Insurance Continuity and Human Papillomavirus Vaccine Uptake in Oregon and California Federally Qualified Health Centers

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Objectives. We examined the association between insurance continuity and human papillomavirus (HPV) vaccine uptake in a network of federally qualified health clinics (FQHCs).

Methods. We analyzed retrospective electronic health record data for females, aged 9–26 years in 2008 through 2010. Based on electronic health record insurance coverage information, patients were categorized by percent of time insured during the study period (0%, 1%–32%, 33%–65%, 66%–99%, or 100%). We used bilevel multivariable Poisson regression to compare vaccine-initiation prevalence between insurance groups, stratified by race/ethnicity and age. We also examined vaccine series completion among initiators who had at least 12 months to complete all 3 doses.

Results. Significant interactions were observed between insurance category, age, and race/ethnicity. Juxtaposed with their continuously insured peers, patients were less likely to initiate the HPV vaccine if they were insured for less than 66% of the study period, aged 13 years or older, and identified as a racial/ethnic minority. Insurance coverage was not associated with vaccine series completion.

Conclusions. Disparities in vaccine uptake by insurance status were present in the FQHCs studied here, despite the fact that HPV vaccines are available to many patients regardless of ability to pay. (*Am J Public Health.* 2014;104:e71–e79. doi: 10.2105/AJPH.2014.302007)

Cervical cancer is a significant public health challenge in the United States. Approximately 12 300 women were expected to be diagnosed with cervical cancer in 2013, and 4030 were expected to die from the disease.[1] The burden of cervical cancer disproportionately affects minority, low-income, and uninsured populations.[2–4] The primary risk factor for virtually all cervical cancer is infection with certain types of human papillomavirus (HPV). Effective vaccines have been developed against HPV-16 and HPV-18, which alone are responsible for approximately 70% of cervical cancer cases.[5–7] These vaccines hold great potential for reducing disparities in cervical cancer morbidity and mortality, if utilization can be encouraged in populations most at risk for cervical cancer.

Federally Qualified Health Centers (FQHCs) serve the primary health care needs of more than 20 million patients in the United States, many of whom are low income, minorities or uninsured,[8] and are thus an ideal setting in which to study the utilization of HPV vaccination among populations at highest risk for cervical cancer.[9] However, few investigators have directly examined HPV vaccination rates in such settings,[9–11] in part because of a lack of readily available data. Consequently, factors affecting HPV vaccine uptake in FQHCs are not well understood. In particular, the role of insurance coverage remains unclear.

To date, studies of HPV vaccination rates in FQHCs have modeled insurance as a static variable, determined at a single visit or at the time services were rendered.[9–11] This approach might be unsuitable when considering the association between insurance and HPV vaccine series completion, which requires multiple visits over several months,[12] and may not accurately reflect the experience of FQHC patients whose coverage can change frequently affecting health care utilization.[13–16] Furthermore, defining insurance status from a single visit prevents consideration of insurance duration or coverage continuity as potential factors influencing vaccine uptake. Among Medicaid enrolled patients, who constitute almost 40% of FQHC patients nationally,[8] duration of insurance enrollment has been associated with HPV vaccine initiation, with longer enrollment being a predictor for initiating the vaccine series.[17,18] Other researchers have demonstrated that, compared with being uninsured or sporadically insured, having continuous insurance coverage is positively associated with the receipt of preventive services in FQHCs, despite the fact that patients can receive care regardless of insurance coverage in these settings.[16,19,20]

Existing studies of HPV vaccination in FQHCs have also been limited to patients younger than 19 years,[9–11] precluding examination of insurance effects across the full age range for which the vaccine is recommended (9–26 years).[12] In FQHC settings, the role insurance plays in vaccine uptake likely differs with age, as HPV vaccine is free for eligible children and adolescents younger than 19 years through the federal Vaccine for Children (VFC) program,[21] but no similar program exists for patients aged 19 to 26 years. A better understanding of how insurance coverage and other factors affect uptake among female FQHC patients aged 19 to 26 years is needed to allow design of future interventions to reduce cervical cancer disparities in underserved populations.

We leveraged electronic health record (EHR) data from a network of FQHCs to examine the association between insurance continuity and HPV vaccination in a large cohort of female patients (9–26 years of age) who accessed care between 2008 and 2010. We hypothesized that HPV vaccine uptake in our study population would be affected by insurance continuity, with lower rates of vaccine series initiation and completion among uninsured and discontinuously insured patients, compared with the continuously insured. We also hypothesized that insurance-related disparities would be most pronounced among

women older than 18 years, who are ineligible for VFC. Our study helps fill a gap in published research by assessing the uptake of HPV vaccine in FQHC patients, including those older than 18 years, and applying EHRs to gather objective longitudinal data on insurance coverage and HPV vaccination rates in this population.

