THE ROLE OF INSURANCE STATUS IN UTILIZATION OF CERVICAL CANCER PREVENTION SERVICES AMONG A SAFETY NET POPULATION

By

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Abstract

This study describes the association between health insurance continuity and receipt of cervical cancer preventive services among female patients who accessed care in a network of Oregon and California safety net clinics between 2008 and 2010. Data were gleaned from electronic health records supplied by OCHIN Inc., a non-profit organization that provides networked electronic health records to community health centers across the United States.

A series of bi-level log-binomial regression models were used to estimate adjusted prevalence ratios and 95% confidence intervals for receipt of cervical cancer preventive services by insurance continuity. Patient-level factors were modeled as fixed effects at level 1. The patient's home clinic was included as a random intercept at level 2.

Three separate cervical cancer preventive service outcomes were examined, each in a distinct population: 1) Receipt of ≥ 1 routine Pap test in 2008-2010 among established female patients ages 24-64 (n=11,560); 2) Receipt of >=1 dose of human papillomavirus (HPV) vaccine in 2008-2010 in female patients age 9-26 (n=18,311) ; and 3) Receipt of >=3 doses of HPV vaccine among female patients who initiated the vaccine series (n=4,284). The primary predictor was insurance continuity, as percentage of time in 2008-2010 (continuously insured = covered 100% of the time; partially insured = covered 1-99% of the study period; uninsured = no coverage during the study period). Co-variables included age, race/ethnicity, and household income as a percent of federal poverty level. Patients with documented reasons to forgo Pap screening or HPV vaccination were excluded. Patients who were pregnant during 2008-2010 were excluded

from the Pap analysis. Pap tests ordered for non-screening reasons (i.e. diagnosis) were also excluded.

Insurance continuity was a significant predictor of Pap screening, but the effect varied by race/ethnicity and age. Compared to having full insurance, having partial insurance increased the risk of non-screening only among younger White and Hispanic women. Having no insurance lowered Pap prevalence more for Whites than for non-Whites. Younger, uninsured Hispanics were more likely to receive a Pap than their fully insured peers, a finding that has not been previously reported.

Insurance continuity was also significantly associated with HPV vaccine series initiation and completion, and the effect was again modified by age and race/ethnicity. Partial insurance had an age-specific effect on vaccine initiation, lowering the likelihood of vaccination only in girls ages 13-18. Being uninsured significantly reduced the likelihood of vaccine series initiation and series completion for the majority of subjects. Opportunities for increasing HPV vaccine uptake may exist through promotion of the federal Vaccines for Children program, which provides free vaccines to uninsured and underinsured patients <19 years of age.

The results of this study demonstrate that having continuous insurance makes a difference in utilization of cervical cancer preventive services this population. The study also highlights how electronic health records enable population-level surveillance amongst the uninsured and underinsured without resorting to cost- and time-intensive chart reviews or patient surveys.

Chapter 1: Introduction

The central hypothesis of this study is that health insurance coverage is associated with utilization of cervical cancer preventive services among female patients in a safety net population. Insurance coverage of persons receiving care in safety net clinics, which include Federally Qualified Health Centers (FQHCs), FQHQ-lookalikes, county Health Department clinics, School Based Health Centers (SBHCs), and Rural Health Centers, is often quite fluid and may change frequently. Compared with the continuously insured, partially (discontinuously) insured patients and continuously uninsured patients will be less likely to receive routine cervical cancer preventive services, specifically Papanicolaou (Pap) screening tests and Human Papillomavirus (HPV) vaccination.

The research goal for this project was to identify insurance coverage patterns among a population of women who access care in a network of safety net clinics and evaluate the association between insurance coverage and utilization of cervical cancer preventive services.

1.1 Specific Aims and Hypotheses

Specific Aim 1: To compare prevalence of cervical cancer screening (Pap) tests at a coalition of safety net clinics, by insurance status and other sociodemographic characteristics, among women age 21 to 64.

Hypothesis 1: Prevalence of Pap tests among continuously uninsured and partially insured subjects in the study population will be lower than among the continuously insured. In addition, there will be disparities in Pap test prevalence by race, age, and socioeconomic status.

Specific Aim 2: To compare prevalence of HPV vaccine series initiation and series completion at a coalition of safety net clinics, by insurance status and other sociodemographic characteristics, among females age 9 to 26.

Hypothesis 2: Prevalence of HPV vaccination among continuously uninsured and partially insured subjects in the study population will be lower than among the continuously insured. In addition, there will be disparities in vaccine uptake by race, age, and socioeconomic status.

1.2 CONDITION DEFINITION

There are two main types of cervical cancers: squamous cell carcinoma and adenocarcinoma. The majority of cervical cancer cases (80% to 90%) are squamous cell carcinomas. These cancers arise from the squamous cells that cover the surface of the exocervix. Adenocarcinoma, which develops from the mucus-producing gland cells of the endocervix, accounts for most of the remaining cervical carcinomas. Less commonly, cervical cancers have features of both squamous cell carcinomas and adenocarcinomas[1].

Cervical cancer does not develop suddenly and is preceded by precancerous changes in the cervix, including cervical intraepithelial neoplasia (CIN), squamous intraepithelial lesion (SIL), and dysplasia[1]. Not all women with pre-cancers of the cervix will develop invasive cervical cancer. Screening can detect CIN and early cervical cancer so that these conditions can be managed or treated to prevent disease progression due to invasive cancer[2]. Screening for cancerous or precancerous changes of the cervix has traditionally been performed by scraping cells from the cervix and fixing them to a glass slide in a method developed by Papanicolaou called the Pap smear (or Pap test).

1.3 PREVALENCE AND BURDEN OF DISEASE

Cervical cancer is a significant public health issue. In 2012, it is estimated that 12,170 women in the United States would be diagnosed with cervical cancer, and 4,220 will die from the disease[3]. Both incidence and mortality rates have declined steadily over the past several decades, a trend generally attributed to adoption of population screening, although the decline in mortality has slowed since 2003. Five-year survival rates for cervical cancer patients vary by age, race and stage of diagnosis. The 5-year relative survival rate for all ages, all races and all stages of diagnosis was 68% in the period 2002-2008. During the same period, patients of all ages and all races diagnosed with localized cervical cancer had a 5-year relative survival rate of 91%[3].

Data from the National Cancer Institute's Surveillance Epidemiology and End Results (SEER) database indicate that cervical cancer incidence varies by age and race/ethnicity. From 2005 to 2009, the overall age-adjusted incidence rate of cervical cancer was 8.1 per 100,000 women per year[3]. The median age at diagnosis for cervical cancer in all women was 48 years. Over half of all incident cervical cancer cases between 2005 and 2009 occurred in women between the ages of 35 and 55 years[4]. Black women and Hispanic/Latino women shoulder a disproportionate burden of the disease. Hispanic/Latino women had the highest cervical cancer incidence rate (11.8 new cases per 100,000 women) of any racial/ethnic group in the United States, approximately 48% higher than for non-Hispanic Whites. The incidence rate of cervical cancer in African American women was 9.8 new cases per 100,000 women. Cervical cancer incidence was lowest among Asian and Pacific Islanders (7.2), non-Hispanic Whites (8.0), and American Indians and Alaska Natives (8.1)[3].

The age-adjusted death rate for cervical cancer was 2.4 per 100,000 women in 2005-2009, and the median age for mortality was 57 years[3]. Mortality rates increase with age and also vary by race and ethnicity. African American women have the highest cervical cancer mortality rate of any racial/ethnic group (4.3 deaths per 100,000 women during 2005-2009), and are more than twice as likely to die from cervical cancer as White women[4]. The overall 5-year relative survival for cervical cancer among African American women was 56.6% in 2008, compared to 69.0% among White women, and African American women are more likely to be diagnosed with regional- or distant-stage disease for which survival is poorer[4]. The death rate for cervical cancer among Hispanic women (3.0 deaths per 100,000 women) is 40% higher than that in non-Hispanic Whites[3].

While racial/ethnic disparities in cervical cancer incidence and mortality appear entrenched, biologic or inherited differences associated with race are thought to make a minor contribution to the disparate cancer burden between different racial/ethnic groups[5]. Rather, the disproportionate burden of cervical cancer in Hispanic/Latino and African American/Black women is primarily attributed to a lack of screening[6–9].

1.4 RISK FACTORS FOR CERVICAL CANCER

The primary risk factor for virtually all cervical cancer is infection with certain types of HPV. The 12 HPV types most strongly associated with cervical cancer are 16, 18, 31, 33, 35, 39, 45, 51, 52, 56, 58, and 59. HPV types 16 and 18 alone are responsible for approximately 70 percent of cervical cancer cases. Other potentially carcinogenic HPV types include 26, 53, 66, 67, 68, 70, 73, and 82[2,10,11]. Women who begin having sex at an early age or who have many sex partners are at increased risk for HPV infection and cervical cancer[2,12]. Persistence of HPV infection and progression to cancer may also be

influenced by a variety of complex and interrelated personal, economic, social, and cultural factors that interact synergistically with HPV to induce cervical carcinogenesis. Such factors include cigarette smoking, immunosuppression, chlamydia infection, poor diet, obesity/overweight, long-term use of oral contraceptives, intrauterine device use, high parity, young age at the first full-term pregnancy, poverty, Diethylstilbestrol (DES), and family history of cervical cancer[1,2,12,13].

1.5 CERVICAL CANCER PREVENTION

1.5.1 Pap Screening

Cervical cancer morbidity and mortality risk can be greatly reduced through timely screening and early detection. Between 60% and 80% of women with advanced cervical cancer have not had a Pap test in the past five years. For women in whom precancerous lesions have been detected through Pap tests, the likelihood of survival is nearly 100% with appropriate evaluation, treatment, and follow-up[14]. The US Preventive Services Task Force (USPSTF) currently recommends Pap screening for cervical cancer in women ages 21 to 65 years every 3 years or, for women ages 30 to 65 years who want to lengthen the screening interval, screening with a combination of Pap screening and HPV testing every 5 years[15].

Many states, including Oregon and California, ensure that private insurance companies, Medicaid, and public employee health plans provide coverage and reimbursement for Pap tests[14]. Medicare is required to cover preventive services rated "A" or "B" by the US Preventive Service Task Force, which includes Pap screening, at no cost to patients. This requirement will be extended in 2014 to cover all insurance companies enrolled in state health insurance exchanges and individuals newly covered

through the Affordable Care Act's expansion of Medicaid[14]. Other programs are also available to help provide financial assistance for women with lower incomes and those without insurance. All states are making cervical cancer screening more available to low-income, underinsured, and uninsured women through the National Breast and Cervical Cancer Early Detection Program (NBCCEDP)[14].

Healthy People 2020 has identified cervical cancer screening as a focus area for public health improvement, with a target for screening compliance of 93%[16]. Based on results from the 2010 National Health Interview Survey, approximately 83% of women with no hysterectomy reported having a Pap test within the past 3 years[17]. Pap rates were lower among Hispanic women than among non-Hispanic women (79% versus 84%, respectively). Rates were lowest among Asians (75%). Those without access to health care were less likely to receive Pap testing; 65% of women with no usual source of care were up-to-date (i.e. reported having a Pap test within the previous 3 years) compared to 86% who had a usual source of care. Only 64% of uninsured women were up-to-date, compared to 82% with public insurance and 89% with private or military insurance[17]. Similar patterns of screening were described in the 2005 Health Information National Trends Survey (HINTS)[18]. Data from the 2008 Behavioral Risk Factor Surveillance System (BRFSS) survey for Oregon indicate that 80% of women surveyed reported having a Pap test within 3 years. Screening rates declined with age, with 74% of women ages 55-64 reporting a Pap test within 3 years[19]. Based in-part on BRFSS 2010 data, the American Cancer Society recently published state-by-state estimates of the proportion of eligible women receiving a Pap test in 2010[14]. In Oregon, 80% of women ages 21-64 were estimated to have been screened within the preceding three years. Screening

prevalence among uninsured Oregon women was estimated at 52%. In California, 87% of women ages 21-64 reported being screened, and screening among the uninsured was estimated at 76%[14].

However, several studies, including a recent meta-analysis, have found that patient self-report consistently overestimated rates of cancer screening[20–22]. Pap prevalence in 1998-2000 NHIS data has been shown to be artificially increased by 8% (observed prevalence 82%, adjusted prevalence 74%)[22]. A 2012 study of cancer screening in rural Oregon based on medical chart review reported that only 30% of women aged ≥55 years were up to date for cervical cancer screening[23]. A study of Pap screening within a private health maintenance organization in Portland, Oregon also found that overall Pap utilization was lower than found in national surveys based on self-report[21]. A recently released report based on billing claims from eight of Oregon's largest health plans, two managed Medicaid organizations and the Oregon Health Authority Division of Medical Assistance Programs (Medicaid) estimated the percentage of women ages 21 to 64 in Oregon receiving one or more Pap tests between July 2008 and June 2011 at 71.0% (95% CI: 70.1%-71.9%)[24].

