2022

Factors Influencing Human Papillomavirus Vaccination Among Hispanic Youth in Bexar County, Texas

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This is to certify that the doctoral dissertation by

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Abstract

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MS, Hood College, 1999

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Dissertation Submitted in Partial Fulfillment

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Abstract

A high number of Hispanic youth in Bexar County, Texas, face morbidity and mortality related to human papillomavirus (HPV) infection due to inadequate vaccination coverage youth. A better understanding of the factors that influence vaccination might help public health authorities to increase coverage. The aim of this quantitative, cross-sectional study, which was based on the socioecological model and involved analysis of weighted survey data from the 2016 to 2018 National Immunization Survey-Teen, was to better understand the multilevel factors influencing HPV vaccine use among Hispanic youth. The weighted sample was representative of the study population in terms of survey characteristics (e.g., response rate) and sociodemographics (i.e., maternal education, teen gender, race/ethnicity, and age). The association of parents' annual income with vaccination intent (n = 816), initiation (n = 632), completion (n = 1,040), and perceived barriers (n = 364) to vaccination was measured using the chi-square test and prevalence ratio. The association of income level with perceived reasons for lack of intent to vaccinate was tested based on five domains of concerns or barriers. In the pooled average of the study years, low-income families (≤$40,000/year) had about 1.3 times higher prevalence of vaccination intention, initiation, and completion than their high-income counterparts (>$40,000/year). Low-income families generally had a higher prevalence of lack of knowledge of HPV and the vaccine, systemic barriers, and sociocultural barriers, but a lower prevalence of safety/effectiveness concerns and misinformation. Public health authorities could use these results to tailor and prioritize interventions to increase HPV vaccination at the local level, and, in turn, mitigate the adverse effects of HPV infection.

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Dedication

In memory of my brother, Dr. Bradley Joy Wallum, who contributed so much and so well to his family, friends, colleagues, and students. He also advanced the scholarship of endocrinology and transformed the lives of patients who entrusted him with their care.

I also dedicate this dissertation to my late father, Joy LaVern Wallum, who instilled in me a value of education and achievement above all else, and my mother, Delores Margaret-Olive Wallum, who supported me in my academic, personal, and professional endeavors.

Acknowledgments

I express my sincere appreciation to my dissertation committee chair, Dr. Jacqueline Fraser, and my quantitative methodologist, Dr. Chinaro Kennedy for their kind guidance, helpful suggestions, and patience. I extend this appreciation to my university research reviewer, Dr. Pelagia Melea; form and style editor, Dr. Tara Kachgal; abstract reviewer, Dr. Arfe Yucedag-Ozcan; and the chief academic officer of Walden University, Dr. Susan Subocz.

I am grateful to the Walden University academic advisors, academic skills facilitators, librarians, methodologists, professors, statisticians, and writing instructors for their support. Their insights and devotion to teaching and mentoring enriched my learning experience and ultimately enhanced the quality of this study.

To my parents, brothers and sister, and friends, I offer my gratitude for their concern, space, and prayers during this work so that I could focus on completing my degree.

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Chapter 1: Introduction to the Study

Practitioners can improve the health of Americans by protecting men and women from the adverse medical consequences of sexually transmitted human papillomavirus (HPV) infections. HPV infection is the most common sexually transmitted infection in the United States (Centers for Disease Control and Prevention [CDC], 2017a). An HPV infection can lead to serious health complications, including six different types of cancer in both men and women (Gillison et al., 2015; Han et al., 2017; Kaiser Family Foundation, 2021). Vaccines against HPV, first available in the United States in 2006, are both efficacious and safe when given to youth before they become sexually active (Markowitz et al., 2016; Vichnin et al., 2015; Zhai & Tumban, 2016). Based on nationally representative data from the National Immunization Survey-Teen from 2010 to 2019, more than half of parents of adolescents aged 13-17 years, who had not initiated HPV vaccination, lacked intent to vaccinate their child throughout this period (Hanson et al., 2018; Rositch et al., 2022; Sonawane et al., 2020). The perceptions and acceptability of HPV vaccination by parents, practitioners, and vaccinating agencies have constituted a critical link in developing initiatives to promote immunization at the national and state level (Brewer & Fazekas, 2007; Das et al., 2016; Holman et al., 2014). These interventions might include new or improved national-level policy, regulation, education, social marketing, health economics, and leadership strategies to increase HPV vaccination (Das et al., 2016; Smulian et al., 2016; Walling et al., 2016). In this light, researchers can share their insights on the acceptability of HPV vaccination for youth with various stakeholders to promote vaccine uptake through state and national level programs.

Likewise, a better understanding of factors influencing the acceptability of HPV vaccination by parents and others at the local level might be help promote vaccine uptake. A limited number of recent studies have identified community-level geographic factors, including racial composition and impoverishment, which have a predictive relationship with HPV vaccination initiation and series completion (Fernandez et al., 2009; Gardner, 2016; Glenn et al., 2015; Henry et al., 2016). In this study of Hispanics in Bexar County, Texas, I explored the association of parents' income level with their intent to vaccinate their teen, series initiation, and completion. In addition, in a subset of parents who lacked intent to vaccinate their child against HPV, I examined the association of income level with parents' perceived barriers to the use of the vaccine. These potential barriers included parental vaccine safety and effectiveness concerns, knowledge of HPV and the vaccine, misconceptions, systemic barriers, and sociocultural barriers. Thus, I gained valuable insights into the factors influencing higher HPV vaccination initiation and completion rates among Hispanics in Bexar County. In turn, public health advocates could use these data to develop interventions tailored to mitigate the adverse effects of HPV infection in this population segment. In conducting this study, I sought to extend previous research by investigating, in the more clearly identified context of a region of Texas, several factors influencing the vaccination of adolescents.

In Chapter 1, I place the study in the context of current vaccine hesitancy research, introduce the essential aspects of the investigation, and establish its purpose and significance. First, I situate the study in the context of current vaccine hesitancy research by providing background information. Second, I state the problem and purpose of the study and present the research questions (RQs) and hypotheses; this information sets the stage for the in-depth elaboration that follows in Chapters 2 to 5. Third, I explain and justify my choice of theoretical framework and methodology. Fourth, I provide relevant definitions and discuss the assumptions, scope and delimitations, limitations, and potential significance of the study. Finally, I summarize Chapter 1 and provide a transition to Chapter 2.

Background

Infection associated with HPV is a serious health threat for both men and women in the United States. An HPV infection can cause reproductive system cancer, anal cancer, oropharyngeal cancer, and other conditions such as genital warts in men and women (CDC, 2017a; Kaiser Family Foundation, 2021). For example, HPV is the most common cause of cervical cancer in women (Rimer et al., 2014). An effective cervical cancer-screening program in the United States has led to a decrease in the incidence of cervical cancer (Drolet et al., 2015; Hariri et al., 2016; Rimer et al., 2014; Van Dyne et al., 2018). On the other hand, the incidence of HPV-positive oropharyngeal cancer and anal cancer has been increasing (Gillison et al., 2015; Han et al., 2017; Van Dyne et al., 2018; Vogel, 2017;). The incidence of HPV-associated oropharyngeal cancer has been increasing faster in men than in women (Han et al., 2017; Vogel, 2017), and the annual rate of this cancer in men now exceeds that of HPV-associated cervical cancer in women (National Cancer Institute, n.d.-a; Van Dyne et al., 2018; You et al., 2019). Although most oropharyngeal cancers associated with HPV occur in men, the incidence of HPV-associated anal cancer is now higher in women (Van Dyne et al., 2018; Vogel, 2017). In brief, the severe health complications resulting from HPV infection in both men and women are a significant personal and social problem for Americans.

The approach to mitigating HPV-associated disease differs in men and women. No formal screening test is available for oropharyngeal and anal cancers (Rimer et al., 2014; Vogel, 2017). Therefore, vaccination is the approved public health intervention for reducing noncervical HPV-associated malignancies in men and women (Rimer et al., 2014). However, a combination of cervical screening and immunization is the best protection against cervical cancer in women (Rimer et al., 2014). HPV vaccination is also helpful to women because it reduces the need for follow-up procedures for abnormal cervical screening (Steinbrook, 2006). HPV vaccination of women reduces the need for medical and surgical care associated with treating cervical precancers. As such, this vaccine can mitigate distress for many women and health care costs for individuals and society. The HPV vaccine is currently the leading way to prevent HPV-associated diseases in men and women. Additional options are available to prevent HPV-associated cancers in women.

A high burden of morbidity and mortality related to HPV infection exists in Hispanics living in Bexar County, despite a safe and effective vaccine. Hispanic women who develop cervical cancer die more than non-Hispanic White women (U.S. Cancer Statistics Working Group, 2021). The average annual age-adjusted cervical cancer mortality rate per 100,000 Hispanic women in Bexar County from 2014 to 2018 was 4.1, compared to 2.9 for non-Hispanic White women (Texas Cancer Registry, 2021a, 2021b). During the study period, the estimated population of Hispanics residing in Bexar County and the city of San Antonio was about 60%, compared to 39% in the rest of Texas and 18% in the nation as a whole (U.S. Census Bureau, n.d.). At the time of this study, Bexar County had a population of almost 2 million (U.S. Census Bureau, 2021b). As such, cervical cancer among the Hispanic community in this region is a substantial human and economic burden due to the high number of Hispanics in Bexar County who experience morbidity and mortality related to HPV infection.

Despite the comparatively high risk of HPV complications in the study population compared to other groups and regions in the United States, HPV vaccination rates of youth in Bexar County are disproportionately low relative to other people. HPV vaccine series completion (up to date) refers to receiving 2 HPV shots for teens under age 15 and 3 for those between age 15 and 17 (CDC, n.d.-a). In 2016, 44.6% of Hispanic boys and 55.3% of Hispanic girls aged 13 to 17 years nationwide were up to date with the HPV vaccine (Walker et al., 2017). Texas was among the five states with the lowest HPV vaccine coverage rates in 2016 (Franco et al., 2019). The up-to-date vaccination rate against HPV in 2016 for Hispanic boys and girls in Bexar County was less than that of Hispanic people nationwide (Walker et al., 2017). In particular, practitioners fully vaccinated 36.5% of Hispanic boys and 48.9% of Hispanic girls aged 13 to 17 years living in Bexar County against HPV (Walker et al., 2017). In 2017 and 2018, the estimated up-to-date coverage nationwide was 54.6% and 56.0% for Hispanic boys and 58.1% and 57.2% for girls, respectively (Walker et al., 2018, 2019). In Bexar County, during the same period, vaccination providers fully vaccinated 38.2% and 46.0% of Hispanic boys and 57.8% and 55.6% of Hispanic girls aged 13-17 years, respectively, against HPV (Walker et al., 2018, 2019). Thus, in 2017 and 2018, the up-to-date vaccination rate for Hispanic boys in Bexar County continued to be less than the national average. However, for Hispanic girls, the gap appeared to narrow between the up-to-date vaccination rate of Bexar County and the nation. On the whole, though, the estimated up-to-date coverage of youth in Bexar County from 2016 to 2018 was lower than that of the nation.

The HPV vaccination rate of youth in Bexar County is inadequate to protect individuals and the community against HPV infection and its potential medical complications. HPV vaccination rates must reach 70% to achieve community (herd) immunity (Kim & Goldie, 2008). Galbraith et al. (2016) noted that the national completion rates for HPV vaccination in preadolescent youth, who are most vulnerable to complications, are below the 70% completion rate required to achieve community immunity. In addition, the number of fully vaccinated Hispanic youth in Bexar County is suboptimal based on the 70% vaccination rate standard to achieve herd immunity (National Cancer Institute, n.d.-b; Walker et al., 2017, 2018, 2019). Although the attainment of community immunity partially protects unvaccinated individuals against HPV infection, immunization is required for the optimal protection of individuals (Rimer et al., 2014). Consequently, an increase in the number of fully vaccinated individuals in the study population might mitigate the susceptibility of this community to the complications of HPV infection.

Several factors could influence vaccine uptake of adolescents in Bexar County. Parents' knowledge and concerns regarding HPV vaccines, for instance, may negatively affect the coverage of youth with these vaccines (Luque et al., 2010; Stager, 2016; Wilson & Bailey, 2016). Therefore, researchers have examined parental influences on the uptake of HPV vaccines in teenagers (Das et al., 2016; Holman et al., 2014; Wang et al., 2015). Similarly, I assessed the parental acceptability of HPV vaccination of youth in Bexar County. In addition, cultural and social differences can lead to various social norms and create unique barriers to HPV vaccination (Kowalczyk Mullins et al., 2015). For instance, low-income and minority racial and ethnic populations have a disproportionate number of individuals who do not receive the recommended doses of the HPV vaccine (Fisher et al., 2013; Galbraith et al., 2016; Rimer et al., 2014). For this reason, public health advocates also need to understand and address the unique sociocultural challenges of low-income, underinsured, and racial minority populations to mitigate the disparities in HPV vaccination (Fisher et al., 2013; Ford, 2011; Holman et al., 2014). The Hispanic community of interest in this study has a relatively low employment rate and median income (Schlenker & Huber, 2015). In 2014, about 31% of Hispanics aged 18 to 64 in Texas lived in poverty compared to 10% of non-Hispanic Whites (Pew Research Center, n.d.). In addition, about 31% of Hispanics in Texas were uninsured during this period compared to 11% of non-Hispanic Whites (Pew Research Center, n.d.). In Bexar County, from 2014 to 2018, 17.2% of all adults lived in poverty compared to 11.8% statewide (U.S. Census Bureau, n.d.). Furthermore,16.9% of people in the county under the age of 65 were without health insurance compared to 10.0%

statewide (U.S. Census Bureau, n.d.). In this context, realizing the prevention of HPV complications in the study population will involve understanding and altering the underlying causes of hesitancy to vaccinate youth.

A gap exists in the literature on the factors influencing HPV vaccination coverage for youth. Public health advocates of increased HPV immunization of teens might use knowledge of the predictors of HPV vaccination to develop and enhance immunization programs. In particular, practitioners need reliable information about the factors influencing parents of different racial and ethnic groups to vaccinate their children against HPV to improve vaccination rates (Brewer & Fazekas, 2007; Holman et al., 2014; Rambout et al., 2014). In addition, Lechuga et al. (2011) recognized the importance of applying an understanding of the variation in the predictors of HPV vaccination intentions among cultures. Thus, to uncover potential cultural variation in predictors of HPV vaccination of youth, it might be essential to stratify analyses of these predictors by ethnicity or culture. Ferrer et al. (2014), Glenn et al. (2015), and Galbraith et al. (2016) called for more studies on the determinants of HPV vaccine acceptability in Hispanic parents. They stressed these studies should be grounded in theories such as the socioecological framework. In this light, practitioners need more information on the factors influencing Hispanic parents to vaccinate their teens to promote HPV vaccination.

This study is worthwhile because I examined the impact of various factors on the uptake of HPV vaccines in the study population using an appropriate theoretical foundation. I used the socioecological model of health (SEM) in this study to investigate the influence of multilevel factors (e.g., personal and family level) on the uptake of HPV vaccines in Hispanic youth. Public health professionals use the SEM to formulate their ideas of how behavioral, social, and cultural circumstances shape disease and well-being (Coreil, 2010). Thus, HPV vaccination advocates might use the knowledge gained from this study of parents' sociodemographics and barriers at various levels negatively influencing HPV vaccine uptake for teens to develop strategies to increase vaccination rates.

Problem Statement

The incidence of HPV-associated cancer and resultant morbidity and mortality is relatively high in the study population. Hispanics in Bexar County, Texas, are disproportionately susceptible to HPV (National Cancer Institute, n.d.-c). In Bexar County, the average annual age-adjusted incidence of cervical cancer in all races of the Hispanic population from 2012 to 2016 was 11.6 cases per 100,000 women under age 65 (National Cancer Institute, n.d.-d). During the same period, the statewide incidence of cervical cancer was lower for Hispanics of all races at 10.6 (National Cancer Institute, n.d.-d). In addition, the rate of cervical cancer among non-Hispanic White women in Bexar County at 10.1 was lower than that of Hispanic women (National Cancer Institute, n.d.-d). Concerning men, HPV-associated oropharyngeal and anal cancers are an increasing health concern (Gillison et al., 2015; Han et al., 2017; Jemal et al., 2013; Vogel, 2017). As mentioned, cervical cancer among Hispanics in Bexar County is a substantial human and economic burden due to the high number of these people experiencing morbidity and mortality from this cancer (Texas Cancer Registry, 2021a, 2021b; U.S. Cancer Statistics Working Group, 2021; U.S. Census Bureau, 2021b).

Compared to other demographic groups and regions, Hispanics' high incidence and burden of HPV-related cancer in Bexar County is a public health concern.

Vaccination against HPV in youth in the study population is crucial to reduce the potential for severe medical complications. Public health experts recommend the immunization of children against HPV at ages 11 or 12 years to prevent most complications of HPV infection (Rimer et al., 2014; Stokley et al., 2014). Franco et al. (2019) reported that Texas was among the five states with the lowest HPV vaccine coverage rates in 2016. As mentioned, the number of fully vaccinated Hispanic youth in Bexar County is suboptimal as of 2016, 2017, and 2018 on the 70% vaccination rate standard to achieve herd immunity (National Cancer Institute, n.d.-b; Walker et al., 2017, 2018, 2019). Given the level of vaccination of Hispanic youth in Bexar County is incommensurate with their susceptibility to HPV infection complications, public health advocates need to increase the vaccination rate for this adolescent population.

Public health promoters need knowledge of factors that influence whether Hispanic youth in Bexar County receive vaccines against HPV to develop effective interventions to improve vaccination rates and, in turn, mitigate HPV complications. Public health authorities need reliable information, from studies of superior methodological quality, on factors that influence the decisions of parents of different demographic groups to vaccinate their children against HPV (Brewer & Fazekas, 2007; Holman et al., 2014; Rambout et al., 2014). A limited number of recent studies have identified community-level geographic factors, including racial composition, impoverishment, and cultural beliefs, which might have a predictive relationship with

HPV vaccination initiation and series completion (Fernandez et al., 2009; Gardner, 2016; Glenn et al., 2015; Henry et al., 2016). However, published quantitative research is limited to date at a local level on the factors that predict the vaccination status of Hispanic youth; to my knowledge, there is no literature related to Hispanic adolescents living in Bexar County. In this light, local health authorities need to learn more about predictors of HPV vaccination uptake and completion of Hispanic adolescents in Bexar County.

Researchers need to base studies on the determinants of HPV vaccination in multilevel models. In particular, researchers need to ground more studies on the determinants of HPV vaccine acceptability of Hispanic parents in theories such as the socioecological framework (Ferrer et al., 2014; Galbraith et al., 2016; Glenn et al., 2015). Studies based on this multilevel SEM would be more likely than studies grounded in other theories to result in the kind of information that public health officials need to address this gap in knowledge of the predictors of HPV vaccine coverage among Hispanic youth (Galbraith et al., 2016). The use of the SEM is vital because factors at different levels could influence whether parents decide to have their children vaccinated against HPV.

Purpose of the Study

In this study, I examined the association of Hispanic parents' total annual income with their perceived barriers, intention to vaccinate their teen, and initiation and completion of vaccination. The study population of parents and their 13-17-year-old children lived in Bexar County, Texas. Publicly available data are in the National

Immunization Survey-teen (NIS-Teen) data set on the family income level (independent variable) and outcomes variables (dependent variables), which included intent, initiation, completion, and perceived barriers to vaccination (CDC, n.d.-a, 2016a, 2020a, 2020b).

To make my sample more representative of the study population, I used the survey weights developed by the NIS-Teen surveyors. I used the weights to adjust for the stratified sample design of the survey and nonsampling error, mainly due to participants' nonresponse (CDC, 2018; Wolter et al., 2017), in my study population estimation area-level of Bexar County, Texas. In addition, the NIS-Teen surveyors used these weights to adjust for study population control totals of maternal education categories, race/ethnicity of the child, age group of the teen, gender of the youth, and telephone status. I used survey weights provided by the NIS-Teen surveyors to adjust my data based on these factors to better represent the geographical population under consideration (CDC, n.d.-a). That is, I used survey weights to make my NIS-Teen data more representative of the population of interest.

A single independent variable and several variables used to adjust survey weight were common to all RQs. The independent (predictor) variable of interest for RQs1-8 was total family income. In Table 1, I describe the independent variable of total family income and the sociodemographic variables involved in survey weight adjustment. I detailed in the far-right column of Table 1 the levels of the SEM that applied to these variables.

Table 1

Independent and Sociodemographic Survey Weight Adjustment Variables of Research Questions 1 to 8, 2016-2018

Variable name	The code in the NIS-Teen data set	Specific explanation or operational definition of the variable	Level of the SEM
Total family income[a]	INCQ298A	Family income with 11 categories	Intrapersonal
Parent's education level[b]	EDUC1	The education level of the parent with four categories (less than 12 years, 12 years, more than 12 years/non-college graduate, graduate)	Intrapersonal
Teen's gender[b]	SEX	Gender of the child (male, female)	Intrapersonal
Teen's race[b]	RACE_K	Race of child (White only, Black only, Other + multiple race)	Intrapersonal
Teen's age [b]	AGE	Age of the child (13, 14, 15, 16, or 17)	Intrapersonal

Note. NIS = National Immunization Survey. SEM = socioecological model of health. [a]Independent (predictor) variable for Research Questions 1 to 8. [b]Used by NIS-Teen to adjust survey weights in the final step of weight development (CDC 2020b).

Each RQ has a different dependent variable. The dependent variables for RQs1-3 were parental intent to have their child vaccinated against HPV, series initiation, and completion. See the HPV Vaccination Initiation and Completion subsection in this section and the Intent and No-Intent to Vaccinate subsection for more discussion. The dependent variables for RQs4-8 were parental vaccine safety and effectiveness concerns, vaccination misinformation, lack of knowledge of HPV and the vaccine, systemic barriers, and sociocultural barriers. I used the chi-square test and prevalence ratio to test the extent to which family income level is related to the dependent (outcome) variables of RQs1-8. The mathematical calculation of the prevalence ratio is identical to that of relative risk (Fonseca Martinez et al., 2017). However, as prevalence, not risk, applied to this cross-sectional study (Tamhane et al., 2016), I used prevalence ratio instead of relative risk. See the Procedures for Data Collection subsection and the Data Analysis Plan subsection of the Methodology section in Chapter 3 for more discussion.

In Table 2, I describe the dependent variables for RQs4-8. I defined and named the five parental HPV vaccination barrier domains similar to Cheruvu et al. (2017). As shown in the far-right column of Table 2, each of the five barrier domains relates to one or more levels of the SEM. In addition, I describe all the independent, dependent, and weight adjustment variables in the Definitions section of this chapter. Additional data on these variables are available in the NIS-Teen data set (CDC, n.d.-a).

Table 2

Reasons Parents Lacked Intent to Vaccinate Their Child Against HPV, 2016-2018

Domain	Reason number in the NIS-Teen dataset	Main reason teen will not receive HPV shots in the next 12 months	Level of the SEM
Safety and effectiveness concerns	HPVI_Reas_11	Safety concern/side effects	Intrapersonal
	HPVI_Reas_12	Effectiveness concern	
	HPVI_Reas_21	Need more information/new vaccine	
Vaccine misinformation	HPVI_Reas_2	Not needed/not necessary	Intrapersonal
	HPVI_Reas_5	Not sexually active	
	HPVI_Reas_6	Not appropriate age	
	HPVI_Reas_13	The shot could be painful	
	HPVI_Reas_15	College shot	
	HPVI_Reas_25	Increased sexual activity	
	HPVI_Reas_27	Already sexually active	
	HPVI_Reas_29	Child is male	
Lack knowledge of HPV effects and vaccine need	HPVI_Reas_3	Parent did not know about complications and the vaccine	Intrapersonal
	HPVI_Reas_22	Already up-to-date	
Systemic access barriers to HPV vaccine use	HPVI_Reas_1	Not endorsed by doctor	Organization/ Policy/ Intrapersonal
	HPVI_Reas_10	Cost	
	HPVI_Reas_18	Handicapped /Special needs/Illness	
	HPVI_Reas_20	Time	
	HPVI_Reas_23	Vaccine not available	
	HPVI_Reas_24	Not a school requirement	
	HPVI_Reas_26	No Ob-Gyn appointment	
	HPVI_Reas_28	No doctor/no visit set	
	HPVI_Reas_30	Intend to complete but have not yet/planned	
	HPVI_Reas_31	Difficulty making or getting to appointment	
Sociocultural barriers to HPV vaccine use	HPVI_Reas_14	Child's decision	Community
	HPVI_Reas_16	Do not believe in vaccines	
	HPVI_Reas_17	Parents' decision	
	HPVI_Reas_19	Religion/Orthodox	

Note. NIS = National Immunization Survey. SEM = socioecological model of health.

HPV Vaccination Initiation and Completion

I have operationally defined the outcome (criterion) variables of teens' HPV vaccine initiation and completion. The Advisory Committee on Immunization Practices (ACIP) has recommended, as of late 2016, the receipt of 2 doses of HPV vaccine for teens under age 15 years, but 3 for those between age 15 and 26 years (Meites et al., 2016). The population of interest in this study was teens aged 13 to 17 during the NIS-Teen survey years 2016 to 2018. Therefore, I defined HPV vaccine series completion as a teen receiving 2 shots before age 15 and 3 for those between ages 15 and 17 (CDC, n.d.-a; Walker et al., 2017). For similar reasons, vaccine uptake (initiation) referred to the administration of 1 dose of HPV vaccine for teens under the age of 15 and the receipt of 1 or 2 shots for those aged 15 to 17.

Intent and No-Intent to Vaccinate

Data are also available from the NIS-Teen data set to examine the influence of independent (predictor) variables on parental intent and no-intent to immunize their teen. Researchers have historically studied the factors associated with teens' initiation and completion of the HPV vaccine series (Cheruvu et al., 2017). However, researchers have begun to examine the population of unvaccinated and undervaccinated teens to determine the influences of parental intent and no-intent to vaccinate their teens (Cheruvu et al., 2017). Data are available in the NIS-Teen data set to assess reasons for parents' no intent to immunize their teens. As mentioned, teens are considered up to date with HPV immunization if they have received at least 2 doses before age 15 and 3 shots for those between ages 15 and 17 (Walker et al., 2017). NIS interviewers asked the parents of teens who were not up to date with the HPV vaccination at their interview to rank the likelihood they would have their teens vaccinated against HPV in the next 12 months (CDC, n.d.-a, 2016b, 2020b). Parents rated their intention to immunize teens as *very likely*, *somewhat likely*, *not too likely*, *not likely at all*, or *not sure/do not know* (CDC, 2016b, 2020b). Parents intended to vaccinate their teens if they stated that it was very likely or somewhat likely they would have their child receive the HPV vaccine (Cheruvu et al., 2017). I classified parents as having no-intent to vaccinate their teen if their response was *not too likely*, *not likely at all*, or *not sure/do not know*. Cheruvu et al. (2017) reported in their 2008 to 2012 national-level study of NIS-Teen survey data that less than 3% of parents responded *not sure/do not know*. On the other hand, in 2016 to 2018 NIS-Teen surveys, 7%-8% of parents responded *not sure/do not know* (CDC, n.d.-a).

I have categorized reasons for parental no-intent to vaccinate their teens into five domains. Reasons (i.e., variables) related to one another make up each domain. In the NIS-Teen, interviewers ask parents who have no intention for their teen to receive the HPV vaccine to give the main reason their teen will not get the HPV vaccine (CDC, n.d.-a). I grouped the parents' rationales for no-intent to use the HPV vaccine into the domains of safety and effectiveness concerns, vaccine misinformation, lack of knowledge about HPV and the vaccine, systemic access barriers (including a lack of vaccine provider endorsement), and sociocultural barriers. As shown in Table 2, each of the five domains corresponds to an outcome variable of RQs4, 5, 6, 7, or 8. Each of the five domains relates to one or more levels of the SEM, as shown in the far-right column of

Table 2. I defined the domains of parental barriers similar to Cheruvu et al. (2017) and used the same terms for the domains. Using the same terminology as Cheruvu et al. (2017), I could compare the results of the studies, as detailed in Chapter 5.

In my statistical analyses, I considered each domain listed in Table 2 a binary outcome, as previously described by Cheruvu et al. (2017). That is, if a parent reported at least one reason in a particular domain for not intending to vaccinate their teen, I recorded the data value of the corresponding dependent (outcome) variable for that domain as a "Yes" response (Cheruvu et al., 2017). If a parent did not select any reason in a domain, I assigned a value of "No" to the dependent variable corresponding to the domain (Cheruvu et al., 2017).

Research Questions and Hypotheses

RQ1: Is there an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months?

$H_0$1: There is no association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months.

H_a1: There is an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months.

RQ2: Is there an association between Hispanic parents' total family income level and the teens' HPV vaccination initiation?

$H_0$2: There is no association between Hispanic parents' total family income level and the teens' HPV vaccination initiation.

H_a2: There is an association between Hispanic parents' total family income level and the teens' HPV vaccination initiation.

RQ3: Is there an association between Hispanic parents' total family income level and the teens' HPV vaccination series completion?

H_03: There is no association between Hispanic parents' total family income level and the teens' HPV vaccination series completion.

H_a3: There is an association between Hispanic parents' total family income level and the teens' HPV vaccination series completion.

RQ4: Is there an association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns?

H_04: There is no association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns.

H_a4: There is an association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns.

RQ5: Is there an association between Hispanic parents' total family income level and their HPV vaccination misinformation?

H_05: There is no association between Hispanic parents' total family income level and their HPV vaccination misinformation.

H_a5: There is an association between Hispanic parents' total family income level and their HPV vaccination misinformation.

RQ6: Is there an association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination?

$H_0$6: There is no association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination.

H_a6: There is an association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination.

RQ7: Is there an association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination?

$H_0$7: There is no association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination.

H_a7: There is an association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination.

RQ8: Is there an association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination?

$H_0$8: There is no association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination.

H_a8: There is an association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination.

Theoretical Framework

The theoretical basis for this study was the SEM, a model that public health professionals use to formulate their ideas of how behavioral, social, and cultural circumstances shape disease and well-being. Analogous to a biological ecosystem, the SEM is a system of progressive levels of social influences on health from the individual to successively higher levels of networks involving family, organizations, communities, and society (Coreil, 2010). Primary prevention involves altering underlying disease causes at the individual level and the more distal levels depicted in the SEM, such as health policy (Allen et al., 2010; Larson et al., 2015). The SEM was suitable for use in this study because HPV vaccine uptake in youth is a multifactorial phenomenon that depends on many barriers and facilitators at different levels that vary among populations (Ferrer et al., 2014; Galbraith et al., 2016; Glenn et al., 2015; Holman et al., 2014). Ultimately, the SEM served as the framework for understanding how parents, medical practitioners, and policymakers' decisions at various levels might influence access to the HPV vaccine for undervaccinated Hispanic populations.

I can classify the variables used in this study at different levels of the SEM. I listed in Tables 1 and 2 the independent, dependent, and weight adjustment variables and the SEM level they apply. For example, these determinants of vaccine utilization for youth include demographic characteristics of parents and teens and parents' perceived barriers to vaccinating their teens at the intrapersonal and interpersonal levels (Das et al., 2016; Lechuga et al., 2011; Rambout et al., 2014). In addition, predictors of youth vaccination include providers' recommendations for parents to vaccinate their children at the organizational level and government insurance to subsidize the cost of vaccines for families at the policy level (Das et al., 2016; Lechuga et al., 2011). The NIS-Teen dataset includes data on these and other predictors (influences) of HPV vaccine uptake by teens at each level of the SEM (CDC, n.d.-a, 2016a, 2020b). A thorough awareness of the circumstances at multiple levels of the SEM impacting HPV vaccination in distinct groups of people could allow vaccine advocates reaching them using tailored interventions. In turn, advocates could attain goals for a high prevalence of immunization of adolescents.

Nature of the Study

The research approach in this study was quantitative. In survey research of the social sciences, researchers commonly use the cross-sectional type of quantitative study design (Frankfort-Nachmias et al., 2015). In particular, researchers have extensively employed the quantitative survey approach in correlation studies of HPV vaccination (Wang et al., 2015). Therefore, a cross-sectional design was consistent with the primary focus of my secondary analysis of archived survey data to understand the predictors of HPV vaccination of Hispanic teens aged 13-17 years in Bexar County, Texas.

Specifically, I studied the association between one independent (predictor) variable and different dependent (criterion) variables for each of the eight RQs. For RQs1 to 3, I examined the association of family income level with parents' intent to vaccinate their child, initiation, and completion. The ACIP defines HPV vaccine series completion as a teen receiving 2 shots before age 15 and 3 for those between ages 15 and 17 (CDC, n.d.-a; Walker et al., 2017). In this study, vaccine uptake (initiation) referred to the administration of 1 dose of HPV vaccine for teens under the age of 15 and the receipt of 1 or 2 shots for those aged 15 to 17. For RQs4 to 8, the predictor variable of interest was Hispanic parents' total family income level. The outcome variables were parents' vaccine safety and effectiveness concerns, vaccination misinformation, lack of knowledge of HPV and the vaccine, systemic barriers, and sociocultural barriers. I used the chi-square test and prevalence ratio to assess the association of the predictor variables with the outcome variables. Data on the independent and dependent variables as well as sociodemographic variables used by NIS-Teen surveyors to develop and adjust survey weights were available in the NIS-Teen dataset (CDC, n.d.-a).

Definitions

Some terms used in this study have interchangeable meanings. I defined the following terms for the current research:

Childs' age (a variable used to adjust survey weights): Age of Hispanic child aged 13, 14, 15, 16, or 17 years (NIS-Teen staff interviewed parent; CDC, n.d.-a).

Childs' race (a survey weight adjustment variable): Race of Hispanic child classified as White only, Black only, or Other plus multiple races (CDC, n.d.-a).

HPV vaccine series completion (up to date): The receipt of 2 HPV shots for teens under age 15 and 3 for those between age 15 and 17 (CDC, n.d.-a).

Intent to vaccinate: The likelihood that parents of teens who were not up to date on the HPV vaccination would have their teens vaccinated against HPV in the next 12 months, based on parental responses in the NIS-Teen interview (CDC, n.d.-a, 2016b, 2020b). I considered parents as having the intent to immunize their teen if they stated it was *very likely* or *somewhat likely* they will have their child receive the HPV vaccine, as described by Cheruvu et al. (2017).

No-intent to vaccinate: Parents were classified as having no-intent to immunize their teen if their response to NIS-Teen interviewers was *not too likely*, *not likely at all*, or *not sure/do not know* (Cheruvu et al., 2017). I grouped the parents' reasons for no-intent to use the HPV vaccine into the following domains: a) safety and effectiveness concerns,

b) vaccination misinformation, c) lack of knowledge about HPV and the vaccine, d) systemic access barriers (including lack of provider endorsement), and e) sociocultural barriers. I briefly describe these domains as follows.

Parental HPV vaccine misinformation: I considered parents misinformed about HPV vaccines if their grounds for no intention to vaccinate their child was due to one of eight reasons (CDC, n.d.-a, 2016b, 2020b). The NIS-Teen interviewers asked Hispanic parents the following eight questions to assess whether they were misinformed about HPV vaccines (CDC, n.d.-a, 2016b, 2020b). Parental misinformation evaluated were: a) vaccine not needed or not necessary, b) child not sexually active, c) child not the appropriate age, d) shot could be painful, e) shot not needed until the child reaches college age, f) HPV vaccination might result in the child becoming more sexually active, g) shot will not be helpful because the child is already sexually active, and h) child is a boy (CDC, n.d.-a, 2016b, 2020b).

Parental HPV vaccine safety and effectiveness concerns: I considered parents to have HPV vaccine safety and effectiveness concerns if their basis for no intention to vaccinate their child was due to one of three reasons (CDC, n.d.-a, 2016b). The NIS-Teen interviewers asked Hispanic parents the following three questions to assess whether they were concerned about the safety and efficacy of HPV vaccines available for their teens (CDC, n.d.-a, 2016b, 2020b). Parental concerns evaluated were: a) perceived vaccine side effects in teens such as fainting and infertility, b) perceived ineffectiveness of vaccine to prevent cancer and nonpersistent immunity, and c) need for more information because the HPV vaccines are relatively new (CDC, n.d.-a, 2016b, 2020b).

Parental lack of knowledge about HPV and the vaccine: Parents lacked knowledge about HPV and the vaccine if their motivation for no intent to vaccinate their child was due to one of two reasons (CDC, n.d.-a, 2016b). Interviewers asked Hispanic parents the following questions to ascertain whether they lack knowledge about HPV and the vaccine (CDC, n.d.-a, 2016b, 2020b). First, the NIS-Teen interviewers asked parents whether they did not know about the medical complications of HPV infection and whether they had knowledge of an HPV vaccine for teens (CDC, n.d.-a, 2016c, 2020b). Second, they asked parents whether their child was already up-to-date on HPV vaccination.

Parental sociocultural barriers to HPV vaccination: Parents' choice to vaccinate their child against HPV was influenced by a sociocultural barrier if they lacked vaccination intent for one of four reasons (CDC, n.d.-a, 2016b, 2020b). The NIS-Teen interviewers asked Hispanic parents the following four questions to assess whether sociocultural barriers influenced HPV vaccination of their teens (CDC, n.d.-a, 2016b). Interviewers asked parents whether the decision to vaccinate was their child's choice, whether vaccination was a family/parental decision, whether they did not believe in immunizations, and whether they based their decision not to vaccinate teens on religion (CDC, n.d.-a, 2016b, 2020b).

Parents' education level: The NIS-Teen surveyors categorized the education level of interviewed parents as less than 12 years, 12 years, more than 12 years but noncollege graduate, or college graduate (CDC, n.d.-a). They used this variable to adjust survey weights.

Parents' sociodemographics: These variables are potential predictors of HPV vaccine utilization in this study. They include parents' educational level and total family income level (CDC, n.d.-a).

Provider endorsed the use of vaccine: A doctor or other healthcare professional recommended at some time that teens receive HPV shots (CDC, n.d.-a). As noted above, I classified a lack of provider endorsement as a systemic access barrier.

Systemic access barriers to HPV vaccination: System access to HPV vaccines was a barrier to vaccination if parents' primary reason for no intent to vaccinate their child was due to one of 10 reasons (CDC, n.d.-a, 2016b, 2020b). The NIS-Teen interviewers asked Hispanic parents the following 10 questions to assess whether their HPV vaccination intent might be impacted by systemic access barriers to these vaccines (CDC, n.d.-a, 2016b). First, interviewers asked parents whether a doctor ever recommended the HPV vaccine for the child. Second, they queried parents about whether the cost of vaccination was an obstacle to having their child receive the vaccine. Third, they asked parents whether their child had a handicap, special needs, or illness that impeded HPV vaccination. Fourth, interviewers inquired whether the parent's lack of intent was due to a time constraint. Fifth, interviewers asked parents if the HPV vaccine was not available. Sixth, interviewers asked parents whether their reason for no-intent was that HPV vaccination of their child was not a school requirement. Seventh, they queried parents whether their lack of intent was due to not having an Obstetrician-Gynecologist (Ob-Gyn) appointment. Eighth, interviewers inquired whether the parent's lack of intent was due to not having a doctor or a scheduled visit. Ninth, interviewers asked parents whether they intended to have their teen complete HPV vaccination but have not done so yet. Tenth, they queried parents about whether they had difficulty making or getting to an appointment.

Teens' gender (variable used to adjust survey weights): Sex of the child (male or female) of the interviewed parent (CDC, n.d.-a).

Total family income level (independent variable): Total annual income of the interviewed parents, which I operationalized as equal to or below the medium income level of my study population ($40,000/year) or greater than the medium income (CDC, n.d.-a).

Vaccine uptake (initiation): I defined this variable as administering 1 dose of the HPV vaccine for teens under age 15 and 1 or 2 for those between age 15 and 17.

Assumptions

Fundamental assumptions underlie the credibility of this and other studies. Assumptions are conditions of this study that readers accept as accurate, or at least well reasoned or likely, for the findings and conclusions to be valid and credible (Leedy & Ormrod, 2010; Simon, 2011). That is, scholars will assume that certain premises of this work are accurate, considering the study population, cross-sectional design, statistical analysis, and other delimitations (Leedy & Ormrod, 2010; Simon, 2011). Although I cannot entirely control assumptions, I must be aware of the foundational assumptions of this study and justify to my readers that they are likely true (Adu, 2017; Simon & Goes, n.d.). I have considered assumptions that might apply to this study.

A fundamental assumption of this study is that the NIS-Teen data was accurate and consistent. The credibility of the findings depended on the qualities of the validity and reliability of the NIS-Teen data that I used in the analysis (Frankfort-Nachmias et al., 2015). Researchers can obtain high-quality data through careful adherence to ethical considerations (Frankfort-Nachmias et al., 2015). An essential concern of this study is that surveyors collected sensitive data from participants about sexually transmitted diseases and other issues (CDC, n.d.-a, 2016b, 2016c; Coates et al., 1988). The mode of administration of a survey could affect both the participation rate and frequency of acknowledging sensitive attitudes and behaviors (Frankfort-Nachmias et al., 2015). In turn, participation rate and response to sensitive questions can influence study findings' internal and external validity (Frankfort-Nachmias et al., 2015). The NIS-Teen interviewers could obtain reliable and valid self-report data from surveys of participants' sexual histories by ensuring confidentiality and anonymity (Babbie, 2016; Groves, 2006, Smeaton et al., 1998). In short, how the NIS-Teen staff administered surveys was critical to providing quality data to end users of the data.

The NIS-Teen staff and associates take various precautions to ensure the confidentiality of NIS-Teen data and mitigate the possibility of harm to individual participants. The National Center for Immunization and Respiratory Diseases (NCIRD) takes extensive measures in collecting and processing the NIS-Teen data to prevent disclosure of the identity of survey participants (CDC, 2016b, 2016c). The NCIRD attempts to compile aggregate data, which is difficult to trace back to individuals, by removing from the publicly available data the direct participant identifiers, responses to identity-revealing questions, and extreme or narrow ranges of values of variables (CDC, n.d.-a, 2015a, 2015b, 2016a, 2016c). By taking these precautions during data collection and processing to safeguard the confidentiality of survey data and the participants' privacy, the NIS-Teen staff provides researchers with valid and reliable data (Frankfort-Nachmias et al., 2015, Smeaton et al., 1998). In this context, I can reasonably assume the NIS-Teen staff collected and managed the publicly available data for this study in a manner to ensure it was of high quality. In turn, the results of my analysis of NIS-Teen data are likely valid, credible, and valuable to those who might use it to promote positive social change.

Scope and Delimitations

Delimitations are features of this study that I can influence to define the boundaries (scope) so that they are manageable (Adu, 2017; Leedy & Ormrod, 2010). The scope is comprised of the domain of what I cover in all the elements of my research (Sánchez Patiño, 2015; Simon & Goes, n.d.). For example, I delimited the scope of this study to a cross-sectional design, a population of Hispanic parents and their teens in a specific metropolitan county, and the purpose of identifying particular correlates of HPV vaccination of these youth. These choices are neither good nor bad (Adu, 2017). On the other hand, limitations are constraints of my results, conclusions, and generalizability (Simon & Goes, n.d.). These weaknesses result from the inherent characteristics of my methods and design (Simon & Goes, n.d.). Limitations are mostly beyond my control (Adu, 2017). Here, I clearly state and justify this study's assumptions, delimitations, and limitations so that other researchers can interpret, evaluate, use, and establish the significance of the findings (Sánchez Patiño, 2015; Simon, 2011).

Scope

I examined telephonic survey responses of Hispanic parents to learn more about predictors of whether they have their teens vaccinated against HPV. This cross-sectional study was based on the SEM (Coreil, 2010) and publicly available data from the NIS-Teen, conducted annually throughout the United States (CDC, n.d.-a, 2015b, 2016c). I used data collected in 2016, 2017, and 2018 from Hispanic parents living in Bexar County, located in south-central Texas. Specifically, I examined the association of Hispanic parents' total family income level with barriers to vaccination, parental intention to vaccinate their children aged 13 to 17 years, and the extent of vaccination.

Delimitations

A delimitation of this study is that I am seeking knowledge about the influences of teens' HPV vaccination in a specific population. Although the results of this research appeared to have led to more credible knowledge of various predictors of HPV vaccination of Hispanic teens living in Bexar County, Texas, the results might not generalize to other, more diverse populations. However, these results should benefit the public health field in better understanding HPV vaccination decision-making of Hispanic parents in Bexar County. Consequently, the information gained from this study should aid HPV vaccine advocates in increasing vaccination in this metropolitan region and conducting further research on this topic.

In particular, the findings of this study related to correlates of HPV vaccine uptake by Hispanic youth will probably not apply to countries where vaccinations are universally cost-free. Krawczyk et al. (2015) found an insignificant difference in Canadian parents' education, income level, or employment status between acceptors and nonacceptors of the HPV vaccine for their children. This lack of effect of Canadian parents' demographics on their teens' HPV vaccine uptake might not apply to countries such as the United States without a free, universal vaccine program and with a comparatively low percentage of vaccine uptake (Gilca et al., 2006). As the large-scale promotion of HPV vaccination in foreign countries likely reinforces parents' baseline knowledge level of these vaccines, parental knowledge of the HPV vaccine might be less predictive of HPV vaccination of youth in foreign nations than in the United States (Krawczyk et al., 2015). In this context, the results of my study on predictors of HPV vaccine uptake by youth in Bexar County would likely not be helpful to vaccine promoters in foreign countries where HPV vaccines are free and in high demand.

Another delimitation of this study is that I based it on the SEM. HPV vaccine utilization in adolescents is a multifactorial phenomenon that depends on several factors at the personal, interpersonal, organizational, community, and political/policy levels (Brewer & Fazekas, 2007; Das et al., 2016; Holman et al., 2014). Accordingly, I examined the influence of several factors on HPV vaccine use of Hispanic teens in Bexar County, Texas, ranging from parents' income level to parents' perceived barriers to receiving the vaccine. The SEM is suitable for investigating the significance of HPV vaccine uptake and completion predictors at various levels (Allen et al., 2010; Coreil, 2010; Crosby et al., 2011). Furthermore, the NIS-Teen data set contains data that researchers can use to analyze psychosocial, demographic, socioeconomic, and other high-level influences of HPV vaccine uptake and completion (CDC, n.d.-a, 2015a, 2015b). Larson et al. (2015) pointed out that much of the research on vaccine hesitancy primarily draws on the health belief model and the theory of planned behavior. Neither of these models is appropriate to adequately investigate the significance of social, cultural, and economic factors as determinants of health behavior related to vaccine hesitancy (Krawczyk et al., 2015; Larson et al., 2015). Therefore, this multilevel study is unaligned with theoretical frameworks limited to the individual level. However, I have aligned the focus of my investigation on explicating multilevel correlates to HPV vaccination uptake in Hispanic youth with the SEM.

Limitations

Some limitations could be significant in this study. Limitations are potential restrictions on findings, conclusions, and generalizations that flow from the choice of methods and study design (Simon, 2011; University of Southern California Libraries, 2022). Although these potential research shortcomings are primarily out of my control, it is not reasonable for me to overlook these challenges (Adu, 2017; Simon & Goes, n.d.). Instead, I should be aware of the method and design-related limitations, their consequences, and how to address them to a feasible extent (Sánchez Patiño, 2015; Simon & Goes, n.d.). I have considered the potential limitations of this study.

I am limited to a cross-sectional design due to the nature of data in the NIS-Teen data set that I chose to use. In panel and time-series designs, researchers follow the same individuals over time (Frankfort-Nachmias et al., 2015). Battaglia et al. (1996) showed that panel-conditioning effects would bias vaccine coverage estimates because the influence of annual interviews would lead some parents to give socially desirable responses or influence them to have their children receive vaccines. In contrast, the NIS-Teen surveyors based their annual survey on a cross-sectional study design (Frankfort-Nachmias et al., 2015). In the NIS-Teen survey, a different set of both parents and physicians are interviewed each year (CDC, n.d.-a, 2016a, 2016b, 2020b). In survey research of the social sciences, investigators commonly use the cross-sectional study design (Frankfort-Nachmias et al., 2015). In particular, researchers have widely employed the quantitative survey approach in correlation studies of HPV vaccination (Wang et al., 2015). Thus, the cross-sectional design underlying this secondary analysis of NIS-Teen survey data was likely appropriate to investigate the predictors of HPV vaccination of Hispanic teens aged 13 to17 years in Bexar County, Texas.

The cross-sectional design of this study has some limitations. A potential weakness of the cross-sectional design is a misleading reverse association, such as the possible influence of a medical provider's knowledge of the vaccination rate on their recommendation for parents to have their children receive a vaccine (Salazar et al., 2015). A third variable correlation (confounding) is an even more frequent issue in cross-sectional designs (Salazar et al., 2015). Researchers cannot typically use this study design to obtain substantial evidence to support a cause-and-effect relationship between variables (Salazar et al., 2015). For these reasons, the cross-sectional design is somewhat prone to bias and limited in the extent that it supports causal relationships

Despite the potential limitations of bias and reverse association, the cross-sectional design is suitable for the current study. This study design is a convenient and inexpensive option to gain an initial assessment of potential predictors of vaccine uptake. In addition, researchers can use findings from a cross-sectional design for hypothesis generation that can lead to testing the relationship between variables using more advanced study designs (Burkholder et al., 2016). Furthermore, in public health research, often, it is more feasible and prudent to use a cross-sectional study design (Salazar et al., 2015). For instance, it would be unethical to manipulate the predictor variables, such as the providers' recommendations to give HPV vaccine to Hispanic youth. Consequently, I was entirely justified in using this design for the preliminary investigation of the correlates to HPV vaccination uptake in Hispanic youth in Texas.

The data gathered by NIS-Teen staff is also prone to nonresponse bias. A potential limitation of telephonic interviews is that respondents can terminate the conversation before it is completed (Frankfort-Nachmias et al., 2015). Response rates for all telephone-based surveys have decreased in recent years (Pew Research Center, 2012). If individuals who volunteer to participate in a study respond differently to survey questions than nonrespondents would have answered (if they had participated), researchers will have a hard time knowing how the entire population would have replied (Sivo et al., 2006). For this reason, high nonresponse rates could limit my ability NIS-Teen to generalize results from the sample to the population of interest.

Scientists can mitigate nonresponse bias through quality control measures and statistical approaches. The NIS-Teen surveyors carry out extensive quality control at various data collection and processing stages to address nonresponse bias (National Opinion Research Center, 2015). In addition, data managers use sophisticated statistical methods to adjust for parental nonparticipation and lack of a telephone (CDC, n.d.-a, 2016a, 2016d, 2020b). After implementing a new statistical weighting strategy, the NIS-Teen staff obtained accurate estimates for most measures related to vaccine hesitancy despite the trend of lower response rates (Pew Research Center, 2012). Even though selection bias has increased due to nonresponse to surveys, the NIS-Teen data experts continue to develop innovative approaches to reduce this bias.

Significance

Public health leaders might use the findings of this study on the correlates of HPV vaccination of Hispanic youth in Bexar County, including parental total income and barriers to receiving the vaccine, to develop interventions to mitigate the adverse impact of HPV infection. In particular, the knowledge gained in this study on predictors of HPV vaccination, in combination with the expanding literature on HPV vaccine implementation (Das et al., 2016; Smulian et al., 2016; Walling et al., 2016), might be used to increase rates of HPV vaccination. HPV vaccination advocates have proposed using findings from studies similar to mine to guide better parents or medical providers on the immunization of youth (Community Tool Box, n.d.; Das et al., 2016; Shi & Johnson, 2014). The results of this study could contribute to developing vaccine education, vaccine subsidization, policies, regulatory enforcement, social marketing, and health economics strategies (Getzen, 2013; Resnick & Siegel, 2013; Walling et al., 2016). As a result, public health promoters might have an opportunity to mitigate the human and economic burden associated with HPV infection by applying knowledge gained from the current study about the factors that influence caregivers to favor or disfavor vaccination of youth against HPV.

The results of this study could advance vaccine hesitancy research on the relationship between parents' demographics and their intentions and behaviors concerning teen vaccination. Given the disproportionate prevalence of adverse outcomes of HPV-related diseases in specific populations, health authorities need to learn more about the relationship between parents' demographics and their intentions and behaviors related to the vaccination of their teens (Walling et al., 2016). However, Walling et al. (2016) found a lack of data on participants' race/ethnicity and socioeconomics in the studies covered by their systematic review on initiatives to increase HPV vaccination in the United States and other countries. I examined whether there was an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens and the teens' HPV vaccination uptake. Hence, I addressed a gap in knowledge in the discipline of vaccine hesitancy on how parents' demographics influence their intent or action to have their child vaccinated against HPV.

Summary

Learning more about how to increase HPV vaccination of youth is especially crucial for mitigating HPV-associated disease of Hispanics in Bexar County, Texas. Hispanics in this region are disproportionately susceptible to HPV complications, including cancer, due to predisposing factors such as limited health care access (Schlenker & Huber, 2015). Over the past decade, evidence has been building regarding the safety and efficacy of three currently available HPV vaccines (CDC, n.d.-b, n.d.-c; Luckett & Feldman, 2016; Markowitz, 2016; Van Damme, 2016). Researchers will likely continue to improve vaccines and vaccination strategies to mitigate the adverse health, social, and economic consequences of HPV infection (Angioli et al., 2016; National Cancer Institute, n.d.-b). However, the success of public health leaders in using vaccines to reduce HPV-related diseases will depend mainly on their ability to enhance vaccine uptake (Signorelli et al., 2017). Therefore, health authorities should plan, implement, and evaluate HPV immunization programs. In doing so, they should increase the acceptability of HPV prevention among parents, providers, policymakers, and vaccine users. Public health experts need to know more about the factors influencing vaccine uptake to improve vaccination programs and better inform stakeholders who influence vaccine uptake (Das et al., 2016; Smulian et al., 2016; Walling et al., 2016). Researchers need to address the apparent knowledge gap concerning predictors of HPV vaccination use among Hispanic youth in Bexar County.