METHODS

We used data from OCHIN, a nonprofit organization that provides a linked, hosted EHR platform for FQHCs. OCHIN started as the Oregon Community Health Information Network for FQHCs in Oregon, but shortened its name to "OCHIN, Inc." when the network expanded into other states.[22] Patients seen at any clinic within the OCHIN network are registered in a central database, allowing administrative and medical records to be shared across all sites. A single immunization table contains data for all vaccines ordered via the EHR, plus any additional immunizations reported by the patient or verified by clinic staff. Clinic staff also access information from statewide immunization registries to supplement information that is manually entered into the EHR. OCHIN member clinics collect patients' insurance coverage information at every visit and verify coverage with insurers, including (where possible) coverage start and end dates.

Using electronic queries, we retrieved individual-level records for female patients who had at least 1 visit at any of 30 FQHC clinics (19 primary care and 11 school-based health centers [SBHCs]) in Oregon and California during the study interval (January 1, 2008–December 31, 2010). These clinics were selected because they had both administrative and clinical records available for the entire study period and represented a diverse sample of clinic types in both urban and rural areas. We limited our analysis to patients who were within the target age range for HPV vaccine (9–26 years) throughout the study interval. We excluded patients who appeared in the data set for only pregnancy-related visits and patients who initiated the HPV vaccination series prior to January 1, 2008.

Outcome Variables

We studied 2 patient-level outcomes: vaccine series initiation (receipt of ≥ 1 dose of vaccine), and series completion (receipt of ≥ 3 doses of vaccine) among patients who initiated the vaccine series. Because some initiators had insufficient time in the study period to receive all 3 doses, we evaluated vaccine completion in the subpopulation of patients who got the first vaccine and had at least 12 months to complete the series.[9]

Vaccination during a visit was determined by evidence in the EHR of (1) a completed order with CPT codes 90649 or 90650, (2) a flag indicating patient-reported receipt of the HPV vaccine with an accompanying immunization date, or (3) a flag indicating verified external administration of the HPV vaccine with an accompanying immunization date.

Independent Variables

The primary independent variable was an individual's health insurance continuity as a percentage of time covered during the study interval, quantified by identifying periods of insurance coverage from the OCHIN database, summing the total number of days with coverage, and dividing by 1094 days (3 years). Patients were placed into 1 of 5 coverage categories: uninsured (0% coverage), insured (100% coverage), or discontinuously insured, split into tertiles by percentage of time covered: 1% to 32%, 33% to 65%, and 66% to 99%. Patients who only had insurance that would not cover HPV vaccination (e.g., workman's compensation) were classified as uninsured. Periods of coverage totaling less than 7 days were not considered true coverage periods. Less than 5% of EHR insurance records for patients in the study were missing end dates for coverage periods. All records with missing end dates were associated with nonpublic insurance. If the end date was missing, coverage was assumed to have lasted 9 months based on the mean duration of nonpublic insurance records with end dates.

Informed by previous studies of factors affecting HPV vaccine uptake,[9,10,23–28] we examined age, race/ethnicity, primary language, household income, and visit frequency as covariables in our analyses. Age was calculated at the date of the first visit where an HPV vaccine dose was provided, or the first visit in the study period if no vaccine doses were administered. Race/ethnicity and primary language were self-reported. Household income, which is collected at the visit-level and expressed as a percent of federal poverty level (according to US Department of Health and Human Services guidelines), was averaged for each patient over all visits in the study interval. Visit frequency for each patient was calculated by summing all visits to participating clinics during the study interval. Patients were also assigned a "home clinic" corresponding to the clinic they used most during the study period.

Statistical Methods

We used 2-level robust Poisson regression with empirical sandwich estimators to calculate unadjusted and adjusted relative risks (expressed as prevalence ratios) for each outcome by insurance status. Robust Poisson models were preferred over logistic models, because the latter can strongly overestimate relative risk when the outcome of interest is relatively common (prevalence ≥ 10%).[29] Patient-level factors were modeled as fixed effects at level 1, and the patients' home clinic was entered as a random intercept at level 2 to control for possible interclass correlation of patients within clinics.[30,31]

