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Impact of Number of Providers and Facility Type on Human Papillomavirus Vaccination Coverage

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Abstract

Impact of Number of Providers and Facility Type on Human Papillomavirus Vaccination Coverage

By Meghan K. Herring

Human Papillomavirus (HPV) vaccination coverage for adolescents in the United States remains well below that of other vaccines recommended by the Advisory Committee on Immunization Practices. In 2018, only 51.1% of adolescents 13-17 years of age were up-to-date and only 68.1% had even initiated the series. In the same year, coverage for the tetanus and reduced diphtheria toxoids and acellular pertussis vaccine (Tdap) and the quadrivalent meningococcal conjugate vaccine (MCV4) were 98% and 86.6% respectively. This suboptimal coverage is due to many factors including varied access to health care and general vaccine hesitancy. However, little is known about the impact of fragmented care on immunization coverage. We compared HPV vaccine series initiation and completion proportions for adolescents as a function of the number of providers and types of facilities where they received immunization services using provider-verified vaccination data and parental self-report of vaccination practices from the 2017 National Immunization Survey-Teen. Adolescents with two or more providers were less likely to initiate (7% absolute reduction) or complete (10% absolute reduction) HPV vaccination compared to adolescents with one provider. Adolescents receiving vaccines in hospital settings had higher HPV immunization coverage (69% initiation, 55% completion) compared to those vaccinated in other types of medical facilities (e.g. public – 64%, 46%; private – 66%, 52%). When the number of providers and the facility type are considered together these differences are compounded, leading to large variations in coverage. These results support the recommendation for children to maintain a medical home, as those with this type of consistent care seem to have the best vaccination coverage, while also enhancing support for vaccination services for children without a singular medical home. A focus on consistent care within a medical home, preventive visits, coordination across health entities and targeted interventions at the facility level could improve HPV vaccination coverage across the United States and provide better protection against HPV-related cancers.

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CHAPTER I

BACKGROUND AND LITERATURE REVIEW

Human Papillomavirus

Human Papillomavirus (HPV) is the most prevalent sexually transmitted infection in the world (1). Around 79 million Americans, most in their late teens and early 20s, are infected with HPV (2) and about 74% of new HPV infections occur in those aged 15-24 years (3). HPV infection is most commonly acquired through skin abrasions, sexual intercourse, passage through an infected birth canal, autoinoculation or via oral sex (4). Additionally, HPV can be transmitted horizontally through kissing, digital contact, and other forms of close contact. HPV typically infects the human epithelium, and the life cycle of the virus is dependent on the differentiation of the epithelium it had infected (5). It has also been suggested that in addition to the severe disease caused by high risk HPV infection in both men and women, men could also be considered asymptomatic reservoirs who inadvertently transmit the infection to women, adding to the virus's persistence and stability (6).

A majority of HPV infections do not present with any symptoms and instead are cleared by the body spontaneously (5). Studies have shown that 90% of new cervical HPV infections clear or become undetectable within two years of transmission (7). Several types of low-risk HPV can, however, cause genital warts (8). Additionally, there are some HPV infections considered high-risk because they are associated with several forms of cancer. This includes cervical cancer, in addition to cancer of the penis, vulva, vagina, anus, and oropharynx (9). There are 13 HPV strains that fall into this high-risk category and have been identified as carcinogenic or probably carcinogenic, indicating a strong association with various cancers. These include HPV-16, HPV-18, HPV-31, HPV-33, HPV-35, HPV-39, HPV-45, HPV-51, HPV-52, HPV-56, HPV-58, HPV-59, and HPV-68 (5). Approximately 99% of cervical cancers are caused by one of these types of HPV (5). More specifically, 50-60% of cervical cancers are

caused by HPV-16 and around 20% are caused by HPV-18 (5). HPV infection accounts for an estimated 530,000 annual cervical cancer cases worldwide and around 270,000 deaths (2). Approximately 5% of all cancers worldwide can be attributed to HPV (5) and it has been estimated that on average, 43,999 new cases of cancer caused by HPV occur each year in the US (10).

According to the National Health and Nutrition Examination Survey (NHANES) 2011-2014, HPV infection is not evenly distributed among various demographic groups (8). The prevalence of both oral and genital HPV infection was highest among non-Hispanic black adults and lowest among non-Hispanic Asian adults (8). Additionally, men had a higher prevalence of oral HPV than women, overall and within each race and Hispanic group (8). From the same NHANES study, during 2013-2014, the prevalence of any genital HPV was 42.5% among adults aged 18-59 with 45.2% among men and 39.9% among women (8). Furthermore, the prevalence of high-risk genital HPV was 22.7% among adults aged 18-59 with 25.1% among men and 20.4% among women (8).

HPV Prevention – Vaccines

The discovery of an HPV vaccine offered new opportunities to prevent HPV infection among adolescents when they are most susceptible. First generation vaccines protected adolescents from HPV types 16 and 18, the most common strains associated with various forms of cancer. Then a quadrivalent vaccine offered further protection against types 6 and 11 in addition to 16 and 18. These early vaccines were predicted to prevent the majority of invasive cancers including an estimated 66% protection against cervical cancer, 79% for anal cancer, 60% for oropharyngeal cancer, 55% for vaginal cancer, 47% for penile cancer, and 48% for vulvar cancer (11). Evaluation studies showed a 71% decrease in HPV prevalence among 14-19-year-

olds within 8 years of vaccine implementation (12). Now, the newest nonvalent or nine-valent vaccine offers protection for all of these plus five additional high-risk types preventing an additional 4-18% of HPV related cancers over previous versions of the vaccine (9).

Upon initial roll-out of first-generation vaccines, the recommended schedule was a 3-dose series with the second dose at 2 months following the first, and the 3rd dose 6 months following the first. In 2014, WHO recommended a 2-dose schedule with at least 6 months between doses for girls who initiate the series before 15yrs old (13). The Advisory Committee on Immunization Practices now recommends routine vaccination of all persons in the US aged 11-12 years with several vaccines including the HPV vaccine, quadrivalent meningococcal conjugate vaccine (MCV4), and tetanus and reduced diphtheria toxoids and acellular pertussis vaccine (Tdap) (14). The HPV vaccine is also recommended for all persons not vaccinated up to age 26 and catch up for those aged 27-45 based on shared clinical decision making (15). The U.S. Department of Health and Human Services also declared 80% HPV vaccine coverage for both girls and boys aged 13 to 15 as one of their Healthy People 2020 objectives.

Vaccine Coverage

In 2018, only 51.1% of adolescents aged 13-17 were up to date with their HPV vaccine series, falling well below the aforementioned 80% Healthy People 2020 coverage goal (16). According to CDC, from 2017 to 2018, vaccine coverage for HPV (at least one dose) increased from 65.5% to 68.1%(16). The Tdap vaccine, given to the same age group, has a consistent coverage rate around 89% (16). There are several factors that have been shown to impact whether or not an adolescent has been vaccinated.

Location of residence is one example, as there was a significant difference in coverage when comparing those living in nonmetropolitan areas to those living in metropolitan areas,

(59.3% and 70.1% respectively) in 2017 (14). Some studies have postulated that the overall shortage of healthcare providers, especially pediatricians, in rural areas might help to explain the lower coverage rates among rural adolescents. Pediatric specific providers tend to have higher immunization coverage than family medicine providers (17). It is hypothesized that these family practice providers may not be as familiar with specific adolescent vaccination recommendations because of their broader patient population (14).

Several demographic factors have also been identified as being associated with vaccine coverage for HPV including sex, race/ethnicity, insurance coverage, and socioeconomic status. Several studies comparing coverage rates by sex have shown significantly lower vaccine coverage among males compared to females (2). This is likely because HPV vaccination was not recommended for males until 2011 (5).

Race has been shown in several studies to be one of the few significant predictors for initiation of the HPV vaccine (18). A study comparing coverage rates among different races found that among females, Hispanics, non-Hispanic blacks, and non-Hispanic American Indian/Alaska Natives all have higher rates of initiation of the HPV vaccine series than whites (3). Although initiation is higher in these populations, completion tends to be lower.

Furthermore, several studies have shown an association between insurance status and HPV coverage rates. One study found that those publicly insured were around two times more likely to complete the recommended doses than those with no insurance (18). Another study showed adolescents from low-income families were more likely to get vaccinated for HPV compared to those from higher income levels (2).

Health systems level factors such as number of visits, type of visit and type of clinical facility have also been shown to be associated with differences in vaccine coverage rates. One

study found that one-third of adolescents did not have a single preventive care visit between the ages of 13 and 17 and an additional 40% had only one visit (19). Another study found that having more physician contacts in the past year and having a preventive care well-child visit at age 11-12 years were both associated with higher level of vaccination strictly because they have more opportunities to discuss vaccination status and receive the immunization itself (20). One study in France showed a 2% increase in likelihood of completing the HPV vaccine series with every primary care visit noted in the medical record (18). Significant variation in vaccine coverage has also been seen depending on the type of facility where an adolescent saw a provider (21). These missed opportunities for vaccination and/or failure to review the immunization record during the appointment feed into these health systems level barriers to HPV vaccination coverage.

Vaccine Hesitancy

There has been a broad push across the United States and other countries for vaccine hesitancy, resulting in an increase in parental resistance to childhood vaccinations (1). Recently published studies have found between 13% and 27% of parents have decided to delay the recommended vaccine schedule and 6-16% have declined the recommended vaccinations altogether (22). However, several studies have shown that the number of families who have fairly high confidence with respect to the value, effectiveness, and safety of vaccines remains high (22). One study showed that confidence in vaccines was actually higher than for other health-related products and recommendations from healthcare providers (22). One study also looked at socio-demographic factors affecting the decision to not vaccinate and found that "mothers with a college education, mothers 45 years of age or older, and a higher income were all associated with an increase in the proportion of parents who reported 'no-intent' (23)."

Although vaccine safety has been shown as the prominent concern surrounding vaccine hesitancy, parental demographics, family knowledge/attitudes, the number of vaccines recommended, the perceptions surrounding the risks of the disease, access to healthcare, cost, and timeliness have all been associated (24).

There are several family and parental opinion related factors further leading to HPV specific vaccine hesitancy. The first is the lack of general education among parents around HPV, vaccines and cancer. Several studies have shown that a significant proportion of those highly affected by HPV and the types of cancers it can cause, have a fairly low level of knowledge surrounding the virus, the vaccine, and its association with cancer (25). Fear around the actual injection, after reports of adverse side effects, is another commonly cited reason for declining the vaccine (22). One study also found the number of injections given during a single visit was an important factor for parents when deciding which vaccines to give their child. They determined that the maximum number of injections per visit that parents felt comfortable with was three (24). Some parents have also cited how the 11/12-year-old appointment is not the appropriate time for the vaccine because the effects are not until later in life and their child is not sexually active at that age. The development of HPV related cancers is not until later in adulthood, so the fact that there is no immediate harm from HPV compared to other vaccine related illnesses may cause parents to prioritize other vaccines over HPV (3).

Additionally, one of the main hesitancy factors associated with the HPV vaccine specifically, is its relation to sex. Parent's report it is too early for this type of vaccine because their child cannot be exposed since they are not sexually active. Both parents and providers have stated that discussing this vaccine gives the impression that they approve of adolescent sexual activity and administering the vaccine will be associated with an increase in sexual activity (3).

There have been several studies conducted to counter this argument where researchers measure sexual activity markers among those vaccinated and those unvaccinated and saw no difference. Studies have looked at clinical outcomes related to sexual activity, including sexually transmitted infection testing or diagnosis, and contraceptive counseling, have consistently found no increase among those who received the vaccine (26, 27). These results indicate that vaccination is unlikely to promote sexual activity (28).

Another major factor affecting vaccine programs is state level immunization legislation and school vaccination requirements. As of 2018, 49 states and the District of Columbia require Tdap vaccination for middle school entry while only Rhode Island, Virginia, and Washington D.C. require HPV vaccination for entry (29). Several states have tried to improve HPV vaccination in other ways, through legislation that expands insurance coverage for the vaccine, allows pharmacists to administer the vaccine and/or requires education surrounding cervical cancer and HPV infection in schools (29). These broad requirements have proven effective as vaccine uptake has been higher in countries with school-based vaccination programs and requirements (9).

At the federal level, after being recommended by the Advisory Committee on Immunization Practices, HPV vaccination was included in the Vaccines for Children (VFC) program that provides vaccinations to underinsured and uninsured children at no cost (18). VFC was established in 1993 as a way to eliminate cost as a barrier to recommended vaccinations, especially among minority and poor youth (30). An evaluation of the program showed vaccine coverage for the HPV vaccine series was about the same between eligible VFC adolescents and non-eligible adolescents, while the other recommended 11-12 year old vaccines had considerably

lower coverage among VFC eligible adolescents (30). The VFC program has proven effective in eliminating the disparities in HPV immunization coverage.

