendation increased 23 percentage points ($P < 0.01$) during 2012 to 2016 compared to 2010 to 2011, relative to the change for

females. Similarly, adolescent male HPV vaccine initiation improved by 28 percentage point (P<0.01), and HPV vaccine completion improved by 12 percentage points (P<0.01).

Table 6. Difference in Differences Results for HPV Vaccine Utilization Outcomes

	Provider Recommendation			HPV Vaccine Initiation			HPV Vaccine Completion		
	Coef.	SE	P-Value	Coef.	SE	P-Value	Coef.	SE	P-Value
Males	-0.42**	0.01	0.00	-0.44**	0.01	0.00	-0.26**	0.01	0.00
Males*Post	0.23**	0.02	0.00	0.28**	0.01	0.00	0.12**	0.01	0.00
Family Income									
Greater than 400%	1	1	1	1	1	1	1	1	1
200% to 399%	0.04**	0.01	0.00	0.04**	0.02	0.01	0.04**	0.01	0.00
Less than 200%	0.01	0.01	0.28	0.06**	0.02	0.00	0.03**	0.01	0.01
Race/Ethnicity									
Non-Hispanic White	1	1	1	1	1	1	1	1	1
Non-Hispanic Black	0.01	0.01	0.18	0.03**	0.01	0.00	-0.02*	0.01	0.05
Non-Hispanic Other + Multiple Race	-0.02	0.01	0.16	0.01	0.01	0.25	-0.01	0.01	0.40
Hispanic	0.02	0.01	0.09	0.08**	0.01	0.00	0.03**	0.01	0.00
Parental Education (Mother)									
College Graduate	1	1	1	1	1	1	1	1	1
Less than 12 years	-0.13**	0.01	0.00	-0.02	0.02	0.10	-0.04**	0.01	0.00
12 years	-0.08**	0.01	0.00	-0.03**	0.01	0.01	-0.03**	0.01	0.00
More than 12 years, non-college grad	-0.03**	0.01	0.00	-0.02**	0.01	0.12	-0.02**	0.01	0.00
Health Insurance Type									
Private	1	1	1	1	1	1	1	1	1
Public	-0.01	0.01	0.54	0.03**	0.01	0.01	0.01	0.01	0.16
Uninsured	-0.06**	0.02	0.00	-0.04*	0.02	0.04	-0.04**	0.02	0.01
Usual Place of Care									
Private	1	1	1	1	1	1	1	1	1
Public	-0.08**	0.01	0.00	-0.04**	0.01	0.00	-0.04**	0.01	0.00
Hospital	0.00	0.01	0.86	0.03*	0.01	0.03	0.01	0.01	0.53
STD/School/Teen Clinics or Others	-0.06**	0.02	0.00	-0.02	0.02	0.27	-0.04**	0.02	0.01
Mixed	0.00	0.01	0.60	0.01	0.01	0.33	0.01	0.01	0.35
Census Region									
Northeast	1	1	1	1	1	1	1	1	1
Midwest	-0.05**	0.01	0.00	-0.04**	0.01	0.00	-0.03**	0.01	0.00
South	-0.09**	0.01	0.00	-0.07**	0.01	0.00	-0.04**	0.01	0.00
West	-0.05**	0.01	0.00	-0.02	0.01	0.09	-0.03*	0.01	0.02
Marital Status									
Married	1	1	1	1	1	1	1	1	1
Non-Married	0.02*	0.02	0.05	0.04**	0.01	0.00	0.01	0.01	0.09
Year									
2010	1	1	1	1	1	1	1	1	1
2011	0.07**	0.01	0.00	0.06**	0.01	0.00	0.01	0.01	0.18
2012	0.07**	0.02	0.00	0.00	0.02	0.78	-0.01	0.01	0.39
2013	0.15**	0.02	0.00	0.08**	0.02	0.00	0.03*	0.02	0.04
2014	0.23**	0.02	0.00	0.12**	0.02	0.00	0.07**	0.01	0.00
2015	0.26**	0.02	0.00	0.14**	0.01	0.00	0.09**	0.02	0.00
2016	0.29**	0.02	0.00	0.17**	0.02	0.00	0.11**	0.01	0.00

Source: National Immunization-Teen, 2010-2016 person files

Note: Standard Errors (SE) are calculated using Taylor Series Linearization with Stata version 14.2

Note: * for P-Value ≤ 0.05 , ** for P-Value ≤ 0.01

Note: N = 263,401

Note: Coef (Coefficient)

Discussion and Conclusion

Family Income and HPV Vaccine Utilization Outcomes

Informed by the Fundamental Cause Theory, we hypothesized that adolescents with a lower family income would have reduced odds of receiving provider recommendation, HPV vaccination initiation, and vaccine completion. However, my findings negate my hypothesis and defies the Fundamental Cause Theory. I found that adolescents within the 200 to 399% of the FPL had increased odds of receiving a provider recommendation, initiating, and completing the vaccination series compared to adolescents with a family income greater than 400% of the FPL. Additionally, adolescents with less than 200% of the FPL had increased odds of initiating and completing the vaccine series compared to adolescents with a family income greater than 400% of the FPL.