In this study, I addressed the gap in the literature on knowledge of predictors of HPV vaccine use among Hispanic youth in Bexar County using a comprehensive research design, high-quality data, and appropriate methods. Promoters of HPV vaccination need to understand several factors influencing vaccination uptake in adolescents, including parental demographics and vaccine acceptability (Holman et al., 2014; Rambout et al., 2014; Ramírez et al., 2014; Wang et al., 2015). However, much of the research on vaccine hesitancy primarily draws on theoretical models that are inadequate for investigating the significance of multilevel determinants of vaccine use

(Krawczyk et al., 2015; Larson et al., 2015). In contrast, the SEM is appropriate to examine the importance of potential predictors of HPV vaccine uptake and completion at various levels (Allen et al., 2010; Ferrer et al., 2014; Galbraith et al., 2016; Glenn et al., 2015). I used publicly available data in the NIS-Teen data set to assess whether factors at multiple levels of the SEM significantly correlate with HPV vaccination of youth (CDC, n.d.-a, 2015a, 2015b). I used the chi-square test and prevalence ratio to test the association of independent and dependent variables. Using the SEM in conjunction with the analysis of high-quality NIS-Teen survey data aided me in examining the significance of potential predictors of HPV vaccine use.

Health authorities need information from studies such as this on the predictors of HPV vaccine uptake of Hispanic youth in Bexar County to promote vaccination. Stakeholders of HPV vaccination need to tailor policy, regulation, education, social marketing, health economics, and leadership strategies to the local context (Gardner, 2016; Glenn et al., 2015; Henry et al., 2016). In particular, the parental perceptions and acceptability of HPV vaccination of youth constitute a critical link in the development of initiatives to increase vaccination (Das et al., 2016; Galbraith et al., 2016; Law, 2008; Rimer et al., 2014). Given the adverse health, quality of life, social, and economic consequences associated with HPV infection in Bexar County (Han et al., 2017; Schlenker & Huber, 2015; Texas Cancer Registry, 2021a, 2021b; U.S. Cancer Statistics Working Group, 2021; Vogel, 2017), the cost of not protecting Hispanics against HPV-associated health complications is high. Vaccination providers might use the information

I gained regarding the factors influencing HPV vaccine uptake of Hispanic teens in Bexar County to increase vaccination rates.

In Chapter 1, I established the research problem, purpose, significance, and context of my dissertation by presenting a survey of the essential elements of each section. I further develop and explain these crucial aspects of my research in later chapters. In Chapter 2, I review the literature on general information related to HPV, such as health complications and prevalence rates, as well as the safety and effectiveness of the HPV vaccines. In addition, I discuss theories used in previous HPV research, scientific advances in prevention, and research on vaccine acceptability by parents, providers, policymakers, and vaccine users.

Chapter 2: Literature Review

Introduction

The incidence of HPV-related cancer is relatively high in the population of interest for the current study. The National Cancer Institute (n.d.-b) has indicated that Hispanics in Bexar County, Texas, are disproportionately susceptible to HPV. In the study population of Bexar County, the average annual age-adjusted incidence of cervical cancer in Hispanics from 2009 to 2013 was 10.2 cases per 100,000 women under age 65 (National Cancer Institute, n.d.-c). At the national level during the same period, the average annual age-adjusted incidence of cervical cancer was lower for Hispanics at 7.0 cases per 100,000 women and races in total (i.e., all inclusive) at 6.3 (National Cancer Institute, n.d.-c). From 2012 to 2016, the average annual age-adjusted rate of cervical cancer in all races of the Hispanic population in Bexar County was 11.6 cases per 100,000 women, but the statewide incidence in Texas was lower at 10.6 (Rimer, 2018). In addition, non-Hispanic White women's cervical cancer rate in Bexar County was lower during this period at 10.1 (Rimer, 2018). Cervical cancer among the Hispanic population in Bexar County is a substantial human and economic burden due to the high number of these Hispanics with morbidity and mortality from this cancer (Texas Cancer Registry, 2021a, 2021b; U.S. Cancer Statistics Working Group, 2021; U.S. Census Bureau, 2021b). For men, HPV-associated oropharyngeal and anal cancers are an increasing health concern (Han et al., 2017; Vogel, 2017; Van Dyne et al., 2018). These results suggest that during the current study, HPV-associated cancer was a substantial burden in Bexar County.

As the youth in the study population are prone to severe medical complications from HPV infection, practitioners should vaccinate these youth against HPV. Before late 2016, the ACIP recommended 3 doses of the HPV vaccine for youth aged 13-17 years to prevent HPV infection (Rimer et al., 2014; Stokley et al., 2014). In 2015, 19.9% of Hispanic boys aged 13-17 years in Bexar County were up to date with the HPV vaccine, whereas 35% of Hispanic boys countrywide were up to date, signifying that vaccination rates in Bexar County were just over half the national average (CDC, 2016e). The vaccination rate among Hispanic girls in the county was higher, but it, too, was lower than the rate for the United States; 32.8% of Hispanic girls aged 13-17 years in Bexar County in 2015 had received 3 doses of the HPV vaccine compared to 46.2% of Hispanic girls nationwide (CDC, 2016e). These findings indicated that about three quarters of boys and girls in Bexar County in 2015 lacked HPV vaccine protection.

This disparity in HPV vaccination of Hispanic youth in Bexar County persisted throughout the current study period. In the present study involving 2016 to 2018, HPV vaccine series completion (up to date) refers to the receipt of 2 HPV shots for teens under age 15 and 3 for those between age 15 and 17, as recommended by the ACIP since late 2016 (CDC, n.d.-a; Meites et al., 2016). In 2016, Bexar County's up-to-date HPV vaccination rates of 36.5% for Hispanic boys and 48.9% for girls were less than the national incidences of 44.6% for boys and 55.3% for girls (Walker et al., 2017). In addition, in 2017, Bexar County's up-to-date HPV vaccination rates of 38.2% for Hispanic boys and 57.8% for girls were less than the national rates of 54.6% for boys and 58.1% for girls (Walker et al., 2018). Furthermore, in 2018, Bexar County's up-to-date

HPV vaccination rates of 46.0% for Hispanic boys and 55.6% for girls were less than the national rates of 56.0% for boys and 57.2% for girls (Walker et al., 2019). Considering that the level of HPV vaccination of Hispanic youth in Bexar County is out of proportion with their susceptibility to HPV complications, a need exists to increase the rate of HPV vaccination for this adolescent population.

Public health workers need knowledge of factors influencing whether Hispanic youth receive vaccines against HPV to develop effective interventions to increase vaccination rates. A limited number of researchers have identified community-level geographic factors, such as racial makeup, poverty, and cultural beliefs, which might predict HPV vaccination initiation and series completion (Davlin et al., 2015; Fernandez et al., 2009; Gardner, 2016; Glenn et al., 2015; Henry et al., 2016). More limited to date is published quantitative research at a local level on the factors that predict the vaccination status of Hispanic youth; as far as I know, there is no quantitative literature related to Hispanic adolescents in Bexar County. However, vaccination practitioners need reliable and current information, from studies of superior methodological quality, on factors that influence the decisions of parents of different demographic groups to have their children vaccinated against HPV (Brewer & Fazekas, 2007; Holman et al., 2014; Rambout et al., 2014). From this perspective, the current study helped address a gap in understanding the possible influences of HPV vaccination on Hispanic youth in Bexar County.

Public health experts need to learn more about a wide range of potential predictors of HPV vaccination uptake and completion among Hispanic adolescents in

Bexar County. Researchers need to base more studies of the determinants of HPV vaccine acceptability of Hispanic parents on the socioecological framework (Ferrer et al., 2014; Galbraith et al., 2016; Glenn et al., 2015; Lacombe-Duncan et al., 2018). Investigators would more likely be able to produce the data needed to address this gap in knowledge of the predictors of HPV vaccination among Hispanic youth by grounding their studies in the multilevel SEM than other theories (Galbraith et al., 2016; Rimer, 2018). This model was suitable for the current study because factors at different social levels could affect whether parents decide to vaccinate their children against HPV (Brewer & Fazekas, 2007; Das et al., 2016; Holman et al., 2014). Ultimately, public health authorities could use the results of my study to develop interventions to counter a multitude of factors negatively influencing the HPV vaccination of youth. Increased vaccination coverage for Hispanic youth in Bexar County could reduce the burden of HPV complications in this vulnerable population.

Purpose of the Study

The objective of this study was to investigate the association of potential influences of HPV vaccination with vaccine coverage of 13 to 17 years old Hispanic youth in Bexar County, Texas. The potential predictors of HPV vaccine use assessed in this study were parents' total income and barriers to vaccination. The NIS-Teen data set contains publicly available data on all of these potential predictors (influences), at different levels of the SEM, of teens' vaccine use (CDC, n.d.-a, 2016a, 2020b). I performed a quantitative secondary analysis of archived survey data to address this gap in the literature on knowledge related to predictors of HPV vaccine coverage among Hispanic youth.

Background of the Problem

In this study, I sought to determine whether the low HPV vaccine uptake of Hispanic teens in Bexar County is due to vaccine hesitancy of parents and other stakeholders. The SAGE Working Group on Vaccine Hesitancy advanced the definition of hesitancy and its scope, as well as a model to classify predictors of hesitancy (MacDonald, 2015). As defined by the SAGE Working Group, vaccine hesitancy refers to an ambivalence of parents (and other stakeholders) toward vaccinating teens against HPV despite the vaccine being readily available. Vaccine hesitancy of parents, medical providers, or communities falls on a continuum between the majority who accept all vaccines with no reservations and the minority who refuse all with no doubts. A hesitant individual or group in need of a vaccine might accept getting it but still have doubts, delay obtaining it, or refuse being given it but be uncertain about their decision. Therefore, the SAGE Working Group's definition of vaccine hesitancy departs from a dichotomous view of parents' decision to vaccinate their child (i.e., adamant acceptance or refusal). In short, there are a variety of ways parents and other stakeholders can be hesitant to have a child vaccinated against HPV. Reluctance to have their child receive the HPV vaccine could influence the vaccination coverage for teens.

Vaccine hesitancy is a complex factor that might explain parents' reluctance to vaccinate their teens against HPV. Vaccine hesitancy stems from issues related to confidence, complacency, and convenience (MacDonald, 2015). One can broadly categorize the determinants of vaccine hesitancy as contextual, individual and group, and vaccine/vaccination specific (MacDonald, 2015). However, researchers differ on the most important causes or explanations of parents' hesitancy to have their children receive vaccines, including those against HPV (Corben & Leask, 2016; Galbraith et al., 2016; Lacombe-Duncan et al., 2018; Radisic et al., 2017). In this context, researchers should carefully explore parents' reasons for HPV vaccination hesitancy.

Researchers need to study parental HPV vaccination hesitancy in context. The factors influencing whether parents are hesitant for their teens to receive the HPV vaccine are unique to the time, place, and population under consideration (MacDonald, 2015; Thomson et al., 2016). Parents' sociodemographics and concerns about HPV vaccination that might contribute to vaccine hesitancy are queried yearly by NIS-Teen interviewers (CDC, n.d.-a). NIS-Teen analysts record the resulting data in publicly available data sets researchers use in their studies (Hanson et al., 2018). Using these data, I was able to investigate, at a local level, the hesitancy of some Hispanic parents to have their teens vaccinated against HPV.

Other factors might contribute to low HPV vaccine uptake in the study population. A low vaccine uptake could be due to reasons other than vaccine hesitancy, including geographic residence, sociodemographics (e.g., household income), and vaccination services or supply constraints (Finney Rutten et al., 2017; MacDonald, 2015). For this reason, public health professionals must consider various factors influencing vaccine uptake. These factors include not only sociodemographics but also access, affordability (i.e., financial and time), awareness, acceptance, and action (Thomson et al., 2016). Concerning action, from 2017 to 2018, the American Cancer Society adapted its thorough national-level HPV vaccination campaign in Bexar County to improve vaccine coverage (Garza, 2017). The American Cancer Society and other organizations developed this comprehensive program to increase HPV vaccination in part as a response to a call from the President's Cancer Panel (Rimer et al., 2014) to address the underuse of the HPV vaccine, a correctable threat to progress against cancer prevention. The Mission: HPV Cancer Free campaign included tracking vaccination progress and educating parents and the public about HPV and the vaccine (American Cancer Society, 2020b). Understanding whether parental (stakeholder) vaccine hesitancy or other influences contribute to low HPV vaccine uptake of Hispanic teens in Bexar County is necessary for public health authorities to choose appropriate interventions to increase the vaccination rate.

As parental characteristics could influence the HPV vaccine uptake in their child, I sought to understand these factors better. Researchers expect parents' knowledge and concerns regarding HPV vaccines to impact the parental promotion of these vaccines (Luque et al., 2010; Stager, 2016; Wilson & Bailey, 2016). Therefore, they have researched parental influences on the uptake of HPV vaccines in teenagers (Das et al., 2016; Holman et al., 2014; Lacombe-Duncan et al., 2018; Radisic et al., 2017; Wang et al., 2015). Similarly, I assessed the parental acceptability of HPV vaccination of youth in Bexar County.

I also designed the study to address several other factors that could influence vaccine uptake of adolescents in Bexar County. Cultural and social differences can lead to various social antivaccination norms and create unique barriers to HPV vaccination (Kowalczyk Mullins et al., 2015). For instance, low-income and minority racial and ethnic populations disproportionately fall short of the recommended doses of the HPV vaccine (Fisher et al., 2013; Galbraith et al., 2016; Rimer et al., 2014). For this reason, public health advocates also need to understand and address the unique sociocultural challenges of low-income, underinsured, and racial minority groups to mitigate the existing disparities in HPV vaccination (Fisher et al., 2013; Ford, 2011; Holman, 2014; Livingston, 2015). The Hispanic community of interest in this study has a relatively low employment rate and median income (Schlenker & Huber, 2015). In 2014, about 31% of Hispanics 18 to 64 in Texas lived in poverty compared to 10% of non-Hispanic Whites (Pew Research Center, n.d.). In addition, about 31% of Hispanics were uninsured during this period compared to 11% of non-Hispanic Whites (Pew Research Center, n.d.). From 2014 to 2018, 17.2% of all adults in Bexar County lived in poverty compared to 11.8% statewide (U.S. Census Bureau, n.d.). Also, during this period, 16.9% of people under age 65 were without health insurance compared to 10.0% statewide (U.S. Census Bureau, n.d.). In this context, realizing the prevention of HPV complications in the study population will involve understanding and altering the underlying causes of hesitancy to vaccinate youth and other factors influencing vaccine uptake.

A gap exists in the literature on knowledge about the factors that influence the HPV vaccination of youth. Public health advocates of increased HPV immunization of teens might use additional understanding of the predictors of HPV vaccination to develop and enhance immunization programs. In particular, vaccination providers need reliable information about the factors influencing parents of different racial and ethnic groups to vaccinate their children against HPV to improve vaccination rates (Brewer & Fazekas, 2007; Holman et al., 2014; Rambout et al., 2014). In addition, Lechuga et al. (2011) recognized the importance of applying an understanding of the variation in the predictors of HPV vaccination intentions among cultures. Thus, to uncover potential cultural variation in predictors of HPV vaccination of youth, it might be essential to stratify analyses of these predictors by ethnicity or culture. Ferrer et al. (2014), Glenn et al. (2015), and Galbraith et al. (2016) called for more studies on the determinants of HPV vaccine acceptability of Hispanic parents, grounded in theories such as the socioecological framework. In this light, practitioners need more information on the factors influencing Hispanic parents to vaccinate their teens to promote HPV vaccination.

This study was worthwhile because I examined the impact of various factors on the uptake of HPV vaccines in the study population using a relevant theoretical basis. I used the SEM in this study to investigate the influence of multilevel factors (e.g., personal, family, and policy levels) on the uptake of HPV vaccines in Hispanic youth. Public health professionals use the SEM to formulate their ideas of how behavioral, social, and cultural circumstances shape disease and well-being (Coreil, 2010). Thus, HPV vaccination advocates might use the knowledge from this study of barriers to the parental endorsement of HPV vaccine uptake for teens to develop strategies to increase vaccination rates.

Preview of Chapter 2

This chapter aims to provide an in-depth literature review related to the theoretical framework, ongoing research on HPV vaccine use, background on HPV/sequelae/vaccines/coverage, and variables of interest in the investigation. In the first section, I describe the literature search strategy. The second section involves a discussion of the SEM, which formed the basis of this study. In the third section, I discuss approaches used in research and practice to increase HPV vaccine coverage and the importance of promoting HPV vaccination for positive social change. The fourth section comprehensively explains HPV, the burden of sequelae, vaccine safety/effectiveness, vaccine coverage by gender, and the potential benefits of increasing coverage. The fifth section contains a detailed discussion of the literature on the independent and dependent variables. Also, I cover the sociodemographic variables used to adjust survey weights. The chapter concludes with a summary of the current research that relates to HPV vaccination acceptance and hesitancy, as well as a discussion of how the approach of the present study helped to address gaps in and build on the strengths of other studies on vaccine use.

Literature Search Strategy

Researchers have published much literature regarding vaccination acceptance and hesitancy in general (Betsch et al., 2015; Corben & Leask, 2016; Das et al., 2016; Larson et al., 2014; Schmid et al., 2017). Likewise, researchers have conducted a substantial amount of research on HPV vaccination in particular (Ferrer et al., 2014; Galbraith et al., 2016; Lacombe-Duncan et al., 2018; Radisic et al., 2017; Smulian et al., 2016; Stager, 2016; Walling et al., 2016; Warner et al., 2015). Researchers across public health, psychology, education, and medicine have examined HPV vaccination hesitancy (Betsch et al., 2015; Ferrer et al., 2014; Galbraith et al., 2016; Walling et al., 2016; Warner et al., 2015). For this reason, I searched databases of multiple disciplines.

I searched the literature for findings related to the RQs and variables. Also, I reviewed the theoretical frameworks used in vaccination acceptance and hesitancy research. The independent (predictor) variable of interest for all RQs in the study was total parental income. The dependent (outcome) variables for RQs1-3 were parents' intent to vaccinate their teens and teens' vaccine initiation and completion. Perceived parental reasons or barriers for their lack of intent to have their child receive the HPV vaccine were the dependent (outcome) variables for RQs4-8. These perceived reasons or barriers were safety and effectiveness concerns, vaccination misconceptions, lack of knowledge of HPV and the vaccine, systemic barriers, and sociocultural barriers. I also explored the literature on sociodemographic variables used by NIS-Teen surveyors to develop and adjust survey weights, including parents' education and teens' gender, race, and age. Data on these variables, including parents' income and educational attainment, teen's demographics, intentions to vaccinate their child against HPV, vaccine uptake, and reasons (concerns) for being hesitant to do so, are included each year in the NIS-Teen data set (CDC, n.d.-a; Hanson et al., 2018). In addition, I searched for literature on the socioecological model, other ecological models, and behavioral theories applied to vaccination acceptance and hesitancy research.

I found academic articles in this review by searching databases primarily at the Walden University Library, including Medline, Cumulative Index to Nursing & Allied Health Literature (CINAHL), SAGE Journals, Wiley, Google Scholar, JSTOR, ScienceDirect, and Thoreau Multi-database Search. I used search terms in various combinations to collect relevant articles and reach saturation of the literature on my topic in the past 5 years. I used some research articles with an earlier publication date if they were an essential source for the development of the study. For example, the keywords I used for the searches on the SEM were *social ecological model AND screening, social ecological model AND vaccination, social ecological model AND vaccine, social ecological model AND immunisation, social ecological model AND immunization.* Similarly, I searched other theories used in HPV vaccination acceptance and hesitancy research, such as the health belief model. In the final phase of this literature review, I focused on studies that addressed the predictors and outcomes of HPV vaccination acceptance and hesitancy of Hispanic parents, especially those living in Texas.

I examined several comprehensive literature reviews on vaccine acceptance and hesitancy in general and HPV vaccination specifically. My purpose for doing so was to better understand theories and variables related to my study and to identify original research articles that were appropriate for inclusion in the literature review. I also mined references in original research articles to find earlier related studies. Furthermore, I searched forward in time using Google Scholar to find current articles that cited key publications related to my research. Finally, I read the relevant articles in more depth.

Theoretical Foundation

Researchers can use theory as a guide to study parental vaccine acceptance and hesitancy and develop interventions related to this phenomenon. A theory is a lens through which researchers often interpret and possibly explain or predict phenomena (Babbie, 2016). Researchers need to know the elements or variables involved in their research problem to choose the appropriate theory or set of theories to interpret, explain, or predict a phenomenon (Creswell, 2009). Therefore, I strived to align the theoretical framework that I chose for this study with the research problem, RQs, and variables. In this context, my choice of theory for this study related to the phenomenon of parental HPV vaccine acceptance and hesitancy was a critical consideration.

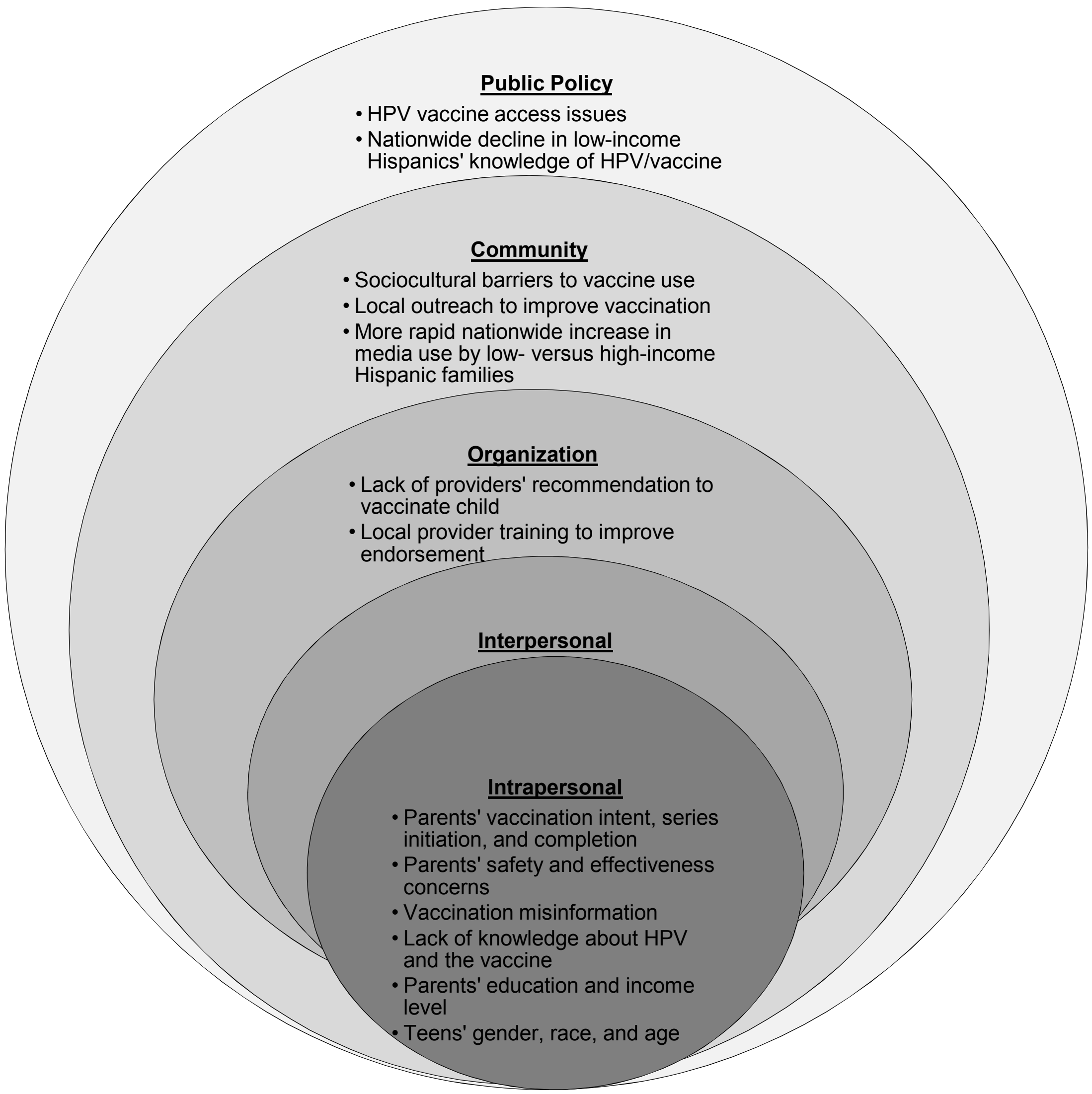
Socioecological Model

The theory that I used as a guide in this dissertation was the SEM. McLeroy et al. (1988) developed this theoretical framework that has been used to study health-related behavior and develop interventions to promote health (National Cancer Institute, 2005; Sallis et al., 2008; West, 2017). This theory indicates that multilevel influences influence health behaviors (see Figure 1). Analogous to a biological ecosystem, the SEM is a system of progressive levels of social influence (i.e., family, organizations, communities, and society) on individuals' health and disease prevention (Coreil, 2010; Sallis & Owen, 2015). Figure 1 of the SEM provides an image of five concentric but connected circles, with the individual level placed in the center, surrounded successively by the interpersonal, organizational, community, and society/policy levels (Golden & Earp, 2012). The individual is at the center of Figure 1 (i.e., the lowest concentric layer) to signify a central premise of the SEM that individuals' health promotion and prevention behaviors are influenced by higher level social networks, organized groups, and policies (Golden & Earp, 2012). Each successive layer of Figure 1, starting from the individual at the center, as symbolized in the diagram by concentric layers like those of an onion, is embedded in higher levels (Golden & Earp, 2012). That is, individuals are part of interpersonal networks such as families and friends. These networks of people with common goals make up organizations. In turn, the networks and organizations are building blocks of communities. Various communities form state, regional, and federal levels of society with common policies. Consequently, higher levels of influence likely have a more significant impact by affecting more people. Public health advocates can use the SEM to identify, at different levels, health and prevention influences on individuals and ultimately use this understanding to design interventions to enhance population health and disease prevention.

Factors at different levels of the SEM might have influenced vaccine hesitancy in my study population. As shown in Tables 1 and 2, each of my independent, dependent, and survey weight adjustment variables applied to a level of the SEM (see Figure 1). External factors might also have influenced vaccine hesitancy, as detailed in Chapter 5. First, Brown et al. (2016) found that the increase in internet and social media use in the United States between 2009 and 2016 was greater among lower income than higher income Hispanic families (see Figure 1). These nationwide media changes might have influenced vaccine hesitancy in Bexar County more in low- than high-income Hispanics. Second, Chido-Amajuoyi et al. (2021) found a substantial nationwide decline in awareness of HPV and the vaccine in low-income Hispanics between 2013 and 2018 (see Figure 1). Third, Garza (2017) noted the American Cancer Society and local organizations implemented the Mission: HPV Cancer Free program in Bexar County in 2017 and 2018 to improve HPV vaccination in low-income families (see Figure 1). This program could have influenced vaccine hesitancy at the organization level by training vaccine providers and the community level by educating parents (American Cancer Society, 2020b). To conclude, each of my study variables and external factors might have influenced vaccination hesitancy in Bexar County at different levels of the SEM.

Figure 1

The Socioecological Model of Influences of HPV Vaccination



Note: Adapted from "Improving Human Papillomavirus Vaccination Uptake Among College Students: A Socioecological Perspective," by B. Lanning, M. Golman, & K. Crosslin, 2017, *American Journal of Health Education, 48*(2), p.118. Copyright 2020 by Taylor & Francis Informa. Adapted with permission, as shown in the Appendix.

The SEM provides a visual representation of fluid bidirectional relationships of influence among persons, groups, and their contexts. Systems thinking regarding health promotion and prevention in which there are reciprocal influences between the personal, interpersonal, organizational, community, and society/policy levels is the basis of the SEM, as depicted visually in Figure 1 by the connection of the concentric circles (Sallis & Owen, 2015). For example, a reciprocal relationship could exist in a community or medical practice between the general strength of provider recommendations for parents to have their child vaccinated against HPV and the overall parental risk versus benefit perceptions of HPV vaccination. Public health experts would expect an improvement in the overall quality of vaccine provider recommendations to reduce parental vaccine hesitancy and increase HPV vaccine coverage in a medical practice and community (Dempsey et al., 2019). Conversely, medical providers would likely be more hesitant to recommend the HPV vaccine strongly for teens if they practice in a community with a strong presence of people opposed to vaccination, contributing to a reduction in vaccination coverage (Karafillakis et al., 2016, 2019). Health promotion and prevention practitioners have used the SEM to understand the relationships of influences among multiple levels and identify how they can intervene to promote health and prevent illness (McLeroy et al., 1988; Sallis & Owen, 2015). Examination of reciprocal associations among individuals, the people with which they interact, organized groups, communities, and society might provide vital information to develop interventions to promote health and prevention.

Multilevel interventions used to promote HPV vaccination illustrate the premise inherent in the SEM that higher level social networks, organized groups, and their context influence individual behavior. At the intrapersonal level, vaccine advocates might influence individuals to use the HPV vaccine by increasing their understanding of HPV illness and the vaccine and improving their attitudes and beliefs about vaccination (Rimer, 2018; Walling et al., 2016). Vaccination promoters generally use interventions at the interpersonal level to improve vaccine acceptance of parents by affecting social and cultural norms and getting past individual barriers (Brunson, 2013; Fu et al., 2019; Kowalczyk Mullins et al., 2015; Opel & Marcuse, 2013; Rimer, 2018). Provider recommendations and assistance in making vaccination more convenient are examples of strategies that might be useful to improve vaccination coverage at this level (Opel, Heritage, et al., 2013). At the organizational level, interventionists facilitate vaccine acceptance in parents by shaping institutional systems and standard procedures, such as promoting vaccination reminders for providers and parents (Doucette et al., 2019; Rimer, 2018). Efforts at the community level act as a catalyst to address parental vaccine hesitancy by using to the involvement of community stakeholders, such as media and advocacy groups, to provide communication and support (CDC, n.d.-b; Gollust et al., 2016; Margolis et al., 2019). Finally, at the policy level, interventions to improve HPV vaccination coverage entail understanding, clarifying, and carrying out policies at all levels of government (Kaiser Family Foundation, 2021; Keim-Malpass et al., 2017). For example, interventionists might collaborate with a vaccine promotion coalition to explain policy decisions, such as an insurance mandate, to the public. Interventions to facilitate

HPV vaccine use for teens provide examples of how the SEM serves as a sound foundation for understanding and positively changing factors affecting parents' decision to vaccinate their children.

Appropriateness of the SEM to This Study

In this study, the SEM provided a valuable guide for studying the predictive correlates of HPV vaccination in Hispanic youth. HPV vaccine uptake in adolescents is a multifactorial phenomenon that depends on many barriers and facilitators at different levels that vary among populations (Brewer & Fazekas, 2007; Ferrer et al., 2014; Holman et al., 2014; Lacombe-Duncan et al., 2018; Radisic et al., 2017). For example, these determinants of vaccine use for adolescents include demographic characteristics of parents and parents' perceived barriers to vaccinating their teens at the intrapersonal level (Das et al., 2016; Lechuga et al., 2011). In addition, predictors of youth vaccination include providers' recommendations for parents to vaccinate their children at the organizational level and government insurance to subsidize the cost of vaccines for families at the policy level (Das et al., 2016; Lechuga et al., 2011). As applied to the current study, the SEM holds that one would expect the variables of parents' income level and perceived barriers to vaccinating their child to influence or explain the variables of intent (and no-intent) to vaccinate their child and vaccine uptake. For instance, RQs1 to 3 had the same independent (predictor) variable of income level. In RQs1, 2, and 3, the dependent (outcome) variables were parental intention to have their child receive the HPV vaccine and HPV vaccine uptake and series completion in youth, respectively. In short, the SEM was suitable for this study involving multilevel influences of HPV vaccine uptake.

The SEM that formed the theoretical basis for this study was also suitable for use with available data for this study and the population under consideration. The NIS-Teen dataset includes data on these and other predictors (influences) at each SEM level on HPV vaccine uptake by teens (CDC, n.d.-a, 2016a, 2020b). A thorough awareness of the circumstances at multiple levels of the SEM impacting HPV vaccination in distinct groups of people could allow vaccine advocates reaching them using tailored interventions. In turn, advocates could attain goals for a high prevalence of immunization of adolescents. Ultimately, the SEM served as the framework for understanding how the decisions of parents, medical practitioners, and policymakers at various levels might influence the use of the HPV vaccine in the undervaccinated Hispanic population of this study.

A gap exists in the literature on using the SEM, the basis of this dissertation, for HPV vaccine hesitancy research. Ferrer et al. (2015) and Larson et al. (2015) pointed out that much of the research on vaccine hesitancy primarily draws on behavior change models, especially the health belief model and theory of planned behavior. HPV vaccine utilization in adolescents is a multifactorial phenomenon that depends on several factors at the personal, interpersonal, organizational, community, and political/policy levels (Brewer & Fazekas, 2007; Das et al., 2016; Holman et al., 2014). Therefore, these behavioral change models are inappropriate for adequately investigating the significance of social, cultural, and economic factors as determinants of health behavior related to vaccine hesitancy (Krawczyk et al., 2015; Lacombe-Duncan et al., 2018; Larson et al., 2015). Consequently, public health professionals need an alternative theoretical approach to organize factors influencing HPV vaccination, design interventions to increase HPV vaccination of youth, and guide future research.

Need for the SEM Versus Behavior Change Models

The SEM is more appropriate for this study than the behavior change models. In health promotion, most studies have continued to include only one or two determinants of health or interventions at the individual and interpersonal level (Richard et al., 2011; Wold & Mittelmark, 2018). In contrast to these behavioral change models that focus on the individual and interpersonal level, the SEM is suitable for investigating the significance of predictors of HPV vaccine uptake and completion at various levels (Allen et al., 2010; Coreil, 2010; Crosby et al., 2011). Researchers need to ground more studies on the determinants of HPV vaccine hesitancy of Hispanic parents in ecological theories such as the SEM (Ferrer et al., 2014; Galbraith et al., 2016; Glenn et al., 2015). This study of HPV vaccine use by Hispanic teens in Bexar County, Texas, examined the influence of not only personal and interpersonal factors but also cultural, social, and other higher level influences while ensuring the sample was representative of the population under consideration. In short, using the SEM instead of behavioral models allowed me to examine the effect of different levels of influence on the HPV vaccination of youth.

Value of the SEM Versus Other Ecological Models

The SEM is a suitable ecological model for this study. Since the introduction of the SEM by McLeroy et al. (1988) as the first ecological model, there has been an increase in the number of researchers studying multilevel determinants of health-related behaviors and multilevel interventions (Richard et al., 2011; Wold & Mittelmark, 2018). In addition, in the field of health promotion and public health, there has been an evolution in the comprehensiveness of the ecological models (Richard et al., 2011; Wold & Mittelmark, 2018). Nonetheless, because researchers can use the NIS-Teen data to analyze psychosocial, demographic, socioeconomic, and other high-level influences of HPV vaccine uptake and completion, this data is compatible with the current SEM-based research (CDC, 2015b). Despite increased use and improvement in alternative ecological models, the SEM is still a relevant model for this study.

The SEM is more suitable for this study than other multilevel ecological models. The NIS-Teen data is not appropriate for use with ecological models based on a coconstructive relationship between the individual and their social context, as described by Burke et al. (2009), which are more elaborate than the SEM. Second, other ecological models are inappropriate for use in this study. The theory of triadic influence is another ecological model that allows for an overall view of health behavior (Nyambe et al., 2016). Still, unlike the SEM, Nyambe et al. consider it unsuitable for cross-sectional studies on vaccination, such as the present study. Likewise, the host-agent-environment ecological model is inapplicable to this study because it focuses on morbidity and mortality as outcomes and collapses the physical and social environment into a single source of influence (McLeroy et al., 1988). For these reasons, the focus of my investigation on explicating correlates to HPV vaccination uptake in Hispanic youth using the NIS-Teen data is in alignment with the SEM but not with some other ecological models.

Usefulness of SEM in Health Promotion Research

Health promotion advocates have applied the SEM in several areas. They have used the SEM to promote healthy behaviors, including nutrition, physical activity, smoking, sexual behavior, alcohol/substance use, disease screening, vaccination, and more (Golden & Earp, 2012; Sallis & Owen, 2015). Social and behavioral researchers define health behavior in various ways depending on the behavior under consideration, the purpose of the study or intervention, the population of interest, and other circumstances (Sallis & Owen, 2015). Health behavior can pertain to the overt and observable actions of individuals, groups, and organizations that are health enhancing or health impairing, as well as the determinants, correlates, and consequences of those actions (Glanz et al., 2008; Sallis & Owen, 2015). Alternatively, health behavior can be less visible mental events, feeling states, and other cognitive attributes of individuals (Glanz et al., 2008). Summing up, health promotion practitioners have applied the SEM in different areas of their field to study and improve both explicit and implicit health behaviors.

Public health workers need to use theoretical frameworks such as the SEM to develop and test interventions to enhance health behaviors and, in turn, the health of populations. As the ultimate goal of health behavior research and practice is to improve population health, health advocates need to transform their understanding of health behavior into interventions to improve health (Sallis & Owen, 2015). Health behavior professionals formulate, use, and test theoretical frameworks to aid them in producing healthy behaviors and mitigating unhealthy ones (Babbie, 2016; Coreil, 2010). Sallis and Owen (2015) asserted that a dynamic exchange among theory, research, and practice that build on each other is most likely to achieve these behavioral changes. In other words, public health experts base the most promising research and practices on theory and ground the most valuable theories in research and real-life lessons. Public health workers promote health through a cycle of interacting activities: research into behavior determinants and methodologies, research on behavior change intervention, research to track population health, application of knowledge, and dissemination of programs (Sallis & Owen, 2015). Health behavior professionals synthesize and critically appraise the literature on the results of these endeavors in periodic updates to identify promising interventions to reduce disease burden and improve health. However, Sallis and Owen warned there are too little use and testing of theory and practice in various areas of health behavior. Therefore, public health leaders need to apply and test theory more through research and real-life situations in an iterative process in which theory, research, and practice converge.

The SEM is suitable to aid researchers and practitioners in better understanding and addressing problems in health promotion. As there is a complicated relationship between psychological, social environmental, and physical environmental influences and health behaviors, health promotion researchers should consider factors at each level using a multilevel framework (McLeroy et al., 1988). The SEM can fulfill this need to study health behavior and its change (McLeroy et al., 1988). Health promoters influence these actions through individual, interpersonal, organizational, community, and policy factors. Accordingly, the SEM is likely helpful in health promotion research and practice. Health promotion researchers could use this ecological model to design studies on the social determinants of disease and health and analyze their findings. The SEM could guide health promotion professionals in explaining and predicting behaviors and suggesting ways to achieve desired behavior change (Sallis & Owen, 2015). The SEM is proper to understand better the correlates of health behaviors at multiple levels and improve these behaviors.

An eclectic group of health promotion practitioners uses the SEM as a guide to intervening in promoting health behavior changes. Health promotion professionals must collaborate in applying the SEM to research and practice because they need their unique expertise at different levels of this model (Mittelmark et al., 2012; Sallis & Owen, 2015). Health psychologists and educators work at the individual level; clinical, public health, and social researchers work at various levels of the health and social welfare systems (Mittelmark et al., 2012). Professionals in fields other than health also contribute to the area of health promotion (Sallis & Owen, 2015). For example, policy analysts act at the macro levels of community organizations (Mittelmark et al., 2012). These professionals use the SEM and their knowledge of disease and health predictors to develop, implement, and evaluate community-wide interventions (Sallis & Owen, 2015). That is, they carry out activities at various levels of the SEM to bring about changes at the same or other levels with the ultimate aim of improving population health (McLeroy et al., 1998; Stokols, 1996). In this context, researching and addressing problems of population health in multiple areas of health behavior through the lens of the SEM requires the contributions of professionals with varied expertise and perspectives.

Health behaviorists often use the SEM to aid in developing interventions. Researchers use the SEM to help design studies of health behaviors' determinants (Sallis & Owen, 2015). However, the primary purpose of the SEM is to guide the development, implementation, and evaluation of health behavior interventions (Sallis & Owen, 2015). A principle of the SEM is the interconnectedness of the various levels of health influence (McLeroy et al., 1988). Therefore, health promotion professionals, who use this framework to guide their research and interventions, must view the complexity of health processes in a systemic manner (Mittelmark et al., 2012). For instance, interventions to improve HPV vaccine coverage need to be multifactorial because low coverage is due to multiple factors at the different levels of the SEM, including parents, medical providers, health systems, communities, and policies (Markowitz et al., 2018). In light of this, the SEM is useful in developing multilevel interventions to improve population health.

Extent of Use of SEM in Health Promotion

Although the SEM is helpful in understanding and improving health-related behavior, health behavior researchers and practitioners do not currently use this model extensively in many areas. The use of the multitude of available theoretical frameworks and models in the social sciences is challenging for researchers and practitioners who strive to promote health behavior change (Sallis & Owen, 2015). Still, their use could be beneficial. Over the past three decades, researchers have used only a few theories and models in multiple studies (Sallis & Owen, 2015). These approaches were primarily behavior (lifestyle)-focused versus more comprehensive and multilevel and included the transtheoretical model, social cognitive theory, and the health belief model (Golden & Earp, 2012; Sallis & Owen, 2015). Between 1989 and 2008, less than 10% of 132 intervention studies published in *Health Education Quarterly* identified the SEM as the basis for action (Golden & Earp, 2012). These interventions rarely targeted higher institutional, community, or public policy levels and seldom focused on more than one or two ecological levels (Golden & Earp, 2012). Leading health promotion agencies in the United States have called for developing interventions on social and behavioral health determinants that focus on multiple levels of influence on health behavior change (Healthy People.Gov, 2022; Smedley et al., 2001). Despite this call over the past two decades to use the SEM more, researchers and practitioners have found it challenging to do so (Wold & Mittelmark, 2018). In summary, over the past 30 years, the SEM has remained a subordinate model in health behavior research and practice, despite calls for increased use.

Public health professionals are also concerned about how they use or do not use theories in research and practice. Although there have been calls for more operationalization, application, evaluation, and refinement of health behavior theories in recent decades, progress has been slow (Noar & Zimmerman, 2005). Sallis and Owen (2015) reviewed and classified the level of use of health behavior theories in 69 articles from 2000 to 2005 (139 theories). In about two thirds of these reviewed studies, the authors specified the application of theory but did not apply the theory or apply it to a limited extent (Sallis & Owen, 2015). In only 17.9 percent of these studies, the authors used several constructs of the specified theory in the components of their research (Sallis & Owen, 2015). Researchers tested theories in another 3.6 percent of studies by measuring or evaluating more than half the constructs or by comparing two or more theories (Sallis & Owen, 2015). Finally, in only 9.4 percent of these studies, the authors used constructs specified, measured, and analyzed in their research to build a new, revised, or expanded theory (Sallis & Owen, 2015). Other health promotion researchers have made similar observations (Davis et al., 2015). These results indicate a need for intervention designers and researchers to more thoroughly operationalize, apply, test, and modify health behavior theories to advance the health promotion field further.

On the other hand, in a limited number of areas of health promotion, practitioners are more commonly using the SEM. An early and exemplary application of all the levels of the SEM was in the development of comprehensive, multilevel interventions for tobacco control (Sallis & Owen, 2015). As one of the first ecological models of health behavior formulated 30 years ago (McLeroy et al., 1988), the SEM has become a more commonly used model since the late 1990s (Sallis & Owen, 2015). Richard et al. (2011) reported that practitioners have increasingly applied the results of studies using the SEM to improve individuals' physical activity and nutrition. Furthermore, researchers and practitioners have employed all levels of the SEM in studies on the inherently multilevel issue of implementing and disseminating health promotion interventions (Tabak et al., 2012). During the recent two decades, health promotion practitioners have increasingly used the SEM in particular areas of health promotion.

Use of the SEM in Vaccine Use Studies

Influenza Vaccine Use Studies

Researchers have used the SEM in studies of the determinants of influenza vaccination. During the 2009 H1N1 influenza pandemic, Kumar et al. (2012) analyzed the impact of potential influences of H1N1 vaccination, at five levels of the SEM, on eligible recipients' intention to receive the vaccine in the next month and the ultimate receipt of the vaccine. Researchers recruited the sample of participants from the Knowledge Networks panel of 55,000 individuals representing 97% of the United States population (Hays et al., 2015; Kumar et al., 2012). The authors examined, apparently, for the first time, the impact of factors at multiple levels thought to be influential in the decision of individuals to receive the influenza vaccine (Kumar et al., 2012). The analysis of self-reported survey data indicated that the participant's decision to receive the H1N1 vaccine derived from not only their personal view of risk but also their perception of the extent of vaccination in their networks and the risk of disease in their communities. These findings support the value of the SEM in studying social determinants of influenza vaccine use at the intrapersonal and interpersonal levels.

Other multilevel factors were found to influence study participants' decision receive the H1N1 vaccine. The decision of individuals to receive the vaccine depended on whether they had an endorsement from a medical provider and a policy preference for access to the vaccine from the federal government (Kumar et al., 2012). The findings validate the theoretical basis of the SEM, proposed by McLeroy et al. (1988), in which individuals are assumed to be an intricate part of their social networks, which are, in turn, entwined in institutions and communities and affected by policies. In addition, these results mean public health practitioners must intervene at multiple levels to promote HIN1 vaccine uptake best. The study of Kumar et al. (2012) demonstrates the importance of the SEM in understanding the complexity of the vaccination decision-making process and identifying strategies at each level to increase vaccine uptake.

Other researchers have extended the SEM to study H1N1 vaccine use during the 2009 pandemic. Boerner et al. (2013) used focus group data to explore in-depth the factors at four levels of the SEM that influence the receipt or nonreceipt of the H1N1 vaccine at the participant versus aggregate level. Therefore, the researchers could assess not only factors they preconceived to influence H1N1 vaccination, using theory or other means but also those of utmost importance among individuals. Unlike Kumar et al. (2012), who produced aggregate data from a large nationwide random sample, Boerner et al. were unable to generalize their findings to a Canadian population beyond their sample. However, Boerner et al. assessed the interaction and relative weight of factors across fifteen focus groups with 143 participants at multiple levels of the SEM, in particular, decisions to receive or refuse the H1N1 vaccine. In their mixed method case study, Boerner et al. quantified the number of vaccinated and nonvaccinated participants who identified specific factors to be influential in their decision to receive or not the H1N1vaccine. The authors then designated how these participant-identified factors influenced their decision to receive or not the H1N1 vaccine, and they presented cases in which one factor overrode the impact of others on an individual’s choice. For example, 23 out of 143 participants stated that the distribution and availability of the H1N1 vaccine influenced, to some extent, their decision to receive the vaccine. Of 16 nonvaccinated participants, all stated that this reason was a negative influence. In contrast, five vaccinated individuals affirmed this reason positively influenced their decision, and two noted that personal risk perception and altruism outweighed the inconvenience. The application of the SEM in this mixed method study demonstrates the usefulness of this model in studying vaccination decision influences.

HPV Vaccine Use Studies

Based on the SEM, government-funded research is ongoing in the United States to better understand the causes of low HPV vaccine use in individual states and potential solutions. Within a few years after introducing the HPV vaccine in 2006, the national coverage of girls with this vaccine began to lag behind vaccines released at about the same time for adolescents (Walker et al., 2017). The other adolescent vaccines were tetanus, diphtheria, pertussis (Tdap), and quadrivalent meningococcal conjugate (MenACWY). In 2014, the President's Cancer Panel responded to this low national HPV vaccine coverage by making recommendations to address obstacles to HPV vaccination across the patient, provider, and health system/policy levels (Rimer et al., 2014). This panel emphasized that public health workers can best overcome shortfalls in HPV vaccination with interventions at multiple levels of the SEM (Rimer, 2018). Also, the panel stressed that vaccine promoters need to consider the preferences and needs of state residents and align strategies to increase uptake with the existing medical systems, assets, and policies (Rimer, 2018). The National Cancer Institute answered the panel's call for action by providing research funding to states with low HPV vaccine uptake to do environmental scans of local factors that might reduce uptake (Healthcare Delivery Research Program, 2021). States, in turn, used this support to identify deterrents and catalysts of HPV vaccine uptake at different levels of the SEM and multilevel strategies needed to increase coverage (Healthcare Delivery Research Program, 2021). In 2014, the National Cancer Institute funded 18 cancer centers and health science universities across the country for 1 year with the long-term aim of building and expanding applied research programs to improve vaccine coverage (Rimer et al., 2014). Again, in 2017, the National Cancer Institute awarded funding to 12 National Cancer Institute-designated cancer centers in regions with low HPV vaccine coverage (Healthcare Delivery Research Program, 2021). This research to improve HPV vaccine uptake in areas of small use through multilevel and context-aligned approaches should decrease disparities in vaccine coverage. Ultimately, this work could lead to decreased adverse outcomes of HPV infection, including several types of cancer in men and women.

National Cancer Institute-designated cancer centers applied the SEM to their research in diverse ways. In several studies, researchers examined factors related to HPV vaccine uptake using qualitative, quantitative, and mixed method approaches (Cartmell et al., 2018; Javaid et al., 2016; Warner et al., 2017). Researchers collected data from professionals involved in the care of adolescents at the county, state, or regional level through interviews, focus groups, or surveys (Cartmell et al., 2018; Javaid et al., 2016; Warner et al., 2017). Researchers conducted a statewide study in Texas between 2009 and 2014 to assess factors that might promote or impede HPV vaccine uptake in youth 9 to 17 years old (Javaid et al., 2016). Researchers formulated a web-based survey with open-ended, close-ended, and Likert-type questions based on a literature review of potential influences of HPV vaccine uptake as well as themes identified in the President's Cancer Panel report (Javaid et al., 2016; Rimer, 2018). The researchers tailored this data collection tool to vaccination staff in healthcare, administration, management, data entry, and other capacities to obtain insights into what might be currently facilitating and hindering HPV vaccine uptake in their settings (Javaid et al., 2016). The authors used the survey to assess vaccine providers' recommendations and patient education practices, views on parents' reasons for refusal, understanding of uptake barriers, administration status (i.e., ordering, stocking, and payment), and use of alert and documentation systems. The researchers reported descriptive statistics of their analysis of responses from 1,132 participants. This examination at different levels of the SEM of providers' views regarding what is influencing HPV uptake across Texas aligns with a call from the President's Cancer Panel for comprehensive and context-based research to promote HPV vaccine uptake.

In investigating factors influencing HPV vaccine coverage in Utah, researchers used methodological approaches similar to those used in the Texas environmental scan by Javaid et al. (2016). Warner et al. (2017) assessed HPV vaccination in Utah based on the input of 254 providers who completed a web survey. The researchers recruited participants between 2014 and 2015 from pediatric, family medicine, and nursing organizations across Utah, obtaining 75,136 participants. The aim of this study was twofold, with a quantitative and qualitative component. First, the authors compared quantitatively medical providers' knowledge of HPV vaccines and vaccination guidelines by their demographics (e.g., age, religion) and practice features (e.g., specialty type, patient load, and the form of payment) to identify provider groups lacking knowledge. Second, the researchers analyzed the content of providers' responses to four open-ended questions designed to seek their views regarding what might be impeding HPV vaccination in their region and possible ways to improve uptake. As medical providers have experience in the health system and work closely with patients and parents, they might have insights on clinical obstacles to uptake and approaches to improve vaccination. Warner et al. (2017) chose variables at different levels of the SEM related to providers' demographics and practice attributes, HPV vaccine knowledge measures, and perceptions of vaccine uptake barriers and interventions. In particular, these authors selected factors influencing HPV vaccine uptake at the individual (i.e., patients and parents), interpersonal (i.e., providers), organization, and public policy levels, as described by McLeroy et al. (1988). Warner et al. (2017) also based their choice of variables on a review of the literature and their prior research on the influences of HPV vaccination in Utah. In short, the purpose and methodological approach of this research in Utah were similar to the study by Javaid et al. in Texas, and HPV vaccine coverage for youth is low in both states.

Literature Review Related to Key Concepts and Variables

Methodological Strengths and Limitations of Similar Studies

The methodological approaches used in the present study build on similar studies on the influences of HPV vaccine coverage in teens. Unlike previous studies, this study involved current data from NIS-Teen interviews with parents of teens during the years

2016, 2017, and 2018. In contrast to previous research on populations at the national and state level, the present study focused on a more homogeneous study population of Hispanic families in Bexar County, Texas. In addition, the present study combines and extends the strengths of approaches used in investigations by Kumar et al. (2012), Jeyarajah et al. (2016), and Cheruvu et al. (2017) as well as those by Javaid et al. (2016) and Warner et al. (2017) discussed in the previous section. Thus, I might compare my research approach and results to other studies examining the influence of parents' income levels and perceptions on their intent to have their child vaccinated against HPV and the ultimate vaccination. The innovative approaches taken by the authors of these studies inspired me to build a dissertation of superior methodological quality in the field of HPV vaccination hesitancy research. In turn, I could produce the valid, reliable, and meaningful results to achieve my study objectives. Next, I detail and compare some of the strengths and limitations of these studies.

The approaches used in the study by Kumar et al. (2012) had strengths that I applied to the current research. The outcomes measured by Kumar et al. (2012) were the intention to receive the H1N1vaccine and the vaccine's initiation (i.e., uptake of one or more doses). The authors analyzed, using logistic regression, the association of sociodemographic factors with both intent to use the H1N1vaccine and initiation of the vaccine series. The authors studied the relationship of personal (e.g., vaccine safety concerns), interpersonal (e.g., provider recommendation), community, organizational, and systemic factors with both outcomes. In brief, Kumar et al. (2012) studied the impact of factors, at each level of the SEM, on H1N1 influenza vaccine use following the 2009 outbreak in the United States. This study was one of the first involving the assessment of influences on vaccine use at all levels of the SEM. Like Kumar et al. (2012), I gained support for predictive relationships between independent and dependent variables by applying a multilevel approach.