1.5.2 HPV Vaccination

The introduction of prophylactic HPV vaccines holds great potential for reducing the incidence of cervical cancer. Effective vaccines have been developed against HPV-16 and HPV-18 and other subtypes. In June 2006, a vaccine (Gardasil) that protects against four types of HPV, including types 16 and 18, was approved by the FDA for use in females ages 9 to 26. In October 2009, the FDA approved a second HPV vaccine (Cervarix) and expanded the approval of Gardasil for use in boys and young men to

prevent genital warts, warts, anal cancer, and associated precancerous lesions[14]. The reduction of cervical cancer risk by 70% or more becomes a theoretic possibility depending on the number of carcinogenic HPV types eventually included in a future HPV prophylactic vaccine and on the percent of the population vaccinated[10]. However, the vaccines do not protect persons who are already exposed to the HPV virus or persons who initiated sexual activity prior to vaccine availability.

To be most effective, the HPV vaccine should be given before a person becomes sexually active, and in three doses within one year. The Advisory Committee on Immunization Practices (ACIP), the federal entity charged with making recommendations for the administration of vaccines to the pediatric and adult populations, recommended that the vaccine be routinely given to females ages 11 to 12 years and as early as age 9 years at the discretion of doctors. The committee also recommended females ages 13 to 26 who have not yet been vaccinated receive "catchup" vaccinations[25]. In January 2007, the American Cancer Society published its own recommendations for HPV vaccine use that are generally consistent with those of the ACIP[10].

As of July, 2011, the HPV vaccine cost in the US is approximately $130 per dose (or $390 for the entire three-dose series during one year)[26]. This cost does not include the cost for giving the injections or the doctor's charge. However, most large health insurance companies do include ACIP-recommended vaccines as a plan benefit, and most have agreed to cover the HPV vaccine. The vaccines are included in the federal Vaccine for Children (VFC) program, which provides free vaccines to children and adolescents younger than 19 years of age, who are either Medicaid-eligible, American Indian or Alaska Native, or uninsured. The VFC program also allows children and teens to get

VFC vaccines through federally qualified health centers or rural health centers if their private health insurance does not cover vaccinations[26].

Healthy People 2020 identified increasing routine vaccination coverage levels for adolescents as a focus area for public health improvement, including vaccination with 3 doses of HPV vaccine by age 13 to 15 years. The target for vaccine coverage is 80%[16].

Recent analysis of data from the National Immunization Survey–Teen (NIS-Teen) indicated that HPV vaccination coverage among females age 13-17 increased between 2009 and 2010; ≥1 dose of HPV from 44% to 49%, and ≥3 doses of HPV from 27% to 32%[27]. Based on NIS-Teen, patterns of HPV vaccine uptake differed by racial/ethnic group and poverty status. HPV initiation among Whites was lower than among Hispanics and American Indian/Alaskan Natives; receipt of ≥3 HPV doses among those who initiated the series was lower among blacks and Hispanics than among Whites. A difference was not observed in coverage by poverty status for ≥1 dose of HPV; however, coverage with ≥3 doses of HPV was lower among those living below the poverty level than those living at or above the poverty level[27]. Coverage estimates also varied by state and reporting area. Oregon reported a coverage rate for ≥1 dose of HPV of 54% and a for ≥3 doses of 38%. Rates in California were similar; at 56% and 32%, respectively.

Data sources that do not rely on self-report have also been used to assess HPV vaccine coverage. A study of HPV vaccine completion among adolescents (ages 8-17) attending school-based health centers (SBHC's) in Oregon, which utilized SBHCs' data combined with data from the state's immunization information system, found that 51% of persons who initiated the HPV vaccine series in 2007 received all 3 doses by December 2008[28]. Series completion increased significantly with age, differed

significantly between race groups, being highest among White persons (56%) and lowest among black persons (38%), and did not differ significantly by insurance status[28].

Several other studies have utilized immunization registry data[29,30], claims data[31–33], or clinical and billing data from paper and/or electronic health records[34–37] to examine rates and factors associated with HPV vaccine uptake and adherence. In studies utilizing immunization registries, overall vaccine series completion rates among initiators varied from 42% among females age 9-26 in a California managed care organization[30] to 55% in among females age 9-26 in North Carolina[29]. Studies utilizing Florida Medicaid claims data for 2006-2008 found low ($\leq$ 20%) rates of vaccine series initiation among 11-18 year olds[31,32] and a completion rate among initiators of 27%[32]. Analysis of outpatient claims data from a university medical center in Maryland in 2006-2010 returned an overall initiation rate of 35% among patients ages 9-26 and a series completion rate among initiators of 29%[33]. Studies utilizing both clinical and billing data reported results that varied widely. Rates for vaccine series initiation ranged from 18% among 19-26 year olds at a university-based health clinic in Michigan[37] to 37% among 11-18 year olds across four safety net clinics in Texas[35]. In the same studies, vaccine series completion among initiators varied between 69% and 40%, respectively. Completion rates as high as 75% have also been reported among initiators ages 9-18 based on clinical and billing data[36].

1.6 DISPARITIES IN CERVICAL CANCER PREVENTIVE CARE

While cervical cancer is preventable, risk reduction efforts are hindered by persistent disparities in Pap screening compliance and HPV vaccine coverage. Disparities in Pap screening compliance have been attributed to a wide range of factors, including

cultural beliefs, perceptions of vulnerability, sociodemographic factors, immigration status, English literacy, and lack of a usual source of care[6,12,14,38–42]. The role of race/ethnicity as a significant independent predictor of cervical cancer screening remains unclear[9,38,43–45]. Numerous studies, based both on survey data[9,46–54] and others sources of data[23,38], have highlighted the importance of insurance coverage as a predictor of cervical cancer screening utilization, demonstrating that differences in utilization among uninsured compared with insured individuals persist across racial, age and economic groups. Further, type of insurance affects screening utilization[46,50].

Risk factors that have been associated with disparities in HPV vaccine initiation include being sexually active[32,35], poverty level[37], vaccine program type[31], practice/provider type [36,37], mothers attitudes toward prevention[55], and receipt of other adolescent vaccines[35]. Age, race/ethnicity, insurance coverage and insurance type have all been independently associated with HPV vaccine initiation, but associations differed markedly across studies highlighting the complexity of interactions between variables[31–33,35–37,56,57]. Risk factors and associations for completion of the 3 dose vaccine series are similar to those for vaccine initiation. Additional risk factors such as use of contraception that required intramuscular injection every three months[34] and socioeconomic status[30] have also been identified. Psychological and environmental factors such as physician recommendations, perceptions of the beliefs of peers and significant others, history of childhood immunizations, and communication with adolescents regarding sexual topics also appear to influence HPV vaccination outcomes[58]. As with vaccine series initiation, conflicting results have been observed between different studies with respect to the

association between series completion and age, race, insurance type, and insurance coverage status[28–30,32–37].

1.7 RATIONALE FOR THE STUDY

Federally-funded safety net clinics are dedicated to meeting and surpassing Healthy People 2020 targets, including those related to reducing disparities in cervical cancer incidence and mortality. To achieve these targets, it will be necessary to increase both Pap screening compliance and HPV vaccine coverage, especially among the vulnerable populations where screening and vaccination rates are disproportionately low.

This study sought to investigate how one particular factor—continuity of health insurance coverage—is associated with the receipt of cervical cancer preventive care among a cohort of women who seek care in safety net clinics. Justification for the study is threefold:

1. Health insurance may play a key role in helping increase Pap screening and HPV vaccination coverage rates to meet Healthy People 2020 targets. However, previous studies investigating the association between insurance coverage and uptake of cervical cancer preventive services have delivered conflicting results. This is especially true with respect to studies focused on HPV vaccine uptake[28–30,32–37]. Additional research is required to more accurately characterize associations, inform design of interventions, and to provide population-level data to establish baselines and allow evaluation of interventions.

2. Much of the existing research describing disparities in utilization of cervical cancer preventive services, especially Pap screening, has been based on self-reported survey data[9,27,46–54]. However, survey-based studies introduce the risk of recall bias that

may confound and negatively impact the validity of findings. New studies, based on alternative and potentially more accurate data-collection methods, will allow better assessment of existing data and improve understanding of the factors driving disparities.

3. Where non-survey data has been utilized to explore factors associated with Pap screening and HPV vaccine uptake, studies have typically been limited to insured populations [21,29–32,59]. While such studies are important, the findings may not be generalizable to the uninsured and underinsured; a population at high-risk for non-compliance with Pap screening and HPV vaccination guidelines. Medical chart audits have been employed in a few studies to capture data on the uninsured. However, this data-gathering method is time- and cost-prohibitive, thus not well suited to studying disparities among large population groups.

My study leverages a unique resource, clinical and billing data gleaned from a network of safety net clinics that have implemented electronic health records (EHRs), to sidestep the necessity for medical chart audits, reduce the potential for self-report bias, and capture the experiences of a large cohort of uninsured and underinsured patients invisible in claims-based research. The study allows validation of existing research while offering new insights into the relationship between insurance coverage and cervical cancer prevention, adding to our understanding of the barriers to preventive service utilization faced by a safety net population.

Chapter 2: Methods

2.1 DATA SOURCE

This study was based solely on data retrieved from EHRs. Data was supplied OCHIN, Inc., a non-profit organization in Portland, OR, that provides networked EHRs to community health centers (CHCs) serving safety net populations across Oregon, California, Washington and nine other states. As of December 2012, OCHIN included 69 member organizations that operate 271 separate clinics, providing primary care, mental health, dental, public health, early childhood, school-based, and various other specialty and ancillary services to their patients. OCHIN CHCs have served more than 1.3 million unique patients with over 12 million distinct visits since 2002.

OCHIN's EHR data includes Practice Management (PM) information (claims, billing, and appointments) and electronic medical records (EMRs), providing excellent detail on race, ethnicity, poverty status, insurance status, and primary care services utilized by both insured and uninsured clients. OCHIN's data resource is one of the richest CHC-based EHR data sources in the country, and provides rare access to the underinsured and uninsured; groups that are invisible in most population-level cancer prevention behavior surveillance. Data from 30 clinics were utilized in this study. These clinics were drawn from five OCHIN-affiliated CHCs located in Oregon and California. The CHCs included county health departments and not-for-profit organizations. All clinics had both PM and EMR data available for the entire study period (2008-2010). Clinic locations spanned both urban and rural settings, and included primary care/family medicine facilities, school-based health clinics, and several specialty clinics serving teens and homeless individuals.

2.2 SUBJECT AND VARIABLE SELECTION

2.2.1 Pap Screening Analysis

Subject selection**:** Eligible subjects were defined as females ages 24 to 64 in 2010 that had at least one medical visit at a study clinic during 2010 and, to ensure a minimum level of continuity of care, at least one visit in or before 2008. Patients with a documented history of hysterectomy were excluded from the analyses. Evidence of a hysterectomy was sought as far back as possible in the patient's history through EHR review. Surgical codes for hysterectomy utilized in the query were: CPT 51925, 56308, 58150, 58152, 58200, 58210, 58240, 58260, 58262, 58263, 58267, 58270, 58275, 58280, 58285, 58290-58294, 58550, 58551, 58552-58554, 58951, 58953-58954, 58956, 59135 and ICD-9-CM 68.4-68.8, 618.5. Pregnancy was considered a potential confounder in the analysis. Pregnancy is associated with both the outcome of interest, since Pap smears are often administered as part of routine prenatal care, and with the primary independent variable, since women who may otherwise be uninsured can, on becoming pregnant, access health insurance via state programs (if income eligibility criteria are met) or through commercial high-risk insurance pools. Consequently, subjects who were pregnant at any time during the study period, identified by ICD9 codes 630-679, V22, V23, V24, V72.42, were also excluded.

Outcome variable: The outcome of interest in the Pap analysis was receipt of a routine Pap smear in the period 2008-2010. A routine Pap smear was defined as any completed or resulted order for a Pap smear (CPT codes 88142, 88143, 88144, 88145, 88150, 88155, 88164, 88165, G0123, P3000, P3001, Q0091, 88175, LT388, LT389, LT390, LT420, LP344, LP349, LS152, LS533, LS540, LP921, LP922, LP923, LP924, LP958, LP971, LP972, LS819, LS823, LP1049, LS860, LP1072, LP1073, LP1074,

LP1075, LP1076 and LV683), for which there was no evidence of follow-up for a prior Pap smear abnormality or related diagnosis of a cervical abnormality (ICD9 codes 108.0-180.9, 233.1, 622.1, 795.0, 796.9, V10.41,) during the previous 9-months[21]. All other Pap smears were considered diagnostic tests (e.g. test was performed as a follow-up for a previously detected abnormality). Routine Pap tests were identified via examination of billing codes in the PM module of the EHR and/or documentation of the procedure in a reportable field in the subject's EMR.

Independent variables: The primary independent variable was health insurance continuity as a percentage of time covered during 2008-2010. Percentage of time covered was quantified by summing the total number of days with coverage, identified from the OCHIN database, which included start and end dates for coverage periods. In cases where a coverage records had no end date, coverage was assumed to have lasted three months. Coverage that would not pay for cervical cancer preventive services (e.g. dental, mental health, behavioral health, worker's compensation and motor vehicle accident coverage) was not included in calculations. Periods of insurance coverage totaling <7 days were considered administrative errors and excluded.

The number of days with coverage was then divided by 1,094 days (three years) to obtain a percentage. Subjects were classified into one of three categories as follows: (1) "continuously insured" if they had coverage for 100% of the study period; (2) "continuously uninsured" if they had no coverage in the study period; (3) "partially insured" if they had coverage for 1% to 99% of the study period. Receipt of routine Pap tests was evaluated in each of these groups. Covariates included age, race/ethnicity, and household income as a percentage of the federal poverty level. These covariates were

selected based on the findings of previous studies that examined factors affecting utilization of cervical cancer prevention services[6,13,31,32,34,39–41,51] and on availability of data. The covariates were categorized to ensure adequate cell counts during analysis.