Finally, studies have repeatedly shown that provider recommendation is one of, if not the, strongest predictor for vaccination (20). Provider recommendation has been repeatedly observed to significantly impact a parents' decision to vaccinate their child. In one study looking at data over the course of 4 years, over 60% of adolescents who did not receive the HPV vaccine reported not receiving a recommendation from their provider. (23). Studies have shown that even among those providers who do recommend the HPV vaccine, parents often report the way the provider talks about the vaccine indicates only a mild recommendation compared to other vaccines discussed in the same appointment. This is often cited as presenting the vaccine as "special" or "different" (3). Furthermore, research has shown that although physicians tend to lack concerns about the HPV vaccine, non-physician healthcare providers may have personal concerns leading to inconsistent communication during any one healthcare visit (24). One study comparing provider assumptions and parental beliefs showed a tendency for physicians to underestimate the importance parents attach to vaccines and overestimate parental concerns surrounding immunizations (24). They go on to postulate that providers with busy clinical schedules may be hesitant to bring up vaccines in an appointment if they believe there will be push back or extensive questions from the parent (24). All of these factors and perceptions, whether true or not, have repeatedly been shown to have a strong impact on HPV vaccine coverage in the United States.

Knowledge Gap

HPV vaccine coverage remains well below that of other routine vaccinations for many of the reasons previously listed including general vaccine hesitancy, sociodemographic disparities,

lack of provider support, and health systems level factors. A major focus of HPV immunization related research and interventions fall into increasing provider recommendations and attitudes towards the vaccine and/or trying to find ways to limit missed opportunities for vaccination. Fewer studies have looked at how the number of providers or the type of care the adolescent is receiving, based on the facility where they are being seen, can impact vaccine coverage. This study evaluated how fragmented care and lack of a medical home (defined by the number of healthcare providers who administered vaccines to a given adolescent and the different types of health care facilities used for vaccination services) can impact HPV immunization uptake.

CHAPTER II

MANUSCRIPT

Introduction

Human Papillomavirus (HPV) is the most prevalent sexually transmitted infection in the world (1). Around 79 million Americans, most in their late teens and early 20s are infected with HPV (2). HPV infection is associated with several severe forms of cancer including that of the penis, vulva, vagina, anus, and oropharynx (9). Approximately 5% of all cancers can be attributed to HPV infection and it has been estimated that 43,999 new cases of cancer via HPV infection occur each year in the United States (3, 10). To combat these high infection rates, an effective vaccine was developed in 2006. The vaccine series is now recommended by the Advisory Committee on Immunization Practices for all persons aged 11-12 years of age with catch up for all persons not vaccinated up to age 26 and those aged 27-45 based on shared clinical decision making (15). However, the vaccination coverage rates have remained low for both initiation and series completion, especially compared to the other vaccines recommended at this age. In 2018 only 51.1% of adolescents aged 13-17 were up to date with their HPV vaccine series and only 68.1% had even initiated the series (16).

There are several factors that have been shown to impact whether or not an adolescent has been vaccinated. Researchers have postulated that location of residence could be a factor, type of physician who saw the child, provider recommendation, and many other sociodemographic factors could all be impacting the decision to vaccinate for HPV (14). There has also been a broad push across the United States and other countries for vaccine hesitancy resulting in parental resistance to childhood vaccinations (1). The number, and type, of provider visits are two additional factors being explored in recent studies. One study found that around one-third of adolescents did not have a single preventive care visit in their teenage years and an additional 40% only had a single visit during this same time frame (19). There is a lack of

exploration in these studies however, around the relationship between vaccine coverage and fragmented care. The number of physicians or healthcare providers on an adolescent's care team and the type of facility where they are actually receiving their care may be impacting their vaccine coverage rates. Without an integrated immunization information system or a designated medical home, additional providers may not have access to the immunization history for the adolescent, especially if the adolescent only accesses the health system for acute visits (31). Furthermore, the decision of where to access the health system, more specifically, which facility type, depends on several factors including sociodemographic status, insurance status, and the reason for the visit. These factors can also influence the type of care the adolescent receives, including whether or not immunization status is discussed at the appointment (32). These hypotheses, however, have not been widely studied but could highlight potential opportunities for public health intervention to increase immunization uptake. The purpose of this study is to explore this relationship and compare how fragmented care and lack of a medical home (defined by the number of healthcare providers who administered vaccines to a given adolescent and the different types of health care facilities used for vaccination services) can impact HPV immunization uptake, both in terms of initiation and series completion.

Methods

We conducted a secondary analysis of HPV vaccination initiation and completion coverage on the 2017 NIS-Teen public use dataset from the US Centers for Disease Control and Prevention using SAS. NIS-Teen is a random digit dial telephone, both landline and cell phone, survey of parents of 13-17-year-olds in the United States. With their expressed consent, parents are asked a series of questions about the sociodemographic, general health, and immunization history of their adolescent. After completing the household survey, parents are asked permission for the survey team to contact their adolescent's health care provider(s) for confirmation of the immunization history and information about the type of facility they were seen in. This analysis was restricted to those adolescents with provider verified vaccination information.

All analyses were conducted in SAS version 9.4 (SAS Institute, Cary, North Carolina), using the complex survey method-specific weighted procedures PROC SURVEYMEANS and PROC SURVEYREG with weights provided in the 2017 NIS-Teen dataset as stated in the associated data user guide. For ease of analysis and data visualization, several variables were adjusted or combined. This included aggregating values for the number of providers from whom the adolescent received vaccines (zero, one, and two or more providers) and income to poverty ratio (above poverty, below poverty, and unknown poverty status). All sociodemographic factors used were self-reported by the survey participant. A new variable for completion of the HPV vaccination series was created to include the entire study sample as opposed to only those who initiated the vaccine. The main exposure variable of number of vaccination providers was also self-reported by the survey participant. The facility variable was identified by the specific provider on the Provider Immunization History Questionnaire.

PROC SURVEYMEANS was used to calculate population proportions and weighted coverage percentages for both HPV vaccine initiation and series completion. It was assumed that the number of providers who saw the adolescent would impact the facility type, so all figures were divided by these two variables to evaluate this interaction. The data was then stratified by known association factors for immunization coverage such as having an 11/12-year-old well-child visit, receiving a provider recommendation, the adolescent's income to poverty ratio, their insurance status, and their race/ethnicity. The results were exported into Excel version 16.35 (Microsoft, Redmond, Washington) for the creation of bubble plot figures, where the size of the bubble represents the population proportion, to compare the trends in initiation and completion by facility type and number of providers.

PROC SURVEYREG was used to complete two regression analyses using models for the HPV vaccine initiation and completion outcomes that included the previously mentioned known confounding factors such as, having a well-child visit, receiving a provider recommendation, income to poverty ratio, insurance status and race/ethnicity. The two exposures, facility type and number of providers, were tested in the model in addition to their interaction term.

This secondary analysis of previously collected, publicly available, deidentified data does not meet the definition of human subject's research requiring Institutional Review Board review.

Results

Compared to adolescents with only one vaccinating healthcare provider, adolescents with two or more providers were less likely to initiate HPV vaccination (67% versus 63%) and less likely to be up to date for the full vaccine series (54% versus 46%) (Table 1 and Figure 1). Adolescents who exclusively received vaccinations in public health facilities had lower vaccination coverage (64% initiation, 46% completion) than those receiving vaccination exclusively in private facilities (66% initiation, 52% completion) or hospital settings (69% initiation, 55% completion) (Table 1 and Figure 2).

These differences are compounded when considering number of providers and type of facility together. While adolescents with only one provider receiving vaccines in hospital settings had the highest initiation and completion (71% and 59%, respectively), adolescents with two or more providers receiving vaccines at this same facility type were less likely to have initiated or completed the series (65% and 49%, respectively) (Figure 3). Although private facilities are seeing the largest proportion of adolescents, 55% of those with a single provider and 38% of adolescents with multiple providers, private facilities do not maintain the highest vaccination rates. The "other" facility category which represents military hospitals, school clinics, etc. makes up the smallest proportion of the study population but has the largest decrease in both initiation and completion (14% and 18%, respectively) with two or more providers (Appendix 2).

Among adolescents with two or more providers, the mixed facility category begins to make up a large proportion of the population (27%) (Figure 4B). Each facility type appears to have a similar initiation and completion coverage among adolescents with a single provider (e.g. private – 67%, public – 67%) however, when an additional provider(s) is added, the completion rate begins to fall behind rapidly (private – 58%, public – 38%).

In multivariable regression modeling, having a provider recommendation and being Hispanic were significantly positively associated with both HPV vaccine initiation and completion, while number of providers and income to poverty ratio were negatively associated with HPV vaccine uptake (Table 2). For HPV vaccine initiation specifically, having received care at a hospital and having a well child visit were both significantly positively associated, while being uninsured had a significant negative association (Table 2). Additionally, being on Medicaid and being non-white were significantly positively associated with HPV vaccine series completion (Table 2). The interaction term between facility type and number of providers resulted in a non-significant result indicating that the effect of the number of providers on immunization coverage is not significantly different among the various facility types.

Poverty Status

Those who live below the federal poverty level have higher HPV immunization initiation proportions compared to those living at or above the federal poverty level (73% vs 62%) and fall above the national average (68%) (Table 2). Those who fall below the federal poverty level but received vaccinations from multiple providers have similar completion rates to those living at or above the federal poverty level with a single provider (Figure 5). Among adolescents living at or above the federal poverty level who saw their one provider at a hospital, there was a 5% drop in the initiation percentage and an 8% drop in completion compared to those who live below the federal poverty level seen at the same facility type (Figure 6A/B). Furthermore, 23% of adolescents living below the federal poverty level with two or more providers were seen at a public facility compared to only 9% of those living at or above the federal poverty level (Figure 6C/D). A similar pattern is seen among those with a single provider, where a larger percent of adolescents who live below the federal poverty level were seen at public facilities compared to

those living at or above the federal poverty level (Figure 6A/B). Among adolescents living below the federal poverty level with multiple providers, most facility types have around the same initiation rates, however completion varies considerably with the highest rates among mixed facilities (59%) and lowest rates among other facilities (34%) (Figure 6D).

Well-Child Visit

Overall, 80% of the adolescent population had a well-child visit at 11-12 years of age (Appendix 4). HPV immunization series completion rates, among those with a single provider, decrease for every facility type when the adolescent lacks a well-child visit (Figure 8A/B). HPV immunization initiation rates among those with a single provider and no well-child visit varied with private, hospital, and mixed facilities having a decrease in coverage, while public, unknown and other facility types showed an increase in coverage, compared to those with a well-child visit (Figure 8A/B). Additionally, 21% of adolescents with multiple providers and no well-child visit were seen at a public facility while only 11% of those with a well-child visit and multiple providers were seen at the same facility type (Appendix 4). A similar pattern was seen among those with a single provider where the proportion seen at public facilities is larger among those who did not have a well-child visit (Figure 8B/D).

Provider Recommendation

Overall, parents and guardians of 71.4% of adolescents indicated that they received a provider recommendation for the HPV vaccine. There is a large difference in vaccine uptake with a provider recommendation compared to those without the recommendation. Among those seen in private facilities, there is an average 34% decrease in both initiation and series completion coverage without a provider recommendation (Figure 9). The proportion of the population seen at public facilities is larger among those without a provider recommendation

compared to those with a provider recommendation for adolescents seen by a single provider (21% vs 13%) and those seen by two or more providers (18% vs 10%) (Figure 10B/D). Among those seen by a single provider, the lack of provider recommendation negatively affects both the completion and initiation coverage in addition to exacerbating the variation between the facility types (Fig. 10A/B). Among adolescents with multiple providers lacking a provider recommendation, other than at hospital facilities, there is a similar drop in completion coverage for all facility types and initiation appears to decrease to around 38% (Fig. 10D).

Insurance Status

Adolescents seen at private facilities with private, other, or Medicaid forms of insurance have fairly consistent HPV vaccine uptake. Those without insurance, however, saw a decrease in initiation coverage by around 23% (Figure 12D/H). There is an increase in the variability of vaccine coverage among each of the insurance categories when comparing those with a single provider to those with multiple providers (Figure 12). The proportion of the population seen at public facilities is larger among those with Medicaid or those who are uninsured compared to those with private or other forms of insurance.

Race/Ethnicity

Hispanic adolescents have the highest HPV vaccine coverage rates compared to the other race and ethnicities, while Non-Hispanic Whites have some of the lowest coverage percentages (Figure 13). Among Hispanic and Non-Hispanic white adolescents, those seen at private facilities make up the largest proportion of their populations. There is a large decrease in completion coverage among Non-Hispanic whites seen at these private facilities however, with a 7% drop among those with a single provider and a 4% drop among those with multiple providers

(Figure 14). Non-Hispanic Other/Multi-race adolescents also tend have lower completion coverage than Non-Hispanic Blacks although their initiation is around the same (Figure 14).

Discussion

Our findings of lower HPV vaccine series initiation and completion for adolescents with more than one vaccinating healthcare provider compared to those with only one provider, and compounded differences by healthcare facility type, support the need for better coordination of adolescent health care to improve HPV vaccine coverage.

The American Academy of Pediatrics has recommended the use of a medical home to improve health outcomes for youth. They say that a medical home should be accessible, continuous, comprehensive, family-centered, coordinate, compassionate and culturally effective (33). These medical homes have several components including having a usual source of care, a personal physician, receiving all needed referrals for specialty care, receiving help as needed in coordinating health and health related care and receiving family centered care (34). Our findings emphasize the importance of the first two components; a usual source of care and a personal physician. Adolescents with two or more providers were less likely to initiate (7% absolute reduction) or complete (10% absolute reduction) HPV vaccination compared to adolescents with one provider. In addition to our findings, other studies have shown adolescents with a medical home have greater overall likelihood of receiving preventive care, including the HPV vaccine (35). They are also more likely to have all of their medical needs met (34). However, in 2016, a study using the National Survey of Children's Health, reported that only 50% of children reported to have access to a medical home (36). Our research and that of many others underscore the importance of this type of coordinated, comprehensive care offered via a medical home and highlights specific populations who may not have access to this type of care leading to lower vaccination coverage.