Kumar et al. (2012) also designed their study to mitigate the frequent shortcoming of cross-sectional study designs. Kumar et al. pointed out that a frequent limitation of nonexperimental, cross-sectional studies of vaccine uptake, such as their study and this one, is a reverse correlation, as described by Campbell and Stanley (2015). For instance, increased parental concern about the safety of the HPV vaccine could result in decreased vaccine use among youth (Ołpiński, 2012). Conversely, declining vaccine use in a community due to hesitancy among healthcare workers (Karafillakis et al., 2019) could lead to an increased perception of parents that the vaccine is unsafe. To account for the possibility of reverse correlation, Kumar et al. (2012) included the dependent variables of both individuals' intent to use the HPV vaccine and vaccine uptake. An independent variable (e.g., fear of cervical cancer) that is similarly correlated with an intention (e.g., plan to use a vaccine) and behavior (e.g., use of the vaccine) is more likely to be a determinant of the behavior than an independent variable only correlated with the behavior (Kumar et al., 2012). Thus, by examining the influence of independent variables on both intent to use the H1N1 vaccine and vaccine uptake, Kumar et al. had more support for a predictive relationship between their independent variables and vaccine uptake. My dependent (outcome) variables for RQs1, 2, and 3 were parental intent to have their child vaccinated against HPV, vaccine series initiation, and completion, respectively. Therefore, I applied a similar approach to reduce the chance of reverse correlation between my independent and dependent variables.

In another study, with strengths similar to mine, some gaps existed in the methodological approach. Cheruvu et al. (2017) studied a subgroup of parents with unvaccinated teens who did not intend to have their children vaccinated against HPV. The researchers examined, using logistic regression, the relationship of sociodemographic factors with “no intent” of parents to have their child vaccinated against HPV. In addition, they studied the association of sociodemographics with parental reasons (concerns) for not intending to vaccinate their child. Some reasons for lack of parental intent studied at the personal level of the SEM by Cheruvu et al. (2017) included lack of knowledge of HPV-associated disease, vaccine safety and effectiveness concerns, and misperceptions related to the use of a vaccine to prevent a sexually transmitted disease. Cheruvu et al. (2017) examined parental reasons for not intending to use the HPV vaccine at the organizational (e.g., provider recommendation), community and sociocultural (e.g., religious beliefs), and policy and society (e.g., a requirement for school entry, cost) levels of the SEM. Furthermore, the authors studied trends in the relationship of sociodemographics with “no-intent” to vaccinate teens. Although the researchers examined influences at different levels of the SEM on "no-intent" to use the vaccine, they did not explore the impact of sociodemographics and parental concerns on vaccine uptake. Consequently, the study by Cheruvu et al. had several strengths, but they could have improved it by including vaccine uptake as another outcome (dependent) variable.

Gaps existed in the approach used in other research similar to the present study. Jeyarajah et al. (2016) used data from the 2008-2011 NIS-Teen to study the association of sociodemographics with the initiation of HPV vaccination and missed vaccination opportunities. Unlike Kumar et al. (2012) and Cheruvu et al. (2017), these authors did not assess the influence of multilevel factors (i.e., independent variables) on the outcomes of HPV vaccine uptake or missed clinical opportunities (Jeyarajah et al., 2016). In addition, Jeyarajah et al. (2016) did not assess the relationship of sociodemographics with peoples' intent to use the vaccine, as did Kumar et al. (2012) and Cheruvu et al. (2017). Thus, Jeyarajah et al. might have improved their study by examining influences, at multiple levels of the SEM, on HPV vaccination and missed vaccination opportunities and studying the association of sociodemographics with the parental intent to vaccinate their child. I used insights gained from analyzing the study of Jeyarajah et al. (2016) to inform the design of this study.

Ongoing Efforts in Research and Practice to Increase HPV Vaccine Coverage

Nationwide Aims to Increase HPV Vaccine Coverage

The President's Cancer Panel (PCP) set three goals to increase HPV vaccine use in the United States. In 2014, the PCP pointed out public health workers could increase HPV vaccine use by achieving three critical goals (Rimer et al., 2014). The PCP summarized the specific objectives and corresponding individuals and entities responsible for achieving each goal in a report. The PCP identified responsible stakeholders as state and national governments, clinical and public health practitioners, and nonprofit organizations with a public health focus. Responsible stakeholders also included parents, youth, and other public members. First, the PCP called for a reduction in the frequency that providers fail to take advantage of patient visits to recommend or give the HPV vaccine. Researchers have consistently shown a positive influence of physician endorsement on HPV vaccine series initiation and completion (Burdette et al., 2017; Fisher et al., 2013; Gilkey et al., 2016; Gilkey & McRee, 2016; Mohammed et al., 2016). Second, the PCP set an improvement goal in the acceptance of HPV vaccination by parents and other caregivers as well as teens. Third, the PCP recommended optimizing access to HPV vaccines by ensuring their affordability and convenient administration. In summary, the PCP identified paths to increase HPV vaccine use and provided specific guidance on how to do so to individuals and groups responsible for HPV vaccination.

The Impact of Missed Vaccination Opportunities on HPV Vaccine Coverage

The main reason for suboptimal HPV coverage by the age of 13 in the United States is likely failure to vaccinate youth against HPV when clinical opportunities arise before this age. Immunization at an older age results in a lower level of immune protection from infection (Jeyarajah et al., 2016). Using a sample of 33,707 girls from the 2008 to 2013 NIS-Teen data sets, Jeyarajah et al. (2016) examined the proportion of unvaccinated girls under age 13 who had missed at least one opportunity for HPV vaccination. Jeyarajah et al. defined at least one missed opportunity as a medical visit with a vaccine provider, on or after age 11 years and before age 13 years, during which a girl received at least one vaccine but did not get the 1st dose of the HPV vaccine. Missed clinical opportunity is one of the most common reasons providers do not vaccinate youth against HPV (Rimer et al., 2014). The authors also estimated the potential coverage before age 13 years if these girls had not missed at least one chance to be vaccinated on time between age 9 and 12 years (Jeyarajah et al., 2016). Delay in receipt of the HPV vaccine, as recommended between ages 11 and 12, might lower the likelihood of later vaccination as fewer opportunities tend to be available at an older age (Jeyarajah et al., 2016). For girls who aged 13 in 2012 or 2013, 57.2% had not received at least 1 dose of the HPV vaccine (Jeyarajah et al., 2016). Among these unvaccinated girls, 80.1% missed at least one chance to get the HPV vaccine at age 11 or 12 years, and the authors estimated that coverage with one or more doses might have reached 88.6% if the girls had received the vaccine during these visits. By reducing missed vaccination opportunities for youth between the recommended ages of 11 and 12, providers might better protect adolescents and adults from HPV infection.

Predictors of Missed Vaccination Opportunities and Low HPV Vaccine Use

Healthcare-related sociodemographic factors are associated with missed vaccination opportunities and potentially achievable immunization coverage. Using NIS-Teen data, Jeyarajah et al. (2016) assessed the relationship of medical care-related sociodemographic variables with missed clinical vaccination opportunities for girls before age 13. The authors also estimated the population vaccination coverage achievable by immunizing the girls on time. Some sociodemographic variables examined were whether the adolescent had a provider recommendation, an 11- to 12-year preventive care visit, a private healthcare provider, and insurance coverage. The authors found that missed vaccination opportunities were usually high, ranging from 60.4% to 93.3% in the examined sociodemographic groups. In addition, potentially attainable vaccination coverage was high across groups, ranging from 74.9% to 96.7%. Teens with less than 80% achievable coverage were usually less likely to have a visit for vaccination at a private facility, provider recommendation, wellness visit at age 11 to 12 years, or health insurance. Thus, barriers to health care might negatively affect HPV vaccination of certain groups, including lack of insurance, provider stability, and vaccine affordability.

Another study revealed a need to encourage HPV vaccination of teens at an earlier age. Jeyarajah et al. identified missed HPV vaccination opportunities in 93.3% of patients who had a preventive visit at ages 11 to 12 and 87.1% of those who got a provider's recommendation. Even though 61.9% of patients received an endorsement, providers might not have addressed parents' concerns and made a strong recommendation for vaccination. Cumulative coverage with one or more doses of HPV vaccine was 47% in girls under age 13, 54% in those under 14, and 60% in those under 18. Provider and parental preference to have teens vaccinated against HPV at an older age might contribute to the higher vaccination after age 13. Thus, parental counseling, strong HPV vaccine endorsements from providers, and perhaps better healthcare access could improve vaccine coverage.

The quality of HPV vaccine recommendations in the United States might be low. In 2014, Gilkey, Malo, et al. (2015) conducted one of the first studies to assess the quality of HPV vaccine endorsements nationwide by surveying 776 pediatricians and family physicians online. The authors evaluated the quality of HPV vaccine endorsement based on urgency, timeliness, strength, and consistency criteria. They defined urgent recommendations as being done on the same day as the medical visit and timely ones completed by age 11 or 12. Providers made strong endorsements by stressing the importance of vaccination. They gave consistent recommendations by doing so at the recommended age versus giving them on a risk basis by waiting until the child was sexually active. Providers could miss an opportunity to vaccinate and protect a child during their medical visit if one or more quality aspects of the recommendation are low. Gilkey, Malo, et al. (2015) reported that a large percentage of physicians recommended the HPV vaccine in a weak manner (27%), behind schedule (26% for girls, 39% for boys), without urgency (49%), or inconsistently on a risk basis (59%). The authors noted that the overall quality of the provider recommendations was lower if the providers were uncomfortable discussing the HPV vaccine with parents or underestimated the degree to which parents and their children valued the vaccine. The researchers found that the quality of recommendations was higher when providers firmly recommended the vaccine instead of providing vaccine information and seeking questions. Similarly, Shay et al. (2018) found through their exploratory analysis from 2014 to 2015 of providers' communication with HPV vaccine-hesitant parents that engaging them and addressing their concerns led to high rates of same-day vaccination. Health authorities might be able to inform providers on how to make quality HPV vaccine endorsements by being aware of recommendation quality criteria and understanding factors that positively and negatively influence recommendations.

Higher quality provider recommendations for parents to have their child receive the HPV vaccine are associated with improved vaccination outcomes for youth. From 2014 to 2015 in the United States, Gilkey et al. (2016) examined the relationship between the quality of providers' HPV vaccine endorsement to parents and vaccination among their children. The researchers grouped parents by whether their provider advised them to receive the HPV vaccine and the quality of the recommendations, including none, low quality, or high quality. The researchers then evaluated the association of recommendation receipt and quality with vaccine initiation (i.e., $\geq$1 dose), series completion (i.e., 3 doses), refusal, and delay, using separate multivariable logistic regression models for each behavioral outcome. Of all parents in the study, 48% had no HPV vaccine recommendation, 16% had one of low quality, and 36% had one of high quality. Thus, only about one third of parents had a high-quality recommendation, and almost half had no guidance. Children of parents who received a high-quality endorsement to receive the HPV vaccine compared to none were 9 and 3 times more likely to initiate and complete the 3-dose series, respectively. In contrast, a low-quality recommendation was less strongly associated with HPV vaccine initiation and unassociated with completion. Compared to parents who received a low-quality endorsement, those who got a high-quality one from their providers were less likely to report that they refused or delayed the vaccination of their children. In an exploratory analysis from 2015 to 2016, Dempsey et al. (2019) found that a strong recommendation was associated with higher parental trust in the providers' information, increased vaccination urgency, decreased vaccination hesitancy, and increased uptake. These results highlight the value of high-quality HPV vaccine recommendations from providers to promote HPV vaccine use.

Strategies to Increase HPV Vaccine Use

Researchers have explored the factors influencing HPV vaccination psychologically to reveal their potential impact. Brewer et al. (2017) reviewed and consolidated findings on vaccination influences from research across diverse social, behavioral, and health sciences areas. These authors analyzed three major psychological factors that might shape the decision to vaccinate or not and help intervene to increase coverage. The first general premise for interpreting and taking action to improve vaccine use is that thoughts and feelings can motivate one to get vaccinated or not, and the second proposition is that social processes can do the same. The third psychological principle is that providers can use strategies to promote vaccination by leveraging directly. However, they should not try to change how people interact (social processes) or what people think and feel. For example, if parents intend to have their child receive the HPV vaccine, a reminder might help them follow through with their aim. Numerous studies have shown that the thoughts and feelings of individuals, as well as social processes, correlate with vaccine use (Brewer et al., 2017). However, most interventions used currently to change peoples' thoughts and feelings and social processes have a small or variable impact on vaccine use in randomized control trials (Brewer et al., 2017). The influences of thoughts, feelings, and social processes on vaccine use are areas for future intervention development and theory testing.

Researchers have obtained more promising results from studies on whether providers can promote vaccination by leveraging directly. Vaccine advocates can design effective strategies to intervene directly in vaccine use without attempting to change peoples' thoughts, feelings, or social context (Brewer et al., 2017). That is, interventions to increase vaccine use directly are currently available.

Researchers have proposed models to help vaccine policymakers, program managers, and practitioners choose the most relevant interventions to increase vaccine use in their context. Researchers recommend applying the most appropriate psychological principles and interventions to increase vaccine use based on current challenges to vaccination in a population (Betsch et al., 2015; Brewer et al., 2017). Betsch et al. (2015) developed a model to tailor interventions depending on whether vaccine underuse involves complacency, convenience, confidence, or costs. For example, practitioners might aim to increase peoples' perceived risk of disease if they are complacent about receiving a vaccine or challenge individuals' false beliefs if their confidence in vaccination is low. Brewer et al. (2017) proposed selecting the most effective intervention for a population based on whether people are in favor of, uncertain about, or disapproving of vaccination. For instance, if people favor immunization, an appropriate intervention might support their positive intention with a reminder. However, if people are indecisive about vaccination, providers might shape their behavior through an incentive to receive the vaccine. Brewer et al. (2017) identified 16 interventions to increase vaccine coverage and categorized and tabulated their likely positive impact (i.e., little or none, modest, or substantial) based on available noncausal and causal evidence (i.e., none, some, or substantial). In addition, the authors described when vaccine providers should expect each intervention to be beneficial, based on whether people have a favorable, ambivalent, or unfavorable intention to receive the vaccine and other challenges related to vaccination. Interventions shown through research to increase HPV vaccine use might be helpful in practice if tailored to the needs of the population of interest.

Several strategies increase the probability that youth receive the HPV vaccines when chances arise at the recommended age and dosage intervals. A missed clinical opportunity to vaccinate children against HPV is one of the main reasons for suboptimal HPV vaccine coverage (Espinosa et al., 2017; Jeyarajah et al., 2016). Provider recommendations and improvements at the health system level have the highest chance of reducing missed vaccination opportunities (Brewer et al., 2017; Rimer, 2018). The strength and quality of the provider recommendation are particularly crucial for parents who are questioning whether to vaccinate their children (Dempsey & O'Leary, 2018; Gilkey & McRee, 2016). Thus, there is a need for improvements in provider communication approaches and health care systems. Evidence-based practice to a strong recommendation includes presenting HPV vaccination as the social norm and affirming confidence in its safety and effectiveness (Gilkey & McRee, 2016). In addition, providers should recommend the HPV vaccine at the same time and in the same manner as other adolescent vaccines with a focus on vaccinating young adolescents and boys as well as girls (Gilkey & McRee, 2016; Rimer, 2018). A system-level improvement includes training providers to answer parents' questions and demonstrate confidence in the vaccine and its effectiveness (Gilkey & McRee, 2016; Rimer, 2018). Another system-level improvement involves informing providers and parents when teens are due or overdue for vaccination. In addition, healthcare administrators might facilitate access to protection by offering the HPV vaccine at all appointment types, making it easy to schedule appointments or get the vaccine on a walk-in basis, and allowing medical personnel to give the vaccine without a doctor's order (Rimer, 2018). Children who receive an endorsement to get the HPV vaccine in line with these guidelines are more likely to initiate and complete the series than those who get a low-quality recommendation or none (Gilkey et al., 2016). Strategies are available at the organizational level of the SEM, targeting improvements in providers' recommendations and HPV vaccination procedures in health systems.

Public health authorities disseminating educational messages on HPV vaccination is part of a multi-faceted approach to improve vaccine coverage. A goal set by the PCP in 2014 is an improvement in the acceptance of HPV vaccination by parents and other caregivers as well as teens (Rimer et al., 2014). The PCP partially attributes improvements in HPV vaccine coverage over the past decade to public health communication campaigns by the CDC, the American Cancer Society, and the vaccine manufacturer, as well as provider promotion of the vaccine (Rimer, 2018). However, HPV vaccination coverage falls short of the Healthy People 2020 goal of 80% coverage for boys and girls under the age of 13 (Bednarczyk et al., 2019; Healthy People.Gov, 2022). In addition, in a national survey in 2015, about half of parents of unvaccinated teens reported "no intent" to have their child vaccinated against HPV (Hanson et al., 2018). Reasons (concerns) for parents not intending to protect their child included lack of knowledge of HPV illness and the vaccine, no provider recommendation, safety concerns, a child not being sexually active, and misperception of vaccination being unnecessary (Hanson et al., 2018). The PCP has encouraged public health authorities and vaccine providers to continue efforts to increase parents' acceptance of the HPV vaccine by preparing and disseminating evidence-based education campaigns (Rimer, 2018). Communication campaigns are part of a multi-pronged approach by public health leaders to facilitate the HPV vaccination of youth in the United States.

Vaccine practitioners might more potently promote HPV vaccine coverage in HPV vaccine-hesitant parents by enhancing provider recommendations and vaccine access. Although public health messages are part of multiple intervention approaches to expand HPV vaccine coverage, Brewer et al. (2017) found that strategies to increase vaccine coverage by affecting parental knowledge, ideas, and emotions probably have a negligible effect. Rimer (2018) stated that a strong provider recommendation is perhaps the most potent way to increase hesitant parents' acceptance of the HPV vaccine for their children. In addition, interventions at the organization or community level of the SEM to promote access to the HPV vaccine might help increase vaccine series initiation or completion in children of parents with a neutral or positive attitude about vaccination (Rimer, 2018). Mohammed et al. (2016) found disparities in HPV vaccine recommendation based on adolescent and parent sociodemographic characteristics. The authors emphasized that providers must address these disparities to achieve optimal vaccine uptake among specific populations. Information on the association of adolescent and parental influences of HPV vaccination with vaccine use might inform how providers counsel parents about the HPV vaccine and make recommendations, as well as how public health experts conduct educational campaigns.

Researchers recommend strategies for overcoming barriers to access to the HPV vaccine and improving vaccine coverage for youth. Affordability and convenience of access influence the optimal HPV vaccine use in the United States (Rimer, 2018). Access barriers can contribute to not only low HPV vaccine use but also disparities in uptake across regions, populations, and health care settings (Rimer, 2018). In addition, the strategies required to address access barriers can vary from one context to another due to differences in laws, culture, collaborative organizations, and accessible resources (Rimer, 2018). Therefore, researchers need to make efforts to understand the current and potential access barriers to HPV vaccine use and appropriate interventions in different study populations at the local, state, and national levels. Various private and public sources, including the Affordable Care Act, Vaccines for Children Program, Medicaid, state-level Children's Health Insurance Programs, and vaccine manufacturers, currently cover HPV vaccine costs for most youth in the United States (Kaiser Family Foundation, 2021). The PCP Chair stressed that this coverage should continue so that cost does not become a barrier to HPV vaccination (Rimer, 2018). Immunization in nonmedical venues such as pharmacies or schools might be more convenient for some people, especially those without a consistent source of medical care (Rimer, 2018). Currently, receipt of the HPV vaccines in schools and pharmacies is challenging compared to vaccination in medical offices due to schools' complex billing, competing priorities, and small demand, and because of pharmacies' limited authority, insurance restrictions, and low demand (Rimer, 2018). Even so, promoting and giving the HPV vaccine in these alternative venues might increase access in some cases, such as in regions with fewer primary care providers and other obstacles. Vaccine advocates must consider various factors in developing and carrying out strategies to address access barriers to HPV vaccine use and ultimately improve vaccine coverage for youth.

Some Recent Progress in Improving HPV Vaccine Coverage

Public health innovators can do more despite their recent progress in reaching the goals set by the PCP to increase the use of the HPV vaccines. Researchers have explored strategies to avoid missed vaccination opportunities (Dempsey & O'Leary, 2018). As medical facilities provide the opportunity to educate parents and teens about the HPV vaccine and other preventative services, this venue is the optimal place for teens to receive the vaccine, especially the 1st dose (Rimer et al., 2014). However, the PCP recommends increasing opportunities to vaccinate teens at other venues, such as schools and pharmacies, to increase the chance of teens completing the series (Rimer et al., 2014). Medical staff favorably rated an assessment of the feasibility of a clinic giving the 1st dose and a pharmacy offering subsequent doses of the HPV vaccine (Doucette et al., 2019). In addition, the PCP chair stressed that the government programs must maintain the coverage of HPV vaccine cost for most youth to ensure that cost does not limit access to vaccination (Rimer et al., 2014). By reaching HPV vaccination coverage goals for children through these and other strategies, public health authorities can mitigate the cancers of adults later in life.

Intervention to Improve HPV Vaccination in Bexar County, Texas

During my study, the American Cancer Society and local foundations employed the Mission: HPV Cancer Free campaign in Bexar County. In 2015, 19.9% of Hispanic boys aged 13-17 years in Bexar County were up to date on the HPV vaccine, and 32.8% of Hispanic girls had received 3 doses of the HPV vaccine (CDC, 2016e). Therefore, the HPV vaccination coverage of teens in 2015 in Bexar County was well below the goal of 80% set by Mission: HPV Cancer Free. The primary reason for bringing the Mission: HPV Cancer Free program to Bexar County was to increase HPV vaccination in medically underserved youth (Munoz, 2017). Interventionists adapted this comprehensive campaign to low-income Bexar County families who received care from local and regional Federally Qualified Health Centers (Munoz, 2017). In addition, the program involved community-based HPV vaccination education for parents and families (Munoz, 2017; U.S. Preventive Services Task Force, 2021). The American Cancer Society (2020b) helped each Federally Qualified Health Center assess its current practice and develop a tailored program of vaccination-related quality improvement (American Cancer Society, 2020b; Munoz, 2017). The program's efforts included provider and parent education, outreach, and follow-up (American Cancer Society, 2020b; Munoz, 2017). Garza (2017) pointed out that educating parents about HPV and the diseases prevented by the vaccine was crucial to improving vaccine coverage, even when parents received a healthcare provider recommendation. The ultimate objective of the Mission: HPV Cancer Free program, as noted by Munoz (2017), was to sustain HPV vaccination coverage levels achieved through the program after the completion of the 2-year project.

HPV-Associated Disease and Vaccine Coverage

HPV, Burden of Infection and Sequelae, and Available Vaccine

Several strains of HPV contribute to anogenital warts and cancers in men and women. About 40 strains of HPV can infect mucosal epithelial cells, such as those on the genitals, mouth, and throat, and they can be transmitted by any type of sexual contact (CDC, n.d.-d). Researchers consider thirteen sexually transmittable strains of HPV to be definite or probable carcinogens (Human Papillomaviruses Working Group, 2012; Schiffman et al., 2009). In descending order, the frequency of association of these high-risk HPV strains with cervical cancer globally is 16, 18, 58, 33, 45, 31, 52, 35, 59, 39, 51, 56, and 68 (Li et al., 2010). Of all the high-risk type infections, HPV 16 is the most likely to persist and progress to cervical intraepithelial neoplasia grade 3 (CIN3) and cervical cancer (Forman et al., 2012; Human Papillomaviruses Working Group, 2012). In cervical cancer tissue, HPV types 16 and 18 have a prevalence globally of 57% and 16%, respectively (Forman et al., 2012). Therefore, in agreement with Saraiya et al. (2015) from the United States, HPV types 16 and 18 cause about 73% of all cervical cancers worldwide. Gillison et al. (2008) reported that strains 16 and 18 cause 86% to 95% of noncervical HPV-associated cancers (i.e., anogenital and oropharyngeal). Researchers have found at least one of the first seven high-risk types (16, 18, 58, 33, 45, 31, and 52) in about 90% of cervical cancer specimens worldwide (Paz-Zulueta et al., 2018) and in the United States (Saraiya et al., 2015). Also, high-risk strains 58, 33, 45, 31, and 52 contribute to additional cases of noncervical cancers (above that caused by HPV types 16 and 18; Saraiya et al., 2015). Infection with low-risk HPV types 6 and 11 cause most genital warts, laryngeal papillomas, and sometimes benign or low-grade cervical cell abnormalities (CDC, n.d.-d). Low-risk HPV strains 6 and 11 account for about 96% to 100% of anogenital warts due to HPV infection (Ball et al., 2011; Forman et al., 2012). In summary, seven high-risk HPV strains and two low-risk types account for most cases of HPV-associated cancers and anogenital warts, respectively.

HPV infection affects a high proportion of people worldwide and can result in many severe health complications. The high-risk (oncogenic) HPV strains can cause cancers of the cervix, vagina, and vulva in women; the penis in men; and the anus and oropharynx (i.e., base of the tongue and tonsils) in both women and men (CDC, n.d.-c). A persistent HPV infection is a necessary but not sufficient prerequisite for the progression of precancerous HPV lesions to cervical or noncervical (i.e., anogenital and oropharyngeal) cancer (Human Papillomaviruses Working Group, 2012; Lieblong et al., 2019; Plummer et al., 2007). About 14 million new sexually-transmitted HPV infections occur yearly in the United States, and most newly infected individuals are teens and young adults (CDC, n.d.-d). This virus currently infects almost 80 million men and women (CDC, n.d.-c). Nearly all sexually active men and women are exposed to at least one of the sexually-transmittable HPV strains at some point in their lives (CDC, n.d.-c). For 91% of these individuals, their immune system resolves the infection within a couple of years (Plummer et al., 2007). However, in some cases, especially those individuals with high-risk HPV types or low-risk types 6 and 11, the condition persists and can lead to oral, anal, or reproductive system cancers or genital warts, respectively (Plummer et al., 2007). Each year about 35,900 men and women in the United States are afflicted with malignancies attributable to HPV (CDC, 2020a; Saraiya et al., 2015). In 2015, a significant number of individuals in the United States died from cancer in the oropharynx (1,108), anus (1,014), penis (301), vagina (438), and vulva (1,127) sites (U.S. Cancer Statistics Working Group, 2021). In the same year, cervical cancer resulted in the death of about 4,175 women in the United States (U.S. Cancer Statistics Working Group, 2021). Furthermore, in 2018, cervical cancer led to the demise of 311,365 women worldwide (Bray et al., 2018). Hence, HPV infection is a substantial public health burden.

Three HPV vaccines have been available in the United States since 2006. Researchers have developed Cervarix, Gardasil, and Gardasil 9 vaccines for administration to girls or boys at age 11 to 12 to prevent the types of HPV infections that lead to most instances of genital warts, papillomas, and cancers (CDC, 2018). Vaccine manufacturers marketed Cervarix for vaccination against HPV 16 and 18 strains (Harper et al., 2006). Researchers designed Gardasil to protect vaccinated individuals against not only HPV strains 16 and 18 but also types HPV 6 and 11 (Garland et al., 2007). As with Cervarix, Gardasil should safeguard people from a high percentage of cervical and noncervical cancers through immunity to oncogenic strains 16 and 18. In addition, Gardasil should insulate men and women d from getting 96% to 100% of anogenital warts due to their immunity to the low-risk HPV 6 and 11 types (Ball et al., 2011; Forman et al., 2012). Gardasil and Cervarix were the only HPV vaccines in the United States before 2015 (Markowitz et al., 2007, 2014). However, public health authorities removed Cervarix from use in the United States in 2016 due to a consistently low demand compared to Gardisil (LaJoie et al., 2018). Therefore, Gardasil was the primary HPV vaccine in the United States before 2015. Gardasil 9 became available in 2015 (Petrosky et al., 2015). Since December 2016, Gardasil 9 has been the only HPV vaccine used in the United States (Joura et al., 2015; Paz-Zulueta et al., 2018). Gardasil 9 protects vaccinated individuals against the high-risk HPV strains 16 and 18 and the low-risk types 6 and 11, as does the quadrivalent Gardasil (Joura et al., 2015). The nine-valent Gardasil 9 protects vaccinated individuals against five additional oncogenic HPV strains 31, 33, 45, 52, and 58 (Joura et al., 2015). For this reason, Gardasil 9 could protect vaccinated individuals in the United States and worldwide against about 20% more cervical cancers than Gardasil and additional cases of noncervical cancer (Paz-Zulueta et al., 2018; Saraiya et al., 2015). In summary, parents have had an opportunity since 2006 to vaccinate their teens against HPV and subsequently protect them from HPV infections and associated complications.

HPV Vaccine Safety and Effectiveness

HPV vaccines are safe. The ACIP approved the 9vHPV (Gardasil 9) for use in the United States in December of 2014 (Petrosky, 2015), and it has been the only HPV vaccine in use since late 2016 (Paz-Zulueta et al., 2018). The pre-licensure analysis of the 9vHPV in seven stage 3 clinical trials with over 15,000 participants, which assessed a broad range of potential adverse events, revealed only expected side effects of 9vHPV such as injection site reactions and syncope (Moreira et al., 2016). The United States government uses the Vaccine Adverse Event Reporting System (VAERS) and the Vaccine Safety Datalink (VSD) to monitor the safety of HPV vaccines early after their release for use by the general population (CDC, n.d.-e). VAERS is a passive system to identify vaccine safety concerns (Arana, 2018). Still, researchers need other vaccine safety systems or investigations to confirm a causal link between an adverse event and vaccination (Arana, 2018). Of the 29 million doses of 9vHPV given in the United States between late 2014 and 2017, the VAERS system identified over 7,000 suspected adverse events with no new concerns or unexpected patterns (Arana, 2018). The VSD system, a collaboration of the CDC and eight integrated health plans, is also used to identify potential HPV vaccine adverse events and investigate whether a causal connection with vaccination exists using a medical record review or research study (CDC, n.d.-e). The VSD investigated about 900,000 HPV vaccinations between late 2014 and 2017 but found only expected injection site and syncope reactions to 9vHPV (Donahue, 2018). These data from the VAERS and VSD vaccine safety systems are consistent with over 10 years of pre- and post-licensure studies of the 4vHPV (Arana, 2018; Gee et al., 2016). For these reasons, vaccination providers should reassure parents in the United States that the currently available 9vHPV is safe for their children.

Public health authorities monitor HPV vaccine effectiveness in the ongoing National Health and Nutrition Examination Surveys (NHANES) and other study populations. Before the release of Cervarix, Gardasil, and Gardasil 9 for public use in the United States, researchers demonstrated their efficacy in preventing HPV infection and disease in numerous clinical trials (Harper et al., 2006; Joura et al., 2007, 2008, 2015; Paavonen et al., 2009). However, the effectiveness of HPV vaccines might be lower in women in healthcare and community settings because they could be less compliant and healthy than those volunteering to participate in HPV vaccine pre-licensure trials and more likely to be infected with HPV before vaccination (Spinner et al., 2019). For this reason, public health workers have monitored the long-term effectiveness of HPV vaccines post-licensure in various settings (Gargano et al., 2017). Also, HPV vaccine experts continue to check for waning vaccine effectiveness and the impact of changes in the HPV vaccine program, such as the introduction of vaccines for boys in 2011 or Gardasil 9 for girls and boys in 2015 (Gargano et al., 2017). Furthermore, researchers monitor to detect indirect effects of vaccination such as cross-protection against HPV types genetically related to vaccine types 16 and 18 and herd immunity, defined as the prevention of the spread of infection to unvaccinated susceptible groups due to a high level of protection in a population (Brisson et al., 2016; Spinner et al., 2019). The ongoing study of HPV vaccine effectiveness in these different populations allows researchers to gain insights into the long-term effect of HPV vaccination under various conditions.

Researchers use various surveillance programs in the United States to monitor HPV vaccine effectiveness. As a decline in HPV strains targeted by the vaccine is an early indication of HPV vaccine effectiveness, researchers use HPV vaccine strain prevalence as an early indicator of the impact of the vaccine. In the NHANES, HPV type prevalence has been monitored in self-collected cervicovaginal swabs of teenage girls and young women during the prevaccine era (2003-2006) and vaccine era (2006 to present; Johnson et al., 2014). In addition, researchers collect data in this ongoing series of cross-sectional surveys on study participants' demographics, sexual behaviors, and self- and parent-reported vaccination status (Johnson et al., 2014). Therefore, researchers can compare the prevalence of HPV types at different time points or periods in the vaccine era to levels in the prevaccine age. In addition, researchers can assess the impact of vaccine coverage on HPV type prevalence, controlling for other population changes, including demographics and sexual behavior that might influence HPV prevalence. Similarly, Spinner et al. (2019) collected cervicovaginal swabs and data (i.e., sociodemographics and sexual behaviors) from women between 13 and 16 years old in a clinic and health department. This study took place from 2006 to 2017 over four 2-year waves: 2006-2007 (prevaccine era), 2009-2010, 2013-2014, and 2016-2017 (Spinner et al., 2019). Researchers continue to monitor HPV vaccine effectiveness in the United States to ensure the vaccination program is as effective as possible.

HPV vaccines are effective in preventing HPV infection in vaccinated women. The quadrivalent HPV vaccine (4vHPV) became available in the United States in 2006 to vaccinate girls and young women (Markowitz et al., 2007). HPV vaccine series completion of 3 doses increased from 17.9% to 41.9% in girls 13 to 17 years old at 2 and 9 years after the vaccine introduction, respectively (Reagan-Steiner et al., 2016). Vaccine uptake, defined as greater than or equal to 1 dose, increased from 37.2% to 62.8% in this group during the same period (Reagan-Steiner et al., 2016). Four years after the 4vHPV introduction, analysis of NHANES data revealed a 56% decline in 4vHPV-type prevalence among girls 14 to 19 years old (Markowitz et al., 2013). After 6 years, when more vaccinated teens had reached their 20s, researchers found a 34% decline in vaccine-type prevalence in women 20 to 24 years old (Markowitz et al., 2016). After 8 years, 4vHPV-type prevalence had declined 71% among women 14 to 19 years old and 61% among those 20 to 24 years old (Oliver et al., 2017). After 10 years, 4vHPV-type prevalence had decreased by 86% among girls 14 to 19 years of age and 71% among those 20 to 24 years old (McClung, Lewis, et al., 2019). Eleven years post 4vHPV introduction, Spinner et al. (2019) estimated an 81% decline in 4vHPV-type prevalence among women 13 to 26 years of age with greater than or equal to 1 dose coverage of 84.3%. These results show that 4vHPV-type prevalence has declined, controlling for population changes in demographics and sexual behavior. Oliver et al. (2017) estimated vaccine effectiveness of 83% in sexually active women 14 to 24 years old with greater than or equal to 1 dose coverage of 50.8% by comparing 4vHPV-type prevalence in vaccinated and unvaccinated women. In sexually active women 13 to 26 years old with 71.5% covered with greater than or equal to 1 dose of the HPV vaccine, Spinner et al. (2019) estimated vaccine effectiveness of 90.6%. These results, taken together, suggest that increasing protection against HPV in young women led to lower levels of HPV infection. Therefore, parents can be confident that vaccines protect young women from HPV infection.

HPV vaccines effectively prevent anogenital warts in women due to HPV infection. The primary HPV vaccine used in the United States before 2015 was 4vHPV, which protects against HPV types 6, 11, 16, and 18 (Markowitz et al., 2014). Type 6 and 11 infections lead to 96% to 100% of anogenital warts in men and women (Ball et al., 2011; Forman et al., 2012). From 2007 to 2010, the prevalence of anogenital warts declined significantly by 38% (2.9 per 1000 person-years in 2007 to 1.8 in 2010) in privately insured women 15 to 19 years old living in the United States (Flagg et al., 2013). In addition, the prevalence of anogenital warts decreased significantly in 2010 in women 20 to 24 years old (Flagg et al., 2013). Researchers cannot attribute the declines in anogenital wart prevalence to more cervical cancer screening during this period because the testing frequency did not change significantly (Flagg et al., 2013). By 2011, 4vHPV coverage of greater than or equal to 1 dose and 3 doses (i.e., series completion) in girls 13 to 17 years old had increased to 62.8% and 41.9%, respectively (Reagan-Steiner, 2016). As 4vHPV vaccination increased in young women during the study period, the observed decline in the prevalence of anogenital warts in these age groups was likely due to protection (Flagg et al., 2013). In low-income women in California from 2007 to 2010, the prevalence of anogenital warts decreased significantly by 35% (9.4 per 1000 person-years in 2007 to 6.1 in 2010) in those 15 to 19 years old (Bauer et al., 2012). Hence, the prevalence of anogenital warts among young women in the United States might be declining, despite low rates of HPV vaccine uptake. In contrast, Australia observed declines of 73% to 90% in the prevalence of anogenital warts after achieving a vaccination coverage of 65% to 80% with greater than or equal to 1dose through a national HPV vaccination program initiated in 2007 (Donovan et al., 2011; Read et al., 2011). These results, taken together, suggest vaccination providers could further reduce the prevalence of sequelae of HPV infection in the United States by increasing vaccination coverage.

Researchers have used the prevalence of early sequelae of HPV infection in women to monitor the effectiveness of the HPV vaccine since its approval for use in women in 2006. Cervical cancer develops sequentially from an initial HPV infection to the persistence of this infection to abnormal tissue growth to cervical precancer and, ultimately, invasive disease (Ho et al., 1998; Schlecht et al., 2003; Trottier & Franco, 2006). The gap between the onset of HPV infection and the development of cervical cancer is variable, but it is typically decades (Gargano et al., 2017). Therefore, researchers have accessed the potential effectiveness of HPV vaccines post-licensure in reducing cervical cancer in young women by the declining prevalence of early markers of cervical cancer, including high-risk HPV types, genital warts, and cervical precancer (Human Papillomaviruses Working Group, 2012; Winer et al., 2005; Wudtisan et al., 2019). After HPV infection, genital warts can develop within months, and cervical precancer often occurs within 1 to 3 years (Winer et al., 2005). For these reasons, researchers assess the ongoing effectiveness of HPV vaccines in women by monitoring the prevalence of genital warts, cervical precancers, and high-risk HPV types.

HPV vaccines are effective in preventing cervical precancers due to HPV infection. Types 16 and 18 contribute to about 73% of all cervical cancers (Saraiya et al., 2015). From 2007 to 2014, the average annual percent change (AAPC) in prevalence of high-grade squamous intraepithelial lesions (HSIL) and high-grade histologically detected cervical intraepithelial neoplasia grades 2 and 3 (CIN2+) was -8.3% and -14.4% ($p < .001$ for both estimates), respectively, in 15 to 19 years-old women of the United States (Flagg et al., 2013). In addition, the prevalence of HSIL and CIN2+ decreased significantly in women 20 to 24 years old (Flagg et al., 2013). As high-grade lesions have a higher association with HPV types 16 and 18 than low-grade ones and 4vHPV vaccination increased in young women during this period, the observed decline in the prevalence of precancers in these age groups was likely due to protection through immunization (Flagg et al., 2013). Also, from 2008 to 2014, the AAPC in the prevalence of 4vHPV type-specific cervical precancer (i.e., lesions with strains 16 or 18) in the United States was -20.7% and -11.6% in women 18 to 20 years old and 21 to 24 years old, respectively (McClung, Gargano, et al., 2019). The prevalence of nonvaccine type cervical precancer (i.e., any other HPV in tissue) did not decline during this period (McClung, Gargano, et al., 2019). These results, taken together, suggest that the decline in precancer prevalence was due to an increase of 4vHPV coverage in these age groups. If these declines in precancer prevalence had been due to changes in precancer screening or management guidelines, one would have expected a decrease in the prevalence of all HPV types of cervical precancer (McClung, Gargano, et al., 2019). Therefore, the observed declines in cervical precancers of women in these age groups were most likely due to their vaccination against HPV at the recommended ages. In short, the observed reduction in the prevalence of cervical precancers in young women in the United States was an early indication that the HPV vaccination is protective, despite low levels of coverage.

HPV Disease Burden and Vaccine Coverage Rates by Teen Gender

A shift has occurred over several decades in the extent of the burden from cervical to noncervical HPV-associated diseases among men and women in the United States. From 1999 to 2015, the annual age-adjusted incidence of cervical cancer and vaginal squamous cell carcinoma (SSC) per 100,000 women decreased significantly with an

AAPC of -1.6% and -0.6%, respectively (Van Dyne et al., 2018). During this period, the AAPC of cervical cancer was significantly more negative in Hispanics at 3.4% compared to non Hispanics at -1.5% (Van Dyne et al., 2018). Even so, as of 2015, the annual rate of cervical cancer per 100,000 women was 8.9 in Hispanics compared to 7.0 in non Hispanics (Van Dyne et al., 2018). On the other hand, Van Dyne et al. (2018) reported that rates increased from 1999 to 2015 for noncervical HPV-associated cancers, including oropharyngeal SSC in men (AAPC = 2.7%) and women (0.8%), anal SSC in men (2.1%) and women (2.9%), and vulvar SSC (1.3%). Cervical cancer is currently the only HPV-associated cancer that researchers monitor through routine screening (Lieblong et al., 2019). For this reason, HPV vaccination is critical to reducing the rate of noncervical HPV-associated cancers. Cervical cancer screening has been effective since the 1950s in reducing cervical cancer incidence and mortality (Alemany et al., 2014; Peirson et al., 2013). However, cervical cancer screening does not meet national goals in the United States (Moreno et al., 2019; White et al., 2017). Therefore, the HPV vaccination program in the United States is also essential to reduce further the prevalence of sequelae of cervical infection. These trends in HPV-associated cancer indicate that vaccination is increasingly vital in the United States to prevent sequelae of HPV-related disease in the cervix and noncervical anatomical sites.

The HPV vaccines have effectively reduced noncervical HPV-related infections and diseases in men and women. HPV type 16 causes about 90% of noncervical HPV-associated cancer (Forman et al., 2012; Saraiya et al., 2015). The 4vHPV was shown in pre-licensure trials for men from 2004 to 2008 to be effective in reducing infection due to

HPV types 6, 11, 16, and 18 as well as associated genital warts and intraepithelial neoplasia of the anal canal and external genital (penile/perineal/perianal) skin (Giuliano et al., 2011; Markowitz et al., 2014, Palefsky et al., 2011). In clinical trials in women, the 4vHPV provided protection for close to 4 years for anogenital warts and low and high-grade cervical, vulvar, and vaginal intraepithelial neoplasias (Dillner et al., 2010; Kjaer et al., 2009). Through immunobridging to efficacy trials in women, researchers presumed the 9vHPV to be effective in men because the immune response of the 9vHPV in men was non-inferior to that of women 19 to 26 years old (Petrosky et al., 2015). In a post-licensure study from 2013 to 2014, Gargano et al. (2017) showed a decrease in HPV types 6, 11, 16, and 18 prevalence in penile skin of men aged 14 to 19 years and 20 to 24 years within the NHANES that was likely attributable to the vaccine program. In a double-blind, randomized controlled trial of 5,840 women in Costa Rica to investigate the effectiveness of the bivalent vaccine (2vHPV) 4 years after vaccination, HPV types 16 and 18 prevalence were significantly lower in the vaccinated group with an effectiveness of 93.3% (Herrero et al., 2013; Tota et al., 2017). In a cross-sectional study of 2,627 men and women 18 to 33 years old within the NHANES between 2011 and 2014, the prevalence of HPV types 6, 11, 16, and 18 were significantly lower in vaccinated than unvaccinated men, after adjusting for age, sex, and race (Chaturvedi et al., 2018). During this period, 29.2% of women and 6.9% of men under 26 years old had received at least 1 dose of the HPV vaccine (Chaturvedi et al., 2018). These results suggest that HPV vaccines effectively reduce noncervical HPV-related infection and disease in young men and women.

HPV infection and associated sequelae are becoming more prevalent in men than women. In 1999, doctors diagnosed 34% of all cancers attributable to HPV in males (Van Dyne, 2018). In 2014, 44% of all HPV-related diseases occurred in males (Van Dyne, 2018). The increasing prevalence of HPV-associated cancers in men compared to women means that it will become increasingly important to improve vaccine coverage levels in both genders. Oropharyngeal cancer among males accounted for 23% of all HPV-related cancers in 1999 and increased to 35% of all HPV-associated cancers in 2014 (Van Dyne, 2018). In 2015, oropharyngeal cancer in men had the highest incidence rate of all HPV-associated cancers (Van Dyne et al., 2018). On the other hand, cervical cancer was 44% of all HPV-attributable cancers in 1999, and it decreased to 27% of all HPV-associated cancers in 2014 (Van Dyne, 2018). Reductions in cervical cancer incidence and mortality, which have occurred since the 1950s, are primarily due to cervical precancer screening and treatment (Alemany et al., 2014; Peirson et al., 2013). These results indicate that the burden of HPV-associated cancers is becoming disproportionately higher in males than females.

Increasing coverage of teenage males with HPV vaccines has occurred since the ACIP recommendation to vaccinate males in 2011. Some countries, including the United States and Australia, began their HPV vaccine programs by protecting only females but later added the vaccination of males (Georgousakis et al., 2012; Petrosky et al., 2015). Public health authorities added males to these vaccination programs both to protect males from disease due to HPV and to indirectly protect the entire population through a reduction in exposure to HPV through herd (community) immunity (Georgousakis et al., 2012; Petrosky et al., 2015). In the United States, the ACIP recommended using the 4vHPV in females in 2006 and males in 2011 (CDC, 2011; Markowitz et al., 2007). The 9vHPV became available in 2015 for both males and females (Gargano et al., 2017; Petrosky, 2015). As of 2017, vaccine coverage of greater than or equal to 1 dose was 69% in females and 63% in males aged 13 to 17 years (Walker et al., 2018). In late 2016, the ACIP changed the recommended HPV vaccination from 3 doses to 2 doses for adolescents under the age of 15, but they still recommend 3 shots for those between the age of 15 and 26 years (Jenco, 2016; Meites et al., 2016). Adolescents who are up to date with HPV vaccines include those reaching 3 doses and those receiving 2 doses with the 1st dose before age 15 years and the second at least 146 days later (Walker et al., 2018). As of 2017, the up-to-date nationwide coverage was 53% for females and 44% for males 13 to 17 years old (Walker et al., 2018). Similarly, in Bexar County, Texas, 56% of females and 37% of males of this age were up to date (Texas Department of State Health Services, 2021). The gap in vaccine coverage between males and females aged 13 to 17 has rapidly narrowed since the recommendation for males in 2011 (Texas Department of State Health Services, 2021; Walker et al., 2018). These results indicate that HPV vaccine coverage in males aged 13 to 17 is approaching that of women.

Vaccine providers can best achieve an optimal reduction of the risk of HPV infection by vaccinating youth at a young age. Ideally, adolescents should complete HPV vaccination by age 13 and only need 2 doses if the series completion is by age 15 (Meites et al., 2016). These stipulations of the ACIP for youth vaccination enhance the HPV vaccination program in the United States. HPV vaccines provide optimal prevention of infection for adolescents when given before potential exposure to the virus during first sexual activity. In the National Survey of Family Growth from 2011 to 2015, results indicated the proportion of teens that had their first sexual activity increased with age (Abma & Martinez, 2017). In youth aged 16 to 19, 11% of females and 16% of males reported having sexual intercourse by age 15 (Abma & Martinez, 2017). Moreover, individuals can become infected with HPV through not only sexual intercourse but also skin-to-skin contact, including oral-oral, oral-genital, and digital-genital sexual activities (Liu, 2016). Therefore, it is crucial to vaccinate teens before sexual activity.

Vaccine providers should vaccinate youth at a young age for additional reasons. First, the immune response to vaccination with the three types of HPV vaccine is more robust in individuals given the vaccine before age 15 than older (Meites et al., 2016). Second, the need to be up to date with only 2 doses of the HPV vaccine when given before age 15 reduces a barrier to vaccination due to inconvenience. Finally, the ACIP recommends giving the Tdap and MenACWY at 11 or 12 years (Robinson et al., 2017). Giving these vaccines and the HPV vaccine might reduce missed opportunities for vaccination of all three vaccines. In addition, the longer vaccine providers delay giving the HPV vaccination, the higher the risk of HPV infection. Hence, practitioners can best protect youth in the United States against HPV infection by vaccinating them according to the dosing schedule recommended by the ACIP for preteens and teens.

HPV vaccination series completion of adolescents before turning 13 and 15 years of age in the United States is substantially lower than the coverage among those 13 to 17 years old overall. Bednarczyk et al. (2019) reported provider-verified HPV vaccination status of preteens and teens at the national and state level using data from the 2016 NIS-Teen survey. The estimated overall up-to-date coverage nationwide among 13 to 17-year-olds was 43%, but coverage by the age of 13 was 15.8%, and before age 15 was 34.8%. Texas was among six states in the lowest tertile for adolescent HPV vaccine series completion measures, with coverage by age 13 being 11.7% and before age 15 at 26.1%. The percentage of females nationwide with up-to-date coverage was higher than for males at both cutoff ages at 20.1% versus 11.6%, respectively, completed by age 13 and 41.6% versus 28.3%, respectively, completed by age 15. In contrast, nationwide up-to-date coverage in 2017 among youth 13 to 17 years old was 53% for females and 44% for males (Walker et al., 2018). These findings, taken together, indicate a larger gap between male and female up-to-date coverage among youth in younger age categories.

These findings have implications for public health. Practitioners need to close the gap in the HPV vaccination of young adolescent males, especially those younger than the 13-year-old cutoff point. Also, these findings are concerning because the Healthy People 2020 goal in the United States is for 80% of boys and girls aged 13 to 15 years to be up to date with HPV vaccination (Healthy People.Gov, 2022). These results point to a need to increase HPV vaccine uptake before the critical cutoff ages of 13 and 15 years, especially in males, as recommended by the ACIP.

Potential of Reduction in HPV Infection/Sequelae With Higher Vaccine Coverage

Some countries have achieved a higher level of HPV vaccination coverage in young adolescents than the United States and more significant reductions in HPV-associated diseases. In Australia, a free school-based HPV vaccination program using 3-

dose series of 4vHPV was initiated nationwide for girls 12 to 13 years old in 2007 and extended to boys in 2013 (Patel et al., 2018). HPV vaccine series completion (3 doses) of 67% among 15-year-old boys was the highest in the world as of 2017, and coverage for girls was 78% (Brotherton et al., 2017). Researchers reported significant decreases in genital warts and high-grade cervical precancers in Australia before and after the initiation of the HPV vaccination of girls (Donovan et al., 2011; Patel et al., 2018; Read et al., 2011). Before the initiation of vaccination of boys, researchers observed a substantial herd effect, due to six years of female-only immunization, in young unvaccinated heterosexual males with declines in vaccine-type HPV prevalence and genital warts (Ali et al., 2013; Patel et al., 2018). For instance, after five years of 4vHPV vaccination of girls above 70%, anogenital warts among heterosexual men declined by greater than 80% (Ali et al., 2013). In contrast, 3-dose coverage (i.e., series completion) in the United States gradually increased to 41.9% during the first 5 years of vaccination of girls 13 to 17 years old (Reagan-Steiner, 2016). At this level of coverage, a 35%-38% decrease in anogenital warts occurred in women 15 to 19 years old (Bauer et al., 2012; Flagg et al., 2013). In Scotland, the 2vHPV series completion (2 doses) among 14- to 15-year-old girls was 86% as of 2016 (Joint Committee of Vaccinations and Immunisations of Scotland, 2016). In a population-based study in Scotland, significant reductions of cervical intraepithelial neoplasia grades 1, 2, and 3 (29%, 50%, and 55%, respectively) were associated with a sustained 2vHPV coverage of 66% over 4 years (Pollock et al., 2014). These findings suggest that vaccine providers might further reduce the prevalence of HPV infection and sequelae in the United States by maintaining vaccination coverage at the levels in Australia, Scotland, and other countries.

High levels of HPV vaccine coverage could lead to eliminating HPV vaccine types. Researchers have developed many mathematical models over the past decade to understand the natural history of HPV-related disease better and inform vaccination and cervical precancer screening policy (Chesson, 2019). Brisson et al. (2016) did a systematic review and meta-analysis of transmission-dynamic model predictions of the impact of 4vHPV vaccination on the long-term prevalence of HPV types 6, 11, 16, and 18 in men and women. Most models evaluated by Brisson et al. predicted that 80% vaccine coverage in boys and girls would eliminate HPV types 16, 18, 6, and 11, as long as the vaccine retains its effectiveness. As the series completion of the HPV vaccine for youth in some countries such as Australia is close to 80%, practitioners might eliminate or at least control endemic vaccine-type HPV infection at a manageable level (Patel et al., 2018). Chesson (2019) estimated that vaccine providers could prevent 53,000 more cases of cervical cancer in the United States over the lifetimes of females 12 years old or younger, as of 2014, by increasing 2vHPV or 4vHPV vaccine coverage from 30% to 80%. By reaching this higher level of HPV vaccine coverage, practitioners could reduce morbidity and mortality related to HPV-associated diseases for years to come in men and women.

Low Vaccine Coverage Rates of the HPV Vaccine Compared to Other Adolescent Vaccines

The coverage of teens is less with the HPV vaccine than other adolescent vaccines introduced at about the same time in the United States. In 2005, the ACIP recommended the Tdap and MenACWY for youth aged 11 or 12 in the United States (CDC, 2007; Liang et al., 2018). Adolescents who have received one or more doses of the Tdap and MenACWY are up to date with ACIP recommendations (CDC, 2022; Liang et al., 2018; Robinson et al., 2017). In 2006, the ACIP recommended the 4vHPV for 11- or 12-year-old girls in the United States (Garland, 2007). As of late 2016, adolescents are up to date with the HPV vaccine if they received 2 doses before the age of 15 or 3 doses between 15 to 26 years (Jenco, 2016; Meites et al., 2016). The 9vHPV has been the only HPV vaccine used in the United States since December 2016 (Joura et al., 2015; Paz-Zulueta et al., 2018). In 2017, the estimated up-to-date coverage nationwide among 13 to 17 year olds was 88.7% for the Tdap and 85.1% for the MenACWY, but 48.6% for the 9vHPV (Texas Department of State Health Services, 2021). In Hispanics, the coverage at a national level was 86.4% for the Tdap and 86.0% for the MenACWY, but 56.4% for the 9vHPV (Walker et al., 2018). These data indicate that the coverage of 9vHPV, which prevents a sexually transmitted infection, is substantially lower than that for the other adolescent vaccines nationwide.