Age was calculated for each subject on the first day of the study period (1/1/2008) and dichotomized as 21-39 years and 40-64 years. A combined race/ethnicity variable was generated using the following algorithm: if a patient had ever been identified as Hispanic or primarily Spanish-speaking, she was considered Hispanic. Among the non-Hispanic patients, if at any visit a person had been identified as black, Asian/Pacific Islander, or American Indian/Alaska native, she was considered to be that race/ethnicity; if a patient had always been classified as White, she was considered as such. Those without any race/ethnicity data were classified as unknown. Race/ethnicity was collapsed into just three categories for statistical analyses; Non-Hispanic White, Hispanic, and non-Hispanic Other. Hispanic subjects could be any race. Household income as a percentage of the federal poverty level (FPL) was calculated as an average of all household income data over all visits in the study period. Values >1000% were considered missing. Categories of 0-99% of FPL and 100% or greater of FPL were utilized in all analyses.

2.2.2 HPV Vaccination Analysis

Subject selection: Eligible subjects were defined as females who had a least one medical visit during the period 2008-2010 at a study clinic and who were age 9 to 26 at time of the visit. Excluded from the analyses were subjects who appeared in the dataset for only pregnancy-related visits (indicated by ICD-9 codes V22, V23, and V72.42).

Otherwise eligible patients who initiated the HPV vaccination series prior to the start of the study period (1/1/2008) or outside of the recommended age range (9-26 years of age) were also excluded.

Outcome variables: The concept of vaccine uptake was separated in to two outcomes: initiation of the vaccine series (receipt of at least 1 dose of vaccine), and completion of the series (receipt of ≥ 3 doses of vaccine among those patients who had initiated). HPV vaccination during a visit was identified using common CPT codes 90649, 90650, TM221, and TM184, which are specific to HPV vaccine. Vaccination records that were incomplete, deferred, deleted, or that preceded the earliest approval date for HPV vaccine (Gardasil, 08/6/2006) were excluded from the analysis.

Independent variables: The HPV analysis assessed the same set of patient-level covariates as the Pap analysis. Race/ethnicity and household income were categorized as for the Pap analysis. Age was calculated on the date of the index visit, defined as the date of first vaccination for those who initiated the vaccine series or the earliest visit in the study period for those who did not initiate the vaccine series. Age was categorized as 9-12 years, 13-18 years, and 19-26 years. The 9-12 years bracket represents a combination of the early and recommended vaccination windows suggested by ACIP[25]. The two remaining age brackets encompass the "catch-up" period for females who have not been previously vaccinated or who have not completed the full series[25]. Stratification of the catch-up period into two age groups (13-18 years and 19-26 years, respectively) was adopted to reduce confounding that might be introduced by the fact that HPV vaccine is included in the federal VCF program, which entitles any child 18 years or younger who is uninsured, underinsured, or eligible for Medicare to the vaccine for free[60].

2.3 STATISTICAL TECHNIQUES

The data sets used for analysis included only subjects with complete information for all covariates. Demographic characteristics of the study populations were described, and tests performed to examine the differences in distribution of sociodemographic covariates among the three insurance groups.

Three rounds of regression modeling were performed to identify the most appropriate method for estimating univariable and multivariable associations between the three insurance continuity variables (continuously insured, partially insured, continuously uninsured) and receipt of each of the outcomes. The first modeling round utilized simple and multiple logistic regression to estimate unadjusted and adjusted odds ratios for receipt of service. Only patient-level factors were included in these models.

In the second round of modeling, a multilevel logistic approach was utilized to account for the possible inter-class correlation of subjects within clinics[61–64]. Patient-level factors were entered into models as fixed effects at level 1 and a clinic variable entered as a random intercept at level 2. The clinic variable was defined as the clinic visited most frequently by each subject during the study period (e.g. the patient's "home clinic"). In cases where a subject visited two or more clinics an equal number of times, the subject was randomly assigned to one of the clinics she had visited. Modeling clinic variation as a random intercept was preferred over entering each clinic into models as a separate fixed effect since the difference between clinics was not of primary interest in this study and the random intercept approach avoids the addition of a large number of nuisance parameters into the models[61,62].

In the final round of modeling, a log link function was substituted for the logit link function in multilevel models, allowing estimation of unadjusted and adjusted

prevalence ratios, rather than odds ratios, for each respective outcome. While there is nothing intrinsically wrong with estimating odds ratios, my ultimate interest was in assessing the relative risk of receiving preventive services between subjects with different insurance status. When working with frequent outcomes (prevalence ≥ 10%), as was the case in this study, the odds ratio can strongly overestimate the relative risk[65–69]. In contrast, log-binomial models can generate unbiased point estimates of relative risk when outcomes of interest are relatively common, and the log link has been shown to be suitable in models where all independent variables are categorical [65–69].

In all modeling rounds, independent variables associated with the outcome of interest at the $p<.01$ level in univariable models were entered into multivariable models. Pairwise and three-way interactions between independent variables were assessed. Backward stepwise selection with an exclusion level of $p<.05$ was used to identify variables for inclusion in final multivariable models. All analyses were conducted in SAS Enterprise Guide version 9.4 (SAS Institute, Inc., Cary, NC) using PROC LOGISTIC for single-level logistic models and PROC GLIMMIX for multilevel modeling. The default pseudo-likelihood method (RSPL)[70] was used for parameter estimation in multilevel logistic models. Laplace approximation was used for parameter estimation in log-binomial models, which facilitated model convergence and was useful in model selection as the value of the log likelihood at the solution could be directly compared between nested models[71]. Several different correlation structures for the covariance matrix of the random intercept (G-side matrix) were tested during multilevel modeling. These tests indicated the models were not sensitive to correlation structure. Compound symmetry was ultimately chosen as the correlation structure. Since PROC GLIMMIX does not

generate an interclass correlation coefficient as part of default output, the significance of the random intercept in multilevel models was tested using the COVTEST statement with the ZEROG option. The ZEROG option requests that the reduced model be formed from the fitted model by imposing restrictions that reduce the G matrix to zero. This allowed performance of likelihood-based tests comparing full and reduced models with respect to the covariance parameters[71].

Chapter 3: Results

3.1 Choice of Final Models

Goodness-of-fit statistics indicated that single-level multivariable logistic regression models were over-dispersed, thus not well specified[72]. For example, the chosen multivariable logistic model for Pap analysis returned a Pearson's Goodness-of-fit statistic = 4.1 (p<.0001) and area under the ROC curve = 0.637, indicating that the model had minimal discriminative ability[72]. Similar results were obtained in the single-level logistic models of HPV vaccination (data not shown). The introduction of a clinic-level random intercept improved model fit and corrected over-dispersion. Logit and log link functions produced similar patterns of association in multilevel multivariable models, although, as would be expected, the magnitude of point estimates and width of 95% CIs differed considerably. Ultimately, log-binomial models were preferred for the final analysis as they provide a more appropriate estimate of relative risk given that the outcomes of interest were relatively common[65–68]. All results and discussion presented from this point onwards refer exclusively to the output of multilevel log-binomial modeling. For comparison purposes, selected results from multilevel logistic modeling can be viewed in Appendix 1.

3.2 Pap Screening Analysis

A total of 12,306 women were excluded from the base population of 24,382 as they had a history of hysterectomy (n=1,680), did not meet the patient continuity criteria (n=8,436), and/or were pregnant during the study period (n=3,694). An additional 516 subjects (2.1% of base population) were excluded due to incomplete race/ethnicity or FPL data, leaving a sample of 11,560 for statistical analysis. Six percent (n=1,217) of all

Pap tests for the study population were ordered for diagnostic reasons thus excluded from the analysis

Sample characteristics: Of the 11,560 women in the analytic sample, 23% (n=2,642) had no known insurance coverage in 2008 to 2010, 33% (n=3,856) had partial coverage, and 44% (n=5,062) were continuously covered (Table 1). Among those with continuous coverage for the three-year study period, 80% had Medicaid, 16% had Medicare, and 4 % had other insurance (mostly private). Among the partially insured group, 68% had Medicaid, 4% had Medicare and 28% had other insurance. Almost one third of the partially insured (n=1,185) were covered for 80-99% of the study period (data not shown). Another 20% (n=784) of partially insured patients were covered for 60-79% of the study period. Coverage among the remaining partially insured patients was as follows; 13% (n=499) were covered for 40-59% of the time, 14% (n=541) were covered for 20-39% of the time, and 22% (n=847) were covered for 1-19% of the time. The average period of coverage among the partially insured was 603 days (SD 350 days) or 55% (SD 32%) of the study period. Roughly two fifths (n=4,839) of subjects in the analysis sample had a home clinic associated with one CHC in Oregon. The remaining subjects were evenly split between the two other Oregon CHCs (n=1,675 and n=1,471, respectively) and the two California CHCs (n=1,617 and 1,958, respectively).

Slightly more than half of subjects (54%) were 40 years of age or older. The mean age in the study sample was 41 years (SD 11 years). Non-Hispanic Whites comprised the largest proportion of patients by race/ethnicity (47%) followed by Hispanics (38%) and patients of other race/ethnicity (15%). Over two-thirds (69%) of patients had an average household income below 100% of FPL.

Table 1. Demographics of Pap screening analysis sample: female patients eligible for Pap screening in OCHIN clinics during the period 2008-2010, overall and stratified by insurance coverage group (n=11,560).

	Total population		**No coverage**		**Partial coverage**		**Continuous coverage**	
	n	(%)	n	(%)	n	(%)	n	(%)
Total (row percent)	11560	(100.0)	2642	(22.9)	3856	(33.4)	5062	(43.8)
Received Pap test**	7346	(63.5)	1787	(67.6)	2322	(60.2)	3237	(63.9)
Age**								
21-39 years	5324	(46.1)	1479	(56.0)	1985	(51.5)	1860	(36.7)
40-64 years	6236	(53.9)	1163	(44.0)	1871	(48.5)	3202	(63.3)
Race/Ethnicity**								
NH White	5426	(46.9)	928	(35.1)	2246	(58.2)	2252	(44.5)
Hispanic	4424	(38.3)	1523	(57.6)	880	(22.8)	2021	(39.9)
Other	1710	(14.8)	191	(7.2)	730	(18.9)	789	(15.6)
Poverty level**								
≥ 100% of FPL	3551	(30.7)	1286	(48.7)	1232	(32.0)	1033	(20.4)
0% - 99% of FPL	8009	(69.3)	1356	(51.3)	2624	(68.0)	4029	(79.6)

Abbreviations: FPL, federal poverty level. (%) = column percent unless noted otherwise.
**$p<.001$ test for an association between variable and insurance continuity.

There were significant differences between insurance coverage groups in the distribution of each of the demographic characteristics and in receipt of Pap screening tests. A total of 7,346 (64%) patients from the analytic sample received at least on routine Pap test in the period 2008-2010. Pap screening was most prevalent among women with no insurance coverage during the study period (68%) and least prevalent among women with partial insurance coverage (60%). Among women who had continuous insurance coverage, 64% received a routine Pap test.

Univariable Analysis: Each of the independent variables was significantly associated with receipt of routine Pap testing ($p<.001$) when entered into univariable regression models. The strongest association was with race/ethnicity (Table 2).

Table 2. Prevalence ratios from univariable random intercept log-binomial regression models for receipt of routine Pap screening test during 2008-2010 (n=11,560).

	n	n (%) receiving Pap	PR (95% CI)
Total	11,560	7,346 (63.5)	
Insurance coverage			
Continuous coverage	5062	3,237 (63.9)	1.00 (ref)
Partial coverage	3856	2,322 (60.2)	0.98 (0.95-1.01)
No coverage	2624	1,787 (67.6)	1.08 (1.04-1.12)***
Age			
21-39 years	5324	3,531 (66.3)	1.00 (ref)
40-64 years	6236	3,815 (61.2)	0.93 (0.91-0.96)***
Race/Ethnicity			
NH White	5426	2,899 (53.4)	1.00 (ref)
Hispanic	4424	3,337 (75.4)	1.39 (1.34-1.44)***
Other	1710	1,110 (64.9)	1.16 (1.11-1.22)***
Poverty Level			
100% of FPL or greater	3551	2,335 (65.8)	1.00 (ref)
Below 100% of FPL	8009	5,011 (62.6)	0.95 (0.92-0.98)**

Abbreviations: PR, prevalence ratio; CI, confidence interval; FPL, federal poverty level. ** PRs and 95% CI are statistically significant at $p<0.001$; *** significant at $p<0.0001$;

Hispanic women were 1.39 (95% CI: 1.34-1.44) times as likely to receive a routine Pap test as non-Hispanic Whites; women of other races/ethnicities were 1.16 (95% CI: 1.11-1.22) times as likely. Women ages 40-64 years were less likely to receive a routine Pap test compared women ages 21-39 years (PR 0.93, 95% CI: 0.91-0.96). The prevalence of routine Pap screening among women with no insurance was significantly higher than among the continuously insured (PR 1.08; 95%CI: 1.04-1.12). There was no significant difference in Pap prevalence between the partially insured and those with continuous insurance. Women with lower household incomes were less likely to receive Pap screening than those with higher household incomes (PR 0.95; 95% CI: 0.92-0.98).

