UNDERSTANDING PROVIDER BARRIERS TO RECOMMENDING AND ADMINISTERING THE HPV VACCINE TO ADOLESCENTS IN COLORADO: A MIXED METHOD APPROACH

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Thesis directed by Professor Richard Lindrooth

ABSTRACT

Human Papillomavirus (HPV) vaccination among adolescents lags behind those of other adolescent vaccines, including the tetanus-diphtheria-acellular pertussis (Tdap) and the meningococcal conjugate vaccine (MCV4). This research sought to understand barriers to recommending and administering the HPV vaccine to adolescents in Colorado, with focus on providers serving low-income populations who are at high risk for HPV related cancer and other diseases.

Colorado's Vaccine for Children (VFC) and primary care service area data were used to identify high and low HPV vaccine ordering practices compared to Tdap vaccine and compared to neighboring practices. Using adapted grounded theory, semi-structured interviews were conducted with 26 providers from these practices. This study identified barriers and facilitators to HPV vaccine uptake among VFC participating providers. Hypotheses generated using qualitative findings were tested for generalizability using All Payer Claims Database data. Logit regression was used to model likelihood of HPV vaccine initiation and completion among children ages 11-18. Oaxaca-Blinder (OB) regression decomposition was used to identify explained and unexplained factors between ethnicity and public- versus privately-insured groups.

Qualitative research results described parental, provider, and policy level barriers and facilitators to HPV vaccine delivery. Barriers included parental vaccine

hesitancy and lack of consistent recommendation by providers. Steps taken to improve HPV vaccine acceptability included creative communications with parents and adolescents about HPV and extended office hours to administer vaccines.

Quantitative analysis showed that males, adolescents with male providers, and patients who saw providers other than primary care providers were significantly less likely to initiate the HPV vaccine and less likely to complete the full dose. Hispanics were more likely to initiate and complete the three dose HPV vaccine series. A 12.15 percentage point of disparity in initiating and 2.99 percentage point in completing the HPV vaccine existed between non-Hispanics and Hispanics. Additionally, publicly insured adolescents were more likely to initiate (3.99 percentage point disparity) where as non-publicly insured were more likely to complete (5.4 percentage point disparity) the three dose HPV vaccine series. OB decomposition showed explained and unexplained factors in driving the observed disparity in HPV vaccine initiation and completion between the groups. Patient and provider gender, provider type, and insurance status influenced explained differences in HPV vaccine uptake.

Even though higher vaccination rates among low income groups than non-low income groups are observed, significant challenges to HPV vaccine initiation and completion remain. Efforts to improve HPV vaccine uptake should target amenable factors that influence and explain HPV vaccine uptake. The findings from this research quantify explainable factors in variation that could be influenced to improve HPV vaccine uptake. Researchers, policy makers, and practitioners could use this information to identify and intervene in priority areas. Further research needs to be

done to understand unexplained patient, provider, and population level factors that influence HPV vaccine uptake.

The form and content of this abstract are approved. I recommend its publication.

Approved: Richard Lindrooth

DEDICATION

This dissertation would not have been possible without the unwavering support from extraordinary individuals. This work is dedicated to you all.

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Advisory Committee on Immunization Practices (ACIP)

All Payers Claims Database (APCD)

American Academy of Pediatrics [AAP]

Association of Religion Data Archives (ARDA)

Centers for Disease Control and Prevention (CDC)

Colorado Department of Public Health & Environment [CDPHE]

Food and Drug Administration (FDA)

Geometric mean titers (GMTs)

Human Papillomavirus (HPV)

Meningococcal conjugate vaccine (MCV4)

National Immunization Survey–teen (NIS-teen)

Primary Care Service Area (PCSA)

Sexually Transmitted Infection (STI)

Tetanus-diphtheria-acellular pertussis (Tdap)

Vaccine for Children (VFC)

CHAPTER I

INTRODUCTION

Human Papillomavirus (HPV) is the most common sexually-transmitted virus in the United States, and it is transmitted through intimate skin-to-skin contact (CDC, 2015). Some HPV strains can cause warts (papillomas) while other types can lead to cancer, especially cervical cancer (CDC, 2015). About 79 million Americans are currently infected with HPV and about 14 million people become newly infected each year (Centers for Disease Control and Prevention [CDC], 2015). The annual overall direct medical cost of preventing and treating HPV-associated disease was estimated to be $8 billion (2010 U.S. dollars) (Chesson et al., 2012).

Vaccines given in three doses over six months or two doses over six months, depending on age of initial vaccination, can prevent infection with the most common strains of HPV. Three types of HPV vaccines are licensed by the Food and Drug Administration (FDA) to prevent infections related to the most common types of HPV: the quadrivalent HPV vaccine for HPV types 6,11,16,18 (Gardasil), the bivalent HPV vaccine for types 16, 18 (Cervarix), and the 9-valent vaccine for HPV types 6,11,16,18, 31, 33, 45, 52, 58 (9vHPV). As of this writing, essentially all the HPV vaccines delivered in the US in the near term will be 9vHPV. The bivalent HPV vaccine can be given for ages 9-26, quadrivalent vaccine for ages 9-26, and 9-valent for girls and boys aged 9-26. The HPV vaccine is currently recommended for adolescent children 11 through 12 years of age primarily because the vaccine is most effective when administered before the onset of sexual activity, when exposure could occur. In addition, older adolescents are known to visit medical providers less

frequently than younger adolescents. The vaccine is ineffective against HPV types previously acquired by the vaccine recipient (Committee on Infectious Diseases, 2012). Antibody responses are also higher among children ages 9 through 15 compared to 16-24 year-olds, though the clinical significance of this is unclear. Although geometric mean titers (GMTs) are lower in the older age groups, the immune response is still likely protective (Centers for Disease Control and Prevention [CDC], 2012).

Three dose of the HPV vaccine were originally recommended until a change in dosage was announced in October 2016. The current recommended immunization schedule is 2 doses of the HPV vaccine for those initiating the HPV vaccine before age 15. The second dose should be administered 6-12 months after the first dose. However, for those initiating HPV vaccinations after their 15th birthday, the recommended immunization schedule is 3 doses. The second dose should be administered one to two months after the first dose, and the third dose should be administered six months after the first dose. Three doses of the HPV vaccine for all age groups was the standard until October 2016 (Meites, Kempe, & Markowitz, 2017).

The National Immunization Survey–teen (NIS-teen) in the United States showed that the HPV vaccination rate lags behind that of other recommended adolescent vaccines such as tetanus-diphtheria-acellular pertussis (Tdap), and the meningococcal conjugate vaccine (MCV4). In Colorado, only 58% of females and 33.5% of males have received one dose of the HPV vaccine (NIS teen, 2013). In 2015, the three-dose HPV vaccine had been received by 46% of girls and 37% of

boys in Colorado (Colorado Department of Public Health & Environment [CDPHE], 2017). Although this is an increasing trend, it is significantly lower than Tdap and other adolescent vaccine rates. Healthy People 2020 vaccination targets for adolescent children aged 13-15 years were reached in many states for Tdap (target: 80%) and meningococcal (target: 80%) vaccines. However, no state met the Healthy People 2020 target of 80% for HPV vaccine doses (Elam-Evans et al., 2014; Healthy People 2020).

Several barriers have been identified to explain the low HPV vaccination rates. A systematic review of barriers to HPV vaccination among U.S. adolescents found that health care professionals and parents cited financial concerns as one of the primary barriers to provision and receipt of the HPV vaccine, although this barrier appears to have been mitigated in recent years (Holman et al., 2014). In addition, parents consistently cited health care professional recommendations as one of the most important factors in their decision to vaccinate their children. In 2013 parents indicated that one of the top reasons they had not vaccinated their adolescent children with HPV vaccine was that there had not been a provider recommendation for the vaccination (Elam-Evans et al., 2014).

The perceived high cost of the HPV vaccine, combined with too few provider recommendations, might have slowed current vaccine dissemination. The drug company price for the HPV vaccine is around $130-$140 per dose, not including the cost of giving the shots or the provider's fee. As a result, three shots over six months could cost $500 or more for uninsured individuals, making it one of the most expensive recommended vaccines (Centers for Disease Control and Prevention

[CDC], 2016). Expensive vaccines may present financial challenge for families. However, the Vaccine for Children (VFC) program offers vaccines, including HPV, free of charge for qualifying individuals. The program removes the cost barrier for obtaining immunizations among children 18 years of age and younger. However, even among VFC providers, the HPV vaccine coverage rate is lower than other adolescent vaccines. Furthermore, a 2009 study compared VFC and non-VFC eligible adolescent immunization rate and found that coverage among non-VFC eligible adolescents was about 43% for at least one dose and about 46.6% for VFC eligible adolescents between ages 13-17 (Lindley, Smith, & Rodewald, 2011). HPV vaccine coverage in the adolescent population is a few percentages higher in the VFC-eligible population, but not adequate. This research study will focus on VFC program-participating providers in Colorado to understand barriers to HPV vaccine recommendation and provision. VFC providers serve low-income populations who are at higher risk for HPV infection and related disease, making this a very important focus area. Findings from VFC providers will further be explored to explore the generalizability of findings to HPV vaccine landscape in Colorado.

The overall objective of this study is to identify VFC provider barriers to providing the adolescent HPV vaccine, and to understand provider barriers, attitudes, and practices towards HPV vaccination, which will help researchers and policy makers to target interventions to increase HPV vaccine uptake and decrease disease burden.

Specific Aims and Hypotheses

Aim 1

Identify geographic areas and VFC provider sites that are high and low performing in terms of HPV vaccine relative to Tdap vaccine ordering ratio.

Hypothesis. Providers who are less likely to administer HPV vaccinations than Tdap will have a lower HPV vaccine ordering ratio due to low anticipated usage of the HPV vaccine.

Rationale. The VFC program, which is aimed at removing cost barriers to vaccination, provides free vaccines for eligible patients under participating providers. However, HPV vaccine coverage in the VFC-eligible adolescent population is inadequate, as it is among the non-VFC eligible population. At the time of this study's conception, the recommended three-dose HPV vaccination rate was quite low and the two-dose recommendation was just starting. To focus on HPV-specific barriers and precursors rather than issues surrounding the vaccine in general, we identified practices that have either a high or low HPV vaccine-ordering ratio relative to Tdap. This allowed us to identify providers for qualitative interviews about the provision of the HPV vaccine. Focusing on the low performers provided information that could be used for vaccine uptake improvement efforts whereas high performing sites could share their best practices that helped them.

Existing VFC provider ordering data was analyzed to identify providers and primary care service areas (PCSAs) with high and low HPV vaccine-ordering ratios relative to Tdap. This information was used to develop a qualitative interview sample to query providers regarding their HPV vaccine-ordering patterns. Providers were

asked if they were interested participating in key informant interviews to identify barriers to providing the HPV vaccine to adolescents in their practice.

Aim 2

Use key informant interviews to identify the root causes of provider variations and barriers to recommending and administering the HPV vaccine to adolescents in Colorado.

Hypothesis. Significant provider variation and barriers to recommending and administering HPV vaccine for adolescents exist in Colorado among VFC providers due to provider concerns such as their personal discomfort discussing sexually transmitted infections with teens.

Rationale. Because the VFC program provides vaccines free of charge to children, removing the cost burden of the HPV vaccine series, understanding additional factors that influence HPV vaccine ordering and recommendation variations will lead to a better understanding of the challenges providers face in Colorado. Analysis of this qualitative information will provide key information in Colorado that could be used to focus interventions to increase HPV vaccine uptake. Furthermore, hypotheses that emerged from our qualitative results were used to inform Aim 3 analyses.

Aim 3

Understand the contribution of provider, patient, and PCSA characteristics to HPV vaccination rates and test hypotheses informed by the qualitative interviews.

Hypothesis. We expected testable hypotheses to emerge from the qualitative interviews related to patient, provider, and population level factors that could be tested using our quantitative data.

Rationale. The analysis of quantitative data will provide a more general description of how patient, provider, and population level factors influence HPV vaccination rates among adolescents in Colorado. It provides more generalizable information across Colorado to assess whether findings from the qualitative sample pertain to the rest of Colorado. In doing so, the analysis will support or refute some of the conclusions and hypotheses that arise from the qualitative inquiry. In addition, it allows us to control for patient characteristics in a way that was not possible in our qualitative analysis. We can also measure patient trend in HPV vaccination and control for other factors that were not the focus of our qualitative interviews.

Impact

Of all cancers in the world, 7.7% are attributable to HPV (Parkin, 2006). HPV infection causes a significant health and economic burden — about 8 billion dollars annually in the United States — that can be prevented with adequate HPV vaccination (Chesson et al., 2012). Providing immunization for adolescents before their sexual debut is currently the best way to prevent HPV infection and illness. Providers play a central role in the initiation and completion of the HPV vaccination series through conversations with parents and recommendations to vaccinate adolescents with the recommeded three dose of the HPV vaccine series. Understanding barriers, attitudes, and the practice of adolescent HPV vaccination is critical to attaining adequate HPV vaccination rates. Furthermore, understanding the

sources of variations among providers and variations in different regions is paramount to determine and inform policy level interventions.

Significance

HPV-related disease and infection presents a significant amount of cost burden. Of a total cost of 8 billion U.S dollars, about $6.6 billion (82.3%) was for routine cervical cancer screening and follow-up, $1.0 billion (12.0%) was for cancer (including $0.4 billion for cervical cancer and $0.3 billion for oropharyngeal cancer), $0.3 billion (3.6%) was for genital warts, and $0.2 billion (2.1%) was for recurrent respiratory papillomatosis (RRP) (Chesson et al., 2012). Several studies showed that routine HPV vaccination program implementation for adolescents is instrumental in reducing HPV incidence, precancerous lesions, and cervical cancer rates over time (Dee & Howell, 2009; Insigna, Dasbach, & Elbasha, 2007; Shobert, 2012). Economic evaluations also showed that quadrivalent HPV vaccination programs are cost effective compared with cervical cancer screening alone or no vaccination (Elbasha, Dasbach, & Insigna, 2007). Additionally, a study that compared the population-level effectiveness and cost effectiveness of 9- and 4-valent HPV vaccination in the United States found that switching to the 9-valent gender-neutral HPV vaccination program saves money (Brisson et al., 2016). The economic burden of HPV disease can be lessened if providers increase their recommendations or provide high-quality recommendations to parents to vaccinate their adolescents (Gilkey et al., 2016).

Vaccines are a great tool in our fight against infectious diseases. However, challenges are experienced in HPV and other vaccine provision due to population

and delivery system related factors. For an immunization delivery system to be effective, it must address the needs of both the target populations and primary care practitioners (Orenstein, Douglas, Rodewald, & Hinman, 2005). As frontline personnel, providers can influence parents and adolescents in their decision to vaccinate, provide information, and offer advice and vaccinations. From the provider's perspective, factors that influence their delivery of adolescent immunization include: organizational recommendations, vaccine cost and reimbursement, and disease and vaccine characteristics (Humiston et al., 2009). In 2013, parents indicated that one of the top reasons for not vaccinating their adolescent children with HPV vaccine was a lack of provider recommendation for vaccination (Elam-Evans et al., 2014). In addition, data about missed opportunities (during which a teen received at least one vaccine but did not receive the HPV vaccine) demonstrated that if the HPV vaccine was given every time a provider gave the Tdap or meningococcal vaccine, HPV vaccine initiation would be more than 80%. In 2012, if all missed opportunities for HPV vaccination had been eliminated, coverage with ≥ 1 dose of HPV vaccine could have reached 92.6% (CDC, 2013). Therefore, understanding and addressing provider barriers to recommendating the HPV vaccine for their adolescent patient population is critical for increasing HPV vaccination, lowering the HPV infection and disease burden, and lowering the economic burden of HPV. Although provider barriers have been examined in several prior research, this work takes a unique approach by identifying practice level HPV vaccine ordering trends among VFC providers compared to Tdap to capture the perspectives of the providers. This approach then followed the VFC program vaccine

supply differences between practices, asked provider perspectives, and compared that data to actual vaccine uptake among adolescents in Colorado. The VFC Program is a vaccine supply program intended to remove cost barriers for obtaining immunizations among children 18 years of age and younger. This research study will focus on the VFC provider population to understand barriers they face in recommending the 3-dose HPV vaccine to their adolescent population via mixed methods and further test generalizability of findings to different types of providers in Colorado. The literature review in chapter three details currently known research about VFC providers and the gap in knowledge about HPV vaccine trends.

Theoretical Framework and Conceptual Model

Theories of behavioral change provide a framework to understand, design, and evaluate health promotion and disease prevention efforts. We considered several different theoretical models to guide our aims. The Theory of Planned Behavior proposes that the most important determinant of behavior is an individual's intention to perform that behavior (Millstein, 1996). Several studies have shown that there is a strong association between intention and actual behavior (Godin & Kok, 1996; Sheeran & Orbell, 1998). The Theory of Planned Behavior has been used to predict healthcare provider behaviors in preventive health services such as immunization practices (Prislin et al., 1999; Millstein, 1996). Determinants of behavioral intention include the individual's attitudes about performing the behavior, perceptions about the attitudes of other people who are important to that individual, and perceived control over performing the behavior (including barriers to performing the behavior). This model is best used to understand and change periodic behaviors.

This theory has been used to predict HPV vaccine uptake among adult men and women. One study surveyed women aged 18-26 using the Theory of Planned Behavior constructs and assessed their HPV vaccine uptake 10 months later. It found that the Theory of Planned Behavior showed key predictors of uptake (Gerend & Shepherd, 2012). Another study looked at the mother's intentions to vaccinate their daughters against HPV and found that attitudes were the strongest predictor of mothers' intentions to vaccinate, but intentions were low. They also found that risk perceptions were unrelated to intention and that mother's perceptions of their daughter's risk were low (Askelson et al., 2010). Although the Theory of Planned Behavior has some utility in predicting behavior, it has several drawbacks, including assumptions that an individual has acquired the opportunities and resources necessary to be successful in performing the desired behavior, regardless of the intention. It does not account for other variables that factor into behavior intention, such as past experiences. While it does consider normative influences, the theory of planned behavior does not take into account other factors that influence a person's intention to perform a behavior such as economic factors. We examined alternative models because the theory of planned behavior was too restrictive to guide our understanding of variations in HPV vaccine recommendations. First, HPV vaccine recommendations are repetitive rather than a periodic behavior. They are not the result of a simple, one-time linear decision-making process, because the behavior can change over time.

It is essential to understand provider intentions as well as factors that closely influence their intentions to consistently provide HPV vaccine to eligible patients.

Consequently, we looked at the Competing Demands Model, which was originally developed to understand delivery of preventive health services in the primary care setting (Jaén, Stange, & Nutting, 1994). This model was previously used to explain factors that influence physicians' HPV vaccine recommendations (Vadaparampil et al., 2011; Vadaparampil et al., 2014). This model proposes three domains of factors influencing physicians' HPV vaccine recommendations: physician, patient, and practice factors. Physician factors include personal characteristics, knowledge, beliefs, attitudes, and experiences. Patient factors include characteristics such as payment amount and vaccine preferences. Practice factors are the immediate setting in which a physician delivers care (practice size, geographic location, single vs. multi-specialty group). Practice factors can also include issues outside the immediate practice environment, such as state/policy factors that may affect HPV vaccine recommendation (e.g., physician participation in the VFC program). Taken together, these theories provide a useful theoretical framework for identifying key attitudinal and normative beliefs that shape HPV vaccination intentions and ultimately behavior among providers.

This study is grounded in a conceptual model represented in Figure 1, which was adapted from a previously developed conceptual model by Kahn et al. (2007). The model depicts the interrelated factors that impact HPV vaccine recommendation to adolescents. These include professional and personal characteristics, vaccine policies and procedures, awareness of HPV vaccine policies and guidelines, communication about and endorsement of HPV vaccines, perception of likely parental refusal/acceptance of vaccines, general attitudes about vaccines, and

actual vaccine recommendations. We adapted this conceptual framework by adding an essential element of provider perception of likely parental refusal/acceptance of vaccine that could influence communication about and endorsement of the HPV vaccine as well as intention to recommend HPV vaccine. In our aims, we assessed these factors and how they impact HPV vaccine ordering and actual recommendation. We hypothesized that initiation of the HPV vaccine series might depend on VFC provider characteristics (left side of the conceptual model) such as awareness of the vaccine, perception of likely parental refusal/acceptance of vaccine, and consequently recommendation. Additionally, we hypothesized that the completion of the three dose HPV vaccine series might be mainly due to parental/patient factors such as request for vaccines, vaccine cost and insurance coverage (bottom of the conceptual model). Because of these hypothesized different factors affecting initiation and completion of the HPV vaccine, we analyzed these outcomes separately.

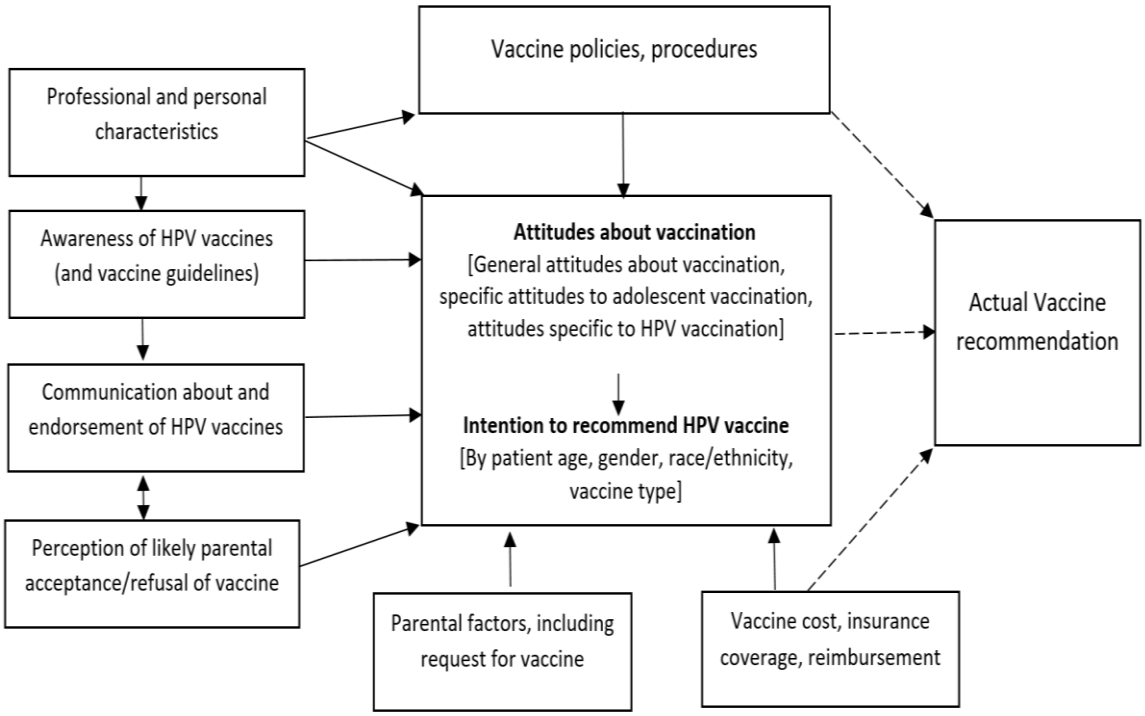


Figure 1: Conceptual model explaining factors influencing provider's intention to recommend the HPV vaccine. Adapted from "Factors influencing pediatricians' intention to recommend human papillomavirus vaccines," by J. A. Kahn, S. L., Rosenthal, A. M. Tissot, D. I. Bernstein, C. Wetzel, & G. D. Zimet, 2007, *Ambulatory Pediatrics, 7,* pp. 367–373. https://doi.org/10.1016/j.ambp.2007.05.010

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter begins by describing human papillomavirus, HPV-associated diseases, current prevention methods for these diseases, and the safety, efficacy, and cost effectiveness of these prevention methods. Next, this chapter discusses previous research that was done related to the three aims of the dissertation proposal, and includes a comprehensive review of literature in the realm of HPV vaccine delivery and patient and provider characteristics that facilitate or hinder the three-dose HPV vaccine receipt among adolescents. The chapter continues by describing the inclusion criteria used to select articles for the different aims. Content of these relevant articles will be summarized. This chapter will conclude with a summary of what is known about the three aims from previous research literature review and how this proposal will fill gaps in the literature.

Literature Search Method

This literature review looked at published articles that focused on the three aims of the proposal. PubMed and Google Scholar were used to search existing published research in the realm of HPV vaccination in the VFC provider population, qualitative research that explored provider challenges and facilitators in HPV vaccine ordering and administration to adolescents, and research that explored regional, patient, and provider level variations in the provision and receipt of the HPV vaccine in Colorado. The literature review was focused on the United States.

Searches were performed using combinations of the following keywords:

- *HPV infection, HPV infection related disease, HPV infection prevention, HPV vaccine, HPV vaccine in Colorado, Barriers to HPV vaccine, Barriers to HPV vaccine in Colorado*
- *HPV vaccine trends in Colorado, variation in HPV vaccine uptake in Colorado*
- *HPV vaccine safety, HPV vaccine effectiveness*
- *Differences in HPV vaccine uptake, disparities in HPV vaccine uptake, HPV vaccine cost effectiveness*
- *Provider barriers to HPV vaccine recommendation, provider barriers to HPV vaccine recommendation in Colorado*

This search yielded hundreds of citations. To further examine this evidence base and identify foundational work for this research study, only studies published in the past 10 years were reviewed. This criterion was established because more recent studies tend to employ more rigorous research methods and present a more accurate assessment of contemporary patterns of variation in the HPV vaccine. Furthermore, the HPV vaccine has been in the market since 2006, making the existing research relatively current by default. We ensured that the research articles were:

- Publications in peer-reviewed journals
- Not studies focused on detailed HPV cellular level infection discussion

- Only studies whose primary purpose was to examine variation in HPV vaccine compared to other adolescent vaccines

Research studies and publications that met these criteria were selected. The researcher read the abstracts to ensure it would be of interest and proceeded. Many of the findings and relationships between these studies are summarized next in this chapter.

Human Papillomavirus

There are nearly 200 recognized, distinct strains of HPV, and each is associated with a specific set of clinical lesions that are associated with a spectrum of diseases (Ljubojevic & Skerlev, 2014). Infections with different strains result in different skin appearances and malignancies. Some HPV strains can cause warts (papillomas), while other types can lead to cancer, especially cervical cancer (CDC, 2015). HPV can affect any area on the skin and mucous membranes. HPV is the most common sexually transmitted virus in the United States and is transmitted through intimate skin-to-skin contact (CDC, 2015). A person can get HPV by having vaginal, anal, or oral sex with someone who has the virus. HPV is so common that nearly all sexually active men and women are infected with it at some point in their lives (CDC, 2015). HPV can be passed even when an infected person has no signs or symptoms. One can develop symptoms years after having sex with someone who is infected, making it hard to know when one first became infected (CDC, 2015). About 79 million Americans are currently infected with HPV and about 14 million people become newly infected each year, making HPV infection costly. (Chesson et al., 2012).

HPV-Associated Diseases

Most HPV infections resolve spontaneously on their own but some persist and can cause cell changes in the infected area. There is no way to pre-determine whether individuals infected with HPV will develop diseases, such as warts or cancer, or remain asymptomatic. (CDC, 2015). When the HPV infection is symptomatic, the majority of clinically apparent anogenital warts are caused by HPV genotypes 6 or 11 and are infrequently associated with high risk types of HPV. If left untreated, warts can spontaneously regress or continue to increase in size (Ljubojevic & Skerlev, 2014).

The most common HPV-associated cancer among women is cervical cancer, whereas among men it is oropharyngeal cancers (cancers of the back of the throat, including the base of the tongue and tonsils) (CDC, 2015). From 2006-2010, about 33,000 HPV-associated cancers (22,000 among women and 12,000 among men) occurred in the United States each year. In general, it is believed that HPV also is associated with approximately 91% of cervical cancers; 90% of anal cancers; 40% of penile, vaginal, and vulvar cancers; 25% of oral cavity cancers; and 35% of oropharyngeal cancers (Parkin, 2006; Gargano et al., 2006; Steinau et al., 2013).

Significantly increased trends in HPV-associated oropharyngeal cancers have been shown between years 1983 to 2002, mostly in developed countries and at younger ages (Chaturvedi et al., 2013). The prevalence of oral HPV infection in the United States was 6.9% in 2010, and the prevalence was higher among men than among women (Gillison et al., 2012). Incidence rates for most cancers are on the decline but two HPV-associated cancers, oropharynx and anus, are on the rise

(Jemal et al., 2013). These numbers emphasize the role HPV infection plays in increasing the incidence of oropharyngeal cancers, particularly among men (Chaturvedi et al., 2013).

Disparities in HPV Infection

There are documented racial, ethnic, and income disparities in the rates of HPV and high-risk HPV (cancer-causing) infection. A previous study that looked to examine whether socio-demographic characteristics were associated with HPV prevalence found that poor women, Mexican American women, and unmarried women were more likely to test positive for HPV (Kahn et al., 2007). This disparity in infection shows the need for attention in this population to ensure HPV vaccine coverage reaches optimal levels. This study underlined the need for focused intervention efforts to ensure low-income men and women have access to preventive services, including HPV vaccination.

HPV causes several types of cancers, and some ethnic minorities have higher rates of these cancers. Black men have higher rates of anal cancer than white men, Hispanic men have higher rates of penile cancer than non-Hispanic men, and women of color are often diagnosed with cervical cancer at a later stage than white women, which makes it difficult to treat (Freeman & Wingrove, 2005).

Hispanic women get cervical cancer at the highest rate compared to other groups, but Black women have the highest rates of dying of cervical cancer (U.S. Cancer Statistics Working Group, 2013), and they also have higher rates of vaginal cancer than women of other races (McCarthy, Dumanovsky, Visvanathan, Kahn, & Schymura, 2010). Because of this drastic disparity in infection and disease

developments rates, providing increased HPV vaccination is vital to prevent HPV infection and further disease (CDC, 2016). Fewer HPV infections mean healthier communities — especially in those communities most impacted by HPV — and that can be achieved by high HPV vaccination rates.

Current HPV Infection Prevention Methods

Currently, there are vaccinations to prevent infection with HPV, screening tests to identify if cells are infected with HPV, and counseling regarding safe sex to decrease risk of infection with HPV. However, condoms are not fully protective of HPV infection because of the skin-to-skin contact transmission of the virus.

Vaccination

There are three vaccines that can prevent infection with the most common types of HPV, and these are given in three doses over a six-month time period or two doses if initiated before a patient's 15th birthday. The three types of HPV vaccines are licensed by the Food and Drug Administration (FDA) and include the quadrivalent HPV vaccine for HPV types 6,11,16,18 (Gardasil-licensed for females in June 2006 and males in October 2009), bivalent HPV vaccine for types 16, 18 (Cervarix-licensed in October 2009), and 9-valent vaccine for HPV types 6,11,16,18, 31, 33, 45, 52, 58 (9vHPV-licensed December 2014). Currently, the 9vHPV vaccine is used widely in the United States, which protects against more HPV strains.