To build multivariable models, we included patients' insurance coverage category a priori as the main predictor of interest, along with home clinic as a random intercept. Other variables were selected if they were associated with the outcome in univariable models at the $P < .1$ level and were not highly correlated with each other (e.g. primary language was excluded because of correlation with race/ethnicity). As effect measure modification of HPV vaccine series initiation by age, race/ethnicity, and insurance program type has been previously reported,[18] we also assessed pairwise and 3-way interactions between independent variables in the multivariable model. We used backward stepwise selection with an exclusion level of $P < .05$ to specify the final model. To ensure adequate cell counts, categorical variables were collapsed as necessary and patients with missing observations excluded. With these criteria, we selected the following covariables in the multivariable model for vaccine initiation: insurance coverage, age (collapsed to 3 categories: 9–12,

13–18, and 19–26 years), race/ethnicity (collapsed to 3 categories: non-Hispanic White, Hispanic, non-Hispanic other), visit frequency (continuous), 3 pairwise interactions (insurance coverage by age, age by race/ethnicity, and insurance coverage by race/ethnicity), and one 3-way interaction (age by race/ethnicity by insurance coverage). The process was repeated for multivariable modeling of vaccine completion. In our presentation of univariable and multivariable analysis, we utilize categories employed in the final multivariable models. All analyses were conducted in SAS Enterprise Guide version 9.4 (SAS Institute, Cary, NC).

RESULTS

There were 16 435 female patients in the study population who were evenly distributed by insurance coverage, with roughly 20% of the sample falling in each of the 5 coverage categories (Table 1). In total, 24.2% of patients initiated HPV vaccination and 8.9% completed the vaccine series. The proportion of vaccine initiators and series completers generally increased as percent of time insured increased.

Univariable Analysis

Vaccine initiation. In the univariable models, insurance coverage, age, race/ethnicity, household income and visit frequency were significantly associated with vaccine initiation (Table 2). Uninsured patients and those insured for less than 66% of the study period were less likely to receive dose 1 compared with the insured. Older patients were less likely to initiate the vaccine series than the youngest patients, and the magnitude of the effect grew with increasing age. Non-Hispanic Whites were the least likely to initiate the vaccine series. Patients in households earning less than 100% of the federal poverty level (FPL) had a higher likelihood of vaccine initiation than those with higher household incomes. Each additional visit increased

TABLE 1—Demographics for Female Patients Aged 9 to 26 Years Attending OCHIN-Affiliated Federally Qualified Health Centers in Oregon and California: 2008–2010

	Insurance Category (% of Study Period Insured)				
	0% (Uninsured), No. (%)[a] or Mean ±SD	1%–32%, No. (%)[a] or Mean ±SD	33%–65%, No. (%)[a] or Mean ±SD	66%–99%, No. (%)[a] or Mean ±SD	100% (Insured), No. (%)[a] or Mean ±SD
Total (row percent)	3328 (20.2)	3696 (22.5)	3134 (19.1)	3283 (20.0)	2994 (18.2)
HPV vaccine					
No vaccines documented	2825 (84.9)	3075 (83.2)	2420 (77.2)	2138 (65.10)	1992 (66.5)
Initiated vaccine series	503 (15.1)	621 (16.8)	714 (22.8)	1145 (34.9)	1002 (33.5)
Completed vaccine series	188 (5.6)	170 (4.6)	251 (8.0)	437 (13.3)	423 (14.1)
Age, y					
9–10	59 (1.8)	48 (1.3)	51 (1.6)	182 (5.5)	212 (7.1)
11–12	189 (5.7)	207 (5.6)	212 (6.8)	387 (11.8)	384 (12.8)
13–18	1878 (56.4)	1751 (47.4)	1580 (50.4)	1549 (47.2)	1322 (44.2)
19–26	1202 (36.1)	1690 (45.7)	1291 (41.2)	1165 (35.5)	1076 (35.9)
Race/ethnicity					
Non-Hispanic White	1429 (42.9)	1307 (35.4)	1274 (40.7)	1256 (38.3)	1097 (36.6)
Hispanic	1039 (31.2)	1443 (39.0)	1053 (33.6)	1143 (34.8)	1150 (38.4)
Non-Hispanic Black	332 (10.0)	406 (11.0)	408 (13.0)	540 (16.4)	476 (15.9)
Non-Hispanic API	278 (8.4)	313 (8.5)	203 (6.5)	184 (5.6)	127 (4.2)
Non-Hispanic AIAN	25 (0.8)	30 (0.8)	27 (0.9)	41 (1.2)	33 (1.1)
Missing/unknown	225 (6.8)	197 (5.3)	169 (5.4)	119 (3.6)	111 (3.7)
Primary language					
English	1444 (43.4)	1744 (47.2)	1896 (60.5)	2049 (62.4)	1768 (59.1)
Spanish	685 (20.6)	977 (26.4)	564 (18.0)	686 (20.9)	782 (26.1)
Other	163 (4.9)	381 (10.3)	250 (8.0)	364 (11.1)	311 (10.4)
Missing/unknown	1036 (31.1)	594 (16.1)	424 (13.5)	184 (5.6)	133 (4.4)
Household income					
< 100% of FPL	2090 (62.8)	2414 (65.3)	2342 (74.7)	2362 (71.9)	2184 (72.9)
≥ 100% of FPL	1069 (32.1)	1124 (30.4)	669 (21.3)	750 (22.8)	650 (21.7)
Missing/unknown	169 (5.1)	158 (4.3)	123 (3.9)	171 (5.2)	160 (5.3)
Visits in study period	3.7 ±4.6	6.2 ±6.6	6.2 ±6.9	6.8 ±7.3	6.9 ±7.1