Multivariable Analysis: Multivariable models estimating the prevalence of routine Pap testing adjusted for covariates indicated significant interactions between insurance

coverage, age, and race/ethnicity. Likelihood-based tests comparing full and reduced models with respect to the covariance parameters indicated that the random intercept was highly significant (p <.0001) in all models. The final model included a clinic-level random intercept, all main effects (insurance coverage status, age, race/ethnicity, and average FPL), three pairwise interactions (insurance coverage by age, insurance coverage by race/ethnicity, and age by race/ethnicity), and a three-way interaction term between age, race/ethnicity and insurance coverage.

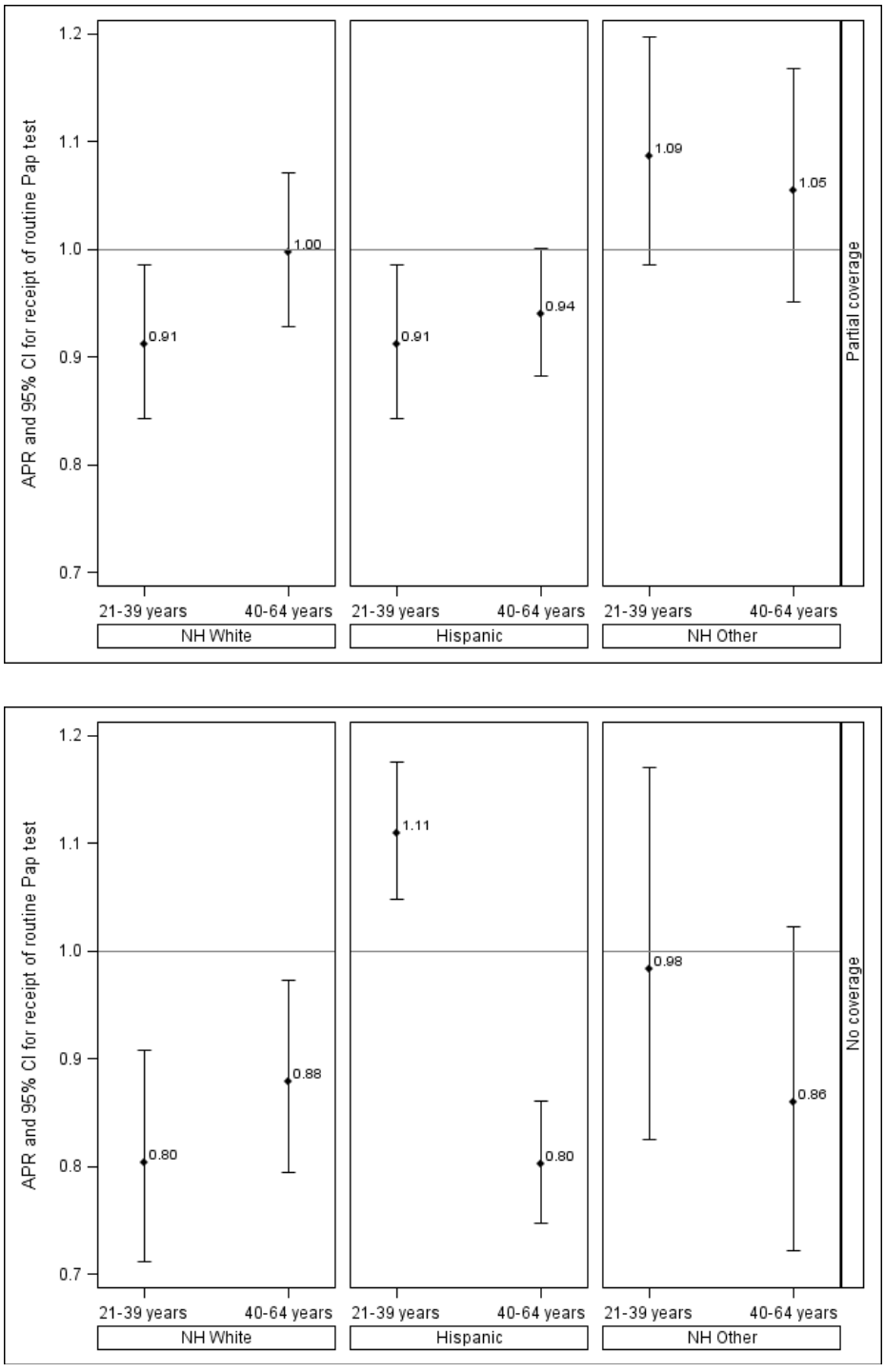
Insurance coverage was a significant predictor of receipt of routine Pap testing, but its effect depended on age and race/ethnicity (Table 3; Figure 1). Among non-Hispanic Whites, Pap prevalence was significantly lower for the uninsured compared to the fully insured, both for women age 21-39 (APR 0.80; 95% CI: 0.71-0.91) and for women age 40-64 (APR 0.88; 95% CI: 0.79-0.97). Younger White women (age 21-39) with partial insurance coverage were also less likely to receive a routine Pap smear than their peers with full insurance (APR 0.91, 95% CI 0.84-0.99).

Among Hispanic women, the prevalence of Pap receipt varied more widely within age and insurance subgroups. Hispanic women age 21-39 with partial insurance coverage were less likely to receive a routine Pap test compared to the fully insured Hispanic women of the same age (APR 0.91; 95% CI: 0.84-0.99). However, among the same age group, Hispanic women with no insurance coverage were significantly more likely to receive a pap test when compared to the fully insured (APR 1.11; 95% CI: 1.05-1.18). Among older Hispanic women, having no insurance was significantly associated with a lower likelihood of receiving a Pap test (APR 0.80; 95% CI: 0.75-0.86). Partially insured

Table 3. Adjusted prevalence ratios from multivariable random intercept log-binomial regression model for receipt of routine Pap screening test during 2008-2010 (n=11,560).

	n	n (%) receiving Pap	APR (95% CI)
Effect of insurance coverage by age and race/ethnicity			
NH White			
21-39 years			
Continuous coverage	735	434 (59.0)	1.00 (ref)
Partial coverage	1149	627 (54.6)	0.91 (0.84-0.99)*
No coverage	368	174 (47.3)	0.80 (0.71-0.91)**
40-64 years			
Continuous coverage	1517	819 (54.0)	1.00 (ref)
Partial coverage	1097	588 (53.6)	1.00 (0.93-1.07)
No coverage	560	257 (45.9)	0.88 (0.79-0.97)*
Hispanic			
21-39 years			
Continuous coverage	839	576 (68.7)	1.00 (ref)
Partial coverage	471	303 (64.3)	0.91 (0.84-0.99)*
No coverage	1041	907 (87.1)	1.11 (1.05-1.18)**
40-64 years			
Continuous coverage	1182	916 (77.5)	1.00 (ref)
Partial coverage	409	301 (73.6)	0.94 (0.88-1.00)
No coverage	482	334 (69.3)	0.80 (0.75-0.86)***
NH Other			
21-39 years			
Continuous coverage	286	192 (67.1)	1.00 (ref)
Partial coverage	365	270 (74.0)	1.09 (0.99-1.20)
No coverage	70	48 (68.6)	0.98 (0.83-1.17)
40-64 years			
Continuous coverage	503	300 (59.6)	1.00 (ref)
Partial coverage	365	233 (63.8)	1.05 (0.95-1.17)
No coverage	121	67 (55.4)	0.86 (0.72-1.02)
Effect of FPL			
100% of FPL or greater	3551	2335 (65.8)	1.00 (ref)
0 to 99% of FPL	8009	5011 (62.6)	0.95 (0.92-0.97)***

Abbreviations: APR, adjusted prevalence ratio; CI, confidence interval. * APRs and 95% CI are statistically significant at $p<0.05$; **significant at $p\leq0.001$; ***significant at $p<0.0001$. Regression model included a clinic-level random intercept, insurance coverage, age, race/ethnicity, average FPL; three pairwise interactions: insurance coverage by age, insurance coverage by race/ethnicity, and age by race/ethnicity; and one 3-way interaction between age, race/ethnicity and insurance coverage.



Abbreviations: NH, Non-Hispanic; APR, adjusted prevalence ratio; CI, confidence interval.

Figure 1. Summary of adjusted prevalence ratios for receipt of a routine Pap test by insurance continuity, age, and race/ethnicity. Top panel; partially insured versus continuously insured. Bottom panel; uninsured versus continuously insured.

older Hispanic women also appeared to be at risk for no screening, although the prevalence estimate was marginally significant at α=0.05 (APR 0.94; 95% CI: 0.88-1.00; *p*=.054). Among non-Hispanic women of other races/ethnicity, there was no evidence of a significant association between insurance coverage and receipt of a routine Pap smear.

Household income, expressed as percent of FPL, was a significant predictor of receipt of Pap test but did not interact with insurance coverage, age or race/ethnicity. Women with lower household income (0-99% FPL) had a lower prevalence of Pap receipt than those whose household income was higher (APR 0.95; 95% CI: 0.92-0.97).

3.3 HPV VACCINATION ANALYSIS

A total of 3,009 subjects were excluded from the base population of 23,242 as they initiated the vaccine series prior to 1/1/2008 (n=2,257), initiated the vaccine series prior to their 9th birthday or after their 27th birthday (n=2), or had visits during the study period associated only with pregnancy (n=762). Of the remaining 20,233 subjects, an additional 1,922 (8.3% of base population) were excluded due to missing observations for race/ethnicity or FPL, leaving 18,311 subjects in the analysis sample. Six hundred and nine incomplete, deferred or deleted HPV vaccination records were excluded from the analysis, along with 11vaccine records dated prior to 08/6/2006.

Sample characteristics: The majority of subjects in the analysis sample (n=11,867 or 65%) were from one CHC in Oregon. The two other Oregon CHCs contributed 8.3% (n=1,524) of subjects and 5.8% (n=1,057) of subjects to the analysis sample, respectively. The remaining 21% (n=3,863) of subjects were from the two CHCs in California. Twenty percent of the analysis sample (n=3,576 patients) had no known insurance coverage in 2008 to 2010, 61% (n=11,092) had partial coverage, and 20% (n=3,643) were

Table 4. Demographics of HPV vaccination analysis sample: female patients eligible for HPV vaccination in OCHIN clinics in 2008-2010, overall and stratified by insurance coverage group (n=18,311).

	Total Population		No coverage		Partial coverage		Continuous coverage	
	n	(%)	n	(%)	n	(%)	n	(%)
Total (row percent)	18311	(100.0)	3576	(19.5)	11092	(60.6)	3643	(19.9)
HPV vaccine**								
Initiated vaccine series	4284	(23.4)	502	(14.0)	2635	(23.8)	1147	(31.5)
Completed vaccine series	1528	(8.3)	188	(5.3)	897	(8.1)	443	(12.2)
Age**								
9-12 years	3152	(17.2)	331	(9.3)	1801	(16.2)	1020	(28.0)
13-18 years	7397	(40.4)	1774	(49.6)	4414	(39.8)	1209	(33.2)
19-26 years	7762	(42.4)	1471	(41.1)	4877	(44.0)	1414	(38.8)
Race/Ethnicity**								
NH White	7149	(39.0)	1583	(44.3)	4221	(38.1)	1345	(36.9)
Hispanic	7363	(40.2)	1319	(36.9)	4491	(40.5)	1553	(42.6)
Other	3799	(20.7)	674	(18.8)	2380	(21.5)	745	(20.5)
Poverty Level**								
0% to 99% of FPL	13129	(71.7)	2279	(63.7)	8082	(72.9)	2768	(76.0)
100% of FPL or greater	5182	(28.3)	1297	(36.3)	3010	(27.1)	875	(24.0)

Abbreviations: FPL, federal poverty level. (%) = column percent unless noted otherwise.
**$p<.001$ test for an association between variable and insurance continuity.

continuously covered (Table 4). Among those with continuous coverage for the 3-year study period, 90% had Medicaid, 2% had Medicare, and 8 % had other (mostly private). Among the partially insured group, 73% had Medicaid and 27% had other insurance. Approximately 22% of the partially insured (n=2,431) were covered for 80-99% of the study period, 17% (n=1,901) were covered for 60-79% of the study period, and 16% (n=1,732) were covered for 40-59% of the time. Among the remaining partially insured

Table 5. Prevalence ratios from univariable random intercept log-binomial regression models for HPV vaccine series initiation (n=18,311) and vaccine series completion among initiators (n=4,284) during 2008-2010.