Additionally, throughout our research we saw the importance of preventive care visits as a means of not only improving vaccine uptake but also the general health of adolescents. The importance of a well-child visit and other preventive care visits on immunization coverage has been shown in several studies, including one in France where they saw a 2% absolute increase in likelihood of completing the HPV vaccine series with every preventive care visit noted in the medical record (18). Our research exposed several potential target areas for improvement and intervention especially among those seen at public clinics, who throughout our study had some of the lowest vaccine coverage but represent a large proportion of the population. Public facilities act as a safety net for disadvantaged populations including those lacking private insurance or a stable medical home. Our results highlight the negative impact, especially on HPV vaccine series completion, of multiple providers and public forms of insurance. These adolescents, who lack a medical home, may only be going to the doctor for acute health problems which may stop the physician from discussing or providing the vaccine (32). Some providers may believe that immunizing during an acute visit will reduce attendance at subsequent preventive care visits (37). Providers may also be limited by time constraint pressure put on by the facility type which causes hesitancy for fear of push back or extensive questions from the parents surrounding the vaccine (24). Finding ways to improve access and use of preventive care visits, especially among these populations, is an important step in improving HPV immunization coverage.

To ensure access to routine immunization for all adolescents in the US, especially those who lack a medical home and see multiple providers for their care, special attention must be paid to finding ways to vaccinate at every opportunity. This could include encouraging provider recommendation for the vaccine, building upon the Vaccines for Children program and

improving utilization of Immunization Information Systems (IIS) to coordinate care and awareness of vaccination needs between different health systems and providers.

Provider recommendation has been repeatedly observed to significantly impact a parents' decision to vaccinate their child. Our results draw a similar conclusion, where the addition of providers and lack of recommendation had a negative impact on an adolescents' vaccine uptake. In another study looking at data over the course of 4 years, over 60% of adolescents who did not receive the HPV vaccine reported not receiving a recommendation from their provider (23).

The Vaccines for Children (VFC) program was established in 1993 as a way to eliminate cost as a barrier to recommended vaccinations, especially among minority and poor youth (30). An evaluation of the VFC program showed vaccine coverage for the HPV vaccine series was approximately equivalent between eligible VFC adolescents and non-eligible adolescents (46.6% and 43.2%, respectively (30). The VFC program has proven effective in eliminating the disparities in immunization coverage, particularly those due to poverty status and insurance coverage. Several studies have attributed higher HPV vaccine coverage among those living in areas with high levels of poverty, to the VFC program (38). This is further evidenced by our study which saw higher vaccine series initiation and completion among those living below the federal poverty level compared to those living at or above the federal poverty level.

Our results highlight the need for active communication and coordination among health systems and providers, as those with an increased number of providers or those seen at specific types of facilities, saw lower vaccine uptake. Immunization Information Systems have the ability to hold immunization data across various providers and health systems over time (39). These systems offer comprehensive vaccination histories plus strategies for informatics such as assessment reports, client follow-up reminders, vaccine ordering capability, and can help inform

clinical decisions (31). It also allows for bidirectional data exchange where providers can submit their immunization data directly from the electronic medical records and request/receive immunization history from IIS that can be added to their patient's medical record but recent evaluations of IIS have shown that providers and health systems are not using IIS to its full potential (40). This type of bidirectional data exchange system and its associated resources, if used effectively, could allow for coordinated care specifically targeting those with multiple providers and mixed facilities types who have lower vaccine coverage rates.

The NIS-Teen is a nationally representative sample used each year by the CDC to estimate vaccination coverage. It is weighted to represent the entire US population and provides valuable demographic information to help understand barriers to vaccination. There are some limitations to this dataset however, including certain participant exclusions. The facility type variable was only provided by the medical providers who responded to the request for confirmation of the adolescent's immunization history, after permission was granted by the parent of the subject. This restriction to those with provider confirmed information removed approximately half of all subjects interviewed. On one hand, these exclusions could have biased the results toward higher vaccination coverage because parents who gave permission may be more closely engaged in the health care of their adolescent. On the other hand, restricting the dataset in this way also ensures data validity beyond participant recall by following up with providers to confirm an adolescent's vaccination history. Furthermore, there was a small population of adolescents who were seen at multiple facility types but only saw a single provider, which may call into question some of the accuracy of the information related to reporting of number of providers and types of providers. Additionally, several key variables were based on self-reporting by the survey participant which could lead to recall bias. Finally, although it is a

nationally representative sample, NIS-Teen has a low overall response rate which could potentially limit the generalizability of the study's findings (41).

Our results underscore the importance of the medical home, with a usual source of care and personal physician. They also emphasize the need to ensure that every adolescent, especially those without a medical home, has access to preventive care services with effective data sharing. A focus on targeted interventions in these areas could make a significant difference in improving the HPV vaccination coverage rate across the US. If we can improve HPV vaccination coverage, especially in at-risk populations, with targeted health system, facility, and provider level interventions, we can decrease the burden caused by HPV infection and HPV related cancers across the United States.

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Tables and Figures

Table 1. *Demographics of the sample survey population using unweighted and weighted analysis, 2017 NIS-Teen public use dataset from the US Centers for Disease Control and Prevention.*

Demographics	Population				HPV Vaccine Initiation				HPV Vaccine Series Completion			
	Unweighted		Weighted		Unweighted		Weighted		Unweighted		Weighted	
Variable - Values	Num. within Sample	% of Total Sample	% of Total	Std. Error	Num. within Sample	% within each Value	% within each Value	Std. Error	Num. within Sample	% within each Value	% within each Value	Std. Error
Age												
13	4283	20.4	20.1	0.5	2630	61.4	60.7	1.4	1717	43.1	41.5	1.5
14	4429	21.1	19.7	0.5	2880	65.0	35.1	1.3	2111	50.4	50.9	1.5
15	4212	20.1	21.0	0.6	2849	67.6	66.5	1.4	2201	54.5	52.9	1.5
16	4218	20.1	20.8	0.5	2851	67.6	67.3	1.3	2266	55.5	54.2	1.5
17	3807	18.2	18.5	0.5	2583	67.9	68.1	1.3	2038	55.1	53.7	1.5
Facility Type												
All Public	2821	13.6	14.4	0.5	1814	64.3	64.3	1.7	1274	47.0	46.2	1.9
All Hospital	2270	10.9	8.8	0.3	1628	71.7	69.4	1.9	1248	58.3	55.9	2.0
All Private	9495	45.6	48.1	0.4	6381	67.2	66.4	0.9	4878	53.9	52.0	1.0
All Other	630	3.0	31.8	0.3	353	56.0	34.7	3.5	237	39.4	43.7	4.2
Mixed	3681	17.7	15.7	0.5	2414	65.6	66.8	1.4	1821	51.6	53.0	1.6
Unknown	1911	9.2	9.8	0.4	1203	63.0	60.9	2.2	875	47.7	46.6	2.4
Income to Poverty Ratio												
Above Poverty	16591	79.2	73.1	0.6	10619	64.0	62.8	0.7	7941	50.1	48.7	0.8
Below Poverty	3579	17.1	20.5	0.6	2644	73.9	73.3	1.3	1982	57.9	56.1	1.6
Unknown	779	3.7	6.4	0.4	530	68.0	72.1	2.4	410	55.7	56.3	3.2
Insurance Status												
Private Insurance Only	11919	56.9	50.5	0.7	7621	63.9	62.5	0.8	5727	50.6	49.0	0.9
Any Medicaid	6504	31.1	37.5	0.7	4618	71.0	71.3	1.0	3509	56.1	55.3	1.2
Other Insurance	1708	8.2	7.6	0.3	1086	63.6	62.0	2.1	794	48.3	48.5	2.2
Uninsured	818	3.9	4.4	0.3	468	57.2	57.5	2.9	303	39.0	35.5	2.8
Number of Providers												
0	66	0.3	0.1	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
1	10959	52.3	55.4	0.7	7566	69.0	67.7	0.8	5760	55.1	54.3	0.9
2+	9924	47.4	44.5	0.7	6227	62.8	63.0	0.9	4573	48.2	46.4	1.0
Race/Ethnicity												
Hispanic	3882	18.5	23.7	0.6	2885	74.3	74.5	1.4	2222	59.4	58.1	1.7
Non-Hispanic White	13011	62.1	52.3	0.6	8115	62.4	60.0	0.7	6024	48.7	46.8	0.8
Non-Hispanic Black	1742	8.3	13.8	0.5	1251	71.8	70.0	1.8	915	54.9	52.2	2.0
Non-Hispanic Other + Multiple Races	2314	11.1	10.2	0.4	1542	66.6	66.9	1.8	1172	52.9	51.3	2.0

Provider Recommendation												
Yes	14906	72.4	69.3	0.6	11160	74.9	73.2	0.7	8530	60.3	58.4	0.8
No	4294	20.9	22.7	0.6	1674	39.0	44.1	1.5	1104	26.4	29.9	1.5
Unknown	1392	6.8	8.0	0.4	825	59.3	63.3	2.3	601	44.9	47.6	2.6
Refused	1	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
Sex												
Male	11104	53.0	51.0	0.7	6981	62.9	62.6	0.8	5038	47.7	46.4	0.9
Female	9845	47.0	49.0	0.7	6812	69.2	68.6	0.9	5295	56.1	55.2	1.0
Well-Child Visit												
Yes	16805	92.1	91.3	0.4	11571	68.9	67.9	0.7	8957	55.8	54.6	0.8
No	836	4.6	4.7	0.3	454	54.3	61.2	3.1	259	33.3	35.4	3.5
Unknown	603	3.3	4.0	0.3	366	60.7	62.2	3.2	258	45.4	47.6	3.6
Refused	3	0.0	0.0	0.0	1	33.3	40.9	31.1	0	0.0	0.0	0.0

Table 2. *Linear regression results for the association between number of providers and facility type to HPV vaccination initiation and completion with several potential confounders*

Estimated Regression Coefficients	**Initiation**				**Completion**			
Parameter	**Estimate**	**Standard Error**	**t Value**	**Pr > |t|**	**Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	0.2416	0.0442	5.47	<.0001	0.4507	0.0441	10.22	<.0001
All Public	-0.0398	0.0256	-1.55	0.1202	-0.0358	0.0234	-1.53	0.1262
All Hospital	0.0563	0.0242	2.33	0.0201*	0.0404	0.0222	1.82	0.0692
All Other	-0.1027	0.0642	-1.6	0.1098	-0.0289	0.0495	-0.58	0.5588
Mixed	0.0335	0.0227	1.47	0.1413	0.0012	0.0207	0.06	0.9535
Unknown	-0.0441	0.0305	-1.44	0.1487	-0.0548	0.0283	-1.94	0.0525
Number of Providers	-0.0829	0.0170	-4.89	<.0001*	-0.0354	0.0154	-2.3	0.0212*
Well Child Visit	0.1224	0.0349	3.51	0.0004*	0.0275	0.0349	0.79	0.4303
Provider Recommendation	0.2938	0.0192	15.32	<.0001*	0.3052	0.0183	16.68	<.0001*
Income to Poverty	-0.0584	0.0232	-2.52	0.0118*	-0.0801	0.0210	-3.82	0.0001*
Any Medicaid	0.0387	0.0205	1.88	0.0595	0.0452	0.0185	2.45	0.0145*
Other Insurance	0.0136	0.0294	0.46	0.6434	-0.0212	0.0275	-0.77	0.4406
Uninsured	-0.0872	0.0391	-2.23	0.0257*	-0.0282	0.0416	-0.68	0.4978
Hispanic	0.1039	0.0253	4.11	<.0001*	0.1177	0.0209	5.62	<.0001*
Non-Hispanic Black	0.0355	0.0243	1.46	0.1443	0.0667	0.0228	2.92	0.0035*
Non-Hispanic Other + Multiple Races	0.0348	0.0252	1.38	0.1675	0.0586	0.0238	2.46	0.0139*

*indicates statistically significant results

Figure 1. *Weighted HPV vaccination coverage for initiation and completion by number of providers*