Note. AIAN = American Indian/Alaska Native; API = Asian/Pacific Islander; FPL = federal poverty level (according to US Department of Health and Human Services). χ^2 analysis found significant differences between insurance coverage categories on all of the covariates ($P < .001$). The sample size was n = 16 435.
[a]Column percentage unless otherwise noted.

TABLE 2—Univariable 2-Level Random Intercept Poisson Regression Models for Human Papillomavirus (HPV) Vaccine Series Initiation and Vaccine Series Completion: Oregon and California, 2008–2010

	HPV Vaccine Series Initiation			HPV Vaccine Series Completion[a]		
	No.	Initiated, No. (%)	PR (95% CI)[b]	No. Initiated	Completed, No. (%)	PR (95% CI)[b]
Total	16 435	3985 (24.2)	. . .	3170	1391 (43.9)	. . .
Insurance coverage, %						
100 (insured)	3328	1002 (33.5)	1.00 (Ref)	864	410 (47.5)	1.00 (Ref)
66–99	3283	1145 (34.9)	0.98 (0.87, 1.10)	973	421 (43.3)	0.90* (0.82, 0.98)
33–65	3134	714 (22.8)	0.69* (0.58, 0.82)	549	237 (43.2)	0.88 (0.76, 1.03)
1–32	3696	621 (16.8)	0.47* (0.38, 0.58)	390	151 (38.7)	0.78* (0.68, 0.90)
0 (uninsured)	3328	503 (15.1)	0.43* (0.35, 0.53)	394	172 (43.7)	0.87 (0.75, 1.01)
Age, y						
9–12	1931	1034 (53.5)	1.00 (Ref)	855	410 (47.9)	1.00 (Ref)
13–18	8080	2540 (31.4)	0.72* (0.64, 0.80)	2017	873 (43.3)	0.87* (0.81, 0.94)
19–26	6424	411 (6.4)	0.13* (0.08, 0.23)	298	108 (36.2)	0.73* (0.62, 0.85)
Race/ethnicity						
Non-Hispanic White	6363	1293 (20.3)	1.00 (Ref)	1047	478 (45.7)	1.00 (Ref)
Hispanic	5828	1496 (25.7)	1.47* (1.33, 1.63)	1187	514 (43.3)	1.00 (0.87, 1.14)
Non-Hispanic other	3423	1010 (29.5)	1.32* (1.13, 1.55)	793	345 (43.5)	0.95 (0.81, 1.13)
Missing data/not included in regression model	821	186 (22.7)	. . .	143	54 (37.8)	. . .
Household income						
≥ 100% of FPL	4262	969 (22.7)	1.00 (Ref)	797	367 (46.1)	1.00 (Ref)
< 100% of FPL	11 392	2893 (25.4)	1.20* (1.05, 1.36)	2287	991 (43.3)	0.93* (0.87, 0.99)
Missing data/not included in regression model	781	123 (15.8)	. . .	86	33 (38.4)	. . .
No. of visits in study period (per visit)	16 435	3985 (24.2)	1.02* (1.01, 1.04)	3170	1391 (43.9)	1.03* (1.02, 1.03)

Note. CI = confidence interval; FPL = federal poverty level (according to US Department of Health and Human Services); PR = prevalence ratio.
[a]Includes only patients from denominator with nonmissing data for covariate.
[b]Among initiators who had ≥ 12 mo in the study period to complete the vaccine series.
*$P < .05$.

the likelihood of vaccine initiation by approximately 2%.

Vaccine completion. Among initiators with at least 12 months of follow up time in the study (n = 3170), insurance coverage, age, household income, and visit frequency were significantly associated with series completion (Table 2). Patients insured for 1% to 32% and 66% to 99% of the study interval were less likely to complete the vaccine series compared with insured patients. Older patients were less likely to complete the series than were patients aged 9 to 12 years. Patients with household income less than 100% of the FPL were less likely to complete than those at or above 100% of the FPL.