In my study population, there appears to be a need to understand the reasons for differences in vaccination coverage between the HPV vaccine and other adolescent vaccines. In Texas, the up-to-date coverage was 83.2% for the Tdap and 85.1% for the

MenACWY, but 39.7% for the 9vHPV (Texas Department of State Health Services, 2021). Thus, the gap in coverage between 9vHPV and the other adolescent vaccines appears to be higher in Texas than nationwide. Similarly, in Bexar County, Texas, the up-to-date coverage was 83.7% for the Tdap and 86.0% for the MenACWY, but coverage with 9vHPV was 37.2% for boys and 55.6% for girls (Texas Department of State Health Services, 2021). Since the approval of the HPV vaccine in 2006, parents' main reasons for not vaccinating their child against HPV have differed from the other adolescent vaccines (Darden et al., 2013; Walker et al., 2017, 2018, 2019). Parents' reasons for not seeking the HPV vaccine have also been more diverse and changed dramatically over time (Beavis et al., 2018; Darden et al., 2013; Krakow et al., 2017; Shah et al., 2019; Stokley et al., 2014). A need exists to understand better the factors that influence HPV vaccine uptake in teens in Bexar County.

Some perceptions of vaccine providers might explain why they recommend the HPV vaccine less often than other adolescent vaccines. The ACIP recommends giving the Tdap and MenACWY at age 11 or 12 (Robinson et al., 2017). Giving the HPV vaccine along with Tdap and MenACWY at age 11 or 12 might reduce missed opportunities for all three adolescent vaccines. However, in an online survey of 776 pediatricians and family medicine doctors in the United States in 2014, significantly fewer providers reported endorsing the HPV vaccine (73%) compared to Tdap (95%) and MenACWY (87%) for parents' children (Gilkey, Moss, et al., 2015). In addition, Gilkey et al. (2016) noted that most providers with a preferred order for discussing adolescent vaccines with parents (70%) discussed the HPV vaccine last. Gilkey, Moss, et al. (2015)

offered two reasons providers might endorse the HPV vaccine less often than other adolescent vaccines and usually discuss it last. First, Gilkey, Moss, et al. (2015) stated significantly fewer physicians perceived parents wanted their teens to receive the HPV vaccine (13%) than Tdap (74%) and MenACWY (62%). Most providers might be hesitant to recommend the HPV vaccine due to their perception that parents lack interest in or are concerned about it, but be confident to endorse the other adolescent vaccines. However, Healy et al. (2014) found that providers might underestimate the importance of the HPV vaccine to parents or overestimate parental concerns. Second, doctors reported that discussing the HPV vaccine with parents took about twice as long as talking about Tdap (Gilkey, Moss, et al., 2015). Most providers might discuss Tdap and MenACWY first because they anticipate parents are more interested in these vaccines and doctors need less time for discussion. The time available during medical visits is limited, and many healthcare and prevention issues need to be covered by doctors within the allotted time (Mbaeyi et al., 2020). Providers could avoid missed opportunities to give the HPV vaccine through training to improve their ability to understand parents and accurately interpret their concerns.

Key Study Variables

In this subsection of Chapter 2, I review the research literature on each independent and dependent variable. As mentioned, I examined the influence of expected predictors of HPV vaccine use on parental intention to vaccinate their child and uptake of the vaccine. In RQs1, 2, and 3, I evaluated the influences of one independent (predictor) variable (family income level) on parents’ intent to immunize their child within the next

12 months, initiation of the vaccine series, and completion, respectively. Again, in RQs4 to 8, parents' household income level was the common independent variable studied. The outcome variables for RQs4, 5, 6, 7, and 8 were parental vaccine safety and effectiveness concerns, misconceptions about immunization, lack of knowledge of HPV illness and vaccination, systemic barriers, and sociocultural barriers, respectively.

Influence of Parents' Sociodemographics on HPV Vaccine Use for Their Children

Family factors might explain the level of HPV vaccine series completion in youth. Franco et al. (2019) examined the association of maternal educational attainment and family poverty status with HPV vaccine series completion in adolescents. The authors based multilevel logistic regression analysis in this cross-sectional study on a subset of nationally representative data from the 2016 NIS-Teen in which a medical provider confirmed the HPV vaccination of teens. The authors defined poverty status as a family income above or below the federal poverty cutoff and maternal education as either attainment of at least a college degree or any education below a college degree. According to the ACIP, youth under the age of 15 years are up to date with the HPV vaccination series if they have received two or more HPV shots, and those aged 15 to 17 years are up to date with three or more doses (Meites et al., 2016). Teens were more likely to complete the HPV vaccine series than their counterparts if their mothers had a college degree and their families lived below the federal poverty line (Franco et al., 2019). These results underline the importance of considering the influence of family characteristics in intervening to increase HPV vaccine series completion in youth.

Researchers have examined the association of parental age, educational attainment, and family income with HPV vaccine coverage and missed vaccination opportunities. Jeyarajah et al. (2016) examined the association of parents' age and socioeconomic status variables with vaccine series initiation (i.e., one or more doses of HPV vaccine) before age 13. In addition, they analyzed trends from 2008 to 2013 in vaccination series initiation stratified by sociodemographic variables. Furthermore, they assessed the relationship of these sociodemographic variables with missed clinical opportunities to vaccinate girls at age 11 or 12 years and potential coverage if they had received timely vaccination. The data analysis from the current study might provide valuable insights into what subgroups of parents in populations benefit most from educational campaigns or vaccine provider counseling to mitigate missed vaccination opportunities.

Parental age, educational attainment, and family income are associated with HPV vaccine coverage of youth with one or more doses. Teens with low HPV vaccine coverage at a particular age include those who will never receive the vaccine and those who will eventually get it after a delay. Jeyarajah et al. (2016) found in girls, who turned 13 years old in 2012 and 2103, there was lower HPV vaccine initiation among those whose household income was higher than 503% of the federal poverty level (34.4%) compared to less than 133% (51.7%). Also, Jeyarajah et al. identified lower coverage in girls whose mothers were 45 years old or older (36.4%) compared to 35 to 44 years old (44.5%) or 34 years old and younger (50.5%). Furthermore, Jeyarajah et al. revealed lower coverage in girls whose mothers were college graduates (38.6%) compared to high school graduates (50.6%) or those with less than a high school education (54.9%). In summary, HPV vaccine coverage with one or more doses was substantially lower in 13-year-old girls whose families had higher income, whose mothers were 45 years old or older, and whose mothers had a college degree.

Parental age, educational attainment, and family income are associated with missed vaccination opportunities. Low coverage and delay in vaccination can occur due to a conscious and intentional choice of parents and others, as well as unintentional inaction or hard-to-control factors such as affordability and other access constraints. Jeyarajah et al. (2016) showed in girls, who turned 13 years old in 2012 and 2103, a higher number of missed vaccination opportunities in those whose household income was higher than 503% of the federal poverty level (87.5%) compared to 133% to less than 322% (76.8%) or less than 133% (76.5%). In addition, Jeyarajah et al. reported a higher number of missed opportunities in girls whose mothers were 45 years old or older (84.2%) compared to 35 to 44 years old (78.1%). Furthermore, Jeyarajah et al. presented a higher number of missed opportunities in girls whose mothers were college graduates (86.0%) compared to high school graduates (77.1%) or less than high school education (72.5%). Earlier studies have shown a higher percentage of HPV vaccination delay and refusal in adolescents whose households have a higher income, whose parents are older, and whose parents are more highly educated (Bednarczyk et al., 2014; Dorell et al., 2014). Similarly, higher maternal age, educational attainment, and family income are associated with lower vaccine uptake and more missed vaccination opportunities in children (Smith et al., 2004). These findings, taken together, suggest that the lower vaccination coverage and the higher number of missed vaccination opportunities among these sociodemographic segments relate to their more significant active delay or refusal of the HPV vaccine.

Parental age, parental educational attainment, and family income are associated with trends in HPV vaccine coverage of one or more doses in 13-year-old girls. As mentioned, Jeyarajah et al. (2016) analyzed patterns from 2008 to 2013 in HPV vaccine series initiation by stratified sociodemographic characteristics. Jeyarajah et al. noted that sociodemographic subgroups with the lowest series initiation, across cohorts of girls who turned 13 years old each year between 2008 and 2013, also tended to have smaller average birth year percentage increases (ABYPI). That is, among girls in families with income greater than 503% of the federal poverty level, mothers older than 45 years, and mothers with educational attainment at a college degree level, series initiation and ABYPI were consistently correlated and of lower value. Consequently, the gap in HPV vaccination series initiation of 13-year-old girls between those with lower versus higher income families, younger versus older mothers, and less versus more educated mothers grew wider from 2008 to 2013.

Dependent Variables for Research Questions 4 to 8

Influence of Parents' Lack of Knowledge of HPV-Related Diseases and the Vaccine on Its Use for Their Child. Survey results in the United States indicate a lack of understanding of HPV-associated disease, and the vaccines might negatively influence parents' decision to vaccinate their teens. Stokley et al. (2014) analyzed data from the 2013 NIS-Teen survey to rank the top five reasons parents of boys and girls reported they were unlikely to have their teens vaccinated in the next 12 months or were unsure about their own plans. The top five reasons from highest to lowest for parents of girls were lack of knowledge (15.5% of all teens), not needed or necessary (14.7%), safety concerns and side effects (14.2%), not recommended (13.0%), and not sexually active (11.3%). For parents of boys, the top five reasons from highest to lowest were not recommended (22.8%), not needed or necessary (17.9%), lack of knowledge (15.5%), not sexually active (7.7%), and safety concerns and side effects (6.9%). Thus, parents' knowledge about HPV and the vaccines was the most common reason (15.5%) for "no-intent" of parents of girls to vaccinate their child and the third most common reason (15.5%) for that of parents of boys. In an analysis of data from the 2014 NIS-Teen survey, lack of knowledge was the fourth most common reason (8.4%) for "no-intent" of parents with provider recommendation to vaccinate their children and not needed or unnecessary (19.9%) was the most common reason (Krakow et al., 2017). Lack of knowledge was the third most common reason (15.8%) for parents without provider recommendation, and not needed or unnecessary (20.2%) was the most common reason. From 2017 to 2018, Shah et al. (2019) queried 1,196 parents of children 9 to 17 years old about the HPV vaccine information they wanted from their child's health care provider. Shah et al. operationalized the variable knowledge as the parents' awareness of diseases prevented by the HPV vaccine, the age to start the HPV vaccine series, ACIP vaccination guidelines, and the inclusion of both boys and girls in the recommendations. Compared to 44% of parents who wished to receive information on vaccine safety, 43% of parents wanted this information on HPV illness and prevention. The percentage of parents of girls who said lack of knowledge was a reason for not vaccinating their children in 2010 and 2016 was 14% and 13%, respectively, and for boys, it was 16% and 14%, respectively (Beavis et al., 2018). These findings indicate that the percentage of parents reporting a lack of knowledge as a reason for not having their children vaccinated against HPV did not change substantially between 2010 and 2016. Hence, lack of knowledge continues to be a significant reason parents nationwide hesitate to have their children receive the vaccine or complete the series.

Influence of Parents' Perception of HPV Vaccine Safety on Its Use for Their Child. Research indicates that parents in the United States are concerned about the safety of HPV vaccines. Stokley et al. (2014) analyzed data from the 2013 NIS-Teen survey to rank the top five reasons parents reported they were unlikely to vaccinate their teens in the next 12 months or were unsure about their own plans. The top five reasons from highest to lowest for parents of girls were lack of knowledge (15.5% of all teens), not needed or necessary (14.7%), safety concerns and side effects (14.2%), not recommended (13.0%), and not sexually active (11.3%). For parents of boys, the top five reasons from highest to lowest were not recommended (22.8%), not needed or necessary (17.9%), lack of knowledge (15.5%), not sexually active (7.7%), and safety concern and side effects (6.9%). Thus, parents' safety concern about the HPV vaccine was the third most common reason (14.2%) for parents of girls and the fifth most common reason (6.9% of all teens) for parents of boys to have "no-intent" to vaccinate their children. In an analysis of data from the 2014 NIS-Teen survey, safety concern was the second most common reason (19.1% of all teens) for parents with provider recommendation not to intend to vaccinate their children, and not needed or unnecessary (19.9%) was the most common reason (Krakow et al., 2017). Safety concern was the fifth most common reason (8.0% of all teens) for parents of teens without provider recommendation not to intend to vaccinate their children. The most common reason was not needed or unnecessary (20.2%). From 2017 to 2018, Shah et al. (2019) queried 1,196 parents of children 9 to 17 years old about the HPV vaccine information they wanted from their child's health care provider. Safety information about the HPV vaccine was the information that the most significant percentage of parents (44%) wanted the most from their child's provider. These findings, taken together, suggest that parents' concern about the safety of the HPV vaccine continues to be one of the main reasons they hesitate to have their children receive the vaccine or complete the series.

Influence of Parents' Perception of HPV Vaccine Effectiveness on Its Use for Their Child. Analysis of survey data suggests that parents are less concerned about the efficacy of the HPV vaccine than other potential reasons for not vaccinating their children. In a study of data from the 2013 NIS-Teen survey, concern about vaccine effectiveness was not among the top five reasons parents were unlikely to have their teens vaccinated in the next 12 months or unsure about their plans (Stokley et al., 2014). The top five reasons from highest to lowest for parents of girls were lack of knowledge (15.5% of all teens), not needed or necessary (14.7%), safety concerns and side effects (14.2%), not recommended (13.0%), and not sexually active (11.3%). For parents of boys, the top five reasons from highest to lowest were not recommended (22.8%), not needed or necessary (17.9%), lack of knowledge (15.5%), not sexually active (7.7%), and safety concern and side effects (6.9%). Similarly, in an analysis of data from the 2014 NIS-Teen survey, vaccine effectiveness concern was not among the top ten reasons (less than 1% of all teens) for parents to have “no-intent” to vaccinate their children (Krakow et al., 2017). In contrast, the most common reason for no-intent” of parents with a provider recommendation was not needed or unnecessary (19.9%). For parents without an endorsement, not needed or unnecessary was also the most common barrier to HPV vaccination (20.2%). n a survey from 2017 to 2018, parents did not rank vaccine effectiveness concerns as one of their children's top five barriers to vaccination that they wanted clarification on from their provider (Shah et al., 2019). However, data analysis from the 2010 NIS-Teen survey revealed that parental uncertainty about the effectiveness of HPV vaccination was among the top four reasons for delaying and refusing to vaccinate their youth (Dorell et al., 2014). Therefore, parents’ concerns about the effectiveness of the HPV vaccine nationwide appear to have changed over the past decade. A review of the literature through 2015 by Galbraith et al. (2016) revealed that perceived HPV vaccine effectiveness among African Americans and Latinos was associated with vaccine uptake. These findings, taken together, suggest that an association of parental concerns regarding vaccine effectiveness with vaccine coverage of teens might exist in specific populations and vary over time. In short, these results suggest that in Bexar County, Texas, Hispanic parents’ concern about HPV vaccine effectiveness could negatively influence vaccine coverage for teens.

Influence of Parents’ Misbelief That Boys Do Not Need the HPV Vaccine on Its Use for Their Child. Results of survey studies over the past decade indicate that parents have become more aware and accepting of the need to vaccinate boys for HPV. Around the time of HPV vaccination approval in the United States in 2006, multiple stakeholders, including parents and medical providers, largely viewed the vaccine as unnecessary for boys (Daley et al., 2017). However, in an analysis of data from the 2013 NIS-Teen survey, the false belief that boys do not need the HPV vaccine was not among the top five reasons parents of boys were unlikely to have their teens vaccinated in the next 12 months or were unsure about their own plans (Stokley et al., 2014). These authors identified the top five reasons from highest to lowest for parents of boys as recommended (22.8%), not needed or necessary (17.9%), lack of knowledge (15.5%), not sexually active (7.7%), and safety concern and side effects (6.9%). Similarly, in an analysis of data from the 2014 NIS-Teen survey, the false belief that males do not need the HPV vaccine was not among the top ten reasons for "no-intent" of parents with a provider recommendation (1.5% of all teens) and for those without a recommendation (<1%) to vaccinate their child (Krakow et al., 2017). In contrast, the most common reason for parents with a provider recommendation (19.9%) was not needed or unnecessary. For parents without an endorsement, not needed or unnecessary was also the most common barrier to HPV vaccination (20.2%). These findings between 2006 and 2014 suggest parents have become more aware and accepting of the need to vaccinate boys for HPV.

Recent studies further support that parents have become more aware and accepting of the need to vaccinate boys for HPV. In a survey from 2017 to 2018, parents did not rank vaccination of male children as one of the top five barriers to immunization of their children that they wanted clarification on from their provider (Shah et al., 2019).

The proportion of boys' parents who said the male gender was a reason for not vaccinating their child in 2010 and 2016 was 13% and 2%, respectively (Beavis et al., 2018). Thus, the percentage of parents reporting the HPV vaccine was unnecessary because their child is a male decreased substantially between 2010 and 2016.

Influence of Parents' Misconception That the HPV Vaccine is Not Needed Because Their Child is Not Sexually Active on Its Use for Their Child. Data from nationwide surveys indicate that parents' misperceptions related to the purpose of the HPV vaccine to prevent sexually transmitted infections might be declining. Stokley et al. (2014) analyzed data from the 2013 NIS-Teen survey to rank the top five reasons parents reported they were unlikely to vaccinate their teens in the next 12 months or were unsure about their plans. For girls' parents, the false belief that the HPV vaccination is unnecessary because their child is not sexually active was the fifth most common reason (11.3% of all teens) for "no-intent" to use the vaccine. For boys' parents, this false belief was the fourth most common reason (7.7%) for "no-intent". The top five reasons from highest to lowest for parents of girls were lack of knowledge (15.5% of all teens), not needed or necessary (14.7%), safety concerns and side effects (14.2%), not recommended (13.0%), and not sexually active (11.3%). For parents of boys, the top five reasons from highest to lowest were not recommended (22.8%), not needed or necessary (17.9%), lack of knowledge (15.5%), not sexually active (7.7%), and safety concern and side effects (6.9%). In an analysis of data from the 2014 NIS-Teen survey, the child not sexually active was the third most common reason (11.2%) for parents with provider recommendation to vaccinate their children, and not needed or unnecessary (19.9%) was the most common reason (Krakow et al., 2017). The child not sexually active was the fourth most common reason (10.2%) for “no-intent” of parents without provider recommendation and not needed or unnecessary (20.2%) was the most common reason. From 2017 to 2018, Shah et al. (2019) queried 1,196 parents of children 9 to 17 years old about the HPV vaccine information they wanted from their child’s health care provider. Information about whether the HPV vaccination is unnecessary because their child is sexually inactive was the fifth most common type of information desired by parents (7% of all parents). These findings indicate that the percentage of parents reporting HPV vaccine unnecessary because their child is not sexually active decreased substantially between 2010 and 2016. The misconception that the HPV vaccine is unnecessary because their child is not sexually active is currently less prevalent nationwide than other reasons parents decide against having their children vaccinated against HPV, such as lack of knowledge and vaccine safety.

Studies indicate that providers are hesitant to recommend the HPV vaccine because of the connection of immunization with sexual activity as well as other reasons. The percentage of girl’s parents who said lack of provider recommendation was a reason for not vaccinating their children in 2010 and 2016 was 9% and 10%, respectively (Beavis et al., 2018). The percentage boys’ parents who said lack of provider recommendation was a reason for not vaccinating their children in 2010 and 2016 was 22% and 17%, respectively. Thus, the absence of provider recommendations has remained an essential barrier to HPV vaccine uptake over the past decade. Calo et al. (2018) noted that providers report that they are hesitant to engage parents and teens about sensitive topics such as sexual activity. In addition, a study found that providers might overestimate or underestimate parents' concerns about the HPV vaccine, including those related to sexual activity (Healy et al., 2014). These misperceptions and apprehensions of providers could influence whether they make a recommendation for teens to get the vaccine and the quality of their recommendations. A lack in either the frequency of provider recommendations or their quality might hinder HPV vaccine use by teens. Gilkey et al. (2016) found a strong association between the quality of HPV recommendations and measures of vaccine use, including initiation, series completion, refusal, and delay. However, in their study, only 36% of parents reported receiving a high-quality recommendation. These findings indicate public health practitioners might improve HPV vaccine coverage for teens by addressing providers' misunderstanding of HPV vaccination and teaching them how to engage parents and youth about the importance of vaccinating against HPV.

Dependent Variables for Research Questions 1 to 3

Parental Intent to Vaccinate Their Child Against HPV. Parents' intent to have their child get an HPV vaccination and their reasons for planning to do so vary based on whether their child has begun the series or not. Hanson et al. (2018) examined, using multinomial logistic regression analysis, the relationship of the independent variables of vaccination status and gender of teens as well as survey year with parents' intent to have their child vaccinated against HPV within the next 12 months. The researchers defined teens' HPV vaccination status as either unvaccinated with the uptake of zero doses or undervaccinated with a receipt of less than the series completion of 3 shots. The researchers based the study on interview data from 76,971 parents, with teens aged 13 to 17 years, who responded to the NIS-Teen survey between 2010 and 2015. In addition, the authors assessed the association of the independent variables with the main reason parents with low intent chose not to have their children vaccinated against HPV. Parents with *low intent* stated it was *not too likely* and *not likely at all* they would have their child get the HPV vaccine. The authors found that parental intent to have their child receive the HPV vaccine increased during the six-year study period. Still, parents' intent remained low, and their concerns persisted even if their child had started the vaccine series. In addition, the results suggested that parental concerns might be a more significant obstacle to HPV vaccine series initiation than completion (Hanson et al., 2018). Even so, series completion of youth might require additional interventions (Hanson et al., 2018). In agreement with these findings, strong provider recommendations are vital to encouraging parents to have their children start the HPV vaccine series (Dempsey & O'Leary, 2018; Gilkey et al., 2016). In addition, Kornides et al. (2018) showed that providers should conduct follow-up counseling to ensure the child completes the series. These findings underscore the importance of assessing factors that might contribute to both the initiation of the HPV vaccine series and its completion.

HPV Vaccine Series Completion by Teens. Researchers conducted a national-level study to examine the influence of potential predictors at multiple SEM levels on HPV vaccine series completion in youth. Using multilevel logistic models, Franco et al. (2019) studied the association of possible individual and state-level (e.g., religiosity, political ideology, school entry requirement, and sexual education) predictors with HPV vaccine series completion. The authors examined the influence on HPV vaccine series completion of factors at the individual (e.g., teen gender), interpersonal (e.g., family income), organization (e.g., provider recommendation), and society/policy (e.g., statewide sex and abstinence education policies) levels of the SEM. The authors used individual-level data from the 2016 NIS-Teen, and state-level data gathered from publically available sources. This study could inform comprehensive, multilevel interventions to improve HPV vaccine series completion in youth.

Franco et al. (2019) provided insights into the influences of HPV vaccine series completion. Individual factors and statewide religiosity, political environment, school mandates, and sex and abstinence education policies correlated with HPV vaccine series completion rates. Similarly, a study in Utah showed that nonreligious females were more likely to complete the HPV vaccine series than their religious counterparts (Bodson et al., 2017). Texas was among the five states with the lowest HPV vaccine coverage rates in 2016: Likely, the fact that Texas was more politically conservative and religious than the five states with the highest coverage rates contributed to this outcome (Franco et al., 2019). Thus, it might be beneficial for public health practitioners in Texas to implement interventions focused on and geared to promoting HPV vaccine series completion in children of parents who attend churches. In the United States, there is significant political opposition to the enactment of HPV school entry mandates (Keim-Malpass et al., 2017; Roberts et al., 2018). However, Rhode Island, Virginia, and the District of Columbia have enacted an HPV vaccine mandate to take advantage of this evidence-based intervention (Franco et al., 2019). As a result, these states have some of the highest HPV vaccination completion rates. As states' general religiosity, political ideology, sex and abstinence education policies, and teen gender were not associated with Tdap completion in youth, these variables were independent predictors of HPV vaccine completion rates. The latter finding, together with the fact that the HPV vaccine, but not Tdap, prevents a sexually transmitted disease, suggests parents, providers, and vaccination policymakers do not think and act the same when discussing, considering, and deciding on HPV vaccination of youth. These findings illuminate the substantial influence of factors at different levels of the SEM on HPV vaccine coverage but not coverage of other adolescent vaccines.

Summary and Conclusions

A safe and effective HPV vaccine is available in the United States. Still, vaccine providers could further reduce the burden of HPV-related disease by increasing the use of this vaccine. The burden of HPV-related disease in the United States is substantial in men and women, especially in the study population of Bexar County, Texas (National Cancer Institute, n.d.-c). Government agencies continuously monitor the safety and effectiveness of the HPV vaccines (CDC, n.d.-e). Public health workers have not verified any serious adverse effects of the currently available HPV vaccine (9vHPV) after giving millions of doses of the vaccine to people in the United States and worldwide from 2014 to 2019 (Arana, 2018; Donahue, 2018; Moreira et al., 2016). Parents should use the HPV vaccine more for their children because it is safe and potent.

Public health and medical practitioners have made progress in improving HPV vaccine coverage for youth, but they need to make more progress in reaching established goals. Researchers have observed a substantial reduction in HPV-related diseases since the introduction of the HPV vaccines in the United States in 2006, even with suboptimal vaccine coverage (Markowitz et al., 2018; Spinner et al., 2019). These findings indicate progress in increasing HPV vaccination in the United States due to parents' and providers' understanding of the importance of giving the vaccine to youth. However, there is room for improvement in HPV vaccine coverage, especially in specific sociodemographic subgroups (CDC, n.d.-a) and youth under 13 (Bednarczyk et al., 2019). HPV vaccine coverage in the United States is well below the Healthy People 2030 goal for 80% of boys and girls to be up to date with the HPV vaccine by age 13 (Healthy People.Gov, n.d.). By reaching this goal, the stakeholder of HPV vaccination could eliminate or reduce to an acceptable level the burden of HPV-related disease in the United States (Chesson, 2019). Therefore, practitioners need to intervene effectively to educate further parents, vaccine providers, and policymakers about the threat of HPV and the benefits of the vaccine.

The effectiveness of the HPV vaccine is optimal when youth receive the vaccine at the appropriate age and dose schedule. The ACIP sets the recommended age for providing the HPV vaccine to teens and the frequency of doses to ensure optimal protection from HPV infection (Meites et al., 2016). The ACIP determines this schedule for vaccination after extensive deliberation based on their assessment of safety and effectiveness data and other information (CDC, 2022). The ACIP reevaluates vaccination guidelines yearly or more often to ensure recommendations involve current data on how to best administer the vaccine, the sexual activity of youth, and evolving HPV-related disease patterns (CDC, 2022). For these reasons, parents and vaccine providers should be confident that the HPV vaccine is safe and effective and aware of the optimal age to vaccinate youth against HPV, so they are more likely to follow the recommended vaccination schedule.

Researchers have proposed various classifications (taxonomies) of the influences of HPV vaccine use to aid in better understanding, communicating, and addressing suboptimal use. Promoters of vaccine use have categorized the extensive list of determinants of vaccine use in domains of influence to facilitate the identification of critical factors and the development of effective strategies to improve vaccine use (Betsch et al., 2015; Brewer et al., 2017; MacDonald, 2015; Thomson et al., 2016). Based on evidence from social and behavioral research, especially psychology, Betsch et al. (2015) proposed a Four C model in which researchers should tailor strategies to mitigate vaccine hesitancy to one or more of four broad categories of causes: complacency, perceived convenience, confidence, and usefulness calculation. Thomson et al. (2016) showed that researchers could group determinants of vaccine coverage identified in their narrative review into a reliable, complete, and practical organization consisting of access, affordability, awareness, acceptance, and activation domains. Brewer et al. (2017) conducted an extensive narrative review across several scientific fields on interventions intended to promote HPV vaccination. These authors developed guidelines for the conditions under which strategies will likely be helpful, including whether people have favorable, ambivalent, or unfavorable intentions to receive the vaccine for their children or themselves (Brewer et al., 2017). Coordinated, mutually reinforcing efforts, based on strategies to address the influences of vaccine use covered in these taxonomies, might act synergistically to mitigate the underuse of HPV vaccines (Rimer et al., 2014). These taxonomies provide vaccine program managers, policymakers, and vaccine providers with a set of common frameworks to understand better and discuss potential causes of suboptimal HPV vaccine use and tailor interventions to improve coverage.

Health promotion experts recommend the multilevel approach to understand the predictors of HPV vaccination taken in my investigation. The current SEM-based study aimed to examine the influence of factors at multiple levels on HPV vaccination. The PCP states practitioners can best approach the suboptimal HPV vaccination through interventions targeting personal, interpersonal, organizational, community, and policy/society levels (Rimer, 2018). This guideline aligns with the use of the SEM as a basis of the methodological approach to the current study.

Current Knowledge About Influences of HPV Vaccine Use and Interventions to Increase Use

Researchers know much about factors that might influence HPV vaccination. Still, a better understanding of how to intervene to improve vaccine coverage might be helpful to those concerned with HPV vaccine coverage. Studies have shown that individuals' thoughts and feelings and social processes correlate with vaccine use (Brewer et al., 2017). However, findings from randomized control trials suggest that most current strategies to change peoples' thoughts and feelings and social processes have a small or variable impact on vaccine use (Brewer et al., 2017). Even so, further intervention development and theory testing might lead to ways to increase vaccine coverage by changing peoples' thoughts and feelings, and social processes. In contrast, interventions used to intervene on vaccine use directly without attempting to alter individuals' thoughts and feelings or the social context are effective (Brewer et al., 2017). Although current strategies to increase vaccine use directly are available, researchers need to do more to find ways to improve vaccine use by altering peoples' thoughts and feelings as well as social processes.

Interventions are available to reduce missed HPV vaccination opportunities and parental hesitancy to vaccinate children. Missed clinical opportunities to vaccinate youth at the appropriate age and dose interval is one of the main reasons for suboptimal HPV vaccine coverage (Espinosa et al., 2017; Jeyarajah et al., 2016). The best chance to reduce missed vaccination opportunities is to enhance provider recommendations and health-system-level vaccination procedures (Brewer et al., 2017; Rimer, 2018). Researchers have developed evidence-based approaches to improve providers' recommendations and vaccination protocols of health systems (Gilkey et al., 2016; Rimer, 2018; Shay et al., 2018). Likewise, the most effective strategy to increase ambivalent parents' acceptance of the HPV vaccine is likely a strong provider recommendation (Brewer et al., 2017; Rimer, 2018). In sum, interventions are available to increase HPV vaccine use due to missed vaccination opportunities and parental vaccine hesitancy. The results of the current study should help identify and correctly apply interventions to address inadequate HPV vaccination coverage in Bexar County.

Public health workers might also need to address access to the vaccine. For children of parents with a neutral or positive attitude about HPV vaccination, improving access to the HPV vaccine might help increase vaccine series initiation or completion (Rimer, 2018). However, attempts to influence HPV vaccine-related knowledge, thoughts, and feelings of parents with a neutral or positive view of HPV vaccination have a negligible effect (Rimer, 2018). Access issues can also contribute to suboptimal HPV vaccine coverage and disparities in uptake across regions, populations, and clinical settings (Rimer, 2018). Current coverage of the HPV vaccination fee through private and public insurance should continue so that cost does not become a barrier to vaccination (Rimer, 2018). Immunization in pharmacies or schools might make HPV vaccine access easier in areas with fewer primary care providers and other obstacles (Rimer, 2018). Addressing access barriers requires understanding local laws, culture, collaborative organizations, and accessible resources (Rimer, 2018). In short, interventions to increase HPV vaccine use due to access barriers are available, but practitioners must intervene appropriately to be effective.

This Study's Contribution to Research on HPV Vaccine Use

To optimize the validity of tests of association between independent and dependent variables, I carefully designed this cross-sectional study similar to Kumar et al. (2012). The current research examined the factors that might influence whether parents have their children vaccinated against HPV. By including the dependent variables of parental intent to use the HPV vaccine, vaccination initiation , and series completion in this study, I obtained stronger support for a predictive relationship between the independent and dependent variables. An independent variable, such as income level that correlates with both parental intent to use the HPV vaccine and the behavior of vaccine use is more likely to have a causal relationship with the behavior than a variable that only correlates with the behavior (Kumar et al., 2012). Data obtained on influences of parental intent to use the HPV vaccine and vaccine series initiation and completion further strengthen this study. In this way, I gained support for predictive relationships between independent variables and HPV vaccine use by applying approaches similar to those of Kumar et al.

In addition, I assessed the influences of HPV vaccine use at multiple levels of the SEM. In particular, this study evaluated the association of parental household income level with the dependent variables of eight RQs. The dependent variables of RQs1 to 3 were parental intent to have their child vaccinated against HPV, vaccine series initiation, and completion. For RQs4 to 8, the dependent variables were multilevel parental barriers or reasons (concerns) for deciding against having their child vaccinated against HPV. In this respect, my study builds on the multilevel approaches used in investigations by Kumar et al. (2012) and Cheruvu et al. (2017). My study's strengths included examining multiple potential influences of HPV vaccination for teens.

The approaches used in the current study are strengths lacking in previous studies on the influence of HPV vaccine use. As mentioned, the design of this study shares positive features with a 2008 to 2012 study by Cheruvu et al. (2017) and a 2010 study by Kumar et al. (2012). However, I based this research on more current data from NIS-Teen interviews with parents of teens in 2016, 2017, and 2018. In addition, in contrast to previous research on populations at the national and state level, my study focused on a more homogeneous study population of Hispanic families in Bexar County, Texas. Overall, my study builds on and extends the methodological strengths of other research.

Chapter 3: Research Method

Introduction

To document how I carried out this study and the reasons for doing so, I divided Chapter 3 into several sections. The purpose of a methods chapter is to describe and justify the strategies and steps for the research and data analysis (Creswell, 2014; Rudestam & Newton, 2015). I will discuss my research design and underlying methodology and their alignment with the research problem and purpose, use of the NIS-Teen data, steps to analyze the data, and efforts to promote the reliability and validity of the study. The sections of this chapter include Secondary Data Set, Research Design and Rationale, Methodology, and Threats to Validity. In each section, I fully describe the steps I took to understand better the extent to which parents' total income and their concerns and awareness influence HPV vaccination of their children.

The purpose of this study is consistent with the research problem and planned statistical analysis. To the best of my knowledge, a gap exists in the literature on quantitative evidence about the factors that influence HPV vaccination of Hispanic girls and boys between ages 13 and 17 years in Bexar County, Texas. This study aimed to contribute insight into how to improve HPV vaccination of Hispanic youth in Bexar County. To achieve this purpose, I tested whether and to what extent parents' total income, concerns, and knowledge of HPV and the vaccine influence their intention and decision to vaccinate their child. As this purpose addresses the apparent gap in research on the factors influencing HPV vaccination of youth, I have aligned it with the problem. I conducted a quantitative, cross-sectional analysis of NIS-Teen data from 2016 to 2018 using the chi-square test, proportions, and prevalence ratio. This study's statistical test and measures require categorical dependent variables (Field, 2013). The dependent variables (parental intent and ultimate use of the HPV vaccine) are categorical (Field, 2013). Therefore, these approaches were appropriate to test the independent variable of parents' total income relationship with their concerns and knowledge about the HPV vaccine and disease and other dependent variables. In summary, this study's overall purpose and data analysis plan was appropriate to examine the association of Hispanic parents' total income with their intent, barriers, and ultimate use of this vaccine to protect their children.

Secondary Data Set

The NIS-Teen in the United States is an add-on to the NIS for children. In 2006, NIS researchers expanded the NIS-Child, which has focused on vaccination coverage estimates of children since 1994, to include a national sample of adolescents aged 13 to 17 (Jain et al., 2009). Later, they broadened the NIS-Teen to collect state- and region-specific data to determine vaccination coverage estimates (Jain et al., 2009). The NIS-Teen staff gathers and analyzes data related to adolescent vaccinations to provide public health authorities and researchers with current population-based state and local area estimates of vaccine coverage among adolescents (CDC 2020b). The NIS-Teen survey includes a telephone interview of households and a mailed provider record check of teens' vaccination status with standardized questionnaires for each section (CDC 2020b). During the household interview phase of the survey, interviewers request consent from the teen's guardian to contact by mail the child's vaccine provider(s) to request information about the child's HPV vaccinations from medical records. The NIS-Teen, which surveyors built on the solid foundation of the NIS-Child, evolved into a sound and state-of-the-art telephonic and mail survey (CDC 2020b). In short, the NIS-Teen researchers have continued to improve and demonstrate the effectiveness of their survey over a long period.

NIS-Teen Questionnaires

The telephonic household interview and mailed provider questionnaire entails multiple parts. The household survey has five sections (CDC 2020b). The first section is the NIS-Teen Screener. In Section A, the screener or interviewer randomly selects one eligible teen from each household in which more than one is present. In Section B, interviewers ask parents about the HPV vaccination status of teens. In Section C, the NIS-Teen team collects from parents about their demographics, socioeconomics, and HPV vaccination concerns. In Section D, interviewers receive information from parents to contact health care providers and consent to do so. In Section E, the NIS-Teen team collects information related to the child's health insurance. In the second part of the NIS-Teen, staff mail an Immunization History Questionnaire to vaccination providers. This questionnaire's primary purpose is to verify parents' information about their child's vaccination status during the telephone interview. Interviewers also ask providers to provide information about their practice. The NIS-Teen household and provider-verification sections are suitable for research because they provide data collected by survey experts using standardized questionnaires to address a variety of RQs.

NIS-Teen Data Set Sections

The NIS-Teen data set, which results from interviews with parents, contains data on a multitude of variables. The NIS-Teen public-use data file is comprised of 10 sections (CDC, n.d.-a). The data in each section correspond to parents' and vaccine providers' responses in corresponding parts of the household telephonic interview and immunization history questionnaire, respectively (CDC 2020b). The first section of the data set contains participants' identifiers and their survey weights (CDC 2020b). The second and third sections provide data on variables of the household interview, and the fourth on geographic variables. Parts 5 to 9 have data on variables related to provider verification of teens' vaccination status. Finally, data on variables of the NIS-Teen health insurance module are in Section 10. The NIS-Teen data set provides data to researchers on a broad set of variables from the survey's household interview and provider-verified vaccination status sections.

Research Design and Rationale

Using secondary data from the NIS-Teen was appropriate to examine different levels of predictors of parents' intentional and actual use of the HPV vaccine to protect their children against infection and sequelae. The goal of research based on the quantitative methodology, which the NIS-Teen employs, is to describe, explain, relate, predict, or evaluate observable phenomena of importance to public health using numbers (Frankfort-Nachmias & Leon-Guerrero, 2015). NIS staff developed the ongoing NIS-Teen study to provide data to estimate vaccination coverage rates and identify characteristics of teens, parents, and households associated with disparities in vaccination coverage (Wolter et al., 2017). However, the NIS-Teen team also designed their survey to investigate factors influencing parents' decision to vaccinate their children (Wolter et al., 2017), a focus of my study. Using data from the NIS-Teen data set, I could examine the association of parents' concerns about HPV vaccination and sociodemographics with their intentions to have their youth vaccinated and use of the vaccine. Thus, I aligned the use of archived data publicly available from the NIS-Teen data set with this study's purpose and conceptual basis to examine different levels of predictors of parents' intentional and actual use of the HPV vaccine to protect their children against infection and sequelae.

The quantitative approach employed in the NIS-Teen is congruent with statistical procedures. Quantitative researchers generalize their findings from statistical data analysis on a large sample of participants to a target population (Frankfort-Nachmias et al., 2015). Researchers express participants' responses to questions in surveys in various levels of measurement, including nominal, ordinal, interval, and ratio (Field, 2013; Groves et al., 2004). In the NIS-Teen interviews, parents choose from lists of possible responses to questions, rank their responses on scales, and provide short answers (CDC, 2016a, 2016b). The nominal variable gender, for example, could be quantified using zero to designate male participants and one for female counterparts. The ordinal variable of parental intent to vaccinate a child is ranked using a 4-point Likert-type scale ranging from *very likely* to *not likely at all* (CDC, 2016a, 2016b). I could measure the frequency of participants' selection of different responses to questions based on these categorical variables, such as the number of parents concerned or not about vaccine safety. The NIS-

Teen data set was an appropriate source for this study because it provided numerical data on sociodemographics, parental concerns, and decision-making about HPV vaccination. In turn, I could analyze influences at multiple levels on parental intentions and use of the HPV vaccine for their children using numerical values of these variables and statistical procedures.

I needed to consider various issues in the current study because of the use of NIS-Teen data collected by surveyors using a cross-sectional design. Using probability sampling in a natural setting, a researcher can obtain a more representative sample of the population of interest (i.e., more externally valid) than through a controlled experiment (Frankfort-Nachmias et al., 2015). However, in studies featuring a nonexperimental design (vs. an experimental one), it is more complicated for a researcher to be sure an effect on a dependent variable is due to the independent variables of interest. Achieving internally valid results is especially challenging when many variables other than the independent variables under consideration can influence the dependent variable, as is the case in this study. Internal validity of a study based on cross-sectional survey data is essential because the findings cannot be externally valid unless they are internally valid (Akobeng, 2008; Frankfort-Nachmias et al., 2015). In brief, the cross-sectional design of the NIS-Teen has advantages and disadvantages.

The characteristics of adult participants and families in the NIS-Teen were appropriate for the present investigation. In households with at least one girl or boy between ages 13 and 17, the NIS-Teen staff interviewed the adult most aware of the selected child's HPV vaccination status (CDC, 2018, 2020b). Adults usually give consent for teens in their household to receive the HPV vaccine (CDC, n.d.-a). The adult self-report of teens' HPV vaccination status was preferable in the NIS-Teen study because these adults were typically aware of the HPV vaccination status of children in their households.

The inclusion and exclusion criteria of the participants were a constraint to the generalization of the results of this study. NIS-Teen surveyors excluded institutionalized parents and teens (CDC 2020b). Institutionalization of parents and youth could occur for many reasons, including boarding school education, imprisonment, and hospitalization (CDC 2020b). Research shows that families in which parents and their children live apart for long periods have different barriers to adolescent HPV vaccination than those in which the parents and their children live together (Emerson et al., 2020; Roberson & McGee-Avila, 2021; Rowe et al., 2017). Interventions to increase HPV vaccination might vary depending on the reason for parents' separation from their children (da Silva Carvalho et al., 2020; Moore et al., 2019; Weise et al., 2021). Researchers need to examine further how to improve HPV vaccination under the various circumstances that lead to parents living apart from their children (Allison et al., 2019; Emerson et al., 2021; O'Neill et al., 2020). For this reason, public health advocates are limited to using my analysis of NIS-Teen data to improve HPV vaccine uptake in families where parents live with their children.

The characteristics of the participants in the NIS-Teen surveys reflected the study population of Bexar County, Texas. First, the Hispanic parents included in the NIS-Teen interviews were characteristic of the study population regarding immigration status. From

2016 to 2020, the percentage of authorized and unauthorized foreign-born Hispanics living in Bexar County at 13.0% was lower than that in Texas at 16.8% (U.S. Census Bureau, 2022). Researchers need to explore further the HPV vaccination coverage of U.S. immigrants (Barnack-Tavlaris et al., 2014). However, the NIS-Teen data set does not contain the data needed to assess the immigrant status of Hispanic respondents (CDC, 2018, 2020b). Second, the relatively large percentage of mothers interviewed by the NIS-Teen staff might reflect that mothers had a more significant role than fathers in making decisions about the vaccination of their children (CDC, n.d.-a, n.d.-c, 2016a). Summing up, various groups of people were not only represented but also unrepresented or underrepresented in the NIS-Teen target population, and, in turn, in the current study. Even so, the characteristics of the participants in the NIS-Teen surveys were appropriate to attain the data needed in the present investigation to address the RQs.

Methodology

Population

The population of interest in the current study was Hispanic teens aged 13 to 17 years and their primary caregivers, age 18 years or older, who participated in the NIS-Teen between 2016 and 2018 and lived in Bexar County, Texas. The NIS-Teen team includes data on this population in their dataset (CDC, n.d.-a, 2020b). During my study period, Bexar County, located in south-central Texas, had a population of close to 2 million (U.S. Census Bureau, 2021b). About 60% of this population was Hispanics (Metro Health Informatics Division, 2018; U.S. Census Bureau, 2021a; U.S. Census Bureau & National Center for Health Statistics, n.d). Currently, Bexar County has a population exceeding 2 million (U.S. Census Bureau, n.d.). I examined the telephonic survey responses of adults living in households with teens to learn more about predictors of HPV vaccine use by teenage girls and boys 13 to 17 years of age. As Texas encourages immunization of minors, a broad list of adults can consent to vaccinate a child against HPV, including parents, male or female guardians, grandparents, other family members, and friends (CDC, n.d.-f; Texas Health Steps, n.d.). Therefore, vaccine providers usually authorize adult NIS-Teen survey participants in Bexar County to consent to the HPV vaccination of teens under their care, control, or possession. In turn, most adult participants in the NIS-Teen interviews are likely knowledgeable of the HPV vaccination status of their child. For these reasons, the target population of the NIS-Teen, upon which I based this study, was in alignment with the ultimate aim of my research to provide information to HPV vaccine advocates for improving coverage of youth in Bexar County Texas. However, the results of my analysis of predictors of HPV vaccination of teenagers might not generalize to other populations and periods.

Sampling and Sampling Procedures

Sampling for the NIS-Teen is a multi-step process. NIS-Teen researchers select samples of populations of parents or guardians of teens, who are eligible for HPV vaccination at the national, state, and local levels in the United States to participate in telephonic interviews (CDC 2020b). Interviewers randomly select and call landline and cell phone numbers to enroll one age-eligible child between the ages of 13 and 17 from each household. In addition, they ask the parents of eligible children during the telephone interview for the names of their child’s vaccination providers and permission to contact them through mail surveys. Interviewers use independent, quarterly samples of telephone numbers in the NIS-Teen random digit dialing telephone survey phase. The Marketing Systems Group provides sampling frames. The NIS-Teen surveyors have sampled landline and cellular phone numbers within 58 estimation areas of the United States in each calendar quarter since 2014. However, in 2018, they contacted potential participants only using cell phone numbers because landline phones became a small proportion of phones used in households. In designing the target sample size of completed telephone interviews in each region, investigators with the NIS-Teen aim to achieve a coefficient of variation (precision) of 6.5% for an estimation of vaccination coverage based on provider-reported immunization (CDC 2020b). The coefficient of variation is an expression of the standard deviation of values of a variable as a percentage of the mean (Daniel & Cross, 2013). Data analysts use it to compare the dispersion of variable values with different units of measurement and mean values. In sum, interviewers recruit participants for the NIS-Teen survey through random digit dialing of telephone landline and cellphone numbers with a target sample size of completed telephone interviews. Researchers can obtain precise information on parent-reported or provider-verified HPV vaccination rates.

Managers of the NIS-Teen establish criteria to select participants for interviews. Inclusion criteria for adult participants are the adult aged 18 years and older in a household who is most knowledgeable, at the time of the interview, about the HPV vaccination history of the child under consideration (CDC, n.d.-a). The target population of parents and teens for the NIS-Teen interviews is noninstitutionalized adults and adolescents living in United States households at the time of the interview (CDC, 2016b; CDC 2020b). NIS-Teen interviewers identify families with at least one child aged 13 to 17 (CDC, n.d.-a). If a home has more than one teen in this age range, interviewers randomly select one of the teens. In effect, the NIS-Teen surveyors exclude institutionalized teens, those younger than 13 years or older than 17, and those residing outside the United States. Similarly, surveyors exclude institutionalized adults, those lacking United States citizenship, and those less informed of the child's HPV vaccinations than another adult in the household is aware.

Surveyors use five criteria to establish whether the teen of interest is noninstitutionalized at the time of the survey. NIS-Teen interviewers classify the teen under consideration as noninstitutionalized if the child's living situation in the household could be described in any of the following ways (CDC, n.d.-a; CDC, 2016b). First, the teen of interest had been staying in the household (or was expected to stay there) for at least two months. Second, the teen usually stayed in the home but was away for less than two months due to travel, hospitalization, or other reasons. Third, the teen usually resided in the house but was away for two months or more for schools such as college, boarding school, military academy, and prep school. Fourth, the teen lived in the household only part-time due to custody issues but was staying there at the time of the interview. Finally, the length of the teen's stay in the home was unknown, but they had no other usual residence. Ultimately, surveyors exclude from the NIS-Teen study teens who do not meet at least one of these criteria.

Analysis in the current study involved a subset of NIS-Teen data from guardians of teens meeting predefined criteria. I based my research on publicly available data from the NIS-Teen, conducted annually throughout the United States (CDC, n.d.-a, 2016a). The NIS-Teen dataset includes information I needed to produce results that practitioners might use to improve HPV vaccination coverage in Bexar County, Texas. First, this study consisted of Hispanic adolescent boys or girls between the ages of 13 and 17 during the NIS-Teen surveys in 2016, 2017, and 2018. Second, this study included Hispanic adolescents and their primary caregivers living in Bexar County, Texas, but excluded those residing elsewhere in Texas and the United States. Third, the current study included adolescents in 2016, 2017, and 2018 NIS-Teen studies who received any number of HPV shots or none between the age of 9 and 17. The ACIP recommends routine vaccination of youth ages 11 or 12, but vaccine providers can start the immunization series as early as age 9 (CDC, 2022). Fourth, included in the present study were the adult respondents who told the NIS-Teen interviewer they were the adult in the household at the time of the survey most knowledgeable of the child's vaccination history (CDC 2020b). Fifth, I excluded data involving answers from guardians of "don't know" or "refused," with one exception from the analysis. The NIS-Teen team classified parents asked to rank the likelihood they would have their teens vaccinated against HPV in the next 12 months as having *no-intent* to protect their teen if their response included *not sure* and *do not know*. I describe the operationalization of this variable in the Parental Intent to Have Their Child Vaccinated Against HPV subsection. This subsection is under the Instrumentation and

Operationalization of Constructs section. Finally, I excluded data marked as missing from the analysis.

Instrumentation and Operationalization of Constructs

I used a subset of data contained in the NIS-Teen dataset for this study. Specifically, I used only data of variables in the public use data file from sections 1, 2, 3, and 4, as described in the NIS-Teen user's guide (CDC 2020b) and data codebook (CDC, n.d.-a). Section 1 pertains to participant identification numbers and survey weights (CDC 2020b). Section 2 includes data on household-reported vaccination histories of teens. Section 3 entails data on sociodemographics of parents and teens as well as parental knowledge and attitudes about HPV and the vaccine. Section 4 has geographic residence codes to identify respondents from Bexar County, Texas. The names and definitions of these variables are in the NIS-Teen user's guide (CDC 2020b) and the data codebook (CDC, n.d.-a). The NIS-Teen dataset was suitable for use in my study because it provided data to address the RQs. In this section, I describe in detail the variables used in the current research and their operationalization.

The purpose of this section is to describe the independent, dependent, and sociodemographic variables used to adjust survey weights as well as other NIS-Teen variables used in my analysis. I studied the association of total family income level with parents' intent to vaccinate their child (RQ1), the teens' vaccine initiation (RQ 2), and completion (RQ 3). In a subset of parents who lacked intent to have their unvaccinated or undervaccinated child receive the HPV vaccine, I examined the association of income level with parental reasons for no-intent (RQs4-8).

Research Questions 1 to 8: Independent (Predictor) and Sociodemographic Variables Used to Adjust Survey Weights

As shown in the following list of RQs, total family income was a common independent (predictor) variable of RQs1 to 8. Total family income was associated with the dependent variables of parents' intent to vaccinate their child (RQ1), teens' vaccine initiation (RQ2), completion (RQ3), and parents' knowledge and concerns about HPV disease and the vaccine (RQs4 to 8). To test this potential relationship, I defined total family income as having two categories. Data on this variable is available in the NIS-Teen dataset (CDC, n.d.-a, n.d.-b). The NIS-Teen code for total family income is INCQ298A, and this variable is at the intrapersonal level of the SEM (see Table 1, Chapter 1).

In Table 1, I also list sociodemographic variables used by NIS-Teen surveyors to develop and adjust survey weights. I addressed to the extent feasible the challenge of making my sample representative of the study population by applying survey weights to my data (CDC 2020b). The survey weights allowed me to adjust for the number of telephone lines in a household, the combination of landline and cellphone samples, and the poststratification to population control totals of maternal education categories, teen race and ethnicity, teen age, teen gender, and telephone status (CDC, 2018; Wolter et al., 2017). In this way, I used the survey weights to make the data more representative of my study population of Hispanics in Bexar County, Texas.

Research Questions 1 to 3: Dependent (Outcome) Variables

HPV Vaccination Series Completion. I based the definition of HPV vaccination series completion on the current vaccination schedule recommendations of the ACIP. As of late 2016, the ACIP has defined HPV vaccine series completion as the receipt by a teen of 2 doses for adolescents under the age of 15 years but 3 doses for those between the age of 15 and 26 years (Meites et al., 2016). Teens are considered up to date with HPV immunization if they have received at least 2 doses before age 15 and 3 doses for those between ages 15 and 17 years (Walker et al., 2017). Until 2016, the ACIP recommended 3 doses of HPV vaccine for teens under the age of 15 and those older than this cut-off age (Meites et al., 2016). As mentioned, the population under consideration in this study was teens 13 to 17 years old during the NIS-Teen survey years of 2016, 2017, and 2018. Therefore, I based my analysis of teens' vaccination *completion* (up to date) status on those who received 2 doses before age 15 years and 3 doses between ages 15 and 17.