The Advisory Committee on Immunization Practices (ACIP) originally recommended administration of a 3-dose series of the HPV vaccine on a schedule of 0, 1-2, and 6 months to all adolescents aged 11 through 12 years. Currently, two doses of HPV vaccine are recommended for people starting the vaccination series

before the 15th birthday. The second dose is recommended 6-12 months after the first dose (0, 6-12 month schedule). Catch-up regimens of the vaccine series are recommended for females with the bivalent, quadrivalent or 9-valent vaccine, and for males with the quadrivalent and 9 valent vaccines at age 13 through 26 years for females and males through age 21 and up to age 26 in high risk males, if not previously vaccinated (CDC, 2016; Petrosky et al., 2015). The bivalent, quadrivalent, and 9-valent HPV vaccines may be used for females, and only the 9-valent or quadrivalent HPV vaccines may be used for males. In June 2006, Gardasil, a recombinant HPV vaccine for protection against HPV types 6, 11, 16, and 18, was licensed for use among females aged 9-26 years for the prevention of HPV-type-related cervical cancer, cervical cancer precursors, vaginal and vulvar cancer precursors, and anogenital warts (Markowitz et al., 2007). The bivalent vaccine prevents against infection with HPV types 16 and 18, which cause 70% of cervical cancers, and it is licensed for use in females aged 9 through 25 years (Markowitz et al., 2014). In 2014, the FDA approved the use of the 9-valent vaccine for HPV types 6,11,16,18, 31, 33, 45, 52, and 58 for girls 9-26 years of age and boys 9-15 years of age.

HPV vaccines are most effective when given at 11 or 12 years of age for both boys and girls. This is because optimal vaccine efficacy is derived if the vaccine is administered before the onset of sexual activity when exposure is likely to occur. Also, antibody responses are highest among children ages 9 through 15 years, although the clinical significance of this is not known (CDC, 2002). The HPV vaccine is inactive against HPV strains previously acquired by the vaccine recipient

(Committee on Infectious Diseases, 2012). Because of this, early vaccination of adolescents is important to ensure protection.

Screening for HPV-Associated Infections

Other than vaccination, the other method of HPV-associated severe disease prevention is regular screening tests for early detection of precursors to cervical cancer (Hairi, Dunne, Saraiya, Unger, & Markowitz, 2014). Cervical cancer is the easiest gynecologic cancer to prevent with regular screening tests and follow-up. However, cervical cancer screening guidelines by the American Cancer Society recommend that for average-risk women, screening should begin at age 21 regardless of the age of sexual initiation or other risk factors (CDC, 2016). Two screening tests can help prevent cervical cancer or find it early. One is the Pap test, which looks for pre-cancers or cell changes on the cervix that might become cervical cancer if not treated appropriately. Pap tests are recommended for all women ages 21-65 years old. According to a 2016 CDC report, the Pap test is one of the most reliable and effective cervical cancer screening tests available. The second test is the HPV test that specifically looks for the virus that can cause these cell changes. Pap test samples can be used to test for HPV-associated cancers and can be specifically requested if an individual is interested in knowing their status (CDC, 2016). However, these screening tests do not prevent individuals from acquiring the HPV infection, leaving vaccination as the best strategy to prevent HPV infection. The fact that the screening test is only recommended for women 21 years of age and older means that younger individuals with an HPV infection might not be identified until later in the infection stage.

Other HPV Prevention Methods

Other methods that may reduce likelihood HPV infection include counseling adolescents about abstinence, and safe sex practices, including proper condom use. However, because of the skin-to-skin contact transmission of HPV, condoms are not reliable in preventing HPV infection. There is also evidence that indicates circumcision of males reduces the risk of HPV infection. However, these methods are imperfect because HPV is transmitted through skin-to-skin contact (American Academy of Pediatrics [AAP] Task Force on Circumcision, 2012; AAP Committee on Adolescence, 2001).

Vaccine Safety and Efficacy

HPV vaccine safety and efficacy has been established by several studies. Among women who had not been previously exposed to targeted HPV types, the bivalent vaccine efficacy study showed 93% vaccine efficacy in preventing cervical precancers due to HPV 16 or 18. Bivalent vaccine efficacy was 91.6% against incident infection and 100% against persistent infection. All studies of the bivalent HPV vaccine showed that 99% of females developed HPV 16 and 18 antibody response one month after completing the 3-dose series. Over 99% of vaccinated girls in these studies developed antibodies after vaccination. The vaccine was generally safe and well tolerated (Harper et al., 2004).

Another study looked at the efficacy of the quadrivalent HPV vaccine and concluded that the vaccine could substantially reduce the acquisition of infection and clinical disease of HPV types 6,11,16, and 18. The vaccine is 90% effective against

these four types of HPV (Villa et al., 2005). The vaccine was generally considered safe and well tolerated.

Joura and colleagues looked at the efficacy and immunogenicity of the 9-valent HPV vaccine and concluded that the vaccine prevented infection and disease related to HPV-31, 33, 45, 52, and 58 in a susceptible population, and generated an antibody response to HPV-6, 11, 16, and 18 that was non-inferior to that generated by the quadrivalent HPV vaccine (Joura et al., 2015; Petrosky et al., 2015). Safety also has been evaluated in this vaccine and was well tolerated other than injection site pain, swelling, and mild to moderate erythema (Petrosky et al., 2015).

Cost Effectiveness of Current Vaccinations

Several studies assessed the cost effectiveness of providing quadrivalent or bivalent vaccines compared to cervical cancer screening or no vaccination at all, and concluded that vaccinating with either vaccine is cost effective compared to no vaccination (Elbasha, 2007). Furthermore, studies that compared the cost effectiveness of the bivalent to the quadrivalent HPV vaccine concluded that the bivalent HPV vaccine needs to be 22% cheaper than the quadrivalent vaccine because it protects against fewer HPV types than the quadrivalent vaccine (Dee & Howell, 2010; Jit, Chapman, Hughes, & Choi, 2011).

Because the quadrivalent vaccine was primarily a female-only vaccine and males were added later, the cost effectiveness of male vaccination is affected by different conditions, including the vaccine coverage of females, different health outcomes, vaccine efficacy, and quality of life impacts from HPV disease (Kim & Goldie, 2009; Elbasha & Dasbach, 2010; Chesson, Ekwueme, Saraiya, Dunne, &

Markowitz, 2011). With low vaccine uptake among females and majority heterosexual transmission of HPV, immunization of males is a cost-effective solution for preventing HPV-associated disease in both genders.

A recent study that looked at incremental costs and benefits of the 9-valent HPV vaccine compared with the quadrivalent HPV vaccine for both sexes concluded that a vaccination program of the 9-valent vaccine for both sexes can improve health outcomes and can be cost-saving (Chesson, Markowitz, Hariri, Ekwueme, & Saraiya, 2016). In 2015, the ACIP recommended the 9-valent HPV vaccine for routine immunization. Therefore, the cost effectiveness of HPV vaccines compared to no vaccination at all has been established, and vaccinating with any of the three vaccines is considered beneficial compared to not vaccinating or relying only on available screening tests.

HPV Vaccination Rate

The national immunization survey for teens in the United States showed that in 2016, the HPV vaccination rate lags behind that of the other two recommended adolescent vaccines, Tdap and MCV4. In Colorado, only 58% of females and 33.5% of males have received ≥ 1 dose of HPV vaccine (Centers for Disease Prevention and Control [CDC], 2013b). In 2015, the three-dose HPV vaccine has been received by 46% of girls and 37% of boys in Colorado (CDPHE, 2017). Healthy People 2020 vaccination targets for adolescents aged 13–15 years were reached in 42 states for Tdap and 18 states for meningococcal. However, no state met the target for three HPV doses (Elam-Evans et al., 2014). There is a significant gap in immunization among adolescents with the recommended three doses of the HPV

vaccine. In 2013, one of the top five reasons parents discussed for not vaccinating their adolescents with the HPV vaccine was because it was not recommended by a provider (Stokley et al., 2014). This gap shows a need to focus efforts to increase immunization with the recommended 3-dose HPV vaccine to protect individuals against HPV infection, and to find ways to support providers to improve vaccine coverage by providing strong recommendations to parents of adolescents.

Low vaccination coverage among adolescents and documented increases in incidence rates of some HPV-associated cancers underscore the need for additional prevention efforts for HPV-associated cancers, and especially for efforts to increase vaccination coverage. This is of additional importance in minority and poor communities due to the prevalence of high-risk HPV infections and associated increased death. In these communities, improved HPV vaccine coverage is essential for protection from HPV associated infection and further diseases.

Vaccines for Children Program

The VFC Program is a vaccine supply program that allows enrolled health care providers to give ACIP-recommended vaccines to eligible children. The intent is to remove cost as a barrier from receiving timely immunizations. VFC is considered one of our nation's most successful public-private partnerships for improving public health (CDC, 2015). A child is eligible for the VFC Program if he or she is younger than 19 years of age and is one of the following: Medicaid-eligible, uninsured, underinsured (FQHC only), and Native American or Alaska Native (CDC, 2015).

VFC was created by the Omnibus Budget Reconciliation Act of 1993 and was implemented a year later in 1994. It was created to ensure that children who qualify

for the program do not contract vaccine preventable diseases due to their inability to afford the vaccine. This program was created in part due to the 1989-1991 measles resurgence in the United States.

A 2014 analysis looked at the benefits of immunization during the VFC program era from 1994-2013 and found that among 78.6 million children born during this time period, routine childhood immunization was estimated to prevent 322 million illnesses (averaging 4.1 illnesses per child) and 21 million hospitalizations (0.27 per child) over the course of their lifetimes, and avert 732,000 premature deaths from vaccine-preventable illnesses (Whitney, Zhou, Singleton, & Schuchat, 2014). Routine childhood vaccines that were introduced during the VFC era (excluding influenza and hepatitis A) together will prevent 1.4 million hospitalizations and thousands of deaths (Whitney et al., 2014). VFC program has been instrumental in attempting to remove cost of vaccines as a barrier and making vaccines affordable for children who need and qualify for it.

Enrollment in VFC. Providers who are interested in becoming a VFC provider must agree to follow VFC program requirements. There are requirements about vaccine handling and storage as well as about screening and documentation of individuals for eligibility at each immunization visit. The program requirements around storage and handling reflect best practices to protect and safeguard vaccines. Additional requirements to screen and document eligibility for VFC vaccines ensure stewardship and accountability for vaccines purchased with federal tax dollars (CDPHE, 2016). VFC providers must also complete two annual trainings.

Providers enrolled in the VFC program are responsible for ordering appropriate amounts of vaccines and maintaining proper vaccine inventory. The amount of vaccines needed for a practice is based on the number of VFC-eligible children seen in a practice as reported on the Medical Practice Profile and validated by KIDS Plus Immunization Information Systems. This is a confidential, population-based, computerized system that collects and disseminates consolidated immunization information.

Opportunities with the VFC Program. The ability of the VFC program to remove financial and logistical barriers hindering vaccination for low-income children likely played a significant role in obtaining the current coverage rates, near or above 90% coverage for many vaccines (Whitney et al., 2014). However, there is room to improve when it comes to HPV vaccines. A 2009 study looked at the vaccination coverage among U.S. adolescents eligible for the VFC program and found that vaccination coverage was only 46.6% for at least 1 dose of the quadrivalent HPV vaccine compared to 43.2% for the non-VFC-eligible population (Lindley, Smith, & Rodewald, 2011). Even though there is a slightly increased coverage among the VFC eligible population, it is nowhere near the desired immunization coverage of 90% or more. Additionally, VFC program also serves low-income communities who are at high risk for HPV infection and associated morbidity and mortality. Furthermore, this 2009 study shows that there is more to be explored than the cost of the vaccine alone in the VFC population to explain the low vaccine coverage. VFC's ability to provide vaccines for poor families makes it an invaluable program suited to remove HPV infection and high-risk HPV infections. As Holman and

colleagues found in the systematic review about barriers to HPV vaccine coverage, both health care professionals and parents cited financial concerns (reimbursement for providers and out-of-pocket cost to patients) as one of the barriers to provision and receipt of HPV vaccine for adolescents (Holman et al., 2014). Understanding what other factors affect low HPV vaccine coverage among VFC providers is important. Data regarding missed opportunities for vaccination (during which a teen received at least one vaccine but did not receive the HPV vaccine) showed that if the HPV vaccine was given every time a provider gave the Tdap or meningococcal vaccine, HPV vaccine coverage would be more than 80% (CDC, 2013b). Reasons cited by parents for not vaccinating or not planning to vaccinate their adolescent include lack of knowledge about the vaccine, a belief that the vaccine is not necessary, concerns about the safety of the vaccine and side effects, that it was not recommended to them by their provider, and that their adolescent is not sexually active (Stokley et al., 2014). Because providers are frontline personnel in recommending immunizations for their patient population, focusing on understanding reasons why vaccines were not recommended to their adolescent population seems to be important for improving HPV vaccine coverage.

Barriers and Facilitators to HPV Vaccination

Several provider barriers to adolescent HPV vaccination have been discussed and documented. Providers identified multiple factors that impeded HPV vaccination, including vaccine safety concerns, a low perceived severity of HPV disease, lack of school mandates, and policies against co-administration of HPV and meningococcal vaccines (Perkins & Clark, 2012b). One study discussed that perceived parental

misconceptions may act as barriers, and include the belief that adolescents do not need vaccinations (only younger children do), and that programs such as Vaccines for Children are only available for younger children (Javanbakht et al., 2012). A different study that looked at providers' attitudes towards immunizing males with the HPV vaccine found that providers who did not offer vaccination believed that parents would not be interested in vaccinating sons. Furthermore, they were largely unaware of serious HPV-related diseases in males (Perkins & Clark, 2012a).

Additionally, some providers discussed financial concerns and insurance coverage and reimbursement issues as barriers to providing HPV vaccines (Luque, Raychowdhury, & Weaver, 2012; Malo et al., 2013). Malo and colleagues found that the VFC status of providers remained significantly associated with the barriers regarding lack of adequate reimbursement for vaccination (Malo et al., 2013). Another study looked at VFC provider challenges to providing vaccines in rural settings and found that there were cost issues related to stocking the vaccines and reaching a target community (Luque et al., 2012). The financial barriers to HPV provision among some providers, coupled with parental attitudes towards HPV vaccine, could create the perfect environment for lower HPV vaccine administration, especially in communities serving high-risk individuals. This combination of parental refusal, lack of knowledge about vaccine benefits for adolescents, as well as VFC provider-related reimbursement and stocking challenges in rural clinics, impact how and when providers offer the HPV vaccine to their adolescent population.

In 2013, parents discussed the top five reasons for not vaccinating their adolescents with the HPV vaccine. For their adolescents girls, these reasons

included lack of knowledge (15.5%), not needed or necessary (14.7%), safety concern/side effects (14.2%), not recommended (13.0%), and not sexually active (11.3%). For their adolescent boys, the reasons included not recommended (22.8%), not needed or necessary (17.9%), lack of knowledge (15.5%), not sexually active (7.7%), and safety concern/side effects (6.9%) (Stokley et al., 2014). Additionally, a more recent study that looked at why adolescents do not complete their HPV vaccine series interviewed parents and providers and found that the failure to complete the HPV vaccine series occurred because providers expected parents to make appointments while parents expected to be reminded (Perkins et al., 2016). Poor communication about expectations created missed opportunities for HPV vaccination. This shows that among other reasons, providers have an enormous opportunity to recommend the HPV vaccine for both boys and girls, to remind parents, and to address some concerns these families might have with HPV vaccine during their visit. Addressing these interconnected barriers to HPV vaccine uptake is crucial to improve HPV vaccine rate among adolescents.

Previous qualitative studies documented several facilitators to HPV vaccination, including certain processes and procedures in place at clinics such as the availability of an immunization registry system, provision of additional information regarding the HPV vaccine, verification of vaccines by non-physician staff, family history, especially of mothers' abnormal Pap or cervical cancer, and supportive family and friends (Javanbakht et al., 2012). This study also discussed the need for tailored community support for different populations, such as using *promotoras*-peer liaisons to drive HPV immunization rates among Spanish-speaking populations.

The current vaccination rate with the recommended three-dose HPV vaccine is low in Colorado (NIS teen, 2014). In 2015, the three-dose HPV vaccine had been received by 46% of girls and 37% of boys in Colorado (CDPHE, 2017). VFC providers play a vital role in providing vaccines for adolescents who are high risk. Although there are some reimbursement issues cited by previous studies with VFC providers, there has not been a study that looked at VFC provider barriers to HPV vaccination in Colorado. This study will add to the literature by identifying VFC provider challenges, facilitators, and opportunities to HPV vaccination.

Variation in HPV Vaccine Uptake

Inequalities in the uptake of HPV vaccination exist among different races, geographic locations, rural/urban areas and genders. A systematic review and meta-analysis conducted in 2013 looked at studies that compared HPV vaccination initiation and/or completion by at least one ethnicity or socioeconomic-related variable in adolescent young women. They found evidence of differences in HPV vaccination initiation by ethnicity and healthcare coverage (Fisher, Trotter, Audrey, MacDonald-Wallis, & Hickman, 2013). Receipt of a health professional's recommendation to vaccinate is strongly associated with vaccine uptake; however, the odds of receiving a recommendation are negatively associated with low socio-economic status and Black racial/ethnic status (Polonijo & Carpiano, 2013). We expect to see a similar trend in our Colorado population.

Perkins and colleagues looked at a comparison of factors associated with HPV and meningococcal vaccination among adolescent girls and found provider recommendation of HPV vaccine was different for girls of different races (Perkins,

2014). This study further solidifies the need to understand what sources of variations in HPV vaccine receipt and recommendation exist, if any, in Colorado. Recent studies found that higher rates of HPV vaccine initiation are associated with urban residence and physician recommendation (Holman et al., 2014). Many Colorado counties are in mountain and rural regions, so understanding HPV vaccine receipt variations is essential to address vaccine coverage issues in these regions (Colorado Rural Health Center, 2016).

Previous studies have used regression decomposition techniques to identify sources of variations among immunization recipients and the extent to which those sources contribute to the observed disparities. O'Malley and colleagues looked at immunization disparities in older Americans and found that despite similarities in insurance coverage and usual care by a physician, Black beneficiaries were significantly less likely than their white counterparts to receive influenza and pneumococcal vaccinations (O'Malley & Forrest, 2006).

Gaps in the Literature

Although there are some data indicating financial issues VFC providers face in stocking vaccines in other regions, there has not been a study that looked at VFC provider barriers to HPV vaccination in Colorado. Because of Colorado's vast geographical variation, understanding rural, plains, and urban VFC provider barriers to ordering, recommending and administering HPV vaccine needs to be assessed to properly address challenges they face. This study will add to the literature by identifying VFC provider challenges, facilitators, and opportunities to HPV vaccination.

To our knowledge, there has not been a study that looked at provider HPV ordering data to understand variation and intention to vaccinate adolescents. This study uses a unique approach to understand HPV vaccine variation trends in Colorado. This variation data will inform the qualitative inquiry to explore in-depth the reasons behind provider and regional variations and the barriers they see that hinder HPV uptake. This approach is unique in that it fills the gap in the literature to understanding the Colorado HPV vaccination landscape. Understanding the reasons behind HPV vaccine ordering and receipt variations is key to identifying barriers and addressing them to improve low immunization rates. Furthermore, testing the different hypothesis that emerge from qualitative data using claims data is important for generalization in the larger population.

Summary

In summary, HPV-associated disease is deadly and costly to those affected. Because of its transmission through skin-to-skin contact, the burden of disease is high. Vaccines that protect against the most common strains of HPV infections exist and are available starting at adolescence. However, vast challenges exist in closing the coverage gap for the HPV vaccine. Some barriers to adequate immunization include provider factors (reimbursement, lack of recommendation, etc.) and parental factors (vaccine refusal). The VFC program aimed at removing cost as a barrier has been providing free vaccines for children via participating providers. However, vaccine coverage in this population is as inadequate for HPV as it is for the non-VFC eligible population. There is more work that needs to be done to understand practice variations in HPV vaccine ordering compared to other adolescent vaccines,

understanding variations in provider barriers to recommending the HPV vaccine to their adolescent population, and disparities in HPV uptake and factors that contribute to these disparities in uptake in Colorado.

CHAPTER III

METHODOLOGY

Introduction

Colorado is one of the states that lags in achieving the needed vaccination rate for HPV prevention for their adolescents. The 2013 National Immunization Survey filed by the CDC found that the HPV rate lags behind the other two recommended adolescent vaccines, Tdap and MCV4. This project applies mixed methods to understand provider variations in HPV vaccine practices and identify the barriers and facilitators providers face in recommending and administering HPV vaccine to their adolescent population. We also examine patient factors that explain variation in uptake among groups.

The purpose of Aim 1 is to identify geographic areas and VFC provider sites that are high and low performing in terms of HPV vaccine ordering relative to Tdap vaccine-ordering ratio. The practices identified in Aim 1 were used as the qualitative samples in Aim 2 to apply qualitative methods to gather in-depth information as to why variation in HPV vaccine-ordering rates exist. This approach enabled us to understand providers' experience and discuss their perspective about HPV immunization rates in their adolescent population. To date, there has not been a mixed methods study done in Colorado that looked at VFC providers' HPV vaccine-ordering ratio.

The purpose of Aim 3 was to test the hypotheses that arose from Aim 2 and confirm or refute findings. We expected population, patient, and provider level variation in HPV vaccine recommendation and receipt in Colorado. We analyzed All

Payer Claims Data (APCD), PCSA data, Association of Religion Data Archives (ARDA) data and VFC ordering data in Colorado to examine initiation and completion of the HPV vaccine series. We analyzed these outcomes using logistic regression and performed a regression decomposition to understand the main determinants of differences in HPV vaccination rates across different populations to inform future interventions and policies.

In sum, this research study used mixed methods to uncover variations in HPV vaccine recommendations, initiation, and completion of the 3-dose HPV vaccine. Integrating mixed methods in health services research delivery is important and timely. When researchers gather data directly from system leaders and practitioners, it provides opportunities to better understand stakeholder perspectives. Mixed methods have the capacity to capture the experiences, emotions, and motivations of people delivering healthcare, as well as the objective conditions of healthcare delivery. Furthermore, mixed methods allow for full engagement of policy makers and practitioners in understanding current healthcare delivery for comprehensive policy implications of the findings (Miller, Crabtree, Harrison, & Fennell, 2013).

Research Design and Methods

Aim 1. Identify geographic areas and VFC provider sites that are high and low performing in terms of HPV vaccine relative to TDAP vaccine-ordering ratio.

Previous studies have shown that there is a gap nationally in administering HPV vaccines compared to other adolescent vaccines. This aim explores to what extent the trend holds in Colorado, and if so, how prevalent the issue is among VFC providers. VFC data provided information, including how HPV vaccine ordering

compares with other adolescent vaccines such as Tdap. This information was then used to compare providers who order the HPV vaccine versus those who do not, and to infer Colorado HPV vaccine administration and provider recommendation based on statewide representative samples.

Data source. VFC data from over 500 VFC providers with clinics ranging in size from 2-200 providers were analyzed from the period 2012-2015, consisting of adolescent vaccine (HPV, Tdap, and meningococcal vaccines) ordering information in Colorado. The data included provider name, vaccine type, ordering intention, quantity of vaccine ordered, unit price per vaccine type, and net value of the vaccine ordered.

Primary Care Service Area. Practice location was used to identify the practice's catchment area using the PCSAs defined by the Dartmouth Health Atlas (Dartmouth Institute for Health Policy and Clinical Practice, 2016). These data were used to meet Aim 1 and to determine Aim 2 qualitative interview participating providers. PCSA was used to identify areas with low supply of primary care and safety net providers, and populations with relatively high health risk. At the heart of the data are 6,542 areas defined by aggregating ZIP codes to reflect patient travel to primary care providers. These geographic markets of primary care are linked to hundreds of measures relevant to improving the availability of primary care services.

Data analysis. Using VFC data, we conducted descriptive analysis by examining provider-specific versus PCSA-specific factors that explain variations in the percent of HPV vaccines ordered in Colorado. The PCSA offers data and

analytic tools to identify primary care provider supply and needs in communities across the United States, with areas that reflect patients' travel to primary care. Our primary outcome of interest in this aim is VFC providers' intention to provide the HPV vaccine. Intention to provide the HPV vaccine was defined as a VFC participating provider ordering the HPV vaccine at the same rate as other adolescent vaccines.

Benchmarking HPV ordering ratio patterns compared to other adolescent vaccines was performed using VFC ordering data. Providers from practices whose HPV vaccine-ordering ratio was low were sampled, as were PCSAs for the qualitative key informant interviews to understand current barriers and facilitators to recommending and administering the HPV vaccine. We calculated the percent of HPV vaccines ordered compared to the Tdap vaccine to determine the HPV ordering ratio for each provider and separately for PCSAs using the equation:

$$\% = \% \, \boldsymbol{HPV\ ordering\ ratio}_{A} = \frac{\textbf{Total order of HPV Vaccine at Clinic(or PCSA)}_{A}}{\textbf{Total order of Tdap Vaccine at Clinic (or PCSA)}_{A}} * 100\%$$

The Tdap vaccine was used for benchmarking instead of meningococcal vaccine because Tdap is a school required vaccine that has reached many more adolescents than the meningococcal vaccine. It is a vaccine in the adolescent immunization platform that has been received relatively well and one that the HPV vaccine should aspire to reach or surpass.

Total variance across all providers and PCSAs was calculated to determine within and across PCSA variations. We expected to see large variations in HPV vaccine-ordering ratio.

HPV ordering ratio was then ranked and quartiles were computed and identified (Kohler, 2005). We categorized providers and their PCSAs as follows: high provider/high PCSA, low provider/high PCSA, high provider/low PCSA, low provider/low PCSA.

This provider sample was used for the Aim 2 qualitative study key informant selection. Once we identified the potential sample for Aim 2, we contacted individuals to set up a one-on-one phone interview to understand the extent that variation in HPV recommendation and provision is explained by practice/provider and regional factors.

Aim 2. Through key informant interviews, identify root causes of provider variations and barriers to recommending and administering the HPV vaccine to adolescents in Colorado. Awareness of vaccines and national vaccine recommendations precede the formulation of attitudes about HPV vaccination, which in turn influences actual vaccine recommendations. Several factors, including provider characteristics and communication about vaccines with patients and their families affect awareness (see figure 1). Factors that directly impact attitudes about HPV vaccine recommendation include provider characteristics, communication, perception of parental refusal/acceptance, vaccine policies and procedures, vaccine cost, and parental factors.

Methods. Using an adopted grounded theory approach, key-informant interviews were conducted from October 2016 to March 2017 from providers in the three different categories: low practice-high PCSA, high practice-low PCSA, and low practice-low PCSA. In-depth, key informant interviews were conducted with 25

providers including those with backgrounds in public health nursing, as well as primary care providers, nurse practitioners, and physician assistants. The interviews lasted 30-60 minutes with each provider. These providers were identified in Aim 1, using their HPV vaccine-ordering ratio. The interviews were completed over the phone, were recorded and transcribed by a professional transcriptionist, and validated by the researcher to ensure data accuracy and agreement with the voice recording.

The interview guide questions were designed to explore:

1. Provider perceptions, barriers, and facilitators to HPV vaccine recommendation and uptake compared to other adolescent vaccines
2. Provider understanding of parental decision-making, and to understand factors that influence parental willingness to vaccinate their adolescents
3. Any emerging themes that depict the changing landscape of HPV vaccination in Colorado

Data analysis. We followed the analysis strategy described by Miller and Crabtree (1999). This approach included five phases that are described below and outlined in Table 1. Data analysis and management was conducted using Nvivo 10. The grounded theory approach allowed us to explore existing areas of interest in HPV vaccination for adolescents in Colorado while allowing for participants to introduce new themes and factors they feel are important to HPV vaccination of adolescents.

After completing each interview, our initial phase involved reading all transcripts and writing memos to capture salient factors and themes discussed by

each provider. Our second phase involved the development of preliminary codes to identify and organize key themes and factors, and coding revisions to compare, reconcile, and validate codes and themes. The researcher and a colleague initially double-coded one transcript and then met to discuss and clarify meanings of codes and discuss themes and codes that emerged from the data. Inconsistencies and disagreements were resolved using a consensus-based process. Subsequent transcripts were coded using the initial codebook but emergent themes and codes were added as they emerged from the data. This iterative process continued until no additional themes emerged. The researcher and colleague then double-coded two additional transcripts to ensure coding consistency. Coding agreement between the researcher and colleague was assessed using percent agreement and kappa statistics (≥ 0.4).

After each transcript was coded, our third phase involved discovery of themes and patterns, and making linkages between themes and categories. Codes were summarized and integrated to tie together different themes that emerged across different practices. Preliminary synthesis was shared with the research mentor and research committee members with HPV vaccine-related research expertise to further validate the codes developed and the themes identified. Connections within and between our qualitative findings and quantitative findings were hypothesized for further exploration.

Our fourth phase was to generate findings and conclusions from the interpretation and synthesis of the qualitative findings. We compared our findings with previous published research to validate, solidify our conclusions, and explain

variations if any emerged. This process involved the researcher's review and validation and expert review from this research study's committee members. At this stage, the researcher identified ways in which generalizability of initial findings and additional insights into the themes and factors we identified relate to the Aim 3 analysis.

The final phase in our analysis involved identifying the most meaningful ways of disseminating the results of this research study, including this dissertation write-up.

Aim 3. Understand the contribution of providers, patients, and PCSA factors to disparities in HPV vaccination rates and to test any hypothesis generated by the qualitative interviews. We expected to find disparities by race, ethnicity, provider type (i.e., primary care versus other types of providers), and PCSA. Hypotheses we expected to emerge from qualitative interviews included regional, patient-level and provider-level variation in HPV vaccine recommendations and receipt in Colorado.

Research outcomes of interest for Aim 3 were:

- Receipt of at least one dose of the HPV vaccine (HPV initiation)
- Completion of 3 doses of the HPV vaccine (HPV completion)
- Completion of 3 doses of the HPV vaccine (HPV completion), conditional on HPV initiation
- HPV initiation and completion by Medicaid-insured Hispanic and non-Hispanic adolescents (decomposition between the two groups)
- HPV initiation and completion by publicly-insured and non-publicly insured adolescents (decomposition between the two groups)

Table 1: Five-Phase Data Analytical Process

Phase	Analytical Process
1. Describing	Read transcripts in detail and described factors related to the various phenomena seen. Involved memo writing using individual key informant interview to describe each participant's perspective.
2. Organizing	Involved the development of preliminary codes to identify and organize key themes and factors, and coding revisions to compare, reconcile, and validate codes and themes. Helped in the development and application of a static codebook.
3. Connecting	Reviewed the coded text for discovery of themes and patterns, and making linkages between categories to draw on connections within and between our qualitative findings and quantitative findings or analysis plans. This process involved PI validation and colleague review.
4. Determining validity	Generated findings and conclusions from the interpretation and synthesis of my qualitative findings. Compared findings with previous published research to validate, solidify my conclusions and explain variations if any emerged.
5. Representing the account	Identified ways of sharing understandings and interpretations, found ways to represent an account of what has been learned in the research in a meaningful way.