These findings contradict results reported by Niccolai et al. (2011) and Polonijo and Carpiano's (2012) where they found that adolescents of lower family incomes had reduced odds of receiving provider recommendation, initiating, and completing the vaccine series. The difference in our finding can be attributed to using different time periods of data. I used six years of data (2010 to 2016) and the data I analyzed was more reliable because providers verified the responses of parents or guardians.

Given that family income and educational attainment are correlated (Jeudin et al., 2014). I was surprised that our findings related to parental education did not agree with the findings regarding family income. Our findings align with Polonijo and Carpiano (2010), adolescents with lower parental education had significantly reduced odds of the HPV vaccine utilization outcomes compared to adolescents with mothers who graduated from college. These findings contradict with Jeudin et al. (2014), who found that mothers who had a high school diploma or less were more willing to have their daughters vaccinated than mothers who had bachelor's

degrees. These difference in findings may be an indication that maternal education is not a strong indicator of the HPV vaccine utilization outcomes as it does not necessarily reflect the highest level of educational attainment within the household whereas family income has the potential to be a more accurate indicator of socioeconomic position.

Unlike, Jeudin et al. (2014), Polonijo and Carpiano (2010), and Niccolai et al. (2011) our study included adolescent males in the analysis. The inclusion of adolescent males may be skewing the association of maternal education and HPV vaccine utilization outcomes., All of these study focus solely on the role of the mother's education excluding the potential role father play on the HPV vaccine utilization outcomes. Future studies should examine the role the father plays on HPV vaccine uptake for adolescent males and females. Additionally, future studies should explore if mothers and fathers have differential impact on receipt of provider recommendation, HPV vaccine initiation, and completion.

Gender and HPV Vaccine Utilization Outcomes

Aim 2 measured the association between gender and the HPV utilization outcomes and explored if socioeconomic gradients in HPV utilizations were consistent across genders, I hypothesized that adolescent males would have reduced odds compared to adolescent females and that adolescents with lower family income would have reduced odds of the three HPV vaccination outcomes compared to those with higher family income. Findings from Table 3 support our hypothesis regarding reduced adolescent male vaccination. However, Tables 4 and 5, continue to defy the Fundamental Cause Theory as adolescent males with family incomes less than 200% of the FPL have increased odds of initiating the vaccination series compared to adolescent males with incomes greater than 400% of the FPL. A similar trend occurs among adolescent females as those with family incomes between 200 and 399% of the FPL have

increased odds of all three outcomes when compared to adolescent females with family incomes greater than 400% of the FPL. Likewise, adolescent females with family incomes less than 200% of the FPL have increased odds initiating and completing the HPV vaccine series compared to adolescent females with family incomes greater than 400% of the FPL

Understanding patient-provider communication experiences among adolescent males and their families could explain the low utilization of the HPV among adolescent males. Exposing this can provide practical and policy implications to improve uptake and coverage of the vaccine in young males. Per Gilkey et al. (2016) findings, high quality provider recommendation significantly improved the odds of initiating and completing the vaccine series compared to low-quality or no provider recommendation.

Therefore, there is a need to educate pediatricians on effective recommendation tactics for parents and guardians of adolescent males. There is also a need to ensure that all pediatricians are aware of the impact of HPV on males and the need for male vaccine uptake as males have been equally susceptible to HPV. Given that there is no routine HPV preventative screening mechanism for males, they can serve as a vehicle in the transmission of HPV if uptake does not improve.

Effect of 2011 ACIP Recommendation on HPV Vaccine Utilization Outcomes

Lastly, in Aim 3, measured the effect of the 2011 ACIP on adolescent male HPV vaccine utilization outcomes. Table 6 shows that there was a significant increase in all of the male adolescent HPV vaccine utilization series before and after the 2011 ACIP recommendation. The magnitude of the increase in male receipt of provider recommendation and HPV vaccine initiation is moderate, while the increase in HPV vaccine completion was mild. Even though, these outcome have increased since the implementation of the 2011 ACIP recommendation,

there is still a need for improvement on each of these outcomes especially when considering adolescent females HPV outcomes since the HPV vaccine became a routine immunization for females in 2006.

Study Limitations

Limitations of the study relate to methodologic changes of the NIS-Teen survey. In 2011, cell-phones were added to the sampling frame, which prior to 2011, previously only utilized landline phones (“A User’s Guide for the 2016 Public-Use Data File,” 2016). The addition of cell-phones to the sampling frame potentially increased the representation of younger parents or guardians. Younger parents or guardians could have different views of the HPV vaccine compared to older parents or guardian, which could also explain the difference in our study’s findings compared to older studies that used data prior to 2011.

Moreover, the definition of adequate provider data (APD) changed in 2014 (Reagan-Steiner et al., 2015). As of 2014, all coverage estimates are based on provider-reported immunization records. The revised APD definition has affected the vaccine coverage estimates along with characteristics of the adolescents in the sample, in fact, it decreased coverage estimates of the HPV vaccine (Reagan-Steiner et al., 2015). However, I consulted directly with NIS-Teen affiliated statisticians at the CDC about the potential implications of the sample frame and adequate provider definition and they expressed little concern that these survey design changes adversely impacted the time series.

A related issue had to do with the exclusion of males from the HPV questions in years 2008 and 2009. This particularly affected the pre-period (2010 to 2011) of the difference in differences analysis. The lack of data prior to 2010 limits my ability to fully attribute the increase

in the HPV vaccine utilization outcomes to the 2011 ACIP recommendation. Specifically, I was unable to fully examine if pre-period trends were similar for males and females.