HPV Vaccination Series Initiation. In this study, vaccine uptake (*initiation*) referred to the administration of 1 dose of HPV vaccine for teens under the age of 15. For those aged 15 to 17 years, I considered vaccine initiation to be the receipt of 1 or 2 doses.

Parental Intent to Have Their Child Vaccinated Against HPV. In the NIS-Teen, the outcome of parental intent to vaccinate their child is determined by asking parents of teens, who were not up to date with the HPV vaccination, to rank the likelihood they would have their teen vaccinated in the next 12 months (CDC 2020b). Parents rate their intention to immunize teens as *very likely, somewhat likely, not too likely, not likely at all, not sure, and do not know* (CDC 2020b). In the current study, I considered parents to have the *intent* to vaccinate their teen if they stated it was *very likely* or *somewhat likely* they would have their child receive the HPV vaccine (Cheruvu et al., 2017). On the other hand, parents were classified as having *no-intent* to vaccinate their teen if their response was *not too likely*, *not likely at all, not sure, or do not know*. Cheruvu et al. (2017) reported that in data from 2008 to 2012 NIS-Teen surveys, less than 3% of parents responded *not sure or do not know*. In 2016 to 2018 NIS-Teen studies, 7%-8% of parents responded *not sure or do not know* (CDC, n.d.-a).

I present in Table 3 a summary of dependent (outcome) variable names, NIS-Teen codes, and operational definitions for RQs1 to 3.

Table 3

Dependent Variables of Vaccine Use of Teens and Parental Intent to Vaccinate Teens

Variable name	Codes in NIS-Teen dataset	Specific explanation or operational definition of variable	Research question
HPV vaccination series completion	HPVI_NUM_TOT, P_NUMHPV, AGE	The receipt by a teen of 2 HPV vaccine doses for those under age 15 years; 3 doses for those between age 15 and 17 years.	3
Vaccination series initiation	HPVI_NUM_TOT, P_NUMHPV, AGE	Receipt of 1 HPV vaccine dose for those under age 15 years; 1 or 2 doses for those age 15 to 17 years	2
Parental intent to vaccinate their child	HPVI_NUM_TOT, P_NUMHPV, AGE, HPVI_INTENTR	Parents stated it was *very likely* or *somewhat likely* they will have their child receive the HPV vaccine in the next 12 months.	1

Note. NIS = National Immunization Survey. HPV = human papillomavirus.

Research Questions 4 to 8: Parental Reasons for No-Intent to Have Their Child Receive the Vaccine

I examined the relative importance (influence) of parents' reasons (or barriers) for not intending to vaccinate their teens against HPV. In the NIS-Teen, interviews ask parents considered to have no-intent for their teen to receive the HPV vaccine to give the main reason their teen will not get the vaccine (CDC 2020b). The parents asked this question are a subset of all interviewed parents who had teens who were not up to date on HPV vaccination at the time of their interview and had no-intent to vaccinate their teen in the next 12 months (CDC 2020b). Like Cheruvu (2017), I classified reasons for parental no-intent to inoculate their teens into five domains. Reasons related to each other make up a given domain.

Table 2 of Chapter 1 shows that each domain of parental reasons (or barriers) to HPV vaccination used in this study corresponded to a dependent (outcome) variable of RQs4 to 8. The domains were parental safety and effectiveness concerns (RQ4), vaccination misinformation (RQ5), lack of knowledge about HPV and the vaccine (RQ6), systemic access barriers including lack of provider recommendation (RQ7), and sociocultural barriers (RQ8). I give in Table 2 the NIS-Teen dataset codes applicable to each domain and a description of the domains (CDC, n.d.-a). In addition, each of these domains relates to a level of the SEM of health. I assigned each dependent variable to a level of the SEM based on the rationale of Kumar et al. (2012) and Cheruvu et al. (2017).

I treated each domain listed in Table 2 as a binary outcome in my analysis (chi-square test, proportion, and prevalence ratio), as previously described by Cheruvu et al.

(2017). If a parent reported at least one reason in a particular domain for not intending to vaccinate their teen, I recorded the data value of the corresponding outcome variable for that domain as a “Yes” response (Cheruvu et al., 2017). If a parent did not select any reason in a domain, I assigned a value of “No” to the variable corresponding to the domain (Cheruvu et al., 2017).

Other NIS-Teen Variables Needed for Data Analysis

Table 4 lists other variables needed for analysis in this study. The NIS-Teen team coded missing values in the household interview survey as “77” for not sure and do not know and “99” for refused (CDC 2020b).

Table 4

Variables Besides Independent, Dependent, and Survey Weight Adjustment Variables

NIS-Teen variable name	Specific explanation or operational definition of the variable	Section	Column position
SEQNUMT	Unique teen identifier	1	1-5
YEAR	Sampling year	1	51-54
I_HISP_K	Is teen Hispanic or Latino?: Imputed	3	289-289
ESTIAPT17	Estimat. area of residence (55 for Bexar County)	4	304-306
RDDWT_D	Final dual-frame RDD-phase weight (excl. terr.)	1	7-26
STRATUM	Stratum variable for variance estimation	1	47-50

Note. NIS = National Immunization Survey. Estimat.= estimation. RDD = random digit dialing. Excl. terr. = excluding territories.

Procedures for Data Collection

The NIS-Teen data management team verifies the quality of their data and provides users with indicators of its validity and reliability. To this end, the NIS-Teen team carries out quality control at various stages of data collection and processing to assure the validity and reliability of data (National Opinion Research Center, 2015). Notably, data managers use sophisticated statistical methods to adjust for parental nonparticipation and lack of a telephone as well as provider nonreporting of immunization histories (CDC, 2002, 2016a, 2016d). Ultimately, data analysts with the NIS-Teen extensively prepare and process data from the household interview, and the provider verified vaccination phases.

The editing and cleaning of NIS-Teen data involve several steps. First, the NIS-Teen survey includes a computer-assisted telephone interviewing (CATI) technique in which the interviewer follows a script provided through a software application (National Opinion Research Center, 2015). The interviewers reconcile critical errors as they enter data during the CATI and the respondent is still on the telephone. After completion of each quarterly interviewing, data experts conduct post-CATI editing and data cleaning to produce a final interview data file. This postCATI cleanup involves a thorough review of data values, a cross-tabulation of data, and the recoding of verbatim responses on race and ethnicity. Data handlers review and edit manually returned immunization history questionnaires from medical providers similarly. After the data management team cleans and enters data, they substitute estimated values for missing or inconsistent data, including item nonresponse on selected variables (National Opinion Research Center, 2015). In addition, they calculate survey weights. The NIS-Teen team abides by the procedures and rules of the National Health Interview Survey (National Center for Health Statistics, n.d.). These rules serve as the standard in all data cleaning and editing stages. The final product is a valid and reliable analytic file of household and provider verified data for estimating vaccination coverage and assessing associated participant information.

I appropriately retrieved, managed, and secured for the current study archived NIS-Teen data available online. I used a secure file-transfer-protocol server of the National Center for Health Statistics to download public-use data files and associated documents from 2016, 2017, and 2018(CDC 2020b). For each survey year, I downloaded a text-based DAT file and SAS statistical analysis software input statement (script) from the NIS-Teen website on data sets and related documentation (CDC, n.d.-a). Then, I used the SAS input statement to transform the DAT type file into a format compatible with Microsoft Excel 365 software for statistical analysis and data management. I ran the SAS input statement using SAS Studio University Edition version 94 and Oracle VM VirtualBox version 6.1.8-137981 for Windows software programs (SAS Institute Inc., n.d.). However, in 2021, SAS OnDemand for Academics replaced the discontinued SAS University Edition (SAS Institute Inc., n.d.). In this way, I transformed the NIS-Teen data using appropriate, publicly available software procedures.

I took precautions to avoid disclosure of the identity of NIS-Teen survey participants. Although the NIS-Teen data is publicly available, the CDC and the National Center for Immunization and Respiratory Disease (NCIRD) stipulate how users are to safeguard participant information (CDC, 2016c). First, users are to limit the use of NIS-

Teen data to analysis and statistical reporting. Second, the CDC and NCIRD prohibit researchers from using personally identifiable information and require them to report any identifying information found inadvertently in the NIS-Teen data files. Third, the CDC and NCIRD preclude data analysts from using participant identifiable information to link NIS-Teen data files with other files. In short, I adhered to CDC and NCIRD stipulations to avoid any intentional or unintentional identification or disclosure of a parent or vaccine provider that might breach the assurances of confidentiality given to these survey participants.

Data Analysis Plan

Compromise Power Analysis

Chi-Square Test for Association in a 2x2 Contingency Table. I used a compromise power analysis to determine the optimal alpha criteria and statistical power for the chi-square test of independence for each RQ, based on the available secondary data (sample size). I used the G*Power program version 3.1.9.2 to conduct the compromise power analysis to calculate the alpha (α) error probability (cutoff) and power, given the sample size, beta/alpha (β/α) ratio, and effect size (Faul et al., 2007, 2009, 2014). False-positive or Type I (alpha, α) errors occur in inferential statistics when an analyst calculates a significant association among variables that is not actually present, and false-negative or Type II (beta, β) errors take place when one misses an association that is real (Frankfort-Nachmias & Leon-Guerrero, 2015). Power (1-β) is the probability a researcher will detect, using a statistical test, a real effect of a particular size (Field, 2013). I used the effect size measure for the chi-square test (omega, ω) in the power analysis for the chi-square test (Faul et al., 2007, 2009, 2014). This effect size measure is the square root of the standardized chi-square statistic, and a value of 0.1 is considered small (Cohen, 1988; Statistical Consulting Group, n.d.). I estimated the population effect size value needed for power analysis based on previous HPV vaccine use studies in which most values were small (Cheruvu et al., 2017; Franco et al., 2019; Galbraith et al., 2016; Rodriguez et al., 2018). For this reason, I chose a small effect size ω of 0.1 for my power analysis. By following this approach, I could determine the appropriate alpha cutoff and power for the chi-square test based on the sample size of secondary data available for each RQ.

An example illustrates how I found the cut-off value and power for one of my RQs. In the pooled average of the 2016 to 2018 NIS-Teen data sets, there were 816 participants available to address RQ1 using the independent variable of family income level and the dependent variable of parents' intent to have their child vaccinated against HPV. For the chi-square statistics test, I calculated that based on a total sample size of 816, a small effect size ($\omega = 0.1$), an error probability ratio ($q = \beta/\alpha$) of 1/2, and one degree of freedom, there is a 92% chance of correctly rejecting the null hypothesis of no association between the independent and dependent variables. The probability (p) of the results of this test being a false positive is $p = .153$. Therefore, I set the alpha criteria (cutoff) and statistical power for the chi-square test of RQ1 at $p = .153$ and 92%, respectively. Thus, in this statistical analysis, the chance of detecting a real association of the independent variables and HPV vaccination initiation or completion with a small effect size ω of 0.1 is high, and the probability of a statistically significant relation being due to a false positive error is at an acceptable level. In this way, I determined an optimal alpha cutoff and power level for the chi-square test of RQ1.

Proportions and Prevalence Ratio. I also used a compromise power analysis to optimize confidence intervals of the proportions and prevalence ratio of each RQ. Similar to the chi-square test, the optimal confidence intervals of the proportions and prevalence ratio of each RQ depend on the available sample size. Again, I used the G*Power program to do a compromise power analysis to calculate the α criteria (cutoff) and power, given the sample size, beta/alpha (β/α) ratio, and effect size (Faul et al., 2007, 2009, 2014). For each of my statistics, I calculated the α criteria and power using a different procedure in the G*Power program. Next, I describe the procedures used in the G*Power program to determine the optimal α criteria and statistical power of my proportions and prevalence ratio, based on the available secondary data.

I used specific procedures to calculate α criteria and power in the G*Power software. First, I opened the G*Power program version 3.1.9.2 (Faul et al., 2014). For proportions, I selected "Proportion: Sign test (binomial test)" in the Exact test family (University of Düsseldorf, n.d.). Input parameters were the two-tailed test, a small to medium Cohen's effect size (g = 0.1), an error probability ratio (q = β/α) of 1/2, and the total sample size. Second, for the prevalence ratio, I selected "Proportions: Inequality, two independent groups (unconditional)" in the Exact test family (University of Düsseldorf, n.d.). Under options, I chose risk ratio (p1/p2) and *t* test. Input parameters were two-tailed, ratio (p1/p2) corresponding to the risk of outcome (e.g., HPV vaccination initiation) in low- versus high-income groups, proportion (p2) or risk in high-income group, and β/α ratio of ½ or 0.5. In addition, I entered the sample size of Groups 1 and 2 corresponding to low- and high-income groups, respectively. In this way, I used the G*Power program to determine the α criteria (cutoff) needed to optimize the confidence intervals of my proportions and prevalence ratio based on the available sample size for each RQ.

Rationale for Withholding Multivariable Analysis With Control Variables

I decided to measure the association of my independent and dependent variables with the chi-square test and prevalence ratio instead of binomial logistic regression. Bollen et al. (2016) noted it is controversial whether researchers should use survey weights with multivariable methods, especially logistic regression, and, if so, under what conditions. In developing and adjusting the sample weights, the NIS-Teen surveyors used control totals of my study population for sociodemographic variables and trimmed their values (CDC 2020b). As I would alter the values of these variables used to adjust survey weights in the weighting of my data, it might be inappropriate to use them as control variables in binomial logistic regression of weighted data (Young & Johnson, 2012a, 2012b). An alternative might be to use unweighted data to examine sources of variation in my dependent variables (Mobley et al., 2019; Young & Johnson, 2012a, 2012b). However, comparing participants' unweighted versus weighted frequency, I found a substantial difference of more than 10% (Tables 9, 13, 17, 23, 26, 29, 32, and 35). If I were to perform logistic regression of unweighted data, I might get biased regression coefficients (Young & Johnson, 2012a, 2012b). Most statisticians agree that researchers should apply survey weights to complex survey samples used to produce descriptive statistics (Johnson, 2008; Young & Johnson, 2012a, 2012b). The primary purpose of my study was to compare the crude prevalence of vaccination-related outcomes and barriers in low- versus high-income families. Therefore, using the prevalence ratio and chi-square test, adapted for the complex survey, was suitable for my weighted data. Considering the surveyors' derivation of the sample weights and the observed effect of weighting my descriptive data, I withheld logistic regression as initially planned to reduce the chance of getting misleading results.

Description of Methods

I derived the descriptive and inferential statistics to address my RQs from survey data of multiple years and a weighted average. I studied NIS-Teen survey data from 2016, 2017, and 2018. For simplicity, I will generally refer to the results of data analysis from a given NIS-Teen survey year as a study. In all RQs, I present tables of the results of each statistical measure and test by year and the three years combined. In the text preceding the tables, I compare and contrast my data analysis results among the three survey years and describe any trend. For each study, I also assess the results of the hypothesis test of the RQs. To reiterate, I tabulate, present, and describe the results of descriptive and inferential statistics from the analysis of data for each survey year and their weighted average.

I used cross-sectional data to address my RQs. In the NIS-Teen survey, interviewers queried a different set of parents each year about the HPV vaccination of their child (CDC, 2018). The NIS-Teen researchers base these annual surveys on a cross-sectional study design (Frankfort-Nachmias et al., 2015). Therefore, I used the cross-sectional design underlying my secondary analysis of NIS-Teen survey data to investigate the predictors of HPV vaccination of Hispanic teens aged 13 to17 years in Bexar County, Texas.

I based the evaluation of the null hypothesis of no association for each RQ on an inferential statistical test of data for each survey year. I used the chi-square test of independence. Researchers use this inferential test to evaluate whether two variables are independent or associated (Agresti, 2013; McDonald, 2014; McHugh, 2013). Therefore, it helped assess my null hypothesis of no association between independent and dependent variables. Researchers have used the chi-square test in cross-sectional studies as a bivariate test for the presence or absence of a statistically significant association between variables without proceeding to a more refined multivariable analysis (e.g., Karthikeyan et al., 2022). As mentioned, I studied NIS-Teen survey data from 2016, 2017, and 2018. For all the RQs, I tabulated and described the statistics for each year and the three years combined. Using the chi-square test to assess the null hypothesis of no association for each RQ, I obtained evidence to reject or fail to reject the null hypothesis.

I also based my evaluation of the null hypothesis of no association for each RQ on a descriptive statistical test. I used the prevalence ratio as a descriptive measure to compare the prevalence of the outcome of interest for each RQ in low- and high-income families (Benichou, 2007). The prevalence of the outcome under consideration in the two income groups was statistically different if the confidence interval of the prevalence ratio estimate did not contain the null value of one (Armitage et al., 2002; Gerstman, 2015). In my study, the prevalence ratio indicated both the strength and the direction of association of the independent and dependent variables (Gerstman, 2015). Researchers have used the prevalence ratio in cross-sectional studies instead of multivariable analysis to test for an association between variables (see Morhason-Bello, 2021, for a systematic review). Vaccine hesitancy researchers have used survey-weighted NIS-Teen data to compare the prevalence of HPV vaccine use in low- and high-income families (Walker et al. 2017, 2018, 2019). Using both descriptive and inferential statistics to test the null hypothesis of no association for each RQ, I obtained stronger evidence to reject or fail to reject the null hypothesis.

The study design of this investigation limited my choice of the relative measure of association. In my cross-sectional study design, based on NIS-Teen survey data, the surveyors collected data on variables simultaneously (CDC, 2020b). Specifically, they concurrently measured the exposure of interest in my study, income level (independent variable), and the outcome of each RQ (dependent variable). Therefore, I could estimate the exposure and outcomes' prevalence but not the incidence (Benichou et al., 2007; Fonseca Martinez et al., 2017). For this reason, the prevalence ratio, but not the incidence (rate) ratio, was a candidate measure of association in this study. As I illustrate in this section, the mathematical calculation of the prevalence ratio is identical to that of the incidence (rate) ratio (i.e., relative risk; Fonseca Martinez et al., 2017). The odds ratio and prevalence odds ratio, which are required in case control studies, can be unsuitable for cross-sectional studies (Chen et al., 2010; MarinStatsLectures-R Programming & Statistic, 2018). As I explain in the limitations section of Chapter 5, the prevalence ratio is more straightforward to interpret than the prevalence odds ratio and provides consistent results over a wide range of sample sizes, as in this study (Ellis, 2010; Szklo & Nieto, 2014; Zhang & Yu, 1998). For these reasons, the prevalence ratio was a preferable measure of association in this cross-sectional study. In short, I used the prevalence ratio as an easy-to-interpret and consistent measure of the strength and direction of association between the independent and dependent variables.

I also present for each RQ and study year the frequencies of both categories of independent and dependent variables in a 2 x 2 contingency table. I used this data to do the chi-square test of independence and estimate the prevalence ratio. I provide the reader with enough information in the 2 x 2 table to independently assess the validity of my statistical results and underlying assumptions, as Ellis (2010) recommended. I also used the data in this cross-tabulation table to compare the prevalence of low- and high-income parents who had the outcome of interest (Armitage et al., 2002; Gerstman, 2015). By presenting the 2 x 2 table along with separate tables of the chi-square test results and prevalence ratio estimates, I help the reader understand and evaluate the results.

I used sample weights to make my sample more representative of the study population. The NIS-Teen surveyors provided me with sample weights (CDC, 2018; Wolter et al., 2017). As mentioned, I used these sample weights to estimate population statistics from my NIS-Teen survey data (Lehtonen & Pahkinen, 2004). Specifically, I used the NIS-Teen weights to make my sample more representative of the population from which researchers obtained the sample in terms of multiple characteristics considered necessary by the NIS-Teen surveyors in developing and adjusting the weights (CDC 2020b). The weights provided by the NIS-Teen surveyors allowed me to make my sample more like the study population in terms of survey related variables (e.g., parental nonresponse to interviewer) and sociodemographic characteristics of the participants (i.e., maternal education and teen gender, race/ethnicity, and age; CDC 2020b). Ultimately, the results of descriptive and inferential statistical tests in all phases of my study should represent the study population. As I applied survey weights to my complex survey samples, using the inferential chi-square test and descriptive prevalence ratio measure was likely appropriate and adequate to test the null hypothesis of no association for RQs.

After using survey weights to adjust my sample of NIS-Teen data to represent better my study population, I analyzed the weighted data. For each of my statistical tests, I used special procedures to account for my complex survey data. First, I used a chi-square statistical procedure for weighted survey data, as described by Lohr (2010). I employed this statistical procedure to test the association of my independent and dependent variables (Noordzij et al., 2017). Second, I based my calculations of the prevalence ratio on the estimated population size (*N*). Prevalence ratio = [N of low-income parents with a given outcome of interest for a dependent variable / (N of those with the outcome + N of those without the outcome)] / [N of high-income parents with a given outcome of interest / (N of those with the outcome + N of those without the outcome)]. I was able to make comparisons between the prevalence of exposed (low-income) and unexposed (high-income) groups that were representative of my study population (Lehtonen & Pahkinen, 2004; Rosner, 2016). In addition, I used the Taylor series method to adjust the variance of population estimates for the intricate survey design (CDC, 2018; Wolter, 2007). Several statistical formulations were required to determine the variance values used to calculate confidence intervals of the proportions and prevalence ratio (Fleiss et al., 2003; Szklo & Nieto, 2014). Consequently, my results should be relevant to the target population and valuable to those concerned with improving HPV vaccination rates in this setting.

I employed additional strategies to improve the evaluation of research hypotheses. The NIS-Teen samples comprised data from parents about their teens (CDC, 2018). The sample sizes (i.e., number of participants) for the RQs varied widely. For this reason, I ran separate power analyses for the different RQs and statistical tests, as detailed in the Compromise Power Analysis section. As Ellis (2010) advised, I reported the power and exact *p* values for inferential tests. For descriptive statistics, I presented the size and direction of estimated population effects and the confidence interval and level. In addition, I optimized the power of my statistical tests by making the sample size of the income categories of my independent variable approximately equal (Rusticus & Lovato, 2014). I defined the income groups as values above and below the median income of my study population (CDC, 2018). In short, I refined my study plan to mitigate the potential negative impact of the varied and sometimes small sample sizes.

Preanalysis Data Processing and Assessment

Initially, I simplified the NIS-Teen data set used in this study and assessed it for errors. After downloading data from the NIS-Teen website (CDC, n.d.-a), I made the data set easier to manage by identifying variables relevant in the current study, based on the variables listed in Tables 1 to 3, and deleting nonrelevant ones. Then I inspected the data set for incorrect, duplicate, or missing data points. I excluded missing data from statistical analyses as appropriate. However, the originators of the NIS-Teen data sets often impute values to account for missing data due to the nonresponse of participants (CDC 2020b). I designated variables with missing data with appropriate codes to accurately account for the missing data during analysis.

The next data preparation phase for statistical analysis was recoding variables and checking for outliers. As necessary, I recoded the variables under consideration, as listed in Tables 1 to 3. All the variables used in this study were nominal. As nominal variables are unlikely to have outliers, it was generally not necessary to check for and remove outliers.

I ensured the fulfillment of statistical assumptions before conducting the chi-square test. Before and during data analysis, I assessed whether the assumptions held for the chi-square test of association, as shown in Table 5. The criteria for the chi-square test can vary somewhat from those listed in Table 5 and reported by Field (2013). For example, MarinStatsLectures-R Programming & Statistic (2018) states that all expected values for cells of 2 x 2 contingency tables, as in my study, need to have a value of five or greater, and all observed values for cells need to have a value of at least one. In addition, my study sample needed to be representative of the study population (MarinStatsLectures-R Programming & Statistic, 2018). The latter condition was likely satisfied because I applied statistical weights to my data to make it more representative of the study population (CDC 2020b; Heeringa et al., 2010; National Institute of Mental Health, n.d.). Accordingly, I used a chi-square statistical procedure appropriate for weighted survey data, as described by Lohr (2010). Sometimes, if researches find the conditions for the chi-square test are unfulfilled, they can use a nonparametric alternative test, the Fisher's exact test, to test the association between two variables (Field, 2013). As discussed in Chapter 4, I met the conditions for the chi-square test listed in Table 5 for most of my tests.

Table 5

Evaluation of Chi-Square Test of Association Assumptions

Assumptions[a]	Preliminary assessment of whether assumptions were met	Evaluation of assumptions done during data analysis
IVs[b] and DVs[c] should be categorical.	All IVs were categorical (i.e., nominal or ordinal) and the DVs were dichotomous.	
Each variable should have at least two independent categories.	Categories of the IVs and DVs were mutually exclusive and exhaustive. I operationalized all IVs to the categorical data type with two or more independent categories, and the DVs were dichotomous.	
All expected values for cells of the contingency tables should have a value greater than five in at least 80% of the cells.		I checked contingency tables to ensure the value in each cell was greater than five in a minimum of 80% of the cells.

[a]Field (2013) [b]IVs = independent variables, [c]DVs = dependent variables

I ensured the satisfaction of an assumption for measuring the proportions and prevalence ratio. To satisfy the conditions required to validly measure the proportions and prevalence ratio, I considered my research design and use of weighted data (Grol-Prokopczyk, 2018; Mobley et al., 2019; Tamhane et al., 2016). For the proportions and prevalence ratio to be unbiased in cross-sectional studies, the sample's prevalence must reflect the population's prevalence (MarinStatsLectures-R Programming & Statistic, 2018). Accordingly, I ensured my selected samples represented my entire study population by applying statistical weights to my data (CDC 2020b; Heeringa et al., 2010; National Institute of Mental Health, n.d.). I used this population estimate of prevalence to calculate the proportions and prevalence ratio (Fleiss et al., 2003; Szklo & Nieto, 2014). The results of all statistical tests in my study were representative of the larger study population because I similarly based them on weighted data (Babbie, 2016; CDC 2020b). That is, I adjusted my sample characteristics to match the target population by weighting the sample mathematically. In addition, to calculate valid confidence intervals, I used the Taylor series method to adjust the variance of population estimates for the intricate survey design (CDC, 2018; Wolter, 2007). I used several statistical formulations in a Microsoft Excel spreadsheet to determine the variance values used to calculate confidence intervals of the proportions and prevalence ratio (Fleiss et al., 2003; Szklo & Nieto, 2014). In this way, I ensured the fulfillment of the conditions necessary in my study to measure unbiased proportions and prevalence ratios, and corresponding confidence intervals.

In this cross-sectional study, two primary assumptions are required for a valid measurement of the prevalence ratio. Using prevalence instead of incidence data can distort the examination of the cause of diseases (Szklo & Nieto, 2014). Gefeller (1990) pointed out that when data on only prevalence is available to study the association between a disease and potential risk factors, the satisfaction of two assumptions is of prime importance. First, in cross-sectional disease studies, researchers must rule out the possibility of reverse causality in which an association between exposure and an outcome is not due to direct causality from exposure to outcome (Gefeller, 1990; Khosravi and Mansournia, 2019). That is, reverse causality means a change in the disease occurrence leads to a change in the exposure status (Szklo & Nieto, 2014). However, the outcomes of interest in this study are not disease outcomes. Instead, the outcomes (dependent variables) in the RQs are parents' intent to vaccinate their child (RQ1), vaccination coverage (RQs2 and 3), and the prevalence of parental barriers (RQs4 to 8). Therefore, it is hard to imagine a scenario in which a change in the outcomes could lead to a change in the independent variable of parental income level, the exposure of interest. Second, a bias of a measured association between an exposure and outcome, based on the prevalence data, often occurs when the disease duration varies by the exposure status (Gefeller, 1990; Khosravi and Mansournia, 2019). In other words, an association between an exposure and outcome can be biased when the exposure of interest affects or is related to the disease's likely course (prognosis; Szklo & Nieto, 2014). Again, this assumption does not apply in the current study because the outcome is not a disease in any of the RQs. For these reasons, my assessment of the association between parental income level and different outcomes was unlikely distorted due to the use of prevalence instead of incidence data in the analysis.

I had to meet other conditions to obtain a valid measurement of the prevalence ratio in this cross-sectional study. Bias, chance, and confounding are three additional reasons for a noncausal association between exposure and outcomes in any investigation (Aschengrau & Seage, 2014; Szklo & Nieto, 2014). Aschengrau and Seage (2014) noted that researchers must rule out these conditions as alternative explanations for an observed association between variables to be considered authentic (i.e., internally valid). First, a false association between an exposure and outcome can be due to chance (random errors), which are unidentifiable and uncontrollable factors. Second, an untrue association between exposure and outcome can be due to bias resulting from a systemic error in participant selection and measurements by surveyors. Researchers avoid bias by carefully designing and conducting a study (Aschengrau & Seage, 2014). Third, an erroneous association between exposure and outcome can be due to confounding. This noncausal association between exposure and outcome is due to a third variable (confounder) associated with both the exposure and outcome variables under consideration (Szklo & Nieto, 2014). Unlike bias, researchers typically control for confounding after data collection in the statistical analysis stage of a study (Aschengrau & Seage, 2014). Ultimately, I needed to rule out systematic bias, confounding, and random error as alternative explanations for an association between variables.

I addressed some of these alternative explanations for the current study's association between exposure and outcomes. I quantified the role of chance in the occurrence of associations using statistical inference (Aschengrau & Seage, 2014). The chi-square test was my formal test of the statistical significance of associations. Similarly, the prevalence ratio and corresponding confidence intervals provided insight regarding statistical significance (Frankfort-Nachmias & Leon-Guerrero, 2015). The prevalence ratio and confidence interval also allowed the determination of the direction, magnitude, and range of possible values for the associations (Frankfort-Nachmias & Leon-Guerrero, 2015). On the other hand, the NIS-Teen survey team takes extensive measures to minimize selection and measurement bias, especially in the design stage of their annual surveys (CDC 2020b). For example, they mitigate nonresponse bias through quality control measures and statistical approaches, as I describe in Chapter 1 under the Limitations section. In later sections of the current chapter, I discuss the efforts of the NIS-Teen surveyors to minimize other forms of bias. My actions and those of the NIS-Teen surveyors to address these alternative explanations for the association between the exposure and outcomes added further support for the internal validity of my results.

My preanalysis also included a compromise power analysis of data to achieve valid and reliable results. I used a compromise power analysis, as explained in the Power Analysis section (Faul et al., 2009). I used this preanalysis to determine the optimal parameters for statistical analysis, including the power of tests to detect an actual (i.e., true positive) relationship between independent and dependent variables, the alpha error rate criteria, and critical test scores (Faul et al., 2009). I based statistical significance for tests on the alpha values, which I present in the Compromise Power Analysis section, and on corresponding critical test scores. The alpha cut-off criteria vary depending on the dependent variables under consideration, as do corresponding critical test scores. If the *p* value from a test was less than or equal to the alpha level of significance, I rejected the null hypothesis in favor of the alternative hypothesis. I report the actual *p* value obtained from tests in the tables and text of Chapter 4.

By assessing and preparing the data as detailed up to this point, I was familiar with the data and confident about its reliability and validity. The data was ready for statistical analysis, as described next.

Phases of Statistical Analysis

I analyzed the data in steps to test research hypotheses. First, I did the univariate analysis and presented the results in tables as descriptive statistics such as percentages (Frankfort-Nachmias & Leon-Guerrero, 2015). For instance, I showed the annual income of the participants. Second, I did the bivariate analysis using the chi-square test of association and prevalence ratio to test for a relation between independent and dependent variables (Field, 2013). If an association of these variables was present, I used the prevalence ratio to measure the strength and direction of the relationship (Field, 2013). I carried out the analysis using weighted survey data to assess the influence of independent (predictor) variables on dependent (outcome) variables (CDC 2020a). The chi-square test and prevalence ratio helped me ascertain whether the relationship was significant (Field, 2013). I based the significance of the chi-square test of the association of independent and dependent variables on the critical *z* value optimal for the parameters of the power analysis. Next, I describe how I performed and interpreted statistical tests to address each RQ.

Research Question 1. Is there an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months? $H_0$1: There is no association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months. H_a1: There is an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months.

I operationalized total family income as a nominal variable: Income equal to or below $40,000 per year was coded as zero and greater than $40,000 as one. I considered parents as having the *intent* to vaccinate their teen if they stated it was *very likely* or *somewhat likely* they will have their child vaccinated against HPV (CDC 2020b; Cheruvu et al., 2017). I operationalized parental intent to have their child vaccinated against HPV as a nominal variable: Parental no-intent to protect their child received a code of zero and intent a code of one.

I used the chi-square test and prevalence ratio to assess the association of Hispanic parents' total family income level with their intent to vaccinate their children. The prevalence ratio assessed the extent and direction in which total family income influenced parents' intent to vaccinate their children against HPV. The interpretation of the prevalence ratio was as follows. A prevalence ratio value greater than 1.0 indicated a higher probability of low- compared to high-income parents intending to have their child vaccinated against HPV. A prevalence ratio value of less than 1.0 showed a lower chance of low- compared to high-income parents intending to have their child receive the vaccine.

Research Question 2. Is there an association between Hispanic parents' total family income level and the teens' HPV vaccination initiation? $H_0$2: There is no association between Hispanic parents' total family income level and the teens' HPV vaccination initiation. H_a2: There is an association between Hispanic parents' total family income level and the teens' HPV vaccination initiation.

I operationalized the total family income level as above. I operationalized the dependent variable of Hispanic parents' HPV vaccine series *initiation* (i.e., less than series completion) as a nominal variable. Not reaching series initiation (i.e., no receipt of a shot) was coded as zero, and reaching series initiation (i.e., at least 1 shot, but less than series completion) as one.

I used the chi-square test and prevalence ratio to assess the association between total family income and HPV vaccination initiation. The prevalence ratio was used to assess the extent and direction in which total family income influenced HPV vaccination series initiation. The interpretation of the prevalence ratio was as follows. A prevalence ratio value greater than 1.0 indicated an increased chance of initiating the HPV vaccination series in the low- compared to the high-income group, and a prevalence ratio value less than 1.0 showed a decreased likelihood in the low- compared to high-income group.

Research Question 3. Is there an association between Hispanic parents' total family income level and the teens' HPV vaccination completion? $H_0$3: There is no association between Hispanic parents' total family income level and the teens' HPV vaccination completion. H_a3: There is an association between Hispanic parents' total family income level and the teens' HPV vaccination completion.

I operationalized total family income level as above. I operationalized the dependent variable of Hispanic parents' HPV vaccine series completion as a nominal variable. Not reaching series completion (i.e., <2 shots if under age 15 and <3 shots if age 15 to 17 was coded as zero, and reaching series *completion* (i.e., 2 shots if under age 15 and 3 shots if age 15 to 17) as one.

I used the chi-square test and prevalence ratio to assess the association between total family income and HPV vaccination completion. The prevalence ratio assessed the extent and direction in which total family income influenced HPV vaccination series completion. The interpretation of the prevalence ratio was as follows. A prevalence ratio value greater than 1.0 indicated an increased chance of completing the HPV vaccine series in the low- compared to the high-income group, and a prevalence ratio value less than 1.0 showed a decreased likelihood in the low- compared to high-income group.

Research Questions 4 to 8. The NIS-Teen data used to address RQs4 to 8 was a subset of that for RQs1 to 3. NIS-Teen interviewers asked parents to select one reason from a list for not intending to have their child vaccinated against HPV (CDC 2020b). The parents asked this question were a subset of parents who had a child incomplete on HPV vaccination and had no intention to vaccinate their teen in the next 12 months (CDC 2020b). Therefore, I could not test the association of the dependent variables of RQs4 to 8 with parents' intent to have their child receive the vaccine or teens' initiation and completion of the series.

I classified reasons for parental no-intent to vaccinate their teens into five domains of related reasons, as shown in Table 2 of Chapter 1. Each of these domains corresponds to a dependent (outcome) variable of RQs4 to 8. In proportion, chi-square test, and prevalence ratio analysis, I considered each domain listed in Table 2 to have a binary outcome, as previously described by Cheruvu et al. (2017). If a parent reported at least one reason in a particular domain for not intending to vaccinate their teen, I recorded the data value of the corresponding outcome variable for that domain as a "Yes" response. If a parent did not select any reason in a domain, I assigned a value of "No" to the variable corresponding to the domain.

Research Question 4. Is there an association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns? $H_0$4 There is no association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns. H_a4: There is an association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns.

I operationalized total family income level as above. The domain of parental HPV vaccine *safety and effectiveness concerns*, shown in Table 2, was comprised of three related reasons from which parents could select one (i.e., safety concern/side effects, effectiveness concern, and need more information/new vaccine). I operationalized the outcome of parental HPV vaccine safety and effectiveness concerns domain as a nominal variable. I coded the lack of parental safety and effectiveness concerns (i.e., the parent of interest did not select a reason from the domain) as zero. The presence of parental safety and effectiveness concerns got a code of one.

I used the chi-square test and prevalence ratio, adjusted for weighted complex survey data, to assess the association of Hispanic parents' total family income level with parental HPV vaccine safety and effectiveness concerns. The prevalence ratio evaluated the extent and direction in which total family income influenced parental HPV vaccine safety and effectiveness concerns. A prevalence ratio greater than 1.0 indicated an increased chance of parental HPV vaccine safety and effectiveness concerns in the low- compared to the high-income group. A prevalence ratio less than 1.0 showed a decreased likelihood in the low- compared to the high-income group.

Research Question 5. Is there an association between Hispanic parents' total family income level and their HPV vaccination misinformation? $H_0$5: There is no association between Hispanic parents' total family income level and their HPV vaccination misinformation. H_a5: There is an association between Hispanic parents' total family income level and their HPV vaccination misinformation.

I operationalized the total family income level as above. I operationalized the domain of *misinformation* of Hispanic parents as a nominal variable. As shown in Table 2, I formed this domain using eight related reasons. Parents could select one of the following reasons from this domain: not needed or not necessary, not sexually active, not appropriate age, the shot could be painful, college shot, increased sexual activity concern, already sexually active, and child is male. I coded the absence of misinformation of

Hispanic parents (i.e., the parent of interest did not select a reason from the domain) as zero. The presence of misinformation of parents received a code of one.

I employed the chi-square test and prevalence ratio, adjusted for weighted complex survey data, to assess the association of Hispanic parents' total family income level with the misinformation of parents. The prevalence ratio assessed the extent and direction in which total family income influenced parental HPV vaccination misinformation. The interpretation of the prevalence ratio results was similar to that above.

Research Question 6. Is there an association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination? $H_0$6: There is no association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination. H_a6: There is an association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination.

I operationalized total family income level as above. I operationalized the domain of parents' *lack of knowledge* of the importance of HPV vaccination, shown in Table 2, as a nominal variable. This domain consisted of two related reasons from which parents could select one (i.e., the parent did not know about medical complications of HPV infection and a vaccine recommended for teens, parent thought child was already up to date on HPV vaccination). I coded parents knowledgeable about the importance of HPV vaccination (i.e., the parent of interest did not select one of the reasons from the domain) as zero. Parents lacking knowledge of the importance of HPV vaccination got a one.

I used the chi-square test and prevalence ratio, adjusted for weighted complex survey data, to assess the association of Hispanic parents' total family income level with their lack of knowledge of the importance of HPV vaccination. I applied the prevalence ratio to evaluate the extent and direction in which total family income influenced parental lack of knowledge of the importance of HPV vaccination. The interpretation of the prevalence ratio results was similar to that above.

Research Question 7. Is there an association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination? $H_0$7: There is no association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination. H_a7: There is an association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination.

I operationalized total family income level as above. I operationalized the domain of parents' *systemic access barriers* to HPV vaccination, shown in Table 2, as a nominal variable. This domain consisted of 10 related reasons. Parents could select one of the following reasons: not endorsed by doctor, cost, handicapped/special needs/illness, time, vaccine not available, not a school requirement, no Ob-Gyn appointment, no doctor/no visit set, intend to complete but have not yet/planned, and difficulty making or getting to appointment. I coded parents lacking systemic access barriers to HPV vaccination (i.e., the parent of interest did not select one of the reasons from the domain) as zero. Parents having a systemic access barrier to HPV vaccination received a one.

I used the chi-square test and prevalence ratio, adjusted for weighted complex survey data, to assess the association of Hispanic parents' total family income level with their systemic barriers to HPV vaccination. I employed the prevalence ratio to evaluate the extent and direction in which total family income influenced parental systemic barriers to HPV vaccination. The interpretation of the prevalence ratio results was similar to that above.

Research Question 8. Is there an association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination? $H_0$8: There is no association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination. H_a8: There is an association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination.

I operationalized total family income level as above. I operationalized the domain of parents' *sociocultural barriers* to HPV vaccination, shown in Table 2, as a nominal variable. This domain consisted of four related reasons. Parents could select one of these reasons: the decision to vaccinate was their child' decision, vaccination was a family/parental decision, they do not believe in immunizations, and the decision to not vaccinate their child was based on religion. I coded parents lacking sociocultural barriers to HPV vaccination (i.e., the parent of interest did not select one of the reasons from the domain) as zero. Parents having a sociocultural barrier to HPV vaccination got a one.

I used the chi-square test and prevalence ratio, adjusted for weighted complex survey data, to assess Hispanic parents' total family income level association with their sociocultural barriers to HPV vaccination. The prevalence ratio assessed the extent and direction in which total family income influenced parental sociocultural barriers to HPV vaccination. The interpretation of the prevalence ratio results was similar to that above.

Evaluation of the Association of Outcomes Among Research Questions

In the current study, it was essential to distinguish between direct and indirect influences of HPV vaccination-associated outcomes. Researchers broadly define an exposure as any factor associated with an outcome of interest in a study (Aschengrau & Seage, 2014). They often describe exposures as either proximate or distal (Frakt, 2019). A proximate (downstream) exposure is one that directly affects outcomes of interest, and a distal (upstream) exposure indirectly affects outcomes (Frakt, 2019). In this study, I classified parental income level as a distal exposure because its effect on outcomes, such as those associated with HPV vaccination, is indirect (Frakt, 2019). I support this assertion in Chapter 5 through a synthesis of my results with that of other sources. Family income level and other social determinants of health can influence more proximal factors, such as parents' barriers to HPV vaccination (Szklo & Nieto, 2014). This effect can occur through complex experiences that affect parents' attitudes and beliefs (Frankfort-Nachmias & Leon-Guerrero, 2015). Some authors note that the study of distal (upstream) exposures, such as income level, might produce results more beneficial to the entire population (Distelhorst et al., 2021; Szklo & Nieto, 2014). Even so, most social epidemiologists hold that researchers should consider both proximate and more distal exposures in searching for sufficient causes of study outcomes (Diez-Roux, 1998; Krieger, 2008; Szklo & Nieto, 2014). Researchers should examine both proximate and more distal exposures because interdependence is frequent between exposures at different levels on a multilevel causality framework. Accordingly, as I discuss next, I considered the influence of both proximate and distal exposures on HPV vaccination-associated outcomes of each of my RQs.

I assessed the potential association between the prevalence of parental intent to vaccinate their child and HPV vaccine series initiation and completion. The common independent variable (exposure of interest) for my RQs was family income level. I surmised that this attribute of participants in my study was likely a hard-to-modify (resistant) surrogate for more proximate (susceptible) exposures that influence HPV-associated outcomes (Rockhill et al., 1998). In social science research, scenarios sometimes occur where investigators cannot quantify the impact of proximal exposures on outcomes of interest (Babbie, 2016) directly. Instead, they might measure the influence of a distal factor, such as income level, on outcomes, as I did in the current study. I examined the association of family income with parental intent to vaccinate their child (RQ1), HPV vaccine series initiation (RQ2), and completion (RQ3). As I found an association of family income with parental intent to vaccinate and vaccination series completion, I reasoned that income level could be a proximate exposure of intent to vaccinate and a more distal surrogate exposure of completion. In addition, these results suggest parental intent to vaccinate had a proximal influence on completion. In other words, family income level appeared to influence the prevalence of parental intent to vaccinate their child, and, in turn, parental intent seemed to affect vaccination completion directly. By studying the family income level association with parental intent to vaccinate and vaccination coverage, I identified some likely proximal and distal influences on my dependent variables.

In addition, I indirectly assessed the potential association between the prevalence of parents' barriers to HPV vaccination of their child and the lack of intent to vaccinate the child. As mentioned, family income level was the independent variable in all of my RQs. As shown in Table 2 of Chapter 1, the dependent (outcome) variables of RQs4-8 were parental safety and effectiveness concerns (RQ4), vaccination misinformation (RQ5), lack of knowledge about HPV and the vaccine (RQ6), systemic access barriers including lack of provider recommendation (RQ7), and sociocultural barriers (RQ8). I posited that family income level would distally influence (positively or negatively) the dependent variables of RQs4-8. In addition, I expected a direct association between any or all of these barriers to HPV vaccination to parental lack of intent to vaccinate. For some RQs, I found an association of family income with both parental vaccination barriers and lack of parental intent to vaccinate their child. In these cases, I reasoned the parents' barrier to vaccination might have had a proximal influence on their lack of intent to vaccinate. In Chapter 5, I discuss how the synthesis of the results of my RQs with that of other studies supported, in some cases, a direct association between a parental vaccination barrier and to lack of parental intent to vaccinate. In short, for RQs4-8, I studied the association of family income level with both the prevalence of parents' vaccination barriers and their lack of intent to vaccinate. In doing so, I identified for certain RQs a possible proximal influence of a parental barrier to vaccination on lack of intent to vaccinate.

Threats to Validity

Efforts of NIS Staff to Safeguard Validity and Reliability

The NIS-Teen surveyors make efforts to optimize the quality of their data. Researchers refer to their activities to promote the validity and reliability of data before data collection as quality assurance (Szklo & Nieto, 2014). They consider efforts to monitor and maintain data quality during the conduct of a survey to be quality control (Szklo & Nieto, 2014). NIS-Teen managers attend to each step before and during the survey, from the design of the sample and development of the instruments to sample preparation and data collection to cleaning and editing of the data to the calculation of sampling weights and estimates (CDC, 2002, 2020b; Wolter et al., 2017). Sampling and nonsampling errors affect the accuracy of survey estimates (Frankfort-Nachmias et al., 2015). The extent of sampling errors (variation) is primarily a result of the sample design and size. In 2016 and 2017, the NIS-Teen surveyors sampled cellular and landline phones to minimize sampling error (CDC 2020b). However, in 2018, they used only cellular phones to contact participants because the use of landline phones in households was negligible. The NIS-Teen surveyors also identify and control incomplete or over coverage of the telephone frame due to households with no phone number or more than one, respectively. In survey research, nonsampling errors mainly result from participant nonresponse (Frankfort-Nachmias et al., 2015). The NIS-Teen staff use survey weights, as described in the Considerations in Weighting of Complex Survey Data of NIS-Teen section, to adjust for sampling and nonresponse errors (CDC 2020b). They provide these weights to other researchers using NIS-Teen data. Furthermore, the NIS-Teen researchers identify and mitigate potential self-report bias from adults who report on the vaccination history of teens by matching household interviews and provider-verified information on teens' HPV vaccination (CDC 2020b). In sum, the NIS-Teen surveyors carefully monitor each survey step and take measures to produce quality data.

The NIS-Teen staff also identifies and controls measurement errors. Survey researchers assign numerical values to variables such as parental age or concern about HPV vaccination (Field, 2013; Groves et al., 2004). However, measurements reflect not only the real value of a variable property but also some degree of artifact referred to as measurement error (Frankfort-Nachmias et al., 2015). A critical research consideration is scientific measures' validity (accuracy; Frankfort-Nachmias et al., 2015; Sullivan, 2011). Respondent-, vaccine provider-, interviewer-, and questionnaire-related measurement errors can influence the quality of survey data (CDC 2020b). By identifying and addressing validity issues that can affect the accuracy of survey measurements, researchers can improve the quality of their measures and, in turn, the credibility of their findings.

The NIS-Teen team assesses and addresses three primary forms of measurement validity to promote the accuracy of measurements in their surveys. Researchers classify in various ways the different types of validity related to measurement error (Babbie, 2016; Frankfort-Nachmias et al., 2015; Groves et al., 2004). One set of criteria used to assess the accuracy of research measurements involves empirical (criterion), content, and construct validity (Groves et al., 2004). Empirical or criterion validity is the degree to which investigators verify an expected empirical association of a construct with some external (criterion) variable (Babbie, 2016). Investigators might assess the degree to which the construct correlates with the criterion at the same time, in the future, or in the past (Westen & Rosenthal, 2003). Construct validity, which is widely considered to encompass all forms of validity, is the degree to which researchers can adequately assess a construct using their measures of the construct (Westen & Rosenthal, 2003). In the next section, titled Empirical Validity and Reliability of Survey Instrument, I cover efforts by the NIS-Teen researchers to examine the empirical validity of their survey instrument. Later, in the same section, I discuss how the NIS-Teen surveyors strive to assure construct validity. In brief, I consider how the NIS-Teen staff assesses and addresses empirical and construct validity in their surveys.

On the other hand, content validity is a measurement error issue primarily under my control. Therefore, I discuss how I safeguarded the content validity of this study. Content validity is the adequacy with which the researchers sample the full content of the domain of measures (survey questions) that comprise a construct (Frankfort-Nachmias et al., 2015). Later, I discuss how I assessed and safeguarded content validity in the Optimization of Content Validity subsection under a section concerned with validity issues titled Efforts to Safeguard Validity in the Current Study.

Empirical Validity and Reliability of NIS Instrument

The data managers of the NIS-Teen strived to empirically confirm their collected data's validity. Researchers have developed and refined approaches to validate NIS data since the inception of the NIS-Child in 1994, including comparing NIS data with data from other immunization surveys and vaccine registries (Jain et al., 2009). Public health researchers commonly use this empirical method of evaluating measures (Hahn, 2013). As mentioned, empirical or criterion validity refers to an expected empirical association of a construct with some external (criterion) variable (Babbie, 2016). In this section, I describe research by the NIS-Teen researchers to assess their survey instrumentation's empirical (criterion) validity. First, the NIS-Teen researchers evaluated the validity of the NIS-Teen instrumentation empirically by comparison with another nationwide survey. Wong et al. (2011) compared estimates of HPV vaccine uptake among adolescents aged 13 to17 years in the National Health Interview Survey 2008 with those from the 2008 NIS-Teen. The vaccination coverage estimates in the NIS-Teen were statistically significantly higher than those recorded in the National Health Interview Survey (Wong et al., 2011). Even though both the NIS-Teen and National Health Interview Survey are nationally representative surveys, administrators of these studies use different sampling methods, survey operations, and vaccination status reporting that might have accounted for the differences (Wong et al., 2011). For example, the NIS-Teen identifies and recruits participants based on telephone random digit dialing, and the National Health Interview Survey enrolls participants with or without a telephone. Hence, surveyors supported the validity of the NIS-Teen, a telephone survey, by its agreement with the National Health Interview Survey, a nationally representative, household, door-to-door survey.

The NIS researchers assess the quality of the NIS data in other ways. They report information about the reliability of data (CDC 2020b). The confidence interval size for population estimates indicates the reliability (precision) of these estimates of vaccine coverage or other variables such as income level (CDC, 2016d, 2020b). The confidence interval is a suitable measure of reliability for the NIS data because the research goal is usually to find a population parameter (Field, 2013). Khare et al. (2006) evaluated the validity and reliability of the data collected by the NIS surveyors. These researchers compared vaccination coverage levels recorded in the NIS dataset to those documented in immunization information systems of states. Khare et al. selected four mature registry sites from three states and one urban area to achieve geographical diversity and to represent both mandated and voluntary vaccine provider participation. Therefore, researchers could compare the data from these state registries to NIS-Child data from different states with (or without) provider verification of the vaccination status of children. Compared to NIS-Child data, the state registry data were not as valid, consistent, and complete and were less comparable across states (Khare et al., 2006). In summary, the data managers of the NIS used appropriate methods to measure the reliability and validity of the data, and the NIS dataset was of higher quality than state-level registry data.

Investigation of the reliability and criterion validity of the NIS-Teen instrument preceded that of other instruments developed and used for researching parental factors affecting HPV vaccine use. In studies other than the NIS-Teen and NIS-Child, researchers assessed some measures of factors influencing HPV vaccine use for content validity through expert opinion (Allen et al., 2010; Perez et al., 2016). However, researchers did not report a more helpful type of empirical validation involving criterion validity in these reviewed publications. Recently, researchers have begun to test and write more on the psychometric properties of measures of influences of vaccination against

HPV and other vaccine-preventable infections based on nonNIS survey instruments (Guvenc et al., 2016; Perez et al., 2016; Wallace et al., 2019). Allen et al. (2010) called for researchers to evaluate and report more on the reliability and validity of data collected for studies on the influences of HPV vaccine use. Recently, researchers, in addition to those of the NIS, have begun to test and describe the reliability of research on the HPV vaccine acceptability (Guvenc et al., 2016; Perez et al., 2016; Wallace et al., 2019). In this context, researchers of the NIS-Teen and NIS-Child have conducted more advanced reliability and empirical validity testing than other researchers in the parental vaccine acceptability research field.

The NIS staff found their data was appropriate to test constructs of the health belief model related to parents' decision to have their teens vaccinated against diseases. Researchers can define construct validity as the degree to which they can adequately assess a construct using their measures of the construct (Westen & Rosenthal, 2003). Smith et al. (2011) used NIS-Child data from 2009 to show psychosocial factors (constructs) suggested by the health belief model of Rosenstock et al. (1959) were associated with parental refusal or delay of childhood vaccinations and vaccine coverage of the children. Specifically, the psychosocial factors of parental knowledge of HPV and its adverse outcomes, vaccine safety concerns, and perceived benefits of vaccination were associated with parents' decision to delay or refuse to vaccinate their children and vaccine coverage (Smith et al., 2011). The construct of HPV vaccine safety and effectiveness was the independent variable of one of my RQs, as was knowledge of HPV and the vaccine. These findings support my use of NIS-Teen data to explain why parents hesitate to use vaccines for their children.