Adapted from "Integrating Mixed Methods in Health Services and Delivery System Research," by W. L. Miller, B. F. Crabtree, M. I. Harrison, & M. L. Fennell, 2013, *Health Services Research, 48,* p. 53. Copyright 2013 by the Health Research and Educational Trust.

Vaccine receipt was defined in the APCD data as a claim for HPV vaccination given to children aged 11-18. Completion of the full course of HPV vaccination only considered unique claims that did not occur on the same date.

A logistic regression of the probability of a positive outcome as a function of the covariates was estimated to test the hypotheses. This analysis was used to

estimate the relationships between the covariates and outcomes. The results were used to test whether the factors discussed by providers (e.g., Are Hispanics really initiating and completing HPV vaccine series more than non-Hispanics?) were represented in the data.

The results of the logistic regression informed a regression decomposition that was estimated to understand the determinants of the variation in rates of HPV vaccination between groups (Hispanics vs. non-Hispanics and publicly-insured vs. non-publicly insured). Specifically, we performed an Oaxaca–Blinder decomposition to identify the reasons for disparities in the outcomes between the groups. The disparity in the outcome was decomposed into a part that is explained by group differences in the magnitude of the covariates and a part that was due to between group differences in the relationship between the covariates and the outcomes (Jones, 2012). The first part is commonly referred to as “explained” because it represents the portion in the disparity that is due to between group differences in the values of the covariates. The second part is the portion that is “unexplained” by the covariates because it is due to factors that are not included in the model. Unexplained factors could represent differences in culture, discrimination, or other elements of decision-making and behavior that are not possible to measure in the data.

In our specific application, the decomposition reveals how much variation in HPV immunization rates is due to between group differences in the relationship between immunization and patient, provider, or PCSA characteristics and immunization as distinct from between group differences that are due to differences

in the characteristics of each group. For example, a hypothesis that religious beliefs that are significantly more prevalent in one group is a major reason why the group's vaccination rates were significantly lower can be tested using the decomposition by assessing the extent to which between group differences in vaccination rates are explained by differences in the prevalence of religious adherents in each group. Similarly, a hypothesis that group differences in mothers' level of education contributes to disparities in HPV vaccine receipt can be assessed by examining the magnitude and significance of the disparity that is explained by parents' level of education. In other words, if highly educated people were less likely to have their children vaccinated, and highly educated people were more prevalent in one group, then the decomposition enables us to measure the extent that the increased prevalence of highly educated mothers led to the group's lower vaccination rates. On the other hand, if children of highly educated mothers in one group were more likely to be vaccinated whereas children of highly educated mothers in the one group were less likely the decomposition would define this component of the disparity as unexplained because there is some other difference between the groups that leads highly educated mothers to behave differently with respect to HPV vaccination. (Jann, 2008).

***Data*.** The dataset used in this analysis included claims data from the CO APCD merged with PCSA-level demographic info (Dartmouth Health Atlas, 2010) and county-level information on religion adherence (Religion Census, 2010).

The sample population of interest is children aged 11-18 years of age who received the Tdap vaccine between years 2011-2014 (Index event) and were

continuously in the sample for 365 days after receiving the Tdap vaccine. Tdap is a school-required vaccine in Colorado and one of three vaccines in the adolescent immunization platform. Tdap receipt by adolescents is high compared to HPV and meningococcal vaccine. We anchored the initial HPV vaccine uptake to Tdap vaccinations to hold constant general attitudes towards vaccines in order to better focus the analysis on the barriers an precursors that are specific to HPV vaccination. We used a 365-day follow-up period to assess whether required series of vaccinations was completed. Another reason for using TDAP vaccination as the index event is because vaccination guidelines suggest that HPV vaccinations should be performed at the same age as Tdap. Thus HPV vaccinations should be conducted within a year of Tdap receipt, which would leave more than enough time to complete the six-month series. It is possible that we excluded some children who received the HPV vaccine before TDAP but we expect this to be rare given that TDAP is required for school attendance and is much more common.

We identified immunization administration using Current Procedural Terminology (CPT) codes for Tdap and HPV vaccines. CPT codes were also used to identify primary care utilization (preventive, vaccine only or sick visit; see Appendix C). These were selected to ensure all pertinent immunization CPT codes, primary care utilization, and dates and times of services were captured. For example, if our CPT codes were repeated for the same person twice on the same day, the data were cleaned to ensure zero duplications of services in the data.

The models for Aim 3 were estimated using key covariates drawn from the PCSA and CO APCD data. The CO APCD is a secure database compliant with

privacy laws and in 2016 it contained more than 510 million health insurance claims from more than 21 commercial health insurance companies, Medicare, Medicare Advantage, and Health First Colorado (Colorado's Medicaid Program). It is the only claims repository in the state that represents the majority of insured individuals in Colorado. It contains more than five years of data and thus offers a more comprehensive picture of Colorado's health care system than other available sources of claims information from individual insurers.

Covariates. The covariates included variables that measured patient, provider, and population characteristics. Patient characteristics were obtained from CO APCD data. Patient characteristics included: age in years, gender, race, ethnicity, insurance, rural/urban residence, CPT codes, and visit type. These were included because there is established evidence that showed that the HPV vaccine is most effective with younger patients before they are exposed to any HPV types. VFC eligible children, a large population of which are Medicaid-insured, receive vaccines free of cost, and it is important to understand their utilization by age. Furthermore, the adolescent vaccine platform that includes Tdap and HPV vaccine recommendations is age-specific, and controlling for age is important in controlling for age-related confounders.

Trends in the HPV vaccination rate among men and women vary significantly, and men lag behind in initiation and completion of the HPV vaccine for several reasons, including that the HPV vaccine was indicated for women before men, and differences in the perceived higher severity of HPV-related diseases that impact women (cervical cancer) and not men. Because of these baseline differences,

research has demonstrated that parents and providers encourage more women to get the HPV vaccine than men. For these reasons we controlled for gender.

Race and ethnicity are important factors because there are clear and established disparities in vaccination rates and in the severity of HPV-related diseases. For example, African-American women die of cervical cancer at higher rates than Hispanic women, even though Hispanic women have a higher rate of HPV infection (McCarthy, Dumanovsky, Visvanathan, Kahn, & Schymura, 2010). Because the infection rate and preventative healthcare access are not uniform among different racial and ethnic groups, it is crucial to understand the association of each racial and ethnic group with our outcomes of interest.

Health insurance and the type of TDAP visit are included in the model to measure the role these factors play in HPV vaccinations. Furthermore, they provide an avenue for assessing and comparing between different insurance types and patient ability to access the HPV vaccine. We hypothesized that HPV vaccination rates would be influenced by insurance type, which is related to overall access to health care. We also hypothesized that HPV vaccination rates differ among adolescents who receive regular preventative services compared to those who do not. To test this, we included the index visit type: preventative, sick, and vaccine-only visits in a year.

The provider characteristics included provider type (primary care or other types) and gender (male or female). Primary care provider categories included family medicine physicians, internal medicine, nurse practitioner, pediatrics, physician assistant, registered nurse, students in an organized healthcare facility,

and local FQHC clinics. Providers in the other category included midwife, obstetrics & gynecology, pharmacy, and other specialists. Children in our cohort were seen by variety of providers, ranging from pediatricians to obstetrics and gynecologists. However, how adolescent vaccine access interacts with the types of providers in care settings is unclear. For example, previous research shows better health communication among female providers compared to male providers in recommending preventative services. It was unclear if that same phenomena held true in our data. However, prior research has shown that provider gender influences the provision of preventive screening and counseling. (Henderson & Weiman, 2001)

We merged in information about local populations measured at the PCSA level to control for population characteristics. In addition, we merged in county-level data on religion adherents from the U.S. Religion Census: Religious Congregations and Membership Study (2010). This study, designed and completed by the Association of Statisticians of American Religious Bodies (ASARB), represents statistics for 149 religious bodies on the number of congregations within each county of the United States. This included the number of members by religion, and total adherents. The data included 149 Christian denominations, associations, or communions (including the Latter-Day Saints and Unitarian/Universalist groups); two specially-defined groups of independent Christian churches; Jewish and Islamic totals; and counts of temples for six Eastern religions. While these data contain membership data for many religious groups in the United States, including most of the larger groups, they do not include every group.

Population characteristics included religion adherence per 1000 populations: evangelical rate, Catholic rate, mainline Protestant rate, black Protestant rate, Orthodox rate, and other religion rate (including Islam, Buddhist, etc) obtained from the religion census data. The role of religion in HPV vaccine uptake — especially among parents of adolescents — is an ongoing theme in which vaccinating their children against a sexually transmitted infection presents a moral dilemma for some parents. Parental religious beliefs and the education they receive from their faith communities about HPV and other vaccines may influence vaccine uptake. Several dimensions of religion such as behaviors, beliefs and attitudes could be linked to health seeking behavior (Koenig, Larson, & Larson, 2001; Cotton et al., 2007). Furthermore, studies have shown association between religion and sexual health behavior such as delayed sexual initiation and fewer sexual partners (Cotton & Berry, 2007). These are important factors to consider when studying adolescent health outcomes. Controlling for religious affiliations and adherence rates is essential to understanding the alignment between religious beliefs and HPV vaccine uptake.

The role of education in health care utilization, understanding provider recommendations, and the ability to afford and access vaccine is important to control for in our analysis. However, there are also pockets of educated communities who are opposed to all or some types of vaccines and who refuse or hesitate to provide any vaccine to their adolescents. Controlling for parental and population level educational attainment is important to remove confounding due to education. For example, one study showed a link between maternal education and low probability

of HPV vaccine initiation (Feiring et al., 2015). However, a lack of parental education status in our individual level data necessitated the use of population-level education levels by PCSA. These educational variables included population under age 25 who received below a high school education, percent high school graduation, and college graduation rates in the population.

PCSA-level variables also included the percent of residents who are white, black, and Hispanic. The percentage of other races was constructed by subtracting percent white and black from 100% (100 -%white - %black = % other race). Non-Hispanic percentage was constructed by subtracting the Hispanic rate from 100 percent (100 - %Hispanic = %non-Hispanic). Including both individual and population level race and ethnicity data was necessary because healthcare utilization could be impacted by different combinations of factors such as differences between diverse communities and communities where families feel like they are the only families of color. For example, health care utilization for black families living in white neighborhoods might be different than those living in diverse communities due to factors such as perceived or actual differences in treatment when visiting provider offices.

Estimation approach. The outcomes were modeled as a function of the covariates using a logistic regression. This model provided us with estimates of the relationship between the probability of a positive outcome and the covariates. First, the following logit model specifications were estimated:

$$Pr(HPV\ Initiation = 1) = F(\alpha + \beta_1 Patient_i + \beta_2 Provider_i + \beta_3 Populaitons_i) \quad (1)$$

$$Pr(Full\ HPV = 1) = F(\alpha + \beta_1 Patient_i + \beta_2 Provider_i + \beta_3 Populaitons_i) \quad (2)$$

Marginal effects were calculated to measure the change in the probability of initiating or completing the HPV vaccine given a one unit increase in each respective covariate, holding other covariates at their mean values. For our binary outcomes, the change is from 0 (no initiation, no completion) to 1 (initiation, completion), or one "unit" as it is usually termed. The standard errors (SEs) reported are those of the average marginal effects.

Next, we performed an Oaxaca-Blinder decomposition to assess whether the observed differences in outcomes were due to changes in explained or unexplained differences. This analysis also further helped test if results were aligned with the qualitative findings. The decomposition also sheds light on the underlying reasons behind disparities in HPV initiation and completion uncovered in the logit models. This method was used to decompose the disparity in each outcome variable.

Motivation for regression-based decomposition. This method provides insight into the nature of the observed differences in outcomes whether due to the characteristics of the groups (i.e. Endowments) or unexplained factors such as cultural nuances. Oaxaca-Blinder (OB) decomposition methods have not been used widely in health services research. Decomposition analysis of differences is important for understanding the main determinants of differences and for policy analysis. The major distinction between a simple regression and Oaxaca-Blinder

decomposition is that the former model does not show the various covariates that impact HPV vaccination differently but only that they affect immunization rates, and it assumes that the impact of insurance is the same between the two groups. However, the OB method provides an avenue to indicate to what extent the variation is due to the covariates and the interactions with the groups being studied (Yoo, 2015). OB decomposition explains the gap in the means of an outcome variable between two groups. The gap is decomposed into the part that is due to group differences in the magnitudes of the determinants of the outcomes in question as well as the group differences in the effects of these differences on the outcome. (O'Donnell, 2008; Jann, 2008).

We explained the distribution of the outcome variables in question through a set of factors that vary systematically with HPV immunization. We used OB decomposition on CO APCD claims data to look at patient, provider, and health care access characteristics that facilitate or hinder patient propensity to receive the HPV vaccination. The decomposition method is used because it reveals how far immunization variation with HPV can be explained by differences among groups of patient, provider, or health care access characteristics. The decomposition method outlined below will explain the gaps in the means of an outcome variable between two groups (i.e., vaccinated or unvaccinated with at least one dose of the HPV vaccine). The gap is decomposed into two parts: group differences in the effects of the determinants, and group differences in the determinants of the outcome in question (Jann, 2008).

An example based on a Hispanic/non-Hispanic decomposition is useful to understanding how the decomposition works in practice. The decomposition is performed using several steps:

1. Calculate the means of all covariates for the pooled, Hispanic and non-Hispanic samples, denoted for males $\overline{Male}^{Pool}$, $\overline{Male}^{H}$, and $\overline{Male}^{NH}$, respectively.

   The difference between the Hispanic and non-Hispanic means reflects the different sample endowments. In my sample:

   $\Delta\overline{Male} = \overline{Male}^{H} - \overline{Male}^{NH}$ = –0.06

   The negative sign implies that there are more Males in the non-Hispanic sample than Hispanic sample.

2. Estimate a linear probability model using the pooled sample:

   $Any\ HPV_i = \alpha^{Pool} + \beta_{male}^{Pool} Male + X_i'\beta^{Pool} + \varepsilon_i$ to yield: $\hat{\alpha}$, $\hat{\beta}_{male}^{Pool}$, and $\hat{\beta}^{Pool}$

   $\hat{\beta}_1^{Pool}$ measures the difference in the probability of vaccine initiation of males versus females. In this example, the probability of males receiving HPV is 0.0624 points lower than females:

   $\hat{\beta}_{male}^{Pool}$= –0.0624

3. Re-estimate the model using only the Hispanic sample:

   $Any\ HPV_i = \alpha^{H} + \beta_{male}^{H} Male + X_i'\beta^{H} + \varepsilon_i$ to yield: $\hat{\alpha}^{H}$, $\hat{\beta}_{male}^{H}$, and $\hat{\beta}^{H}$

   $\hat{\beta}_{Male}^{H}$ measures the difference in the probability of Any HPV vaccine of *Hispanic* males versus *Hispanic* females:

   $\hat{\beta}_{male}^{H}$= -0.04

4. Re-estimate the model using the Non-Hispanic sample:

   $Any\ HPV_i = \alpha^{NH} + \beta_1^{NH} Male + X_i'\beta^{NH} + \varepsilon_i$ to yield: $\hat{\alpha}^{NH}$, $\hat{\beta}_1^{NH}$, and $\hat{\beta}^{NH}$

   $\hat{\beta}_{Male}^{NH}$ measures the difference in the probability of Any HPV vaccine of Non-*Hispanic* males versus females. In my sample:

   $\hat{\beta}_{male}^{NH}$= –0.8

5. The portion of the Hispanic – Non-Hispanic differential that is ***explained*** by differences in the number of males in the respective groups is measured by multiplying the pooled Male coefficient by the difference in mean Males in the respective samples:

   Explained: $\left(\overline{Male}^{H} - \overline{Male}^{NH}\right) * \hat{\beta}_{male}^{Pool}$= (–0.06)* (–0.0624) = 0.0037

In other words, 0.0037 of the differential is explained by the different number of males in the respective samples.

6. The portion of the Hispanic – Non-Hispanic differential that is ***unexplained,*** i.e. related to differences in the probability that Hispanic and non-Hispanic males get HPV is:

   Unexplained: $\left(\hat{\beta}_{male}^{H} - \hat{\beta}_{male}^{NH}\right) * \overline{Male}^{Pool}$=(–0.04) – (–0.08) * (0.36) = 0.0144

   In other words, 0.0144 of the differential is due to unexplained difference the likelihood Hispanic males and non-Hispanic males receive HPV vaccinations. This is interpreted as differences in the general cultural approach to medical care, and other factors that are not in the model:

7. Steps 3-6 are repeated for each covariate. The sum over all covariates represents an estimate of the entire portion of the HPV vaccine differential that is explained by different endowments of characteristics and the portion that is unexplained.

Ethical Considerations

Ethical approval was obtained from the Colorado Multiple Institutional Review Board (COMIRB) on March 16, 2016. Providers were consented prior to participation in the key informant interviews. Qualitative data that was collected and recorded was stored in a safe, locked cabinet to which the researcher has access. Quantitative data was only be accessed through secure computer access that the researcher has. The needs assessment report was de-identified and aggregated before dissemination so that provider information is protected.

CHAPTER IV

RESULTS

Results are presented by research aim. This research was conducted between October 2016 and August 2017.

Aim 1

The objective of Aim 1 was to identify geographic areas and VFC provider sites that are high and low performing in terms of HPV relative to Tdap vaccine ordering ratio. Additionally, this aim was used to identify sites for Aim 2 qualitative interviews.

Using VFC ordering data from 2015, we examined variations among practices in ordering HPV vaccines versus Tdap vaccines. We set the minimum quantity of Tdap ordered at 24 doses per year (at least 2 doses of Tdap per month for 1 year) to ensure that we captured practices with experience in Tdap vaccine ordering and administration. The HPV vaccine-ordering ratio was calculated using the formula:

$$\%\ \boldsymbol{HPV\ ordering\ ratio_A} = \frac{\text{Total order of HPV Vaccine at Clinic(or PCSA)}_A}{\text{Total order of Tdap Vaccine at Clinic (or PCSA)}_A} * 100\%$$

Detailed summary statistics for the percent of HPV vaccines ordered were obtained and low and high provider as well as PCSA cut off points were determined. We used the 25th top and 25th bottom percentile of the cut-off points to identify low and high ordering practices. Means of percent of HPV vaccine ordered were obtained for each of the four groups of interest: low practice-low PCSA, high practice-high PCSA, low practice high PCSA, and high practice- low PCSA.

To obtain the PCSA cut offs, we used PCSAs with more than one practice to ensure that we would be able to compare at least two practices in the same PCSA. Stata/IC version 13 was used for analysis.

Based on this characterization, we identified practices in each of the four categories. The largest number of practices were in the high practice-high PCSA (*n* = 92) category followed by practices in the low practice-low PCSA (*n* = 40). The smallest number of practices were found in the high practice-low PCSA category (*n* = 12), as shown in Table 2.

Table 2: Category of Practices Based on Vaccine for Children HPV Vaccine Ordering Ratio

		PCSA	
		High (% HPV > 0.67)	**Low** (% HPV < 0.35)
Practices/clinics	High (%HPV > 0.79)	*N* = 93 Mean % HPV = 1.30	*N* = 12 Mean % HPV = 1.22
	Low (%HPV < 0.34)	*N* = 32 Mean % HPV = 0.23	*N* = 40 Mean % HPV = 0.19

Based on identifying high and low HPV vaccine ordering sites in Colorado (Aim 1), we chose three main categories for Aim 2 qualitative sampling.

HPV Ordering Ratio is the ratio of HPV to Tdap orders by VFC clinics. After identifying high and low HPV VFC vaccine ordering sites in Colorado (Aim 1), we created three main categories for analysis:

1) Low practice-high PCSA: clinics with low HPV ordering ratios located in PCSAs with aggregate HPV ordering ratios in the top 25th percentile.
2) Low practice-low PCSA: clinics with low HPV ordering ratios located in PCSAs with aggregate HPV ordering ratios in the bottom 25th percentile.
3) High practice-low PCSA: clinics with high HPV ordering ratios located in PCSAs with aggregate HPV ordering ratios in the bottom 25th percentile.

Providers and PCSAs in these top 25th and bottom 25th percentile were considered for the qualitative sample. This measure was used to stratify the sample up to 30 providers or until we reached information saturation.

Aim 2

The objective of Aim 2 was to identify root causes of provider variations and barriers to recommending and administering the HPV vaccine to adolescents in Colorado using key informant interviews. This was done using an interview questions designed to understand:

- provider perceptions, barriers, and facilitators to HPV vaccine recommendation and uptake compared to other adolescent vaccines
- provider understanding of parental decision-making and to understand factors that influence parental willingness to vaccinate their adolescents
- Any emerging themes that may show the changing landscape of the HPV vaccine in Colorado

Key Informant Interviews

We interviewed a total of 26 participants: seven from the high provider-low PCSA category, 12 from the low provider-low PCSA category, and seven from the low provider-high PCSA categories. Although there was a mix of primary care

providers from the different categories, the low provider-low PCSA category responders were largely public health nurses from local public health departments. There were no interviews conducted from the high-practice, high-PCSA sites. With limited capacity to do interviews with all the categories, the researchers determined that barriers to HPV vaccine uptake and variation would emerge mostly from the three categories that were chosen for qualitative interviews. We reached saturation at the 23rd interview but added three more interviews to ensure no more themes were arising from our interviews. This method of checking for new themes once the analyst feels saturation has been reached has been used in prior studies and is considered methodologically rigorous (Francis et al., 2010).

Barriers and Facilitators Identified by Providers

Key consistent themes regarding barriers were fundamentally present across the three (high-provider, low-PCSA category; low-provider, low-PCSA; and low-provider, high-PCSA) categories. These categories describe the same underlying dynamic; however, the magnitude of how and when providers experience these barriers may partially have driven the differences in the categories. Furthermore, participant discussion of facilitators explained how providers addressed these similarly-experienced barriers and showed differences across the three categories. Many participants across categories identified parental, provider, and policy-related barriers to recommending and delivering the HPV vaccine to adolescents. Participants from all three categories identified knowledge and attitude and perception of parental interest as factors in engagement in HPV and other vaccine uptake for their adolescents.

Like barriers to HPV vaccine uptake, participants from all sites discussed some facilitators to the HPV vaccine in their sites. These facilitators were factors that enabled them to provide or recommend the HPV vaccine to their adolescent population. Even though all the categories expressed experiencing similar barriers, there was variation in how participants from these sites addressed these barriers (see Table 3). Participants from all three categories discussed several facilitators to HPV vaccine uptake in their practices. Some of these facilitators were efforts they made to ensure vaccine uptake by adolescents, whereas other facilitators included what providers perceived as supportive parental behaviors towards the HPV vaccine. Provider factors discussed varied greatly across the three categories and might have been drivers of differences among categories (Table 3). Some of these patient and provider level facilitators discussed by participants included: receptive segments of the population, moving away from a focus on sexually transmitted infection prevention to a focus on cancer prevention and new billing methods that improved their billing process for vaccines. Providers in the key informant interviews were unaware of their performance categories during their interview with the researcher. All barriers and facilitators discussed to improve HPV vaccine uptake in their practice were not influenced by the researcher-determined performance category. The following section details barriers and facilitators to HPV vaccine uptake of adolescents as discussed by participants.

Parental factors. Participants across categories elaborated on the role of parental factors in determining HPV vaccine uptake by adolescents. They discussed parents as gatekeepers with varying agendas, varying amounts of background

knowledge about vaccines, and varying perceptions when they arrive at the clinic. Most barriers to HPV vaccine uptake were attributed to parental factors, and participants across all three categories discussed vaccine hesitancy and refusal. Reasons for vaccine hesitancy and refusal included parental fear of inadvertently promoting an early sexual debut, religious conservatism, and a lack of regular well child visits for adolescents that created less opportunity for providers to interact with parents and their adolescents. Additionally, providers from low practice-low PCSA and low practice-high PCSA categories mentioned parental barriers to immunizing adolescent boys with the HPV vaccine. Furthermore, high practice-low PCSA category participants identified the need for written parental consent for vaccines for institutionalized adolescents as another barrier to HPV vaccine uptake.

Even though the majority of the barriers related to parental factors were similarly discussed across categories, facilitators to HPV vaccine uptake discussed were mainly different with some overlap between categories. Participants from the three different categories discussed parental factors that enabled them to provide the HPV vaccine to adolescents they serve. The role of certain vaccine-receptive populations in the community was consistently discussed by all three categories. These receptive populations were described as trusting provider recommendations more and were publicly-insured individuals and/or minority/Hispanic populations. Parental factors discussed in the low-practice high-PCSA also included parental prior experience with HPV or other cancers and the role the Tdap school requirement played in convincing parents to come to the clinic. The Tdap's role in

facilitating other vaccine recommendation and discussion was also discussed by providers from low-practice, low-PCSA sites.

Participants from low-practice, low-PCSA sites also discussed how parents generally trusted local public health departments, especially in rural settings. The parental factor facilitators were not strong in driving differences between categories. However, they provide a further understanding of facilitators. These facilitators are described in more detail below, and are supported by illustrative quotes.

Because barriers were discussed similarly between the three categories, it was at times unclear how these barriers were driving the differences in practice categories to high or low HPV vaccine-ordering ratio. However, the discussion of facilitators provides an insight into drivers of the variation between categories and a glimpse at efforts made by different practices to address these barriers. For example, participants from low practice-low PCSA and low practice-high PCSA categories mentioned parental barriers to immunizing adolescent boys with the HPV vaccine. However, neither discussed specific efforts to improve HPV uptake among boys. This might explain why these two sites have low practice-level HPV vaccine ordering ratios. However the discussion of creative communication as a facilitator by high-practice, low-PCSA sites might have helped them reach more parents of boys and girls. The following section details each of these parental barriers and facilitators to HPV vaccine uptake among adolescents with selected illustrative quotes from participants to support the synthesis.

Vaccine hesitancy and refusal. Participants across the three categories mentioned parental HPV vaccine hesitancy and refusal in their practices. Most

participants discussed experiencing some type of vaccine hesitancy and/or complete refusal of all vaccines from parents of adolescent patients. Some of the reasons included religious conservatism, alternative vaccine schedules, fear of inadvertent promotion of early sexual debut, fear of vaccine side effects, and lack of trust in provider recommendations.

Many participants stated that some parents had already decided to refuse the HPV vaccine for their adolescent before coming to the clinic. Participants described these parents as stern in their stance against the HPV vaccine but vague about their reasons, thus creating no room for an open communication with providers. Some participants explained that they didn't push the vaccine discussion further to avoid tarnishing their existing relationship with the parent and to not jeopardize future vaccine-related discussions.

> . . . for HPV, occasionally somebody will say well, I just don't want it. I've read a bunch of stuff about it, and they're pretty vague, but you know, I've read the things on the internet. I know what they're reading, they're reading about brain damage and things that are not valid, but they don't want to go into it, they'll just say, ah I just don't think we're gonna get that one [HPV vaccine]. *Low-practice, low-PCSA provider*

> Almost all families are willing to get that 11 year Tdap for their budding adolescent and some, most of them are OK with the Meningococcal which is also due at that age, but they are very hesitant to get the HPV or Gardasil. *High-practice, low-PCSA provider*

Participants from all three categories discussed segments of the population who are anti-vaxxers but some participants from all three categories discussed the role of vaccine-receptive segments of the population. Participants said that low-income families are generally receptive to HPV and other vaccines recommended by providers. They discussed how parents with public insurance such as Medicaid are

more receptive of provider recommendations to vaccinate their adolescents with the HPV vaccine as opposed to private-pay patients. Participants felt that the reason for the public-insured population's vaccine acceptance was less about lack of significant out-of-pocket cost and more about trusting providers. Similarly, participants mentioned that the Latino community and the underserved population are the most receptive to HPV and other vaccines. They discussed how this population generally trusts provider recommendations, and that they perceive the vaccine to be safe and important.

> The patients who have, you know, Medicaid and access to VFC vaccines, I don't think it's a cost thing, it's more of a mindset when they seem to be more you know, acceptable of the HPV vaccine or they accept it more frequently. . . . it seems like I don't have to have as long of a discussion with my Medicaid patients as I do with the private pay. *Low-practice, high-PCSA provider*

> . . . it seems like maybe VFC [recipient population] is a little bit more accepting to them all I think, cause you know they're like well yeah, let's get everything that I need. I think they're just more likely to accept recommendations by a health care provider. *Low-practice, low-PCSA provider*

> I think our population is at least 50 percent Hispanic and a decent amount that are Spanish speaking . . . I think there's also just a culture of vaccines are safe and important, you know, in that subset of our population, too, so it makes it a pretty easy sell. *High-practice, low-PCSA provider*

This also aligns with the overall HPV vaccine recipient characteristics of certain populations who trust and use certain avenues such as the public health department for vaccines—who tend to be publicly insured individuals. Participants from low-practice, low-PCSA sites mentioned that there is some level of trust in public health departments that helps facilitate parental acceptability of immunizations. Providers from rural public health departments especially felt that parents trusted them more

because they are not a for-profit organization, but because their goal is to prevent disease.

> I think there's a lot of trust in public health. I think the general public, one they trust nurses a lot and they trust public health. They don't want everything we have to offer, but I think they feel like we're not in the money-making business. We're just here to try to make everybody healthier and decrease disease, and I think people realize that, so I think that's, you know, whether they take it or not, I believe they put some trust into we say, at least think about it. *Low-practice, low-PCSA provider*

Religious conservatism. Religion was discussed as an underlying reason some parents refused the HPV vaccine for their adolescents. These parents usually hoped for monogamous relationship for their adolescents and believed that the HPV vaccine might promote early sexual activity, which goes against their beliefs. However, a few participants mentioned increasing numbers of anti-vaccinators in their community who believed in faith healing and oppose medical intervention. Some participants stated that it was difficult to change the attitudes of such parents regarding the HPV vaccine. All participants talked about pockets of conservative religious groups present in their communities who are strictly opposed to the HPV vaccine. However, some participants from low practice-low PCSA sites discussed a unique trend in which their community composition changed notably in the past few years after several people moved in who believed strongly in faith healing and absolutely refused vaccines. Although religious conservatism was discussed across the different categories, it was unclear if this perspective alone was the driver in the differences between categories.

> . . . most of it is religiously oriented. Like I said, they don't want to trigger sexual activity, and they feel like if they get this shot, I have to giggle cause I mean it's just so ridiculous, if they get the shot then they're basically saying OK, you can go have sex now. Which obviously doesn't make any sense.