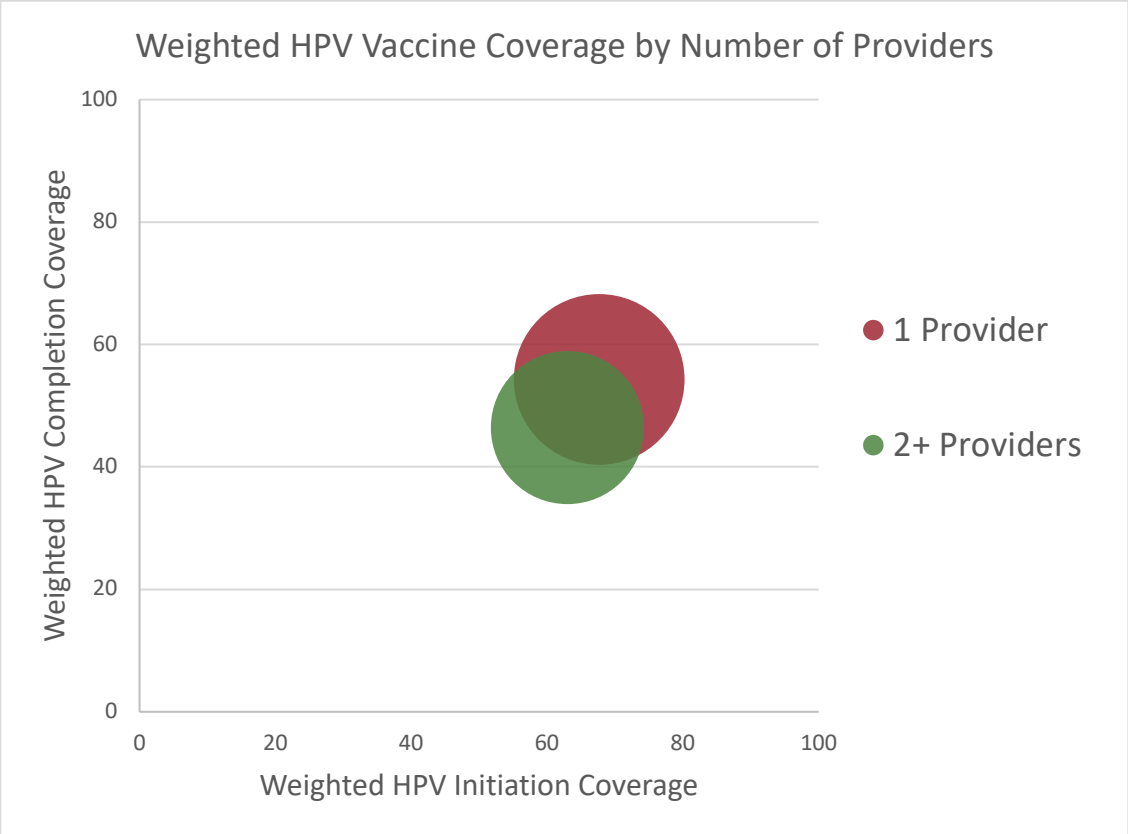


Figure 2. *Weighted HPV vaccination coverage for initiation and completion by facility type*

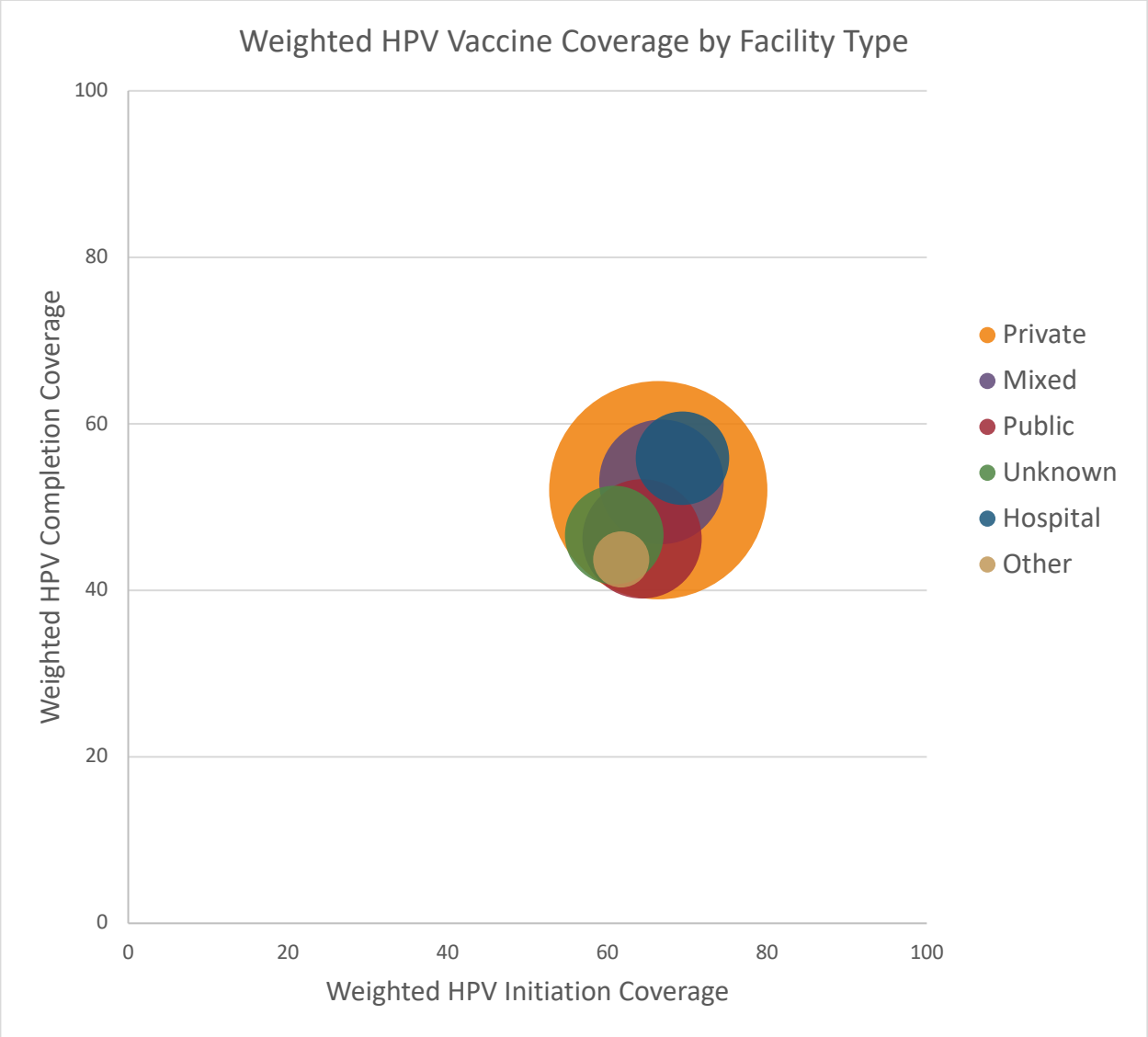


Figure 3. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers*

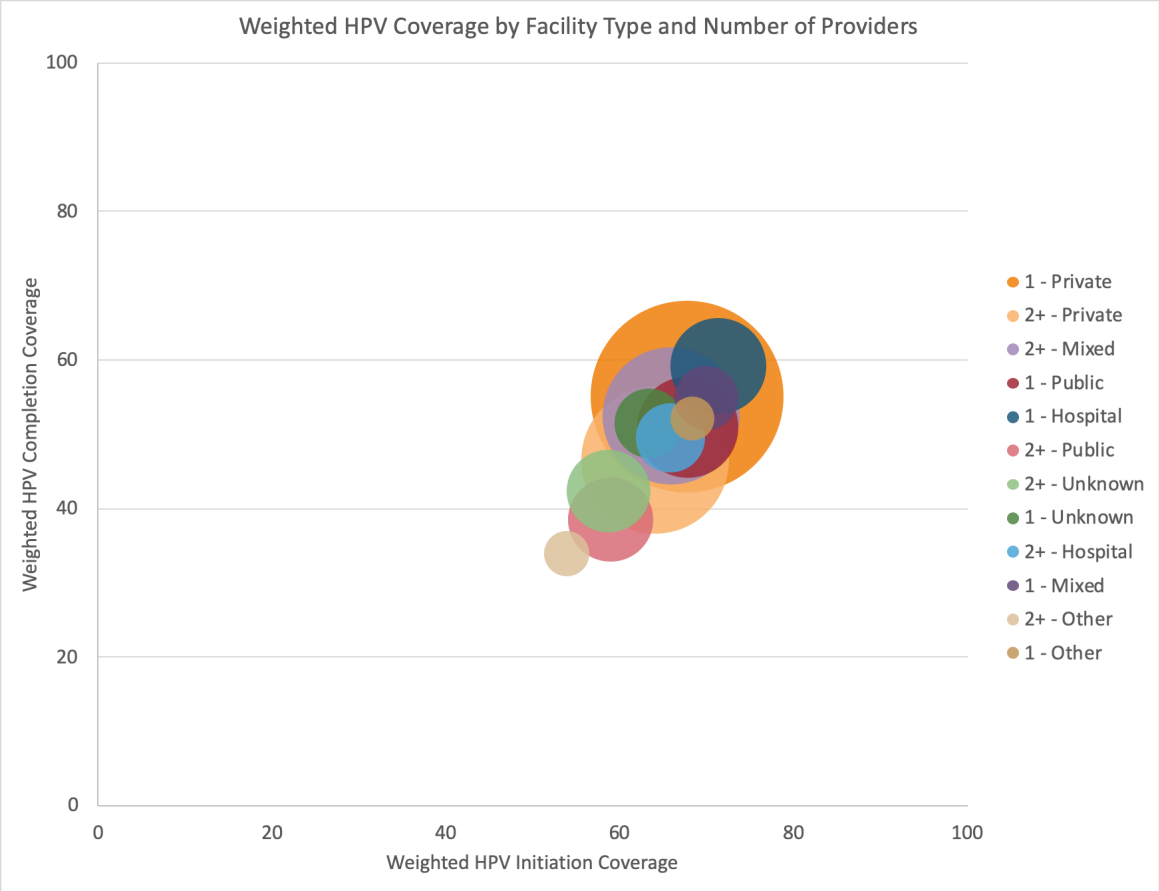


Figure 4. *Weighted HPV vaccination coverage for initiation and completion by facility type stratified by the number of providers. Figure 4A shows weighted results for those with a single provider. Figure 4B shows weighted results for those with multiple providers.*

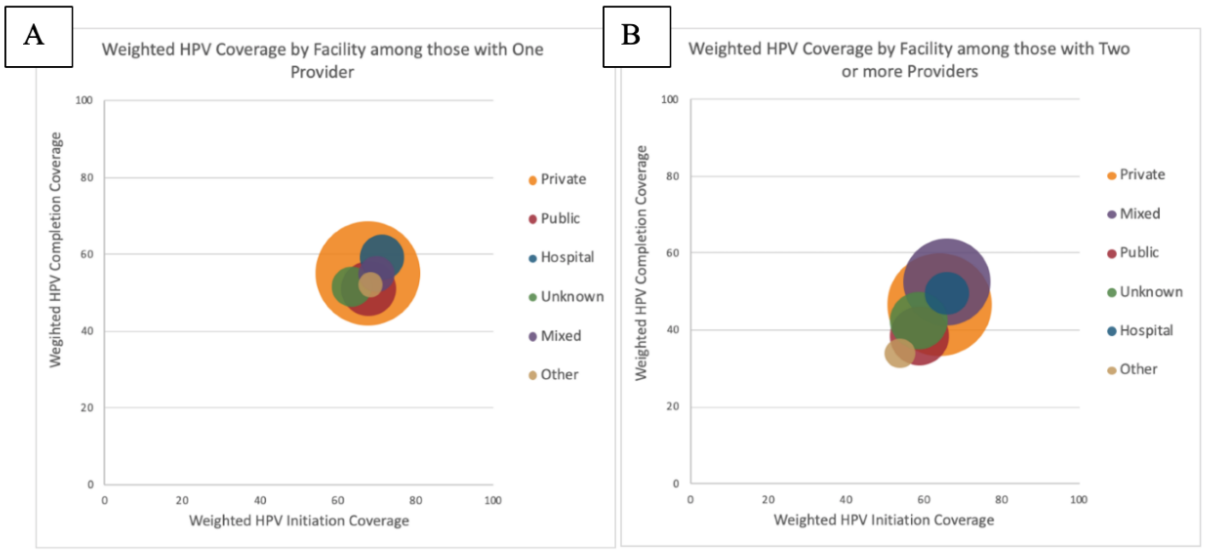


Figure 5. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by income to poverty ratio*

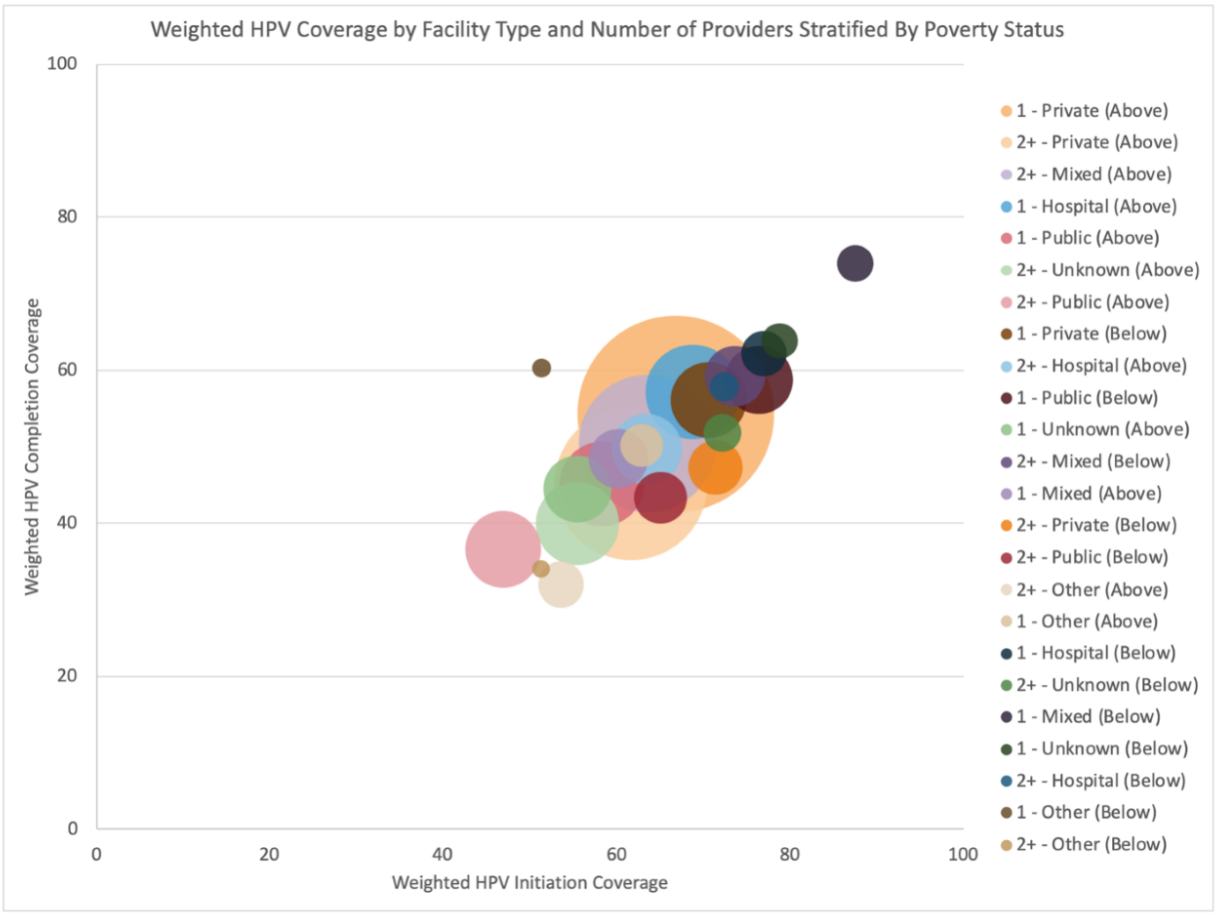


Figure 6. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by income to poverty status. Figure 6A shows weighted results for those with a single provider and identified as living at or above the federal poverty level. Figure 6B shows weighted results for those with a single provider and identified as living below the federal poverty level. Figure 6C shows weighted results for those with multiple providers and identified as living at or above the federal poverty level. Figure 6D shows weighted results for those with multiple providers and identified as living below the federal poverty level.*