Assessment of NIS-Teen Response Rates

NIS-Teen staff report nonresponse rates of participants in the landline and cellphone samples of the household survey. Surveyors of the NIS-Teen and other telephonic surveys use a standard telephonic response rate defined by the Council of American Survey Research Organizations (CASRO; American Association for Public Opinion Research, 2016; Ezzati-Rice et al., 2000). The CASRO response rate used by the NIS-Teen surveyors for both landline and cell phone samples is the product of the resolution rate, the screening completion rate, and the interview completion rate among eligible households (CDC 2020b; Ezzati-Rice et al., 2000). Researchers base the CASRO rate on the assumption that the rate is the same for unresolved and resolved telephone numbers and unscreened and screened numbers (CDC 2020b). The resolution rate is the percentage of telephone numbers selected randomly from all available residential, nonresidential, and nonworking numbers (CDC 2020b). The screening completion rate is the percentage of appropriate screening of identified households for the presence of age-eligible teens. The interview completion rate is the percentage of households with one or more age-eligible teens that finished the household interview. I show in Tables 6 and 7 these rates in Bexar County, Texas, for landline and cellphone samples, respectively. The CASRO response rate for the combined landline and cellphone sample is the total number of households with a complete interview (i.e., those reached by landline or cellphone) divided by the estimated total number of eligible families with a landline or cellphone (CDC 2020b). In Bexar County, this rate was 28.9% and 25.6% in 2016 and 2017, respectively (CDC, 2017b, 2018). In 2018, the NIS-Teen team only collected a cellphone sample (CDC, 2018, 2020b). In sum, the CASRO rate provides NIS-Teen researchers and other data users with a numerical measure of the extent of successfully conducted interviews in different study populations.

Table 6

Key Indicators for the Landline Sample of Participants in Bexar County

Year	Resolution rate (%)	Screener completion rate (%)	Interviewer completion rate (%)	CASRO[a] response rate (%)
2016	80.4	81.5	78.0	51.1
2017	80.3	78.1	82.4	51.7

[a]CASRO: Council of American Survey Research Organizations

Table 7

Key Indicators for the Cellphone Sample of Participants in Bexar County

Year	Resolution rate (%)	Screener completion rate (%)	Interviewer completion rate (%)	CASRO[a] response rate (%)
2016	53.6	75.3	69.2	27.9
2017	46.0	76.3	71.0	24.9
2018	44.1	79.3	68.5	24.0

[a]CASRO: Council of American Survey Research Organizations

Considerations in Weighting of Complex Survey Data of the NIS-Teen

The NIS-Teen researchers use various means to mitigate the impact of sampling and nonsampling bias, thereby making their data more representative. External validity refers to the estimated degree to which researchers can truthfully generalize the results of a study to other populations and settings (Khorsan & Crawford, 2014; Polit & Beck, 2010). Research findings applicable to people and settings outside the study sample will probably be more helpful in developing widely effective interventions than less representative results (Khorsan & Crawford, 2014; Polit & Beck, 2010). The NIS-Teen survey experts used a variety of approaches to promote representative responses to surveys by members through questionnaire design and administration (CDC 2020b). They also made efforts to develop a representative selection of participants. However, survey nonresponse and the unequal selection of types of participants are inevitable (Babbie, 2016). A survey sample might inadequately represent a study population (i.e., low external validity) due to unequal probability of selection of participants (intentional or unintentional) or differential response rates of subgroups of participants (Frankfort-Nachmias et al., 2015). Therefore, survey researchers often need to adjust data during the analysis phase of a study to make their secondary data more representative.

The NIS-Teen managers developed and used survey weights to make their data more representative. Researchers can make sample data more representative of the entire target population by applying a survey weight to the data for each participant (Groves et al., 2004; Heeringa et al., 2010). In its purest form, researchers can define survey weight as the inverse probability of selecting a participant in a study (Babbie, 2016; Mansournia

& Altman, 2016). A survey participant's weight in a sample can be considered the number (or share) of individuals represented in the population (Heeringa et al., 2010). Therefore, if researchers assign each participant a weight equal to the inverse probability of being selected in the sample, the sum of the weights for a sample subset (e.g., vaccinated youth) will approximate the population size of that group (Heeringa et al., 2010). For example, the NIS-Teen staff applied survey weights to adjust for sampling and non-sampling errors in provider-verified data on each teen's vaccination status (CDC 2020b). The NIS-Teen surveyors used this weighted provider-verified data to estimate vaccination coverage rates representative of the study population (CDC 2020b). The NIS-Teen analysts provided users of their data with separate survey weights for data from the household- and provider-phase (CDC 2020b). Using these weights, researchers might correct the effects of oversampling and undersampling of certain types of participants and differential responses of subgroups. In turn, they might increase the external validity of the results.

Quality Control Related to NIS-Teen Data

Although the data managers of the NIS-Teen make extensive efforts to produce a high-quality data set, the data gathered by researchers at the NIS-Teen might have some limitations. For example, changes in nonresponse bias of NIS-Teen participants from year to year might impact the accuracy of comparing estimates of vaccination coverage of teens between survey years (CDC 2020b). By being aware of and understanding the limitations of the NIS-Teen data, I could report the resulting limitations in my data analysis.

I avoided collecting and analyzing unreliable and imprecise data by knowing how to identify potential NIS-Teen data limitations. Small sample sizes might result in unreliable estimates of data stratified by state/local area or by race/ethnicity (CDC 2020b). Accordingly, data analysts report as not available unreliable or imprecise estimates in the NIS-Teen data set, such as HPV vaccine coverage (CDC, 2016d). Also, the NIS data managers do not report estimates for a subgroup if the unweighted sample size for the numerator of an estimate is less than 30 or the confidence interval half-width/estimate is greater than 0.6 because the estimate might not be reliable or precise (CDC, 2016d). Furthermore, the NIS-Teen staff report and mark by a footnote any unreliable estimates at the state level or lower with a confidence interval half-width greater than 10 (CDC, 2016d). In these ways, personnel at NIS-Teen take extensive measures to ensure they provide users with valid and reliable data securely and confidentially.

Quality Assurance of NIS Using Special Studies

In addition to the global mechanisms for quality control, the NIS-Teen staff conducts special studies to improve the survey methods. Researchers frequently conduct evaluation studies and controlled experiments to identify the reasons for sampling and nonsampling errors and their impacts on parameter estimates (CDC 2020b). The NIS-Teen experts use the results of these studies to make methodological refinements and improvements and safeguard data validity and reliability (Wolter et al., 2017). First, early research of the NIS-Child, the forerunner of NIS-Teen, related to measurement errors indicated more accurate estimates of vaccination coverage could be obtained using a cross-sectional sample design than a panel design (Battaglia et al., 1996). In a panel design, the same participants are interviewed year-to-year (Battaglia et al., 1996). The authors showed that panel-conditioning effects would bias vaccine coverage estimates. That is, the influence of annual interviews would lead some parents to give socially desirable responses during interviews or influence them to have their children receive vaccines. Second, the NIS-Child researchers conducted studies to increase participant response rates in telephone surveys by improving the effectiveness of advance letters sent to households (Camburn et al., 1995). In sum, the NIS staff continually conducts studies to develop sound methodological approaches, improving the quality of their data.

Assessment of NIS-Teen Total Error

The NIS-Teen staff also measures sampling and nonsampling errors. From 2009 to 2013, the NIS-Teen analysts monitored vaccine coverage estimates using a total survey error (TSE) approach, which is the sum of the errors that arise at every step of the survey, including sampling and nonsampling errors (CDC 2020b). From 2012-2013, the estimate of the TSE for greater than or equal to one dose of the HPV vaccine among girls aged 13 to 17 years was positive in value but small and not statistically significantly different from zero (CDC, 2018). Similarly, in the 2018 household survey, the TSE for up-to-date coverage of HPV vaccination among girls and boys aged 13 to 17 years was small and not statistically significantly different from zero (CDC 2020b). In addition, the TSE for up-to-date coverage of HPV vaccination among teens was not statistically significantly different between 2017 and 2018 (CDC 2020b). These results suggest the NIS-Teen staff effectively uses quality assurance and control protocols to mitigate TSE and produce reliable and valid data.

Efforts to Safeguard Validity in the Current Study

Optimization of Content Validity

I optimized the content validity of each construct of potential predictors of parental no-intent to vaccinate their teens for RQs4-8. Researchers cannot measure directly or indirectly some concepts or attributes of persons, such as HPV vaccination safety concerns (Babbie, 2016). Instead, they propose constructs to assess such challenging-to-measure concepts or characteristics of persons using a composite of several observable variables as an indicator (Babbie, 2016). In the current study, constructs corresponding to the dependent variables of RQs4, 5, 6, 7, and 8, including parental HPV vaccine safety and effectiveness concerns, vaccination misconceptions, lack of knowledge about HPV and the vaccine, systemic barriers, and sociocultural barriers, respectively. I operationalized each of my constructs based on multiple related familial reasons or barriers for no-intent to have their child vaccinated against HPV. Content validity is the adequacy with which researchers sample the full content of the domain of measures (responses to survey questions) that comprise a construct (Frankfort-Nachmias et al., 2015). Scientists can threaten the validity of constructs in their research by inappropriate measures to define the constructs operationally (Westen & Rosenthal, 2003). Therefore, content invalidity is a source of measurement error, as described by Frankfort-Nachmias et al. (2015). I optimized the content validity of my constructs by adequately sampling the full content of the domain of potential reasons (barriers) to HPV vaccination that comprise each construct. For example, in defining the construct of parental HPV vaccination misconceptions, I covered all the ways in which parents' views or opinions about HPV vaccination were incorrect due to faulty thinking or understanding, based on their responses to the NIS-Teen interview questions. As a public health researcher, I should identify and address not only lack of statistical conclusion, internal, and external validity but also lack of content validity. My research findings should be more valuable because I took steps to assure and control the content validity of the constructs (variables) under consideration.

Promotion of Internal, External, and Statistical Conclusion Validity

Various other types of validity issues can compromise the credibility of my epidemiological research. The validity of a quantitative study refers to how accurately investigators address the RQs or the strength of their inferences (Babbie, 2016). A lack of internal, external, and statistical conclusion (inference) validity can adversely affect a study (Babbie, 2016; Frankfort-Nachmias et al., 2015). The internal validity of a study is the estimated extent to which researchers can use the findings to make correct inferences about causal relationships between independent and dependent variables (Frankfort-Nachmias et al., 2015). However, conclusion validity means a measured statistical association or lack thereof is valid (Groves et al., 2004). Therefore, a study might have statistical conclusion validity but not internal validity. As statistical conclusion validity is making reasonable inferences based on data analysis, inferences can be invalid due to underpowered statistical tests or violation of assumptions (Field, 2013; Groves et al., 2004). I addressed statistical conclusion validity in the current study by performing a compromise power analysis. Using a compromise power analysis allowed me to optimize my study's statistical power based on the size of the sample available in the NIS-Teen dataset and α- and β-error rate cut-off values appropriate to test RQs. In addition, I safeguarded the accuracy of all measured associations of independent and dependent variables by ensuring the satisfaction of assumptions for each statistical test. On the other hand, I strived for internal validity, as described in this section, by making an accurate inference that a change in the independent or predictor variable caused a change in a dependent or outcome variable (Groves et al., 2004). By identifying, addressing, and mitigating internal and statistical conclusion validity issues in my study, I improved the quality of my measurements and, in turn, the credibility of my findings and inferences.

Both internal and external validity issues will negatively affect the credibility of my findings. Experts can qualitatively assess internal and external validity on a continuum ranging from low to adequate to high (Groves et al., 2004). Applying research results of relatively high internal validity to design preventative interventions is more likely to be successful than using findings with lower internal validity (Frankfort-Nachmias et al., 2015). Similarly, research findings applicable to people and settings outside the study sample will probably be more helpful in developing widely effective interventions than less representative results (Khorsan & Crawford, 2014; Polit & Beck, 2010). The findings and inferences of my study will likely be helpful to public health advocates who aim to improve HPV vaccine use because I optimized internal and external validity.

In a nonexperimental study, it is challenging to support both a causal relationship between independent and dependent variables and the generalizability of the findings to other populations and settings. Generally, an inverse relationship exists between the internal and external validity of results in a given study (Campbell & Stanley, 2015; Frankfort-Nachmias et al., 2015). Studies more characteristic of real experiments tend to allow greater control over intrinsic and extrinsic variables, strengthening the validity of causal inferences (Campbell & Stanley, 2015; Frankfort-Nachmias et al., 2015). In addition, in true experiments, the introduction of the independent variable permits the determination of the direction of causation (Campbell & Stanley, 2015; Frankfort-Nachmias et al., 2015). On the other hand, studies more nonexperimental, such as the current study based on cross-sectional survey data, permit investigators to research in natural social settings, thereby increasing external validity (Campbell & Stanley, 2015; Frankfort-Nachmias et al., 2015). The results of experimental and nonexperimental studies, taken together, can sometimes support the existence of a representative causal relationship between variables (Frankfort-Nachmias et al., 2015). However, it can be challenging to support, based on the results of a single study, the existence of a causal relationship between independent and dependent variables that generalizes to other populations and settings.

I took various actions to identify and mitigate the internal invalidity of the results and inferences. Despite the challenges in supporting a causal relationship in nonexperimental studies, researchers should attempt to identify the source of systematic or random measurement errors, which can lead to internal invalidity of findings, and apply techniques to reduce these errors (Frankfort-Nachmias et al., 2015; Polit & Beck, 2010; Sullivan, 2011). The present nonexperimental study involved the analysis of cross-sectional NIS-Teen data. Accordingly, I strengthened the validity of my causal inferences, based on the association of independent and dependent variables, by choosing variables, as explained in the next section titled Use of Logic to Support Validity.

I weighted the survey data to improve the external validity of the results. As mentioned, I improved internal validity, which is a prerequisite for external validity. In addition, I applied available survey weights unique to each participant to adjust data and thereby make my sample more representative of the target population (i.e., more externally valid). Using these weights should have corrected the effects of oversampling and undersampling of certain types of participants and differential responses of subgroups (Groves et al., 2004; Heeringa et al., 2010). I likely optimized the representativeness of my results by carefully applying survey weighting to the data.

Use of Logic to Support Validity

I took into account the potential issue of reverse causality. In the cross-sectional design, reverse causality can be problematic among acquired factors that can both determine and be determined by other variables (Babbie, 2016; Frankfort-Nachmias et al., 2015). These authors pointed out that a researcher using data from cross-sectional surveys, such as the NIS-Teen, can substantially improve internal validity by using supplementary evidence against competing hypotheses. In this way, researchers can use cross-sectional data to draw approximate conclusions about the true relationship between independent and dependent variables of interest.

I used logic to support the validity of some of my results and inferences. In the present study, my independent variable of RQs1 to 3 (i.e., parental income) is, by nature, permanent or unchangeable (Frankfort-Nachmias et al., 2015). For this reason, this variable can be a determining factor of an association between variables but not a determined effect. Suppose one found an association between this permanent independent variable and a dependent variable, such as parents’ intent to vaccinate their child. In that case, they could establish logical support for the independent variable being the determining factor of the relationship. Researchers might find it hard to imagine a scenario in which an increase or decrease in the parental intent or ultimate vaccination coverage of youth in a population could cause parents’ annual income to change. A cross-sectional study such as this might provide evidence of an association between parents' income level and their intent to vaccinate their children against HPV. In this case, researchers could use the logic above to counter an opposing hypothesis that the extent of vaccine coverage for teens influenced parents’ intent to have their children receive the vaccine. In the current study, I applied logic, when appropriate, to support the validity of my inferences, as discussed in Chapter 5.

Decision of Whether to Weight Data

Whether and when to apply survey weights to complex survey data is an important consideration. Most statisticians agree that researchers should apply survey weights to complex survey samples to make descriptive statistics, such as proportions and means, more representative of the population of interest (Johnson, 2008; Young & Johnson, 2012a, 2012b). Fewer statisticians concur on whether researchers should use survey weights with multivariable methods, such as logistic regression, and, if so, under what conditions they should use weights with these methods (Bollen et al., 2016). Researchers can use survey weights to compensate for oversampling or undersampling or for a disproportionate sampling of population subsets as well as lack of response from particular members of the population of interest (Bell et al., 2012; Hahs-Vaughn et al., 2011b; Kalton & Flores-Cervantes, 2003). In addition, researchers can employ these weights to mitigate the impact of complex samplings, such as stratification or clustering, that are seldom random (Hahs-Vaughn et al., 2011b). Furthermore, the use of weights can avoid the reduction of sample size and statistical power due to the deletion of missing observations (Kalton & Flores-Cervantes, 2003). Summing up, using weights with complex survey data can be beneficial.

Using weights with complex survey data is not always advantageous. The effect of nonrandom sampling and nonresponse on bias is relatively complicated in household surveys (Groves, 2006). First, applying weights to data might lead to increased sampling and estimator variance (Pike, 2008). Weights might decrease the precision of regression coefficients with no improvement in their accuracy (Pike, 2008). Second, weighted estimators might be less accurate than their nonweighted counterparts (Pike, 2008). Third, weighting complex survey data might reduce the statistical power of multivariable tests, such as logistic regression (Bollen et al., 2016). Researchers should avoid weighting adjustment when not warranted due to the potential adverse consequences of using this technique (Pike, 2008). Thus, I assessed whether I needed to use weighting adjustment to improve the validity of results and how it might affect the precision of population estimators, such as standard errors of means. However, well-established criteria are unavailable to inform researchers about when to use weighting adjustments (Bollen et al., 2016; Gelman & Hill, 2007; Kott & Frechtel, 2019; Pike, 2008). Although weighting is a valuable technique to improve the representativeness of survey data, it has limitations.

Some researchers recommend using both weighted and unweighted data in statistical analysis. As mentioned, the effect of weighing survey data on sample bias and other aspects of data quality are complex, and simple criteria are not available to ascertain the acceptability of weighting with this type of data (Bollen et al., 2016). Therefore, Pike (2008) proposed it is best to calculate and compare the accuracy and precision of weighted and unweighted estimators of interest. Bollen et al. (2016) reviewed and compared various empirical tests researchers can use to assess the suitability of using weighted data in regression modeling and other procedures. Researchers have begun to use these tests to compare logistic regression results with and without weighted data (Grol-Prokopczyk, 2018; Mobley et al., 2019). Support exists for using both weighted and unweighted data in statistical analysis.

I considered other researchers' rationale for using weighted or unweighted data in statistical analysis. First, Grol-Prokopczyk (2018) found that weighted and unweighted models in their analysis produced similar regression coefficients. However, the authors presented the results of weighted models because they are generally less statistically powerful than unweighted ones, providing a more conservative estimate of results (Grol-Prokopczyk, 2018). In contrast, Mobley et al. (2019) reasoned that it was best to present findings on their unweighted regression analysis because it is statistically more powerful than the weighted approach. In addition, these authors tabulated their regression results with unweighted data because of the use of an independent variable in their model as a population characteristic to calculate the sampling weight (Mobley et al., 2019). Similarly, I based my use of weighted or unweighted logistic regression coefficients on their potential accuracy and precision, as well as other factors. By using correctly weighted or unweighted survey data, I likely optimized the external validity of population parameter estimates, the variance of these estimates, the statistical power of hypothesis tests, and other factors influencing the quality of results.

Statistical procedures and computer software are available for me to perform logistic regression using weighted complex survey data. The NIS-Teen data set has valuable data to address my broad set of RQs (CDC 2020b). However, I must address disproportionate sampling and nonindependence of variance when analyzing complex survey data (Hahs-Vaughn, 2011b). Unequal selection probability results from disproportionate samplings, such as oversampling and nonresponse adjustment (Hahs-Vaughn, 2011b). Compared to simple random sampling, a stratified cluster sampling approach can lead to nonindependence of variance, which, in turn, results in the homogeneity of variance (Hahs-Vaughn, 2011b). As a user of complex survey data, I should strive to compensate for unequal selection probability and nonindependence of variance in data (Hahs-Vaughn, 2011a). By compensating for unequal selection and nonindependence of variance, I could avoid biased regression coefficients and underestimated standard errors that could translate to invalid conclusions and increased Type I error rates, respectively (Hahs-Vaughn, 2011a). A statistical method to fit logistic regression models to complex survey data has been available for over three decades (Kott, 2018; Kott & Frechtel, 2019; Liu & Koirala, 2013). However, I decided to assess whether a weighted analysis was appropriate (Bollen et al., 2016). The NIS-Teen user's guide, codebook, and questionnaire provided details on the sampling design and variables and advice on how to analyze the nonsimple random sample, produce results representative of the study population, and appropriately estimate variance (CDC, n.d.-a). Software user's guides, methods textbooks, and reviews of current software tools detailed for me how to include complex survey data in various analytical procedures, such as Taylor series linearization and logistic regression, available in their programs (Heeringa et al., 2010; International Business Machines, 2012, 2021; Liu, 2016; West et al. 2018). By better understanding the value and intricacies of analysis using the complex survey data of the NIS-Teen, I made more prudent methodological decisions before conducting statistical analysis and produced more accurate and meaningful findings.

After careful consideration, I used weighted survey data in the statistical analysis. The inferential chi-square test and descriptive prevalence ratio were adequate to assess the null hypothesis of no association for my RQs, as I explained earlier in this chapter titled Rationale for Withholding Multivariable Analysis with Control Variables. Also, see the section called Limitations of the Study in Chapter 5. I used sample weights provided by the NIS-Teen surveyors to estimate these population statistics from my secondary survey data (Lehtonen & Pahkinen, 2004). Using these weight-adjusted parameters, I could attain results more representative of the study population (CDC, 2018; Rosner, 2016; Wolter et al., 2017). Thus, multivariable statistical procedures, such as logistic regression, were not necessary to measure the association of independent and dependent variables. In this manner, I could address my RQs using appropriate and adequate statistical approaches.

Summary of Measures to Safeguard Validity

Information on the quality of NIS-Teen data was available to me, as were various means to optimize the validity of my results. The NIS-Teen staff provides researchers with extensive information on the validity and reliability of their secondary data source (CDC 2020b). They also provide researchers guidance on producing valid results from the secondary data. I used NIS-Teen survey weights to make my samples more representative of the target populations (CDC, n.d.-a). As the NIS-Teen staff extensively reviews and edits their data set for public use, I did not need to remove data points or minimize the effect of outlier observations (Field, 2013, Walfish, 2006). The quality assurance and control efforts of the NIS-Teen surveyors and their publicly available means for researchers to optimize the quality of results were invaluable to me in preparing the data for analysis and conducting statistical tests.

Ethical Procedures

NIS-Teen Procedures

The NIS-Teen interviewers and data analysts ethically collect and manage the data they provide to researchers. In particular, the NIS-Teen staff safeguards the privacy of participants and the confidentiality of the data at every step of the process, from interviewing participants to processing the data to evaluating whether the data meet high standards of privacy, confidentiality, and quality before releasing it for use by researchers

(CDC 2020b). Data managers of the NIS-Teen survey ensure respondents that their responses are confidential and voluntary (CDC, 2020c). The interviewers obtain informed consent from guardians of teens to conduct the interview and contact the adolescent's vaccination provider(s) regarding the youth's vaccination history (CDC, 2020c). The NIS-Teen staff also abides by strict security standards in collecting and processing all information from parents and vaccine providers to ensure their privacy and the confidentiality of sensitive data (CDC 2020b). End users of the NIS-Teen data can only use it for research (CDC 2020b). Before NIS-Teen managers release their data to the public, the National Center for Health Statistics Disclosure Review Board extensively reviews the contents of the public-use data file to protect participant privacy and safeguard data confidentiality (CDC 2020b). In summary, managers of the NIS-Teen survey ensure informed consent, the privacy of participants, data security, and confidentiality of information. The high ethical standards by which the NIS-Teen staff collect and manage their data not only protect participants' privacy and confidentiality of the data but also help produce reliable and valid data for the advancement of research.

My Procedures

I managed and analyzed my secondary data ethically due to the extensive privacy and confidentiality safeguards of the NIS-Teen surveyors. In accessing the public-use data file from the NIS-Teen website (CDC, n.d.-a), I did not have direct access to the original, completed surveys described in CDC (2022). In addition, I did not have access to personally identifiable information (CDC 2020b). Instead, I analyzed only anonymous archived data via a secure weblink of the National Center for Health Statistics (CDC

2020b). As I had access only to anonymous survey data, I could not directly associate survey responses with individual participants. Ultimately, these safety measures enabled me to ethically manage and analyze NIS-Teen data and present the methods and findings.

I safeguarded the confidentiality of the publicly available NIS-Teen data used in the current research. Researchers might reveal a composite picture of a survey participant by piecing together NIS-Teen data with that of other publicly available data sets resulting in the identification of the individual (Paxton, 2020). For this reason, I protected the privacy of survey participants by not sharing the NIS-Teen data used for my study with other researchers or combining it with different data sets, as Paxton (2020) recommended.

I took additional measures to protect the confidentiality of the secondary data used in the current study. First, I safeguarded confidential research data from access and theft by storing it on a password-protected desktop computer with adequate firewalls, virus protection, and encryption (Research Integrity and Assurance Committee of Princeton University [Princeton University], n.d.). The computer was in a locked room used only by myself. Second, I protected Microsoft Excel and Word data files using passwords (Princeton University, n.d.). Third, I created bimonthly backup copies of data on my desktop computer to mitigate loss or corruption of data. I secured these backup copies and the working copy. In addition, I kept quarterly backups on an external hard drive in a locked file cabinet. Fourth, I will destroy the data appropriately five years after the publication of the research findings (Princeton University, n.d.). I will erase all copies of the data by using a program conforming to the Department of Defense 5220.22 media sanitization guidelines (Educause, n.d.; Kissel et al., 2014). Finally, before carrying out any part of the study, I received permission from Walden University's Institutional Review Board (approval number 05-13-20-0554115; Walden University Institutional Review Board, n.d.-a, n.d.,-b). Permission from the Walden University Institutional Review Board allowed me to apply the procedures above to protect the confidentiality of the data (Appendix B).

I also applied ethical standards in my analysis of data and reporting of research methods. The American Statistical Association considers transparency a critical ethical guideline in reporting statistical information (Committee on Professional Ethics of the American Statistical Association, 2018). Bell et al. (2012) systematically reviewed how frequently researchers reported the statistical methods they used to account for the complex sampling of survey data and sample weights. Based on their results, the authors called for improvements in how investigators analyze and report results based on complex survey data in scientific publications. For these reasons, I presented how I handled complex survey data.

Overall, I adhered to several procedures and high data analysis, management, and presentation standards to ensure that the research did not violate any ethical standards. By using complex survey data responsibly to promote positive social change, I contributed to reaching high ethical research standards. I am dedicated to upholding the standards set by the NIS-Teen managers and other leaders in the field of public health research.

Summary

I examined factors that might influence the HPV vaccination of teens in Bexar County, Texas. To this end, I addressed eight RQs using a cross-sectional quantitative approach and archived data from the NIS-Teen. In the first three RQs, I assessed the relation of total family income with parental intent to have their teenage child vaccinated against HPV, vaccination series initiation, and completion. I fulfilled another objective by addressing RQs4, 5, 6, 7, and 8, in which I examined the relationship between income level and parents' concerns and barriers to vaccinating the child against HPV. I compared the strength of evidence to reject or fail to reject the null hypothesis of RQs, based on the prevalence ratio estimate and chi-square test of association results. For each RQ, I used survey weights to make my sample more representative of the study population concerning survey characteristics (e.g., parental response rate) and sociodemographics (i.e., maternal education, teen gender, race/ethnicity, and age; CDC, 2016b).

I took measures to produce reliable and valid responses to the RQs. I studied NIS-Teen survey data from 2016, 2017, and 2018. For all the RQs, I tabulated and described the statistics from each year and the three years combined. I calculated an average weighted estimate of each statistic from the three survey years. These estimates pertained to a hypothetical population in the middle of the three years (CDC, 2018). The NIS-Teen interviewers and data managers strived to obtain accurate responses from participants by ensuring their privacy and securing their personal information (CDC 2020b). The NIS-Teen managers verified and processed the data by high standards before releasing it for use by researchers (CDC 2020b). As I used this complex survey data to address the RQs, I considered the possible benefits, constraints, and complications of using this type of data (Bollen et al., 2016). I used a compromise power analysis to optimize the power of my statistical tests to detect a valid relation between independent and dependent variables (Ellis, 2010; Faul et al., 2009). By realizing a careful and systematic data analysis plan, I addressed my RQs appropriately and presented reliable and valid findings in Chapter 4.

Chapter 4: Results

Introduction

This quantitative cross-sectional study aimed to examine the extent to which family income level influences HPV vaccine series initiation and completion among adolescent Hispanic boys and girls 13 to 17 years old. I also aimed to assess the degree to which income level affects (or is at least related to) parents' intent and barriers to vaccinating their children. I analyzed complex secondary survey data publicly available from the NIS-Teen.

In this chapter, I present the results of each of the study's eight RQs. I first summarize the characteristics of the sample and the estimated population. In addition, I describe any deficiencies in the data. Then I present the results of the analyses to address each RQ and the overall findings. The RQs and hypotheses were as follows:

RQ1: Is there an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months?

> $H_0$1: There is no association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months.
>
> H_a1: There is an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months.

RQ2: Is there an association between Hispanic parents' total family income level and the teens' HPV vaccination initiation?

> $H_0$2: There is no association between Hispanic parents' total family income level and the teens' HPV vaccination initiation.

H_a2: There is an association between Hispanic parents' total family income level and the teens' HPV vaccination initiation.

RQ3: Is there an association between Hispanic parents' total family income level and the teens' HPV vaccination series completion?

H_03: There is no association between Hispanic parents' total family income level and the teens' HPV vaccination series completion.

H_a3: There is an association between Hispanic parents' total family income level and the teens' HPV vaccination series completion.

RQ4: Is there an association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns?

H_04: There is no association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns.

H_a4: There is an association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns.

RQ5: Is there an association between Hispanic parents' total family income level and their HPV vaccination misinformation?

H_05: There is no association between Hispanic parents' total family income level and their HPV vaccination misinformation.

H_a5: There is an association between Hispanic parents' total family income level and their HPV vaccination misinformation.

RQ6: Is there an association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination?

$H_0$6: There is no association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination.

H_a6: There is an association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination.

RQ7: Is there an association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination?

$H_0$7: There is no association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination.

H_a7: There is an association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination.

RQ8: Is there an association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination?

$H_0$8: There is no association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination.

H_a8: There is an association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination.

Results

Research Question 1 and Hypotheses

RQ1: Is there an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months?

$H_0$1: There is no association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months.

H_a1: There is an association between Hispanic parents' total family income level and parents' intent to vaccinate their teens in the next 12 months.

Univariate Analysis

I describe some characteristics of the NIS-Teen sample and estimated population used to examine the relationship between parents' income levels and their intent to have their children vaccinated against HPV. I present similar sample and population descriptive statistics for the other RQs. I present the income distribution of the study participants under consideration in RQ1 in Table 8. A subsample of NIS-Teen survey participants who had an unvaccinated or undervaccinated child (i.e., not up to date) was the focus of RQ1 (CDC, 2018). I report the number of participants in the survey sample with low and high income in Table 8. In addition, I present the weighted prevalence estimates of the income distribution of participants with confidence intervals to better represent the economic status of parents in the broader study population. In summary, the data in Table 8 provide a view across three study years of the distribution of the sample size and estimated population prevalence of low and high-income groups.

The estimated population percentage of the two categories of the independent variable (i.e., income) for RQ1 was similar, and the sample sizes were substantial. The sample size and the balance in the size of subgroups of independent and dependent variables strongly influence the overall power of a statistical test (Rusticus & Lovato, 2014). In the three studies, I observed a reasonably well-balanced distribution of the percentage of low- and high-income parents (see Table 8). In addition, in each study, the size of low- and high-income groups was over 120. Based on the relatively large sample sizes and the balance in the prevalence of income groups, the power of the statistical tests for this RQ was probably adequate.

Table 8

Income of Parents With or Without Intent to Vaccinate Child Against HPV (n = 816)

Survey Year	Income level	*n*	Weighted percent of time period (%)	Confidence interval (%)	Confidence level (%)
2016	Low	135	57.9	[55.7, 60.0]	89.0
	High	130	42.1	[39.5, 44.8]	
2017	Low	149	55.0	[53.0, 57.0]	91.9
	High	145	45.0	[42.7, 47.3]	
2018	Low	122	53.8	[51.6, 56.0]	89.5
	High	135	46.2	[44.0, 48.4]	
Weighted average 2016-2018	Low	406	55.6	[52.0, 59.2]	99.6
	High	410	44.4	[40.4, 48.5]	

Note. HPV: human papillomavirus. Parents had *intent* to vaccinate if they stated it was *very likely* or *somewhat likely* they will have their child get the vaccine (Cheruvu et al., 2017). High income was above the median level for my sample ($40,000) and low income was less than or equal to the median. For each year, the weighted prevalence of an income group was equal to the estimated population size of parents in the group divided by the population size of all parents (low and high income). I calculated the weighted average of results by dividing the sample weight of each case by three, multiplying the data point (variable) values of each case by this average weight, and dividing the sum of these products for each variable by the sum of the weights.

Bivariate Analyses

I present a cross tabulation of the data used for statistical tests and measures of RQ1 and other RQs. The data in Table 9 provide a more refined view than in Table 8 of the study sample and estimated population in RQ1, in terms of independent and dependent variables. In Table 8, I stratify the sample by my independent variable's low- and high-income categories. In Table 9, I stratify the sample further by the dependent variable categories of parental intent and no-intent to vaccinate their child. Therefore, Table 9 consists of a 2 x 2 contingency table for each study year with data on the bivariate income (independent) variable in rows and the bivariate parental intention (dependent) variable in columns. I present a similar cross tabulation of the data for other RQs. In Table 9, I stratify the data for RQ1 into low- and high-income families and parents with or without intent to vaccinate their teens against HPV. I use the data in these 2 x 2 tables to test for an association between my independent and dependent variables based on the chi-square tests of independence. I also use the data in these 2 x 2 tables to calculate the prevalence ratio of intent to vaccinate in low-income families compared to those with high incomes. I show in Tables 10 and 11 for each study the results of the chi-square tests of independence and values of the prevalence ratio, respectively. Likewise, I cross tabulated the data for the other RQs to perform the chi-square test and calculate the prevalence ratio.

In each study, the cross-tabulated data adjusted for the study population pointed to an association between parents' income levels and their intent to vaccinate their teens against HPV. I present in Table 9 for each study, the number of participants with low and high income by those with and without intent. For each sampling year, these results favored rejecting the null hypothesis of no association between Hispanic parents' total family income level and their intent to vaccinate their teen in the next 12 months (see Table 9). The results also suggested that the proportion of parents who intended to vaccinate their teens in low-income families compared to the high-income group became progressively smaller from 2016 to 2018.

Table 9

Income Level of Parents by Status of Their Intent to Vaccinate Against HPV (n = 816)

		No-intent to vaccinate (*n* = 398)			Intent to vaccinate (*n* = 418)		
Sample year	Income level	*n*	Weighted percent of time period	CI	*n*	Weighted percent of time period	CI
2016	Low	59	49.3	[46.3, 52.3]	76	67.1	[65.0, 69.2]
	High	77	50.7	[48.2, 53.2]	53	32.9	[29.8, 36.0]
2017	Low	63	47.9	[45.1, 50.6]	86	60.9	[58.6, 63.3]
	High	79	52.1	[49.8, 54.4]	66	39.1	[36.2, 42.0]
2018	Low	49	46.7	[43.6, 49.7]	73	59.3	[56.9, 61.6]
	High	71	53.3	[51.2, 55.4]	64	40.7	[37.9, 43.6]
Average 2016-2018	Low	171	48.1	[38.9, 57.2]	235	62.3	[55.6, 68.9]
	High	227	51.9	[44.9, 59.0]	183	37.7	[29.1, 46.4]

Note: HPV: human papillomavirus. CI: confidence interval (%).I used the data in this 2 x 2 table to test for an association between the variables using the chi-square test (see Table 10) and prevalence ratio (see Table 11). The confidence levels for parents with no- intent: 2016 - 73.5%, 2017 - 75.8%, 2018 - 68.5%, and average - 95.0%. For parents with intent: 2016 - 74.6%, 2017 - 77.6%, 2018 - 76.8%, and average - 95.5%. I calculated the weighted average of results by dividing the sample weight of each case by three, multiplying the data point values of each case by this average weight, and dividing the sum of these products for each variable by the sum of the weights.

Results of prevalence ratio and chi-square test strongly supported an association, in all the studies and the weighted average of the three studies, between parents' income level and their intent to vaccinate their teen. The chi-square test of independence is an inferential statistical test used to evaluate whether two variables are independent or associated (McDonald, 2014). Therefore, this test helped assess my null hypothesis of no association between Hispanic parents' total family income level and their intent to vaccinate their teen in the next 12 months. In addition, I used the prevalence ratio to quantify the relative risk of low-income parents' intent to vaccinate their child against HPV compared to the high-income group. For 2016, 2017, and 2018 studies and the weighted average of the studies, the results of both the chi-square test (see Table 10) and prevalence ratio (see Table 11) indicated an association between parents' income level and their intent to vaccinate their teen. Thus, in all studies, the results of the prevalence ratio estimate matched those of the chi-square test of association between parents' income level and their intent to vaccinate their teens.

Table 10

Relationship Between Parents' Income Level and Status of Their Intent to Vaccinate Child Against HPV

Sampling year	*n*	Pearson chi-square statistic adjusted for complex survey	*p* value	Significance level	Power
2016	265	8.57	0.003	0.41	0.80
2017	294	5.03	0.025	0.39	0.81
2018	257	4.02	0.045	0.42	0.79
Weighted avg. 2016-2018	816	16.63	$p < .001$	0.15	0.92

Note. HPV: human papillomavirus. I considered parents as having the *intent* to vaccinate their teen if they stated it was *very likely* or *somewhat likely* they will have their children get the HPV vaccine (Cheruvu et al., 2017). High income was above the median level for my sample ($40,000) and low income was less than or equal to the median. I obtained the weighted average of the results from 2016-2018. First, I divided the sample weight for each case by three to get an average. Then, I multiplied the value of the data points (variables) for each case by its respective average weight. Finally, I divided the sum of these products for each variable by the sum of the weights.

Table 11

Prevalence of HPV Vaccination Intent in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	265	1.49	[1.481, 1.488]	87.3
2017	294	1.28	[1.271, 1.281]	74.9
2018	257	1.25	[1.246, 1.255]	69.1
Weighted avg. 2016-2018	816	1.32	[1.303, 1.335]	37.4

Note. HPV: human papillomavirus. Parents had *intent* to vaccinate their teen if they stated it was *very likely* or *somewhat likely* they will have their child receive the HPV vaccine (Cheruvu et al., 2017). High income was above the median level ($40,000) and low was less than or equal to the median. The prevalence ratio, which I used as a measure of association, is mathematically identical to relative risk (Fonseca Martinez et al., 2017). I used the prevalence ratio in this cross-sectional study because it measures prevalence instead of risk. I based my calculations of this measure on the estimated population sizes (*N*). Prevalence ratio = [*N* of low-income parents with vaccination intent / (*N* of those with intent + *N* of those without intent)] / [*N* of high-income parents with intent / (*N* of those with intent + *N* of those without intent)].

Research Question 2 and Hypotheses

RQ2: Is there an association between Hispanic parents' total family income level and the teens' HPV vaccination initiation?

$H_0$2: There is no association between Hispanic parents' total family income level and the teens' HPV vaccination initiation.

H_a2: There is an association between Hispanic parents' total family income level and the teens' HPV vaccination initiation.

Univariate Analysis

In the data used to examine the association of income level with HPV vaccination initiation, the size and balance of the subgroups of the independent variable were favorable. In the 2016, 2017, and 2018 studies, the sample size of low- and high-income groups was 100 $\pm$ 20 (see Table 12). This size of income groups probably contributed positively to the overall power of my statistical tests (Rusticus & Lovato, 2014). The difference in the prevalence of low- and high-income families was insubstantial. Overall, in each sampling year, the sample sizes and prevalence of low- and high-income parents appeared to be sufficient and well balanced for statistical analysis.

Table 12

Income of Parents With or Without HPV Vaccine Series Initiation of Child (n = 632)

Survey year	Income level	*n*	Weighted percent of time period (%)	Confidence interval (%)	Confidence level (%)
2016	Low	97	54.3	[52.4, 56.3]	87.0
	High	113	45.7	[43.8, 47.6]	
2017	Low	106	48.7	[46.4, 50.9]	86.7
	High	128	51.3	[49.7, 53.0]	
2018	Low	84	50.6	[48.4, 52.8]	83.4
	High	104	49.4	[47.8, 51.0]	
Weighted average 2016-2018	Low	287	51.2	[47.4, 55.1]	98.8
	High	345	48.8	[45.7, 51.9]	

Note. HPV: human papillomavirus. Vaccine *initiation* was 1 dose for teens under age 15 years and 1 or 2 shots for those aged 15 to 17 years (Walker et al., 2017). High income was above the median level for my sample ($40,000) and low income was less than or equal to the median. For each year, the weighted prevalence of an income group was equal to the estimated population size of parents in the group divided by the population size of all parents (low and high income). I calculated the weighted average of 2016-2018 results by dividing the sample weight of each case by three, multiplying the data point (variable) values of each case by this average weight, and dividing the sum of these products for each variable by the sum of the weights.

Bivariate Analyses

In each study, the cross-tabulated data adjusted for the study population pointed to an association between parents' income level and the HPV vaccination initiation of their child. I present in Table 13 for each study, the number of participants with low and high income by those with and without a child who had initiated HPV vaccination. These results favored rejection of the null hypothesis that there is no association between Hispanic parents' total family income level and the teens' HPV vaccination initiation (see Table 13). The results also suggested that the difference in the percentage of vaccination initiation of youth in low-income families compared to high-income families became progressively larger from 2016 to 2018.

Table 13

Income of Parents by HPV Vaccine Series Initiation Status of Their Child (n = 632)

		HPV vaccination initiation (*n* = 168)			No HPV vaccination initiation (*n* = 464)		
Year	Income level	*n*	Weighted percent of time period	CI	*n*	Weighted percent of time period	CI
2016	Low	20	52.0	[49.5, 54.6]	77	55.0	[52.2, 57.8]
	High	27	48.0	[45.8, 50.2]	86	45.0	[42.3, 47.7]
2017	Low	35	58.6	[56.7, 60.5]	71	44.7	[41.6, 47.9]
	High	29	41.4	[39.2, 43.5]	99	55.3	[52.9, 57.6]
2018	Low	32	63.7	[61.4, 66.0]	52	45.3	[42.3, 48.3]
	High	25	36.3	[33.0, 39.5]	79	54.7	[52.6, 56.8]
Avg. 2016-2018	Low	87	58.4	[50.4, 66.3]	200	48.6	[39.1, 58.1]
	High	81	41.6	[33.1, 50.1]	264	51.4	[43.9, 58.9]

Note: HPV: human papillomavirus. CI: confidence interval. I used the data in this 2 x 2 table to test for an association between the variables using the chi-square test (see Table 14) and prevalence ratio (see Table 15). The confidence levels for the teens who initiated the series: 2016 - 44.0%, 2017 - 46.8%, 2018 - 57.3%, and avg. - 81.0%. For those teens uninitiated: 2016 - 79.0%, 2017 - 80.8%, 2018 - 70.6%, and avg. - 97.1%. I calculated the weighted average of results by dividing the sample weight of each case by three, multiplying the variable values of each case by this average weight, and dividing the sum of these products for each variable by the sum of the weights.

Based on the prevalence ratio and chi-square test results, I generally found an association between family income level and HPV vaccination initiation. The association between parents' income and HPV vaccination initiation was assessed using the prevalence ratio and chi-square test did not agree in one study year. The 2016 study's chi-square test result was not statistically significant (see Table 14). However, this study showed a statistically significant difference in the prevalence estimate of HPV vaccination initiation in low- and high-income families (see Table 15). This discrepancy might be due to the sensitivity of the chi-square test to a small sample size, especially to small cell counts of the 2 x2 contingency table used for chi-square test calculations (McDonald, 2014). Overall, there was evidence of an association of family income level with HPV vaccination initiation across all study years and the weighted average.

Table 14

Relationship Between Parents' Income Level and Status of HPV Vaccine Series Initiation of Their Child

Sampling year	*n*	Pearson chi-square statistic adjusted for complex survey	*p* value	Significance level	Power
2016	210	0.13	0.716	0.45	0.77
2017	234	3.68	0.055	0.43	0.78
2018	188	5.24	0.022	0.47	0.76
Weighted avg. 2016-2018	632	4.74	0.029	0.21	0.90

Note. HPV: human papillomavirus. HPV vaccine series *initiation* referred to the receipt of 1 dose for teens under age 15 years and 1 or 2 shots for those aged 15 to 17 years (Walker et al., 2017). High income was above the median level for my sample ($40,000/year) and low income was less than or equal to the median. I obtained the weighted average of the results from 2016-2018. First, I divided the sample weight for each case by three to get an average. Then, I multiplied the value of the data points (variables) for each case by its respective average weight. Finally, I divided the sum of these products (weight-adjusted data) for each variable by the sum of the weights.

Table 15

Prevalence of HPV Vaccine Series Initiation in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	210	0.91	[0.897, 0.928]	34.6
2017	234	1.50	[1.484, 1.506]	67.0
2018	188	1.71	[1.704, 1.722]	74.3
Weighted avg. 2016-2018	632	1.34	[1.315, 1.358]	73.1

Note. HPV: human papillomavirus. HPV vaccine series *initiation* was defined as 1 dose of the vaccine for teens under age 15 years and 1 or 2 shots for those aged 15 to 17 years (Walker et al., 2017). High income was above the annual median level ($40,000) and low was less than or equal to the median. The prevalence ratio, which I used as a measure of association, is mathematically identical to relative risk (Fonseca Martinez et al., 2017). I used the prevalence ratio in this cross-sectional study because it measures prevalence instead of risk. I based my calculations of this measure on the estimated population sizes (*N*). Prevalence ratio = [*N* of low-income teens initiated on the HPV vaccine series / (*N* of those initiated + *N* of those uninitiated)] / [*N* of high-income teens initiated / (*N* of those initiated + *N* of those uninitiated)].

Research Question 3 and Hypotheses

RQ3: Is there an association between Hispanic parents' total family income level and the teens' HPV vaccination series completion?

$H_0$3: There is no association between Hispanic parents' total family income level and the teens' HPV vaccination series completion.

H_a3: There is an association between Hispanic parents' total family income level and the teens' HPV vaccination series completion.

Univariate Analysis

The size of the two categories of my independent variable, income, was substantial and similar in the data used to examine the association of income level with vaccination series completion. In the 2016, 2017, and 2018 studies, the sample size of low- and high-income groups ranged from 155 to almost 200 (see Table 16). This size of income categories likely contributed positively to the overall power of my statistical tests (Rusticus & Lovato, 2014). The difference in the prevalence of low- and high-income families in the 2017 and 2018 studies was insubstantial (see Table 16). Overall, the data for RQ3 was suitable for statistical analysis due to the large size of low- and high-income samples and similar estimated population percentages.

Table 16

Income of Parents With or Without HPV Vaccine Series Completion of Child (n = 1,040)

Survey year	Income level	*n*	Weighted percent of time period (%)	Confidence interval (%)	Confidence level (%)
2016	Low	155	60.0	[58.2, 61.8]	92.0
	High	159	40.0	[38.4, 41.6]	
2017	Low	185	51.9	[50.2, 53.6]	94.8
	High	197	48.1	[46.6, 49.7]	
2018	Low	157	53.3	[51.5, 55.2]	93.8
	High	176	46.7	[45.2, 48.2]	
Weighted average 2016-2018	Low	508	55.0	[51.8, 58.2]	99.9
	High	532	45.0	[42.2, 47.8]	

Note. HPV: human papillomavirus. HPV vaccine series *completion* was 2 shots before age 15 years and 3 for those between ages 15 and 17 years (Walker et al., 2017). I set high income above the median level for the sample ($40,000/year) and low income less than or equal to the median. For each year, the weighted prevalence of an income group was equal to the estimated population size of parents in the group divided by the population size of all parents (low and high income). I calculated the weighted average of 2016-2018 results by dividing the sample weight of each case by three, multiplying the data point (variable) values of each case by this average weight, and dividing the sum of these products for each variable by the sum of the weights.

Bivariate Analyses

In each study, the cross-tabulated data adjusted for the study population pointed to an association between parents' income level and the HPV vaccination completion of their child. Table 17 consists of 2 x 2 contingency tables for each study year showing the number of low- and high-income parents who had a child complete and incomplete on the HPV vaccine series. These results favored rejection of the null hypothesis that there is no association between Hispanic parents' total family income level and the teens' HPV vaccination series completion (see Table 17). The results also suggested that the difference in the percentage of vaccination completion of youth in low-income families compared to high-income families became smaller from 2016 to 2017 and 2018.

Table 17

Income of Parents by Status of HPV Vaccine Series Completion of Child (n =1,040)

		HPV vaccination complete (*n* = 408)			HPV vaccination incomplete (*n* = 632)		
Year	Income level	*n*	Weighted percent of time period	CI	*n*	Weighted percent of time period	CI
2016	Low	58	69.5	[68.6, 70.5]	97	54.3	[51.8, 56.8]
	High	46	30.5	[28.9, 32.1]	113	45.7	[43.4, 48.0]
2017	Low	79	56.9	[55.7, 58.1]	106	48.7	[46.1, 51.2]
	High	69	43.1	[41.7, 44.5]	128	51.3	[49.2, 53.4]
2018	Low	73	56.8	[55.1, 58.6]	84	50.6	[48.4, 52.9]
	High	72	43.2	[41.5, 44.8]	104	49.4	[47.4, 51.3]
Avg. 2016-2018	Low	221	60.8	[56.3, 65.3]	287	51.2	[43.5, 58.9]
	High	187	39.2	[33.8, 44.6]	345	48.8	[42.0, 55.5]

Note: HPV: human papillomavirus. CI: confidence interval (%). I used the data in this 2 x 2 table to test for an association between the variables using the chi-square test (Table 18) and prevalence ratio (Table 19). The confidence levels for teens complete (up to date) on series: 2016 - 44.0%, 2017 - 46.8%, 2018 - 57.3%, and avg. - 81.1%. For teens incomplete: 2016 - 79.0%, 2017 - 80.8%, 2018 - 70.6%, and avg. - 97.1%. I calculated the weighted average of results by dividing the sample weight of each case by three, multiplying the data point values of each case by this average weight, and dividing the sum of these products for each variable by the sum of the weights.

In all studies, the results of the prevalence ratio estimate matched those of the chi-square test of association between parents' income level and HPV vaccination series completion of their child. For the 2016, 2017, and 2018 studies and the weighted average of the studies, the chi-square test result (see Table 18) and prevalence ratio (see Table 19) indicated an association between parents' income level and HPV vaccination series completion of their child. Overall, these results strongly supported an association, in all the studies and the weighted average of the three studies, between parents' income level and HPV vaccination series completion.

Table 18

Relationship Between Parents' Income Level and Status of HPV Vaccine Series Completion of Their Child

Sampling year	*n*	Pearson chi-square statistic adjusted for complex survey	*p* value	Significance level	Power
2016	314	7.09	0.008	0.39	0.81
2017	382	2.48	0.115	0.31	0.84
2018	333	1.28	0.259	0.34	0.83
Weighted avg. 2016-2018	1,040	9.21	0.002	0.10	0.95

Note. HPV: human papillomavirus. HPV vaccine series *completion* was the receipt by a teen of 2 shots before age 15 years and 3 for those between ages 15 and 17 years (Walker et al., 2017). High income was above the median level for my sample ($40,000/year) and low income was less than or equal to the median. I obtained the weighted average of the results from 2016-2018. First, I divided the sample weight for each case by three to get an average. Then, I multiplied the value of the data points (variables) for each case by its respective average weight. Finally, I divided the sum of these products (weight-adjusted data) for each variable by the sum of the weights.

Table 19

Prevalence of HPV Vaccine Series Completion in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	314	1.52	[1.502, 1.544]	82.3
2017	382	1.23	[1.219, 1.232]	58.4
2018	333	1.15	[1.150, 1.157]	46.3
Weighted avg. 2016-2018	1,040	1.27	[1.251, 1.281]	88.1

Note. HPV: human papillomavirus. HPV vaccine series *completion* (up to date) referred to the receipt by a teen of 2 shots before age 15 years and 3 for those aged 15 and 17 years (Walker et al., 2017). High income was above the median level ($40,000) and low was less than or equal to the median. The prevalence ratio, which I used as a measure of association, is mathematically identical to relative risk (Fonseca Martinez et al., 2017). I used the prevalence ratio in this cross-sectional study because it measures prevalence instead of risk. I based my calculations of this measure on the estimated population sizes (*N*). Prevalence ratio = [*N* of low-income teens complete on the HPV vaccine series / (*N* of those complete + *N* of those incomplete)] / [*N* of high-income teens complete / (*N* of those complete + *N* of those incomplete)].

Aggregate Results of Research Questions 1 to 3 on Prevalence of Vaccination-Related Outcomes in Low- Versus High-income Families

I observed similarities and differences in the influence of low income compared to high income on HPV vaccination intent, series initiation, and completion in RQs1-3. Results across study years indicated a higher prevalence of low-income parents' intent to vaccinate their children than high-income parents (see Table 20). Similarly, I generally saw a higher prevalence of HPV vaccination series initiation and completion of teens in low-income families compared to high-income families (see Table 20). As stated above in the discussion for RQs1-3, I based these conclusions on the rejection of the null hypothesis that there is no association between Hispanic parents' total family income level and intent, initiation, and completion. The positive influence of low income on HPV vaccination initiation compared to high income increased from 2016 to 2018 (see Table 20). In contrast, there was a decrease of the positive effect, or at least relation, of low income compared to high income on parents' intent to vaccinate their child and series completion. In the weighted average of the three studies, low-income families had about 1.3 times the prevalence of vaccination intention, initiation, and completion for their child compared to high-income families. The weighted prevalence in low-income families compared to high-income families was statistically, but not substantially, different among the outcomes of vaccination intent, initiation, and completion.