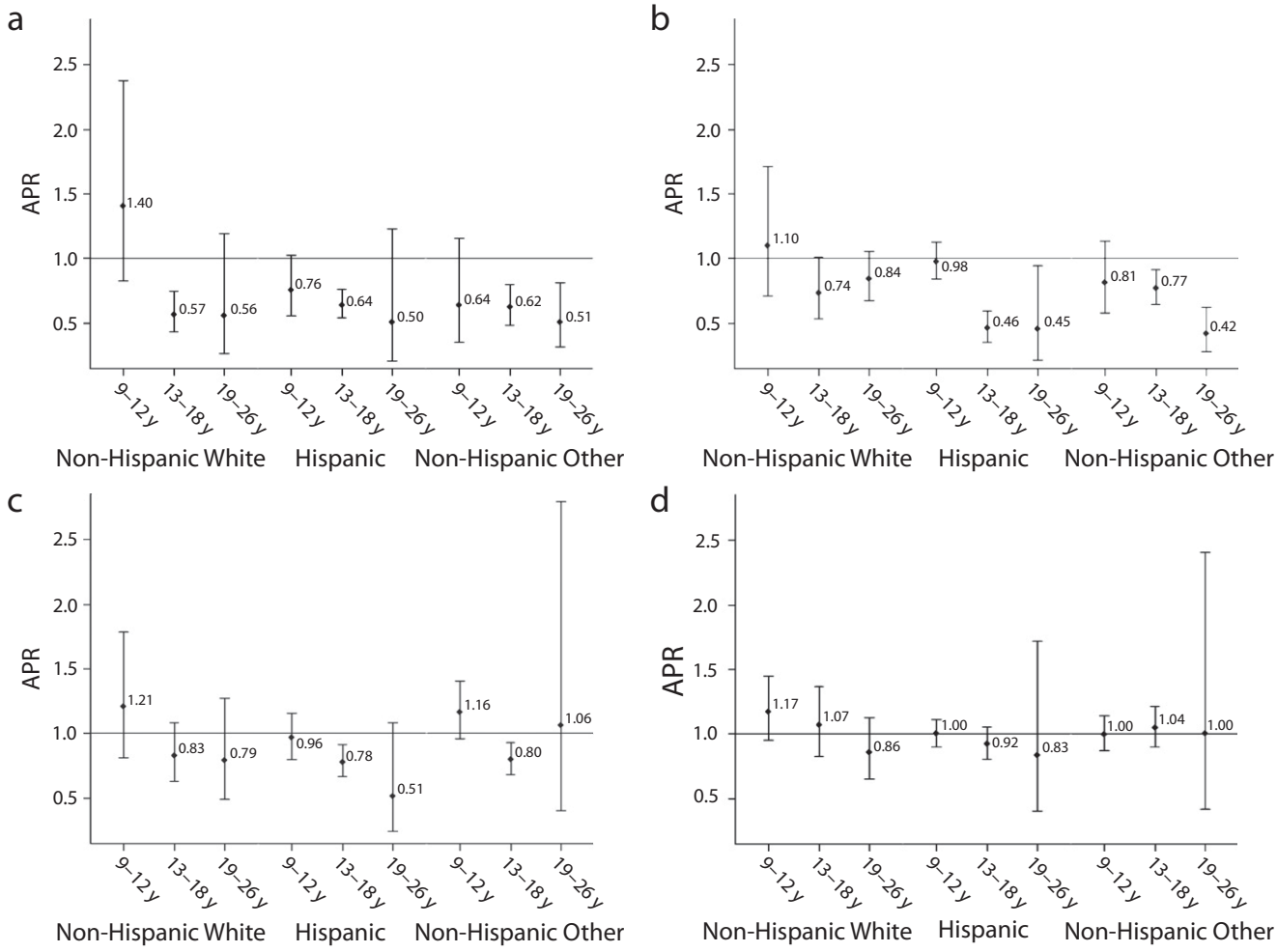
Multivariable Analysis

Vaccine initiation. Given the observed effect modification by age and race/ethnicity, adjusted prevalence ratios (APRs) for HPV vaccine initiation by insurance coverage were presented in subgroups defined by race/ethnicity and age (Figure 1). Five percent of patients (n = 821) of unknown race/ethnicity were excluded, leaving 15 614 observations in the final model. Insurance status was not a significant predictor of vaccine initiation among patients aged 9 to 12 years, regardless of race/ethnicity. Among patients older than 12 years, there was a dose–response relationship between insurance coverage and vaccine initiation, with disparities in vaccine uptake by insurance status diminishing as percent of time covered increased. This dose-response relationship was more pronounced among racial/ethnic minority patients compared with non-Hispanic White patients, and among patients aged 13 to 18 years compared with those aged 19 to 26 years. Patients insured for 66% to 99% of the study interval exhibited no significant difference in vaccine initiation compared with the fully insured, regardless of race/ethnicity or age.