	HPV vaccine series initiation			HPV vaccine series completion		
	n	n (%) initiated	PR (95% CI)	n initiated	n (%) completed	PR (95% CI)
Total	18,311	4284 (23.4)		4284	1528 (35.7)	
Insurance coverage						
Continuous coverage	3643	1147 (31.5)	1.00 (ref)	1147	443 (38.6)	1.00 (ref)
Partially coverage	11092	2635 (23.8)	0.73 (0.69-0.77)***	2635	897 (34.0)	0.84 (0.77-0.92)**
No coverage	3576	502 (14.0)	0.42 (0.38-0.46)***	502	188 (37.5)	0.84 (0.73-0.96)*
Age						
9-12 years	3152	1494 (47.4)	1.00 (ref)	1494	522 (34.9)	1.00 (ref)
13-18 years	7397	2341 (31.6)	0.84 (0.80-0.89)***	2341	879 (37.5)	0.95 (0.86-1.05)
19-26 years	7762	449 (5.8)	0.14 (0.12-0.15)***	449	127 (28.3)	0.75 (0.64-0.89)**
Race/Ethnicity						
NH White	7149	1369 (19.1)	1.00 (ref)	1369	519 (37.9)	1.00 (ref)
Hispanic	7363	1835 (24.9)	1.46 (1.36-1.56)***	1835	630 (34.3)	1.05 (0.95-1.17)
Other	3799	1080 (28.4)	1.34 (1.25-1.44)***	1080	379 (35.1)	0.94 (0.84-1.05)
Poverty Level						
≥100% of FPL	5182	1122 (21.7)	1.00 (ref)	3162	1115 (35.3)	1.00 (ref)
Below 100% of FPL	13129	3162 (24.1)	1.22 (1.15-1.30)***	1122	413 (36.8)	0.94 (0.85-1.02)

Abbreviations: PR, prevalence ratio; CI, confidence interval; FPL, federal poverty level. * PRs and 95% CI are statistically significant at $p<0.05$; ** significant at $p<0.001$; *** significant at $p<0.0001$.

patients 22% (n=2,391) were covered for 20-39% of the time, and 24% (n=2,637) were covered for 1-19% of the time. The average period of coverage among the partially insured was 532 days (SD 331 days) or 49% (SD 30%) of the 3-year study period.

The majority of patients (83%) were age 13 years or older at the index date. The mean age was 18.2 years (SD 4.6 years). The majority of subjects (72%) had a mean household income below 100% of the FPL. Similar proportions of patients were Hispanic (39%) or non-Hispanic White (40%). A total of 4,284 (23%) patients initiated the vaccine series and 1,528 (8%) completed the three-dose series. Vaccine series completion among initiators was 36%. There were significant differences between insurance coverage

groups in the distribution of each of the demographic characteristics and in receipt of HPV vaccine.

Univariable Analysis: *Vaccine Initiation*: Within the analysis sample, vaccine initiation was significantly associated with each of the independent variables. Compared to the continuously insured, the continuously uninsured were less than half as likely (PR 0.42; 95% CI: 0.38-0.46) to initiate the vaccine series (Table 5). Vaccine initiation among the partially insured was also significantly lower than among the continuously insured (PR 0.73; 95% CI: 0.69-0.77). Older subjects were less likely to initiate the vaccine series than younger subjects and the magnitude of the effect grew with increasing age. Compared to the youngest age group (9-12 years), patients in the 13-18 age group were 0.84 (95% CI: 0.80-0.89) times as likely to have received the first vaccine dose, whereas those age 19-26 were 0.14 (95% CI: 0.12-0.15) as likely. Non-White race/ethnicity was positively associated with vaccine initiation. Hispanic subjects were 1.46 (95% CI: 1.36-1.56) times more likely to receive the first dose of the vaccine series than non-Hispanic Whites. Subjects in the non-Hispanic Other race/ethnicity category also had a higher prevalence of initiation (PR 1.34; 95% CI: 1.25-1.44) compared to non-Hispanic Whites. A negative association was observed between household income and vaccine series initiation. Patients with an average household income below 100% of FPL had increased likelihood of vaccine initiation (PR 1.22; 95% CI: 1.15-1.30) compared to patients with higher household incomes.

Vaccine Completion: Significant associations were observed between some independent variables and vaccine series completion in the univariable regression models, but effects were generally weaker than for vaccine series initiation. Insurance

coverage was significantly associated with vaccine series completion. Subjects with partial insurance coverage and subjects with no insurance coverage were less likely to complete the vaccine series than the continuously insured (PR 0.84; 95% CI: 0.77-0.92 and PR 0.84; 95% CI: 0.73-0.96, respectively). Age was also associated with vaccine series completion. Compared to the youngest subjects, those ages 19-26 were significantly less likely to complete the vaccine series (PR 0.75; 95% CI: 0.64-0.89). No significant difference in series completion was observed between 13-18 year olds and the reference group, between the non-White and White subjects, or between subjects with different household incomes.

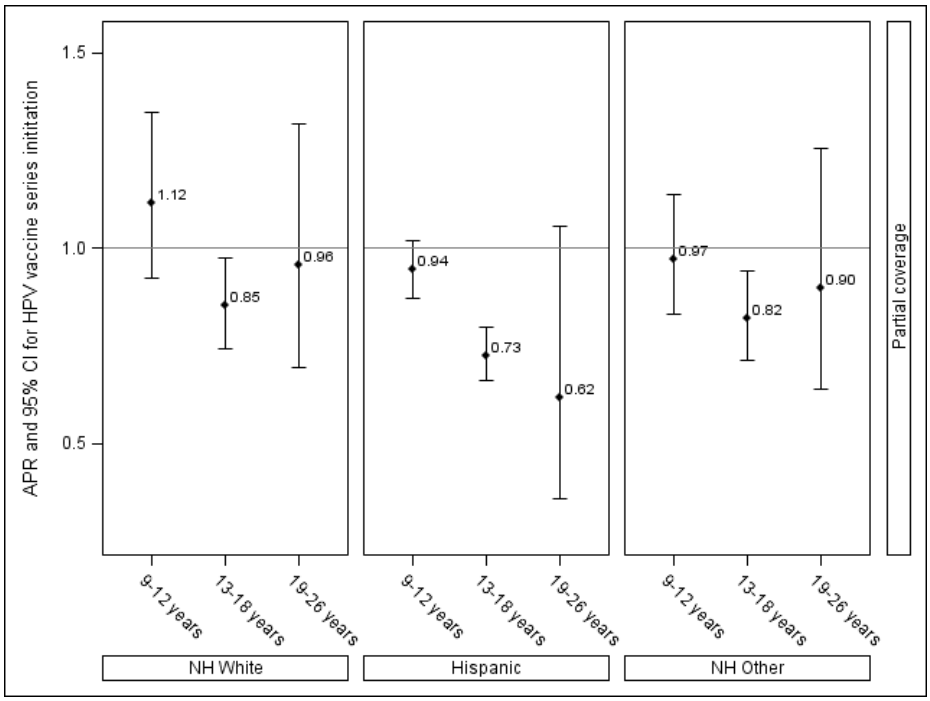
Multivariable Analysis: *Vaccine Initiation*: As in the Pap analyses, adjusted models estimating the prevalence of HPV vaccine series initiation included significant interactions between main effects. The clinic-level random intercept was again found to be highly significant (p <.0001). The final multivariable model contained a clinic-level random intercept, all main effects (insurance coverage status, age, race/ethnicity, and average FPL), three pairwise interactions (age by insurance coverage, age by race/ethnicity, and age by FPL), and one three-way interaction term between age, race/ethnicity and insurance coverage.

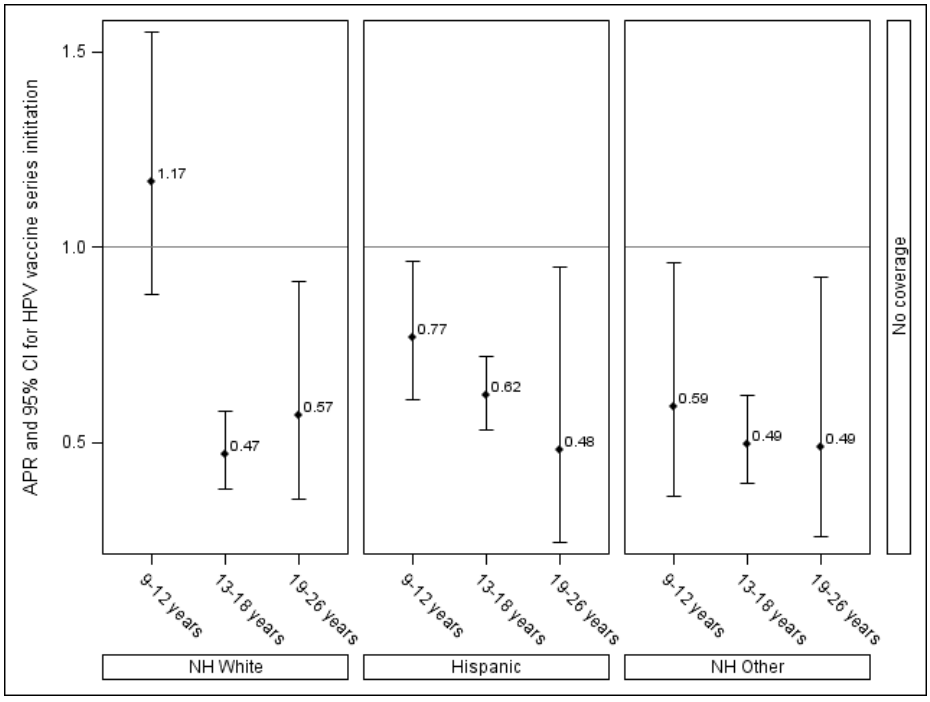
After adjusting for covariates and interactions, insurance coverage was significantly associated with vaccine series initiation, but its effect depended on age and race/ethnicity (Table 6; Figure 2). Among the partially insured, only subjects age 13-18 years were significantly less likely than the continuously insured to initiate the HPV vaccine series. This association held true for Hispanics (APR 0.73; 95% CI: 0.66-0.80),

Table 6. Adjusted prevalence ratio from multivariable random intercept log-binomial regression model for initiation of HPV vaccine series during 2008-2010 (n=18,311).

	n	n (%) initiating	APR (95% CI)
Effect of insurance coverage by age and race/ethnicity			
NH White			
9-12 years			
Continuous coverage	304	101 (33.2)	1.00 (ref)
Partial coverage	560	197 (35.2)	1.12 (0.92 -1.35)
No coverage	143	43 (30.1)	1.17 (0.88 -1.55)
13-18 years			
Continuous coverage	484	176 (36.4)	1.00 (ref)
Partial coverage	1929	528 (27.4)	0.85 (0.74- 0.98)*
No coverage	882	118 (13.4)	0.47 (0.38- 0.58)***
19-26 years			
Continuous coverage	557	45 (8.1)	1.00 (ref)
Partial coverage	1732	136 (7.9)	0.96 (0.69- 1.32)
No coverage	558	25 (4.5)	0.57 (0.35- 0.91)*
Hispanic			
9-12 years			
Continuous coverage	561	325 (57.9)	1.00 (ref)
Partial coverage	873	496 (56.8)	0.94 (0.87- 1.02)
No coverage	129	45 (34.9)	0.77 (0.61- 0.96)*
13-18 years			
Continuous coverage	420	216 (51.4)	1.00 (ref)
Partial coverage	1329	520 (39.1)	0.73 (0.66- 0.80)***
No coverage	447	146 (32.7)	0.62 (0.53- 0.72)***
19-26 years			
Continuous coverage	572	17 (3.0)	1.00 (ref)
Partial coverage	2289	54 (2.4)	0.62 (0.36- 1.06)
No coverage	743	16 (2.2)	0.48 (0.24- 0.95)*
NH Other			
9-12 years			
Continuous coverage	155	89 (57.4)	1.00 (ref)
Partial coverage	368	185 (50.3)	0.97 (0.83- 1.14)
No coverage	59	13 (22.0)	0.59 (0.36- 0.96)*
13-18 years			
Continuous coverage	305	138 (45.2)	1.00 (ref)
Partial coverage	1156	414 (35.8)	0.82 (0.71- 0.94)*
No coverage	445	85 (19.1)	0.49 (0.40- 0.62)***
19-26 years			
Continuous coverage	285	40 (14.0)	1.00 (ref)
Partial coverage	856	105 (12.3)	0.90 (0.64- 1.25)
No coverage	170	11 (6.5)	0.49 (0.26- 0.92)*
Effect of FPL by age			
9-12 years			
100% of FPL or greater	970	472 (48.7)	1.00 (ref)
0 to 99% of FPL	2182	1022 (46.8)	1.00 (0.94- 1.07)
13-18 years			
100% of FPL or greater	1857	523 (28.2)	1.00 (ref)
0 to 99% of FPL	5540	1818 (32.8)	1.15 (1.06- 1.24)**
19-26 years			
100% of FPL or greater	2355	127 (5.4)	1.00 (ref)
0 to 99% of FPL	5407	322 (6.0)	1.11 (0.91- 1.35)

Abbreviations: APR, adjusted prevalence ratio; CI, confidence interval. *APRs and 95% CI are statistically significant at $p<0.05$; **significant at $p<.001$; ***significant at $p<0.0001$. Regression model included a clinic-level random intercept, insurance coverage, age, race/ethnicity, average FPL; three pairwise interactions: insurance coverage by age, age by FPL, and age by race/ethnicity; and one 3-way interaction between age, race/ethnicity and insurance coverage.





Abbreviations: NH, Non-Hispanic; APR, adjusted prevalence ratio; CI, confidence interval.

Figure 2. Summary of adjusted prevalence ratios for initiation of HPV vaccine series by insurance continuity, age, and race/ethnicity. Top panel; partially insured versus continuously insured. Bottom panel; uninsured versus continuously insured.

non-Hispanic Whites (APR 0.85; 95% CI: 0.74-0.98), and subjects of other races/ethnicities (APR 0.82; 95% CI: 0.71-0.94).