Study Implications

Though the 2011 ACIP recommendation is associated with an increase in receipt of provider recommendation, HPV vaccine initiation, and completion among adolescent males there are still significant differences in these outcomes compared to adolescent females. Given that the prevalence of low and high risk HPV is higher among adult males compared to adult females, it is imperative that the utilization of the vaccine is improved among adolescents of all genders prior to sexual debut.

The initiation and completion of the series is likely dependent on the receipt of a provider recommendation (Gilkey et al., 2016) (Moss, Gilkey, Rimer, & Brewer, 2016). Future studies should aim to further understand adolescent males uptake of the vaccine, especially as it related to patient-provider communication. Along with studying parents or guardian knowledge and acceptance of the vaccine for their son(s), it is also crucial to ensure that providers are also aware of the need for adolescent male HPV vaccination and are trained to educate and encourage parents or guardians to vaccinate their son(s).

In addition to further research, health promotion, and interventions, our findings suggest the need for an HPV vaccine mandate for school-aged or college-aged students. The Healthy People 2020 objectives Immunization and Infectious Diseases-11.4 and 11.5 aims to increase the coverage of at least three of the HPV vaccine for adolescent females and males ages 13 to 15 years to 80% (“Immunization and Infectious Diseases | Healthy People 2020,” n.d.). The vaccine became a routine recommendation for girls in 2006 and boys in 2011, and uptake has been low relative to the Healthy People 2020 target. As of 2014, 39.7% and 21.6% of adolescent females

and males, respectively, aged 13 to 17 years have received at least three doses of the vaccine series (“Vaccination Coverage | NIS Teen | 2014 Maps by State | CDC,” 2017).

Our finding that family income was inversely related to vaccine outcomes was surprising. Our motivating theory was that lower income individuals would be excluded from resources that enable health service use, including HPV vaccine use. However, our data suggest the opposite pattern. It is likely that this pattern is driven by the fact that the HPV vaccine is a controversial as it related to sexual activity and preventing a sexual transmitted infection that could cause genital warts or cancer. On top of the vaccine being tied to sexual activity, it is highly recommended to be taken as early as the age of nine. It is possible that lower income parents had or knows someone who has had personal experiences with sexual transmitted infections or HPV-associated cancers and therefore are more understanding or more realistic about the potential for their children’s sexual debut or activity. On the other hand, it is possible that lower income parents do not have access to the information that may hinder more affluent parents from having their children vaccinated, such as effectiveness, side effects, or adverse health events related to uptake of the vaccine.

Since the vaccine was issued in 2006, a plethora of research has been published around understanding and improving parental acceptance, willingness, and barriers to HPV vaccine uptake through community-based interventions, however, the rates of uptake of been slowly increasing over the past 12 years. A mandate for school-aged children would ensure that the vaccine is initiated and completed but more importantly, vaccinating school-aged children is the most effective way of preventing most HPV strains because the vaccine will be received prior to sexual debut. From a population health standpoint, mandating the vaccine for school-aged children will decrease the incident of HPV, which could slow down the rate of transmission, and

ultimate reduce the onset of genital warts and HPV-associated cancer, such as oropharyngeal cancer which has recently been on the rise among adult males (Sonawane et al., 2017).

Appendices

Appendix A: Conceptual Framework for Study Aims

Figure 1: Alm 1: I will investigate the relationship between family income and HPV vaccination outcomes: (1) provider recommendation; (2) vaccine initiation; and (3) vaccine completion.

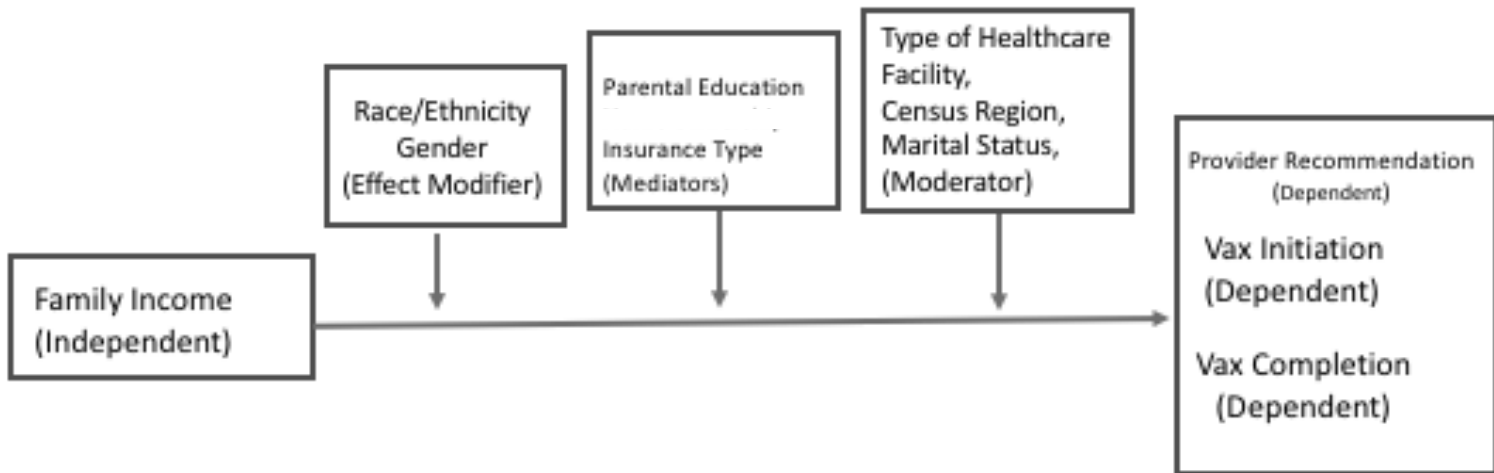


Figure 2: Alm 2: I will investigate the overall association between gender and HPV utilization outcomes and explore if socioeconomic gradients in HPV utilization are consistent across genders.