Vaccine completion. The final multivariable model for vaccine series completion included insurance coverage, age, household income, and visit frequency (Table 3). Three percent (n = 86) of patients who initiated the vaccine series and had at least 12 months follow-up were missing income data, leaving 3084 observations in the model. Insurance coverage was not a significant predictor of vaccine series completion ($P = .121$). Older patients were less likely to complete the series than were younger patients, as were patients with household income less than 100% of FPL compared with their wealthier peers.

DISCUSSION

Our results present a complex picture of HPV vaccine uptake in a medically underserved



Note: APR = adjusted prevalence ratio. Whiskers indicate 95% confidence intervals. The model included the following patient-level variables and interaction terms at level 1: insurance coverage, age, race/ethnicity, visit count, insurance coverage by age, insurance coverage by race/ethnicity, age by race/ethnicity, insurance coverage by age by race/ethnicity. Patients' home clinic was modeled as a random intercept at level 2. Only patients with complete observations for all covariables were included in the model. The sample size was n = 15 614.

FIGURE 1—Multivariable 2-level random intercept Poisson regression models for human papillomavirus (HPV) vaccine initiation, by age and race/ethnicity, for 100% insurance coverage vs (a) 0%, (b) 1%–32%, (c) 33%–65%, and (d) 66%–99%: Oregon and California, 2008–2010.

population. Insurance-related disparities in vaccine initiation were observed in this population even though HPV vaccines are available to many patients regardless of insurance coverage status or ability to pay. These disparities varied by patient age and race/ethnicity. For example, racial/ethnic minorities aged13 years or older were particularly at risk for nonvaccination if continuously or predominantly uninsured during the study period. For those younger than 13 years, insurance coverage was not associated with vaccine initiation. We found no association between insurance and vaccine series completion among those who initiated.

Few studies have examined associations between insurance and HPV vaccination in FQHCs. Tiro et al.[9] reported no association between insurance and HPV vaccine series initiation among female patients younger than 19 years in Dallas, Texas. Our results were similar for patients aged 9 to 12 years, but not for those aged 13 to 18 years. With respect to HPV series completion, our findings were consistent with those reported in a previous study of 450 adolescents in Oregon SBHCs,[10] but contrast with an analysis of 17 349 patients aged 12 to 18 years attending SBHCs and community health centers in Colorado, where insurance was found to be significantly associated with vaccine series completion.[11] This variability in findings may reflect methodological differences; our approach of modeling insurance continuity over time, rather than assessing insurance status at a single point, may offer a more realistic and nuanced view of the relationship between insurance and HPV vaccination in our study population. Previous studies also differed in sample size, which affects power to detect associations, and in other design elements (e.g., length of patient follow-up, definition of denominator for calculations), complicating comparison with results reported here.

TABLE 3—Multivariable 2-Level Random Intercept Poisson Regression Model for Human Papillomavirus (HPV) Vaccine Series Completion Among Initiators With at Least 12-Month Follow-Up and Nonmissing Data for All Variables: Oregon and California, 2008–2010

	HPV Vaccine Series Completion, APR (95% CI)
Insurance coverage, %	
100 (insured; Ref)	1.00
66–99	0.92 (0.84, 1.01)
33–65	0.95 (0.81, 1.11)
1–32	0.90 (0.76, 1.06)
0 (uninsured)	1.00 (0.85, 1.16)
Age, y	
9–12 (Ref)	1.00
13–18	0.81* (0.75, 0.87)
19–26	0.58* (0.49, 0.69)
Household income	
≥ 100% of FPL (Ref)	1.00
< 100% of FPL	0.91* (0.85, 0.97)
No. of visits in study period (per visit)	1.03* (1.02, 1.04)

Note. APR = adjusted prevalence ratio; CI = confidence interval; FPL = federal poverty level (according to US Department of Health and Human Services). The sample size was n = 3084.
*$P < .05$.

We hypothesized that, because of their ineligibility for VFC, insurance-related disparities in HPV vaccination would be most pronounced in patients older than 18 years. Although some patients in this age range appeared to have been impacted by lack of insurance coverage, our ability to detect insurance–vaccination effects among patients older than 18 years was constrained by extremely low vaccine initiation (6.4%) in this group. Additional studies are necessary to more accurately characterize vaccine uptake among FQHC patients aged 19 to 26 years.