> These kids don't even know what we're doing, you know, what kind of shots we're giving. *Low-practice, low-PCSA provider*

> I mean on the HPV, the sexual connotation of exposure is a barrier to some, especially in this little population, we have a Bible church college that just moved in our community, and so we're getting a lot of pushback from that population. We're getting some pushback even on the Tdap though and all vaccines. *Low-practice, low-PCSA provider*

***Alternative vaccine schedules*.** Participants discussed having difficulty addressing vaccine hesitancy and refusal when parents bring their own vaccine schedules and refuse provider recommendations that follow evidence-based guidelines. Some participants mentioned how parents wanted one vaccine at a time for their children, making it difficult to provide all the vaccines in the adolescent platform in one visit. Most of the time parents did not discuss reasons behind their alternative schedules. But some other parents based their decision on "research" they had done that supported their stance against the HPV vaccination. Participants did not know the source or the type of research done by parents, but suspected the research was not from an evidence-based source because it went against standard vaccine practice.

> . . . we do have what we worry is a growing number of "anti-vaxxers" in our community, despite all our efforts, and of interest, it's not the low socio-economic level. It's the well-educated yuppies, and so we have found that if we try to argue or twist their arm to aggressively, it backfires and we lose them forever, so we go along with the parent that says they only want their child to have one vaccination per visit, you know, it's driving us crazy inside, we like to get this kid vaccinated. *High-practice low-PCSA provider*

***Fear of inadvertent promotion of early sexual debut*.** Most participants stated that providing a vaccine that protects against a sexually transmitted disease was the main cause of vaccine hesitancy and refusal among many parents. Many participants discussed the hesitation parents have — especially religious ones —

about the HPV vaccine because they hope that their children will not have sex before marriage or will remain monogamous throughout their life. Although not always discussed as intertwined and connected to religious conservatism, participants also noted that parents were hesitant to give HPV vaccines to their adolescents because they believe that their adolescents are currently not sexually active and do not need the vaccine now.

> I have a few religious people who truly believe their child is only going to have sex with one person in their lifetime, and that person will have been a virgin and, therefore, they don't need it. So, some people are certain that they're going to have a monogamous relationship forever and, therefore, they don't need it. That's a small number, but some. *Low-practice, low-PCSA provider*

Furthermore, many participants discussed parental perceptions that providing the HPV vaccine would mean giving license to their adolescents to be sexually active; as a result, some parents hesitated or refused to vaccinate their adolescents. One participant from a high practice-low PCSA site specifically mentioned a misconception about the HPV vaccine among the Latino population in which parents did not understand that the HPV vaccine would not change an adolescent's desire to be sexually active, nor did they understand that their children need to be protected before sexual debut for full protection. Although this misconception was discussed as a unique phenomenon, it was illustrative of the larger concern among parents to not promote early sexual activity among their adolescent children. Some participants felt that these perceptions by parents were shortsighted because parents were focusing on the short-term age of adolescence and not seeing the life-course need for protection against HPV infection.

> I think what people typically do not understand is that you know it doesn't really change a child's desire to have intercourse or not. I think there's some

> fear that somehow that is gonna make a child want to have sexual intercourse, so. *High-practice, low-PCSA provider*
>
> . . . the main one I am hearing is that they don't want their child feeling like they have a license to be promiscuous. *Low-practice, high-PCSA provider*
>
> . . . that's so engrained that some parents don't see the value, you know, their kids aren't ever gonna have sex in their mind. *Low-practice, low-PCSA provider*

Many participants framed parental refusal or hesitation to vaccinate their young adolescents as their lack of seeing the big picture. Participants felt that some parents are less focused on protecting their children throughout their lives from the HPV infection, instead seeing their children as little kids that are not going to grow up. Participants believed it prevented parents from understanding and discussing the importance of vaccinating their children before sexual debut. Furthermore, a few participants talked about the challenges of discussing the HPV vaccine with parents because parents are not yet ready to face the possibility of their adolescent children having sexual activity. Parental focus on fear of inadvertent promotion of early sexual debut and protecting their children from sexual activity itself was more important than protecting them from HPV infection, making this one of the central concerns for hesitant or refusing parents.

> I know they start having sex younger these days than it seems like 20 years ago or 30 or 40 years ago, so we'll see that more with the little bit, the teens, 13s, 14s if they have not had it you know, we'll see and the parents are really getting into it then, we'll see it more a little bit older, but a lot of the parents are still you know, some parents don't want a written thing when their 11 year old is just 11, oh they're not gonna have sex for a while, that is way, this child is way too young for that. *High-practice, low-PCSA provider*
>
> Yes, I can remember one more recently than others and it was just specifically about the HPV vaccine and that's frequently the vaccine I have the most trouble with and trying to explain the new recommendations for HPV vaccine not only related to cervical cancer in women but also anal and rectal

> and throat cancer in men, and trying to get the parents to more or less see the big picture and not just see their children as little kids that aren't gonna grow up and that's often times hard to do. *Low-practice, high-PCSA provider*

This resistance from parents to immunize their adolescents presented significant challenges to parents but participants also discussed the role of willing parents, especially those with prior parental experience with HPV. Few participants from low-practice, high-PCSA sites discussed the role of a parent's prior experience with cancer or HPV infection in helping vaccinate their adolescents with the HPV vaccine. They said most parents want cancer prevention, which mothers of daughters were interested in protecting their children from HPV infection, and that parents were very receptive to education provided by participants. This interest from parents in HPV vaccine prevention of cancer aligns with some provider efforts to move away HPV vaccine STI prevention to cancer prevention.

> Most of the parents want cancer prevention. Some of the parents, the mothers, especially, some of the mothers have had experience with having HPV infection and they want their daughters protected and most of them are very receptive once you educate and explain to them why this vaccine is being recommended and what the benefits are and you know, once you do that, it's mainly there are a few dads that you know are understanding because we also have dads bring their children in. *Low-practice, high-PCSA provider*

One participant from a high practice-low PCSA site observed that some parents do not want to give the HPV vaccine to their adolescents with a disability or other condition because they assume those children will not need the HPV vaccine. The underlying assumption was that these adolescents will not be sexually active anytime soon, adding to the parental perception that those who are currently sexually active should receive the HPV vaccine. These participants told parents that

because they never know if or when their adolescents will become sexually active, protecting them early is the best option.

> We have a few parents that don't want to give it if their child has autism or some, mentally delayed, down syndrome that kind of thing, that no, they don't need it but you just never know. *High-practice, low-PCSA provider*

Fear of early sexual activity promotion was also a repeated theme, with parents sure their children were not sexually active, and hoping that when they become sexually active that they will remain monogamous. However, this illustrated parental lack of knowledge regarding when the vaccine is most effective —before sexual debut — and that adolescents might not always communicate with their parents when and if they are sexually active. Furthermore, fear that the vaccine would give license to sexual activity hindered parents from seeing the big picture of long-term protection from infection.

Fear of vaccine side effects and ineffectiveness. Fear of vaccine side effects were discussed by many participants from the three categories. Several participants discussed concerns parents have because the HPV vaccine is relatively new. Many participants stated that some parents didn't believe the vaccine had been on the market long enough to convince them it was safe. A few participants mentioned that parents stated they didn't want their children to be "guinea pigs" for new vaccines. Some participants also discussed that parents would conduct internet searches and bring up unproven negative allegations about the HPV vaccine, while others questioned the provider about chemicals in the vaccine and hesitated or refused the vaccine for their adolescents. These types of safety related discussions

made it difficult for providers to address if the topic was layered with other concerns parents have, such as sexual activity debut.

> I will say that there is some concern about vaccine safety just because it, you know, hasn't been on the market for eternity like polio has, you know. *Low-practice, high-PCSA provider*

> . . . how long has it been around, you know, I don't want my kid to be the guinea pig, that kind of hesitation. *High-practice, low-PCSA provider*

> Another big one is because it's so new. They feel that it's, you know, there's not good statistics about it and yet they'll get the Meningitis, and the Meningitis is actually newer than the HPV, so it's, it's just interesting how they rationalize it in their brain. *Low-practice, low-PCSA provider*

Furthermore, a few participants also mentioned that some parents expressed concern about how long the HPV vaccine would be effective if provided to their kids at an early age. Because parents want their children to be protected during the years they really would need such vaccine-when they are sexually active, participants noted that some parents delayed vaccination date so that their adolescents are covered longer.

> I think some people are worried about the length of the effectiveness, you know, is it gonna be good in 30 years, you know, we're looking, talk about their 11-year-old who is likely still gonna be sexually active in 30 years and we don't have data for 30 years. We've got some long-standing data, but I think that's a concern that I don't want to start it too late cause it's gonna wear off. *Low-practice, low-PCSA provider*

A few participants from low practice-high PCSA and high practice-low PCSA sites mentioned examples of concerns parents have with the HPV vaccine and its impact on female reproductive organs and fertility. Those parents were concerned that the HPV vaccine would diminish fertility and result in ovaries that do not grow properly. Because of these perceived side effects and adverse outcomes, the HPV vaccine was deemed unsafe among those parents.

> I mean, it's still fairly new in so many of their minds, that they are like we don't know the long term effects and there are some, . . . fertility concerns are all over the board . . . that have struggled to conceive, their parents say that it had something to do with the HPV vaccine. It's because of that shot; it's making people infertile to control our population. *Low-practice, high-PCSA provider*
>
> . . . she read something about ovaries and they're not growing right or something of that nature, and I said I've never seen that study. I said please note that we would be the first front lines to know of any studies saying that. And the pediatrician did speak with the mom and still, she didn't do it [receive the HPV vaccine]. *High-practice, low-PCSA provider*

Parental concerns about unknown vaccine side effects because the HPV vaccine is relatively new and concerns about long-term coverage from HPV infection were discussed by all participants as a barrier. Although unsubstantiated, parents felt that they were protecting their children from HPV vaccine-related side effects or felt that they were giving them an advantage by delaying the vaccination date to protect them when they need it most. This created clear obstacles to participants who wanted to provide all needed vaccines for their adolescent population earlier rather than later.

Lack of trust in provider recommendations. Participants in all three categories discussed seeing different levels of trust and reliance on provider vaccine recommendations from different segments of the population. A few participants from the different categories discussed differences in parental education and socioeconomic status levels that affected their receptiveness to provider recommendations. Several participants noted that some upper middle class parents with private insurance have no issues with access to care but ask a lot more questions about the vaccines, do their own research, and pick and choose their own vaccine schedules or refuse vaccines completely. Although participants from all

three categories discussed lack of parental trust in provider vaccine recommendations, how providers addressed and communicated to parents regarding these barriers aligned with the differences seen in the three categories. This phenomenon is discussed in-depth in the facilitators section below.

> . . . upper middle class, you know, educated, are much more skeptical about vaccines and ask a lot more questions, they have no problems with access, but they're the ones that are picking and choosing schedules, picking and choosing shots, choosing to do nothing at all. *Low-practice, low-PCSA provider*

However, many participants also noted the contrast with low-income families who are mainly publicly insured and trust provider recommendations, but have challenges accessing care. These challenges included not being able to take time off from work to bring their adolescents to the clinic for vaccines or well child visits. Some participants mentioned how trusting Hispanics and other minority groups are regarding provider recommendations for the HPV vaccine. Perceived willingness for immunization by certain community members might have played a role in provider recommendation trends for HPV vaccines.

> . . . the lower class it has a lot more to do with access, you know, parents have to take time off of work to take their kid in and the parent can't get time off, so it's not that they are not available, it's just they don't have that easy access to them. *Low-practice, low-PCSA provider*

> I think Hispanics and well even, we've had like Jamaican and things like that, I think they're much more accepting and trusting and, for the recommendation, so they tend to be more apt to get them. . . I think it's private insurance people that you know, are sometimes a little bit more resistant. *Low-practice, low-PCSA provider*

> Yeah, it seems like they [public insurance parents] do seem to trust my recommendation more so than a private pay patient, and I don't really know the reason behind that, I think some of the more well-to-do parents of patients that I take care of have their, you know, own ideas about vaccines and they're

somewhat, somewhat against it, at least the HPV vaccine. *Low-practice, high-PCSA provider*

Lack of regular visits for adolescents. Participants described reduced or zero regular adolescent well child visits as a barrier to providing HPV and other vaccines. On top of the previously discussed barriers by participants, they explained that because the adolescent population is generally healthy, parents don't bring them in for well-child checks unless they are involved in sports or need the school-required Tdap vaccine. This prevented providers from seeing these patients regularly and reduced opportunities to catch them in the office for vaccine recommendations. Many participants described how difficult it is for some parents to take time off from work and pull adolescents out of school to bring in their children to the clinic. Participants observed that this trend resulted in lower HPV and other vaccination rates.

> . . . when you have teenagers that are busy with after school activities all the time and parents that work until 5:00, trying to take them out of school or take an hour and a half off work to come down here on a Tuesday, we only do shots once a week, is a burden, so a lot of times, . . . You know, I wouldn't say it's a huge burden, but it's a little bit of a burden, and we try to address that by going up there. *Low-practice, low-PCSA provider*

> . . . that just makes it hard for them to justify, you know, with limited resources, coming, taking time off work to come into clinic or concerns about cost. *High-practice, low-PCSA provider*

> They're below the Healthy People 2020 and they are below the state average or the state immunization rate and it's hard to determine what that reason might be, but what we think it is that when you have a healthy adolescent or teenager but you don't, they don't necessarily go in for an annual exam and so their immunizations get missed at their PCP office. *Low-practice, high-PCSA provider*

However, a few participants from low-practice high-PCSA sites discussed calls they made to parents about vaccines their kids are due to receive, in addition to sending

out reminder notices. They explained how this informed parents of certain needs for their children, and participants said they receive better responses from parents when they call them directly instead of using a letter-only approach.

> so after we give the first initial HPV shot, then two months later, we will send out a reminder notice for the second shot, and then on the day of the clinic, we will call parents and what we have found is that by calling, we get better response than if we send out notices. *Low-practice, high-PCSA provider*

> . . . we pulled up ops with the CIIS operating system teenagers that were due for immunizations, and we called all these parents and told them that you know, what their teenagers needed, and we had quite a huge turnout. *Low-practice, high-PCSA provider*

Additionally, many participants from low-practice high-PCSA and low-practice low-PCSA categories talked about the role of the Tdap vaccine school requirement in bringing parents and their adolescents to the clinic. They said that parents are told by the school that if their children do not receive Tdap vaccine, they are not allowed in the school. This pushes parents and their adolescents to come to the clinic, which in turn provides opportunities for providers to educate parents about HPV and other vaccines. Although this was discussed by participants from these two categories as facilitators, the Tdap a state-wide school requirement and thus provides an avenue for all providers to interact with adolescents and their parents. Tdap vaccine school requirement alone won't drive differences between the three categories, unless some providers have more parents signing the vaccine exemption form for the school rather than coming to the clinic for the required vaccines. In current practice, parents only need to sign the exemption form, which they can get from the school nurse or clinic aide. A lot of parents do not mind getting the Tdap vaccine for their kids but haven't gotten it yet for one reason or another. In most of those cases, they

come in more likely because the school requirement provides them a more motivating deadline.

> . . . once they come in to the office for a vaccination [Tdap], then you talk to them about the others, and we tell them they're recommended. This is the recommendation. It's, while they're here, why don't we go ahead and do this. *Low-practice, high-PCSA provider*

> . . . the only way we can really get kids in here is when the schools buckle down on the required immunizations. *Low-practice, high-PCSA provider*

> . . . a lot of them come over here originally just cause they need the Tdap before they get kicked out of school, so that's the time when we usually, when they're coming for the Tdap as well talk to them about Meningitis and then the HPV as well. *Low-practice, low-PCSA provider*

HPV vaccine for boys. Participants from low practice-high PCSA and low practice-low PCSA sites described challenges in providing the HPV vaccine to adolescent boys. Most participants noted that they observe additional vaccine hesitancy among parents of adolescent boys about vaccinating them with the HPV vaccine. Participants said most parents assumed the HPV vaccination is for girls because it protects against cervical cancer; parents were not knowledgeable about how the vaccine protects adolescent boys. A few participants specifically discussed how HPV vaccine advertisements that excluded adolescent boys may play a role in this perception by giving parents the impression that adolescent boys do not need the vaccine. Even though this theme was explicitly discussed in the low practice-high PCSA and low practice-low PCSA sites, the focus of the HPV vaccine to prevent cervical cancer is a larger phenomenon that might have impacted the high practice-low PCSA category as well and beyond. This theme ties in with the overall knowledge and perception parents have regarding when and who should receive

HPV vaccine — showing a need for increased and consistent messaging on the needs and benefits of the vaccine.

> I think that the parents are more aware and have heard more about the HPV for the girls and so it's kind of got a little bit of background and they are, usually have kind of already made up their minds, but the boys' parents, it seems like they're a little bit more like, oh I didn't know that was recommended, you know, like it's kind of a new thing for them, and then of course, I also add the decreases of the testicular cancer and oral cancer and things like that with the males and the parents as well. *Low-practice, low-PCSA provider*

> . . . a lot of moms of boys don't think that they need the HPV vaccine, so explaining that to moms, letting them know that yes, the HPV is for boys as well as girls. *Low-practice, low-PCSA provider*

> . . . the mother was aware that he had not had the HPV series and she was quite resistant to considering it. *Low-practice, high-PCSA provider*

Parental consent for vaccines. One unique clinic from a high practice-low PCSA site discussed barriers to providing HPV and other vaccines to adolescents housed in their local youth detention center. This facility served adolescents who were there for behavioral treatment. The participant stated that it was difficult to receive consent to vaccinate forms from parents via mail because parents and their detained adolescents do not co-reside. Even when providers receive consent, participants stated that it could be difficult to convince needle-shy adolescent residents to receive vaccines. Although adolescents being afraid of needles is hardly a unique phenomenon, parents are not there to encourage their children to receive the vaccine. This created some discordance between parental wishes and adolescents disinterested in receiving the HPV or other vaccines. In addition, adolescents spent only a limited time at the detention center before moving out to

their home or to other facilities for care, leaving the provider minimal opportunity to vaccinate.

> I mean, on the consent form, if they're under 18, we have to have, you know, we also have to have the parents' consent as well, however, when they come in, the parents and the paperwork that they fill out, there is a consent for medical treatment and I believe immunizations is in there, however, we still have them sign and notify them when we are giving them any type of immunizations. *Low-practice, low-PCSA provider*

> Yes. There are times where if the child will refuse and we call the parents, then the parents says that's fine because ultimately, even if the child refuses and the parent wants them to get it, we still can't force that child to take it, you see what I'm saying. *Low-practice, low-PCSA provider*

> I guess sometimes a lot of it is we are a correctional/treatment facility, but we're also, we deal with committed youth and we deal with detained youth, so with the detained youth, sometimes they're not here to receive the full course of the shots or of the vaccines, and sometimes like they're not even here long enough for me to give them to them, like they're here and two days later they're gone. *Low-practice, low-PCSA provider*

Although this barrier was discussed uniquely in this institution in high-practice low-PCSA sites, other participants from high-practice low-PCSA sites in a different practice arena discussed how they removed barriers to parental consent after adolescents' first visit to the clinic for HPV vaccine. Participants from these sites discussed not expecting parents to remember future schedules to immunize children. Consequently, they suggested receiving parental permissions for future booster shots at the school-based clinic when parents are in the clinic to ensure that adolescents are immunized. Although, participants noted that the school-based clinic removes some of the barriers that pediatric clinics might face, receiving consent for the series at the time of initial visit provides less barriers to HPV vaccine uptake by allowing providers to not need additional parental permission every time an adolescent patient needs a vaccine.

> We tell their parent right in the room, right with them there so that that barrier is taken away and then if they're due for a booster, such as the HPV, we don't expect anybody to remember when to come. We automatically put them in their schedule, in our schedule so they're called down during school and then we already have the parental permission for it. *High-practice, low-PCSA provider*

> I think as a school-based clinic, I think we can cut down the barriers of a pediatric clinic and so we give a lot of immunizations. *High-practice, low-PCSA provider*

This special case from local youth detention center in the high-practice, low-PCSA site was illustrative of an underlying dynamic where adolescent healthcare is reliant on parental willingness to allow uptake of HPV or other vaccines. Although the mailing of consents was unique in this instance, the underlying method by which parents are gatekeepers of care and recommendations by providers remains the same. Asking parents for future consent as done by the school based clinic in the same category facilitates HPV vaccine uptake by removing the need to request consent from parents each time.

Non-inclusive vaccine marketing. A couple of participants from low practice-high PCSA sites discussed the importance of vaccine marketing in informing parents about new and existing vaccines. However, they felt that the marketing was not inclusive of individuals who were uninsured, underinsured, or undocumented and thus these individuals have no exposure or knowledge to these vaccines. This relates to how and where parents receive information regarding HPV and other vaccines. It seems to tie-in with the lack of knowledge parents showed in deciding whether the HPV vaccine is necessary for their adolescent boys as well.

> My current practice is not a private practice. This is a public, this is a federally qualified clinic, so most of my patients are uninsured, underinsured or undocumented patients, so for them, I think a lot of the marketing

techniques are missed and they are not exposed to that. *Low-practice, high-PCSA provider*

Vaccine related decision-making. All of the parental factors in barriers to adolescent HPV vaccine uptake were experienced and framed by different types of decision-making processes. Several participants discussed how the context of parental decision-making impacted and colored adolescent's HPV vaccine uptake in the clinic. On top of parental vaccine hesitation and refusal, participants perceived that some parents were persuaded more by outside factors and less by medical professionals. Most participants stated that a parent's attitude and decision towards vaccines depended on what they have been reading or whom they have spoken to recently regarding vaccines. Some participants talked about parents who discuss and learn about vaccines while in the office but leave without the vaccine to further think about it. Several participants identified these situations as a missed opportunity because they do not know for sure whether the parent and adolescent would return to the clinic for vaccines or not. Other providers discussed how there is no new decision-making process while parents are in the clinic because they have already made up their mind about vaccines in general or about a certain vaccine and the parents do not want their adolescents to be vaccinated.

> But, I don't see a lot of decision-making process in the office. I don't think we've ever had anyone really change their mind in the office. We get phone calls later about, this one's recommended but it's not required, so what can you tell me, you know, what's the difference, why do I need to do it, so you know, they seek more information, but they've already done lots of other information seeking online and from questionable sources. *Low-practice, low-PCSA provider*

> The people who don't want to even have a discussion about it are the ones that already have their mind made up and they're like nope, I don't want it. *Low-practice, high-PCSA provider*

> It's usual, I mean, sometimes when like the 17 and 18-year-old come in alone for like kind of their final visit before going off to college, like the more mature students that you know are like going to college and seem to have been pretty self-sufficient are usually pretty open to vaccinations. *Low-practice, high-PCSA provider*

In most cases, participants discussed parents as the decision makers for their adolescent vaccine needs. However, some participants discussed the role adolescents played in the HPV vaccine decision. In some cases, adolescents did not want a shot and refused the vaccine while in the clinic even though their parents were open to them receiving it. This refusal was more due to adolescents being needle-shy. This disagreement between parents and adolescents made it harder for providers to provide the vaccine. In contrast, a few participants mentioned situations where parents were hesitant but adolescents were receptive to the HPV vaccine. This was elicited when participants followed a standard practice in which they asked parents to step out of the room to speak with adolescents alone about risky behaviors such as alcohol and drug consumption and sexual activity. During this time, these participants explained what the HPV vaccine does and noted interest in receiving it from the adolescents. However, because there was no parental consent, participants were unable to vaccinate those willing adolescents.

> … the kids never want a shot. *High-practice, low PCSA provider*

> I do periodically ask the parents to step out of the room so I can talk to the adolescent about certain health care topics such as STDs and drug, alcohol and tobacco use and often times the adolescent thinks they should probably get the vaccine, but the parents are a little resistant. *Low-practice, high-PCSA provider*

Although there are adolescents who actively refuse or are willing to receive the HPV vaccine, also participants discussed some disengaged and withdrawn adolescents.

Participants explained that most adolescents do not participate in the decision-making process while in the office unless they are at the clinic on their own to get pre-college related vaccines. However, one health clinic physician stated that some adolescents come to their clinic alone, learn about the different vaccines, and go home to think about these vaccines more. They may or may not return to the clinic for HPV and other vaccines but most adolescents do not share their reasons for the HPV vaccine refusal.

> . . . the child, the 16-year-old was just completely withdrawn, you know, he wasn't interested, didn't want to have the conversation, really you could tell that the decision was being guided by the parent. *Low-practice, high-PCSA provider*

In summary, the parental barriers discussed by providers show interrelated themes that influence parental decision-making about the HPV vaccine. All categories discussed similar barriers they faced in interactions with parents and how parents were gatekeepers to their adolescent's health and well-being. In that role, parents were pushing to ensure safety and innocence of their children by refusing or hesitating HPV vaccine, a vaccine they assumed would have an adverse health impact or one that will give their adolescent permission for an early sexual debut. How providers addressed these barriers and differences in approach between categories are discussed in the facilitators section of this dissertation.

Provider Factors. Almost all participants from the different categories discussed several provider factors that hindered and facilitated HPV vaccine uptake for their adolescent patients. Participants noted four main barriers across categories: limited provider persuasiveness, clinic location and vaccines offered, challenges in vaccine ordering and billing, and funding for the cost of vaccines and vaccination

efforts. Barriers to funding for the cost of vaccines and vaccination efforts were mentioned by participants from high practice-low PCSA and low practice-high PCSA sites only. Only participants from the low practice-low PCSA category discussed challenges to vaccine ordering and billing in their clinics. However, participants also discussed facilitators to HPV vaccine that were different between the performance categories. Providers from low-practice high-PCSA sites discussed new billing methods that improved their billing process for vaccines, and using reminder recalls to remind parents to return to the clinic for vaccines. However, there was a drastic difference in the discussion of facilitators by high-practice, low-PCSA sites where provider factors included providers who communicate up-to-date immunization information with parents, increased accessibility to clinics and reminders, and moving away from a focus on sexually transmitted infection (STI) prevention to a focus on cancer prevention. Additionally, low-practice, low-PCSA sites discussed several provider factors including increasing the number of vaccine providers, collaboration with other organizations, and moving from discussing the HPV vaccine as a STI prevention vaccine to a cancer prevention vaccine. Although there was some similarities in the facilitators discussed, there was a clear difference in efforts made among providers from the different categories to facilitate increased HPV vaccine uptake.

It is not clear how the barriers discussed could have resulted in those practices in the different categories, but the facilitators discussed highlight potential mechanisms why some practices were in those categories. For example, some participants were looking for funding to improve vaccination efforts and that might

explain more their intention to improve practice. Some barriers that are unique to some categories further explained reasons why a given practice was in that performance category. For example, low practice-low PCSA challenges in vaccine ordering and billing might have resulted in their facilities' low HPV vaccine-ordering ratio. Participants from this site did not discuss facilitators to improve billing method, however participants from low-practice high-PCSA sites discussed billing-related improvements due to using a new system. This could have explained their PCSA level high HPV vaccine-ordering ratio. The following section provides in-depth discussion of each of these barriers and facilitators with illustrative direct quotes from participants to explain and support the synthesis of barriers and facilitators discussed.

Limited provider persuasiveness. There was a central communication of HPV related information to parents that providers navigated carefully as they discussed their approach to parents who are hesitant about the HPV vaccine or vaccines in general. Although most participants tried to determine the reasons for vaccine hesitancy or refusal by asking direct questions of parents, other participants stated that they do not probe further in anticipation of negative responses from parents. Some participants said they expect to be stonewalled and do not have effective persuasive tactics to move the discussion forward, while other participants assumed parents would not listen to their vaccine-related information, so they found it difficult to even start the conversation.

> Most are so adamant with their 'no' that we don't even ask them why because you know that you're just gonna get stonewalled by them. *Low-practice, low-PCSA provider*

> . . . you can just tell that no matter what you say they're not gonna hear you so at that point it's just hard to even start the conversation. *Low-practice, low-PCSA provider*

While many participants cross categories struggled to balance vaccine related communication and persuading parents, some participants from high-practice, low-PCSA category sites discussed communicating up-to-date immunization information with parents by staying up to date on immunization information. They discussed attending conferences, and reading and sharing materials from the CDC and state health departments with parents on HPV and other vaccine-related information. They also mentioned receiving journal articles and other print materials that kept them informed about current opportunities for vaccine uptake improvement and how to improve communication with patients' parents. These participants also discussed creating an avenue for adolescents and their parents to learn about HPV vaccine directly from providers in schools and the community by using grant money for movie screenings and other activities. They said that being intentional about balancing vaccine information and fun activities might facilitate a better learning environment about HPV vaccine and increased vaccine uptake.

> . . . people do look to us for their vaccination services and they look to us for their answers to their vaccinations questions, so we tend to use all of the materials that are made available to us through the state department of health and also through ACIP, and we try to stay right on, in line with those recommendations. We also, about every, we can't justify it financially every year, but about every three or four years we try to attend the vaccine preventable disease conference that is sponsored by the Centers for Disease Control and then we just try to always do reading you know, there's several periodicals that we get via email, things like vaccinate today and immunization express and there's a lot of things like that. We just always try to make sure we read those and stay up to date on our vaccinations and then we provide the information to the families that we deal with. *High-practice, low-PCSA provider*

> . . . so we've tried to dispel that myth in many ways. We purchased, with a little bit of grant money that we had cause we do work on a shoestring here, we purchased the movie Someone You, what was that, *Someone You Love*? Isn't that crazy, I know that movie well. We purchased that movie and had a special evening for high school students and their parents to come. We had a nice supper for them and then we prepared a little PowerPoint presentation talking about vaccines, all the vaccines, I gave them some statistics on the improvement in mortality since vaccines have been introduced in our country and told them all about the safety process it goes through in having these vaccines developed and put onto the market and just went over each vaccine. We also shared with them the new rules with regard to school and reporting. *High-practice, low-PCSA provider*

In addition, participants wrote articles on HPV and other vaccines for the local newspaper, and provided pamphlets and books for parents to do further reading in hopes of encouraging vaccinations and dispelling any vaccine related myths. This effort by some participants from high-practice, low-PCSA category sites showed their general investment in the effort to improve HPV and other vaccine uptake, which illustrates motivated providers in the practice.

> . . . we are such a small community and we've put articles in the paper and they know us personally when they come in and they hear our little mantra, but on the other hand, we also don't want to turn them off. We have two copies of Dr. Paul Offit's book, which has really been, well I shouldn't say really been successful, but it has been successful in changing one young mother's view of vaccinations. We just checked it out to her and said take it and read it, keep it as long as you want. *High-practice, low-PCSA provider*

> I would, you know, what is your concern, find out what their concern is and then you know, well, let me give you a handout on it and see if this can help alleviate your fears, or let me give you this little booklet on it. *High-practice, low-PCSA provider*

While such efforts to communicate and further improve HPV vaccine uptake was discussed by participants from high-practice, low-PCSA category sites, lack of effort to persuade and communicate HPV vaccine-related information was discussed by a few participants from low provider-low PCSA sites. A few participants from low

provider-low PCSA sites discussed using value/observational judgment of adolescents in their community and encouraging the HPV vaccine for those who they assumed were sexually active or would be soon. This perception was then followed by a push to recommend the HPV vaccine to some adolescents but not all adolescents who are eligible for the HPV vaccine. For example, one participant from a low provider-low PCSA site specifically discussed the lack of dating in their community among adolescents because the kids have directly told the providers that they are not dating anyone. This approach to HPV provision and recommendation is clearly one that prevents some practices from performing well in HPV vaccine provision. Because lack of persuasiveness was discussed across categories and parental barriers were similar across categories, it is difficult to say whether this is the sole driver for the different categories. However, it is one of the potential mechanisms by which participants in these areas are not receiving HPV vaccine.