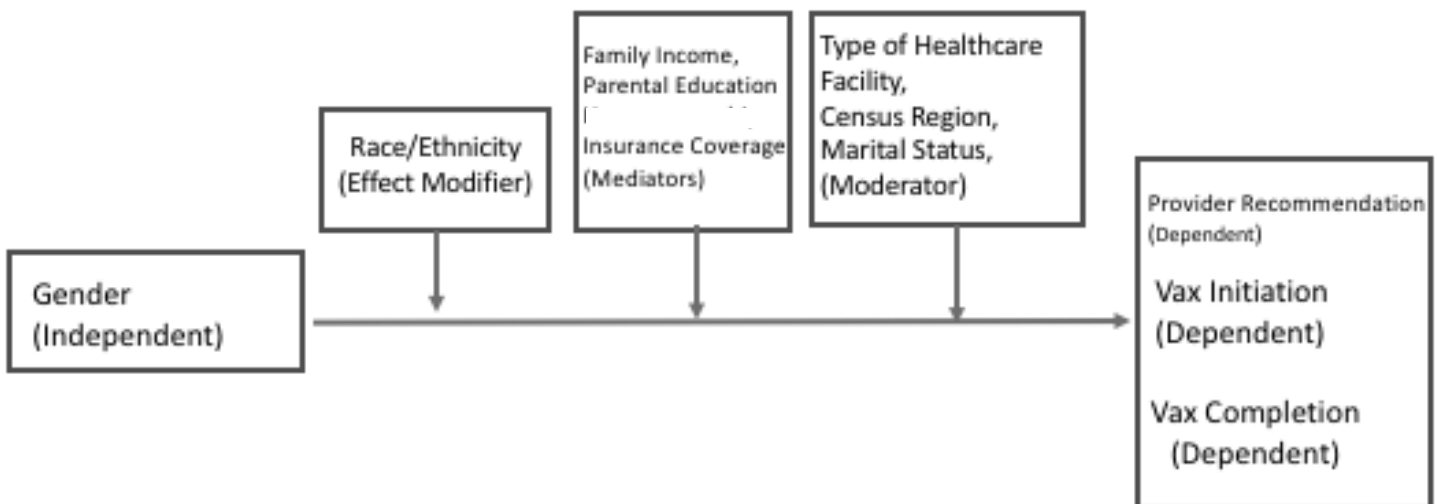


Figure 3. Aim 3: Measure effect of the 2011 ACIP guideline on adolescent male HPV vaccine utilization

	Pre (2010-2011)	Post (2012-2016)	Change
Adolescent Males (Treated)	Y_1	Y_2	$\Delta Y_T = (Y_2 - Y_1)$
Adolescent Females (Control)	Y_3	Y_4	$\Delta Y_C = (Y_4 - Y_3)$
Difference-in-Difference			$DID = \Delta Y_T - \Delta Y_C$



Appendix B: Variable Table for Aim 1

Variable Type	Concept	Variable Name	Variable Description
Independent Variable	<ul style="list-style-type: none"> Family Income 	<ul style="list-style-type: none"> INCORPAR 	<ul style="list-style-type: none"> Income to poverty ratio (recode)
Dependent Variables	<ul style="list-style-type: none"> Vaccination Initiation Vaccination Completion Physician Recommendation 	<ul style="list-style-type: none"> HPVI_NUM_TOT HPVI_NUM_TOT HPV1_RECOM 	<ul style="list-style-type: none"> Number of HH-reported Human Papillomavirus shots received (total) Number of HH-reported Human Papillomavirus shots received (total) Had or has doctor or other healthcare professional ever recommended that teen receive HPV shots?
Effect Modifying Variables	<ul style="list-style-type: none"> Race/Ethnicity 	<ul style="list-style-type: none"> RACEETHK 	<ul style="list-style-type: none"> Race/ethnicity of teen with multirace category (recode)
Moderator Variables	<ul style="list-style-type: none"> Parent Education Family Income 	<ul style="list-style-type: none"> EDUC1 INCPORAR 	<ul style="list-style-type: none"> Education level of mother with 4 categories Income to poverty ratio (recode)

	<ul style="list-style-type: none"> • Marital Status • Type of healthcare facility • Geographic Location 	<ul style="list-style-type: none"> • MARITAL2 • FACILITY • CEN_REG 	<ul style="list-style-type: none"> • Marital status of mother (recode) • Facility types for teen's providers • Census region based on true state of residence
--	--	---	--