Vaccine cost is a widely documented barrier to HPV vaccination,[27,28,32–37] and likely plays a significant role in explaining the insurance-related disparities in vaccine uptake we observed. Because cost is a modifiable barrier, HPV-vaccine uptake in FQHCs could potentially be increased via public health campaigns that target vaccine-eligible patients and their caregivers, and highlight different payment options for HPV vaccine. Such options include VFC (for eligible patients younger than 19 years) and new insurance alternatives that may become available to young adults as a result of the Affordable Care Act.[38] Although we were unable to directly assess VFC status in our study population, it is likely that the majority of patients younger than 19 years would meet 1 or more of the eligibility criteria, which include being uninsured, underinsured, or Medicaid eligible.[21]

Compared with national survey data,[39,40] initiation and completion rates were low, suggesting that female patients in this FQHC population face additional barriers to vaccination. A more comprehensive outreach campaign, designed to increase patient and parent awareness of the vaccine, to addresses documented concerns, beliefs and expectations surrounding HPV vaccine, and to provide information on payment options may thus be required to meaningfully increase HPV vaccine uptake in FQHCs.[27,28,32,37,41,42] The fact that disparities in vaccine initiation were concentrated among racial/ethnic minorities in this FQHC population also argues for outreach and awareness efforts to be developed with special attention to specific linguistic or cultural needs of minority patients and their caregivers. Several recent literature reviews examining barriers to HPV vaccination among US adolescents point to the need for providing correct information about the HPV vaccine that addresses both patient and parental concerns in a culturally appropriate manner.[27,28,37] Interestingly, there is some evidence that Hispanic females are more likely than White females to initiate the HPV vaccine if provided access.[43] Future studies are warranted to determine if increased access, such as awareness of the VFC program, would increase vaccination rates in this population of FQHC patients.

Our findings also support the need for clinic-based interventions that could further boost vaccine uptake. We observed declining vaccine initiation rate with age, which could reflect the fact that providers in the study clinics may not have systems in place to remind them to immunize patients outside the optimal age range (11–12 years) for HPV vaccination.[12] Lack of physician recommendation was cited as a common barrier to HPV vaccination among females aged 15 to 24 years in a recent analysis of national survey data[44] and in other studies of vaccine receipt.[27,28,37] Testing interventions that involve expanding EHR vaccination reminders to cover all indicated patients could potentially help providers identify unvaccinated patients. Linking EHRs to external data sources (e.g., state vaccination registries) could maximize data capture and improve the sensitivity and specificity of reminder systems. Improved vaccination reminders could also be leveraged to increase vaccine series completion by promoting patient follow-up for doses 2 and 3 at appropriate intervals. EHR-based interventions could be further augmented by implementing an education program that emphasizes the importance of provider recommendation in HPV vaccine uptake,[27,28,37,44] and offers provider training on how best to engage patients and caregivers in decisions to vaccinate.

Other factors could also contribute to the insurance-related disparities in vaccine uptake we observed. While our multivariable models adjusted for number of visits in the study period, visit timing (e.g., whether a visit occurred during an interval when a vaccine dose was due),[26] visit location (e.g., primary care clinic vs SBHC),[11] and visit type (e.g., vaccine-only vs problem-based visit),[24,26,27] have also been associated with varying HPV vaccination rates and may influence our results if visit-level characteristics differed between insurance groups. Although beyond the scope of this study, further visit-level analysis could

provide additional information on factors affecting HPV uptake in FQHC settings. Visit-level factors may be particularly important for explaining vaccination disparities among patients aged 13 to 18 years, who likely experience a significant decline in regularly scheduled well-child visits as they transition from pediatric to adult care.

Vaccination disparities by insurance status could also result from patients in different insurance categories disproportionately receiving HPV vaccine outside the OCHIN federally qualified health clinic network. Vaccine doses received elsewhere may not be captured in the OCHIN database, resulting in underestimation of vaccination rates for those patients. However, it seems more likely that vaccine doses would be missed for insured patients rather than uninsured or discontinuously insured patients, as the insured potentially have access to a wider variety of health care facilities that can provide vaccinations. As such, the adverse effect of no or discontinuous insurance coverage on HPV vaccine initiation may be underestimated in this study.

Strengths and Limitations

A strength of our study was the large sample size and the high proportion of uninsured or discontinuously insured patients included in the sample. More than 3300 patients who had no health insurance during 2008 to 2010 were included in this study, along with more than 10 000 patients sporadically insured over the same period. A second strength was the use of EHRs as the primary data source. The analyses performed here would not have been possible with claims data, which misses services utilized during periods without insurance coverage. Other methods of medical chart abstraction would be impractical given the sample size. By applying EHR data, we also minimized the potential for recall bias, an inherent drawback of studies based on self-report data.