Having no insurance was a more consistent risk factor for vaccine initiation. In eight of the nine subject groups defined by age and race/ethnicity, prevalence of vaccine initiation was significantly lower for the uninsured compared to the continuously insured. Among uninsured Hispanic subjects, the estimated likelihood of vaccine initiation declined with increasing age, with 9-12 year olds having an APR of 0.77 (95% CI: 0.61-0.96), 13-18 year olds having an APR of 0.62 (95% CI: 0.53-0.72), and the oldest subjects (ages 19-26) having an APR of 0.48 (95% CI: 0.24-0.95). A similar pattern of association was observed among subjects in the non-Hispanic Other race/ethnicity category. The adjusted prevalence ratio for 9-12 years olds was 0.59 (95% CI: 0.36-0.96), for 13-18 year olds was 0.49 (95% CI: 0.40-0.62), and for 19-26 year olds was 0.49 (95% CI: 0.26-0.92). Among non-Hispanic Whites, the uninsured in the two older age groups were significantly less likely to initiate the vaccine series than the continuously insured (APR 0.47; 95% CI: 0.38-0.58 for age 13-18 years, and APR 0.57; 95% CI: 0.35-0.91 for age 19-26 years, respectively). No significant difference was observed between the uninsured and continuously insured in the youngest White subjects.

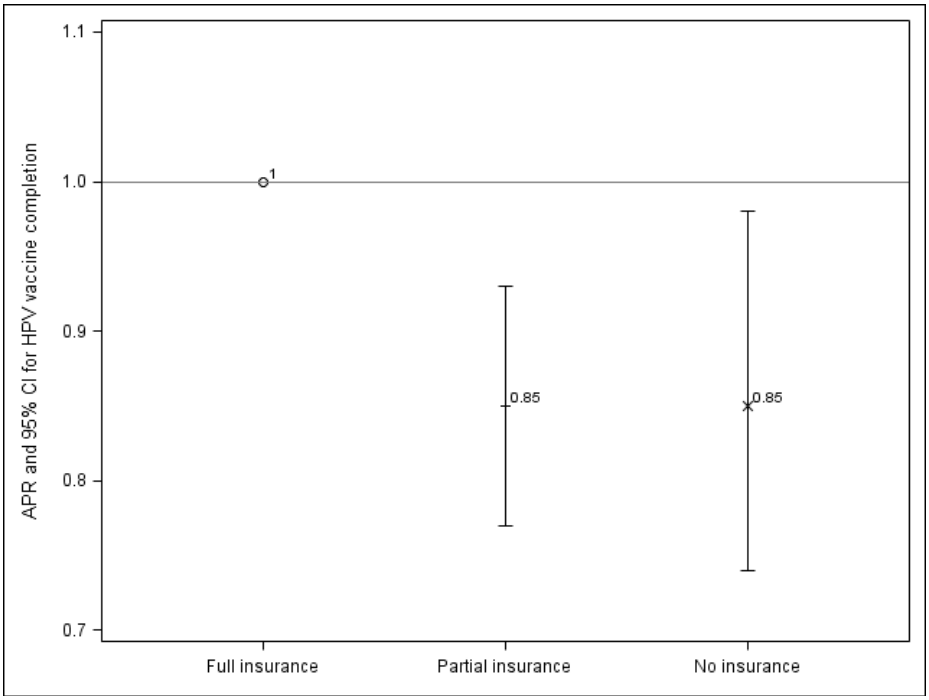
Household income was found to interact with age when adjusted for the other variables in the model. Among subjects ages 13-18, those with lower household income (0-99% of FPL) more likely to initiate the HPV vaccine series that those with higher household incomes (APR 1.15; 95% CI: 1.06-1.24). No association was observed for either of the two remaining age groups.

Table 7. Adjusted prevalence ratios from multivariable random intercept log-binomial regression model for HPV vaccine series completion among vaccine initiators (n=4,284) during 2008-2010.

	n initiated	n (%) completed	APR (95% CI)
Total	4284	1528 (35.7)	
Insurance coverage			
Continuous coverage	1147	443 (38.6)	1.00 (ref)
Partially coverage	2635	897 (34.0)	0.85 (0.77-0.93)**
No coverage	502	188 (37.5)	0.85 (0.74-0.98)*
Age			
9-12 years	1494	522 (34.9)	1.00 (ref)
13-18 years	2341	879 (37.5)	0.96 (0.87-1.07)
19-26 years	449	127 (28.3)	0.77 (0.65-0.91)*

Abbreviations: APR, adjusted prevalence ratio; CI, confidence interval. *APRs and 95% CI are statistically significant at $p<0.05$; ** significant at $p<.001$. Regression model included random intercept (home clinic), insurance coverage and age.

Vaccine Completion: Only insurance and age were significantly associated with vaccine series completion in multivariable models. After adjusting for age, the prevalence of vaccine series completion was lower among both the partially insured (APR 0.85; 95% CI: 0.77-0.94) and the uninsured (APR 0.85; 95% CI: 0.74-0.98), than among the continuously insured (Table 7, Figure 3). Adjusting for insurance status, women in the oldest age group (19-26 years) were significantly less likely to complete the vaccine series than those in youngest age group (APR 0.77; 95% CI: 0.65-0.91).



Abbreviations: NH, Non-Hispanic; APR, adjusted prevalence ratio; CI, confidence interval.

Figure 3. Summary prevalence ratios for completion of HPV vaccine series by insurance continuity adjusted for age.

Chapter 4: Discussion

This study describes the association between health insurance continuity and receipt of cervical cancer preventive services among female patients who accessed care in a network of Oregon and California safety net clinics between 2008 and 2010. Data were gleaned exclusively from electronic health records. Three separate cervical cancer preventive service outcomes were examined, each in a distinct population: 1) receipt of routine Pap screening among 11,560 women ages 21-64; 2) initiation of the HPV vaccine series among 18,311 female patients ages 9-26; and 3) completion of the HPV vaccine series among 4,284 patients who initiated the series.

To my knowledge, this is one of only a few large-scale studies investigating preventive service utilization in CHCs based exclusively on EHR data. The study highlights how EHRs enable surveillance amongst the uninsured and underinsured without resorting to cost- and time-intensive chart reviews or patient surveys. Over 6,000 patients who had no health insurance during 2008-2010 were included in this study, along with almost 15,000 patients sporadically insured over the same period.

4.1 Pap Screening Analysis

The overall prevalence of Pap screening (64%) observed here is lower than reported in survey-based studies such as the 2010 NHIS (83%)[17], 2005 HINTS (90%)[18], the 2008 Oregon BRFSS (80%)[19], and 2010 BRFSS for Oregon (80%) or California(87%)[14]. While not directly comparable to survey data, my results, along with those of others[20–23], provide some evidence that patient self-report overestimate rates of cancer screening. Based on unadjusted estimates, I also found variations in Pap prevalence that appear to contradict findings from survey-based studies[14,17,18]. For

example, routine Pap screening in my study population was more prevalent among Hispanic women (75%) than among non-Hispanic White women (53%), and more prevalent among women with no insurance (68%) compared to the continuously insured (64%). I did, however, find a decline in unadjusted Pap prevalence with increasing age, from 66% for women age 21-39 to 61% for those ages 40-64, which better aligns with previously published survey data.

My findings were more consistent with trends reported in the only other known study that used EHR data to examine receipt of Pap tests among a large cohort of patients seen in CHCs[38]. The prior study, which utilized data from 10 CHCs in Florida, reported unadjusted Pap rates of 36% for non-Hispanic Whites and 64% for Hispanics. Unadjusted Pap compliance was also reported to decline with increasing age, from 61% among women ages 21-30 to 44% among those age 61-64[38]. Interestingly, no difference was reported in unadjusted Pap prevalence for insured versus uninsured women in the Florida study (53% in both groups received a Pap), whereas being uninsured was a positive predictor of Pap compliance in unadjusted estimates from my study population.

While trends in Pap compliance reported here and in the Florida study were somewhat comparable, my unadjusted estimates of screening prevalence were 9% to 17% higher within equivalent age and race/ethnicity categories. The difference in prevalence estimates may reflect the use of different inclusion criteria in the two studies. In my study, to maximize the potential for data capture, only clinics having both practice management and medical record data for the entire study period were included in the analysis, and subjects were limited to those with an established history at each clinic. In contrast, the Florida study did not limit subjects to established patients, and participating

clinics were in differing stages of EHR implementation. Half of the Florida clinics did not have clinical data available for review at the time of the analyses and relied instead on claims and lab interfaces to determine receipt of Pap tests[38]. These differences may have resulted in less complete data capture and underreporting of Pap tests in the Florida study, leading to lower prevalence estimates than reported here. In addition, it should be noted that the Florida study varied from this study in how receipt of care was measured and how populations were defined, which may have also contributed to observed differences in results.

In adjusted models, the association between insurance coverage and receipt of Pap screening was modified by age and race/ethnicity. Compared to being fully insured, being partially insured significantly reduced the likelihood of Pap screening only among non-Hispanic Whites ages 21-39 and Hispanics ages 21-39 in my study population, and the effect was identical in both groups. Partially-insured Hispanic women ages 40-64 also appeared to be at risk for non-screening, although the effect was marginally significant. Compared to the fully insured, partially-insured subjects in the non-Hispanic Other category trended toward a higher likelihood of being screened, although estimates were not significant at the α=0.05 level.

Being uninsured lowered the likelihood of Pap screening more for Whites than for non-Whites. Similar results have been reported previously[73], and other studies have found lower risks of advanced-stage cervical cancer among uninsured and Medicaid-insured Hispanic patients than among similarly insured Whites[74]. Such findings have been interpreted to suggest that minority women are more skilled than White women at accessing free or subsidized screening services offered in safety net clinics[73,74].

Alternatively, the CHCs in my study might have Pap screening programs that are particularly effective at reaching underinsured minorities. For example, it is likely that some or all of the CHCs in this study took part in the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) during 2008-2010, which offers routine Pap screening to underserved and underinsured women. In Oregon, the program provided Pap tests to 18,468 women between July 2006 and June 2011, 29% of whom were Hispanic, 63% who were White, and 99% of whom were ≥ 40 years of age[75]. In California, 57,600 women received a Pap test during the same period, 61% of whom were Hispanic and only 8% of whom were White. Almost 90% of the participating women in California were ≥ 40 years of age[75].

While it was not possible to assess the proportion of patients in my study population who were screened through such programs, it is conceivable that initiatives such as the NBCCEDP reduced or even reversed disparities in screening between insured and uninsured/underinsured women, and between women in different age and race/ethnicity groups, that would otherwise have been evident. Lower Pap compliance among uninsured non-Hispanic White women in my study population may also be indicative of particular access-to-care barriers specific to this group. For example, the non-Hispanic White patients include many recent immigrants from Eastern Europe who have diverse linguistic and cultural backgrounds.

Perhaps the most intriguing finding in my study was that younger Latinas (ages 21-39) who were uninsured had a higher likelihood of Pap screening than their continuously insured peers (APR 1.11; 95% CI: 1.05-1.18). While the effect was modest, this is the only example I am aware of that documents higher Pap screening rates in the

uninsured compared to the fully insured, when controlling for other demographic factors. The result is unlikely to be explained by NBCCEDP participation, since the screening program is aimed almost exclusively at women ≥ 40 years of age. It is possible, however, that the study CHCs may have concurrently participated in state, county, or clinic-led programs that particularly emphasized Pap screening among younger Hispanic women, contributing to the observed findings. For example, the California clinics in my sample may have participated in Family PACT, a program that provides comprehensive family planning services to eligible low-income men and women[76]. Services offered through program include Pap screening which may have been targeted toward, or heavily utilized by, younger Latinas. A more detailed analysis of screening rates by clinic might provide useful insight into factors underlying this result.

Alternatively, the elevated screening rate among uninsured younger Latinas in my study population may be linked to nativity. Rodriguez et al[9] found that, after adjusting for confounding variables, foreign-born status was positively associated with Pap screening and mammography utilization among Latinas in California. Moreover, foreign-born Latinas were found to have disproportionately lower rates of insurance compared to US-born Latinas and non-Latina Whites[9]. If uninsured younger Latinas in my study population were more likely to be foreign-born than their insured peers, such a relationship might explain my findings. Additional research on subpopulations within my sample would be required to identify associations between nativity and screening utilization. While beyond the scope of this study, such work could potentially inform public health strategies to improve Pap utilization rates among the diverse population of women seen in the participating CHCs.

4.2 HPV VACCINATION ANALYSIS

Despite the availability of free vaccinations for Medicaid-enrolled and uninsured children, in my study population the overall proportion of subjects who initiated the HPV vaccine series was only 23%. A meager 8% of the total study population (36% of vaccine initiators) completed the series. While these figures are well below the 70% that is needed for realization of the vaccine's potential to reduce cervical cancer rates[10], and below goals established in Healthy People 2020[16], the results are within the range of values reported in prior studies that utilized clinical, registry, and/or claims based data to examine HPV vaccine uptake in populations comprised mainly of publically insured and uninsured patients[31–33]. As such, the CHC's in my study would appear to be doing no better and no worse in promoting HPV vaccine uptake than similar organizations serving comparable populations around the country.