> We don't ask them why you are not wanting this vaccine. We see that as an opportunity to educate about the importance rather than, so we don't come across as putting someone on the defensive, so we took that opportunity to discuss HPV vaccine and give them both, you know, education by discussion and education by some printed materials to preserve the relationship and not you know make the family defensive because they chose not to immunize for that particular one. *Low-practice, high-PCSA provider*

> They get almost defensive in their, no, we're not doing any vaccines. Do you mind me asking you what your concerns are? No, I don't want to talk about it. Like, they're pretty defensive. So, then the door closes and I just keep it closed. Now, the doctor will then in turn, do their thing, but as a nurse, you know, I'm like OK I gotta go." *High-practice, low-PCSA provider*

> . . . there is not a lot of dating that goes on because a lot of them have grown up together, so I think that is part of the opinion that, you know what, look around, who would they be sleeping with, you know? I think this [HPV vaccine] can wait, a lot of parents I think have a really, the reality is that the kids are probably going to start being sexually active you know, later on because this is a really small town. *Low-practice, low-PCSA provider*

While lack of persuasiveness and communication was discussed by several participants, some participants from high-practice, low-PCSA and low-practice, low-PCSA categories discussed how they changed their approach the HPV vaccine discussion by moving away from emphasizing STI prevention to emphasizing cancer prevention to ease parental and adolescent discomfort. Moreover, participants talked about how parents were persuaded by the HPV television commercial, one that focused on cancer prevention and not STI prevention, and came to the clinic with their adolescents to receive the vaccine or called the clinic to request about the vaccine. Some participants discussed providing other parallels for parents to think about by saying Hepatitis B is also a cancer prevention vaccine and that their adolescents have been immunized with it, making a logical argument for HPV vaccine harmlessness.

> . . . talk about it [HPV vaccine] as a vaccine that prevents cervical cancer in women and several types of cancer in men and then just leave it at that initially. And then if they have more questions, then I go into the details, but I think, and I haven't really had anyone getting upset about the talking about sex part since I sort of switched to that spiel. *High-practice, low-PCSA provider*

> I think the commercial that HPV has put out is, has been amazing. I've actually had many parents with teens come to me and say we want to start this now . . . they shifted the focus from sexually transmitted to the cancer portion of it, and I think that commercial has done a lot of good. *Low-practice, low-PCSA provider*

> I think one of the things specific with HPV was getting away from the sex talk with parents and discussing it from a standpoint of cancer prevention, and even to the point of saying like you gave your child Hepatitis B vaccine and that is also a cancer prevention and helps prevent liver cancer and that's sexually transmitted as well, and people have no idea when you tell that to them, they're like really? *Low-practice, low-PCSA provider*

Even though there is a drastic difference in the HPV vaccine-ordering ratio among the practices in the high-practice, low-PCSA and low-practice, low-PCSA categories, the change in communication might be to focus a wider effort to change community-level HPV vaccine interest, perception, values and societal context. Participants identified concerns about early sexual debut as a major reason for parental hesitancy or refusal throughout the three categories. Providing facts about the vaccine as cancer prevention through innovative communication seems to remove some of the hesitation and concerns about the HPV vaccine.

Additionally, some professional confidence and authority in recommending and vaccinating adolescents played a role in provider's limited effort to persuade parents to vaccinate their children. Some immunization nurses from public health departments mentioned feeling like parents listen to and trust physician recommendations more than their recommendations, and because of that they would try recommending vaccines but not be persistent if they believe the "door is shut" for further discussion with parents. In these instances, they allow the patient to communicate with the physician further. However, participants from low-practice, low-PCSA sites mentioned that there is some level of trust in public health departments—usually led by nurses-- that helps facilitate parental acceptability of immunizations. Providers from rural public health departments especially felt that parents trusted them more because they are not a for-profit organization, but because their goal is to prevent disease. This professional level feeling of inadequacy to recommend and persuade patients to vaccinate their adolescents with HPV vaccine — even though they are trusted professionals by parents — was a lost

opportunity for some providers. It also shows a lack of confidence in future interactions where physicians might not always be present to drive the vaccination agenda further.

> It's definitely a time thing because I look at it as the patient came for the doctor's advice, not the nurse's advice. That patient population trusts doctors more than nurses, so I'm gonna give my spiel, it's gonna be quick, it's gonna be precise, and if they shut me down, I'm gonna leave. I'm not gonna try. If there's a sliver of a, the door open, then I'd be like OK, what is your concern, how can I help you, you know, that kind of thing, but if they're gonna shut me down, then no. *High-practice, low-PCSA provider*

> . . . I can't sit in here for 20 minutes and try to convince you to get this vaccine. Like, they're pretty defensive. So, then the door closes and I just keep it closed. Now, the doctor will then in turn, do their thing, but as a nurse, you know, I'm like OK I gotta go. *High-practice, low-PCSA provider*

> I think there's a lot of trust in public health. I think the general public, one they trust nurses a lot and they trust public health. *Low-practice, low-PCSA provider*

While some participants discussed a lack of professional confidence in persuading parents to vaccinate, others reflected on the process and practice of discussing vaccines and felt that they might be missing an opportunity by currently only discussing about vaccines on well-child visits and not on sick visits. They talked about how they are programmed to think about vaccines on well-child visits only, but felt that they should check vaccine status every visit to ensure communication about up-to-date status with parents and their children. This reflection from providers on their own practice during the interview process showed the motivational aspect of asking individuals regarding their practice.

> . . . right now the way that our system is set up, we only really do a good job of thinking about vaccines on well type visits, like at 14 for an annual check or something and we don't do it a good job if they're there for other reasons, like if they have a cold or something, which I'm trying to change a little bit of our workflow and all age kids, including younger kids, to decrease missed

> opportunities like if we, we should be checking vaccine status every time, regardless of what a kid's there for and hopefully reduce some missed opportunities that way. *High-practice, low-PCSA provider*

Clinic location and vaccines offered. Participants also discussed major barriers in reaching certain populations for vaccines due to geographic and weather conditions. For example, participants from low practice-low PCSA sites discussed the role of geographical distance between clinics and some residents as a barrier to receiving timely well-child and preventive services, making vaccine recommendation and provision that much harder. In some rural areas, other participants noted, parents must take a whole day off from work — especially in the winter — and pull their adolescents out of schools to get to a clinic. This is often extremely difficult for families and it creates missed opportunities for vaccinations when they miss or cancel an appointment. Participants from high practice-low PCSA sites, however, discussed efforts they made to increase access to HPV vaccine uptake by having off-business hour clinics to increase access to adolescents and their families. This entailed staying open in evenings and even on weekends if needed. Participants also mentioned holding back-to-school immunization clinics in the evenings to provide additional access to adolescents and their parents and make sure adolescents are up-to-date on vaccines. They said they usually pre-reviewed patients' previous vaccination status using electronic medical records to ensure patients are told about vaccines they need before arriving to the clinic. Participants also discussed sending letters to parents to inform them of upcoming back-to-school immunization events, and making phone calls to remind them if they do not hear back from them in a certain time frame.

> We are open 8:00 to 4:30 Monday through Friday, but we are willing to stay open evenings. In fact, we do evening clinics from time to time as needed. We will even schedule to come in on a weekend. If it's, say, a college kid that's gone away to college, but they're still under age 18 and they didn't finish their HPV series. If that child is home to visit his parents over a college weekend, we'll meet them up here at our office on a Saturday morning, so the, one thing that could be a barrier would be hours of service, is never a barrier here. *High-practice, low-PCSA provider*

> Because you know, school nursing, now you have to report, you have to look at the students and if they're up to date. If they're not, they get a letter from us. We also are the school nurse in one of the schools, the very small school, but we work closely with the school nurse in the little bit bigger school, and so that's one of the first things you do in the fall when the new school year begins. We have a back to school vaccination evening and then we, those who didn't get their, are lagging behind, their parents get a letter and then if we don't hear from them in two weeks, we start making phone calls. Phone calls are probably something that wouldn't be logical or realistic in a big metropolitan area, but it is here. *High-practice, low-PCSA provider*

These efforts by high-practice, low-PCSA category participants to educate parents and their adolescents about the HPV vaccine, provide resources for parents, and to be more accessible to those who cannot schedule an appointment during normal business hours were discussed only by participants from the high-practice sites. It possibly explains why these practices are in the high practice category even though they were in low HPV-ordering PCSAs. This level of accessibility and communication of information by participants is vital in addressing concerns expressed by vaccine-hesitant or refusing parents.

Another community factor discussed by low practice-low PCSA participants was the difficulty of reaching homeschooled children for vaccinations because many of them do not come to the clinic for vaccines unless they are about to go to college. Inability to reach the homeschooled population made it difficult for participants to recommend and provide HPV and other adolescent vaccines. These challenges

discussed by low-practice, low-PCSA sites might explain in part why their PCSA level HPV vaccine-ordering ratio is low. However, it does not explain why these populations are receiving the Tdap but not the HPV vaccine. Although this phenomenon was only discussed by participants from low practice-low PCSA categories, the challenge of reaching home-schooled children is illustrative of common barriers to reaching these children across all regions.

> Weather, we get snow a lot, we're in between two mountain passes to the nearest town and so I, the, a lot of the kids do not have regular well child visits. I would imagine as much as other places 'cause again, they have to take, either they need to go in the summer or they have to take a day off from school and work and take the whole day to go and do their errands in [town name] and I think that there's a lot of missed opportunity for vaccinations because of that. I do think it's more challenging in rural communities that do not have a regular doctor or pediatrician and so these communities I feel like are a bit more difficult and then like I said before, you know, we, even with my little kids, we would have where oh well shoot, we didn't make their well child check but we'll go next month, well actually we're taking the kiddo in because they're sick and we're not gonna get vaccinations on the day they're sick and so it's just. *Low-practice, low-PCSA provider*

> You don't [reach homeschooled children for immunizations] and the reason we know about it is that we have had homeschool, you know, 18-year-olds come to us for vaccines because they're going to college, and they want to get vaccinated. And so, so we know they're out there, but we don't know how to get to them. *Low-practice, low-PCSA provider*

Additional barriers discussed by participants included physician's offices not providing vaccines for various reasons, even though adolescents went to the clinics for numerous reasons. A few participants from high practice-low PCSA and low-practice high-PCSA health departments discussed fragmented care because the local physician's office did not provide vaccines to their patients, instead recommending that patients go to the local public health department for vaccines. Some participants saw this as a lost opportunity to vaccinate because parents may

not come back or make another appointment at the local public health department just for a vaccine. Participants said that this also happened in their neighboring local health departments, and that the issue is bigger than their county only. Some participants, especially in rural public health departments, stated that the lack of physicians who offer immunizations in their community left the health department as the only option for vaccine-related conversation and delivery. Although it was a phenomenon described by only two of the three categories, referral to local public health departments for vaccines is a common trend that creates fragmentation of care. Participants said that physicians pointed to the cost of vaccines or lack of appropriate reimbursement as the main reason they did not provide them in their patients.

> We're as far out east as you can get. We border the [name of state] state line, so the next county to the north of us is [name of county], and they're like us, their physician's offices also want the public health nurses to do the vaccinations and then the county south of us is [name of county] and they're in the same situation as us. They don't even have many immunization services through their public health agency. *High-practice, low-PCSA provider*

> Another barrier we have in our area is that our lack of physicians in a rural area. A lot of physicians are not giving immunizations. *Low-practice, high-PCSA provider*

> One doctor's office has just stopped offering private stock immunizations due to the cost, so he refers his patients down here. Other offices, they just aren't doing that. It would make sense to do it with well child checks, but they're just not providing them. When people go, yeah, when people go see their doctor, they should be able to receive their immunizations during that visit. *Low-practice, high-PCSA provider*

Participants not only discussed fragmentation of care for adolescents when they are referred to local health departments for vaccines but also the challenge of providing vaccines for people with different types of insurers. Although physician's

offices are referring patients to the local health department for vaccines, some participants discussed difficulties creating contractual agreements with insurance companies, some who refuse to sign a contract with the local public health department. This made vaccine provision extremely difficult and costly. As the sole provider of vaccines for that region, some health departments faced barriers without a contract with private insurance companies, where vaccines are not covered by insurance. Thus, parents must drive hundreds of miles to get to the nearest physician's office that takes their private insurance and provides vaccines to cover the cost of immunization. Participants said that even with the Affordable Care Act in place, there are still patients who are underinsured, and that not all of their vaccination needs were covered. This issue is further complicated when patients receive the vaccine at the health department but insurance companies refuse to reimburse the local health department, leaving them stuck with a vaccine bill.

> There is a hospital that has physicians but they do not provide vaccines other than Tdap in case of emergencies; we're the only provider of infant as well as adolescent vaccinations in our county. *High-practice, low-PCSA provider*

> There's some companies that won't even sign an agreement with us. They won't consider us to be a preferred because we are a department of health. We don't have physicians here. We're nurses, and they want to work with physician's offices. Well there's not a physician's office in our county that is willing to do it. There's only one physician's office in our county and they've said we're not interested in getting into the immunization business, so that means that family that has insurance. Maybe it's even insurance that will pay, but it's insurance that will not sign an agreement with [name of county] County Public Health, so those families then need to drive to a neighboring county, which may be 3 or 4 counties away as in the Front Range, Colorado Springs or Denver and go to a family practice office that has a vaccine. Well, maybe it's not convenient to drive 180 miles into the city. So it really has become a barrier for some. *High-practice, low-PCSA provider*

> Because they're saying that according to the Affordable Care Act, there should be no underinsured. All insurances are required to pay for a vaccine,

> but the plain and simple truth is all don't. Insurance companies refuse payment and usually we get stuck with the bill because we agreed to bill the insurance and so the patient is able to leave. *High-practice, low-PCSA provider*

Participants discussed challenges to HPV and other vaccine provision where not all the physician offices in their area provided vaccines for various reasons, such as low reimbursement rates. However, physician's offices referred parents and their adolescents to the local health department regularly. But local health departments are unsure if all of the referred families are coming to their clinic because it is difficult to make more opportunities once the primary provider misses the opportunity to administer vaccines during the initial visit. The lack of a contractual agreement between insurance agencies and health departments is another diminished opportunity for families to receive the HPV vaccine in a place accessible to them. Even though challenges exist, performance categories for the HPV vaccine were anchored to the Tdap ordering trend.

Furthermore, the role of winter and driving distance due to lack of immunization providers who accept certain insurances was another barrier to HPV vaccine uptake. These insurance and geographic factors experienced by low PCSA categories further explain the challenges experienced by providers and the patients they serve in providing the HPV vaccine to the adolescent population. These phenomena in low-PCSA category might explain the overall challenge faced by low PCSA category sites in providing HPV vaccine to adolescents; however, it might not explain the performance categories that are anchored to the Tdap-ordering trend. If the practices were ordering Tdap, then they should also be ordering the HPV vaccine unless physician offices are picking and choosing which vaccines they offer

to adolescents. In that case, the low PCSA category of these sites explains the regional level low performance.

Challenges in vaccine ordering and billing. Several participants from low-practice, low-PCSA sites discussed barriers related to billing and ordering HPV and other vaccines. They are familiar with billing for VFC/publicly-insured vaccines but discussed challenges they faced with private insurance. Many participants from public health departments across categories noted challenges in billing for private vaccines because they have to learn about insurance companies and negotiate individual contracts with them for payment or reimbursement. They added that some billing programs did not work well in their facility, leaving them with added challenges when billing private insurance for vaccine reimbursement. Some participants noted an additional challenge in which some private insurers assumed that local health departments get vaccines for lower price or for free, and as a result, reimburse them at lower amounts than the actual cost of vaccines. Because of this incorrect assumption, covering vaccine costs became more difficult for local health departments. This ties in with challenges local health departments face in some areas where they are receiving referrals from physician offices with privately-insured adolescents but do not have the means to bill for the service.

> Private is a little difficult because we now are required to bill for private insurance and so that requires getting contracts with insurance companies and so that's been very difficult because public health until about four years ago did not have to do that at all. *Low-practice, low-PCSA provider*

> I think that they've got a good mechanism if they can get it working efficiently because I mean, it sounded great, but and some of the people that were in the pilot loved it and some people were like oh I would never ever, ever, ever do it. *Low-practice, low-PCSA provider*

> Another barrier for us is with private insurance and getting more contracts that, we've come across that insurance companies feel that we're, we get vaccine for a lower price, but at the private level we really don't and so what they want to reimburse us doesn't even cover our costs, and so we've had to turn away many private clients because we don't have a contract with their company. *Low-practice, low-PCSA provider*

Even though, participants from low-practice, low-PCSA sites discussed challenges in billing different insurers for HPV vaccine, several participants from low-practice high-PCSA sites discussed the role of a new and recently implemented billing system that helps them bill private as well as public-insured patients. Because of this new system, called Vaxcare, participants were able to accept more types of insurers and allow more people to have access to vaccines. Furthermore, this new system reduced vaccine waste and cost to the clinic because VaxCare absorbs the cost of any vaccine not administered. Although this was a new billing method, it was addressing challenges these clinics faced that might have initially put them in the low practice category.

> . . . they [VaxCare] contract with all of these insurance agencies, so insurance agencies that we were not able to contract before, that has allowed us to offer vaccinations to more people because we're accepting more insurance companies. *Low-practice, high-PCSA provider*

> . . . it reduces the risk that the public health agencies have in purchasing vaccine, so if you, under, if a public health agency purchases private stock and we're not able to get that administered, then they could incur the loss of that vaccine if it expires. So that eliminates that risk because the company purchases the vaccine and then they do the billing for the insurance agencies and all we do is enter the information in and administer it. *Low-practice, high-PCSA provider*

Because VaxCare is working well to address challenges discussed in vaccine billing by low-practice, low PCSA sites, finding best practices from other regions — in this case from low-practice, high-PCSA sites — is important to transfer best practices for better HPV vaccine ordering and vaccination. Participants from low-practice, low-

PCSA specifically discussed challenges in billing for private vaccines due to lack of contractual agreement with private insurers. If using systems like VaxCare would benefit the low-practice, low-PCSA challenges, solutions like this should be shared.

Even though providers from some sites discussed challenges in billing for private vaccines, other participants discussed barriers to becoming VFC providers. Many participants discussed how VFC vaccine ordering is difficult because of the federal guidelines required to be a VFC provider to order vaccines. Some participants stated that VFC vaccine-related ordering and requirements are burdensome to private clinics without much experience with the program. This deters them from being a VFC provider who could offer more opportunities for adolescents to receive the vaccine in an affordable way. Furthermore, many providers felt like the VFC rules were constraining in rural communities where there are not a lot of vaccine providers. These challenges in vaccine ordering and billing experienced and shared by participants from low-practice, low-PCSA sites helps explain to some extent why sites in these categories are in the lower HPV vaccine-ordering ratio category. While there is a clear lack of immunization providers in this PCSA, one provider from a low-practice, low-PCSA site indicated that more provider offices are starting to provide both private and public vaccines (VFC vaccines) because the public health department helped the private offices with the paperwork and refrigerator purchase needed to stock VFC vaccines using grant money. This new phenomenon might help overcome barriers discussed by participants from this site. Although this factor was only mentioned by one participant, it is worth noting

that having more VFC vaccine providers in the area will provide more opportunities for HPV vaccine uptake among adolescents.

> I guess VFC sometimes is a little more difficult just 'cause of all the ordering guidelines. *Low-practice, low-PCSA provider*

> It's really frustrating that with VFCs [because providers can't give vaccines for children with insurance] if their insurance doesn't cover it [the vaccine], then one time I remember the family of twins who were due for all three vaccines, their closest in-network person was an hour and a half away, so it's really hard for them to get the series of three and so, so you know I kind of, I understand the VFC and I know why they need to do that, but we miss out on some vaccines because of, of vaccinating kids because of those rules. *Low-practice, low-PCSA provider*

> [Name of clinics] has since gotten a provider that got VFC. We were able with a grant to help him get a pharmaceutical grade refrigerator, that was always a big barrier to, you know, to the private doctors because the, you know, the paperwork to do the government-funded vaccine and all of that, so and as they became stricter with the VFC, it became evident to us that we needed to carry two separate sets of vaccine. We needed to carry private fund vaccine and start billing insurance, and we needed to continue to offer VFC because of the Medicaid population and no insurance. So we've done that for probably five years maybe, I don't know, and we've had really good success in billing for private insurance, so it's been, it's been a good deal for everybody. *Low-practice, low-PCSA provider*

Funding for vaccination efforts/cost of vaccines. Some participants from high practice-low PCSA and low practice-high PCSA sites discussed the cost of the HPV vaccine as a barrier for those who are underinsured. Participants wished they could give the VFC vaccine to underinsured patients as well as uninsured, but because of changes in healthcare policy, those opportunities are no longer available.

Participants also noted sporadic vaccine supply shortages due to VFC vaccine backorders, resulting in an inability to provide vaccines when adolescents come to the clinic. Some participants also expressed an interest in improving HPV and other vaccination rates in their community, but said they lacked grants and

funding to help support their efforts. They believe that having more funding would help improve vaccine uptake. This showed some participants are interested in improving HPV vaccine uptake but do not have the means to do so due to lack of resources. However, it does not explain their HPV vaccine-ordering ratio categories but rather an overall challenge faced by participants when they want to improve vaccine uptake.

> . . . there's the folks that do have insurance but they're maybe underinsured, and for some reason or other, the vaccine doesn't get paid for after all. That's a problem. That's why I wish we could just give the darn VFC vaccine to everyone and we'll bill for those who are able to pay and those who aren't, we'll let them have it, but that's just not gonna happen anymore. We enjoyed that, we enjoyed that for 15 years, but it's ancient history now. *High-practice, low-PCSA provider*

> . . . for Medicaid that we order once a month and occasionally, we will get a notice that it's on backorder or there's a shortage, oh, maybe a year ago the HPV was, we had a little shortage and didn't get quite as much as we had hoped. *High-practice, low-PCSA provider*

> Other issues are, you know, finding funding for, you know, vaccinations and things like that. So there is a difference between here and when I was in private practice in Indiana for the number of patients that I see and counsel for this versus the number that are accepting it, but once again, I think you know having availability and you know grants for that will increase compliance with that if we're able to offer it to patients they, you know, it helps. *Low-practice, high-PCSA provider*

Collaboration with other organizations. A few participants from low-practice, low-PCSA sites discussed collaborating closely with school nurses and community health centers to facilitate adolescent immunization. Participants discussed being co-located with a community health center so they could be alerted when someone needs a certain vaccine. This collaboration is starting to help them capture adolescents who are not up-to-date with HPV and other vaccines. Some providers also held immunization clinics at schools to increase opportunities for

adolescents to receive the HPV and other vaccines. In these cases, participants discussed sending consent forms to parents ahead of their visit to these schools to request permission to immunize their children. These efforts might explain this category's efforts to improve immunizations as they were in the low-practice, low PCSA HPV vaccine-ordering ratio.

> We, because we are a rural county, we are able to, every spring I work in conjunction with the school nurse, and we actually go into the schools, we send home like consent forms with children that are needing to be up-to-date on their vaccines for school. We get a list of those and we send home like an information sheet and consent form with those children, and then we actually have an agency go into the schools and get everybody caught up on what they're needing for the following school year. . . .
> *Low-practice, low-PCSA provider*

> . . . . so we have a community health center and we actually screen every child that they see for immunizations and then recommend what they need.
> *Low-practice, low-PCSA provider*

> We work very closely with all the schools in our community. We always hold spring immunization clinics and fall immunization clinics at the schools, that way parents have a chance to get TDAPs and then we offer them Meningitis and HPV and information. *Low-practice, low-PCSA provider*

Policy Factors: Changes due to the Affordable Care Act. A couple of participants from different practices in the low practice-high PCSA category discussed the Affordable Care Act's (ACA) rule change regarding the appropriate use of federally-funded vaccines. Although the rule change they discussed was not due to ACA, the change they discussed removed the ability for providers to give VFC and other federally-funded vaccines to anyone without checking a patient's eligibility. Participants said this new policy made it harder for public health departments to offer vaccines in the clinics if parents did not bring documentation for eligibility, increasing the number of missed opportunities for vaccination. However,

the misinterpretation of the changes to the eligibility rule demonstrates a lack of knowledge among some providers about the policies that govern their immunization practice.

> Prior to the Affordable Care Act, when the federally-funded vaccine laws changed, or the rules around the appropriate use of federally-funded vaccines, we were able to immunize at schools and we did not have to determine eligibility, and our immunization rates were much better, but we were not able to do that, we were not able to use the vaccines, the federally-funded vaccine for you know all those individuals once those rules changed and our rates have been down. *Low-practice, high-PCSA provider*

> I think it has to do with immunization opportunities, so our community was, we had many insured individuals who came to public health because we're easy to access and we're, you know, we're not a provider office where you have to pay for an office visit, make an appointment and things like that, so it was the ease of obtaining immunizations at public health that was a big factor. *Low-practice, high-PCSA provider*

Opportunity for improved HPV vaccine uptake: Change in the HPV vaccine dosage. Participants from all categories discussed the new change in the number of HPV vaccine doses as an opportunity to improve HPV vaccine uptake among their adolescent population. Although most learned about the change at different times — some learned about the new vaccine guideline from the researcher during the interview, while others knew but had not implemented the new guidelines at the time of the interview — they discussed opportunities that will come with the new guideline and shared their optimism that the change will increase vaccine uptake.

Several participants discussed how moving from the three-dose requirement to the two-dose requirement will reduce the HPV vaccine cost burden on families. Furthermore, providers discussed how one of their biggest issues is getting adolescents in the clinic, so having them come to the clinic twice instead of three

times would improve vaccination rates. A few participants also mentioned that adolescents will be happy with less visits since some are needle-shy.

In addition, participants said they plan to communicate with families about the new vaccine guidelines via a letter. Messaging strategies included writing the letter in layman's terms and keeping it positive to capture a parent's attention.

> So I think that's gonna be real good because number one, it's gonna save the family money, number two only two trips in instead of three, so I think it's going to help with our vaccine series completion rate. I have high hopes that it will. High hopes. *High-practice, low-PCSA provider*

> I think the kids will be excited because it . . . it is a painful vaccine for whatever reason, it is more painful than other vaccines, and so I think if they've talked to any of their friends or relatives or they've already had one dose, knowing that they only have to have one more will make them happy, and I think for parents, only having to remember one more visit versus two more visits will make them happy. *Low-practice, high-PCSA provider*

> Yeah, I think it'll probably help people be a little bit more apt to come back if they only have to come back one more time on the HPV. *Low-practice, low-PCSA provider*

In conclusion, these findings enhance our understanding of the current barriers to HPV vaccination of adolescents. Participants from the three categories who participated in key informant interviews described parental, provider, and policy factors that hinder HPV vaccine uptake in Colorado. There were fundamental similarities in barriers experienced by participants from the three categories.

Table 3. Facilitators to HPV Vaccine Uptake among Different Categories

Categories	Low-practice, high-PCSA	High-practice, low-PCSA	Low-practice, low-PCSA
Provider factors	*Billing methods* *Reminder recalls*	*Providers who communicate up-to-date immunization information with parents* *Increased accessibility to clinics and reminders* *Moving away from sexually transmitted infection prevention to cancer prevention*	*Increasing number of vaccine providers* *Collaboration with other organizations* *Moving away from sexually transmitted infection prevention to cancer prevention*
Parental factors	*Receptive populations* *Parental prior experience with HPV* *Tdap vaccine school requirement*	*Receptive populations*	*Receptive populations* *Trust in public health departments* *Tdap vaccine school requirement*

Parental factor barriers to the HPV vaccine combined with provider factors provided a clear picture of the challenges present today in HPV vaccine recommendation and provision. Although progress has been made in improving HPV vaccine provision rates, this qualitative research highlights the effects of parental refusal and hesitancy to vaccinate their adolescents, and the effects of providers who do not recommend the vaccine, who are not sufficiently persuasive, or who do not always have opportune environments to provide the HPV vaccine. For example, parental fear of adverse outcomes can be addressed with evidence-based

data and provider communication. Furthermore, provider assumption that certain adolescents need the HPV vaccine more than others, and thus recommending the vaccine for some but not others by observational judgment, is sure to create missed opportunity to vaccinate.

The findings of this research compliment prior studies that looked at barriers to HPV vaccine uptake nationally. Furthermore, the empirical findings in this research have several practical implications for improving HPV and other adolescent vaccines in Colorado. The variations in HPV ordering ratio showed differences in practice and PCSA level HPV vaccine trends. However, the barriers discussed primarily showed similarities in terms of barriers and very subtle differences in provider practice behaviors. Such information can be used to develop targeted interventions aimed at improving HPV vaccination rates. Further exploration of these qualitative findings will be carried out to test and solidify the generalizability of some themes that were persistent throughout the qualitative exploration.

In summary, participants from the three categories who participated in key informant interviews described several barriers to HPV vaccine uptake in Colorado. These ranged from barriers due to conservative parental outlooks and concerns about their adolescents' untimely sexual debut to provider barriers in believing that certain parents and their children do not need the HPV vaccine. These variations in HPV ordering ratio that showed variations in vaccine ordering also unveiled variations in enabling and hindering factors to adolescent HPV vaccination, such as practice, perceptions of their community, and lack of resources. There were also very subtle differences between categories in provider factors and barrier themes.

For example, vaccine ordering and billing was a barrier discussed only by providers from low-practice, low-PCSA categories. Although there was not a clear difference in all the themes of barriers in driving the three categories apart, how they dealt with these barriers provides a better understanding of differences between categories.

In summary, all three categories discussed facilitators to HPV vaccine provision and recommendation in their sites. Some facilitators included what clinics did to improve HPV vaccine uptake by increasing availability and talking to the parents and adolescents directly about HPV vaccine. Other sites discussed the Tdap vaccine school requirement as a facilitator that motivates parents to come into the clinic so that providers can have the opportunity to speak to them about HPV and other adolescent vaccines. The most striking facilitator was how high-practice, low-PCSA sites discussed their efforts to collaborate with and share HPV vaccine-related information to adolescents directly. They also discussed staying up-to-date on immunization information by attending meetings and receiving journal articles for readings.