Appendix C: Variable Table for Aim 2

Variable Type	Concept	Variable Name	Variable Description
Independent Variable	<ul style="list-style-type: none"> Gender 	<ul style="list-style-type: none"> SEX 	<ul style="list-style-type: none"> Sex of teen
Dependent Variables	<ul style="list-style-type: none"> Vaccination Initiation Vaccination Completion Physician Recommendation 	<ul style="list-style-type: none"> HPVI_NUM_TOT HPVI_NUM_TOT HPV1_RECOM 	<ul style="list-style-type: none"> Number of HH-reported Human Papillomavirus shots received (total) Number of HH-reported Human Papillomavirus shots received (total) Had or has doctor or other healthcare professional ever recommended that teen receive HPV shots?
Effect Modifying Variables	<ul style="list-style-type: none"> Race/Ethnicity 	<ul style="list-style-type: none"> RACEETHK 	<ul style="list-style-type: none"> Race/ethnicity of teen with multirace category (recode)
Moderator Variables	<ul style="list-style-type: none"> Parent Education Family Income Marital Status 	<ul style="list-style-type: none"> EDUC1 INCPORAR MARITAL2 	<ul style="list-style-type: none"> Education level of mother with 4 categories Income to poverty ratio (recode) Marital status of mother (recode)

	<ul style="list-style-type: none"> • Type of healthcare facility • Geographic Location 	<ul style="list-style-type: none"> • FACILITY • CEN_REG 	<ul style="list-style-type: none"> • Facility types for teen's providers • Census region based on true state of residence
--	--	---	---

Appendix D: Variable Table for Aim 3

Variable Type	Concept	Variable Name	Variable Description
Independent Variable	<ul style="list-style-type: none"> • Gender 	<ul style="list-style-type: none"> • SEX 	<ul style="list-style-type: none"> • Sex of teen
Dependent Variables	<ul style="list-style-type: none"> • Vaccination Initiation • Vaccination Completion • Physician Recommendation 	<ul style="list-style-type: none"> • HPV1_NUM_TOT • HPV1_NUM_TOT • HPV1_RECOM 	<ul style="list-style-type: none"> • Number of HH-reported Human Papillomavirus shots received (total) • Number of HH-reported Human Papillomavirus shots received (total) • Had or has doctor or other healthcare professional ever recommended that teen receive HPV shots?
Effect Modifying Variables	<ul style="list-style-type: none"> • Race/Ethnicity • Year 	<ul style="list-style-type: none"> • RACEETHK • Year 	<ul style="list-style-type: none"> • Race/ethnicity of teen with multirace category (recode) • Sampling year
Moderator Variables	<ul style="list-style-type: none"> • Parent Education • Family Income 	<ul style="list-style-type: none"> • EDUC1 • INCPORAR 	<ul style="list-style-type: none"> • Education level of mother with 4 categories

	<ul style="list-style-type: none"> • Marital Status • Type of healthcare facility <p>A. Geographic Location</p>	<ul style="list-style-type: none"> • MARITAL2 • FACILITY <p>A. CEN_REG</p>	<ul style="list-style-type: none"> • Income to poverty ratio (recode) • Marital status of mother (recode) • Facility types for teen's providers <p>Census region based on true state of residence</p>
--	---	--	--

References

- American Cancer Society Guideline for Human Papillomavirus (HPV) Vaccine Use to Prevent Cervical Cancer and Its Precursors - Saslow - 2007 - CA: A Cancer Journal for Clinicians - Wiley Online Library. (n.d.). Retrieved February 5, 2018, from <https://www.ncbi.nlm.nih.gov/pubmed/17237032>.
- Bastani, R., Glenn, B. A., Tsui, J., Chang, L. C., Marchand, E. J., Taylor, V. M., & Singhal, R. (2011). Understanding suboptimal human papillomavirus vaccine uptake among ethnic minority girls. *Cancer Epidemiology, Biomarkers & Prevention: A Publication of the American Association for Cancer Research, Cosponsored by the American Society of Preventive Oncology*, 20(7), 1463–1472. <https://doi.org/10.1158/1055-9965.EPI-11-0267>
- Chatterjee, A. (2014). The next generation of HPV vaccines: nonavalent vaccine V503 on the horizon. *Expert Review of Vaccines*, 13(11), 1279–1290. <https://doi.org/10.1586/14760584.2014.963561>
- Dobson, S. R. M., McNeil, S., Dionne, M., Dawar, M., Ogilvie, G., Krajden, M., ... Young, E. (2013). Immunogenicity of 2 doses of HPV vaccine in younger adolescents vs 3 doses in young women: a randomized clinical trial. *JAMA*, 309(17), 1793–1802. <https://doi.org/10.1001/jama.2013.1625>
- Dorell, C. G., Yankey, D., Santibanez, T. A., & Markowitz, L. E. (2011). Human papillomavirus vaccination series initiation and completion, 2008-2009. *Pediatrics*, 128(5), 830–839. <https://doi.org/10.1542/peds.2011-0950>