Unadjusted models of vaccine initiation revealed trends that contradict findings from a similar study that examined multilevel correlates for HPV vaccination in four safety net clinics in Dallas, Texas between 2007 and 2009[35]. In my study population, less than full insurance coverage and older age were both strongly associated with increased risk for non-vaccination, while non-White race/ethnicity was positively associated with increased likelihood of vaccination. In contrast, neither race/ethnicity, age or insurance status were significantly associated with vaccine initiation in the Texas study[35]. Differences in demographic characteristics between the respective study populations could potentially account for the dissimilar results. However, it is worth noting that the Texas study included 700 subjects of whom only 3.1% were uninsured, whereas my study involved 18,311 subjects of whom 20% were uninsured and 60% partially insured.

As such, my study had significantly more power to detect effects associated with insurance coverage and other independent variables.

In adjusted models, age was found to interact with race/ethnicity to modify the effect of insurance coverage on vaccine series initiation. Interactions between age, race/ethnicity and insurance program have been reported previously in a large (n=237,015) study of HPV vaccine series initiation among adolescent girls enrolled in Florida Medicaid programs[31]. In my study population, compared to the fully insured, having partial insurance decreased the likelihood of vaccine initiation only among subjects ages 13-18, although the effect persisted across race/ethnicity categories. This finding is difficult to explain in light of the VCF program, which might be expected to mitigate insurance-related disparities for all subjects <19 years by eliminating cost as a barrier to insurance[35]. The observed results might be explained by additional factors, not considered in my models, which offset the importance of insurance continuity among the youngest age group but not among those ages 13-18. For example, due to regularly scheduled well child visits, 9-12 year olds may have more opportunities for vaccination than girls ages 13-18. In addition, since the 9-12 age-bracket encompasses the recommended age for HPV vaccination, providers might be routinely prompted to offer vaccination to girls in this age group via automated EMR reminders or other clinic-level vaccine scheduling protocols. Also, younger girls are more likely to be accompanied by parents during medical visits, and parents may influence the decision to vaccinate regardless of cost concerns or insurance status. When combined, such factors could conceivably reduce or eliminate insurance-based disparities in vaccine uptake among the youngest age group but not among girls ages 13-18, explaining my results.

The equality of vaccination rates between partially versus fully insured 19-26 olds is also difficult to interpret, but may be attributable to small sample size and infrequency of outcomes, leading to imprecise point estimates and large 95% confidence intervals that rendered results non-significant at the $\alpha=0.05$ level. It is also possible that the type and/or duration of insurance coverage vary with age among the partially insured, contributing to the observed results. Additional analysis, more closely examining patterns of insurance coverage within age groups, may be required to explain this finding. Such analysis was beyond the scope of this study.

Being continuously uninsured was a more consistent risk factor for vaccine series initiation than being partially insured. Compared to the fully insured, being uninsured significantly lowered the likelihood of vaccination in all but the youngest non-Hispanic Whites. While this finding accords with some previous studies[33,36,56,77] and underscores the importance of continuous insurance coverage for cervical cancer prevention in my population, the results may indicate that the VCF program is being underutilized in the CHCs studied here. Additional promotion of the program through public health campaigns might help narrow the gap in HPV vaccine uptake between insured and uninsured girls < 19 years, and ultimately reduce cervical cancer incidence in vulnerable populations. Similarly, a campaign to increase awareness of new insurance options available for young adults via the Affordable Care Act[78] might help reduce disparities in vaccine uptake between insured and uninsured 19-26 year olds.

In my study population, only insurance coverage and age were independently associated with HPV vaccine series completion among those who initiated the series. Subjects with no insurance and those with partial insurance were significantly less likely

to complete the vaccine series than the continuously insured. This finding is important since many HPV vaccine series completion studies have been restricted to insured patients[29,30,32,36,37,57], and studies that do include the uninsured typically have a low number and/or proportion of uninsured subjects, thus limited power to detect associations. My sample of 502 uninsured subjects in the analysis of vaccine series completion was almost 60% greater than the largest sample reported in any of the similar studies I reviewed[33–35,56,77]. With respect to age, subjects in the oldest age group (19-26 years) were significantly less likely than those in the youngest age group (9-12 years) to complete the vaccine series after adjusting for insurance. Similar declines in vaccine completion with age have been reported for women in North Carolina[29] and Maryland[33]. This type of age-related disparity might be expected since the HPV vaccine is recommended at ages 11-12 and women who are further from the recommended age may perceive a decreased potential for protection, especially if they have been sexually active for several years.

4.3 LIMITATIONS

This study provides a unique view into preventive care received by uninsured and underinsured patients in a network of community health centers. However, several limitations should be kept in mind when considering the results. First, study data are restricted to a finite number of OCHIN-affiliated CHCs in Oregon and California. As such, the results represent a user-rate analysis that may not be generalizable to the broader population. While no comparable national database exists to obtain more generalizable data, the results of my Pap analysis showed reasonable correlation with the only other large-scale study in an CHC population based on EHR data[38]. Similarly, the

results of the HPV analysis were within the range reported by other investigators studying similar populations using non-survey data[31–33].

Second, preventive services were identified using automated search algorithms containing commonly used codes and a small percentage of services may have been missed if they were coded differently. The potential for this type of error is thought to be minor since search algorithms used here were based on scripts developed and maintained by OCHIN's Data Services team for the purposes of federal reporting to the Uniform Data System (UDS)[79]. OCHIN's UDS reporting algorithms are validated by manual chart review during development to ensure accuracy and completeness of data capture. The quality of my data could be verified by randomly selecting a sample of study subjects and checking the accuracy and completeness of electronically extracted data to against a manually-abstracted reference standard. While beyond the scope of this study, other investigators who utilized this approach found good to excellent agreement between manual and electronically extracted data, with electronic methods having notably larger case capture[80].

Perhaps more importantly, some of the patients in my study samples may have received cervical cancer preventive services elsewhere. I had no information about Pap screening or HPV vaccination received outside of the OCHIN CHC network. For example, Pap testing is available at free or at reduced cost through organizations such as Planned Parenthood, and HPV vaccination may be accessed through school-based health centers or county health departments in Oregon and California, not all of which are affiliated with OCHIN. Consequently, rates of preventive service utilization reported here may be underestimates. Moreover, my results may be biased if patients more likely to

seek care outside the participating study clinics were disproportionally distributed among the 3 insurance groups. This could potentially explain some of the differences I observed.

While the scale of underreporting could not be readily assessed, I attempted to minimize the possibility by limiting study subjects to established patients, based on the assumption that patients with an established medical home would be less likely to seek routine preventive services elsewhere. This contention is supported by research indicating that having a usual sources of care appears to increase the likelihood of being up-to-date on cervical and breast cancer screenings[49,52,81,82]. Visit data for my analysis sample appear to confirm that study subjects were established patients at the participating clinics. Over 99% of subjects in the Pap analysis had 3 or more visits to participating clinics during the study period. The mean number of visits per subject was 36.1 (SD 36.8), and over 80% of subjects had 10 or more visits in 2008-2010. In the HPV analysis, the mean number of visits during per subject was 5.7 (SD 6.5), and 74% of subjects had two or more visits during the study period. While not as convincing as the Pap visit data, this also suggests that the majority of HPV analysis subjects were established patients at the study clinics, decreasing the likelihood that they would seek care elsewhere.

It is also worth noting that a 2012 report based on data that covers 75% of the commercially insured population, 71% of the Medicaid population and 38% of the Medicare Advantage population in Oregon, estimated that 71% of eligible women received a Pap in the period July 2008 to June 2011[24]. In comparison, the Pap screening among women in my study sample was estimated at 64%. Taking into account that my inclusion criteria were more restrictive (e.g. pregnant women were excluded from the denominator and diagnostic Pap tests excluded from prevalence calculations, both which

would be expected to decrease the screening rate), and differences in the study populations notwithstanding, the similarity of these results suggests that, with respect to Pap tests, underreporting may be relatively minor. OCHIN's service utilization data has also been validated in other studies, indicating that among persons with a Mediciad ID, fewer than 15% of diabetic preventive services were missing from the OCHIN data alone[83]. While delivery of diabetic preventive services is not directly comparable to delivery of cervical cancer preventive services, and my study was not limited to patients with Medicaid IDs, such results also speak to the completeness of the OCHIN dataset. Moreover, fewer services could be expected to be missing from the OCHIN data among the uninsured because persons without coverage have limited options as to where they can access care[83].

Fourth, estimated periods of coverage by private insurance may be unreliable. Unlike Medicare and Medicaid data, which is supplied to OCHIN by the state and includes both a start date and end date for each coverage episode, details pertaining to private insurance are collected by clinic staff at the visit. Since staff practices for collecting and verifying insurance coverage vary widely by clinic, the accuracy of coverage data for private insurance also vary. Allied to this issue, in cases where an end date was missing from data on private insurance, I assumed that the coverage episode lasted 3 months. As a result, the duration of periods of private insurance may have been over- or underestimated, potentially resulting in misclassification of patients by insurance category. Some patients may have been classified into the fully insured group when they were insured for only part of the study period, or vice versa.

To test the potential impact of misclassification, a sensitivity analysis was performed by running multivariable models after excluding any patient who had non-public insurance (i.e. any insurance other than Medicaid or Medicare) during the study period. Applying this filter, the analysis sample for Pap screening dropped from n=11,560 to n=9,685 and the proportion of subjects by insurance status changed as follows: continuously insured increased from 44% to 48% of the analysis sample; partially insured declined from 33% to 28%; and uninsured increased from 23% to 24%. However, adjusted prevalence ratios for receipt of Pap screening by insurance coverage remained essentially unchanged (Appendix 2, Table A2.1).

Repeating the process for HPV initiation, the analysis sample declined from n=18,311 to n=14,508. Within this sample, the proportion of continuously insured increased from 20% to 23%; partially insured declined from 61% to 57%; and uninsured increased from 20% to 21%. The effect on adjusted prevalence ratios for HPV vaccine initiation was again minimal, typically expressed as a small change in the width of the 95% confidence interval, which would be expected as sample size in each patient category declined. However, for several estimates where the original 95% confidence interval approached the null, recalculation excluding non-publically insured patients rendered the result no longer statistically significant (Appendix 2, Table A2.2). Among the partially insured, this change affected non-Hispanic Whites ages 13-18 years (revised APR 1.00; 95% CI: 0.86-1.16) and non-Hispanic patients of other race/ethnicities ages 13-18 years (revised APR 0.94; 95% CI: 0.81-1.10). Among the uninsured, revised APRs became non-significant for Hispanic subjects ages 9-12 (revised APR 0.83; 95% CI: 0.66-1.04) and 19-26 (revised APR 0.52; 95% CI: 0.26-1.04). Sensitivity analysis on the

model for vaccine series completion (Appendix A2, Table A2.3) changed the estimated APR and 95% CI for the uninsured from significant (APR 0.85; 95% CI: 0.77-0.93) to non-significant (APR 0.86; 95% CI: 0.74-1.01). While the sensitivity analysis indicated that my models may be affected by misclassification of patient insurance status, the overall patterns of association remained largely unaltered suggesting that misclassification is not a major concern.

I also estimated household income as percent of FPL based on the average of all recorded data for each patient in the study period. While FPL is supposed to be calculated at each visit, data were frequently missing, so estimated average FPL used in the study may not be representative of actual household income.

Fifth, while regression models included a random intercept to control for inter-class correlation of patients within clinics, the models did not account for organizational differences among the participating clinics that could potentially influence preventive service utilization. Such differences include demographics of staff and providers, clinic participation in national, state, or local prevention programs, scope of services offered, organizational culture, ratio of patients to providers, and geographic location. While beyond the scope of this study, development of models that include such factors may result in improved estimates of Pap and HPV vaccine compliance. Inclusion of other patient-level factors associated with medical history and service uptake may also improve model accuracy and help identify predictors associated with utilization of cervical cancer preventive services.

Finally, this was a cross-sectional study. A causal relationship between insurance continuity and receipt of preventive services cannot be inferred from the data presented.

Despite these limitations, OCHIN's database remains one of only a few such resources that provide a comprehensive record of care for safety net clinic populations. The analyses performed in this study would not have been possible using claims data, which misses services utilized during periods without insurance coverage. Other methods of medical chart abstraction would be impractical given the size of the analytic samples.

4.4 NEXT STEPS

This study highlights how utilization of cervical cancer preventive services in my populations was influenced by the complex interplay between race/ethnicity, age, poverty level, and insurance status. As more FQHCs transition to EHRs, further studies should be conducted to determine whether results are consistent across other geographic areas. Future studies could also be improved by utilizing more precise measurements of insurance continuity and type of insurance, and by linking with utilization data from outside of the FQHC system. Next steps should also seek to leverage the full potential of EHRs by incorporating an expanded list of variables from across the biopsychosocial spectrum. This would help develop a more nuanced understanding of the role of health insurance in Pap screening utilization and HPV vaccine uptake, and inform design of interventions that can reduce disparities and increase overall utilization of cervical cancer preventive services in CHC populations.

4.5 CONCLUSIONS

My results illustrate that while CHCs continue to provide important preventive services to vulnerable patients regardless of their ability to pay, having continuous insurance makes a difference for this population. My findings contribute to the debate on health care reform by providing insight into the impact of insurance continuity on

preventive services receipt. This study also highlights the importance of electronic health records as a tool for population-level health research, the results of which can inform policy and practice to reduce health disparities and improve care in underserved communities.