The key themes obtained from Aim 2 qualitative research are that there are similar existing barriers faced by all categories. The extent to which these barriers were addressed by the different categories to some extent explained differences in the categories. Because the categories were determined by using VFC ordering data from 2015, it is important to make the distinction that the HPV vaccine-ordering ratio might not equate to HPV vaccine receipt. However, because the ratio was anchored to the Tdap vaccine-ordering ratio, it does provide practice-level initial plans to provide the HPV vaccine.

Several factors influence HPV vaccine provision. Provider, parental and adolescent discussions about HPV vaccine do not occur in vacuum. They are influenced by population level context: culture, norms and values as well as perceived and actual disease risk and system and structural level context: geography, payment systems, insurance, office hours of clinics, etc. Figure 2 was created to depict contextual factors that influence HPV vaccine uptake. Providers, adolescents and their parents are influenced by the population context where they live in that includes values, morality, and messaging about prevention and perceptions and actual risk of HPV-related disease. This population context is influenced by:

- Vaccine messaging and communication via providers and general advertisement
- Religiosity of parents and their influence on adolescents
- Population level perceptions of adolescent health and what is deemed appropriate prevention for their age
- Parental experience with HPV infection-actual risk

There are also system and structural contexts that enable or hinder their willingness to vaccinate. These included current vaccine policy, payment methods at the clinic, availability of immunization providers, office hours and ability to schedule visits. These are observed by:

Figure 2: Contextual factors that influence HPV vaccine uptake

- Communication change in vaccine policy from top down
- Availability of immunization providers who provide off-hour services
- Ability for practices who accept different types of insurance to increase access

The barriers and facilitators discussed by participants revealed interrelated population level as well as system and structural level contextual factors that informed adolescent HPV vaccine uptake. Parents were influenced by cultures, religious beliefs, norms and values, focused on the protection of their adolescents

from vaccine side effects as well as early sexual debut, and their perceived risk of disease due to their prior experience with cancer or HPV infection. Providers in the meantime interacted with different adolescents and their parents while trying to communicate HPV vaccine need. This was clearly influenced by professional confidence (types of providers). Adolescents, however, were less engaged in their care, were needle-shy and had sometimes a say in what their parents decided. This also was dependent on whether the adolescent had come to the clinic to receive HPV vaccine, emphasizing why the role of preventative visits in HPV vaccine initiation and completion is important.

These structural and population level factors can be tested using quantitative data for generalizability and further validity. These possible testable points include:

- Hispanics are open to all vaccines, including the HPV vaccine, for their adolescents
- Parents with public insurance are more likely to accept provider recommendations
- Differences in male and female adolescent HPV rate
- Differences in rural and urban setting with focus on seasonal differences in immunization uptake
- HPV vaccine difference among adolescents in different religious groups
- Obtaining information from parents of adolescents regarding their perception and attitudes towards HPV vaccine

These notions obtained from the qualitative data can be tested for further generalizability and validity. Due to feasibility and availability of data, the two main

testable hypothesis that were tested are below. Testing Hispanic/non-Hispanic HPV vaccine uptake tests the underlying mechanism by which culture, value, attitudes and behaviors influence HPV vaccine uptake in different populations. The insurance status hypothesis however looks at the larger system and structural factors that influence HPV vaccine uptake. Testing these two hypothesis provides insight into the larger contextual factors that hinder or facilitate HPV vaccine uptake.

- Hispanics are open to all vaccines, including the HPV vaccine, for their adolescents. This notion gets at the role of culture and population level norm and value in HPV vaccine uptake and how it contributes to differences in outcomes.
- Parents with public insurance are more likely to accept provider recommendations than privately insured individuals. This notion discusses the role of system and structural factors such as insurance in enabling HPV vaccine uptake.

Understanding nuances by testing these two hypotheses can provide insight into facilitating factors to improve HPV vaccination. Furthermore, decomposition analysis will further help identify explained and unexplained factors contributing to these factors.

Aim 3

The objective of Aim 3 was to understand the contribution of providers, patients, and PCSA factors to disparities in HPV vaccination rates and to test hypotheses informed by the qualitative interviews.

Cohort Preparation

Using APCD data from 2011-2014, children aged 11-18 years of age in Colorado were used for this analysis. There were 345,985 claims in the APCD data from 2011-2015. Among those, 183,743 claims had Tdap vaccine and 54,146 claims were in the data for 365 days after index Tdap visit. Finally, 26,654 children met the 365-day follow-up window requirement after the index event. The reasons someone would not have a full 365 post-Tdap index date include: loss of health insurance during the time following Tdap vaccine, moving to a different state, etc.

Explanatory Analysis

A total of 26,654 patients between ages 11-18 were included in the APCD data between 2011 and 2014. Unadjusted patient level demographic and other characteristics of interest are reported in Table 4. These characteristics included age in years, gender, race, ethnicity, urban/rural residence, insurance status, and visit type (preventative, sick, or vaccine-only visits).

Population level characteristics of the above patients are described in Table 5. These characteristics included religion adherence per 1000 population, percent of racial/ethnic residents in the population, population level educational characteristics, percent linguistically isolated households, percent income below poverty and institutionalized population.

Logit Analysis Results

The marginal effects from the logistic regressions are reported in Table 6. Although race and ethnicity data were available, due to unreliable racial groups labeling in APCD data, the individual estimates are not reported.

Column 1 of Table 6 includes the estimates of the probability of the HPV vaccine initiation. After controlling for several covariates, we found that males compared to females were significantly less likely to initiate HPV vaccine. In addition, individuals who had male providers compared to females and those who saw other types of providers compared to primary care providers were significantly less likely to initiate the HPV vaccine. Individuals living in high mainline Protestant adherence counties as well as in counties with higher black Protestant adherence rates were significantly less likely to initiate the HPV vaccine. Furthermore, adolescents living in areas with higher percentage Hispanic population compared to non-Hispanics, those living in areas with higher percentages of individuals with income below the poverty level, and those living in areas with a higher institutionalized population were significantly less likely to initiate the HPV vaccine.

Table 4: Study Population Characteristics by Receipt of at Least One Dose of HPV Vaccine

Characteristics		**Received at least one HPV (%)** *N* = 12,533	**Did not receive any HPV (%)** *N* = 12,481
Age in years	11	56.62	41.97
	12	16.7	18.03
	13	6.62	6.85
	14	4.94	5.54
	15	4.35	5.27
	16	4.02	5.84
	17	3.38	7.4
	18	3.36	9.08
Gender	Male (Ref)	48.52	54.52
	Female	51.37	45.24
	Unknown	0.11	0.24
Race	Race 1	5.86	5.38
	Race 2	4.68	6
	Race 3	2.75	2.17
	Race 4	0.47	0.45
	Race 5 (Ref)	3.38	3.91
	Race 6	8.03	7.43
	Unknown race	74.83	74.67
Ethnicity	Non-Hispanic (Ref)	25.26	17.75
	Hispanic	74.74	82.25
Insurance	Private	39.66	41.18
	Other	3.37	97.29
	Public (Ref)	51.33	48.16
Rural/Urban	Urban (Ref)	90.12	85.65
	Rural	9.07	13.7
TDAP Visit Type	Vaccine only (Ref)	64.58	41.31
	Preventive	88.23	76.13
	Sick	89.54	88.56
Provider type	Primary care (Ref)	41.16	46.15
	Other providers	58.84	53.85
Provider gender	Male	40.04	51.07
	Female (Ref)	59.85	48.77
	Unknown	0.11	0.16

Note. Unadjusted data.

Table 5: Characteristics of Study Population's Residence

Characteristics		Received HPV	Did not receive HPV
Religion adherence per 1000 populations	Evangelical rate	115.00 (0.37)	122.00 (0.38)
	Catholic rate	158.67 (0.80)	157.00 (0.94)
	Mainline Protestant rate	46.30 (0.16)	48.21 (0.17)
	Black Protestant rate	2.32 (0.037)	2.03 (0.033)
	Orthodox rate	2.15 (0.025)	1.76 (0.021)
	Other religion rate	42.16 (0.15)	41.77 (0.18)
Percent of racial/ethnic residents in the population	White	0.80 (0.001)	0.82 (0.0008)
	Black	0.046 (0.0005)	0.04 (0.0004)
	Hispanic	0.22 (0.0012)	0.20 (0.001)
Population level educational characteristics	Population under age 25 below high school education	0.046 (0.0003)	0.042 (0.0003)
	High school graduation	0.146673 (0.0003)	0.15 (0.00034)
	College graduation	0.14 (0.0005)	0.14 (0.0005)
Additional area characteristics	Linguistically isolated households	0.19 (0.0007)	0.173226 (0.0007)
	Income below poverty	0.12 (0.0005)	0.12 (0.00051)
	Institutionalized population	0.01 (0.0001)	0.013 (0.0002)

Note. Unadjusted County and PCSA level data. Standard deviations are in parentheses

We also found that Hispanics compared to non-Hispanics, those who live in urban settings compared to rural areas, and those who had more preventative visits compared to vaccine-only visits were significantly more likely to initiate HPV vaccine.

Table 6: Logistic Regression Results (Marginal Effects)

Variables	HPV initiation	HPV completion
Observations	n=24,553	n=24,553
Patient characteristics		
Male (ref. female)	-0.0600***	-0.0498***
	(0.0061)	(0.0047)
Urban (ref. rural)	0.0791***	0.0426***
	(0.0151)	(0.0123)
Unknown Hispanic ethnicity	-0.0005	0.0266**
	(0.0153)	(0.0116)
Hispanic ethnicity (ref. non-Hispanic)	0.1340***	0.0557***
	(0.0163)	(0.0130)
Private insurance (ref. public insurance)	0.0086	0.0371***
	(0.0081)	(0.0062)
Other insurance	0.0553***	0.0309**
	(0.0195)	(0.0138)
Provider and visit type characteristics		
Preventative visit	0.0720***	0.0595***
	(0.0024)	(0.0018)
Sick visit (ref. vaccine-only visit)	0.0002	0.0016***
	(0.0004)	(0.0003)
Male provider (ref. female providers)	-0.0760***	-0.0240***
	(0.0065)	(0.0050)
Other providers (ref. Primary care providers	-0.0555***	-0.0311***
	(0.0067)	(0.0051)
Population level characteristics		
Evangelical rate	-0.0002*	-0.0001
	(0.0001)	(0.0001)
Catholic rate	0.0001*	0.0001
	(0.0001)	(0.0000)
Mainline protestant rate	-0.0010***	-0.0002
	(0.0003)	(0.0002)
Black protestant rate	-0.0130***	-0.0073***
	(0.0018)	(0.0014)
Orthodox rate	0.0225***	0.0105***
	(0.0031)	(0.0025)
Other religion rate	-0.0010***	-0.0008***
	(0.0002)	(0.0002)
Pct. Black (ref. pct. white)	0.0822	0.0641
	(0.1209)	(0.0890)
Pct. other race	0.5990***	0.5544***
	(0.1957)	(0.1450)
Pct. Hispanic (ref. non-Hispanic)	-0.2774**	-0.1302
	(0.1351)	(0.1005)
Pct. ling isolated house	0.3039	0.1540
	(0.1861)	(0.1520)
Pct. income below poverty	-0.3541***	-0.2383***
	(0.0930)	(0.0730)
Pct. institutionalized pop	-0.4768**	0.1519
	(0.1963)	(0.1486)

Table 6 cont'd

Variables	HPV initiation	HPV completion
Pct. below High school pop under age 25	0.7604**	-0.1042
	(0.3131)	(0.2533)
Pct. high school graduates	0.4169**	0.5286***
	(0.1702)	(0.1330)
Pct. college graduate	0.5406***	0.4180***
	(0.1441)	(0.1163)

Notes. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$.

Furthermore, individuals who lived in areas with increased number of other races (non-black, non-Hispanic) compared to whites, those living in communities with higher linguistically-isolated households and with a higher percentage of individuals under age 25 who have not completed high school were significantly more likely to initiate the HPV vaccine. Furthermore, individuals living in areas with higher percentages of high school and college graduates were more likely to receive at least one dose of the HPV vaccine (Table 6).

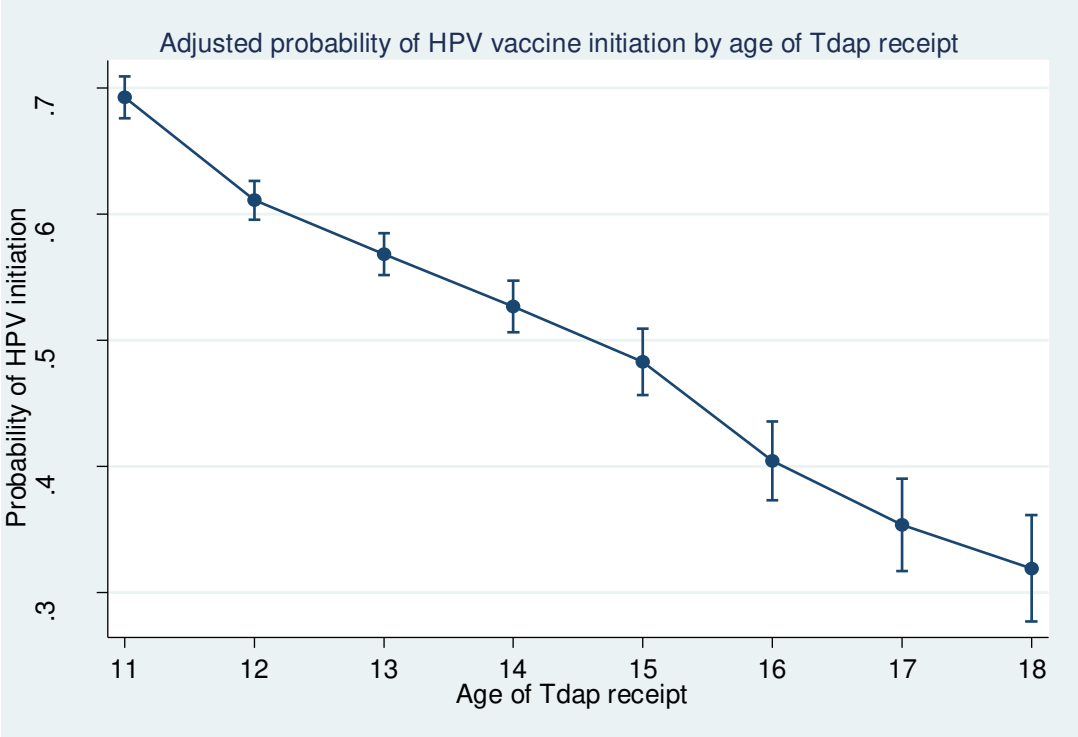
Column 2 reports the estimates related to the HPV vaccine completion. When we look at individuals who completed the three-dose HPV vaccine series, we find that males compared to females were significantly less likely to complete the full dose of the HPV vaccine. Furthermore, adolescents who received care by male providers compared to female providers and those who received care by other types of providers compared to primary care providers were less likely to complete the full dose. Additionally, individuals living in high mainline Protestant, black Protestant and other religion adherence counties, and those who resided in areas where a higher percent of the population lives below the poverty level were less likely to complete the full dose of the HPV vaccine.

Individuals who live in urban settings compared to rural areas, and those who had more preventative and sick visits compared to vaccine-only visits were significantly more likely to complete the full dose. Furthermore, adolescents living in areas with higher Orthodox religion adherence, those with Hispanic ethnicity compared to non-Hispanics, and those with private as well as other insurance types compared to public insurance were more likely to complete the full dose of the HPV vaccine. Additionally, adolescents living in areas with increased number of other races (non-black, non-Hispanic) compared to whites and with more high school and college graduates in the population were significantly more likely to complete the full dose (Table 6).

Furthermore, we graphed the marginal effect of each index age on the adjusted probability of HPV vaccine initiation in Figure 3. The probability of receiving any HPV vaccine declines from about 0.7 at age 11 to about 0.35 at age 18. In Figure 4 we similarly graph the estimates related to the probability of completing the three doses of the HPV vaccine series by age of Tdap receipt, the probability starts low at about 0.3 at age 11 and drops to less than 0.1 for 18-year-olds, indicating a lower probability of completing the HPV vaccine series over the years.

The logit model of HPV vaccine initiation showed increased HPV vaccine initiation by Hispanics compared to non-Hispanics. This finding is in line with our qualitative findings that providers shared indicating vaccine acceptability among Hispanics compared to non-Hispanics. Furthermore, our results show that publicly-insured individuals compared to privately-insured were more likely to initiate the HPV vaccine.

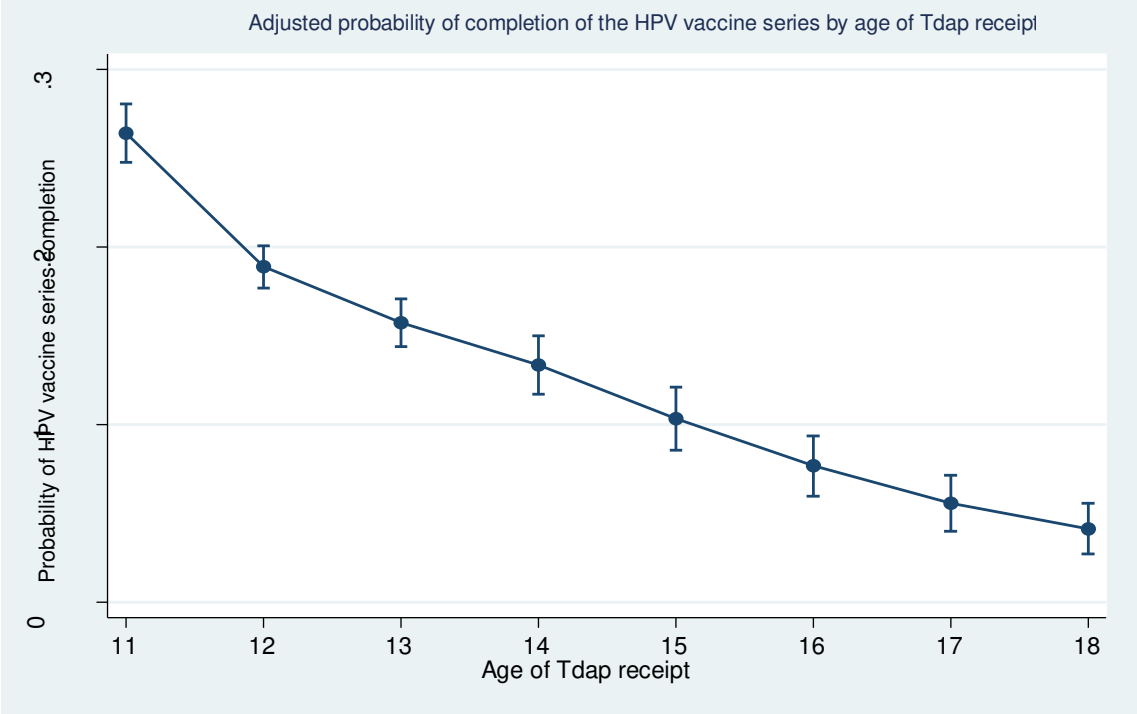
Figure 3. Adjusted probability of HPV vaccine initiation by age of Tdap receipt.



Note: This analysis is adjusted for gender, urban/rural residency, ethnicity, insurance type, trend year, visit type, provider gender, and population level characteristics listed in Table 6. 95% confidence intervals are shown.

The logit model of HPV vaccine completion also showed increased Hispanic HPV vaccine completion compared to non-Hispanics, but indicated the opposite effect of public insurance in HPV vaccine completion. In this model, non-publicly insured individuals were more likely to complete the three-dose series of the HPV vaccine compared to publicly-insured individuals. Because of this, decomposing Hispanic ethnicity and insurance status (public vs. non-public) is important to further understand the contribution of endowments (explainable factors) and coefficients (unexplained factors) on the likelihood of HPV vaccine initiation and completion.

Figure 4. Adjusted probability of completion of the HPV vaccine series by age of Tdap receipt.



Note: This analysis is adjusted for gender, urban/rural residency, ethnicity, insurance type, trend year, visit type, provider gender, and population level characteristics listed in table 6. 95% confidence intervals are shown.

Decomposition on Hispanic ethnicity. Due to the reliability of ethnic group labeling among individuals with Medicaid insurance, the Hispanic decomposition analysis was limited to individuals who had Medicaid insurance only. This allowed for a better comparison of outcomes between Medicaid-insured Hispanics and Medicaid-insured non-Hispanics. Even though the labeling was incorrect, race was still controlled for in the analysis. For example, African Americans in the dataset were incorrectly labeled as American Indian/Alaska natives and we were able to include that data in the analysis but withheld from displaying due to incorrect labeling. Table 7 below shows the decomposition results between Hispanic and non-

Hispanic individuals, their HPV vaccine status outcome-initiation, and completion of the HPV vaccine series.

When we looked at the decomposition results for those who initiated the HPV vaccine, we saw that Medicaid-insured Hispanics were more likely to receive at least one dose of the HPV vaccine compared to Medicaid-insured non-Hispanics. The gap in HPV vaccine initiation between the two groups is 0.121. Adjusting non-Hispanic endowments levels to the levels of Hispanics would increase their probability by 23% (0.0283/ 0.1214). A statistically significant gap of 77% (0.0931/0.1214) remains unexplained (see Table 7).

Table 7: Pooled Regression Decomposition Results on Hispanic Ethnicity of Adolescents who Initiated the HPV Vaccine

	HPV initiation	
Variables	**Differential**	**Decomposition**
Prediction_2 (Hispanic)	0.5977***	
	(0.0070)	
Prediction_1 (non-Hispanic)	0.4762***	
	(0.0086)	
Difference	0.1214***	
	(0.0111)	
Explained		0.0283
		(0.0175)
Unexplained		0.0931***
		(0.0201)
Observations	8,338	

Note. Robust standard errors in parentheses. *** $P < 0.01$, ** $p < 0.05$, * $p < 0.1$

Examination of the decomposition results for those who completed the HPV vaccine series, we notice a significant difference between the two groups, in which Hispanics are more likely than non-Hispanics to complete the three-dose HPV vaccine series. The gap in completing the HPV vaccine series between the two groups was 0.0296. Adjusting non-Hispanic endowment levels to the levels of

Hispanics increased their probability of completing the HPV vaccine series by about -39% (-0.0114/0.0296). However, 139 % (0.0411/0.0296) of the gap remains significantly unexplained (see Table 8). The unexplained gap in differences overcomes the deficit of the explained factors.

Table 8: Pooled Regression Decomposition Results on Hispanic Ethnicity of Adolescents who completed the HPV Vaccine

	HPV Completion	
Variables	**Differential**	**Decomposition**
Prediction_2 (Hispanic)	0.167***	
	(0.00529)	
Prediction_1 (non-Hispanic)	0.137***	
	(0.00592)	
Difference	0.0296***	
	(0.00794)	
Explained		-0.0114
		(0.0118)
Unexplained		0.0411***
		(0.0138)
Observations	8,338	8,338

Note. Robust standard errors in parentheses. *** $P < 0.01$, ** $p < 0.05$, * $p < 0.1$

We also estimated a detailed decomposition to understand the role of individual covariates in determining the explained and unexplained contributions to the difference in HPV vaccine initiation and completion. Tables 9 and 10 report the results of the detailed decomposition between Hispanic and non-Hispanic individuals and HPV vaccination status. Due to a lack of data among individuals with non-Medicaid insurance, the Hispanic decomposition analysis is limited to individuals who had Medicaid insurance only. This allowed for a better comparison of outcomes between Medicaid-insured Hispanics and non-Hispanics.

Table 9: Detailed Regression Decomposition Results on Hispanic Ethnicity Among Individuals who Initiated the HPV Vaccine

	(1) Differential	(2) Explained	(3) Unexplained
Patient characteristics			
Male		0.0001	0.0088
		(0.0008)	(0.0103)
Age 12 (ref. age 11)		0.0010*	-0.0008
		(0.0006)	(0.0061)
Age 13		0.0010*	-0.0004
		(0.0005)	(0.0038)
Age 14		0.0016**	-0.0002
		(0.0007)	(0.0032)
Age 15		0.0036***	-0.0092***
		(0.0010)	(0.0030)
Age 16		0.0045***	-0.0068**
		(0.0011)	(0.0030)
Age 17		0.0052***	-0.0064**
		(0.0016)	(0.0028)
Age 18		0.0055***	-0.0035
		(0.0021)	(0.0025)
Urban (ref. rural)		-0.0011	0.0003
		(0.0008)	(0.0074)
Provider and visit type characteristics			
Preventative visit		0.0068***	-0.0126
		(0.0021)	(0.0135)
Sick visit (ref. vaccine-only visit)		0.0024**	-0.0094
		(0.0010)	(0.0096)
Male provider (ref. female providers)		0.0064***	-0.0040
		(0.0012)	(0.0083)
Other providers (ref. Primary care providers		0.0022***	0.0189
		(0.0008)	(0.0231)
Population characteristics			
Evangelical rate		-0.0026	-0.1179***
		(0.0029)	(0.0454)
Catholic rate		-0.0043	0.0115
		(0.0032)	(0.0329)
Mainline Protestant rate		0.0037*	0.0713*
		(0.0021)	(0.0404)
Black Protestant rate		0.0007	-0.0170
		(0.0010)	(0.0175)
Orthodox rate		-0.0005	-0.0173
		(0.0011)	(0.0247)
Other religion rate		-0.0021**	0.0007
		(0.0009)	(0.0294)
Pct. Black (ref. pct. White)		0.0024	0.0094
		(0.0017)	(0.0201)
Pct. Other race		0.0133	0.1617

Table 9, cont'd

	(1) Differential	(2) Explained	(3) Unexplained
Population characteristics			
		(0.0116)	(0.1216)
Pct. Hispanic (ref. non-Hispanic)		-0.0080	-0.0777
		(0.0219)	(0.1325)
Pct. Ling isolated house		0.0170	-0.0281
		(0.0104)	(0.1216)
Pct. Income below poverty		-0.0061*	-0.0078
		(0.0032)	(0.0479)
Pct. Institutionalized pop		0.0009	-0.0017
		(0.0008)	(0.0074)
Pct. Below High school pop under age 25		-0.0011	-0.0056
		(0.0081)	(0.0536)
Pct. High school graduates		0.0005	-0.0433
		(0.0021)	(0.1027)
Pct. College graduate		-0.0025	0.0554
		(0.0038)	(0.0645)
Total		0.0283	0.0931***
		(0.0175)	(0.0201)
Prediction_1(Hispanic)	0.5977***		
	(0.0070)		
Prediction_2 (non-Hispanic)	0.4762***		
	(0.00860)		
Difference	0.1214***		
	(0.0111)		
Constant			-0.0849
			(0.2429)
Observations	8,338	8,338	8,338

Note. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Decomposing Hispanic ethnicity on HPV vaccine initiation. Factors that significantly explained and drove the gap in initiation of the HPV vaccine among Medicaid-insured Hispanics and non-Hispanics included having preventative or sick visits compared to vaccine-only visits, having male providers compared to female providers, being seen by other types of providers compared to primary care providers, and living in higher mainline Protestant adherence areas.

However, explained factors that closed the gap in any HPV vaccine receipt among Medicaid-insured Hispanics and non-Hispanics included living in areas with

adherence to other religions and living in areas with a higher percentage of the population living below the poverty level (see Table 9).

The predicted probability of HPV vaccine initiation was 0.5977 for Hispanic and 0.4762 for non-Hispanic adolescents. Therefore, a difference of 0.1214 or 12.14 percentage points existed between the two groups. The decomposition estimated a positive coefficient 0.0283 for explained disparity in HPV vaccine initiation between the two groups. Thus only 23% (0.0283/0.1214) of the total difference was explained by observed characteristics. The remaining 77% (0.0931/0.1214) of the difference was due to unexplained factors. Increasing age, visit type, provider gender and provider type, having primary care provider visit and living in communities with higher percentage of mainline Protestant religion adherence were significant factors in the decomposition. The contribution of observed characteristics in explained factors of HPV vaccine initiation decomposition between Medicaid-insured Hispanics and non-Hispanics is presented in table 9. The percent contribution of each covariate is calculated by dividing the individual coefficient estimate from the explained decomposition by the total explained by measurable characteristics and multiplying by 100. The results including the percent contribution are presented in Table 10.

If a higher number of non-Hispanic adolescents had more preventive visits compared to vaccine-only visits, then the likelihood of initiating HPV vaccine would have increased by 24.03%, which would have reduced the observed gap. If a higher number of non-Hispanic adolescents had vaccine-only visits instead of sick visits, then the likelihood of initiating HPV vaccine would have increased by 8.48%, which

would have reduced the observed disparity. If a higher number of non-Hispanic adolescents had visits with female providers instead of male providers, then the likelihood of initiating the HPV vaccine would have increased by 22.61%, which would have reduced the observed gap. If a higher number of non-Hispanic adolescents visited primary care providers instead of other types of providers then the likelihood of initiating HPV vaccine would have increased by 7.77%, which would have reduced the observed gap.

Additionally, if a higher number of non-Hispanic adolescents lived in communities with higher mainline Protestant religion adherence, then the likelihood of initiating HPV vaccine would have increased by 13.07%, which would have reduced the observed gap. However, living in communities with higher adherence to other religions and living in areas with a higher percentage of the population living below the poverty level had an opposite effect in explaining the observed gap in HPV vaccine initiation. If a higher number of non-Hispanic adolescents lived in communities with higher adherence to other religions, then the likelihood of initiating HPV vaccine would have decreased by 7.42%, which would have increased the observed gap.

Similarly, if a higher number of non-Hispanic adolescents lived in communities with a higher percentage of the population living below the poverty level, then the likelihood of initiating HPV vaccine would have decreased by 21.55%, which would have increased the observed gap between Hispanics and non-Hispanic HPV vaccine initiation.

The results of the decomposition show the contribution of observed factors, especially the role of provider and visit type characteristics in HPV vaccine initiation gap between the two groups. The following section discusses the role of observed factors in HPV vaccine completion among Medicaid-insured Hispanic and non-Hispanic groups.