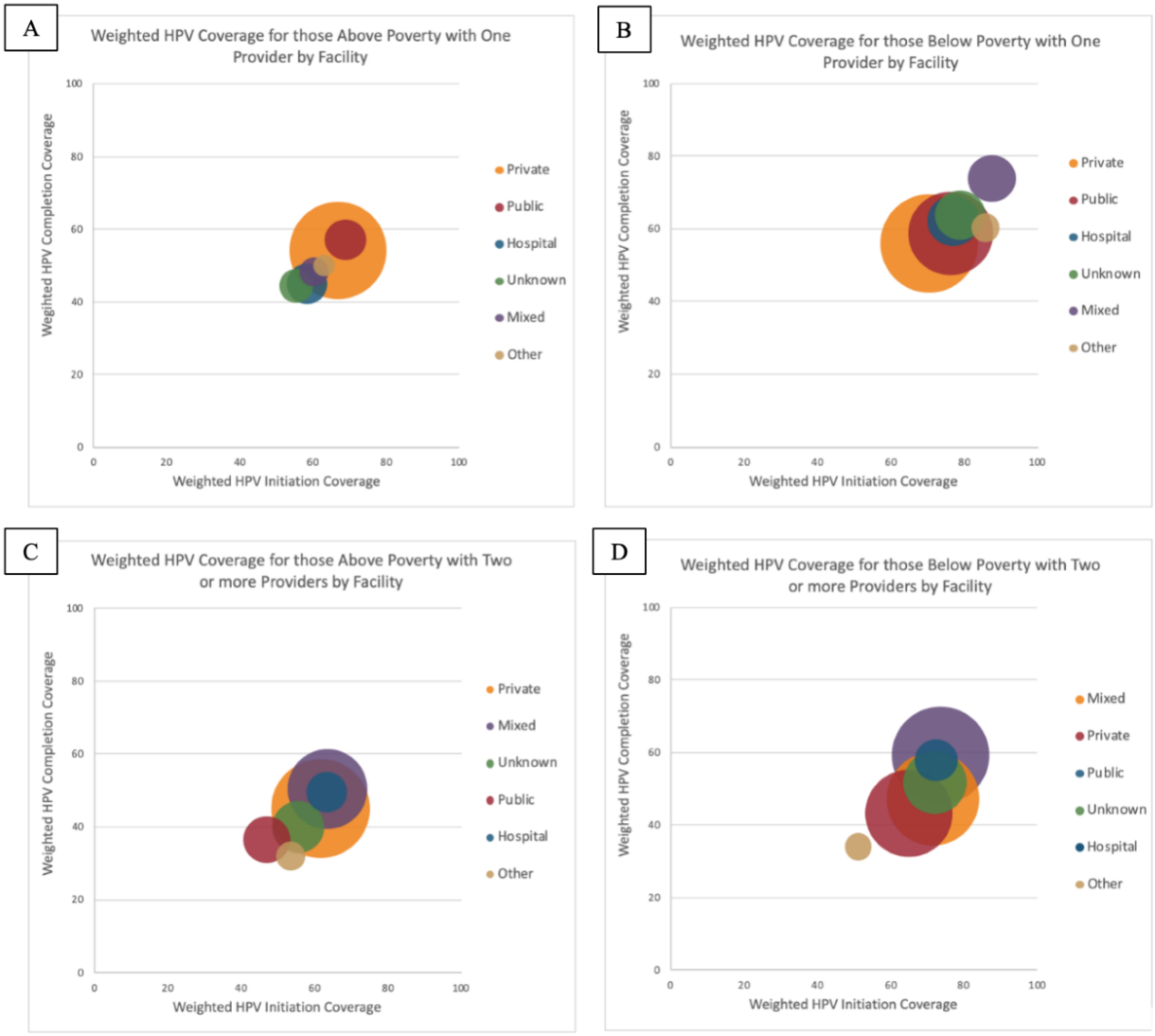


Figure 7. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by having or not having an 11-12-year-old well child visit*

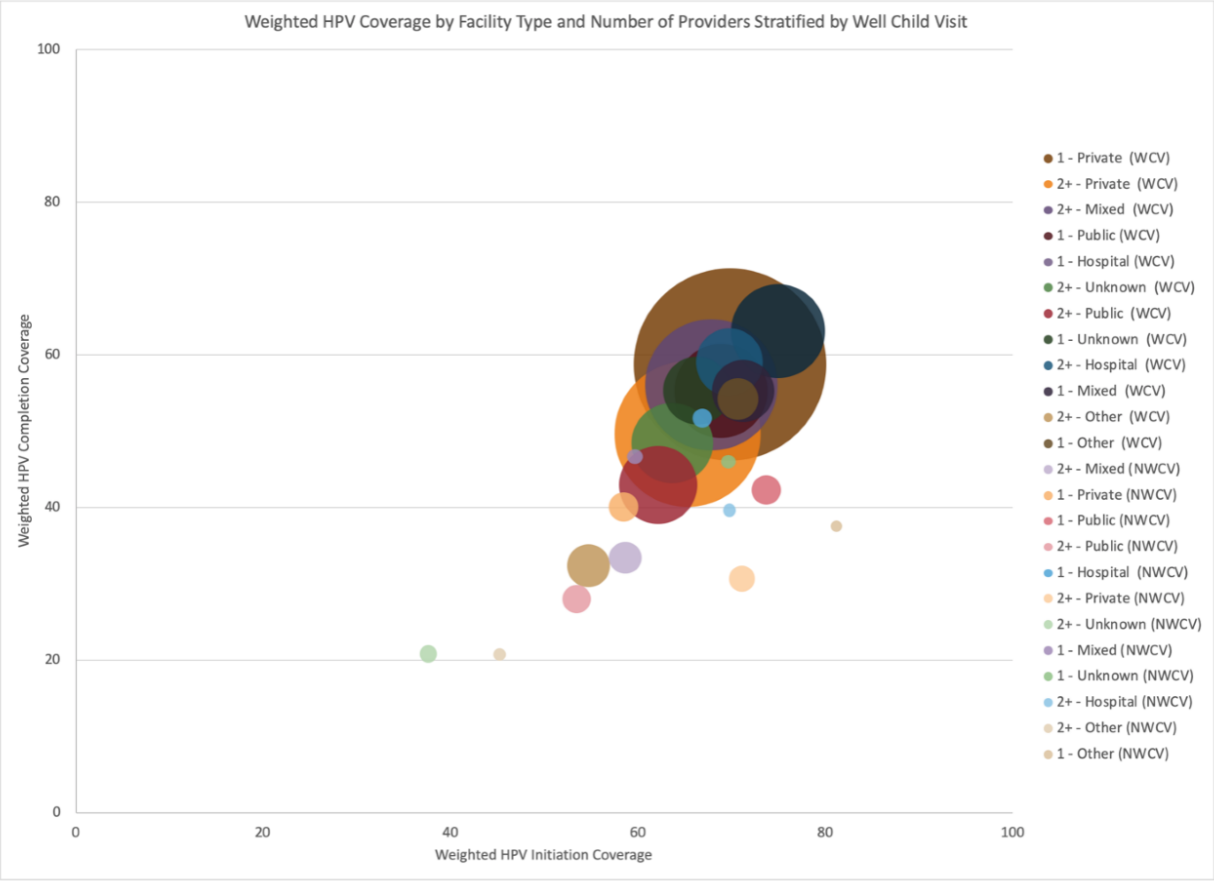


Figure 8. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by well-child visit. Figure 8A shows weighted results for those with a single provider and a well-child visit. Figure 8B shows weighted results for those with a single provider and no well-child visit. Figure 8C shows weighted results for those with multiple providers and a well-child visit. Figure 8D shows weighted results for those with multiple providers and no well-child visit.*

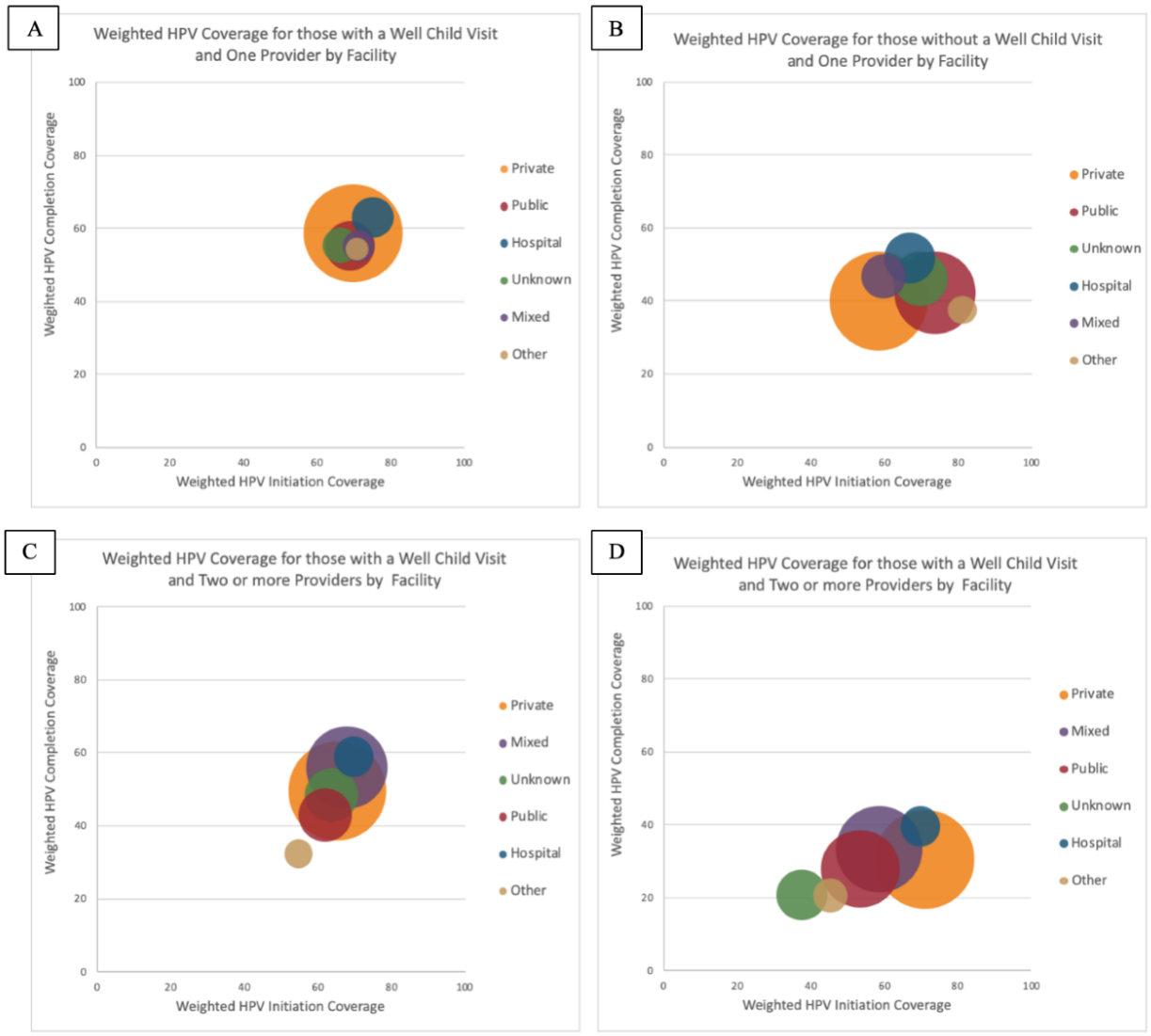


Figure 9. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by whether or not the adolescent received a provider recommendation.*