- Dorell, C., Yankey, D., & Strasser, S. (2011). Parent-reported reasons for nonreceipt of recommended adolescent vaccinations, national immunization survey: teen, 2009. *Clinical Pediatrics*, *50*(12), 1116–1124. <https://doi.org/10.1177/0009922811415104>
- Downs, L. S., Scarinci, I., Einstein, M. H., Collins, Y., & Flowers, L. (2010). Overcoming the barriers to HPV vaccination in high-risk populations in the US. *Gynecologic Oncology*, *117*(3), 486–490. <https://doi.org/10.1016/j.ygyno.2010.02.011>
- Ferris, D., Samakoses, R., Block, S. L., Lazcano-Ponce, E., Restrepo, J. A., Reisinger, K. S., ... Saah, A. (2014). Long-term study of a quadrivalent human papillomavirus vaccine. *Pediatrics*, *134*(3), e657-665. <https://doi.org/10.1542/peds.2013-4144>
- Gilkey, M. B., Moss, J. L., McRee, A.-L., & Brewer, N. T. (2012). Do correlates of HPV vaccine initiation differ between adolescent boys and girls? *Vaccine*, *30*(41), 5928–5934. <https://doi.org/10.1016/j.vaccine.2012.07.045>
- Giuliano, A. R., Palefsky, J. M., Goldstone, S., Moreira, E. D., Penny, M. E., Aranda, C., ... Guris, D. (2011). Efficacy of quadrivalent HPV vaccine against HPV Infection and disease in males. *The New England Journal of Medicine*, *364*(5), 401–411. <https://doi.org/10.1056/NEJMoa0909537>
- Hamlish, T., Clarke, L., & Alexander, K. A. (2012). Barriers to HPV immunization for African American adolescent females. *Vaccine*, *30*(45), 6472–6476. <https://doi.org/10.1016/j.vaccine.2012.07.085>
- Herrero, R., Quint, W., Hildesheim, A., Gonzalez, P., Struijk, L., Katki, H. A., ... CVT Vaccine Group. (2013). Reduced prevalence of oral human papillomavirus (HPV) 4 years after bivalent HPV vaccination in a randomized clinical trial in Costa Rica. *PloS One*, *8*(7), e68329. <https://doi.org/10.1371/journal.pone.0068329>

- Hofstetter, A. M., & Rosenthal, S. L. (2014). Factors impacting HPV vaccination: lessons for health care professionals. *Expert Review of Vaccines*, 13(8), 1013–1026.
<https://doi.org/10.1586/14760584.2014.933076>
- Human Papillomavirus (HPV) Vaccines. (n.d.). [cgvFactSheet]. Retrieved February 17, 2018, from <https://www.cancer.gov/about-cancer/causes-prevention/risk/infectious-agents/hpv-vaccine-fact-sheet>
- Joseph, N. P., Clark, J. A., Bauchner, H., Walsh, J. P., Mercilus, G., Figaro, J., ... Perkins, R. B. (2012a). Knowledge, Attitudes, and Beliefs Regarding HPV Vaccination: Ethnic and Cultural Differences Between African-American and Haitian Immigrant Women. *Women's Health Issues*, 22(6), e571–e579. <https://doi.org/10.1016/j.whi.2012.09.003>
- Kepka, D. L., Ulrich, A. K., & Coronado, G. D. (2012). Low knowledge of the three-dose HPV vaccine series among mothers of rural Hispanic adolescents. *Journal of Health Care for the Poor and Underserved*, 23(2), 626–635. <https://doi.org/10.1353/hpu.2012.0040>
- Kreimer, A. R., González, P., Katki, H. A., Porras, C., Schiffman, M., Rodriguez, A. C., ... CVT Vaccine Group. (2011). Efficacy of a bivalent HPV 16/18 vaccine against anal HPV 16/18 infection among young women: a nested analysis within the Costa Rica Vaccine Trial. *The Lancet. Oncology*, 12(9), 862–870. [https://doi.org/10.1016/S1470-2045\(11\)70213-3](https://doi.org/10.1016/S1470-2045(11)70213-3)
- Laz, T. H., Rahman, M., & Berenson, A. B. (2012). An update on human papillomavirus vaccine uptake among 11-17 year old girls in the United States: National Health Interview Survey, 2010. *Vaccine*, 30(24), 3534–3540. <https://doi.org/10.1016/j.vaccine.2012.03.067>
- Link, B. G., & Phelan, J. (1995). Social conditions as fundamental causes of disease. *Journal of Health and Social Behavior, Spec No*, 80–94.

- Litton, A. G., Desmond, R. A., Gilliland, J., Huh, W. K., & Franklin, F. A. (2011). Factors associated with intention to vaccinate a daughter against HPV: a statewide survey in Alabama. *Journal of Pediatric and Adolescent Gynecology*, *24*(3), 166–171.
<https://doi.org/10.1016/j.jpag.2011.01.004>
- Luque, J. S., Raychowdhury, S., & Weaver, M. (2012). Health care provider challenges for reaching Hispanic immigrants with HPV vaccination in rural Georgia. *Rural and Remote Health*, *12*(2), 1975.
- McQuillan G, Kruszon-Moran D, Markowitz LE, Unger ER., Paulose-Ram R. Prevalence of HPV in adults aged 18–69: United States, 2011–2014. NCHS data brief, no 280. Hyattsville, MD: National Center for Health Statistics. 2017.
- Moss, J. L., Gilkey, M. B., Rimer, B. K., & Brewer, N. T. (2016). Disparities in collaborative patient-provider communication about human papillomavirus (HPV) vaccination. *Human Vaccines & Immunotherapeutics*, *12*(6), 1476–1483.
<https://doi.org/10.1080/21645515.2015.1128601>
- Naud, P. S., Roteli-Martins, C. M., De Carvalho, N. S., Teixeira, J. C., de Borja, P. C., Sanchez, N., ... Descamps, D. (2014). Sustained efficacy, immunogenicity, and safety of the HPV-16/18 AS04-adjuvanted vaccine: final analysis of a long-term follow-up study up to 9.4 years post-vaccination. *Human Vaccines & Immunotherapeutics*, *10*(8), 2147–2162.
<https://doi.org/10.4161/hv.29532>
- Oldach, B. R., & Katz, M. L. (2012). Ohio Appalachia public health department personnel: human papillomavirus (HPV) vaccine availability, and acceptance and concerns among parents of male and female adolescents. *Journal of Community Health*, *37*(6), 1157–1163. <https://doi.org/10.1007/s10900-012-9613-5>