Table 10: Explained Percent Contribution of Observed Factors in Hispanic Ethnicity Decomposition Results of HPV Vaccine Initiation

Probability of initiating any HPV vaccine for Hispanics			0.5977***
Probability of initiating any HPV vaccine for non-Hispanics			0.4762***
Difference in HPV vaccine initiation			0.1214***
Total unexplained by measurable characteristics			0.0931***
Total explained by measurable characteristics			**0.0283**
Independent variables	**Decomposition (explained factors)**	**Standard error**	**% contribution of explained factors**
Patient characteristics			
Male (ref. female)	0.0001	0.0008	0. 35
Age 12 (ref. age 11)	0.0010*	0.0006	3.53
Age 13	0.0010*	0.0005	3.53
Age 14	0.0016**	0.0007	5.65
Age 15	0.0036***	0.0010	12.72
Age 16	0.0045***	0.0011	15.90
Age 17	0.0052***	0.0016	18.37
Age 18	0.0055***	0.0021	19.43
Urban (ref. rural)	-0.0011	0.0008	-3.89
Provider and visit type characteristics			
Preventative visit	0.0068***	0.0021	24.03
Sick visit (ref. vaccine-only visit)	0.0024**	0.0010	8.48
Male provider (ref. female providers)	0.0064***	0.0012	22.61
Other providers (ref. Primary care providers)	0.0022***	0.0008	7.77
Population characteristics			
Evangelical rate	-0.0026	0.0029	-9.19
Catholic rate	-0.0043	0.0032	-15.19
Mainline Protestant rate	0.0037*	0.0021	13.07
Black Protestant rate	0.0007	0.0010	2.47
Orthodox rate	-0.0005	0.0011	-1.77
Other religion rate	-0.0021**	0.0009	-7.42
Pct. Black (ref. pct. White)	0.0024	0.0017	8.48
Pct. Other race	0.0133	0.0116	47.00
Pct. Hispanic (ref. non-Hispanic)	-0.0080	0.0219	-28.27
Pct. Ling isolated house	0.0170	0.0104	60.07
Pct. Income below poverty	-0.0061*	0.0032	-21.55
Pct. Institutionalized pop	0.0009	0.0008	3.28
Pct. Below High school pop under age 25	-0.0011	0.0081	-3.89
Pct. High school graduates	0.0005	0.0021	1.77
Pct. College graduate	-0.0025	0.0038	-8.83

Note. Robust standard errors in parentheses. *** $P < 0.01$, ** $p < 0.05$, * $p < 0.1$

Decomposing Hispanic ethnicity on completion of the HPV vaccine.

Factors that significantly explained and drove the gap in completion of three doses of the HPV vaccine among Medicaid-insured Hispanics and non-Hispanics included having preventative visits compared to vaccine-only visits and living in areas where an increased percent of the population is composed of other races (non-black, non-Hispanic).

However, explained factors that closed the gap in completing the three-dose HPV vaccine among Medicaid-insured Hispanics and non-Hispanics was having more sick visits compared to vaccine-only visits, living in areas with high evangelical Christian and other religion adherence, and living in areas with an increased percentage of population living under poverty and institutionalized (Table 11).

Table 11. Detailed Regression Decomposition Results on Hispanic Ethnicity among Individuals who Completed the Full Dose of the HPV Vaccine

Variables	(4) Differential	(5) Explained	(6) Unexplained
Patient characteristics			
Male (ref. female)		0.0001	0.0103
		(0.0005)	(0.0077)
Age 12 (ref. age11)		0.0008	-0.0015
		(0.0005)	(0.0046)
Age 13		0.0015***	-0.0016
		(0.0006)	(0.0027)
Age 14		0.0020***	-0.0016
		(0.0006)	(0.0022)
Age 15		0.0030***	-0.0015
		(0.0007)	(0.0019)
Age 16		0.0029***	-0.0012
		(0.0007)	(0.0018)
Age 17		0.0020***	0.0004
		(0.0006)	(0.0016)
Age 18		0.0018**	0.0004
		(0.0007)	(0.0013)
urban		0.0003	-0.0024
		(0.0005)	(0.0394)
Provider and visit type characteristics			
Preventative visit		0.0053***	0.0015
		(0.0016)	(0.0112)
Sick visit (ref. vaccine-only visit)		-0.0025***	-0.0130*
		(0.0008)	(0.0076)
Male provider (ref. female providers)		-0.0002	0.0070
		(0.0007)	(0.0061)
Other providers (ref. Primary care providers		0.0002	-0.0067
		(0.0005)	(0.0168)
Population characteristics			
Evangelical rate		-0.0045*	-0.0713**
		(0.0026)	(0.0279)
Catholic rate		-0.0009	0.0397*
		(0.0022)	(0.0227)
Mainline Protestant rate		0.0004	0.0160
		(0.0016)	(0.0294)
Black Protestant rate		0.0004	-0.0033
		(0.0005)	(0.0136)
Orthodox rate		-0.0003	-0.0210
		(0.0007)	(0.0195)
Other religion rate		-0.0012**	0.0046
		(0.0005)	(0.0179)
Pct. Black (ref. pct. white)		0.0007	0.0168
		(0.0011)	(0.0147)
Pct. other race		0.0132*	0.1589*

Table 11, cont'd

Variables	(4) Differential	(5) Explained	(6) Unexplained
		(0.0075)	(0.0844)
Pct. Hispanic (ref. non-Hispanic)		-0.0022	-0.1049
		(0.0141)	(0.0919)
Pct. ling isolated house		0.0082	-0.0827
		(0.0071)	(0.0833)
Pct. income below poverty		-0.0100***	-0.0726**
		(0.0025)	(0.0353)
Pct. institutionalized pop		-0.0011*	0.0003
		(0.0006)	(0.0058)
Pct. below High school pop under age 25		-0.0087	0.0579
		(0.0059)	(0.0391)
Pct. high school graduates		0.0005	-0.0494
		(0.0015)	(0.0739)
Pct. college graduate		0.0010	0.0166
		(0.0029)	(0.0479)
Total		-0.0112	0.0410***
		(0.0118)	(0.0138)
Prediction_1 (Hispanic)	0.1667***		
	(0.0053)		
Prediction_2 (non-Hispanic)	0.1369***		
	(0.0059)		
Difference	0.0299***		
	(0.0079)		
Constant			0.0744
			(0.1943)
Observations	8,338	8,338	8,338

Note. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The predicted probability of HPV vaccine completion was 0.1667 for Hispanic and 0.1369 for non-Hispanic adolescents. Therefore a difference of 0.0299 or 2.99 percentage points existed between the two groups. The decomposition estimated a negative total explained coefficient (-0.112) for gap in HPV completion between the two groups. This indicates that observed characteristics did not successfully explain the difference in HPV vaccine completion of 0.0299 between the two groups. In other words, had non-Hispanic adolescents had similar distribution of observed characteristics as Hispanic adolescents, the observed disparity in HPV vaccine

completion (0.0299 or 2.99 percentage points) would be 37.5% higher (0.0112/0.0299). Significant unexplained factors related to HPV vaccine completion remain between the two groups.

Having sick visits compared to vaccine-only visits, male providers compared to females, living in communities with a higher percentage of evangelical and other religion adherence as well as in communities with higher percentage of people with income below poverty level and institutionalized population were significant factors in the explained decomposition. The percent contribution of covariates in explained HPV vaccine completion can be seen in Table 12. The percent contribution of each covariate is calculated by dividing the individual coefficient results from explained decomposition by the total explained by measurable characteristics and multiplying by 100.

If a higher number of non-Hispanic adolescents had vaccine-only visits instead of sick visits, then the likelihood of completing the HPV vaccine would have increased by 22.32%, which would have reduced the observed gap between Hispanics and non-Hispanics. If a higher number of non-Hispanic adolescents had visits with female providers instead of male providers, then the likelihood of completing the HPV vaccine would have increased by 1.79%, which would have reduced the observed gap.

Additionally, if a higher number of non-Hispanic adolescents lived in communities with higher evangelical Christian religion adherence, then the likelihood of completing the HPV vaccine would have increased by 40.18%, which would have reduced the observed gap.

Table 12: Explained Percent Contribution of Observed Factors in Hispanic Ethnicity Decomposition Results of HPV Vaccine Completion among Adolescents

Probability of completing HPV vaccine series for Hispanics			0.1667***
Probability of completing HPV vaccine series for non-Hispanics			0.1369***
Difference in HPV vaccine completion			0.0299***
Total unexplained by measurable characteristics			0.0411***
Total explained by measurable characteristics			**-0.0114**
Independent variables	**Decomposition (explained factors)**	**Standard error**	**% contribution of explained factors**
Patient characteristics			
Male (ref. female)	0.0001	0.0005	-0.89
Age 12 (ref. age 11)	0.0008	0.0005	-0.14
Age 13	0.0015***	0.0006	-13.39
Age 14	0.0020***	0.0006	-17.86
Age 15	0.0030***	0.0007	-26.79
Age 16	0.0029***	0.0007	-25.89
Age 17	0.0020***	0.0006	-17.86
Age 18	0.0018**	0.0007	-16.07
Urban (ref. rural)	0.0003	0.0005	-2.68
Provider and visit type characteristics			
Preventative visit	0.0053***	0.0016	-47.32
Sick visit (ref. vaccine-only visit)	-0.0025***	0.0008	22.32
Male provider (ref. female providers)	-0.0002	0.0007	1.79
Other providers (ref. Primary care providers	0.0002	0.0005	-1.79
Population characteristics			
Evangelical rate	-0.0045*	0.0026	40.18
Catholic rate	-0.0009	0.002	8.04
Mainline Protestant rate	0.0004	0.0016	-3.57
Black Protestant rate	0.0004	0.0005	-3.57
Orthodox rate	-0.0003	0.0007	2.68
Other religion rate	-0.0012**	0.0005	10.71
Pct. Black (ref. pct. White)	0.0007	0.0011	-6.25
Pct. Other race	0.0132*	0.0075	-1.18
Pct. Hispanic (ref. non-Hispanic)	-0.0022	0.0141	19.64
Pct. Ling isolated house	0.0082	0.0071	-73.21
Pct. Income below poverty	-0.0100***	0.0025	89.29
Pct. Institutionalized pop	-0.0011*	0.0006	9.82
Pct. Below High school pop under age 25	-0.0087	0.0059	77.68
Pct. High school graduates	0.0005	0.0015	-4.46
Pct. College graduate	0.0010	0.0029	-8.93
Total explained by measurable characteristics	-0.0114		**-37.5**

Note. Robust standard errors in parentheses. *** $P < 0.01$, ** $p < 0.05$, * $p < 0.1$

Similarly, if a higher number of non-Hispanics lived in communities with higher adherence to other religions then the likelihood of non-Hispanics completing the HPV vaccine series would have increased by 10.71%.

If a higher number of non-Hispanic adolescents lived in communities with a higher percentage of the population living below the poverty level, then the likelihood of completing the HPV vaccine series would have increased by 89.29%, which would have reduced the observed gap. Similarly, if a higher number of non-Hispanic adolescents lived in communities with a higher percentage of the population is institutionalized, then the likelihood of completing the HPV vaccine series would have increased by 9.82%.

However, preventative visits and living in areas with higher percentage of other races had an opposite effect in explaining the observed gap in HPV vaccine completion between the two groups. In other words, if more non-Hispanic adolescents received vaccine-only visits compared to preventative visits, the observed gap in HPV series completion would have increased by 47.32%. Similarly, if more non-Hispanic adolescents lived in communities with a higher percentage of other races compared to communities with whites, the observed gap in HPV series completion would have increased by 1.18%.

These decomposition results showed several explained and unexplained factors that significantly contributed to the gap in vaccine receipt among Medicaid insured Hispanics and non-Hispanics. Factors such as having male providers compared to female providers seemed to explain and drive the gap in vaccine initiation in this population. However, there were significant unexplained factors that

could be due to cultural influences on the covariates such as religion. Understanding known factors to these differences in HPV vaccine uptake provides a significant opportunity to further explore and address reasons behind the HPV vaccine lag in Colorado and nationwide.

Decomposition on insurance (public vs. non-public) status. The following section reports the decomposition results between publicly-insured and non-publicly insured (private and other types of insurance such as self-pay) individuals and HPV vaccine initiation and completion of the three-dose HPV vaccine.

Race and age variables were controlled for in this model. However, due to the inconsistent labeling of race data described previously, the race coefficients are not reported here. Although the overall ethnicity data has a high number of unknowns (63 % unknown ethnicity, 15.39% non-Hispanic and 21.61% Hispanic), the unknown variables are distributed across the two groups (publicly insured and non-publicly insured) evenly and thus ethnicity is included in this decomposition analysis. Unknown Hispanic ethnicity was created as its own dummy variable and added in the decomposition model along with Hispanic and non-Hispanic groups.

When we look at decomposition results for those who initiated the HPV vaccine, we see that publicly-insured individuals were more likely to receive at least one dose of HPV vaccine compared to non-publicly insured individuals. The gap in any HPV uptake between the two groups is -0.0399. Adjusting publicly-insured individual endowment levels to the levels of non-publicly insured would increase their probability of initiating HPV vaccine by 44% (-0.0176/-0.0399). A significant gap of 56% (-0.0223/-0.0399) remains unexplained (see Table 13).

Table 13. Pooled Regression Decomposition Results on Insurance (Public vs. Non-Public) of Adolescents who Initiated the HPV Vaccine

	HPV vaccine initiation	
VARIABLES	**Differential**	**Decomposition**
Prediction_1(non-public)	0.4866***	
	(0.0045)	
Prediction_2 (public)	0.5265***	
	(0.0046)	
Difference	-0.0399***	
	(0.0064)	
Explained		-0.0176**
		(0.0072)
Unexplained		-0.0223**
		(0.0091)
Observations	24,553	24,553

Note. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

When we look at the decomposition results for the HPV vaccine completion, we notice a significant difference between the two groups where publicly-insured individuals were less likely to complete the three-dose series compared to non-publicly insured individuals. The gap in completing the HPV vaccine series between the two groups is 0.0537. Adjusting non-publicly insured individual endowment levels to the levels of publicly insured would significantly increase their probability of completing HPV vaccine series by about 37% (0.0200/0.0537). However, 63% (0.0338/0.0537) of the gap remains unexplained and statistically significant (see Table 14).

Table 14. Pooled Regression Decomposition Results on Insurance (Public vs. Non-Public) Status of Adolescents who Completed the HPV Vaccine

	HPV vaccine completion	
VARIABLES	**Differential**	**Decomposition**
Prediction_1(non-public)	0.2075***	
	(0.0036)	
Prediction_2 (public)	0.1537***	
	(0.0033)	
Difference	0.0537***	
	(0.0049)	
Explained		0.0200***
		(0.0054)
Unexplained		0.0338***
		(0.0070)
Observations	24,553	24,553

Note. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Decomposing insurance status on initiation of HPV vaccine. Factors that significantly explained and drove the gap in initiation of the HPV vaccine among publicly-insured versus non-publicly insured individuals included: females compared to males, having male providers compared to female providers, having other types of providers compared to primary care providers, living in areas with higher percentage mainline Protestant adhering populations, areas with higher percentage of other races (non-black, non-white), areas with a higher percentage of linguistically isolated households, those with a higher percentage of high school graduates and those with population below high school under age 25.

However, the explained factor that closed the gap in initiation of the HPV vaccine among publicly-insured versus non-publicly insured individuals included having preventative visits compared to vaccine-only visits, being an urban resident compared to a rural resident, and living in areas with a higher percentage of black

Protestant, more Hispanic residents and other religion adhering populations (Table 15).

Table 16 further details the explained portion of the decomposition results. Predicted probability of HPV vaccine initiation was 0.5265 for publicly-insured adolescents and 0.4866 for non-publicly insured adolescents. Therefore, a difference of -0.0399 or 3.99 percentage points exists between the two groups. The decomposition estimated a negative total explained coefficient (-0.0176) for gap in HPV completion between the two groups. This indicates that observed characteristics did successfully explain the difference in HPV vaccine initiation of -0.0399 between the two groups. In other words, had non-publicly insured adolescents had similar distribution of observed characteristics as publicly-insured adolescents, the probability of non-publicly insured individuals receiving the HPV vaccine would have increased 44% higher (-0.0176/-0.0399). Significant unexplained factors (56%) remain regarding HPV vaccine initiation between the two groups.

If a higher number of non-publicly insured adolescents were female, then the likelihood of initiating the HPV vaccine would have increased by 11%, which would have reduced the observed gap between publicly-insured and non-publicly insured individuals. If a higher number of non-publicly insured adolescents were Hispanics, then the likelihood of initiating the HPV vaccine would have increased by 2.88%, which would have reduced the observed gap between publicly-insured and non-publicly insured individuals. If a higher number of non-publicly insured adolescents

Table 15: Detailed Regression Decomposition Results on Insurance (Public vs. Non-Public) Status among Adolescents who Initiated the HPV Vaccine

Variables	(1) Differential	(2) Explained	(3) Unexplained
Patient characteristics			
Female (Ref. Male)		-0.0019***	-0.0139**
		(0.0004)	(0.0059)
Hispanic ethnicity (ref. non-Hispanic)		-0.0507***	0.0091*
		(0.0065)	(0.0048)
Unknown Hispanic ethnicity		0.0083	0.0363
		(0.0100)	(0.0259)
Urban (ref. rural)		0.0056***	0.0146
		(0.0011)	(0.0275)
Age 12		0.0031***	-0.0041
		(0.0005)	(0.0029)
Age 13		0.0021***	0.0002
		(0.0005)	(0.0017)
Age 14		0.0022***	-0.0017
		(0.0005)	(0.0014)
Age 15		0.0017***	0.0004
		(0.0004)	(0.0014)
Age 16		0.0019***	0.0029**
		(0.0004)	(0.0014)
Age 17		0.0004	0.0066***
		(0.0005)	(0.0014)
Age 18		-0.0037***	0.0129***
		(0.0007)	(0.0015)
Provider and visit type characteristics			
Preventative visit		0.0187***	0.0228**
		(0.0014)	(0.0090)
Sick visit (ref. vaccine-only visit)		-0.00001	0.0280***
		(0.0007)	(0.0056)
Male provider (ref. female providers)		-0.0048***	0.0145***
		(0.0006)	(0.0053)
Other providers (ref. primary care providers		-0.0222***	0.0695***
		(0.0033)	(0.0088)
Population characteristics			
Evangelical rate		-0.0012	-0.0603*
		(0.0008)	(0.0310)
Catholic rate		-0.0020*	0.0541***
		(0.0011)	(0.0188)
Mainline protestant rate		-0.0007**	-0.0017
		(0.0003)	(0.0242)
Black protestant rate		0.0058***	-0.0136*
		(0.0010)	(0.0078)
Orthodox rate		0.0002	0.0088
		(0.0008)	(0.0125)
Other religion rate		0.0011***	0.0471**
		(0.0003)	(0.0194)
Pct. Black (ref. pct. white)		-0.0004	0.0113
		(0.0010)	(0.0103)
Pct. other race		-0.0171***	0.1877***
		(0.0061)	(0.0624)

Table 15, cont'd

Variables	(1) Differential	(2) Explained	(3) Unexplained
Patient characteristics			
Pct. Hispanic (ref. non-Hispanic)		0.0181*	-0.1465***
		(0.0098)	(0.0564)
Pct. ling isolated house		-0.0089*	-0.1000
		(0.0052)	(0.0667)
Pct. income below poverty		0.0113***	0.0130
		(0.0027)	(0.0224)
Pct. institutionalized pop		0.0013**	0.0002
		(0.0005)	(0.0033)
Pct. below High school pop under age 25		-0.0136**	0.0740***
		(0.0054)	(0.0257)
Pct. high school graduates		-0.0089***	0.1352***
		(0.0035)	(0.0515)
Pct. college graduate		0.0193***	0.1201***
		(0.0048)	(0.0428)
Total		-0.0176**	-0.0223**
		(0.0072)	(0.0091)
Prediction_1 (non-public insurance)	0.4866***		
	(0.0045)		
Prediction_2 (public insurance)	0.5265***		
	(0.0046)		
Difference	-0.0399***		
	(0.0064)		
Constant			-0.5665***
			(0.1458)
Observations	24,553	24,553	24,553

Note. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

were age 18, then the likelihood of initiating the HPV vaccine would have increased by 21%, which would have reduced the observed gap between publicly-insured and non-publicly insured individuals.

If a higher number of non-publicly insured adolescents were seen by female providers, then the likelihood of initiating the HPV vaccine would have increased by 27.7%, which would have reduced the observed gap between publicly-insured and non-publicly insured individuals. If a higher number of non-publicly insured adolescents lived in communities with higher Catholic religion adherence, then the likelihood of completing the HPV vaccine would have increased by 11.4%, which

would have reduced the observed gap. Similarly, if a higher number of non-publicly insured adolescents lived in communities with higher mainline Protestant religion adherence, then the likelihood of initiating the HPV vaccine would have increased by 4% and by 33% if they lived in communities with higher black Protestant adherence.

If a higher number of non-publicly insured adolescents lived in communities where a higher percentage of the population is linguistically isolated, then the likelihood of initiating the HPV vaccine would have increased by 51%, which would have reduced the observed gap. If a higher number of non-publicly insured adolescents lived in communities with a higher percentage of the population in a linguistically isolated house, then the likelihood of initiating the HPV vaccine would have increased by 51%, which would have reduced the observed gap.

If a higher number of non-publicly insured adolescents lived in communities where a higher percentage of the population has below high school population under age 25, then the likelihood of initiating the HPV vaccine would have increased by 77%, which would have reduced the observed gap. Additionally, if a higher number of non-publicly insured adolescents lived in communities where a higher percentage of the population were high school graduates, then the likelihood of initiating the HPV vaccine would have increased by about 48%, which would have reduced the observed gap.

Table 16: Decomposition Results of HPV Vaccine Initiation between Public and Non-Public Insured Adolescents

Probability of initiating any HPV vaccine for non-public insured			0.4866***
Probability of initiating any HPV vaccine for public insured			0.5265***
Difference in HPV vaccine initiation			-0.0399***
Total unexplained by measurable characteristics			0.0223***
Total explained by measurable characteristics			**-0.0176*** **
Independent variables	**Decomposition (explained factors)**	**Standard error**	**% contribution of explained factors**
Patient characteristics			
Female (ref. male)	-0.0019***	0.0004	11.00
Hispanic (ref. non-Hispanic)	-0.0507***	0.0065	2.88
Unknown Hispanic ethnicity	0.0083	0.0100	-47.2
Urban (ref. rural)	0.0056***	0.0011	-38.82
Age 12 (ref. age 11)	0.0031***	0.0005	-17.6
Age 13	0.0021***	0.0005	-11.9
Age 14	0.0022***	0.0005	-12.5
Age 15	0.0017***	0.0004	-9.7
Age 16	0.0019***	0.0004	-10.8
Age 17	0.0004	0.0005	-2.3
Age 18	-0.0037***	0.0007	21.00
Provider and visit type characteristics			
Preventative visit	0.0187***	0.0014	-6.25
Sick visit (ref. vaccine-only visit)	-0.00001	0.0007	0.06
Male provider (ref. female providers)	-0.0048***	0.0006	27.3
Other providers (ref. Primary care providers	-0.0222***	0.0033	126
Population characteristics			
Evangelical rate	-0.0012	0.0008	6.8
Catholic rate	-0.0020*	0.0011	11.4
Mainline Protestant rate	-0.0007**	0.0003	4.0
Black Protestant rate	0.0058***	0.0010	33.0
Orthodox rate	0.0002	0.0008	-1.14
Other religion rate	0.0011***	0.0003	-6.25
Pct. Black (ref. pct. White)	-0.0004	0.0010	2.27
Pct. Other race	-0.0171***	0.0061	97.2
Pct. Hispanic (ref. non-Hispanic)	0.0181*	0.0098	-10.28
Pct. Ling isolated house	-0.0089*	0.0052	51.00
Pct. Income below poverty	0.0113***	0.0027	-64.2
Pct. Institutionalized pop	0.0013**	0.0005	-7.4
Pct. Below High school pop under age 25	-0.0136**	0.0054	77.3
Pct. High school graduates	-0.0089***	0.0035	47.85
Pct. College graduate	0.0193***	0.0048	-109.7
Total explained by measurable characteristics	-0.0176**		

Note. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The results showed several predictors and their contribution in HPV vaccine initiation among publicly-insured and non-publicly insured adolescents. It specifically demonstrated the role of adolescent gender, Hispanic ethnicity and provider gender in contributing to HPV vaccine initiation. Furthermore, it shed light on certain community characteristics that are more likely to be conducive to HPV vaccine initiation, including living communities where there are linguistically isolated households, younger people under age 25 with below a high school education, and some religions. The following section details OB decomposition results on HPV vaccine completion between the two groups.

Decomposing insurance status on completion of HPV vaccine. We saw in Table 14 that non-publicly insured patients were more likely to complete the three-dose HPV vaccine series compared to publicly-insured individuals. Explained factors that increased the gap in receipt of the three-dose HPV vaccine among publicly-insured versus non-publicly insured individuals included having preventative visits compared to vaccine-only visits, and being an urban resident compared to a rural resident. In addition, living in areas with a higher percentage of black Protestant and other religion adhering populations, with higher percentage of Hispanics compared to non-Hispanics, and in areas with a higher percentage of individuals with income below the poverty line and a higher percentage of college graduates also increased the gap (see Table 17).

Table 17: Detailed Regression Decomposition Results on Insurance (Public vs. Non-Public) Status among Individuals who Completed the Full Dose of the HPV Vaccine

Variables	(1) Differential	(2) Explained	(3) Unexplained
Patient characteristics			
Female (ref. Male)		-0.0016***	0.0061
		(0.0004)	(0.0046)
Urban		0.0023***	0.0505**
		(0.0007)	(0.0196)
Hispanic ethnicity (ref. non-Hispanic)		-0.0199***	0.0041
		(0.0046)	(0.0035)
Unknown Hispanic ethnicity		0.0172**	0.0488***
		(0.0069)	(0.0184)
Age 12		0.0024***	-0.0020
		(0.0004)	(0.0023)
Age 13		0.0019***	0.0011
		(0.0004)	(0.0012)
Age 14		0.0022***	0.0001
		(0.0004)	(0.0010)
Age 15		0.0014***	-0.0010
		(0.0003)	(0.0009)
Age 16		0.0013***	0.0004
		(0.0003)	(0.0009)
Age 17		0.0002	0.0011
		(0.0002)	(0.0009)
Age 18		-0.0018***	-0.0004
		(0.0003)	(0.0008)
Provider and visit type characteristics			
Male provider (ref. female providers)		-0.0018***	0.0032
		(0.0004)	(0.0042)
Other providers (ref. Primary care providers)		-0.0174***	0.0372***
		(0.0026)	(0.0069)
Preventative visit		0.0166***	0.0425***
		(0.0012)	(0.0076)
Sick visit (ref. vaccine-only visit)		-0.0028***	0.0104**
		(0.0006)	(0.0045)
Population characteristics			
Evangelical rate		-0.0003	-0.0611***
		(0.0006)	(0.0217)
Catholic rate		-0.0017**	0.0240*
		(0.0008)	(0.0131)
Mainline Protestant rate		-0.0001	-0.0152
		(0.0001)	(0.0184)
Black Protestant rate		0.0031***	-0.0128**
		(0.0007)	(0.0061)
Orthodox rate		0.0001	-0.0006
		(0.0003)	(0.0093)
Other religion rate		0.0007***	0.0292**
		(0.0002)	(0.0135)
Pct. Black (ref. pct. white)		-0.0009	0.0207**
		(0.0007)	(0.0081)

Table 15, cont'd

Variables	(1) Differential	(2) Explained	(3) Unexplained
Patient characteristics			
Pct. other race		-0.0145***	0.1218***
		(0.0040)	(0.0469)
Pct. Hispanic (ref. non-Hispanic)		0.0110*	-0.0588
		(0.0066)	(0.0420)
Pct. ling isolated house		-0.0040	-0.1381***
		(0.0036)	(0.0471)
Pct. income below poverty		0.0076***	0.0224
		(0.0021)	(0.0173)
Pct. institutionalized pop		-0.0003	-0.0018
		(0.0004)	(0.0024)
Pct. below High school pop under age 25		-0.0003	0.0594***
		(0.0040)	(0.0193)
Pct. high school graduates		-0.0108***	0.0538
		(0.0025)	(0.0378)
Pct. college graduate		0.0116***	0.0852***
		(0.0036)	(0.0325)
Total		0.0200***	0.0338***
		(0.0054)	(0.0070)
Prediction_1(non-public insurance)	0.2075***		
	(0.0036)		
Prediction_2 (public insurance)	0.1537***		
	(0.0033)		
Difference	0.0537***		
	(0.0049)		
Constant			-0.3026***
			(0.1072)
Observations	24,553	24,553	24,553

Note. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

However, factors that significantly closed the gap in receipt of the three-dose HPV vaccine among publicly-insured compared to non-publicly insured individuals included being female compared to male, being of Hispanic ethnicity compared to non-Hispanics, having male providers compared to female providers, having primary care providers compared to other types of providers, having sick visits compared to vaccine-only visits, living in areas with a higher percentage of Catholic and other

religion adhering populations, areas with higher percentage of other races (non-black, non-white), and those living in areas with a higher percentage of high school graduates (see Table 17).

In summary, these results show consistent trends in observed factors that contribute to differences between publicly-insured and non-publicly insured adolescent HPV vaccination uptake. It reinforces the value of having private insurance in HPV vaccine series completion, although publicly-insured individuals are more likely to initiate the HPV vaccine series.

Table 18 further details the percent contribution of the covariates in HPV vaccine completion between the two groups: publicly-insured and non-publicly insured adolescents. The predicted probability of HPV vaccine completion was 0.1537 for publicly-insured adolescents and 0.2075 for non-publicly insured adolescents. Therefore a difference of -0.0537, or 5.37 percentage points, exists between the two groups. Observed characteristics successfully explained the difference in HPV vaccine completion of 0.0537 between the two groups. In other words, had publicly-insured adolescents had similar distribution of observed characteristics as non-publicly insured adolescents, the probability of publicly-insured individuals initiating HPV vaccine would have increased by 37% (0.0200/0.0537). Significant unexplained factors (63%) to HPV vaccine initiation remain between the two groups.

If a higher number of publicly-insured adolescents were living in urban settings, then the likelihood of completing the HPV vaccine series would have increased by 11.5%, which would have reduced the observed explained gap

between publicly-insured and non-publicly insured individuals. If a higher number of publicly-insured adolescents received preventative visits, then the likelihood of completing the HPV vaccine series would have increased by 83%, which would have reduced the observed explained gap between publicly-insured and non-publicly insured individuals. If a higher number of publicly-insured adolescents were older, then the likelihood of initiating the HPV vaccine would have increased in decreasing order from age 12 to 17.

If a higher number of non-publicly insured adolescents lived in communities with higher black Protestant religion adherence, then the likelihood of completing the HPV vaccine would have increased by 15.5%, which would have reduced the observed explained gap. Similarly, if a higher number of publicly-insured adolescents lived in communities with higher other religion adherence, then the likelihood of completing the HPV vaccine would have increased by 3.5%.

If a higher number of publicly-insured adolescents lived in communities where a higher percentage of the population is Hispanic, then the likelihood of completing the HPV vaccine series would have increased by 55%, which would have reduced the observed explained gap. Similarly, if more publicly-insured individuals lived in communities with higher percent of the population with income below the poverty line, then the likelihood of completing the HPV vaccine series would have increased by 38%. If they lived in areas with more college graduates, the HPV vaccine series receipt would have increased by 58%, further closing the gap.