Table 20

Prevalence of Vaccination-Related Outcomes in Low- Versus High-Income Families

	Weighted prevalence ratio of outcomes in Research Questions (RQs) 1 to 3 [confidence interval]					
Year	Intent to vaccinate (RQ1)	Confidence level (%)	Vaccination initiation (RQ2)	Confidence level (%)	Vaccination completion (RQ3)	Confidence level (%)
2016	1.49 [1.481, 1.488]	87.3	0.91 [0.897, 0.928]	34.6	1.52 [1.518, 1.528]	82.3
2017	1.28 [1.271, 1.281]	74.9	1.50 [1.484, 1.506]	67.0	1.23 [1.217, 1.234]	58.4
2018	1.25 [1.246, 1.255]	69.1	1.71 [1.704, 1.722]	74.3	1.15 [1.145, 1.161]	46.3
Avg.	1.32 [1.303, 1.335]	37.4	1.34 [1.329, 1.344]	73.1	1.27 [1.264, 1.269]	88.1

Note. I demarcated high and low income by the median ($40,000/year). Parents had *intent* to vaccinate their teen if they stated it was *very likely* or *somewhat likely* they will have their child receive the HPV vaccine (Cheruvu et al., 2017). *Initiation* was the receipt of 1 dose of vaccine for teens under age 15 years and 1 or 2 for those aged 15 to 17 (Walker et al., 2017). *Completion* was the receipt of 2 shots before age 15 years and 3 between ages 15 and 17. *N* = estimated population size. Prevalence ratio = [*N* of low-income parents with an outcome / (*N* of those with + *N* of those without)] / [*N* of high-income parents with an outcome / (*N* of those with + *N* of those without)].

Research Questions 4 to 8

Rationale for Analyzing the Influence of Income Level on Parents' No-Intent to Vaccinate Child

The objective of RQs4-8 was to identify the reasons parents lacked the intent to have their children vaccinated against HPV. The data on the prevalence of outcomes of these RQs could help explain why low-income families had a lower prevalence of no-intent than high-income families. Therefore, before presenting the analysis of the results of RQs4-8, I describe the prevalence of parents' no-intent to vaccinate their children by income level.

Univariate Analysis

The sample size and income distribution appeared to be adequate in the sample from which I assessed the intent and no-intent of parents to vaccinate their children. In Table 8 presented earlier, I described some characteristics of the sample I used to examine the relationship between parents' income level and their intent (RQ1) or no-intent (RQs4-8) to have their child vaccinated against HPV. Again, the data in Table 8 show the size and distribution of the prevalence of low and high-income families in my study in terms of sample size and estimated population size. The number of low- and high-income parents was similar and over 120 in each study and the weighted average (see Table 8). More revealing, in each study and the average, the difference between the estimated population percentage of low-income and high-income groups was relatively small (i.e., less than 10% in most cases). For these reasons, the power of the statistical tests was likely adequate.

Bivariate Analyses

In each study, the prevalence of parents' no-intent to vaccinate their child appeared to be lower in low- than high-income families. I present on the left side of Table 9 the estimated percent of participants in the study population with no-intent to vaccinate their child. The results of the three study years shown in Table 9 indicated there might be an association between parents' total family income and their no-intent to vaccinate their teens.

In all study years, the result of the prevalence ratio estimate matched that of the chi-square test of association between parents' income level and lack of intent to vaccinate their teens. For the 2016, 2017, and 2018 studies and the weighted average, the chi-square test result (see Table 10) and prevalence ratio (see Table 21) indicated an association between parents' income level and lack of intent to vaccinate their teen. The agreement of these statistics strongly supported an association, in all the studies and the weighted average, between parents' income level and lack of intent to vaccinate their teens.

Table 21

Prevalence of Parents' No-Intent to Vaccinate in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	265	0.71	[0.707, 0.710]	86.2
2017	294	0.75	[0.749, 0.754]	74.9
2018	257	0.75	[0.749, 0.756]	69.1
Weighted avg. 2016-2018	816	0.74	[0.731, 0.748]	37.2

Note. HPV: human papillomavirus. Parents had *no-intent* to vaccinate their teen if their response was *not too likely*, *not likely at all*, or *not sure/do not know* (Cheruvu et al., 2017). High income was above the median level ($40,000/year) and low was less than or equal to the median. The prevalence ratio, which I used as a measure of association, is mathematically identical to relative risk (Fonseca Martinez et al., 2017). I used the prevalence ratio in this cross-sectional study because it measures prevalence instead of risk. I based my calculations of this measure on the estimated population sizes (*N*). Prevalence ratio = [*N* of low-income parents without HPV vaccination intent / (*N* of those without intent + *N* of those with intent)] / [*N* of high-income parents without intent / (*N* of those without intent + *N* of those with intent)].

Research Question 4 and Hypotheses

RQ4: Is there an association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns?

$H_0$4: There is no relationship between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns.

H_a4: There is an association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns.

Univariate Analysis

The size of my independent variable's low- and high-income categories appeared to be similar. The data in Table 22 apply to RQs4-8, in which I examined the relationship between parents' income levels and why they did not intend to vaccinate their children against HPV. I report in Table 22 the number of participants in the survey sample with low and high income. In addition, I present the weighted prevalence estimates with confidence intervals to represent the economic status of parents with an unvaccinated or undervaccinated child in the broader study population. The results in Table 22 indicated differences in the percent of low- and high-income families (less than 10%) were not substantial. Thus, I found an apparent well-balanced distribution of the number of low- and high-income parents in each period.

Table 22

Income of Parents With No-Intent to Vaccinate Non Up-To-Date Child (n = 364)

Survey year	Income level	*n*	Weighted percent of time period (%)	Confidence interval (%)	Confidence level (%)
2016	Low	51	46.4	[45.1, 47.7]	75.3
	High	75	53.6	[52.7, 54.5]	
2017	Low	54	45.4	[44.3, 46.5]	75.0
	High	74	54.6	[53.6, 55.6]	
2018	Low	44	45.0	[43.3, 46.7]	70.6
	High	66	55.0	[52.9, 57.1]	
Weighted average 2016-2018	Low	149	45.6	[43.1, 48.2]	94.1
	High	215	54.4	[51.7, 57.0]	

Note. HPV: human papillomavirus. Parents had *no-intent* if their response was *not too likely*, *not likely at all*, or *not sure/do not know*. A child was *up to date* if they had 2 shots before age 15 years or 3 between 15 and 17 years. I demarcated high and low income by the median level ($40,000/year). For each year, the weighted prevalence of an income group was equal to the estimated population size of parents in the group divided by the population size of all parents (low and high income). I calculated the weighted average of results by dividing the sample weight of each case by three, multiplying the data point values of each case by this average weight, and dividing the sum of these products for each variable by the sum of the weights.

Bivariate Analyses

In each study, the cross-tabulated data adjusted for the study population suggested an association between parents' income and their HPV vaccine safety and effectiveness concerns. In Table 23, I further stratify the data on the percentage of low- and high-income families into those with or without safety and effectiveness concerns about HPV vaccination of their teens. The results on the left side of Table 23 favor rejecting the null hypothesis of no association between Hispanic parents' total family income level and their HPV vaccine safety and effectiveness concerns.

Table 23

Income of Parents by Status of HPV Vaccine Safety and Effectiveness Concern (n = 364)

		Safety and effectiveness concern (*n* = 53)			No safety and effectiveness concern (*n* = 311)		
Year	Income level	*n*	Weighted percent of time period	CI	*n*	Weighted percent of time period	CI
2016	Low	4	38.9	[36.0, 41.8]	47	47.2	[44.0, 50.4]
	High	12	61.1	[60.3, 61.9]	63	52.8	[50.2, 55.4]
2017	Low	4	29.7	[27.0, 32.4]	50	47.1	[44.5, 49.6]
	High	12	70.3	[69.6, 71.0]	62	52.9	[50.8, 55.0]
2018	Low	9	36.7	[33.8, 39.6]	35	47.3	[43.9, 50.7]
	High	12	63.3	[60.9, 65.7]	54	52.7	[50.7, 54.7]
Avg. 2016-2018	Low	17	35.8	[22.1, 49.5]	132	47.2	[37.4, 57.0]
	High	36	64.2	[58.7, 69.7]	179	52.8	[45.7, 59.9]

Note: HPV: human papillomavirus. CI: confidence interval (%). Parents had *HPV* v*accine concern* if they did not intend to vaccinate for one of the reasons listed in Table 2. I demarcated low and high income by the median ($40,000/year). The confidence levels for HPV vaccine concern: 2016 - 19.6%, 2017 - 19.6%, 2018 - 33.6%, and avg. - 60.0%. No concern: 2016 - 70.6%, 2017 - 65.3%, 2018 - 65.7%, and avg. - 93.1%. I used the data to test associations. I calculated the weighted average by dividing the sample weight of each case by three, multiplying the values of each case by this mean, and dividing the sum of these products for each variable by the sum of the weights.

The assessment of the association between parents' income and HPV vaccine safety and effectiveness concerns using the prevalence ratio and chi-square test did not agree in one study year. In the 2016 study, the result of the chi-square test was statistically insignificant (see Table 24). However, this study showed a statistically significant difference in the prevalence of HPV vaccine safety and effectiveness concerns in low- and high-income families (see Table 25). This discrepancy might be due to the sensitivity of the chi-square test to a small sample size, especially to small cell counts of the 2 x2 contingency table used for chi-square calculations (McDonald, 2014). Therefore, I found an apparent association between family income level with HPV vaccine safety and effectiveness concerns in all study years and the weighted average.

Table 24

Relationship Between Income Level and Status of HPV Vaccination Safety and Effectiveness Concern

Sampling year	*n*	Pearson chi-square statistic adjusted for complex survey	*p* value	Significance level	Power
2016	126	0.31	0.577	0.53	0.73
2017	128	1.38	0.241	0.53	0.73
2018	110	0.85	0.356	0.55	0.72
Weighted avg. 2016-2018	364	2.24	0.135	0.34	0.83

Note. HPV: human papillomavirus. Parents had *HPV vaccine safety and effectiveness concerns* if they did not intend to vaccinate their child for one of the reasons listed in Table 2, Chapter 1. High income was above the median level for my sample ($40,000/year) and low income was less than or equal to the median. I obtained the weighted average of the results from 2016, 2017, and 2018. First, I divided the sample weight for each case by three to get an average weight. Then, I multiplied the value of the data points (variables) for each case by its respective average weight. Finally, I divided the sum of these products for each variable by the sum of the weights.

Table 25

Prevalence of HPV Vaccine Safety and Effectiveness Concern in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	126	0.74	[0.712, 0.760]	35.7
2017	128	0.51	[0.497, 0.520]	48.2
2018	110	0.71	[0.695, 0.724]	43.0
Weighted avg. 2016-2018	364	0.66	[0.645, 0.681]	56.5

Note. HPV: human papillomavirus. Parents had *HPV vaccine concern* if they did not intend to vaccinate for a reason listed in Table 2. I demarcated income level by the median ($40,000/year).The prevalence ratio, which I used as a measure of association, is mathematically identical to relative risk (Fonseca Martinez et al., 2017). I used the prevalence ratio in this cross-sectional study because it measures prevalence instead of risk. I based my calculations of this measure on the estimated population sizes (*N*). Prevalence ratio = [*N* of low-income parents with vaccine concern / (*N* of those with concern + *N* of those without concern)] / [*N* of high-income parents with vaccine concern / (*N* of those with concern + *N* of those without concern)].

Research Question 5 and Hypotheses

RQ5: Is there an association between Hispanic parents' total family income level and their HPV vaccine misinformation?

$H_0$5: There is no association between Hispanic parents' total family income level and their HPV vaccine misinformation.

H_a5: There is an association between Hispanic parents' total family income level and their HPV vaccine misinformation.

Univariate Analysis

The sizes of the two categories of my independent variable (i.e., income) appeared to be similar. The data presented in Table 22 applied to this RQ (number 5) and RQs4, 6, 7, and 8. As described for RQ4, the difference in the percentage of low- and high-income families from the 2016, 2017, and 2018 studies and the weighted average was not substantial (see Table 22). Thus, I found an apparent well-balanced distribution of the number of low and high-income parents in each period.

Bivariate Analyses

In most studies, the cross-tabulated data adjusted for the study population pointed to an association between parents' income and HPV vaccine misinformation. In Table 26, I further stratify the data on low- and high-income families into those with or without misinformation about HPV vaccination of their teens. The results of the 2016 and 2017 studies favored rejecting the null hypothesis of no association between Hispanic parents' total family income level and their HPV vaccine misinformation (see Table 26). The result of the 2018 study did not support the rejection of this null hypothesis because there was no statistically significant difference in the percentage of low- and high-income parents misinformed about HPV vaccination.

Table 26

Income Level of Parents by Status of HPV Vaccination Misinformation (n = 364)

		Parents misinformed (*n* = 105)			Not misinformed (*n* = 259)		
Year	Income level	*n*	Weighted percent of time period	CI	*n*	Weighted percent of time period	CI
2016	Low	14	36.4	[33.3, 39.4]	37	51.1	[48.1, 54.2]
	High	31	63.6	[61.7, 65.5]	44	48.9	[46.2, 51.5]
2017	Low	18	40.5	[37.7, 43.3]	36	47.7	[44.6, 50.8]
	High	24	59.5	[57.5, 61.5]	50	52.3	[49.8, 54.7]
2018	Low	8	50.7	[49.1, 52.4]	36	44.0	[40.7, 47.3]
	High	10	49.3	[48.1, 50.4]	56	56.0	[53.7, 58.2]
Avg. 2016-2018	Low	40	40.2	[30.7, 49.7]	109	47.6	[38.3, 57.0]
	High	65	59.8	[53.4, 66.2]	150	52.4	[45.1, 59.7]

Note: HPV: human papillomavirus. CI: confidence interval (%). I considered parents *misinformed* if they did not intend to vaccinate for one of the reasons listed in Table 2. I demarcated low and high income by the median ($40,000/year). The confidence levels for misinformed: 2016 - 44.9%, 2017 - 45.8%, 2018 - 18.5%, and avg. - 67.1%. Not misinformed: 2016 - 62.6%, 2017 - 66.8%, 2018 - 65.2%, and avg. - 89.4%. I used the data in the 2 x 2 tables for the chi-square test (Table 27) and prevalence ratio (Table 28). I calculated the weighted average by dividing the sample weight of each case by three, multiplying the data point (variable) values of each case by this mean, and dividing the sum of these products for each variable by the sum of the weights.

The prevalence ratio estimate and the chi-square test of the association between parents' income and HPV vaccination misinformation did not always agree. In the 2018 study year, the result for the chi-square test was not statistically significant (see Table 27). However, in this study year, there was a statistically significant difference in the prevalence of vaccination misinformation in low- and high-income parents (see Table 28). This discrepancy might be due to the sensitivity of the chi-square test to small sample size, especially to a small cell counts of the 2 x2 contingency table used for chi-square calculations (McDonald, 2014). Therefore, I found an apparent association between family income level and HPV vaccination misinformation in all study years and the weighted average.

Table 27

Relationship Between Income Level and Status of HPV Vaccination Misinformation

Sampling year	*n*	Pearson chi-square statistic adjusted for complex survey	*p* value	Significance level	Power
2016	126	2.41	0.120	0.53	0.73
2017	128	0.59	0.442	0.53	0.73
2018	110	0.24	0.622	0.55	0.72
Weighted avg. 2016-2018	364	1.57	0.210	0.34	0.83

Note. HPV: human papillomavirus. I considered parents *misinformed* about HPV vaccination of their teen if they did not intend to have their child vaccinated for one of the reasons listed in Table 2, Chapter 1 (Cheruvu et al., 2017). High income was above the median level for my sample ($40,000/year) and low income was less than or equal to the median. I obtained the weighted average of the results from 2016, 2017, and 2018. First, I divided the sample weight for each case by three to get an average weight. Then, I multiplied the value of the data points (variables) for each case by its respective average weight. Finally, I divided the sum of these products for each variable by the sum of the weights.

Table 28

Prevalence of HPV Vaccination Misinformation in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	126	0.66	[0.653, 0.668]	35.7
2017	128	0.82	[0.808, 0.832]	40.0
2018	110	1.26	[1.230, 1.289]	36.7
Weighted avg. 2016-2018	364	0.80	[0.793, 0.810]	48.8

Note. HPV: human papillomavirus. Parents were *misinformed* if they did not intend to vaccinate their child for a reasons listed in Table 2. I demarcated income level by the median. I calculated the prevalence ratio as for relative risk, but I based it on prevalence vs. incidence (Fonseca Martinez et al., 2017). *N* = estimated population size. Prevalence ratio = [*N* of low-income parents misinformed about HPV vaccination / (*N* of those misinformed + *N* of those not misinformed) / [*N* of high-income parents misinformed / (*N* of those misinformed + *N* of those not misinformed)]. I calculated the weighted average by dividing the sample weight of each case by three, multiplying the data point values of each case by this mean, and dividing the sum of these products for each variable by the sum of the weights.

Research Question 6 and Hypotheses

RQ6: Is there an association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination?

$H_0$6: There is no association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination.

H_a6: There is an association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination.

Univariate Analysis

The size of the two categories of my independent variable (i.e., income) appeared similar. The data presented in Table 22 applies to this RQ (number 6) and RQs4, 5, 7, and 8. As described for RQ4, the difference in the percentage of low- and high-income families from the 2016, 2017, and 2018 studies and the weighted average was not substantial (see Table 22). Thus, I found an apparent well-balanced distribution of the number of low and high-income parents in each period.

Bivariate Analyses

In all studies except the weighted average, the cross-tabulated data adjusted for the study population suggested an association between parents' income and their lack of knowledge of the importance of HPV vaccination. In Table 29, I further stratify the data on low and high-income families into those with or without a lack of HPV vaccination knowledge. In the 2016 and 2017 studies, a significantly higher percentage of low-income parents lacked knowledge about vaccinating their children than those with high incomes. In the 2018 study, a significantly lower percentage of low-income parents lacked knowledge about vaccinating their children than those with high incomes. Although the difference between 2016 and 2017 was relatively small, it favored rejection of the null hypothesis of no association between Hispanic parents' total family income level and their lack of knowledge of the importance of HPV vaccination. The larger difference in 2018 provided more support for the rejection of the null hypothesis.

Table 29

Income Level of Parents by Status of Knowledge of HPV and the Vaccine (n = 364)

		Lack of HPV vaccination knowledge (*n* = 95)			No lack of knowledge (*n* = 269)		
Sample year	Income level	*n*	Weighted percent of time period	CI	*n*	Weighted percent of time period	CI
2016	Low	8	52.3	[50.6, 54.0]	43	45.4	[42.0, 48.8]
	High	8	47.7	[45.6, 49.8]	67	54.6	[52.2, 56.9]
2017	Low	18	53.6	[51.0, 56.2]	36	42.3	[39.0, 45.5]
	High	19	46.4	[43.7, 49.0]	55	57.7	[55.6, 59.9]
2018	Low	14	41.4	[37.7, 45.1]	30	47.0	[43.8, 50.1]
	High	28	58.6	[57.0, 60.1]	38	53.0	[50.4, 55.7]
Average 2016-2018	Low	40	48.0	[38.0, 57.9]	109	44.9	[35.5, 54.3]
	High	55	52.0	[42.4, 61.7]	160	55.1	[48.0, 62.2]

Note: HPV: human papillomavirus. CI: confidence interval (%). Parents *lacked knowledge* if they did not intend to vaccinate for a reasons listed in Table 2. I divided high and low income by the annual median. The confidence levels for lack of knowledge: 2016 - 19.6%, 2017 - 48.9%, 2018 - 45.8%, and avg. - 69.5%. For no lack of knowledge: 2016 - 70.6%, 2017 - 65.2%, 2018 - 60.4%, and avg. - 88.7%. I used the data for the tests of association. I calculated the weighted average by dividing the sample weight of each case by three, multiplying the values of each case by this mean, and dividing the sum of these products for each variable by the sum of the weights.

In some study years, I got different conclusions from the prevalence ratio estimate and the chi-square test of association between parents' income level and lack of knowledge of HPV and the vaccine. In the 2016 and 2018 studies and the weighted average of the three studies, the result for the chi-square test was not statistically significant (see Table 30). However, there was a statistically significant difference in the prevalence of lack of knowledge of HPV and the vaccine in low- and high-income parents (see Table 31). This discrepancy might be due to the sensitivity of the chi-square test to a small sample size, especially to small cell counts of the 2 x2 contingency table used for chi-square calculations (McDonald, 2014). Overall, in all study years and the weighted average, I found an apparent association between family income level with lack of knowledge of HPV and the vaccine.

Table 30

Relationship Between Income Level and Status of Knowledge of HPV and the Vaccine

Sampling year	*n*	Pearson chi-square statistic adjusted for complex survey	*p* value	Significance level	Power
2016	126	0.29	0.593	0.53	0.73
2017	128	1.33	0.249	0.53	0.73
2018	110	0.31	0.575	0.55	0.72
Weighted avg. 2016-2018	364	0.26	0.613	0.34	0.83

Note. HPV: human papillomavirus. I considered parents as *lacking HPV vaccination knowledge* if they did not intend to have their child vaccinated for one of the reasons listed in Table 2, Chapter 1 (Cheruvu et al., 2017). High income was above the median level for my sample ($40,000/year) and low income was less than or equal to the median. I obtained the weighted average of the results from 2016, 2017, and 2018. First, I divided the sample weight for each case by three to get an average weight. Then, I multiplied the value of the data points (variables) for each case by its respective average weight. Finally, I divided the sum of these products for each variable by the sum of the weights.

Table 31

Prevalence of Lack of Knowledge of HPV Vaccination in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	126	1.27	[1.229, 1.305]	35.7
2017	128	1.39	[1.369, 1.416]	46.1
2018	110	0.86	[0.850, 0.879]	36.6
Weighted avg. 2016-2018	364	1.10	[1.048, 1.147]	36.2

Note. HPV: human papillomavirus. Parents *lacked knowledge* if they did not intend to vaccinate for one of the reasons listed in Table 2. I demarcated low and high income by the median ($40,000/year). *N* = estimated population size. Prevalence ratio = [*N* of low-income parents lacking knowledge / (*N* of those lacking knowledge + *N* of those not lacking knowledge)] / [*N* of high-income parents lacking knowledge / (*N* of those lacking knowledge + *N* of those not lacking knowledge)]. I calculated the weighted average by dividing the sample weight of each case by three, multiplying the data point (variables) values of each case by this mean weight, and dividing the sum of these products for each variable by the sum of the weights.

Research Question 7 and Hypotheses

RQ7: Is there an association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination?

$H_0$7: There is no association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination.

H_a7: There is an association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination.

Univariate Analysis

The size of the two categories of my independent variable (i.e., income) appeared similar. The data presented in Table 22 applies to this RQ (number 7) and RQs4-6 and 8. As described for RQ4, the difference in the percentage of low- and high-income families from the 2016, 2017, and 2018 studies and the weighted average was not substantial (see Table 22). Thus, I found an apparent well-balanced distribution of the number of low- and high-income parents in each period.

Bivariate Analyses

In some studies, the cross-tabulated data adjusted for the study population pointed to an association between parents' income and their systemic barriers to HPV vaccination. In Table 32, I further stratify the data on low- and high-income families into those with or without a systemic barrier to HPV vaccination. The gap in the percentage of low- and high-income parents with a systemic barrier was 7% in 2017 and 9% in 2018. Although these differences were relatively small, they favored the rejection of the null hypothesis of no association between Hispanic parents' total family income level and their systemic barriers to HPV vaccination in the 2017 and 2018 studies.

Table 32

Income Level of Parents by Status of a Systemic Barrier to HPV Vaccination (n = 364)

		Systemic Barrier (*n* = 86)			No Systemic Barrier (*n* = 278)		
Sample year	Income level	*n*	Weighted percent of time period	CI	*n*	Weighted percent of time period	CI
2016	Low	19	53.0	[49.8, 56.2]	32	43.4	[40.4, 46.4]
	High	17	47.0	[44.0, 50.0]	58	56.6	[54.5, 58.8]
2017	Low	12	45.4	[42.2, 48.5]	42	45.4	[42.7, 48.0]
	High	18	54.6	[52.3, 57.0]	56	54.6	[52.6, 56.6]
2018	Low	9	53.2	[50.1, 56.3]	35	43.2	[40.2, 46.1]
	High	11	46.8	[44.8, 48.8]	55	56.8	[54.8, 58.8]
Average 2016-2018	Low	40	50.5	[40.8, 60.3]	109	43.9	[34.5, 53.3]
	High	46	49.5	[42.0, 56.9]	169	56.1	[49.5, 62.7]

Note: HPV: human papillomavirus. CI: confidence interval (%). Parents had a *systemic barrier* if they did not intend to vaccinate for a reasons listed in Table 2. I divided low and high income by the median ($40,000/year). The confidence levels for systemic barriers: 2016 - 48.9%, 2017 - 41.5%, 2018 - 36.6%, and avg. - 66.8%. No systemic barriers: 2016 - 59.8%, 2017 - 63.7%, 2018 - 59.8%, and avg. - 89.5%. I used the data in the 2 x 2 tables for the chi-square test (see Table 33) and prevalence ratio (see Table 34). I calculated the weighted average by dividing the sample weight of each case by three, multiplying the data point (variable) values of each case by this mean, and dividing the sum of these products for each variable by the sum of the weights.

In all studies, the result of the prevalence ratio estimate matched those of the chi-square test of association between parents' income and their systemic barriers to HPV vaccination. In the 2017 study, the chi-square test of the association between parents' income level and their systemic barriers to HPV vaccination was not statistically significant (see Table 33). In agreement with this finding, the prevalence ratio estimate and confidence interval in the 2017 study pointed to a lack of association between income level and systemic barriers (see Table 34). For the 2016 and 2018 studies and the weighted average of the studies, the chi-square test result and prevalence ratio indicated an association between parents' income level and systemic barriers to HPV vaccination. Overall, these results provided strong support for an association between income level and systemic barriers in the 2016 and 2018 studies and the weighted average of the studies, but not in the 2017 study.

Table 33

Relationship Between Income Level and Status of a Systemic Barrier to HPV Vaccination

Sampling year	*n*	Pearson chi-square statistic adjusted for complex survey	*p* value	Significance level	Power
2016	126	1.02	0.313	0.53	0.73
2017	128	0.00	0.999	0.53	0.73
2018	110	0.66	0.416	0.55	0.72
Weighted avg. 2016-2018	364	1.26	0.263	0.34	0.83

Note. HPV: human papillomavirus. I considered parents as having a *systemic barrier* to HPV vaccination if they did not intend to have their child vaccinated for one of the reasons listed in Table 2, Chapter 1 (Cheruvu et al., 2017). High income was above the median level for my sample ($40,000/year) and low income was less than or equal to the median. I obtained the weighted average of the results from 2016, 2017, and 2018. First, I divided the sample weight for each case by three to get an average weight. Then, I multiplied the value of the data points (variables) for each case by its respective average weight. Finally, I divided the sum of these products for each variable by the sum of the weights.

Table 34

Prevalence of a Systemic Barrier to HPV Vaccination in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	126	1.30	[1.270, 1.337]	43.0
2017	128	1.00	[0.980, 1.019]	33.3
2018	110	1.39	[1.360, 1.422]	38.2
Weighted avg. 2016-2018	364	1.22	[1.189, 1.245]	46.0

Note. HPV: human papillomavirus. Parents had a *systemic barrier* if they did not intend to vaccinate for one of the reasons listed in Table 2. I demarcated low and high income by the median level ($40,000/year). I based my calculation of the prevalence ratio on the estimated population sizes (*N*). Prevalence ratio = [*N* of low-income parents with a systemic barrier / (*N* of those with + *N* of those without)] / [*N* of high-income parents with a systemic barrier / (*N* of those with + *N* of those without)]. I calculated the weighted average by dividing the sample weight of each case by three, multiplying the data point (variable) values of each case by this mean, and dividing the sum of these products for each variable by the sum of the weights.

Research Question 8 and Hypotheses

RQ8: Is there an association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination?

*H_0*8: There is no association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination.

*H_a*8: There is an association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination.

Univariate Analysis

The size of the two categories of my independent variable (i.e., income) appeared similar. The data presented in Table 22 applies to this RQ (number 8) and RQs4-7. As described for RQ4, the difference in the percentage of low- and high-income families from the 2016, 2017, and 2018 studies and the weighted average was not substantial (see Table 22). Thus, I found an apparent well-balanced distribution of the number of low- and high-income parents in each period.

Bivariate Analyses

In some studies, the cross-tabulated data adjusted for the study population suggested an association between parents' income and sociocultural barriers to HPV vaccination. In Table 35, I further stratify the data on low- and high-income families into those with or without a perceived sociocultural barrier to HPV vaccination. In the 2016 study, the prevalence of a sociocultural barrier was significantly higher in low- than high-income families (see Table 35). Likewise, I found in the weighted average of the three studies a statistically significantly higher percentage of low-income parents than high-income parents who had a sociocultural barrier. The results of the 2017 study indicated that only two low-income and no high-income families had a sociocultural barrier. Therefore, there was insufficient information to compare using statistics the prevalence of a sociocultural barrier in low- compared to high-income families. The gap in the prevalence of a sociocultural barrier between low- and high-income parents was 17% in 2016 and 14% in the weighted average of the three studies. As these differences were relatively high, they favored the rejection of the null hypothesis that there was no association between Hispanic parents' total family income level and their sociocultural barriers to HPV vaccination. The finding in the 2018 study failed to reject this null hypothesis because there was no statistically significant difference in the percentage of low- and high-income parents reporting a sociocultural barrier.

Table 35

Income Level of Parents by Status of Sociocultural Barrier to HPV Vaccination (n = 364)

		Sociocultural barrier (*n* = 20)			No sociocultural barrier (*n* = 344)		
Year	Income level	*n*	Weighted percent of time period	CI	*n*	Weighted percent of time period	CI
2016	Low	4	58.3	[55.4, 61.2]	47	45.1	[41.7, 48.5]
	High	6	41.7	[39.4, 44.0]	69	54.9	[52.3, 57.4]
2017	Low	2	100.0	[100, 100]	52	44.4	[41.2, 47.5]
	High	0	0.0	[0, 0]	74	55.6	[53.4, 57.9]
2018	Low	3	46.5	[38.5, 54.6]	41	44.8	[41.6, 48.1]
	High	5	53.5	[47.0, 59.9]	61	55.2	[53.0, 57.4]
Avg. 2016-2018	Low	9	56.9	[50.8, 63.0]	140	44.8	[34.9, 54.7]
	High	11	43.1	[38.2, 47.9]	204	55.2	[48.1, 62.3]

Note: HPV: human papillomavirus. CI: confidence interval (%). Parents had a *sociocultural barrier* if they did not intend to vaccinate for a reason listed in Table 2. I divided low and high annual income by the median level. The confidence levels for sociocultural barrier: 2016 - 24.6%, 2017 - 50.0%, 2018 - 49.2%, and avg. - 33.6%. No sociocultural barrier: 2016 - 73.3%, 2017 - 75.3%, 2018 - 67.6%, and avg. - 94.1%. I used the data in the 2 x 2 tables for the chi-square test and prevalence ratio. I calculated the weighted average by dividing the sample weight of each case by three, multiplying the data point (variable) values of each case by this mean weight, and dividing the sum of these products for each variable by the sum of the weights.

The result of the prevalence ratio estimate was generally similar to that for the chi-square test of the association between parents' income and their sociocultural barriers to HPV vaccination. In the 2018 study, the chi-square test of the association between parents' income level and their sociocultural barriers to HPV vaccination was not statistically significant (see Table 36). However, in the 2018 study, the prevalence ratio and confidence interval pointed to a weak association between income level and sociocultural barriers (see Table 37). This discrepancy might be due to the sensitivity of the chi-square test to a small sample size, especially to small cell counts of the 2 x2 contingency table used for chi-square calculations (McDonald, 2014). Overall, family income level appeared related to sociocultural barriers to HPV vaccination in the 2016 and 2018 studies and the weighted average of the study years.

Table 36

Relationship Between Income Level and Status of a Sociocultural Barrier to HPV Vaccination

Sampling year	*n*	Pearson chi-square statistic adjusted for complex survey	*p* value	Significance level	Power
2016	126	0.75	0.386	0.53	0.73
2018	110	0.01	0.917	0.55	0.72
Weighted avg. 2016-2018	364	1.42	0.234	0.34	0.83

Note. HPV: human papillomavirus. Parents had a *sociocultural barrier* if they did not intend to vaccinate for one of the reasons listed in Table 2. I demarcated low and high income by the median level ($40,000/year). I did not show data for 2017. This data did not meet a chi-square test assumption: An expected value of greater than five should be present in at least 80% of the cells of the contingency tables (Field, 2013). I calculated the weighted average by dividing the sample weight of each case by three, multiplying the data point (variable) values of each case by this mean, and dividing the sum of these products for each variable by the sum of the weights.

Table 37

Prevalence of a Sociocultural Barrier to HPV Vaccination in Low- Versus High-Income Families

Sampling year	*n*	Weighted prevalence ratio	Confidence interval	Confidence level (%)
2016	126	1.62	[1.561, 1.668]	42.6
2018	110	1.07	[1.023, 1.106]	32.7
Weighted avg. 2016-2018	364	1.57	[1.535, 1.613]	49.4

Note. HPV: human papillomavirus. Parents had a *sociocultural barrier* if they did not intend to vaccinate for one of the reasons listed in Table 2. I demarcated low and high income by the median ($40,000/year). I based my calculation of the prevalence ratio on the estimated population sizes (*N*). Prevalence ratio = [*N* of low-income parents with a sociocultural barrier / (*N* of those with + *N* of those without)] / ([*N* of high-income parents with a barrier / (*N* of those with + *N* of those without)]. I could not calculate the prevalence ratio for 2017 because no high-income families reported a sociocultural barrier. I calculated the weighted average by dividing the sample weight of each case by three, multiplying the data point values of each case by this mean, and dividing the sum of these products for each variable by the sum of the weights.

Aggregate Results for Research Questions 4 to 8 on Prevalence of Vaccination Barriers in Low- Versus High-Income Families

Lower income families generally had a lower prevalence of vaccine safety and effectiveness concerns and vaccination misinformation. Among RQs4- 8, I observed similarities and differences in the influence of low family income compared to high income on parents' barriers to HPV vaccination. As stated above in the discussion for RQs4- 8, I based these conclusions on whether I rejected or failed to reject the null hypothesis of no association of Hispanic parents' total family income level with the barriers to vaccination. In the three study years, a lower prevalence of HPV vaccine safety and effectiveness concerns occurred in low- compared to high-income parents (see Table 38). In the 2016 and 2017 studies, a lower prevalence of HPV vaccination misinformation occurred in low- compared to high-income parents. In contrast, in the 2018 study, a higher prevalence of HPV vaccination misinformation occurred in low-income parents. Overall, the three study years indicated safety and effectiveness concerns and vaccination misinformation were usually more of an issue with high-income families.

Table 38

Prevalence of Barriers to HPV Vaccination in Low- Versus High-Income Families

Study year	Weighted prevalence ratio of outcomes of Research Questions (RQs) 4 to 8 [confidence interval]				
	Safety and effectiveness concerns (RQ4)	Vaccination misinformation (RQ5)	Lack of knowledge (RQ6)	Systemic barriers (RQ7)	Sociocultural barriers (RQ8)
2016	0.74	0.66	1.27	1.30	1.62
	[0.712, 0.76]	[0.653, 0.668]	[1.229, 1.305]	[1.274, 1.334]	[1.566, 1.663]
2017	0.51	0.82	1.39	1.00	No data
	[0.497, 0.520]	[0.808, 0.832]	[1.369, 1.416]	[0.980, 1.019]	
2018	0.71	1.26	0.86	1.39	1.07
	[0.695, 0.724]	[1.230, 1.289]	[0.850, 0.879]	[1.361, 1.422]	[1.022, 1.108]
Avg.	0.66	0.80	1.10	1.22	1.57
	[0.651, 0.675]	[0.790, 0.814]	[1.073, 1.121]	[1.189, 1.245]	[1.528, 1.621]

Note. N = estimated population size. Prevalence ratio = [*N* of low-income parents with a given barrier / (*N* of those with + *N* of those without)] / [*N* of high-income parents with a barrier / (*N* of those with + *N* of those without)]. Following are the confidence levels by barrier and year. RQ4: 2016 – 35.7%, 2017 - 48.2%, 2018 - 43.0%, and avg. - 56.5%. RQ5: 2016 - 35.7%, 2017 - 40.0%, 2018 - 36.7%, and avg. - 48.8%. RQ6: 2016 - 35.7%, 2017 - 46.1%, 2018 - 36.6%, and avg. - 36.2%. RQ7: 2016 – 43.0%, 2017 - 33.3%, 2018 - 38.2%, and avg. - 46.0%. RQ8: 2016 - 42.6%, 2018 - 32.7%, and avg. - 49.4%.

Lower income families tended to have a higher prevalence of lack of HPV vaccine knowledge and systemic barriers. In the 2016 and 2017 studies, I saw a higher prevalence of lack of HPV vaccine knowledge in low- than high-income parents (see Table 38). In the 2018 study, the prevalence of lack of HPV vaccine knowledge was lower in low-income parents. Thus, in the 2018 study, a reversal of the income level effect appeared for lack of HPV vaccine knowledge. In the 2016 and 2018 studies, I saw a higher prevalence of systemic barriers to HPV vaccination in low- than in high-income parents. In the 2017 study, there was no statistically significant difference in the effect, or at least relation, of low- and high-income levels on systemic barriers to HPV vaccination. The results provided evidence that the influence of income level on vaccination misinformation, lack of vaccine knowledge, and systemic barriers changed over time. In the three study years, the findings indicated that lack of HPV vaccine knowledge and systemic barriers are generally more of an issue with low-income families than their high-income complement.

Data on the relative prevalence of sociocultural barriers in low- compared to high-income families was less conclusive. In the 2016 and 2018 studies, I saw a statistically significantly higher prevalence of sociocultural barriers to HPV vaccination in low-income parents than in high-income parents. The effect of income level on sociocultural barriers in the 2018 study was not substantial. In the 2017 study, there was insufficient data to measure the relative prevalence of sociocultural barriers. Even so, the results of the 2017 study, shown in Table 35, indicated more low-income families had a sociocultural barrier (two) than high-income families (none). The data on the influence of income level on sociocultural barriers in each study year might be unreliable due to the small to nil prevalence of parents who reported sociocultural factors as an obstacle to HPV vaccination. Considering everything, I found evidence that low-income families had a higher prevalence of sociocultural barriers to HPV vaccination in each study year.

The results on the relative influence of low and high income on the prevalence of barriers to HPV vaccination in the individual study years agreed with that of the weighted average of the three studies. First, in the weighted average of the three studies, low-income families had a lower prevalence of safety and effectiveness concerns and vaccination misinformation. Second, in the weighted average of the studies, low-income families had a higher prevalence of lack of HPV vaccine knowledge, systemic barriers, and sociocultural barriers. The data from the weighted average of the studies provided further support for the similarities and differences observed in the influence of low family income compared to high income on parents' barriers to HPV vaccination.

Summary

I determined whether low or high family income was more likely to influence the parents of Hispanic teens to initiate or complete the HPV vaccine series. In addition, I examined the effect of income level on parents' intent to have their unvaccinated or undervaccinated child vaccinated against HPV. Furthermore, I tested whether income level was associated with HPV vaccination barriers of parents who decided not to have their unvaccinated or undervaccinated child receive the vaccine. I used weighted secondary data from 2016 to 2018 NIS-Teen studies for the analysis presented in this chapter. I weighted the samples to represent the number of Hispanic teens in the Bexar

County, Texas, study population. I explained the results of the data analysis to address the eight RQs.

For RQs1-3, I usually found evidence to reject the null hypothesis of no association between parents' income level and their intent to vaccinate their child against HPV, vaccination series initiation, and completion. In RQ1, statistical test results favored the rejection of the null hypothesis of no association between parents' income level and their intent to vaccinate their teens for each sampling year and the weighted average. Similarly, in RQs2 and 3, results of these tests supported, for each sampling year and the weighted average, rejection of the null hypothesis of no association between parents' income level and their child's HPV vaccination series initiation and completion, respectively.

In RQs4-6, I also generally found evidence to reject the null hypothesis of no association in each study year and the weighted average. For RQ4, most evidence of each study year supported the rejection of the null hypothesis of no association between parents' income level and their HPV vaccine safety and effectiveness concerns. For RQ5, evidence of the study years favored rejection of the null hypothesis of no association between parents' income level and their HPV vaccination misinformation. For RQ6, evidence existed during the study years to reject the null hypothesis of no association between parents' income level and their lack of HPV vaccine knowledge.

I found that the evaluation results of the research hypotheses for RQs7 and 8 varied more among study years than other RQs. For RQ7, evidence from 2016, 2018, and the weighted average of the three study years favored rejection of the null hypothesis of no association between parents’ income level and their reporting of systemic barriers to HPV vaccination. However, in 2017, I found no apparent effect of income level on parents' perception of the systemic obstacles to immunization. Therefore, for 2017, I failed to reject the null hypothesis of no association between parents’ income level and their systemic barriers to vaccination. For RQ8, some evidence from 2016, 2018, and the weighted average of the three study years supported the rejection of the null hypothesis of no association between parents’ income level and sociocultural barriers to HPV vaccination. In the 2017 study for RQ8, insufficient data was available to reject or fail to reject the null hypothesis of no association between parents’ income level and sociocultural barriers. The data for this study year was unreliable due to the small to nil prevalence of parents who reported sociocultural factors as an obstacle to HPV vaccination. In summary, the analysis of the research hypotheses for RQ7 was less consistent across the study years than that for the other RQs, and the results for RQ8 were possibly less reliable.

In Chapter 5, I interpret my findings of the effect of income (independent variable) on the outcomes (dependent variables) in the context of published research and other evidence. In Chapter 4, I presented the effect of income level on intent to vaccinate against HPV and ultimate vaccine use as the findings of RQs 1-3. In addition, the results of RQs4-8 on barriers to HPV vaccination pointed to ways income influenced vaccine use. In Chapter 5, I compare the effect of income level on the outcomes in my study population to that in similar populations of parents. In addition, I discuss the current study’s limitations and implications for positive social change. Furthermore, I describe my recommendations for future studies and present a conclusion to the chapter.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Inadequate HPV vaccination coverage of Hispanic youth in Bexar County, Texas, is a public health concern. HPV is responsible for health complications, including warts in various body parts and six types of cancer (Gillison et al., 2015; Han et al., 2017; Kaiser Family Foundation, 2021). These conditions lead to considerable suffering for afflicted individuals and their families (Han et al., 2017; Steinbrook, 2006; Van Dyne et al., 2018; Vogel, 2017). In Bexar County, there has been substantial health and economic burden of HPV-associated disease at the individual and community level (Texas Cancer Registry, 2021a, 2021b; U.S. Cancer Statistics Working Group, 2021; U.S. Census Bureau, n.d., 2021b). However, vaccines can prevent 92% of these cancers (Saraiya et al., 2015). The Healthy People Consortium set the Healthy People goal of 80%-85% HPV vaccine coverage for youth by age 13 to eliminate HPV transmission in the United States by 2030 (Healthy People.Gov, n.d.). HPV vaccine coverage in Bexar County was far below this goal during my study period (National Cancer Institute, n.d.-b, n.d.-c; Walker et al., 2017, 2018, 2019). For this reason, managers of HPV vaccination programs need more knowledge about factors that could influence whether Bexar County parents decide to have their children vaccinated against HPV.

This study aimed to investigate whether and how income level is associated with HPV vaccine use in the study population. The design of this quantitative, cross-sectional study involved two related parts. First, I measured the extent of association of family income level (low and high) with HPV vaccine use by Hispanic teens in Bexar County.

Specifically, I tested the association of income level (independent variable) with parental intent to have their child receive the vaccine and initiation and completion of the series. Second, I examined potential reasons for the associations. That is, I evaluated the association of income level with five distinct domains of reasons reported by parents for not protecting their unvaccinated or undervaccinated child. I grounded this study in the SEM of health and prevention, and each of the five domains of HPV vaccination barriers corresponds to a level of this model. I based this study on publicly available NIS-Teen data from 2016, 2017, and 2018 (CDC, n.d.-a). As I used sample weights to estimate population statistics from the complex survey data, the results should have been representative of the target population (Lehtonen & Pahkinen, 2004). The information I gained from this study might be helpful to vaccine providers, policymakers, and other stakeholders in developing multilevel interventions to reduce the impact of HPV-related disease in Bexar County

The findings revealed an association between the independent variable, income level, and the dependent variable of each of the eight RQs. First, the results of RQ1, for each survey year and the weighted average, favored rejection of the null hypothesis of no association between parents' income level and their intent to vaccinate their teens. Second, the findings of RQ2 and RQ3, for each sampling year and the weighted average, supported the rejection of the null hypothesis of no association between parents' income level and their child's HPV vaccination series initiation and completion, respectively. Third, the outcomes of RQ4-6, for each sampling year and the weighted average, favored rejection of the null hypothesis of no association between parents' income level and their

HPV vaccine safety and effectiveness concerns, vaccination misinformation, and lack of HPV vaccine knowledge, respectively. Fourth, the outcomes of RQ7 and RQ8, for some sampling years and the weighted average, supported the rejection of the null hypothesis of no association between parents' income level and their reporting of systemic barriers to HPV vaccination and sociocultural barriers, respectively. In short, I generally found an association of family income level with parental HPV vaccination intent, vaccination initiation, and completion, and each of the five domains of reasons for lack of intent to use the vaccine.

I further interpret the results in Chapter 5. I discuss findings gleaned from comparison with other studies. Specifically, I compare the prevalence ratio of my various dependent (outcome) variables in low- versus high-income families with that of other studies. Based on the results, I consider the implications of this study and offer recommendations for medical practice and public health interventions. I present the interpretations and implications of my findings in relation to the multilevel framework of the SEM of health. I conceived the research recommendations by examining indications of the effects of interventions in my study population, such as the Mission: HPV Cancer Free program (American Cancer Society, 2018). Finally, I discuss the limitations of the current research and provide a conclusion to the study.

Interpretation of the Findings

Research Question 1

To recap, the prevalence in low- compared to high-income families of parents' intent for their child to get the HPV vaccine appeared to be statistically different and to change across the study years. As mentioned, the prevalence ratio of parental intent in low- compared to high-income families in 2016, 2017, and 2018 was 1.49, 1.28, and 1.25, respectively (see Tables 11 and 20). My results indicated that the prevalence of intent to vaccinate was statistically and substantially more significant in low- than high-income families. In addition, the prevalence ratio of parental intent was statistically significantly different across the study years. These findings suggested that parental intent to vaccinate became less prevalent in low- compared to high-income families.

The finding of a higher prevalence of parental intent to vaccinate in low- compared to high-income families agrees with the results of other studies that total family income level is associated with parental intent to vaccinate. Mansfield et al. (2018) analyzed retrospective, cross-sectional data from the Health Information National Trends Survey from 2006-2007. These authors found that parents with annual earnings of $50,000-$74,999 and $75,000-$99,999 were less likely to report being sure about having their child initiate the HPV vaccine series than those earning less than $19,999. I classified parental intent to vaccinate more broadly than Mansfield et al. I considered parents to have the *intent* to vaccinate their teen if they stated that it was *very likely* or *somewhat likely* they would have their child receive the HPV vaccine. Cheruvu et al. (2017) used binary logistic regression to analyze data from the 2008 to 2012 NIS-Teen surveys. The authors found a lower prevalence of parental lack of intent to vaccinate against HPV in families with an annual income of less than $35,000 than those with an income of $35,001-$75,000. The finding of a higher prevalence of parental intent to vaccinate in low- compared to high-income families in the current study and that of

Cheruvu et al. (2017) and Mansfield et al. (2018) further supports the credibility of my findings.

Findings from another study are consistent with my discovery that parents' total family income level was associated with their intent to vaccinate. Calderón-Mora et al. (2020) conducted a cross-sectional study of HPV vaccination between 2014 and 2017 using survey data collected from uninsured women aged 21 to 65 who were due for cervical cancer screening. Most of the study population, who lived in the Mexico-United States border counties of El Paso and Hudspeth in Texas, were Hispanics (98%), unemployed (61%), uninsured (33%), and low income with an annual income of less than $30,000 (76%). Thus, most of these study participants (i.e., well over three fourths) had a yearly income matching the low-income category of my study (i.e., ≤$40,000/year). The authors reported that over three fourths of parents who had a son or daughter under the age of 26 intended to receive the HPV vaccine. In the current study involving Bexar County, Texas, the weighted average from 2016 to 2018 of the prevalence ratio of low- compared to high-income parents with an intent to vaccinate was 1.32 (see Tables 11 and 20). Calderón-Mora et al. found a lack of statistical association of family income level with parental intention to have their child vaccinated against HPV. However, I would have classified most of their study participants as having in my study a low income. Therefore, Calderón-Mora et al.'s results support my findings of a high prevalence of low- compared to high-income parents intending to vaccinate.

The higher prevalence of parental intent to vaccinate their child in the low- compared to high-income families of my study might have been due, at least partially, to more education and training of low- than high-income parents and providers. From 2017 to 2018, there was substantial funding in Bexar County to increase HPV vaccination of children from low-income families by educating and training healthcare providers (Garza, 2017; Munoz, 2017). In addition, in low-income communities, public health practitioners used this funding to increase HPV vaccination by reaching out to families and countering both political controversy and stigma associated with the vaccine (Garza, 2017; Munoz, 2017). Some parents might be reluctant to use a vaccine due to the stigma associated with its use to prevent sexually transmittable diseases. Education and promotion of HPV vaccination predominantly in low-income groups of Bexar County, Texas, probably contributed to more low- than high-income families deciding to have their children receive the vaccine. Without this focus on increasing HPV vaccination in low-income families, it is possible parental intent to vaccinate would have been similar in low- and high-income families or even higher in high-income families.

The decreasing prevalence of parental intent to vaccinate in low- compared to high-income families suggests that public health authorities should try to reverse this trend and improve HPV vaccination in the low-income group. The local decrease in the prevalence of parental intent to vaccinate in low- compared to high-income families might have been due to, at least partially, a nationwide decline in low-income Hispanics' knowledge of HPV and the vaccine (Chido-Amajuoyi et al., 2021). In addition, before and during my study period, a faster increase in media use at the national level occurred in low- versus high-income Hispanics (Brown et al., 2016). Higher exposure of low-income families to misinformation about HPV vaccination through the media might have contributed to the local decline in the prevalence of parents' intent to vaccinate in the low- versus high-income group. Concurrently, a program in Bexar County focused on increasing HPV vaccination of Hispanic children from low-income families by educating parents and training healthcare providers (Garza, 2017; Munoz, 2017). These efforts might have mitigated the adverse impact of the nationwide declining knowledge and increasing media use of low-income Hispanics. Increased prevalence of parental intent to vaccinate their child against HPV might lead to improved vaccination coverage for teens (Rodriguez et al., 2020). Hanson et al. (2018) showed that parents' intent to have their children vaccinated against HPV remained low from 2012 to 2018. The results of my study and the other studies suggest that current and additional interventions in Bexar County might lead to more teens of low-income families receiving the HPV vaccine.

Research Question 2

The finding of a higher prevalence of initiation of teens' HPV vaccination in low- compared to high-income families is consistent with another set of studies. Compared to high-income families in my investigation, low-income families were generally more likely to have their children initiate HPV vaccination (see Tables 15 and 20). In both 2017 and 2018, Walker et al. (2018, 2019) found that the coverage of one or more doses of HPV vaccine was about ten percentage points higher among youth in households with an income lower than or equal to the federal poverty threshold compared to those with a higher income. Among the various adolescent vaccines, this finding was unique to the HPV vaccine. Walker et al.'s results, which indicated a higher prevalence of HPV vaccination initiation in low- compared to high-income families, support the credibility of my finding.

Researchers base some of their explanations for findings of a higher prevalence of HPV vaccination in low- compared to high-income families on the fact that HPV can cause cancer and other diseases. Bednarczyk et al. (2014) noted that, among the adolescent vaccines, the higher HPV vaccine initiation in low- compared to high-income families was unique to the HPV vaccine. The HPV vaccine is the only teenage vaccine used to prevent cancer and other sexually related diseases (Franco et al., 2019). Some of the reasons for the higher HPV vaccine initiation in low- compared to high-income families are related to the fact the HPV vaccine is the only vaccine given to teens to prevent cancer (Bednarczyk et al., 2014). First, Bednarczyk et al. (2014) noted that mothers with personal experience with HPV-related diseases were generally more willing to have their daughters get the vaccine. In Hispanics living in Bexar County, there is a high burden of morbidity and mortality related to HPV infection, despite the availability of a safe and effective vaccine (Texas Cancer Registry, 2021a; U.S. Cancer Statistics Working Group, 2021; U.S. Census Bureau, 2021b; Han et al., 2017). Second, parents living above poverty might have a lower perceived need to vaccinate their children against HPV due to greater access to cervical cancer screening (Kronenfeld et al., 2021). Thus, two factors related to the parental perception of the need for the vaccine might account for, at least partially, the more prevalent HPV vaccination initiation in low- than high-income families.