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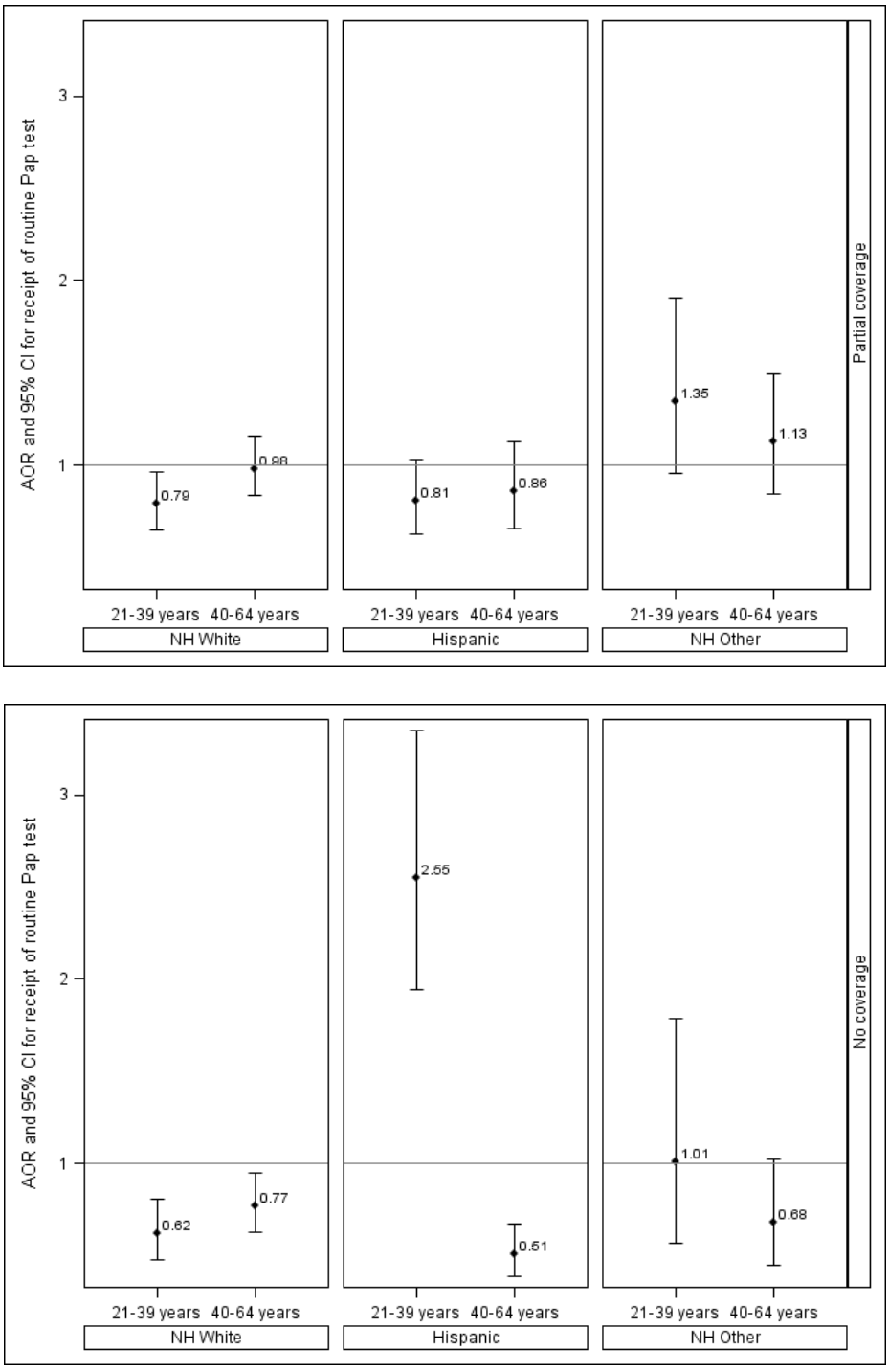
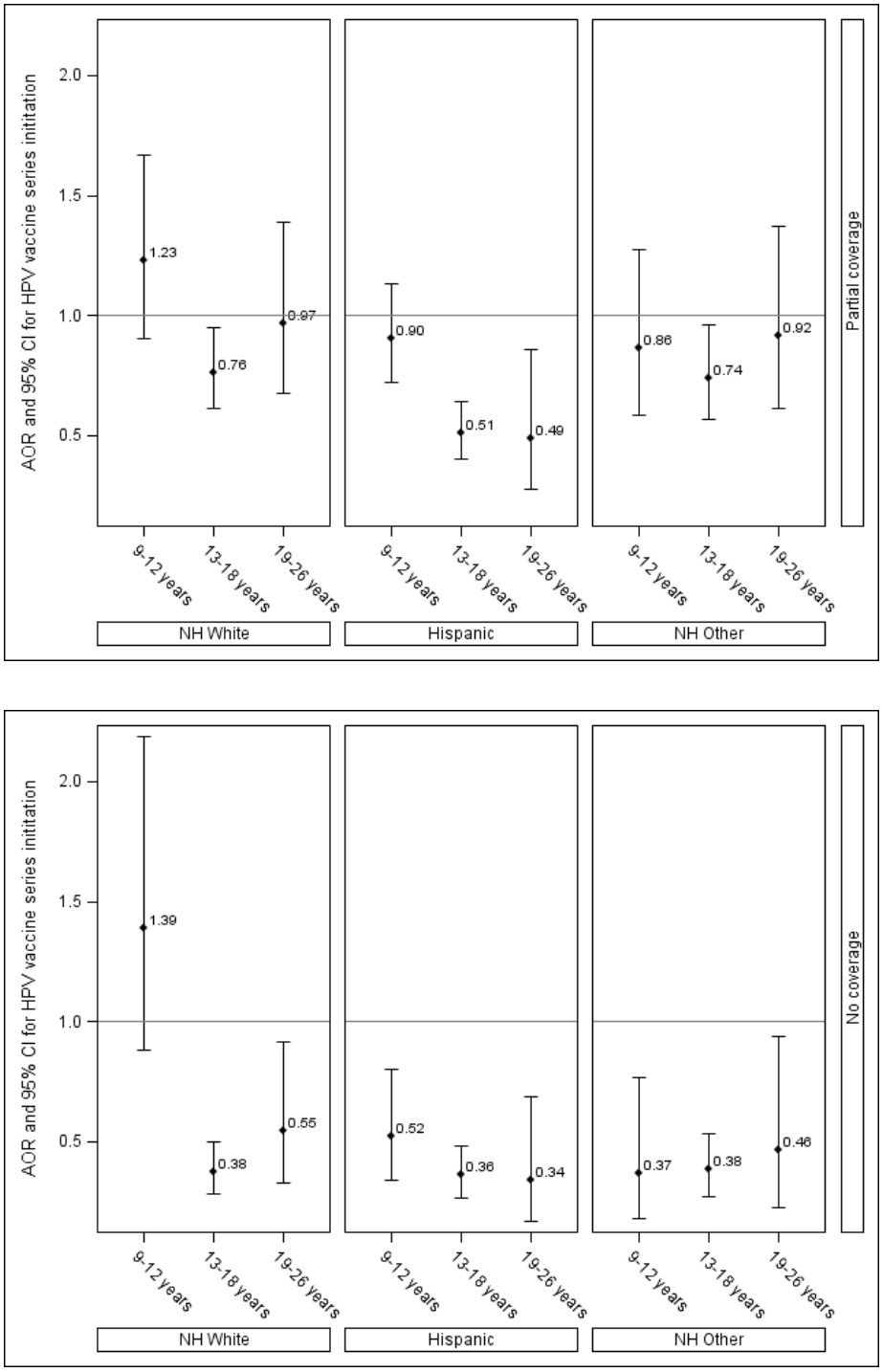
Appendix 1

Selected results from multilevel multivariable logistic modeling for receipt of cervical cancer preventive services. Figure A1.2 shows estimates of adjusted odds ratios for receipt of Pap screening by race/ethnicity and age. Compare to Figure 1 (p.28) showing estimates of adjusted prevalence ratios. Models used to create Figures 1 and 3 were identical with the exception of the link function (log link for Figure 1 and logit link for Figure 3) and estimation method (Laplace for Figure 1, RSPL for Figure 3). Note that although the patterns of association are similar in both models, point estimates in the log link model shrink toward the null and 95% confidence intervals are narrower. Figure A1.2 shows estimates of adjusted odds ratios for HPV vaccine series initiation by race/ethnicity and age. Compare to Figure 2 (p.35). Again, models used to create these figures were identical with the exception of the link function and estimation method.



Abbreviations: NH, Non-Hispanic; APR, adjusted prevalence ratio; CI, confidence interval.

Figure A1.1. Summary of adjusted odds ratios for receipt of a routine Pap test by insurance continuity, age, and race/ethnicity. Top panel; partially insured versus continuously insured. Bottom panel; uninsured versus continuously insured.



Abbreviations: NH, Non-Hispanic; APR, adjusted prevalence ratio; CI, confidence interval.

Figure A1.2. Summary of adjusted odds ratios for initiation of HPV vaccine series by insurance continuity, age, and race/ethnicity. Top panel; partially insured versus continuously insured. Bottom panel; uninsured versus continuously insured.

Appendix 2

Table A2.1. Results of sensitivity analysis for Pap screening. Comparison of adjusted prevalence ratio from multivariable random intercept log-binomial regression models for receipt of routine Pap screening test during 2008-2010.

	Original estimates (n=11,560)	**Sensitivity analysis† (n=9,685)**
Effect of insurance coverage by age and race/ethnicity	APR (95% CI)	APR (95% CI)
NH White		
21-39 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.91 (0.84-0.99)	0.91 (0.83-1.00)
No coverage	0.80 (0.71-0.91)	0.76 (0.66-0.88)
40-64 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	1.00 (0.93-1.07)	1.01 (0.93-1.09)
No coverage	0.88 (0.79-0.97)	0.80 (0.71-0.91)
Hispanic		
21-39 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.91 (0.84-0.99)	0.88 (0.81-0.97)
No coverage	1.11 (1.05-1.18)	1.11 (1.05-1.18)
40-64 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.94 (0.88-1.00)	0.94 (0.87-1.00)
No coverage	0.80 (0.75-0.86)	0.08 (0.74-0.86)
NH Other		
21-39 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	1.09 (0.99-1.20)	1.10 (1.00-1.22)
No coverage	0.98 (0.83-1.17)	1.00 (0.83-1.21)
40-64 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	1.05 (0.95-1.17)	1.08 (0.97-1.21)
No coverage	0.86 (0.72-1.02)	0.85 (0.71-1.03)

†Sensitivity analysis excludes any patient who ever had non-public insurance coverage.

Table A2.2. Results of sensitivity analysis for HPV vaccine initiation. Comparison of adjusted prevalence ratio from multivariable random intercept log-binomial regression models for initiation of HPV vaccine series during 2008-2010.

	Original estimates (n=18,311)	Sensitivity analysis† (n=14,508)
Effect of insurance coverage by age and race/ethnicity	APR (95% CI)	APR (95% CI)
NH White		
9-12 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	1.12 (0.92 -1.35)	1.11 (0.91-1.36)
No coverage	1.17 (0.88 -1.55)	1.15 (0.83-1.60)
13-18 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.85 (0.74-0.98)	1.00 (0.86-1.16)
No coverage	0.47 (0.38-0.58)	0.46 (0.37-0.58)
19-26 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.96 (0.69-1.32)	0.77 (0.54-1.10)
No coverage	0.57 (0.35-0.91)	0.44 (0.25-0.76)
Hispanic		
9-12 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.94 (0.87-1.02)	0.95 (0.88-1.03)
No coverage	0.77 (0.61-0.96)	0.83 (0.66-1.04)
13-18 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.73 (0.66-0.80)	0.74 (0.66-0.82)
No coverage	0.62 (0.53-0.72)	0.60 (0.51-0.70)
19-26 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.62 (0.36-1.06)	0.61 (0.35-1.07)
No coverage	0.48 (0.24-0.95)	0.52 (0.26-1.04)
NH Other		
9-12 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.97 (0.83-1.14)	0.98 (0.84-1.15)
No coverage	0.59 (0.36-0.96)	0.50 (0.29-0.88)
13-18 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.82 (0.71-0.94)	0.94 (0.81-1.10)
No coverage	0.49 (0.40-0.62)	0.50 (0.39-0.64)
19-26 years		
Continuous coverage	1.00 (ref)	1.00 (ref)
Partial coverage	0.90 (0.64-1.25)	0.92 (0.65-1.29)
No coverage	0.49 (0.26-0.92)	0.46 (0.24-0.90)

†Sensitivity analysis excludes any patient who ever had non-public insurance coverage.

Table A2.3. Results of sensitivity analysis for HPV vaccine series completion. Comparison of adjusted prevalence ratio from multivariable random intercept log-binomial regression models for completion of HPV vaccine series among those who initiated during 2008-2010.

	Original estimate (n=4,284)	**Sensitivity analysis† (n=3,552)**
Insurance status	APR (95% CI)	APR (95% CI)
Continuous coverage	1.00 (ref)	1.00 (ref)
Partially coverage	0.85 (0.74-0.98)	0.84 (0.77-0.93)
No coverage	0.85 (0.77-0.93)	0.86 (0.74-1.01)

†Sensitivity analysis excludes any patient who ever had non-public insurance coverage.