Table 18: Decomposition Results of HPV Vaccine Completion between Publicly-Insured and Non-Publicly Insured Adolescents

Probability of completing HPV vaccine for non-public insured	0.2075***		
Probability of completing HPV vaccine for public insured	0.1537***		
Difference in HPV vaccine completion	0.0537***		
Total unexplained by measurable characteristics		0.0338***	
Total explained by measurable characteristics		**0.0200*** **	

Independent variables	**Decomposition (explained factors)**	**Standard error**	**% contribution (explained factors)**
Patient characteristics			
Female (ref. male)	-0.0016***	0.0004	-8.00
Hispanic (ref. non-Hispanic)	-0.0199***	0.0046	-99.5
Unknown Hispanic ethnicity	0.0172**	0.0069	86.00
Urban (ref. rural)	0.0023***	0.0007	11.5
Age 12 (ref. age 11)	0.0024***	0.0004	12.00
Age 13	0.0019***	0.0004	9.5
Age 14	0.0022***	0.0004	11.0
Age 15	0.0014***	0.0003	7.00
Age 16	0.0013***	0.0003	6.5
Age 17	0.0002	0.0002	1.00
Age 18	-0.0018***	0.0003	-9.0
Provider and visit type characteristics			
Preventative visit	0.0166***	0.0012	83.0
Sick visit (ref. vaccine-only visit)	-0.0028***	0.0006	-14.0
Male provider (ref. female providers)	-0.0018***	0.0004	-9.00
Other providers (ref. Primary care providers	-0.0174***	0.0026	-87.0
Population characteristics			
Evangelical rate	-0.0003	0.0006	-1.5
Catholic rate	-0.0017**	0.0008	-8.5
Mainline Protestant rate	-0.0001	0.0001	-0.5
Black Protestant rate	0.0031***	0.0007	15.5
Orthodox rate	0.0001	0.0003	0.5
Other religion rate	0.0007***	0.0002	3.5
Pct. Black (ref. pct. White)	-0.0009	0.0007	-4.5
Pct. Other race	-0.0145***	0.0040	-72.5
Pct. Hispanic (ref. non-Hispanic)	0.0110*	0.0066	55.00
Pct. Ling isolated house	-0.0040	0.0036	-20.00
Pct. Income below poverty	0.0076***	0.0021	38.00
Pct. Institutionalized pop	-0.0003	0.0004	-1.50
Pct. Below High school pop under age 25	-0.0003	0.0040	-1.50
Pct. High school graduates	-0.0108***	0.0025	-54.00
Pct. College graduate	0.0116***	0.0036	58.00
Total explained by measurable characteristics	0.0200***		37.00

Note. Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

However, being female, Hispanic, age 18, having sick visits, visiting male and other providers, living in areas with more Catholic religion adherence, living in communities where higher percentage of community includes other races, and higher percentage of high school education had an opposite effect in explaining the observed gap in HPV vaccine completion between publicly-insured and non-publicly insured adolescents.

In other words, patient characteristics indicate that if more publicly-insured adolescents were female, the observed explained gap in HPV series completion would have increased by 8%. If more publicly-insured adolescents were Hispanic, the observed explained gap in HPV series completion would have increased by 99.5%. If more publicly-insured adolescents were age 18, the observed explained gap in HPV series completion would have increased by 9%.

When we look at provider and visit type characteristics that had the opposite effect: if more publicly-insured adolescents received sick visits compared to vaccine-only visits, the observed explained gap in HPV series completion would have increased by 14%. Similarly, if more publicly-insured adolescents received care by male providers, the observed explained gap in HPV series completion would have increased by 9% and by 87% if they visited providers other than primary care providers.

When we look at population characteristics that had the opposite effect: if more publicly-insured adolescents lived in communities with more Catholic religion adherence, the observed explained gap in HPV series completion would have increased by 8.5%. Similarly, if more publicly-insured adolescents lived in

communities with a higher percentage of other races compared to whites, the observed explained gap in HPV series completion would have increased by 72.5% and by 54% if there were more high school graduates in the population.

These results show several factors that influence HPV vaccine initiation and completion between publicly- and non-publicly-insured adolescents. When we look at patient characteristics, urban residence and receiving preventative visits significantly explained the lower predictive probability of HPV vaccine initiation among non-publicly insured adolescents. In HPV vaccine completion, however, where non-publicly insured adolescents had higher probability, urban residence and receiving preventative visits explained a portion of lower predictive probability of completing the HPV vaccine series among publicly-insured adolescents.

When it comes to provider and visit type characteristics, although provider gender (female vs. males) and type of provider (other provider types vs. primary care providers) had an impact HPV vaccine initiation between publicly- and non-publicly insured adolescents, having preventive visits best explained HPV vaccine completion among non-publicly insured adolescents.

Both HPV vaccine initiation and completion gaps were explained by several population characteristics. HPV vaccine initiation gap between publicly and non-publicly insured adolescents were explained by Catholic, mainline and Black Protestant religions, whereas completion gap was explained by living in communities with black protestant and other religions. Additionally, living in areas with more linguistically isolated households, living in areas with more population under age 25, below high school education, and high school graduates explained the gap in

initiation. However, living in areas below poverty and with more college graduates explained the observed gap in non-public insured completing the HPV vaccine series with a higher predicted probability.

CHAPTER V
DISCUSSION

This research study used HPV vaccine-ordering ratio compared to Tdap among VFC providers to identify regional variations in HPV vaccine ordering in Colorado for qualitative exploration of barriers and facilitators among the different providers. This study further estimated HPV vaccine uptake trends among adolescents who received the Tdap. When observed differences in HPV vaccine initiation and completion were present, a regression decomposition method was used to provide insight into the nature of the observed differences in outcomes, whether due to the characteristics of the groups (i.e. endowments) or unexplained factors such as cultural nuances. The main outcomes of interest for quantitative analysis were HPV vaccine initiation and completion among adolescents who were followed for a year post-Tdap vaccine receipt.

This type of analysis has not been done in Colorado previously and this research provides an additional body of knowledge about HPV vaccine trends in Colorado and factors that drive differences in outcomes. Decomposition analysis of differences is important to understand the main determinants of differences (explained or unexplained) and to inform future interventions and research.

Barriers and Facilitators to HPV Vaccine Uptake

This research found that barriers to the HPV vaccine exist in Colorado even among the high practice-low PCSA practices as well as those in the low-practice, low-PCSA regions. Barriers discussed by these providers focused on provider, parental, and policy level factors. Parental factors identified as a barrier by participants from all three categories included:

- Vaccine hesitancy and refusal
- Religious conservatism
- Alternative vaccine schedules
- Fear of inadvertent promotion of early sexual debut
- Fear of vaccine side effects and ineffectiveness
- Lack of trust in provider recommendations
- Lack of regular visits for adolescents
- HPV vaccine for boys
- Parental consent for vaccines
- Non-inclusive vaccine marketing
- Vaccine related decision-making

Participants also discussed provider factors that acted as barriers to HPV vaccine recommendation and provision. These included:

- Limited provider persuasiveness
- Clinic location and vaccines offered
- Challenges in vaccine ordering and billing
- Funding for vaccination efforts/cost of vaccines

Although these barriers were identified and discussed by participants from all categories, there was a clear difference in the facilitators to HPV vaccine uptake as identified by participants in the different categories. Specifically, there was a notable difference in how participants discussed and addressed barriers to the HPV vaccine. Providers from high-practice, low-PCSA categories talked about being informed about the HPV vaccines by staying up-to-date on immunization information and

communicating with parents and adolescent children in unique ways. However, many facilitators identified by participants in the low-practice, high-PCSA category focused on parental factors, such as having vaccine-receptive populations, prior parental experience with HPV infection, and parents bringing their children to the clinic to fulfill the Tdap requirement. Although low-practice, low-PCSA sites identified facilitators to HPV vaccine provision, they did not discuss individual clinics making extra efforts that stood out from the other categories to improve HPV vaccine uptake. In addition, participants identified population characteristics as facilitators throughout these categories that remained consistent in their receptiveness to the HPV vaccine and overall provider recommendations, such as being publicly-insured or having Hispanic populations. Participants were unaware of their performance categories during the qualitative interviews, which provided for a more authentic reflection of their experiences and perceptions without the added pressure.

Opportunity for improved HPV vaccine uptake exist due to the dosage change for those who receive the vaccine before their 15th birthday. However, there was variation in knowledge regarding the new vaccine dosage recommendation and confusion regarding when to begin implementing the change.

HPV Vaccine Initiation and Completion

Our findings from the logistic regression analysis showed that when comparing adolescent males to females, individuals who had male providers compared to female providers, and those who saw other types of providers compared to primary care providers were significantly less likely to receive at least one dose of the HPV vaccine. However, adolescents who had more primary care

visits compared to vaccine-only visits were significantly more likely to receive at least one dose of the HPV vaccine.

Similarly, when comparing adolescent males to females, those who received care by male providers compared to female providers, and those who received care by other types of providers compared to primary care providers were less likely to complete the full dose of the HPV vaccine. Furthermore, Hispanic adolescents compared to non-Hispanics, those who had more preventative and sick visits compared to vaccine-only visits, and those with private as well as other insurance types compared to publicly-insured patients were more likely to complete the full three-dose HPV vaccine series. Finally, adolescents living in areas where a higher percent of population was living below the poverty level were less likely to initiate or complete the full dose of the HPV vaccine.

Hispanic Decomposition on Medicaid-Insured Adolescents

Medicaid-insured Hispanics were more likely to receive at least one dose and to complete the three-dose HPV vaccine series than Medicaid-insured non-Hispanics. Among those who initiated the HPV vaccine, factors that significantly explained more HPV vaccine initiation of HPV vaccine among Hispanics compared to non-Hispanics included having preventative or sick visits compared to vaccine-only visits, having male providers compared to female providers, and being seen by other types of providers compared to primary care providers. Among those who completed the three-dose HPV vaccine, having preventative visits compared to vaccine-only visits significantly explained the observed increased rate among Hispanics compared to non-Hispanics. Individuals who came only for preventive

visits but not vaccine-only visits typically did not complete the three-dose series because vaccine-only visits are typically for series completion.

Insurance (Public vs. Non-Public) Decomposition on Adolescents

We found that publicly-insured individuals were more likely to receive at least one dose of the HPV vaccine compared to non-publicly insured individuals. However, publicly-insured individuals were less likely to receive the full three-dose HPV vaccine series as compared to non-publicly insured individuals. This is consistent with other studies that looked at the HPV vaccine completion rate among private and public insured individuals (Simmons et. al., 2015).

Some factors that significantly explained initiation of the HPV vaccine among publicly-insured compared to non-publicly insured individuals included being a male adolescent compared to female, having male providers compared to female providers, and having other types of providers compared to primary care providers. Similarly, completion of the three-dose HPV vaccine was higher among non-publicly insured than publicly-insured individuals. Some factors that explained the HPV vaccine completion rate among non-publicly insured included being an adolescent female compared to male, having male providers compared to female providers, and having primary care providers compared to other types of providers.

Barriers to the HPV vaccine identified by Colorado VFC providers are consistent with nationally-available information on the HPV vaccine. For example, one of the top reasons parents gave as a reason for not vaccinating their adolescent children with the HPV vaccine was that there had not been a provider recommendation for the vaccination (Elam-Evans et al., 2014). As some providers

from low-practice, low-PCSA sites indicated, providers do not consistently recommend the HPV vaccine for all adolescents who come to their clinic. The reason these providers gave was that they trust that these children are not sexually active. This demonstrated a general lack of understanding about how the vaccine is protective before exposure and it created a missed opportunity.

Providers identified several facilitators and opportunities for HPV vaccination rate improvement. Some providers discussed collaborating with local high schools to educate adolescents and their parents about HPV vaccine. Almost all providers said that the new two-dose HPV vaccine guideline should improve the HPV vaccine rate and would generate more enthusiasm from parents and adolescents. However, the dissemination of the new vaccine guideline was not consistent across providers, and some only learned about the dose change from the researcher. Inconsistently disseminated information remains a challenge.

The quantitative results also showed a consistent decline in HPV vaccine initiation and completion as adolescents get older. Although the data showed significant differences in HPV vaccine uptake among ethnic groups and in the role of where adolescents live in the population, these factors were typically not amenable to changing. However, this research is an important addition that shows several factors that can be influenced to drastically improve the HPV vaccination rate in Colorado.

Overall, these findings show the impact of adolescent gender, provider gender, the role of the primary care or other types of providers, and insurance status in initiating and completing the HPV vaccine series in Colorado. Our data showed

that male adolescents lag in HPV vaccination initiation and completion compared to females. One of the main reasons for the gender gap is the introduction of the HPV vaccine for males later than females. Additional barriers to HPV vaccine uptake among males is lack of parental awareness about HPV vaccine for boys (Nonzee, Baldwin, Cui, & Singhal, 2017). Although the trend in HPV vaccine is increasing in general, it is not where it needs to be compared to other adolescent vaccines. CDC 2016 data show that only 56% of boys ages 13 to 17 received one or more doses of the vaccine, compared to 65% of girls nationally. And only 37.5% of boys in this age group completed the HPV vaccine series, compared with 49.5% of girls (Walker et al., 2017). Furthermore, new research in 2017 found that one in nine American men is infected with the oral form of HPV. This study estimated the rates for oral HPV infections at 11.5% of men (11 million men) and 3.2% of women (3.2 million women) (Sonowane et al., 2017). The incidence of oropharyngeal squamous cell carcinoma among men increased drastically from prior years (7.8 per 100,000) and has already surpassed the incidence of cervical cancer in women (7.4 per 100,000) (Mourad et al., 2017). The focus of HPV vaccine efforts should be both at preventing cancers that impact both male and female populations. Understanding the urgency of reducing HPV infection among boys and starting the HPV vaccine series when they are young, before sexual debut, is as crucial as it is for girls. Statewide efforts need to take place to reduce the gender gap in HPV vaccine recommendation and uptake among adolescent boys and girls.

Significant difference in initiation and completion of the HPV vaccine series was associated with provider gender, in which adolescents who visited male

providers were less likely to initiate and complete HPV vaccine. Prior research has shown the role of provider gender in effects of preventive screening and counseling. One study concluded that female provider gender influences the provision of preventive screening and counseling (Henderson & Weiman, 2001). This aligns with our findings that adolescents who visited male providers were non-adherent. Even though our data did not explore reasons for the observed variation in male providers versus female providers in vaccination outcome for adolescent patients, several previous studies found that the gender of the physician influences the provision of preventive care. Specifically, female providers are found to engage in more communication that is considered patient-centered care (Roter, Hall, & Aoki, 2002), and influence provision of preventative care such as cancer screening (Osborn, Bird, McPhee, Rodnick, & Fordham, 1991; Levy, Dowling, Boult, Monroe, & McQuade, 1992; Hall et al., 1990., Lurie et al., 1993). However, no studies have specifically analyzed the role of provider gender in influencing HPV vaccine uptake. Understanding and targeting factors that hinder HPV vaccine-related communication among providers, especially male providers, could be an important driver in reducing observed gaps in HPV vaccine provision and uptake.

We also observed significant differences in HPV vaccine initiation and completion among primary care providers compared to other types of providers. The HPV vaccine was less likely to be provided by other types of providers compared to primary care providers. This is important because, if adolescents are visiting other types of providers for vaccines such as Tdap, targeting these providers to also provide HPV vaccine is necessary. We know that children with special health care

needs or chronic conditions visit specialty providers more often to manage their chronic as well as preventive care needs. Furthermore, parents of children with chronic conditions reported lack of provider recommendation and low perceived susceptibility of their children to vaccine-preventable condition as reasons for not immunizing (Daley et al., 2005). It is important to raise awareness among other types of providers regarding the need for HPV vaccine recommendation to their adolescent population to reduce missed opportunities and to educate parents about the tangible probability of infection. Interventions aimed at helping providers better communicate HPV vaccine recommendations should also include these other types of providers in their messaging to help increase HPV vaccine uptake.

Furthermore, this research showed unique findings in Colorado. It was found that adolescents living in areas with higher percentage of Hispanic population compared to non-Hispanics, those living in areas with higher percentages of income below the poverty level, and those living in areas with a higher institutionalized population were significantly less likely to initiate the HPV vaccine. This trend is opposite of what has been seen nationally where adolescents living below the poverty level had higher rates of HPV vaccine initiation (Walker et al., 2017). This discordance in results might be due to the fact that population-level poverty status was used for our analysis rather than individual adolescent poverty status. An adolescent could live in a community with more poverty but not be poor themselves.

Additionally, quantitative analysis revealed that non-publicly insured adolescents were more likely to complete the three-dose HPV vaccine series than publicly-insured. This was opposite of what we saw with qualitative findings where

participants discussed that the publicly-insured population is more willing to allow the HPV vaccine. This perception might be true, but non-publicly insured adolescents are completing the vaccine series. There might be interest but lack of means among publicly-insured individuals might be hindering their HPV vaccine completion rates.

Providers discussed a lack of awareness among parents regarding the HPV vaccine for boys. As our result show, there is agreement between qualitative and quantitative findings where adolescent male HPV vaccine initiation and completion lags behind that of girls. Additionally, the role of provider gender in HPV vaccine was not emergent in the qualitative research but was one of the prominent trends in the quantitative data. This shows the possible lack of awareness among providers and the role of provider gender in HPV vaccine recommendations. This mixed methods exploration identified similar, opposing and additional information that is useful to the HPV vaccine landscape.

Limitations and Strengths

This research study has various strengths and limitations. There are interrelated and complex factors that influence HPV vaccination trends. This work addresses provider perspectives, quantifiable patient, provider and population level characteristics and their influence on initiation and completion of the HPV vaccine.

Strengths. We used in-depth qualitative interviews to understand VFC provider perceptions of barriers and facilitators to HPV vaccine. Hypotheses generated from those VFC provider interviews were tested using quantitative data to provide more generalizability with a larger sample size. The quantitative analysis was not limited to VFC only providers, thus agreement observed between qualitative

perspectives and quantitative data are more generalizable. This allowed for a simultaneous in-depth look at what providers are saying and current HPV vaccination trends in Colorado. Several factors that are relevant in the current literature as impacting immunizations were included in the quantitative data analysis. This allowed for interpretation of findings in confirming or adding to current literature as well as providing new insight that should be further explored.

This research study used regression decomposition, a method widely used in economics to differentiate between explained and unexplained factors in disparities. Furthermore, there currently are no published studies that utilized VFC vaccine ordering data to identify variations in HPV to Tdap ordering ratio and use qualitative key-informant sampling. There are no studies that analyze Colorado All Payer Claims data to understand adolescent HPV vaccine uptake. Thus, this work provides a combination of unique methodological approaches as well as data usage to show complexity of HPV vaccine uptake.

Additionally, this work identified several barriers and facilitators to HPV vaccine uptake in Colorado. This has not been systematically explored to our knowledge. This work provides information for policy makers, practitioners and researchers to target intervention areas. Along with amenable factors identified through quantitative analysis, this work supports and provides more information and actionable data to individuals and agencies in Colorado who are interested in improving HPV vaccine uptake.

Limitations. The qualitative research only targeted small number of VFC providers, thus it is unclear to what extent these issues apply directly to all providers

in Colorado. Although hypothesis generated from qualitative data were tested with larger sample size using APCD data, the analytical approach used in this research only estimated associations between observed covariates. It is possible that unobserved factors could influence outcomes of interest.

Implications for Practice and Future Research

This research provides more body of work where there is currently limited knowledge about HPV vaccine related practice among VFC providers and communities they serve. There is ongoing effort to improve VFC effectiveness in vaccine delivery. Understanding barriers and facilitators to current practice in Colorado informs a clear path for intervention. This work initially came about due to interest from CDPHE's immunization branch to understand current barriers for improvement. This research providers a wealth of information that will be used to inform statewide HPV vaccine landscape. Additionally, results from this study could be used to inform current local efforts to improve HPV vaccine uptake such as Denver Metro Alliance for HPV Prevention and Colorado cancer coalition. These two efforts have made HPV vaccination priorities to eliminate HPV infection, disease and disability. This research results will provide information that is relevant to their ongoing work and provider new insights into barriers to HPV vaccine uptake. There are several opportunities for future research emanating from this work. These include:

a. **Further explore reasons for lower HPV vaccine provision among non-primary care providers for targeted intervention.** Strong partnership with non-traditional HPV vaccine providers could help

champion HPV vaccine uptake and resolve any systemic barriers faced.

b. **Confirm the role of provider gender in HPV vaccine provision**. Further research is needed to confirm the role of provider gender in HPV vaccine uptake. If confirmed, further exploration to understand possible reasons is necessary to intervene.

c. **Conduct qualitative interviews with high-practice, high-PCSA sites.** This research conducted qualitative interviews with only three out of the four categories. Conducting additional qualitative interviews with the high-practice, high-PCSA sites could yield additional insight to variation in HPV vaccine uptake among adolescents.

d. **Further explore unexplained factors, their role and impact on the HPV vaccine uptake.** Regression decomposition analysis showed several factors that were unexplained by the observed data that influence HPV vaccine uptake. Understanding those factors is crucial in the ongoing effort to improve HPV vaccine uptake and recommendation, and to understand unobserved factors such as cultural values that influence the HPV vaccine rate.

Recommendations

Based on findings from this research, the following recommendations can increase HPV vaccine recommendation and uptake by adolescents:

1. **Respond to emerging epidemiologic trends**. HPV infection and oral cancer among men increased drastically in the past few years. Communicating to

parents and providers this trend and addressing the need for HPV vaccination among boys could improve the HPV rate in this group.

2. **Reminder** / **Recall**. In response to adolescents who do not come to clinics when they are due for vaccines, reminder/ recall programs might play a larger role in bringing parents and their adolescents to clinics for well-child visit and vaccinations. Some parents might respond better to information that their child is due for well-child visit instead of vaccinations only to allow them to interact with providers.
3. **Invest in practice infrastructure and capacity.** Lack of immunization providers in rural communities and resources should be addressed by improving practice infrastructure and capacity using resourceful methods to improve HPV vaccine uptake.
4. **Utilize innovative communication skills.** Innovative communication skills that elicit behavior change by patients and providers such as Motivational Interviewing (MI) techniques should be used to influence HPV recommendation and uptake. Training providers to use MI techniques and for their vaccine discussion with parents could yield behavior change among hesitating parents. MI could also be used to target low performing providers to change their prescribing behavior.
5. **Find innovative approaches from public health and other fields.** Informing low vaccine ordering practices their status compared to other practices in their communities could yield practice transformation. This can be

done through sending letters from the state health department (which manages VFC vaccines) to let practices know that they are doing poorly.

6. **Utilize vaccine-ordering trends to make AFIX (Assessment, Feedback, Incentives, and eXchange) program visit.** AFIX program conducts quality improvement visits to different VFC participating practices to improve immunization delivery among VFC providers. Utilizing vaccine ordering ratio yields important avenue for AFIX to be efficient in targeting low performing sites. This will help further understand and address systemic barriers faced by these sites.

Conclusion

There is evidence that shows the value of HPV vaccination in preventing HPV infections that cause cervical, throat, head, and neck cancers as well as genital warts. However, there are significant barriers to optimal immunization of adolescents with the HPV vaccine. There are continued disparities in initiation and completion of HPV vaccine among populations. Understanding what specific factors influence and explain HPV vaccine uptake in Colorado and beyond is crucial for intervening. Through identification of amenable parental, provider and system level factors, HPV vaccination could reach the rates of Tdap and other vaccines.

This work builds on existing research and the body of knowledge about HPV vaccine-related barriers and facilitators. Researchers and health care professionals can utilize findings from this research study to further expand their research, create tailored interventions, or to inform their practice. While the findings from this research show explainable factors that could be influenced for change in HPV

vaccine current practice, further research needs to be done to understand unexplainable patient, provider, and policy level factors that influence HPV vaccine uptake.

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APPENDIX A

Stata code used for generating variation and cut off points for qualitative interview sampling

Used Quartiles i.e. 25th and 75th percentile.

```
sum percenthpv if totaldosestdap >=24, d

gen low_provder =% hpv ordered < 0.3376068 & totaldosestdap>=24
gen high_provder=% hpv ordered >0.7945152 & totaldosestdap>=24
gen low_pcsa       =% hpv ordered < 0.3542484 & totaldosestdap>=1
gen high_ pcsa     =% hpv ordered > .6689151 & totaldosestdap>=1


Sum  if low_provider==1 & low_pcsa==1
Sum  if high_provider==1 & low_pcsa==1
Sum  if low_provider==1 & high_pcsa==1
Sum  if high_provider==1 & high_pcsa==1
```

APPENDIX B

HPV Study Interview Guide V.1

Interview guide
Interviewer Name: Interviewee Name:

Site: Date:

Time Start: Time End:

Hello (Dr./Mr./Ms. insert interview participant name),
My name is Roman Ayele and I am a PhD student at Colorado School of Public Health. I am conducting a series of interviews aimed at **Understanding Provider Barriers to ordering and administering vaccine to adolescents in Colorado.** The purpose of the interview is to help us understand provider practice and perspective to administering and recommending vaccines on the adolescent platform such as HPV, Tdap, Meningitis vaccines, facilitators and barriers to adequate immunization, and obtain general recommendations as to how to improve immunization rates. We will be interviewing providers from throughout Colorado. We are interested in any and all factors that you feel could be important for this topic.

This interview should take 30 to 60 minutes, and my questions relate only to your professional experience as a Primary Care Provider/OBGYN and we won't ask any information related to you that aren't relevant to your work duties and responsibilities. Your decision to speak with me is voluntary. You can also refuse to participate or answer any questions, and you may stop this interview at any time. If, at a later time, you'd like to retract certain statements, you may do so. Your information will be stored on a password-protected computer.

And, lastly, this project will help to inform efforts to improve vaccination rates among adolescents in Colorado. And, if you agree to participate, we'd like to record our interview, so that we can capture all of the important information that you share with us. We will not identify you as a participant, nor will we identify your site in any of our reports. We will aggregate the findings into a single report. Is this ok with you? Y/N If yes, we will ask you these questions again when the audio recording begins.

We will now begin the audio recording: I have three questions for you. The first is, are you willing to participate in this interview? Do you give us permission to record this interview? And, do you give us permission to contact you at a later time if we have additional questions?

If you have questions about this QI project, you may contact me, Roman Ayele (720-402-0489 and Roman.Ayele@ucdenver.edu) or our ethics review board COMIRB (303- 724-1055 and COMIRB@ucdenver.edu).

1. Tell me about your role in recommending and administrating vaccines and how long you have been doing this

2. Focus on a specific visit and describe the vaccine related discussion you had with an adolescent and their family.

    I. How common are such discussions?
    II. Do they vary by vaccine type?

3. What is your perception of the family's decision-making process?
    I. Does it vary by vaccine type?

4. Are there families who specifically request HPV, Tdap, or Meningitis vaccines for their adolescents?

5. Are there parents who refuse HPV, Tdap, or Meningitis vaccine for their adolescents?
    I. What are some of the reasons mentioned? (cost, sexual activity, religious or philosophical beliefs, vaccine safety)
    II. How do you address these concerns brought up by parents?

6. Tell me about HPV, Tdap, Meningitis vaccines. When do you recommend adolescents get vaccinated? What dose do you recommend for adolescents?

7. Do you endorse these vaccines to your adolescent patients/their parents? Why or why not?
    I. Do your patients and\or their families know this?
    II. How do you tell them?
8. Do you recommend these vaccines to all your adolescent patients who come to your clinic?
    I. Why or why not?
9. Are you able to obtain a sufficient supply of adolescent vaccines for your patients?
10. What are some of the barriers you face to providing HPV, Tdap, Meningitis vaccines to adolescents?
11. What are the facilitators to administering HPV, Tdap, Meningitis vaccines to adolescents
12. Is there anything else that we did not ask you about that you would like to add?

APPENDIX C

Current Procedural Terminology (CPT) codes for vaccine and well child visits

- CPT codes in
  - 99201-99205
  - 99211-99215
  - 99241-99245
  - 99381-99387
  - 99391-99397
  - 99401-99404
  - 99411, 99412, 99420, 99429
- In conjunction with diagnosis codes specified:
  - Prior to Oct 2015:
    - Preventive care ICD-9 codes: V20.0, V20.2, V70.0, V70.3, V70.5, V70.6, V70.8, V70.9
    - Sick ICD-9 codes: Any code starting with 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, E
  - Oct 2015 and later
    - Preventive care ICD-10 codes: Z76.1, Z00.129, Z00.00, Z02.89, Z02.1, Z00.8, Z00.5
    - Sick ICD-10 codes: Any code except those starting with “Z”

- Vaccines:
  - Vaccine administration CPT Codes:
    - 90471-90474, 90460, 90461
  - HPV Vaccine CPT Codes:
    - 90649, 90650, 90651
  - Tdap Vaccine CPT Codes:
    - 90714, 90715, 90718

APPENDIX D

Dissertation Committee

Richard Lindrooth, PhD (**Research Mentor**) is a Professor and interim Chair in the Department of Health Systems, Management and Policy in the Colorado School of Public Health at the University of Colorado. He is also a Co-Director of the Department's Health Service Research PhD program. As a health services research methodology expert, he provided expertise on issues related to study design, data management, quality control, data analysis, and preparation of manuscripts.

Catherine Battaglia, PhD, RN (Dissertation committee chair) is an Assistant Professor with the University Of Colorado School Of Public Health and is the Co-Director of the Health Services Research PhD Program. She currently teaches Clinical Outcomes Assessment & Application and Grant Writing in the Health Services Research PhD Program. Dr. Battaglia is also a core faculty member in the interdisciplinary LEADS Program in the School of Medicine. She teaches advocacy and leadership electives and oversees the summer internship program where second year medical and physician assistant students work with a community-based organization. Dr. Battaglia received her PhD in Clinical Sciences/Health Services Research from the University of Colorado. She is a Nurse Scientist in the Denver–Seattle Center for Innovation located at the Veterans Health Administration, Eastern Colorado Health Care System. Dr. Battaglia conducts health services research targeted toward helping improve veterans' health. She has expertise in program evaluation, motivational interviewing, and outcomes research.

Sean O'Leary, MD (Research committee member) is an infectious disease doctor who has participated in the design, implementation, and publication of several research studies involving a variety of immunization related issues including immunization delivery, vaccine safety, and vaccine hesitancy using quantitative and qualitative methodology. His current project is to develop and test a 3-component intervention to improve provider-level communication and recommendation for the HPV vaccine for adolescent patients among selected practices in Denver, Colorado.

Amanda Dempsey, MD, PhD, MPH (Research committee member), is a research scientist in immunization delivery, vaccine refusal, HPV infection and mathematical modeling. She has led several research studies around HPV infection and vaccination and engagement of parents, patients and provider stakeholders to reduce HPV related disease. She utilized both qualitative and quantitative methodology in her previous work and will ensure oversight of this research study and providing insight into the interdisciplinary aspects of the proposal in working with provider groups.

Gregory Tung, PhD, MPH (Research committee member), is a research scientist whose interests relate to how scientific evidence is incorporated into policy and program decision making. He works on a diverse range of topics that include the integration of health services and public health systems. He is a mixed methods researcher and utilizes both quantitative (e.g. longitudinal, multi-level, and time-to-event analysis) and qualitative (e.g. case studies) methods. Dr. Tung is also faculty in the Pediatric Injury Prevention, Education and Research (PIPER) Program.