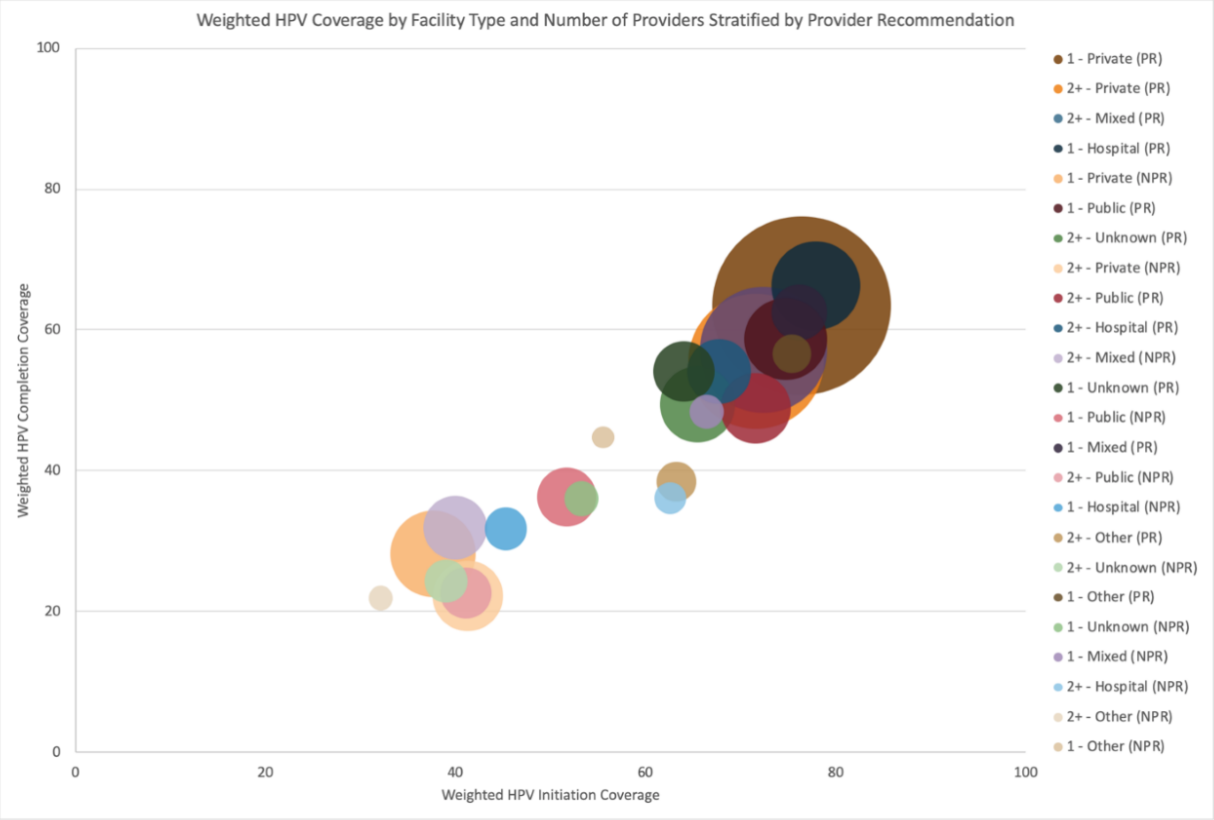


Figure 10. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by provider recommendation. Figure 10A shows weighted results for those with a single provider and a provider recommendation. Figure 10B shows weighted results for those with a single provider and no provider recommendation. Figure 10C shows weighted results for those with multiple providers and a provider recommendation. Figure108D shows weighted results for those with multiple providers and no provider recommendation.*

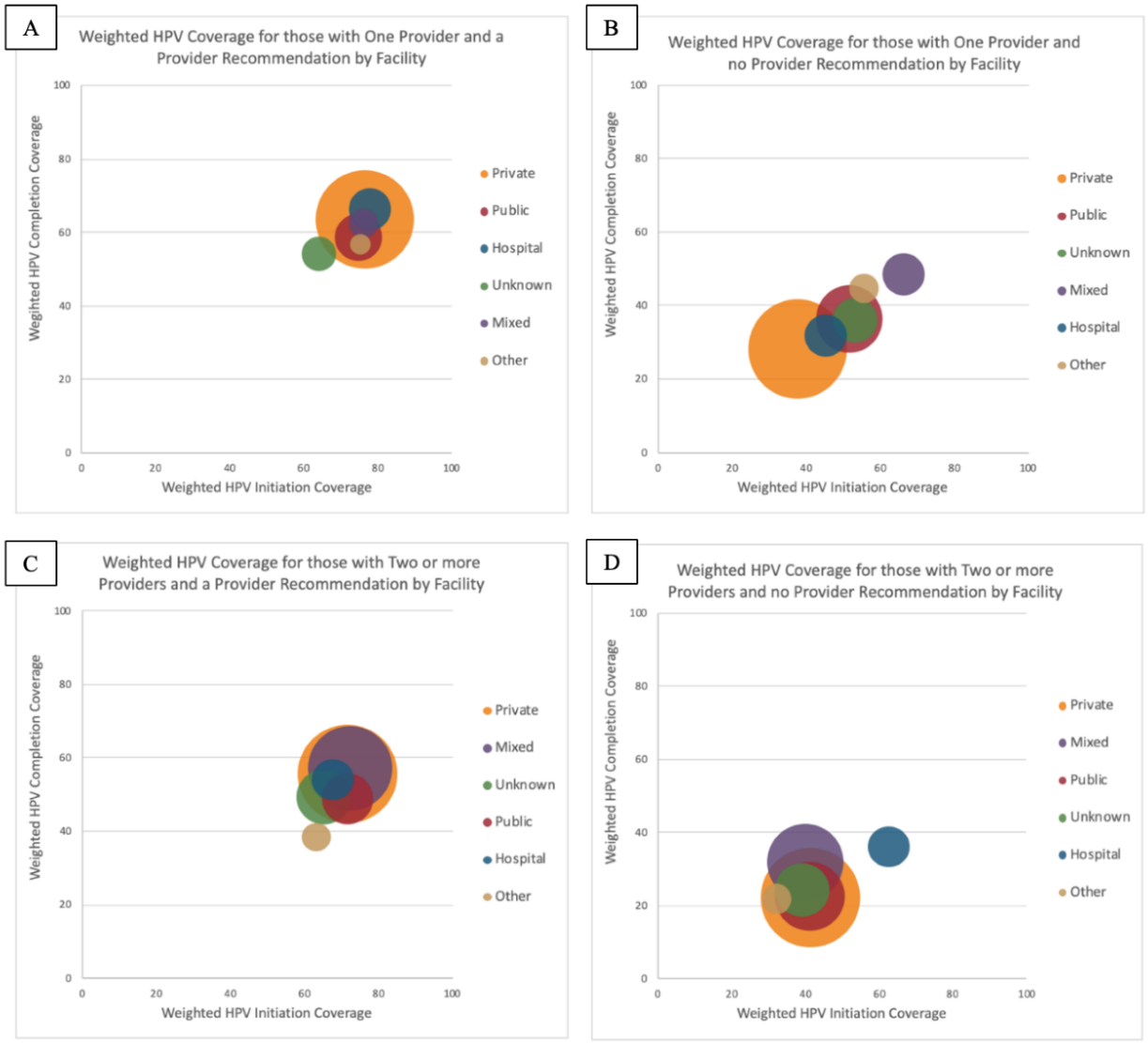


Figure 11. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by insurance status*

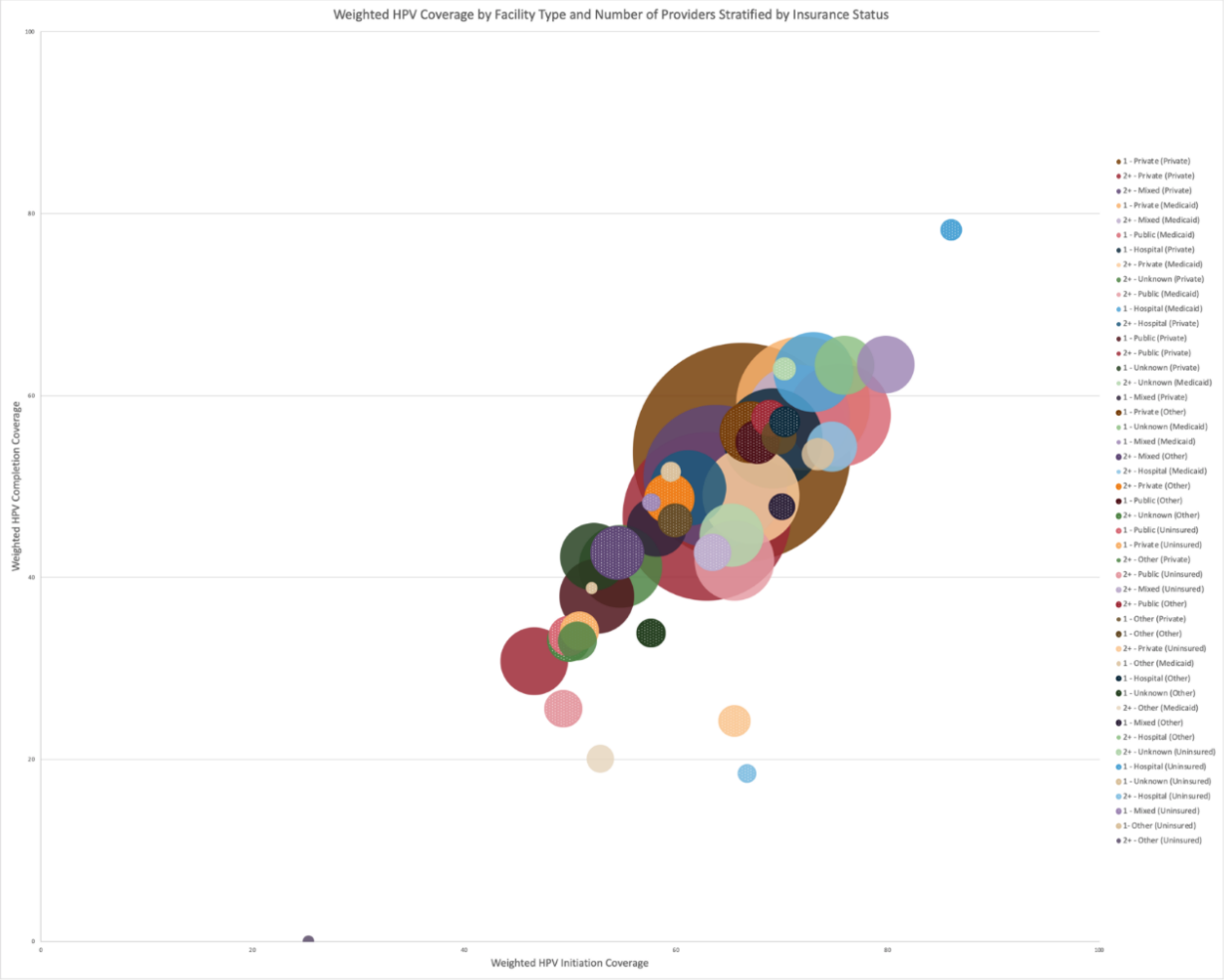


Figure 12. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by insurance status. Figure 12A shows weighted results for those with a single provider and private insurance. Figure 12B shows weighted results for those with a single provider and Medicaid. Figure 12C shows weighted results for those with a single provider and other forms of insurance. Figure 12D shows weighted results for those with a single provider and no insurance. Figure 12E shows weighted results for those with multiple providers and private insurance. Figure 12F shows weighted results for those with multiple providers and Medicaid. Figure 12G shows weighted results for those with multiple providers and other forms of insurance. Figure 12H shows weighted results for those with multiple providers and no insurance.*

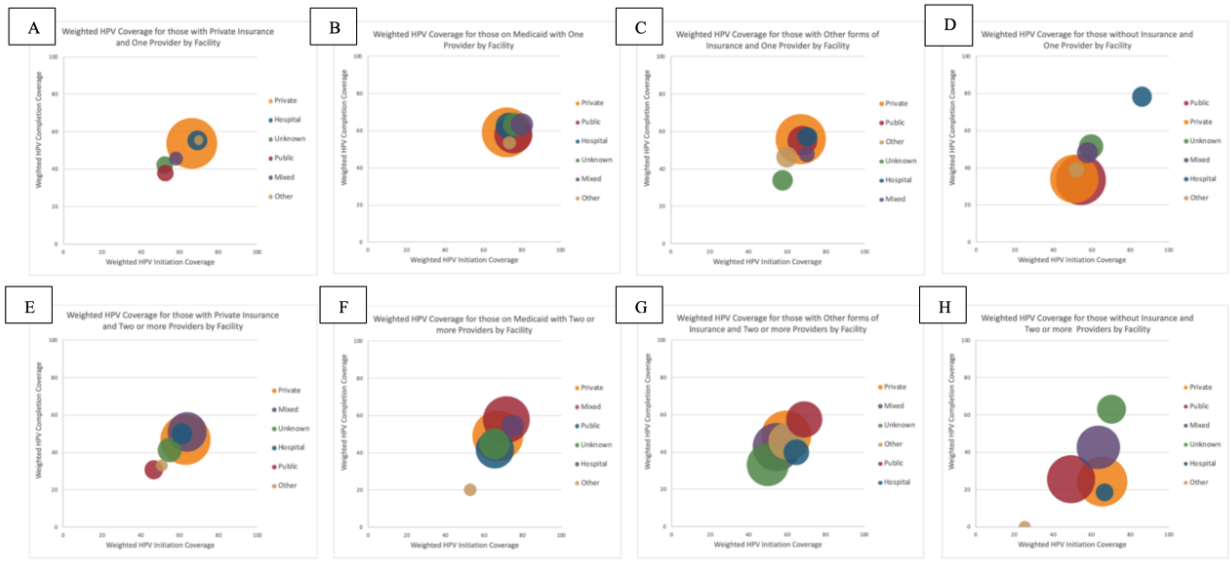


Figure 13. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by race and ethnicity*