- Perkins, R. B., & Clark, J. A. (2012). Providers' attitudes toward human papillomavirus vaccination in young men: challenges for implementation of 2011 recommendations. *American Journal of Men's Health*, 6(4), 320–323. <https://doi.org/10.1177/1557988312438911>
- Phelan, J. C., Link, B. G., & Tehranifar, P. (2010). Social conditions as fundamental causes of health inequalities: theory, evidence, and policy implications. *Journal of Health and Social Behavior*, 51 Suppl, S28-40. <https://doi.org/10.1177/0022146510383498>
- Polonijo, A. N., & Carpiano, R. M. (2013). Social inequalities in adolescent human papillomavirus (HPV) vaccination: a test of fundamental cause theory. *Social Science & Medicine (1982)*, 82, 115–125. <https://doi.org/10.1016/j.socscimed.2012.12.020>
- Romanowski, B., Schwarz, T. F., Ferguson, L. M., Peters, K., Dionne, M., Schulze, K., ... Descamps, D. (2011). Immunogenicity and safety of the HPV-16/18 AS04-adjuvanted vaccine administered as a 2-dose schedule compared with the licensed 3-dose schedule: results from a randomized study. *Human Vaccines*, 7(12), 1374–1386. <https://doi.org/10.4161/hv.7.12.18322>
- Saraiya, M., Rosser, J. I., & Cooper, C. P. (2012). Cancers that U.S. physicians believe the HPV vaccine prevents: findings from a physician survey, 2009. *Journal of Women's Health (2002)*, 21(2), 111–117. <https://doi.org/10.1089/jwh.2011.3313>
- Sonawane, K., Suk, R., Chiao, E. Y., Chhatwal, J., Qiu, P., Wilkin, T., ... Deshmukh, A. A. (2017). Oral Human Papillomavirus Infection: Differences in Prevalence Between Sexes and Concordance With Genital Human Papillomavirus Infection, NHANES 2011 to 2014. *Annals of Internal Medicine*, 167(10), 714–724. <https://doi.org/10.7326/M17-1363>

- Stokley, S., Cohn, A., Dorell, C., Hariri, S., Yankey, D., Messonnier, N., & Wortley, P. M. (2011). Adolescent vaccination-coverage levels in the United States: 2006-2009. *Pediatrics*, *128*(6), 1078–1086. <https://doi.org/10.1542/peds.2011-1048>
- Tsui, J., Gee, G. C., Rodriguez, H. P., Kominski, G. F., Glenn, B. A., Singhal, R., & Bastani, R. (2013). Exploring the role of neighborhood socio-demographic factors on HPV vaccine initiation among low-income, ethnic minority girls. *Journal of Immigrant and Minority Health*, *15*(4), 732–7A
- User's Guide for the 2016 Public-Use Data File. (2016), 219.
- Benard, V. B., Johnson, C. J., Thompson, T. D., Roland, K. B., Lai, S. M., Cokkinides, V., ... Weir, H. K. (2008). Examining the association between socioeconomic status and potential human papillomavirus-associated cancers. *Cancer*, *113*(10 Suppl), 2910–2918. <https://doi.org/10.1002/cncr.23742>
- Brisson, M., Drolet, M., & Malagón, T. (2013). Inequalities in Human Papillomavirus (HPV)–Associated Cancers: Implications for the Success of HPV Vaccination. *JNCI: Journal of the National Cancer Institute*, *105*(3), 158–161. <https://doi.org/10.1093/jnci/djs638>
- Chandra, A., Martinez, G. M., Mosher, W. D., Abma, J. C., & Jones, J. (2005). *Fertility, family planning, and reproductive health of U.S. women: Data from the 2002 National Survey of Family Growth* [Data set]. American Psychological Association. <https://doi.org/10.1037/e414702008-001>
- Dorell, C. G., Yankey, D., Santibanez, T. A., & Markowitz, L. E. (2011). Human papillomavirus vaccination series initiation and completion, 2008-2009. *Pediatrics*, *128*(5), 830–839. <https://doi.org/10.1542/peds.2011-0950>