Increased parental awareness of HPV might be another reason for a higher prevalence of HPV vaccination in low- compared to high-income families. Bednarczyk et al. (2014) pointed out that greater parental awareness of HPV-related diseases might motivate parents in specific communities to have their children get the vaccine despite increasingly prevalent barriers to vaccination, such as vaccine safety concerns. Some populations of low-income parents might be more aware of HPV and the vaccine due to ongoing programs involving education, promotion, and outreach to improve vaccination in their community (American Cancer Society, 2020b). For example, during my study period, public health authorities implemented the Mission: HPV Cancer Free program in Bexar County (Munoz, 2017). Hence, parents' level of awareness of HPV and the vaccine is an alternative reason to explain the higher prevalence of vaccination in low- compared to high-income families

Parents' insurance type could also influence the prevalence of HPV vaccination in low- compared to high-income households. Researchers found children of parents who were Medicaid eligible, compared to those with private insurance, to have higher HPV vaccination coverage (Ng et al., 2015). One explanation for this difference is that public health insurance supported the HPV vaccination of youth more robustly than private insurance (Ng et al., 2017). Moreover, health provider recommendations to have a child receive the HPV vaccine might have differed between private and public insurance plans (Warner et al., 2017). In my study, most families in the low-income groups were Medicaid eligible. On the other hand, families in my high-income category with private insurance could have generally gotten the HPV vaccine with no-cost sharing (Warner et al., 2017). Thus, reasons, besides those related to the parental perception of the need for the HPV vaccine, could explain the higher vaccination prevalence in low- compared to high-income families. These alternative reasons are parents' insurance type and their level of awareness of HPV and the vaccine.

A program in Bexar County, Texas, ongoing during my study period to improve HPV vaccination of youth, might have contributed to the trend of increasing HPV vaccination initiation. As mentioned, the current study's findings indicated that the prevalence of HPV vaccination initiation in low- compared to high-income families increased from year to year (see Tables 15 and 20). The education, promotion, and outreach strategies of the Mission: HPV Cancer Free program related to HPV vaccination focused on low-income families (American Cancer Society, 2020b). These efforts might have contributed to the increasingly higher prevalence of HPV vaccination initiation in low- than high-income families of Bexar County from 2016 to 2018. Parents might have become aware of HPV and the vaccine through positive public education and promotion messages as well as provider endorsement of the vaccine. The positive influence on vaccination initiation of increased parental awareness of HPV and the vaccine through evidence-based communication might have been stronger than negative influences such as parental vaccine safety concerns. A net effect in my study population of influences on HPV vaccination initiation (positive and negative) might have been positive enough to produce the trend of increasing initiation from 2016 to 2018.

An initial trust in positive messages about vaccination might help explain the increase in HPV vaccination initiation in the absence of a similar trend in parental intent to vaccinate their child. My results suggested both parental intent to vaccinate (RQ1) and vaccination completion (RQ3) became less prevalent in low- compared to high-income families across the study years (see Table 20). Some evidence suggest the reasons parents decide to have their child complete (or not complete) the HPV vaccine series are different from the reasons for having their child initiate the series (Downs et al., 2008; Sonawane et al., 2020; Toth, 2020). As mentioned, low-income parents might have initially decided to have their child vaccinated against HPV based on their trust in the positive messages they heard through the Mission: HPV Cancer Free program (American Cancer Society, 2020b). Later, after listening to and reading negative messages about HPV vaccination through media and social networks (Margolis et al., 2019), the same parents might have become hesitant to have their child complete the series (Ortiz et al., 2019). In sum, parents' initial unquestioning faith in medical and public health messages about HPV and the vaccine might result in an increasing trend of HPV vaccination initiation. Later, if the same parents receive negative messages about HPV vaccination, they might become hesitant to have their child finish the series.

The findings of this study might inform the development of strategies to further increase HPV vaccination initiation in the study population. As mentioned, the Mission: HPV Cancer Free program focused during my study period on improving HPV vaccination in low-income families (American Cancer Society, 2020b; Garza, 2017; Munoz, 2017). Without this focus on improving HPV vaccination in the low-income group, the prevalence of initiation, presented in Tables 15 and 20, might have been similar in the low- and high-income groups or even higher in the high-income group. My results suggest that continuing the Mission: HPV Cancer Free program in low-income families could further increase HPV vaccination initiation.

Research Question 3

The findings of other studies are consistent with my discovery that parents' total family income level was associated with the teens' HPV vaccination series completion. Franco et al. (2019) found teens were more likely to complete the HPV vaccine series than their counterparts if their families lived below the federal poverty line. In addition, analysis of nationally representative data from the 2017 and 2018 NIS-Teen survey of all races and ethnic groups combined showed an inverse association between income level and HPV vaccine series completion (Walker et al., 2018, 2019). In the 2017 NIS-Teen survey analysis, children from families living at or above the federal poverty level compared to those below had an HPV vaccination-completion rate of 46.7% and 53.7%, respectively (Walker et al., 2018). Similarly, in 2018, youth from higher compared to lower income families had an HPV vaccination-completion rate of 49.6% and 57.1%, respectively (Walker et al., 2019). These results, indicating a higher prevalence of HPV vaccination completion in low- compared to high-income families, support the credibility of my findings.

The higher prevalence of HPV vaccine series completion in the low- compared to high-income families might have been due to more education and training of low- than high-income parents and providers. During my study period from 2016 to 2018, philanthropic organizations provided substantial funding to Bexar County to increase the vaccination of children from low-income families by educating and training HPV vaccine providers in these families (American Cancer Society, 2020b; Garza, 2017; Munoz, 2017). Vaccination advocates also used this funding to promote the use of the HPV vaccine in low-income families. Education and promotion of the HPV vaccine predominantly in low-income groups of Bexar County, Texas, likely contributed to more teens from low- than high-income families completing the series. Without this focus on increasing HPV vaccination in the low-income groups, completion might have been similar in the low- and high-income groups or even higher in the high-income group.

Efforts to improve parental intent to vaccinate their child against HPV might help improve vaccination completion. As mentioned, I found a decreasing prevalence of parental intent to vaccinate in low- compared to high-income families across study years (see Tables 11 and 20). HPV vaccination advocates might improve HPV vaccination completion in the low-income group by addressing this trend. Hanson et al. (2018) showed that parents' intent to vaccinate their children against HPV remained low from 2012 to 2018, and their concerns persisted even if their children had started the vaccine series. In addition, Kornides et al. (2018) showed that vaccine providers should do follow-up counseling to ensure the child completes the series. My findings in the context of these studies suggest additional interventions in Bexar County might help get more teens from low-income families to finish the HPV vaccination series.

Parents who initiated the HPV vaccination of their child might have later become hesitant to have their child finish the series. My results suggested both parental intent to vaccinate (RQ1) and vaccination completion (RQ3) became less prevalent in low- compared to high-income families across the study years (see Table 20). Researchers have noted that the reasons parents decide to have their child complete (or not complete) the HPV vaccine series might differ from those for their child initiating the series (Downs, 2008; Sonawane et al., 2020; Toth, 2020). Initially, low-income parents in Bexar County might have decided to use the HPV vaccine based on their trust in the positive messages they heard through the Mission: HPV Cancer Free program (American Cancer Society, 2020b). Later, after listening to and reading negative messages about HPV vaccination through media and personal social networks (Margolis et al., 2019), the same parents might have become hesitant to have their child complete the series (Ortiz et al., 2019). Sonawane et al. (2020) pointed out that knowledge of the differences in why parents decide to initiate and complete (or not initiate and complete) the HPV vaccine series could be informative. Vaccine advocates might use this information to better intervene at both steps in the vaccination process to increase vaccine coverage for teens.

Research Question 4

The lower use of various media types among low-income Hispanics might have contributed to, at least partially, the lower prevalence of parental HPV vaccine safety and effectiveness concerns in low- compared to high-income families of Bexar County. As mentioned, in 2016, 2017, and 2018 survey years and the weighted average, the prevalence ratio of parental HPV safety and effectiveness concerns in low- compared to high-income families was 0.74, 0.51, 0.71, and 0.66, respectively (see Tables 25 and 38). At a national level, higher income Hispanics used media sites more during this period than lower income groups (Brown et al., 2016). These forms of communication often expose parents to false information about the HPV vaccine (Zimet & Osazuwa-Peters, 2019). For example, parents might be misinformed that the HPV vaccine can cause harmful side effects and be ineffective in preventing HPV infection. Researchers have shown parental exposure to inaccurate information about the HPV vaccine via these sources to occur more often than exposure to accurate information (Ortiz et al., 2019). For these reasons, a lower prevalence of use of different types of media by low- compared to high-income parents might explain the lower prevalence of HPV vaccine safety and effectiveness concerns in the low-income group in my study.

Additional evidence supports an association of knowledge of HPV and the vaccine with safety and effectiveness concerns. Cheruvu et al. (2017) showed, compared to the reports of parents in the 2008 NIS-Teen survey (baseline), those participating in the 2009 to 2012 surveys were more likely to report both no-intent to vaccinate their child against HPV and vaccine safety concerns. In addition, these authors interpreted their findings to mean as parents' knowledge of HPV and the vaccine increased, so did their safety and effectiveness concerns. After parents acquire a basic knowledge of HPV and the vaccine, they might pay closer attention to information about the vaccine publicized by the media. The media would likely expose parents to false information concerning the vaccine being unsafe (Margolis et al., 2019). Negative versus positive information about the vaccine in the media is more likely to influence parents' views of the HPV vaccine (Volkman et al., 2021). As mentioned, Brown et al. (2016) reported a more rapid increase in media use nationwide in low- compared to high-income families. This national trend might help explain the rise in my study from 2017 to 2018 in the prevalence ratio of parental knowledge of HPV and the vaccine in low- compared to high-income families, as detailed later for RQ6. In turn, the increased parental knowledge of HPV and the vaccine might have led to increased HPV vaccine safety and effectiveness concerns.

A local HPV vaccination campaign in Bexar County, Texas, might help explain the decrease from 2016 to 2017 in the prevalence of parental safety and effectiveness concerns in low- compared to high-income families. Public health authorities implemented the Mission: HPV Cancer Free program, which focused on improving HPV vaccination in low-income families in Bexar County in 2017 and 2018 (American Cancer Society, 2020b). Compared to my 2016 study, the prevalence of parental HPV vaccine safety and effectiveness concerns in my 2017 study appeared to be lower in low- than high-income families (see Tables 25 and 38). This apparent reduction in the prevalence of HPV vaccine safety and effectiveness concerns in low- compared to high-income families of Bexar County could have been due, at least partially, to the success of the Mission: HPV Cancer Free program. One of the five key strategies of the Mission: HPV Cancer Free campaign has been to strengthen provider recommendations for the vaccine. Cheruvu et al. (2017) stressed that strong provider recommendation of the HPV vaccine for teens is a crucial measure to mitigate parental vaccine safety and side effect concerns. Therefore, the reduction in the prevalence of HPV vaccine safety and effectiveness concerns in low- compared to high-income families of Bexar County might have been a direct result of stronger provider recommendations.

HPV vaccination advocates might use an assessment of the prevalence of the domain of safety and effectiveness concerns in low- compared to high-income parents of my study to inform vaccination practices. First, the higher prevalence of HPV vaccine safety and effectiveness concerns in high- compared to low-income families (see Tables 25 and 38) might have implications for intervening to mitigate these concerns. Ultimately, the less favorable attitudes of the high-income families toward vaccination might have resulted in lower HPV vaccination coverage. Therefore, it might be prudent to prioritize clinical and public health efforts to counter false information about the safety and effectiveness of the HPV vaccine in the high-income group. Second, as mentioned, the increase in the use of media at a faster rate in low- than high-income Hispanic families (Brown et al., 2016) might have contributed to the increased prevalence ratio of safety and effectiveness concerns in low- compared to high-income parents from 2017 to 2018 in Bexar County. Based on this potential trend for Hispanics in Bexar County, public health authorities might project a need to increase efforts to mitigate HPV vaccine safety and effectiveness concerns of low-income parents. Comprehensive knowledge of the prevalence of safety and effectiveness concerns in low- compared to high-income parents might help vaccine advocates improve vaccination practices.

Researchers should continue to study parental HPV vaccination safety and side effect concerns in Bexar County. The Healthy People 2030 goal of HPV vaccine series completion by age 13 is 80%-85% by 2030 (Healthy People.Gov, n.d.). Similarly, the goal of the Mission: HPV Cancer Free campaign of the American Cancer Society is 80% series completion by 2026 (American Cancer Society, 2020b). The HPV vaccination coverage of Hispanic youth in Bexar County from 2016 to 2018 was far short of the level needed to reach either of these goals by the projected dates (Texas Department of State Health Services, 2021). As mentioned, efforts to improve HPV vaccination coverage in

Bexar County might have had a positive effect (American Cancer Society, 2020b). Apparently, public health authorities in Bexar County did not evaluate, or at least not report, the impact of the Mission: HPV Cancer Free initiative (Metro Health Strategic Plan Steering Committee, 2018). However, Metro Health of Bexar County plans to evaluate and report the impact of this and other health promotion programs in the future (Metro Health Strategic Plan Steering Committee, 2018). Similarly, researchers should assess the effects of strategies developed to increase HPV vaccine use based on the participants in the current study with HPV vaccine safety and effectiveness concerns.

Research Question 5

Lower use of the internet and social media among low-income Hispanics might explain, at least partially, the lower prevalence of misinformation in low- compared to high-income families in this study. In the 2016 and 2017 studies, the prevalence of HPV vaccination misinformation was less in low- than high-income groups (see Tables 28 and 38). As mentioned, in 2016 and 2017, the prevalence ratio of misinformation in low- compared to high-income families was 0.66 and 0.82, respectively. At a national level, during this period, lower income Hispanics used the internet and social media sites less than higher income groups (Brown et al., 2016). These forms of communication can expose parents to misinformation about HPV and the vaccine (Zimet & Osazuwa-Peters, 2019). Parental exposure to inaccurate information about HPV and the vaccine via these sources probably occurs more than exposure to accurate information (Ortiz et al., 2019). For these reasons, a lower prevalence of use of the internet and social media by low-income parents might explain the lower prevalence of misinformation in the low-income group in my study.

The more rapid increase in the internet and social media use among low-income people might have contributed to the increase across study years of the prevalence of misinformation in low- compared to high-income groups. The prevalence of vaccination misinformation in the low- compared to high-income group progressively increased across my study years (see Tables 28 and 38). The prevalence ratios in 2016, 2017, and 2018 were 0.66, 0.82, and 1.26, respectively. In the United States, between 2009 and 2016, the increased use of the internet and social media sites was greater among lower than higher income Hispanic families (Brown et al., 2016). Some evidence suggests the exposure of parents to social media influences their level of HPV vaccination-related knowledge, attitudes, and actions (Downs et al., 2008; Dunn et al., 2017; Ortiz et al., 2019). The increased use of these forms of communication at a faster rate in low- than high-income Hispanic families might have contributed to the increased prevalence ratio of misinformation throughout my study in Bexar County.

Mitigation of HPV vaccine misinformation might help improve vaccination coverage for youth. An increase in parental vaccination misinformation might drive, at least partially, an increase in parents' lack of intent (no-intent) to use the HPV vaccine. In turn, parental lack of intent to vaccinate their child against HPV would likely lead to decreased vaccination. In support of this argument, Rodriguez et al. (2020) noted parental intent to vaccinate their child could be a potential driver of ultimate vaccine use. These results suggest that increased parental vaccination misinformation might impede vaccine uptake. Ultimately, public health interventions to mitigate HPV vaccination misinformation and other barriers to parental intent could promote vaccine coverage.

Researchers should continue to study HPV vaccination misinformation in Bexar County. The Healthy People 2030 goal of HPV vaccine series completion by age 13 is 80%-85% by 2030 (Healthy People.Gov, n.d.). The HPV vaccination coverage of Hispanic youth in Bexar County from 2016 to 2018 was far short of this desired level (Texas Department of State Health Services, 2021). As I argued in the previous paragraph, an increase in parental HPV vaccination misinformation might drive, at least partially, an increase in parents' lack of intent (no-intent) to vaccinate their children. Thus, it might be feasible to increase parental intent to vaccinate their child against HPV by mitigating misinformation. In 2017 and 2018, HPV vaccination advocates in Bexar County implemented the Mission: HPV Cancer Free program, which focused on improving vaccination in low-income families (American Cancer Society, 2020b). One of the five key strategies of the Mission: HPV Cancer Free campaign has been to strengthen provider recommendations for the vaccine. Cheruvu et al. (2017) stressed that strong provider recommendation of the HPV vaccine for teens is crucial to mitigate parental misinformation about vaccine safety and side effects. For these reasons, researchers should continue to monitor and address parental HPV vaccination misinformation in Bexar County.

Research Question 6

The results of a study might help explain why the prevalence of parental lack of knowledge of HPV and the vaccine was generally higher in low- compared to high-income families in Bexar County. Chido-Amajuoyi et al. (2021) used survey data from 2008 and 2018 to examine parental awareness of HPV and the vaccine. They conducted a stratified analysis of the lack of knowledge by relevant demographic and socioeconomic characteristics of parents, including family income level. Awareness of HPV and the vaccine overall and by various strata increased up to 2013 but gradually declined between 2013 and 2018. The decline in knowledge of HPV and the vaccine was greatest (almost 10%) among Hispanics, less educated parents, and lower income families (i.e., annual income of <$35,000/year). The Hispanic community of interest in my study has a relatively low employment rate and median income (Schlenker & Huber, 2015). The nationwide trend of declining parental awareness of HPV and the vaccine in Hispanics with low socioeconomic status (Chido-Amajuoyi et al., 2021) might explain, at least partially, the higher prevalence of lack of parents' knowledge of HPV and the vaccine in low- versus high-income families in Bexar County.

The higher prevalence of parental lack of knowledge in low- compared to high-income families could have implications for vaccination practice. Mansfield et al. (2018) found a positive association between parental knowledge of HPV and the vaccine with their intent to vaccinate their daughters against HPV (adjusted relative risk ratio = 3.96, $p = .004$). They used a retrospective, cross-sectional data from the Health Information National Trends Survey from 2006-2007. These results imply a decrease in parents' knowledge about HPV and the vaccine could drive a reduction in their intent to use the vaccine. As mentioned, there was a nationwide trend of declining parental awareness of HPV and the vaccine in Hispanics with low socioeconomic status (Chido-Amajuoyi et al., 2021). This decline in parental knowledge of HPV and the vaccine might lead to a reduction in parental intent to use the vaccine and, in turn, impede vaccine uptake. Ultimately, public health interventions to increase parental knowledge of HPV and the vaccine in Bexar County could promote vaccine coverage.

Researchers should continue to study parental lack of knowledge of HPV and the vaccine in Bexar County. The prevalence of parental lack of knowledge of HPV and the vaccine in the current study appeared to be generally higher in low- compared to high-income families (see Tables 31 and 38). The higher prevalence of lack of knowledge of HPV and the vaccine in low- compared to high-income families of Bexar County could have been due to, at least partially, the declining parental awareness of HPV and the vaccine in Hispanics with low socioeconomic status (Chido-Amajuoyi et al., 2021). The Mission: HPV Cancer Free program, which focused on improving HPV vaccination in low-income families, was implemented in Bexar County in 2017 and 2018 (American Cancer Society, 2020b; Garza, 2017; Munoz, 2017). Cheruvu et al. (2017) pointed out that a strong provider recommendation of the HPV vaccine for teens was a pivotal action in improving parents' knowledge of the benefits of the HPV vaccine. Accordingly, one of the five key strategies of the Mission: HPV Cancer Free campaign has been to strengthen provider recommendations for the vaccine (American Cancer Society, 2020b). Direct education of parents about HPV and the vaccine was another of the five key strategies of this campaign to increase vaccine coverage. Ongoing research on how parental lack of knowledge of HPV and the vaccine influences intent to vaccinate in Bexar County could help optimize the Mission: HPV Cancer Free program and other efforts to improve HPV vaccination.

Research Question 7

A study's results could help explain why the prevalence of parental systemic barriers in this study was higher in low- compared to high-income families. In the 2016 and 2018 study years, I found a higher prevalence of systemic barriers in low- versus high-income families (see Tables 34 and 38). Chido-Amajuoyi et al. (2021) showed that parental awareness of HPV and the vaccine overall and by various strata declined between 2013 and 2018. The decline in knowledge of HPV and the vaccine was greatest (nearly 10%) among Hispanics, less educated parents, and lower income families (i.e., annual income of <$35,000/year). The Hispanic community of interest in my study has a relatively low employment rate and median income (Schlenker & Huber, 2015). Conceivably, parents who lack awareness of HPV and the vaccine might be more likely to report that a provider recommendation would positively influence their decision to vaccinate their child against HPV. In my study, the domain of systemic barriers includes a lack of provider recommendations. It follows that the nationwide decline of parental awareness of HPV and the vaccine in low-income Hispanics (Chido-Amajuoyi et al., 2021) might have contributed to the higher prevalence of systemic barriers in low- versus high-income families in Bexar County.

Public health authorities have an opportunity to mitigate systemic barriers that could impede HPV vaccine uptake in Hispanics. As mentioned, Chido-Amajuoyi et al. (2021) reported a declining parental awareness of HPV and the vaccine in Hispanics nationwide. This decline was more prominent in Hispanics with a low socioeconomic status. A firm provider recommendation for parents to have their child vaccinated against HPV is a crucial measure to reduce missed clinical opportunities, a type of systemic barrier, through effective communication of the health benefits of the vaccine (Cheruvu et al., 2017). Glenn et al. (2015) conducted a study to understand HPV vaccination among Hispanic adolescent girls in three U.S. regions. The authors found that most Hispanic parents preferred to have their doctor involved in deciding whether or not to vaccinate the child against HPV. Ultimately, public health practitioners might promote vaccine coverage for Hispanics by addressing systemic barriers.

The higher prevalence of systemic barriers in low- compared to high-income Hispanic parents of Bexar County could have implications for vaccination practice. One of the five key strategies of the Mission: HPV Cancer Free campaign is to increase the strength of provider recommendations for parents to have their child receive the HPV vaccine (American Cancer Society, 2020b). Public health authorities implemented this program in Bexar County in 2017 and 2018 (American Cancer Society, 2018). Again, in the current study, the domain of systemic barriers includes a lack of provider recommendations. Thus, the efforts of the Mission: HPV Cancer Free campaign to improve provider recommendation (and, in turn, parental knowledge) could contribute to a reduction of the prevalence of parents' systemic barriers in low- compared to high-income families.

Researchers need to conduct further research on parental systemic barriers in Bexar County. My study's prevalence of parental systemic obstacles to HPV vaccination appeared to be higher in low- compared to high-income families (see Tables 34 and 38). The primary aim of the Mission: HPV Cancer Free campaign is to improve HPV vaccination coverage for youth in low-income families (American Cancer Society, 2020b). Public health and medical practitioners carried out this program in Bexar County between 2017 and 2018 (Garza, 2017; Munoz, 2017). Cheruvu et al. (2017) and Miller et al. (2018) stated that a strong provider endorsement of the HPV vaccine for youth is vital to motivate parents to have their children receive the vaccine. A crucial strategy of the Mission: HPV Cancer Free campaign has been to improve the quality of provider recommendations for the vaccine (American Cancer Society, 2020b). In the current study, the domain of systemic barriers includes a lack of provider recommendations. Therefore, implementing the Mission: HPV Cancer Free program in Bexar County could have partially mitigated the higher prevalence of systemic barriers in low- compared to high-income families. Ongoing research in Bexar County on how parental systemic barriers influence their intent to use the HPV vaccine could help optimize vaccination promotion.

Research Question 8

A study's results could help explain why the prevalence of parental sociocultural barriers in this study was higher in low- compared to high-income families. For 2016 and 2018, the prevalence of parents' sociocultural barriers was statistically higher in low- compared to high-income families, with prevalence ratios of 1.62 and 1.07, respectively (see Tables 37 and 38). As I stated in my discussion for RQ6, the higher prevalence of lack of knowledge of HPV and the vaccine in low- compared to high-income families of

Bexar County could have been due to, at least partially, the nationwide decline of parental awareness of HPV and the vaccine in Hispanics with low socioeconomic status (Chido-Amajuoyi et al., 2021). The Hispanic community of interest in my study has a relatively low employment rate and median income (Schlenker & Huber, 2015). As low-income parents in my study were more likely to lack awareness of HPV and the vaccine, they might also be more likely to maintain sociocultural barriers to vaccination. Thus, the higher prevalence of the sociocultural barriers in low- versus high-income families might be partially due to the nationwide decline of parental awareness of HPV and the vaccine in low-income Hispanics.

A program to increase HPV vaccination in Bexar County might contribute to a decrease in the prevalence of parents' sociocultural barriers in low- compared to high-income families. As mentioned, my study's prevalence of parents' sociocultural barriers was substantially higher in low- compared to high-income families (see Tables 37 and 38). The Mission: HPV Cancer Free program, which focused on improving HPV vaccination in low-income families, was implemented in Bexar County in 2017 and 2018 (Garza, 2017; Munoz, 2017). One of the five key strategies of the Mission: HPV Cancer Free campaign has been to increase parental knowledge of HPV and the vaccine. Increased knowledge of HPV and the vaccine due to this program might contribute to a decrease in sociocultural barriers.

Efforts to improve provider recommendation of the HPV vaccine might also contribute to reducing the prevalence of Hispanic parents' sociocultural barriers in low- compared to high-income families. Another strategy of the Mission: HPV Cancer Free campaign has been to increase the strength of provider recommendations for parents to have their child receive the HPV vaccine (American Cancer Society, 2020b). Cheruvu et al. (2017) stressed that strong provider recommendations for parents vaccinating their child against HPV were vital to reducing missed clinical opportunities to communicate the vaccine's health benefits effectively. Public health experts consider provider recommendation the strongest predictor of HPV vaccine uptake (American Cancer Society, 2020b). Glenn et al. (2015) conducted a study to understand HPV vaccination among Hispanic adolescent girls in three U.S. regions. These authors found that most Hispanic parents prefer to have their doctor involved in deciding whether or not to vaccinate the child against HPV. Thus, the Mission: HPV Cancer Free campaign's efforts to improve parental knowledge and provider recommendation could reduce the prevalence of Hispanic parents' sociocultural barriers in low- compared to high-income families.

Research on parental sociocultural barriers to HPV vaccination should continue in Bexar County. The HPV vaccination coverage of Hispanic youth in Bexar County from 2016 to 2018 was far short of goals (Healthy People.Gov, n.d.; Texas Department of State Health Services, 2021). Even though the prevalence of Hispanic parents' sociocultural barriers appears to have decreased over the past decade (Beavis et al, 2018, Cheruvu et al., 2017, Stokley et al., 2014), researchers should continue to monitor the level of Hispanic parents' sociocultural barriers to HPV vaccination. Achievement of incremental gains in HPV vaccine coverage each year by addressing sociocultural barriers could make the difference between meeting and not meeting established HPV vaccine coverage goals within the current decade.

Researchers might gain further insights on how to improve HPV vaccine coverage of Hispanic youth in Bexar County by examining vaccination barriers of providers in addition to that of parents. From 2008 to 2018, Cataldi et al. (2021) surveyed nationally representative networks of pediatricians and family physicians to assess their perceptions of parental barriers to HPV vaccination of youth. These authors found an increasing number of providers reported that parents' perceived HPV vaccine safety concerns were a barrier to their child's vaccination (5% in 2008 vs. 35% in 2018, $p < .0001$). In addition, an increasing number of providers stated parents' moral/religious concerns, a sociocultural barrier, were a hindrance to vaccination (5% in 2008 vs. 25% in 2018, $p < .0001$). In contrast, the prevalence of parents' HPV vaccine safety/effectiveness apprehensions and moral/religious concerns have generally decreased over the past decade (Beavis et al., 2018, Cheruvu et al., 2017, Stokley et al., 2014). Thus, providers' perceptions might not reflect changing parental concerns about HPV vaccination. Gilkey et al. (2016) demonstrated a firm and high-quality provider recommendation led to increased HPV vaccine coverage for youth. However, Healy et al. (2014) suggested providers' overestimation of parental concerns hindered the strength of their recommendations for parents to use the HPV vaccine. For these reasons, public health authorities need data on trends in the prevalence of parental barriers to HPV vaccination in Bexar County to inform providers. An ongoing understanding of the providers' views regarding parental barriers might also be helpful. The large shortfall in reaching HPV vaccination coverage goals suggests efforts are needed to overcome all obstacles to HPV vaccination, even those with a relatively small prevalence, such as sociocultural barriers.

Aggregate Interpretation of Results and Implications

The findings of this study relate to the SEM of health promotion and prevention. The basis of the current study was the SEM by McLeroy et al. (1988). A core principle of the SEM is that higher level interpersonal networks, organizations, communities, and policies influence individuals' health promotion and prevention behaviors at the intrapersonal level (Golden & Earp, 2012). I placed parental HPV vaccination intent, series initiation, and completion at the intrapersonal level (see Figure 1). In addition, I put at this level the parental HPV vaccination barriers of safety and effectiveness concerns, vaccination misinformation, and lack of knowledge about HPV and the vaccine (see Figure 1). One higher level influence of the SEM in my study was the Mission: HPV Cancer Free campaign, which focused on increasing HPV vaccination of Hispanic children from low-income families in Bexar County during my study period (Garza, 2017; Munoz, 2017). Other higher level factors were a nationwide decline in low-income Hispanics' knowledge of HPV and the vaccine (Chido-Amajuoyi et al., 2021) and a faster rate of increase in media use at the national level in low- versus high-income Hispanics (Brown et al., 2016). For each of my RQs, I found that these higher level factors likely influenced, in various ways, parents' intent to vaccinate and barriers to vaccination (see Tables 20 and 38). For example, the Mission: HPV Cancer Free initiative at the institutional and community levels appeared to contribute to a decline in the prevalence of parental lack of knowledge of HPV and the vaccine in low- compared to high-income families (see Tables 31 and 38). On the other hand, the nationwide faster rate of increase in media use in low-income families at the community level appeared to increase the prevalence ratio of parental HPV vaccination misinformation (see Tables 28 and 38). Vaccination advocates might use these insights and others gained from my analysis to design interventions for improving HPV vaccination coverage for youth. Ultimately, increased coverage might enhance population health through HPV-related disease prevention.

Vaccination practitioners could directly apply the Mission: HPV Cancer Free program in my study population to mitigate the obstacles of lack of knowledge of HPV and the vaccine, systemic barriers, and sociocultural barriers in low-income families. In the weighted average of data from 2016 to 2018, the prevalence of parents' lack of knowledge, systemic barriers that included lack of vaccine recommendation, and sociocultural barriers was higher in low- compared to high-income families (see Table 38). However, the prevalence of these barriers in low- compared to high-income families tended to decrease statistically and substantially over time (see Table 38). First, the prevalence ratio of parents' lack of knowledge in low- compared to high-income families decreased from 1.39 in 2017 to 0.86 in 2018. Second, the prevalence ratio of parents' systemic barriers decreased from 1.30 in 2016 to 1.00 in 2017. Third, the prevalence ratio of parents' sociocultural barriers decreased from 1.62 in 2016 to 1.07 in 2018. These reductions in the prevalence ratios of lack of knowledge, systemic barriers, and sociocultural barriers could have been due to, at least in part, the success of the Mission: HPV Cancer Free campaign (American Cancer Society, 2018). This program focuses on overcoming HPV vaccination barriers in low-income families (American Cancer Society, 2020b). Therefore, vaccine advocates might be able to continue to use the Mission: HPV Cancer Free program with minimal refinement in Bexar County to reduce the barriers of lack of knowledge, systemic barriers, and sociocultural barriers in the low-income group.

Public health authorities might also apply the Mission: HPV Cancer Free program in Bexar County to reduce the barriers of safety/side effect concerns and misinformation in the high-income group. I found the prevalence of both safety/effectiveness concerns and misinformation to be generally higher in high- compared to low-income families (see Table 38). As shown in Figure 1, I placed provider recommendations at the organizational level of the SEM and vaccination safety/side effect concerns and misinformation at the intrapersonal level. As mentioned, a central part of the SEM is that higher level factors such as provider recommendation influence individuals (Golden & Earp, 2012). Cheruvu et al. (2017) noted a strong provider recommendation of the HPV vaccine for teens was crucial to mitigate parental vaccine safety/side effect concerns and vaccination misinformation. One of the five key strategies of the Mission: HPV Cancer Free campaign has been to strengthen provider recommendations for the vaccine (American Cancer Society, 2020b). Therefore, HPV vaccination providers might use the Mission: HPV Cancer Free program to reduce the barriers of safety/side effect concerns and misinformation in the high-income group.

Disparities by income level in nationwide changes in media use and knowledge of HPV and the vaccine among Hispanics could have driven the local decrease of parental intent to vaccinate in low- compared to high-income families. In Bexar County, I found a decreasing prevalence of intent to vaccinate in low- compared to high-income families from 2016 to 2018 (see Tables 11 and 20). A concurrent nationwide decline in the prevalence of low-income Hispanics' knowledge of HPV and the vaccine might have contributed to this local decrease in the prevalence ratio of intent to vaccinate (Chido-Amajuoyi et al., 2021). This nationwide decrease in knowledge appeared to lead to the local reduction in the prevalence ratio of intent to vaccinate via an increase in the prevalence ratio of lack of knowledge and systemic barriers (see Tables 20 and 38). The local decline in the prevalence of parents' intent to vaccinate in the low- versus high-income group might have also been partially due to a faster increase in media use at the national level in low- versus high-income Hispanics (Brown et al., 2016). This national trend in media use appeared to lead to the local decrease in the prevalence ratio of intent to vaccinate via an increase in the prevalence ratio of vaccination misinformation and lack of knowledge (see Tables 20 and 38). In short, nationwide trends by income level in the prevalence of media use and knowledge of HPV and the vaccine could have contributed to, at least partially, the local decline of the prevalence of intent to vaccinate in low- compared to high-income families.

Public health experts could use the Mission: HPV Cancer Free program to increase parental intent to vaccinate. As mentioned in the previous paragraph, the nationwide trend of decreasing knowledge of HPV and the vaccine in low-income Hispanics and faster increase of media use in low- than high-income families likely drove, at least partially, a decline of intent to vaccinate. The Mission: HPV Cancer Free campaign, which occurred in Bexar County during my study period, focused on increasing HPV vaccination of Hispanic children from low-income families by educating parents and training healthcare providers (Garza, 2017; Munoz, 2017). This local program appeared to lead to a decline in the prevalence ratio of lack of knowledge, systemic barriers, and sociocultural barriers in low- compared to high-income families (see Table 38). In addition, the decline in the prevalence ratio of intent to vaccinate between 2017 and 2018 appeared to be less than that between 2016 and 2017 (see Tables 11 and 20). These results, taken together, suggest the program mitigated the local decline of intent to vaccinate in low- versus high-income families across the study years. Therefore, public health professionals might use the Mission: HPV Cancer Free program to increase the prevalence of parental intent to vaccinate. Ultimately, increasing the prevalence of intent to vaccinate could drive an increase in vaccination.

Limitations of the Study

The use of secondary data is a potential limitation of this study. Smith et al. (2011) defined secondary data analysis as the study of data initially collected for another central purpose. The primary purpose of the NIS-Teen survey data is to measure vaccination coverage and report progress in reaching coverage goals (CDC 2020b). Some researchers also use the NIS-Teen data to assess potential predictors of vaccine use by teens (Walker et al. 2017, 2018, 2019). As researchers mainly use the NIS-Teen data to monitor vaccination coverage, a foremost aim of the surveyors is that the survey data from each geographical sampling area be as representative as possible of the population (CDC 2020b). To this end, the NIS-Teen surveyors carry out a multistep procedure to develop and adjust survey weights (CDC 2020b). Researchers use the resulting weights to accurately represent the NIS-Teen variables (participant characteristics) in the population of interest (CDC 2020b). In creating survey weights, the NIS-Teen surveyors use control totals of the population for sociodemographic variables and trim their values (CDC 2020b). As the weighting of my data would alter the values of the sociodemographic variables, it might be inappropriate to use these variables as independent or control variables in testing for predictors of vaccine use in binomial logistic regression (Mobley et al., 2019; Young & Johnson, 2012a, 2012b). In summary, the NIS-Teen surveyors mainly create weights to obtain valid measurements of vaccination coverage. Using these weights to weight my complex survey data could impede a valid logistic regression analysis involving control variables.

My decision to withhold conducting binary logistic regression involved careful consideration. Confounding variables might have affected the association between the independent and dependent variables (Salazar et al., 2015). Even so, for various reasons, the prevalence ratio and chi-square test measures of association were adequate to address the RQs. First, the primary purpose of this study was to compare the crude prevalence of vaccination intent, initiation, completion, and barriers in low- and high-income families. Second, the prevalence ratio and chi-square test, adapted for a complex survey, are appropriate for weighted data (Johnson, 2008; Young & Johnson, 2012a, 2012b). Third, data analysts generally consider simpler explanations of phenomena, including HPV vaccination, obtained using a basic versus more involved statistical procedures, superior to more complicated interpretations (Field, 2013). These reasons reinforce my justification for using solely the prevalence ratio and chi-square test with weighted data to test the association between independent and dependent variables.

Due to the study design, I was limited in my choice of a relative measure of association. In this cross-sectional study, based on NIS-Teen survey data, the surveyors collected data on variables concurrently (CDC, 2020b). Regarding my variables, they simultaneously measured the independent (income level) and dependent variables of each of my RQs. Therefore, I could estimate for each RQ the prevalence, but not incidence, of outcomes of interest for dependent variables by income level (Benichou et al., 2007; Fonseca Martinez et al., 2017). In turn, I could calculate the prevalence ratio of the outcomes of RQs in low- versus high-income families but not the risk ratio (relative risk; Tamhane et al., 2016). Likewise, researchers can use data from cross-sectional surveys to determine the prevalence odds ratio but not the odds ratio (Tamhane et al., 2016). In sum, due to the cross-sectional study design, I was limited to using measures of association based on prevalence.

The use of the prevalence odds ratio was less suitable for my study than the prevalence ratio because the former is more difficult for people to understand. In my research, the prevalence ratio served as a measure of the strength of association between the exposure (i.e., income level) and outcome of interest for each RQ. In this cross-sectional study, I define the odds of an event occurring as its frequency in a given year divided by the frequency of it not occurring during the same period. In contrast, I define prevalence as the frequency of the event occurring in a given year divided by the sum of the frequency of it occurring and not occurring during the same period. The prevalence ratio refers to the ratio of the prevalence of an event in low- versus high-income families, and the prevalence odds ratio is a ratio of the odds in the groups (Ranganathan et al., 2015). Schmidt and Kohlmann (2008) noted that the interpretation of the prevalence odds ratio is less intuitive than that of the prevalence ratio. For this reason, the prevalence odds ratio is more prone to misinterpretation than the prevalence ratio by people unfamiliar with the precise definitions of these measures of association.

In addition, the prevalence odds ratio is a less consistent measure of association than the prevalence ratio. The magnitude of association between two variables in terms of the prevalence odds ratio exaggerates that of the prevalence ratio (Schmidt & Kohlmann, 2008; Zhang & Yu, 1998). That is, when the prevalence ratio is less than one, the prevalence odds ratio is lower. On the other hand, when the prevalence ratio is greater than one, the prevalence odds ratio is higher. These measures of association are close in value when the outcome is rare (typically <10%). In this case, public health workers can use them interchangeably. However, when there is an increase in the prevalence of the outcome of interest or the strength of the association between the exposure and outcome, researchers can no longer consider the prevalence ratio and prevalence odds ratio equivalent. For example, if the prevalence of the outcome in exposed and unexposed groups combined is 2%, the prevalence ratio (3.0) and odds ratio (3.06) are close in value (Ranganathan et al., 2015, see Table 3). If the prevalence in the exposed and unexposed groups combined is 27.5%, the prevalence ratio (4.5) and odds ratio (7.45) are substantially different. Overall, the higher the prevalence of the outcome of interest or the strength of the association between the exposure and outcome, the more cautious researchers should use the prevalence odds ratio.

The use of the prevalence odds ratio was less suitable for my study than the prevalence ratio due to the nature of my data. Among my RQs, there was a wide range in the number of study participants. Therefore, I could expect a large difference in prevalence ratio and prevalence odds ratio for some RQs and a small difference for others. Considering the prevalence odds ratio is frequently misinterpreted as a prevalence ratio (Gallis & Turner, 2019; Fonseca Martinez et al., 2017; Zhang & Yu, 1998), the strength of association in my study could be overestimated in some cases when using the prevalence odds ratio. As there was a wide range of sample sizes for my RQs, the prevalence ratio was a more consistent measure of association than the prevalence odds ratio.

Recommendations

One limitation of my analysis of secondary NIS-Teen data is the delayed availability of the survey results each year. The NIS-Teen data is typically publicly available 12 months or more after the completion of interviews with parents at the end of each year (CDC, 2018). In my study, I examined NIS-Teen survey data from 2016, 2017, and 2018. Current data on the views of Hispanic parents about HPV vaccination of their child might be more relevant to inform the development of interventions and guidelines to increase vaccine use. Unfortunately, the limitation of delayed availability of NIS-Teen data is largely beyond the control of users of the data. However, researchers planning to use NIS-Teen data should analyze and publish the findings as soon as possible after the data is released each year.

A related potential limitation is the length of my study period. The NIS-Teen data used in my study was of high quality and comprehensive. However, I might have obtained a more refined view of trends in my results by examining an extended study period. In particular, including data from the 2019 NIS-Teen survey might have allowed me to get an expanded view of trends. Researchers should conduct future studies over as long a period as feasible and appropriate.

Sometimes it could be invalid to aggregate or pool survey data across specific years. For example, my secondary data analysis of 2016 to 2018 NIS-Teen surveys would likely differ from that obtained during the COVID-19 pandemic. Early in 2020, the pandemic dramatically began to reduce outpatient medical care delivery (Mehrotra et al., 2021). During the pandemic, the number of medical visits of youth aged 7 to 17 decreased by over 71%. The ACIP recommends that children receive the HPV vaccine at age 11 or 12 (Meites et al., 2016). The routine pediatric opportunities for HPV vaccination of youth decreased during the pandemic due to declining medical visits for children (Ginsburg et al., 2021; Santoli et al., 2020). Therefore, HPV vaccine initiation and completion would likely be lower during the pandemic than during my study period. Ultimately, the increased missed opportunities for HPV vaccination could increase the risk for vaccine-preventable diseases and cancers associated with HPV. An aim of the Mission: HPV Cancer Free Texas campaign has been to increase HPV vaccination during the pandemic (American Cancer Society, 2020a). Researchers could get important information for improving HPV vaccination by comparing data from my study period to similar data obtained during and after the pandemic.

In addition, the pandemic would likely influence the relative prevalence of different parental reasons for no-intent to vaccinate their child against HPV. For instance, one would expect during the pandemic a higher relative prevalence of parents reporting the lack of healthcare visits, a type of systemic barrier to vaccination. For this reason, it might be invalid to aggregate or pool survey data from my study period with that obtained during the pandemic. My study could serve as a baseline for further studies on the factors influencing whether Hispanic parents in Bexar County (and possibly other counties in Texas) have their children vaccinated against HPV.

Implications

Briefly, the problem statement of my study was as follows. Hispanics in Bexar County have a high prevalence of morbidity and mortality related to HPV infection compared to other groups (National Cancer Institute, n.d.-b; Texas Cancer Registry, 2021a, 2021b; U.S. Cancer Statistics Working Group, 2021; U.S. Census Bureau, 2021b). Despite the disparity in HPV-associated diseases and cancers among Hispanics in my study population, the vaccine coverage in this group was lower than the 70% level predicted to achieve herd immunity (National Cancer Institute, n.d.-b; Walker et al., 2017. 2018, 2019). Even so, published quantitative research to date locally on the factors that predict the vaccination status of Hispanic youth is limited. To my knowledge, there is no literature on the influences of HPV vaccination concerning Hispanic adolescents living in Bexar County. Thus, health promoters of Bexar County need an understanding of factors that influence whether Hispanic youth in this region receive vaccines against HPV. The results of this study help to address this gap in the literature.

Professional Practice

Health promotion authorities concerned with HPV vaccine coverage in Bexar County might use my results to improve HPV vaccine coverage in this region. Compared to high-income families in this study, low-income parents had a higher prevalence of intent to vaccinate their child against HPV and series initiation and completion (see Table 20). The Mission: HPV Cancer Free Texas program, which focused on the low-income group, was implemented in Bexar County from 2017 to 2018 (American Cancer Society, 2020b; Garza, 2017; Munoz, 2017). The greater improvement in HPV vaccination-related outcomes in low-income families was likely due, at least partially, to this program. Healthcare and public health authorities of Bexar County might continue to increase HPV vaccine coverage for Hispanic teens by using my data to tailor practice guidelines and interventions to the local population. Medical and public health resources to intervene to increase vaccine coverage could be limited. In such a case, practitioners might use my data to prioritize their efforts for a particular income group. Public health authorities might need my data to refine current HPV vaccination campaigns in Bexar County to achieve large enough increases in HPV vaccine coverage each year to reach the 2030 goal of 80%.

Results from the current study appear to be representative of a broader population. As discussed for RQs1-8, factors influencing HPV vaccination appear to sometimes apply to both Hispanics in Bexar County and nationwide. I base this conclusion on an assessment of the potential impact of nationwide factors on the prevalence of my dependent (outcome) variables in low- compared to high-income Hispanic families of Bexar County. For example, the higher prevalence of use of different types of media by high- compared to low-income parents (Brown et al., 2016) might drive a higher prevalence of HPV vaccine safety concerns in the high-income group locally and nationwide (Zimet & Osazuwa-Peters, 2019). Researchers and practitioners are optimistic they can meet or exceed the HPV vaccine coverage goal for teens in the United States by the end of the current decade (Warner et al., 2017). Achieving this goal could reduce the prevalence of HPV infection and associated diseases and cancer in future generations of adults to an acceptable level. Consequently, using data from the current study to intervene to increase HPV vaccine coverage in Bexar County might have broad implications for professional practice.

Positive Social Change

Public health authorities could use my findings to improve HPV vaccination with wide-ranging, direct and indirect benefits to society. Concerning my dissertation work at Walden University, positive social change refers to broad benefits to society of interventions to improve HPV vaccination of youth (Walden University Form and Style, n.d.). These public health interventions might promote the welfare and development of society at different levels, including individuals, families, organizations, institutions, communities, cultures, and societies as a whole. The interventions developed using my data to improve HPV vaccination could apply to parents and vaccine providers. For example, health promotion professionals could design interventions to increase health care providers' awareness and knowledge of HPV and the vaccine. Providers might use their knowledge of HPV and the vaccine to educate their patients. Parents who receive a firm, high-quality recommendation to vaccinate their child would probably be more likely to accept the HPV vaccine (Gilkey et al., 2016). One would expect HPV vaccine coverage of teens in the providers' practice population to increase, thereby reducing the burden associated with HPV. In this way, patients at risk for HPV could benefit from the current research through the evidence-based interventions and guidelines designed to improve providers' recommendations and parents' acceptance of the HPV vaccine. Ultimately, vaccinated boys and girls would be more likely to live long and healthy lives. These healthy individuals could better contribute to society by developing themselves and their work in organizations and communities.

Youth in Bexar County (and elsewhere) might benefit at even higher levels of the SEM from my findings of potential predictors of HPV vaccination. Stakeholders of HPV vaccination could use my results to develop vaccine education, vaccine subsidization, policies, regulatory enforcement, social marketing, and health economics strategies (Getzen, 2013; Resnick & Siegel, 2013; Walling et al., 2016). For instance, my findings might enable healthcare and public health organizations to improve practices related to HPV vaccination. Public health communicators might use my data to tailor the information they disseminate to families based on income level. Low-income families with higher HPV-associated morbidity and mortality prevalence, such as in Bexar County, might benefit from this education (Schlenker & Huber, 2015). Vaccinated patients would have a substantially reduced probability of contracting HPV. These protected individuals would likely avoid the cost (e.g., pain, disruption of daily activities, financial loss) associated with treating HPV-associated diseases and cancers. During the first 2 years after a cervical cancer diagnosis, the medical cost for publicly insured patients in Texas from 2011 to 2014 was about $200,000 (Lairson et al., 2017). In addition, Priyadarshini et al. (2021) estimated the economic value of lost productivity attributable to HPV cancer mortality of men and women in the United States as of 2017 to be $3.3 billion. Immunization against HPV would benefit groups at high risk of adverse outcomes, such as the low-income Hispanic families in Bexar County (Schlenker & Huber, 2015). Using data from my study to develop interventions to increase HPV vaccination of youth could benefit Hispanic adults for years to come at multiple levels, including individuals, families, organizations, communities, and government.

Conclusion

I fulfilled the aims of this study. In Bexar County, Texas, Hispanics have a high prevalence of morbidity and mortality from HPV-associated diseases and six types of cancers compared to other groups (National Cancer Institute, n.d.-b; Texas Cancer Registry, 2021a, 2021b; U.S. Cancer Statistics Working Group, 2021; U.S. Census Bureau, 2021b). Despite this disparity, vaccine coverage in my study population from 2016 to 2018 was below the 70% level that researchers expect is needed to achieve herd immunity (National Cancer Institute, n.d.-b; Walker et al., 2017, 2018, 2019). Thus, there is a need to understand the factors affecting HPV vaccination of Hispanic teens in my study population. I addressed, in part, an apparent gap in quantitative research evidence on the factors that influence HPV vaccination in my study population. I carried out a cross-sectional, quantitative study using weighted survey data from the 2016 to 2018 NIS-Teen (CDC, n.d.-a, 2018). My first aim was to understand better the extent to which income level influenced (or was at least related to) parents' intent to vaccinate, initiation, and completion. In addition, in a subset of parents who had no-intent for their child to receive the HPV vaccine, I tested whether income level was associated with the prevalence of parental barriers to vaccination. Researchers have identified factors at multiple levels of the SEM associated with parents' lack of intent to have their child receive the HPV vaccine (Cella et al., 2020; Cheruvu et al., 2017; Thompson et al., 2017). Accordingly, I tested whether income level was associated with the five domains of candidate parental barriers to deciding to have their child receive the vaccine. Strengths of this study are the comprehensive study design, appropriate methods, careful data analysis, and thoughtful interpretation and evaluation of the results, as I detailed and argued in Chapters 2, 3, 4, and 5, respectively. By aligning this study from beginning to end, I rigorously achieved what I set out to do.

The results of RQs1-3 suggest local efforts in Bexar County to increase HPV vaccination coverage in low-income families led to an increased prevalence of parental intent to vaccinate, series initiation, and completion. On average, from 2016 to 2018, compared to high-income families (>$40,000 per year), low-income parents had about 1.3 times the prevalence of vaccination intention, initiation, and completion (see Table 20). From 2017 to 2018, public health and medical practitioners implemented the Mission: HPV Cancer Free Texas program in Bexar County (Garza, 2017; Munoz, 2017). This campaign focused on educating parents and providers about HPV and the vaccine, predominantly in low-income communities (American Cancer Society, 2020b). The higher prevalence of vaccination intention, initiation, and completion in the low- compared to high-income families, as shown in Table 20, might have been due to, at least partially, more education and training of low- versus high-income parents and providers. Persistence of the higher prevalence of HPV vaccination intention, initiation, and completion in the low- compared to high-income families might lead to a decrease in the disparity of HPV-related diseases between low- and high-income Hispanics of Bexar County later in life.

Public health and medical practitioners should strive to increase HPV vaccination coverage in youth living in both low- and high-income families. The Healthy People 2030 goal of HPV vaccine series completion before age 13 is 80% to 85% by 2030 (Healthy People.Gov, n.d.). Between 2016 and 2018, the HPV vaccination coverage of Hispanic youth in Bexar County was far short of this level (Texas Department of State Health Services, 2021). To meet the goal of 80% to 85% HPV vaccination coverage by the end of the current decade, increased coverage for the youth of both low- and high-income families will be necessary.

My data from RQs1, 2, and 3 on the prevalence ratio of lack of parental intent to vaccinate, series initiation, and completion, respectively, could inform efforts to improve HPV vaccination. Public health practitioners could use the data on the prevalence ratio of these outcomes in the low- compared to the high-income group to optimize the use of limited resources to achieve HPV vaccination coverage goals. Specifically, the data might indicate how much practitioners can improve HPV vaccination-related outcomes in the high-income group. By focusing efforts to reduce the lack of these outcomes in the high-income group, practitioners might achieve more efficiently a substantial and statistically significant reduction in the potential impact of the lack of each outcome in this exposure group (see Table 20). HPV vaccination campaigns such as Mission: HPV Cancer Free Texas might be adapted (or applied directly) to intervene to improve vaccination coverage of youth from high-income families.

The results of RQs4-8 could also help practitioners increase HPV vaccination of teens in Bexar County. As mentioned, to meet the Healthy People 2030 goal of 80% to 85% HPV vaccination coverage in Hispanic youth of Bexar County, it will be necessary to optimize coverage of children from both low- and high-income families. However, public health practitioners might have limited resources to achieve the Healthy People 2030 goal. In such a case, information on which income group has a higher prevalence of a particular barrier to parental intent to vaccinate could help target strategies to mitigate the obstacle based on income level. My results indicate that low-income families generally had a lower prevalence of HPV vaccine safety and effectiveness concerns and vaccination misinformation (see Table 38). By concentrating efforts to reduce these barriers in the high-income group, practitioners might achieve a substantial and statistically significant reduction of the negative impact of safety and effectiveness concerns and vaccination misinformation by a streamlined approach (see Table 38). In contrast, low-income families generally had a higher prevalence of lack of knowledge of HPV and the vaccine, systemic barriers, and sociocultural barriers (see Table 38). Thus, by focusing efforts to reduce these barriers in the low-income group, practitioners might efficiently achieve a substantial and statistically significant reduction of the potential negative impact of lack of knowledge of HPV and the vaccine, systemic obstacles, and sociocultural barriers (see Table 38). In brief, my findings suggest practitioners could better mitigate safety and effectiveness concerns and vaccination misinformation barriers by concentrating interventions on high-income families. Alternatively, they could obtain larger reductions in the lack of knowledge, systemic barriers, and sociocultural barriers by focusing on the low-income group.

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Title of Research Article: Improving human papillomavirus Vaccination uptake in college students: A socioecological perspective

Authors: Beth Lanning, Mandy Golman & Katie Crosslin

Publication: American Journal of Health Education

Publisher: Taylor & Francis

Publication Date: Mar 10, 2017

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