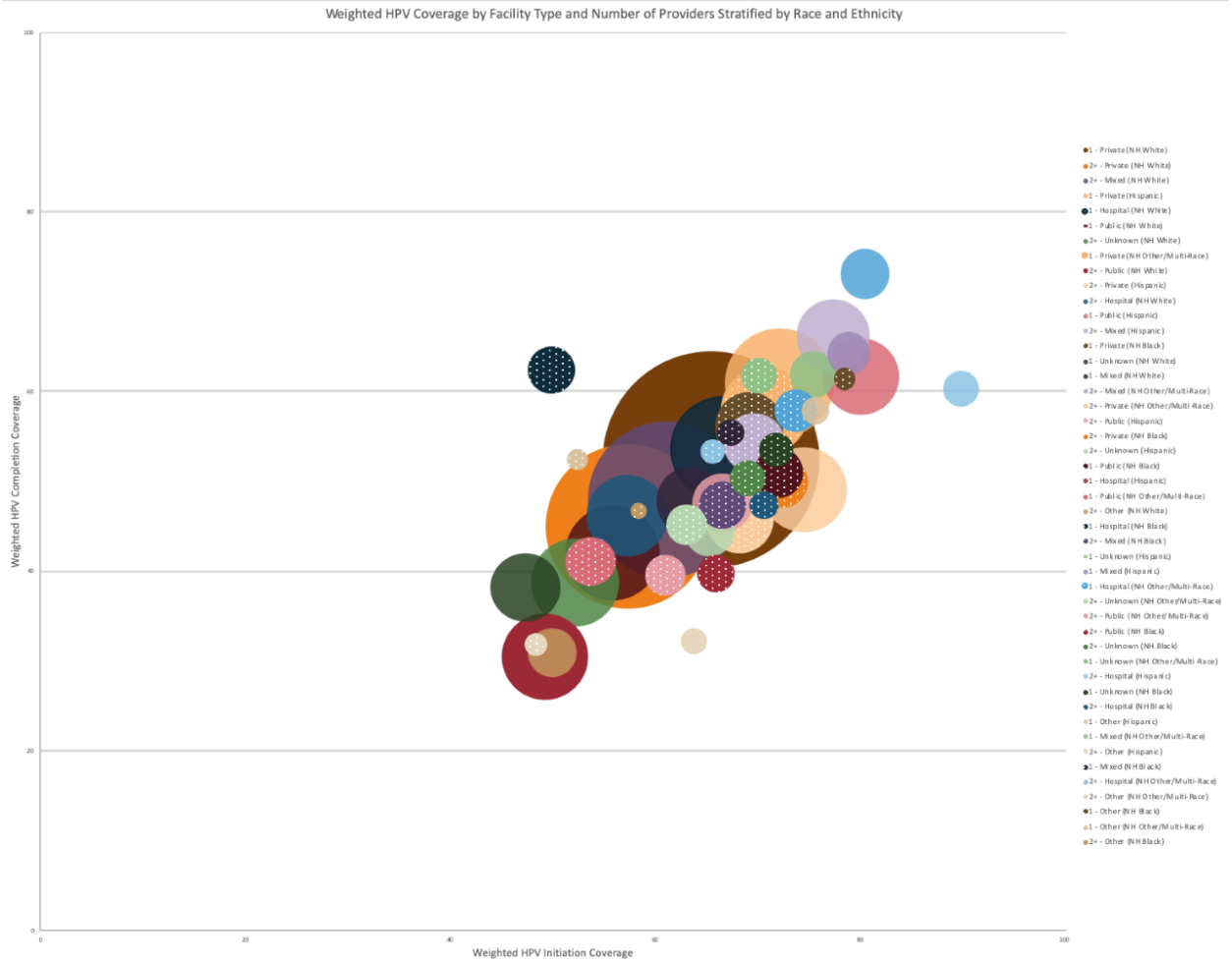
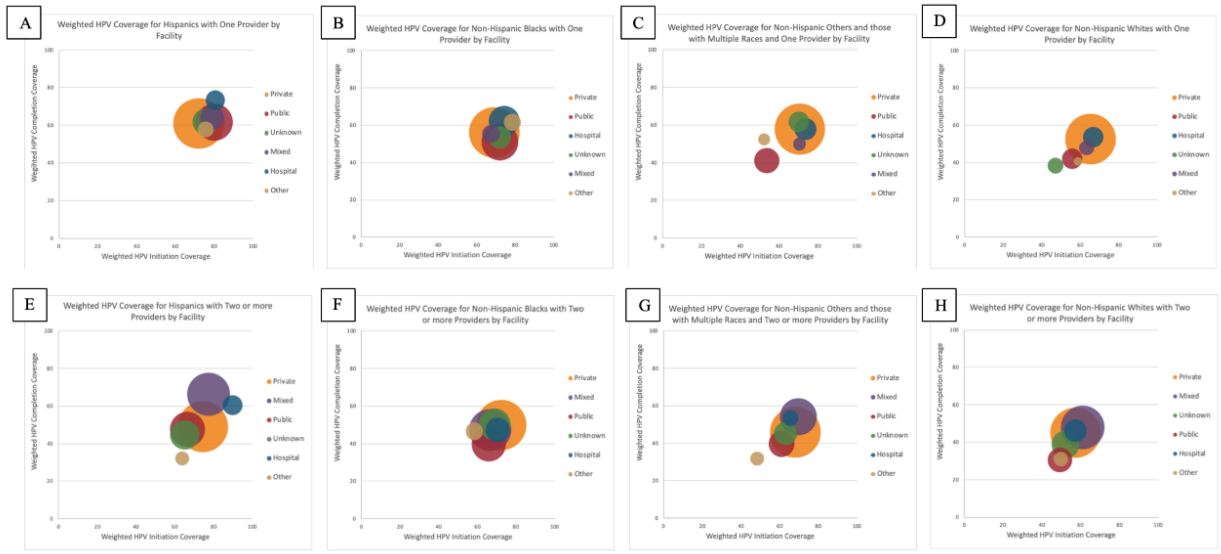


Figure 14. *Weighted HPV vaccination coverage for initiation and completion by facility type and number of providers stratified by race and ethnicity. Figure 14A shows weighted results for Hispanics with a single provider. Figure 14B shows weighted results for Non-Hispanic Blacks with a single provider. Figure 14C shows weighted results for Non-Hispanic Others or Multiple Races with a single provider. Figure 14D shows weighted results for Non-Hispanic Whites with a single provider. Figure 14E shows weighted results for Hispanics with multiple providers. Figure 14F shows weighted results for Non-Hispanic Blacks with multiple providers. Figure 14G shows weighted results for Non-Hispanic Others or Multiple Races with multiple providers. Figure 14H shows weighted results for Non-Hispanic Whites with multiple providers.*



CHAPTER III

PUBLIC HEALTH IMPLICATIONS &

POSSIBLE FUTURE DIRECTIONS

Public Health Implications

There are several important public health implications associated with this study, including the harmful effects associated with fragmented care. This research expresses the importance of consistent primary care teams and facility level programs to increase HPV immunization coverage. It underscores the importance of understanding the patient population seen at different facility types, as distinct groups of adolescents with different needs and resources. This understanding will help to better identify at-risk groups for targeted interventions to improve immunization coverage. This research also explores how facility level and provider level factors can significantly influence health outcomes. This work lays a foundation for future research and implementation programs targeted to improve population health.

The American Academy of Pediatrics has recommended the use of a medical home for youth across the US with coordinated, continuous, family-centered care (33). However, it is not always feasible for adolescents to receive care from a medical home and as this research suggests, focus needs to be paid to ensure these populations are not missed for intervention. Programs such as Vaccines for Children have proven effective in reducing some of the sociodemographic disparities seen in routine immunizations (30). Additionally, the use of a coordinated Immunization Information Systems that function across facility types and health systems can make a significant difference in improving the vaccine coverage for all adolescents.

By limiting the number of missed opportunities for intervention and vaccination, we can decrease the burden caused by HPV infection and HPV related cancers across the United States. With approximately 5% of all cancers being attributed to HPV (5) and an estimated 43,999 new cases of cancers caused by HPV each year in the US, there is no better time than now to address these staggering, and preventable numbers (3).

Possible Future Directions

Future research is needed to continually improve HPV vaccine uptake and target at-risk populations. Specifically, further research is need on the specifics of how immunizations are discussed within different types of appointments such as acute visits compared to preventive care visits. In addition, further research is needed on the type of care being received at various facility types to provide insight on possible targets for intervention. Additional research is needed to identify the at-risk populations, explore where they are being seen for their medical care and what improvements can be made to their care to ensure completion of the HPV vaccine series. Implementation science studies and evaluations should be completed to identify effective facility and provider level interventions to improve HPV vaccination coverage in the United States.

This study exposed the impacts of fragmented care on HPV immunization indicating a continual need for research surrounding how fragmented care affects other health outcomes. For example, another study could be completed comparing these factors of facility type and number of providers for other vaccines. Further, a study could compare HPV vaccination and other vaccines given at the same appointment, to see how facility type and number of providers affects a parent's decision to select one over the other.

CHAPTER IV

APPENDICES

Appendix 1. Table used for Figure 1 and 2

Variable	% of Population	% Initiated	% Completed
Number of Providers			
0 Providers	0.12	0	0
1 Provider	55.36	67.69	54.29
2+ Providers	44.52	63.01	46.43
Facility Type			
Public	14.38	64.34	46.18
Hospital	8.82	69.4	55.87
Private	48.12	66.37	52.03
Other	3.18	61.73	43.71
Mixed	15.68	66.77	53.03
Unknown	9.82	60.86	46.64

Appendix 2. Table used for Figure 3 and 4

# Providers/Facility Type	% of Population in each provider category	% Initiated	%Completed	% of Full Population
1 - Hospital	10.36	71.30	59.25	7.18
1 - Mixed	6.42	69.91	54.89	3.21
1 - Other	3.12	68.35	52.09	1.46
1 - Private	55.80	67.67	55.07	28.83
1 - Public	16.00	67.75	50.96	7.96
1 - Unknown	8.29	63.39	51.5	3.78
2+ - Hospital	6.90	65.88	49.53	3.73
2+ - Mixed	27.19	65.85	52.47	14.48
2+ - Other	3.24	53.82	33.95	1.57
2+ - Private	38.57	64.03	46.57	16.80
2+ - Public	12.37	58.88	38.5	5.60
2+ - Unknown	11.72	58.65	42.36	5.40

Appendix 3. Table used for Figure 5 and 6

Poverty Status	# Providers/Facility Type	% of Population by category	% Initiated	% Completed	% of Full Population
Above poverty	1 - Hospital	11.09	68.83	57.1	5.55
Above poverty	1 - Mixed	5.48	60.2	48.37	2.22
Above poverty	1 - Other	2.95	62.92	50.1	1.12
Above poverty	1 - Private	62.12	66.84	54.19	24.15
Above poverty	1 - Public	10.62	58.34	45.09	4.51
Above poverty	1 - Unknown	7.74	55.45	44.43	2.83
Above poverty	2+ - Hospital	7.12	63.51	49.6	3.08
Above poverty	2+ - Mixed	27.00	63.57	50.44	11.77
Above poverty	2+ - Other	3.49	53.61	31.93	1.32
Above poverty	2+ - Private	41.51	61.66	45.1	14.45
Above poverty	2+ - Public	9.43	46.91	36.53	3.65
Above poverty	2+ - Unknown	11.46	55.51	39.92	4.29
Below Poverty	1 - Hospital	10.37	77.03	62.18	1.29
Below Poverty	1 - Mixed	8.93	87.56	73.94	0.84
Below Poverty	1 - Other	3.20	85.74	60.31	0.22
Below Poverty	1 - Private	38.56	70.55	56.05	3.54
Below Poverty	1 - Public	28.68	76.42	58.72	2.93
Below Poverty	1 - Unknown	10.26	78.78	63.8	0.80
Below Poverty	2+ - Hospital	5.51	72.44	57.86	0.52
Below Poverty	2+ - Mixed	29.61	73.68	59.24	2.29
Below Poverty	2+ - Other	2.24	51.28	34	0.19
Below Poverty	2+ - Private	26.52	71.44	47.23	1.82
Below Poverty	2+ - Public	23.73	65.05	43.28	1.69
Below Poverty	2+ - Unknown	12.38	72.19	51.82	0.90
Unknown	1 - Hospital	7.75	80.93	75.44	0.31
Unknown	1 - Mixed	7.87	74.3	34.22	0.14
Unknown	1 - Other	4.60	65.12	49.59	0.08
Unknown	1 - Private	46.96	71.19	64.36	1.05
Unknown	1 - Public	25.25	78.05	49.3	0.50
Unknown	1 - Unknown	7.56	79.04	69.86	0.13
Unknown	2+ - Hospital	8.42	78.9	30.23	0.12
Unknown	2+ - Mixed	21.74	69.46	56.41	0.38
Unknown	2+ - Other	3.23	62.67	62.67	0.05
Unknown	2+ - Private	38.20	82.1	66.53	0.48
Unknown	2+ - Public	15.23	44.07	31.95	0.25
Unknown	2+ - Unknown	13.19	54.01	42.54	0.05