- Fertility, Contraception, and Fatherhood: Data on Men and Women From Cycle 6 (2002) of the National Survey of Family Growth: (610122007-001)*. (2006). [Data set]. American Psychological Association. <https://doi.org/10.1037/e610122007-001>
- Fisher, H., Trotter, C. L., Audrey, S., MacDonald-Wallis, K., & Hickman, M. (2013). Inequalities in the uptake of Human Papillomavirus Vaccination: a systematic review and meta-analysis. *International Journal of Epidemiology*, *42*(3), 896–908. <https://doi.org/10.1093/ije/dyt049>
- Gainforth Heather L., Cao Wei, & Latimer-Cheung Amy E. (2012). Message Framing and Parents' Intentions to have their Children Vaccinated Against HPV. *Public Health Nursing*, *29*(6), 542–552. <https://doi.org/10.1111/j.1525-1446.2012.01038.x>
- Gilkey, M. B., Calo, W. A., Moss, J. L., Shah, P. D., Marciniak, M. W., & Brewer, N. T. (2016). Provider communication and HPV vaccination: The impact of recommendation quality. *Vaccine*, *34*(9), 1187–1192. <https://doi.org/10.1016/j.vaccine.2016.01.023>
- Hariri, S., Unger, E. R., Sternberg, M., Dunne, E. F., Swan, D., Patel, S., & Markowitz, L. E. (2011). Prevalence of Genital Human Papillomavirus Among Females in the United States, the National Health and Nutrition Examination Survey, 2003–2006. *The Journal of Infectious Diseases*, *204*(4), 566–573. <https://doi.org/10.1093/infdis/jir341>
- HPV Vaccine Administration | Human Papillomavirus Vaccination | CDC. (2017, November 27). Retrieved April 7, 2018, from <https://www.cdc.gov/vaccines/vpd/hpv/hcp/administration.html>
- Immunization and Infectious Diseases | Healthy People 2020. (n.d.). Retrieved April 7, 2018, from <https://www.healthypeople.gov/2020/topics-objectives/topic/immunization-and-infectious-diseases/objectives>

- Jeudin, P., Liveright, E., del Carmen, M. G., & Perkins, R. B. (2014). Race, Ethnicity, and Income Factors Impacting Human Papillomavirus Vaccination rates. *Clinical Therapeutics*, 36(1), 24–37. <https://doi.org/10.1016/j.clinthera.2013.11.001>
- Joseph, N. P., Clark, J. A., Bauchner, H., Walsh, J. P., Mercilus, G., Figaro, J., ... Perkins, R. B. (2012). Knowledge, Attitudes, and Beliefs Regarding HPV Vaccination: Ethnic and Cultural Differences Between African-American and Haitian Immigrant Women. *Women's Health Issues*, 22(6), e571–e579. <https://doi.org/10.1016/j.whi.2012.09.003>
- Moss, J. L., Gilkey, M. B., Rimer, B. K., & Brewer, N. T. (2016). Disparities in collaborative patient-provider communication about human papillomavirus (HPV) vaccination. *Human Vaccines & Immunotherapeutics*, 12(6), 1476–1483. <https://doi.org/10.1080/21645515.2015.1128601>
- Niccolai, L. M., Mehta, N. R., & Hadler, J. L. (2011). Racial/Ethnic and poverty disparities in human papillomavirus vaccination completion. *American Journal of Preventive Medicine*, 41(4), 428–433. <https://doi.org/10.1016/j.amepre.2011.06.032>
- NIS | About the National Immunization Surveys | Vaccines | CDC. (2018, January 30). Retrieved April 6, 2018, from <https://www.cdc.gov/vaccines/imz-managers/nis/about.html>
- NIS - Datasets for the National Immunization Survey - Teen. (2018, March 22). Retrieved April 7, 2018, from https://www.cdc.gov/nchs/nis/data_files_teen.htm
- Perkins, R. B., Pierre-Joseph, N., Marquez, C., Iloka, S., & Clark, J. A. (2010). Why Do Low-Income Minority Parents Choose Human Papillomavirus Vaccination for Their Daughters? *The Journal of Pediatrics*, 157(4), 617–622. <https://doi.org/10.1016/j.jpeds.2010.04.013>

- Polonijo, A. N., & Carpiano, R. M. (2013). Social inequalities in adolescent human papillomavirus (HPV) vaccination: a test of fundamental cause theory. *Social Science & Medicine (1982)*, 82, 115–125. <https://doi.org/10.1016/j.socscimed.2012.12.020>
- Reagan-Steiner, S., Elam-Evans, L. D., Singleton, J. A., Copeland, K. R., Liu, L., Skalland, B., & Wolter, K. M. (2015). National Immunization Survey-Teen (NIS-Teen): Revised definition of Adequate Provider Data, 8.
- Sonawane, K., Suk, R., Chiao, E. Y., Chhatwal, J., Qiu, P., Wilkin, T., ... Deshmukh, A. A. (2017). Oral Human Papillomavirus Infection: Differences in Prevalence Between Sexes and Concordance With Genital Human Papillomavirus Infection, NHANES 2011 to 2014. *Annals of Internal Medicine*, 167(10), 714–724. <https://doi.org/10.7326/M17-1363>
- Vaccination Coverage | NIS Teen | 2014 Maps by State | CDC. (2017, April 27). Retrieved April 7, 2018, from <https://www.cdc.gov/vaccines/imz-managers/coverage/nis/teen/figures/2014-map.html>
40. <https://doi.org/10.1007/s10903-012-9736-x>
- Wilson, R., Brown, D. R., Boothe, M. A. S., & Harris, C. E. S. (2013). Knowledge and acceptability of the HPV vaccine among ethnically diverse black women. *Journal of Immigrant and Minority Health*, 15(4), 747–757. <https://doi.org/10.1007/s10903-012-9749-5>