Appendix 4. Table used for Figure 7 and 8

Well child Visit	# Providers/Facility Type	% of Population by category	% Initiated	%Completed	% of Full Population
Yes	1 - Hospital	10.35	74.98	63.03	5.75
Yes	1 - Mixed	6.08	71.23	55.24	2.47
Yes	1 - Other	3.09	70.69	54.18	1.12
Yes	1 - Private	58.19	69.79	58.64	24.29
Yes	1 - Public	14.38	68.88	55.26	5.75
Yes	1 - Unknown	7.91	66.33	55.32	3.01
Yes	2+ - Hospital	6.65	69.75	59	2.98
Yes	2+ - Mixed	27.19	67.85	56.01	11.34
Yes	2+ - Other	3.22	54.69	32.36	1.21
Yes	2+ - Private	39.42	65.35	49.53	13.96
Yes	2+ - Public	11.73	62.13	42.92	4.01
Yes	2+ - Unknown	11.79	63.67	48.4	4.29
No	1 - Hospital	10.34	66.88	51.72	0.24
No	1 - Mixed	8.07	59.71	46.63	0.16
No	1 - Other	3.20	81.16	37.54	0.08
No	1 - Private	39.19	58.46	40.04	0.59
No	1 - Public	27.34	73.72	42.28	0.57
No	1 - Unknown	11.87	69.68	45.97	0.14
No	2+ - Hospital	5.52	69.76	39.6	0.11
No	2+ - Mixed	26.27	58.67	33.36	0.69
No	2+ - Other	4.25	45.25	20.65	0.10
No	2+ - Private	33.88	71.09	30.6	0.43
No	2+ - Public	21.09	53.42	28.02	0.52
No	2+ - Unknown	9.00	37.67	20.77	0.19
Unknown	1 - Hospital	9.46	72.19	59.6	0.23
Unknown	1 - Mixed	7.06	46.11	22.84	0.13
Unknown	1 - Other	4.50	76.18	71	0.05
Unknown	1 - Private	46.00	58.5	46.1	0.68
Unknown	1 - Public	21.35	66.59	51.47	0.34
Unknown	1 - Unknown	11.64	66.52	62.8	0.14
Unknown	2+ - Hospital	5.34	36.29	14.55	0.10
Unknown	2+ - Mixed	29.57	62.11	54.66	0.43
Unknown	2+ - Other	5.26	66.58	64.18	0.06
Unknown	2+ - Private	38.59	71.5	45.78	0.37
Unknown	2+ - Public	14.52	50.97	31.4	0.23
Unknown	2+ - Unknown	6.72	55.77	25.38	0.12

Appendix 5. Table used for Figure 9 and 10

Provider Recommendation	# Providers/Facility Type	% of Population by Category	% Initiated	% Completed	% of Full Population
Yes	1 - Hospital	10.81	77.93	66.3	5.33
Yes	1 - Mixed	5.60	76.09	62.53	2.09
Yes	1 - Other	2.65	75.36	56.63	0.99
Yes	1 - Private	60.02	76.42	63.45	21.62
Yes	1 - Public	13.42	74.66	58.71	4.64
Yes	1 - Unknown	7.50	63.96	54.11	2.53
Yes	2+ - Hospital	6.98	67.72	54.09	2.77
Yes	2+ - Mixed	28.74	72.37	57.19	10.88
Yes	2+ - Other	3.23	63.23	38.47	1.04
Yes	2+ - Private	38.82	71.64	55.58	12.35
Yes	2+ - Public	10.18	71.56	48.83	3.32
Yes	2+ - Unknown	12.06	65.41	49.4	3.85
No	1 - Hospital	8.49	45.26	31.77	1.22
No	1 - Mixed	8.64	66.36	48.36	0.80
No	1 - Other	4.17	55.5	44.72	0.33
No	1 - Private	47.27	37.6	28.19	4.95
No	1 - Public	21.94	51.69	36.3	2.34
No	1 - Unknown	9.49	53.22	36.06	0.83
No	2+ - Hospital	6.63	62.55	36.13	0.68
No	2+ - Mixed	22.68	39.95	31.94	2.74
No	2+ - Other	3.39	32.1	21.91	0.40
No	2+ - Private	37.36	41.3	22.21	3.33
No	2+ - Public	18.58	41.07	22.61	1.76
No	2+ - Unknown	11.36	38.99	24.32	1.21
Unknown	1 - Hospital	11.37	70.68	62.85	0.55
Unknown	1 - Mixed	6.68	49.25	38.07	0.26
Unknown	1 - Other	3.55	75.96	55.1	0.11
Unknown	1 - Private	46.99	56.55	42.85	1.92
Unknown	1 - Public	19.88	76.51	53.4	0.78
Unknown	1 - Unknown	11.53	78.03	67.59	0.36
Unknown	2+ - Hospital	6.95	65.71	53.84	0.25
Unknown	2+ - Mixed	27.99	69.56	63.01	0.72
Unknown	2+ - Other	2.96	35.07	33.53	0.11
Unknown	2+ - Private	41.94	61.67	37.26	0.94
Unknown	2+ - Public	10.63	48.51	35.4	0.40
Unknown	2+ - Unknown	9.53	44.61	11.86	0.28

Appendix 6. Table used for Figure 11 and 12

Insurance Status	# Providers/Facility Type	% of Population by Category	% Initiated	% Completed	% of Full Population
Any Medicaid	1 - Hospital	11.61	73	62.6	2.58
Any Medicaid	1 - Mixed	8.29	79.81	63.39	1.33
Any Medicaid	1 - Other	2.96	73.39	53.58	0.42
Any Medicaid	1 - Private	43.50	71.99	59.15	7.28
Any Medicaid	1 - Public	24.40	75.42	57.86	4.26
Any Medicaid	1 - Unknown	9.23	75.9	63.33	1.43
Any Medicaid	2+ - Hospital	6.27	74.69	54.41	1.03
Any Medicaid	2+ - Mixed	27.95	71.53	57.72	4.29
Any Medicaid	2+ - Other	2.09	52.84	20.08	0.31
Any Medicaid	2+ - Private	32.53	67.07	49.02	3.82
Any Medicaid	2+ - Public	18.85	65.53	41.86	2.58
Any Medicaid	2+ - Unknown	12.32	65.25	44.66	1.63
Other	1 - Hospital	7.71	70.28	57.1	0.38
Other	1 - Mixed	4.97	70.02	47.78	0.29
Other	1 - Other	9.09	59.91	46.27	0.47
Other	1 - Private	51.74	67.03	55.96	1.57
Other	1 - Public	17.94	67.71	54.91	0.77
Other	1 - Unknown	8.55	57.63	33.88	0.34
Other	2+ - Hospital	6.57	64.65	39.85	0.21
Other	2+ - Mixed	23.20	54.46	42.72	1.18
Other	2+ - Other	14.25	59.9	45.86	0.58
Other	2+ - Private	25.17	59.35	48.68	1.03
Other	2+ - Public	12.83	68.82	57.49	0.54
Other	2+ - Unknown	17.98	49.87	33.13	0.76
Private	1 - Hospital	10.07	69.15	55.3	4.01
Private	1 - Mixed	5.08	58.17	45.6	1.44
Private	1 - Other	2.38	69.73	55.49	0.51
Private	1 - Private	67.78	66.19	53.74	19.28
Private	1 - Public	7.24	52.5	37.92	2.25
Private	1 - Unknown	7.44	52.23	42.28	1.84
Private	2+ - Hospital	7.65	61.16	49.84	2.34
Private	2+ - Mixed	27.66	63.75	51.06	8.40
Private	2+ - Other	2.36	50.7	33.04	0.61
Private	2+ - Private	45.49	62.89	46.73	11.47
Private	2+ - Public	6.40	46.59	30.81	1.87
Private	2+ - Unknown	10.43	54.74	41.23	2.79
Uninsured	1 - Hospital	6.02	86	78.22	0.19

Uninsured	1 - Mixed	6.78	57.67	48.26	0.14
Uninsured	1 - Other	35.89	50.86	34.12	0.62
Uninsured	1 - Private	38.65	54.36	33.6	0.66
Uninsured	1 - Public	9.06	59.5	51.63	0.16
Uninsured	1 - Unknown	3.60	52.02	38.86	0.06
Uninsured	2+ - Hospital	4.09	66.68	18.47	0.14
Uninsured	2+ - Mixed	23.68	63.46	42.72	0.57
Uninsured	2+ - Other	1.93	25.3	0	0.05
Uninsured	2+ - Private	31.56	65.53	24.24	0.43
Uninsured	2+ - Public	28.31	49.36	25.58	0.58
Uninsured	2+ - Unknown	10.43	70.22	62.94	0.21

Appendix 7. Table used for Figure 13 and 14

Race/Ethnicity	# Providers/Facility Type	% of Population by Category	% Initiated	% Completed	% of Full Population
Hispanic	1 - Hospital	6.68	80.47	73.14	1.00
Hispanic	1 - Mixed	9.66	78.86	64.2	0.73
Hispanic	1 - Other	4.27	75.64	57.84	0.31
Hispanic	1 - Private	44.06	72.07	60.94	4.83
Hispanic	1 - Public	23.68	80.1	61.7	2.36
Hispanic	1 - Unknown	11.66	75.34	61.86	0.87
Hispanic	2+ - Hospital	5.61	89.82	60.33	0.48
Hispanic	2+ - Mixed	25.59	77.36	66.25	2.18
Hispanic	2+ - Other	2.8	63.77	32.18	0.29
Hispanic	2+ - Private	36.1	74.49	49.09	2.96
Hispanic	2+ - Public	17.74	66.56	47.64	1.41
Hispanic	2+ - Unknown	12.16	65.23	44.56	1.04
Non-Hispanic Black	1 - Hospital	15.59	74.27	62.38	0.92
Non-Hispanic Black	1 - Mixed	5.1	67.36	55.45	0.29
Non-Hispanic Black	1 - Other	4.94	78.42	61.4	0.19
Non-Hispanic Black	1 - Private	42.7	69.17	56.05	1.93
Non-Hispanic Black	1 - Public	22.8	72.01	50.99	1.01
Non-Hispanic Black	1 - Unknown	8.87	71.73	53.48	0.46
Non-Hispanic Black	2+ - Hospital	8.19	70.58	47.35	0.33
Non-Hispanic Black	2+ - Mixed	23.55	66.61	47.36	0.90
Non-Hispanic Black	2+ - Other	4.16	58.35	46.64	0.11
Non-Hispanic Black	2+ - Private	34.41	72.41	49.89	1.07
Non-Hispanic Black	2+ - Public	16.21	65.95	39.72	0.56
Non-Hispanic Black	2+ - Unknown	13.49	68.95	50.32	0.53
Non-Hispanic Other + Multiracial	1 - Hospital	10.8	73.73	57.83	0.71
Non-Hispanic Other + Multiracial	1 - Mixed	3.75	70.46	49.91	0.31
Non-Hispanic Other + Multiracial	1 - Other	3.31	52.4	52.4	0.19
Non-Hispanic Other + Multiracial	1 - Private	58.05	70.65	57.88	3.15
Non-Hispanic Other + Multiracial	1 - Public	14.52	53.69	41.11	0.99
Non-Hispanic Other + Multiracial	1 - Unknown	9.57	70.09	61.71	0.52
Non-Hispanic Other + Multiracial	2+ - Hospital	4.49	65.57	53.3	0.26
Non-Hispanic Other + Multiracial	2+ - Mixed	24.63	69.62	54.24	1.53
Non-Hispanic Other + Multiracial	2+ - Other	3.56	48.31	31.86	0.21

Non-Hispanic Other + Multiracial	2+ - Private	45.21	68.17	45.82	1.86
Non-Hispanic Other + Multiracial	2+ - Public	12.25	60.98	39.6	0.64
Non-Hispanic Other + Multiracial	2+ - Unknown	9.87	62.98	45.13	0.66
Non-Hispanic White	1 - Hospital	10.5	66.72	53.66	4.57
Non-Hispanic White	1 - Mixed	5.78	63.35	47.79	1.87
Non-Hispanic White	1 - Other	2.01	58.95	40.62	0.78
Non-Hispanic White	1 - Private	64.79	65.42	52.45	18.83
Non-Hispanic White	1 - Public	10.65	55.77	41.96	3.58
Non-Hispanic White	1 - Unknown	6.26	47.29	38.2	1.92
Non-Hispanic White	2+ - Hospital	7.61	57.26	46.12	2.65
Non-Hispanic White	2+ - Mixed	29.2	60.99	48.02	9.83
Non-Hispanic White	2+ - Other	3.16	49.9	31.02	0.96
Non-Hispanic White	2+ - Private	39.31	57.35	45.06	10.86
Non-Hispanic White	2+ - Public	9.24	49.21	30.45	2.97
Non-Hispanic White	2+ - Unknown	11.49	52.18	38.76	3.15