Our study had several limitations. First, our results may not be generalizable to a non-FQHC population. Second, immunization data were limited to those recorded in the OCHIN database and may be incomplete. We had no access to external immunization registries or records from non-OCHIN clinics, so we could not compare vaccine records. However, previous research has demonstrated the completeness of preventive service records among adult patients in the OCHIN database.[45] In addition, the majority of our results showed reasonable correlation to HPV vaccination rates previously reported for comparable populations (e.g., Medicaid recipients and patients seeking care in safety-net settings).[9–11,17,18] To further test the potential for underreporting, we calculated vaccine completion rates in the subset of patients aged 9 to 18 years who initiated the series and received the majority of their care in Oregon SBHCs. Of these 1083 individuals, 49% received all 3 doses. This result compares favorably to 51% reported by Gold et al,[10] who used immunization registry data to calculate completion rates among Oregon SBHC patients in 2007 to 2008.

Any underreporting would likely concentrate among patients older than 18 years, who potentially have more independence in decisions on where to seek care, and may be more aware of alternative low-cost facilities outside FQHCs, such as sexually transmitted disease clinics, Planned Parenthood, pharmacies and college or university clinics, where HPV vaccine may be accessed. Indeed, among those aged 19 to 26 years, we observed an overall vaccine initiation rate of 6%, roughly 2 to 3 times lower than reported in studies of similarly aged non-FQHC populations[24,26,36,46] and considerably less than the rate we observed for patients aged 18 years or younger (36%). Although the low vaccine initiation rate among older patients may be indicative of underreporting, it could also reflect the fact that older patients in our sample face more, different or heightened barriers to HPV vaccination compared with younger patients[47] attending the same clinics, and compared with similarly aged women who access preventive care in other settings. More importantly, a low initiation rate among older patients does not imply differential underreporting by insurance status, which is of main interest here. Nonetheless, the potential for vaccine underreporting remains a limitation of this study. Future analyses could explore this potential by comparing EHR vaccine records to those of external vaccine registries.

In our analysis of vaccine completion, we excluded initiators with less than 12 months follow-up (n = 815 or 20.4% of all initiators), which may have biased our results if factors associated with vaccine completion were disproportionately distributed between patients excluded compared with those retained. Excluded patients were more likely to be insured for less than 66% of the study period; be 13 years old or older; have household incomes less than 100% FPL; and had lower visit counts than those retained in the analysis, suggesting that any bias would be toward the null.

Potential misclassification of insurance status was another limitation of our study. Periods of insurance may have been missed for some patients, leading to an underestimation of time covered. In the absence of all-claims, all-payer data that could be used to validate insurance records in the OCHIN database, it was not possible to estimate the scale of insurance misclassification. However, given that insurance appears to be a predictor of HPV vaccine uptake, any bias introduced by insurance misclassification would likely be toward the null, and our results would underestimate the effect of insurance coverage on vaccine uptake in this population.

Finally, although a clinic-level random variable was included, regression models did not explicitly account for organizational differences among the FQHCs, such as provider attitudes toward vaccination or clinic participation in cervical cancer prevention programs, or for local or regional vaccination policies that could potentially influence vaccine uptake.[27,28]

Conclusions

Our study was one of only a few focused on HPV vaccine uptake in FQHCs, and the first to include patients older than 18 years. We illustrated how EHR data can reveal complex preventive service utilization patterns in primary care settings with a high proportion of uninsured and discontinuously patients. In this FQHC population, insurance-related disparities in HPV vaccine initiation persist even though vaccines were available to many patients regardless of insurance status. HPV vaccination rates may be improved via education campaigns that raise awareness of the vaccine, address patient and parent concerns regarding vaccination, and highlight vaccine payment options. Targeting such campaigns at patients aged 13 to 18 years, and tailoring content to account for cultural differences, may realize the largest improvement in vaccine uptake

among FQHC patients. In addition, FQHCs could test interventions to improve vaccine reminder systems and encourage provider recommendation of the vaccine. As health insurance reforms take effect, especially Medicaid expansion, future research should also focus on how the rates of HPV vaccine initiation and completion change in FQHC populations. ■

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This article was accepted March 20, 2014.

Contributors

S. Cowburn was involved in study design, compiled the data sets, completed all data analysis, created the figures and tables, was involved in interpretation of the findings, and wrote the initial and final versions the article. J. DeVoe conceptualized and supervised the study, was involved in study design, participated in interpretation of the findings, and helped revise and edit the article. M. Carlson and J. Lapidus were involved in study design, participated in interpretation of the findings, and helped revise and edit the article. S. Bailey and J. Heintzman participated in interpretation of the findings, and helped revise and edit the article.

Acknowledgments

Preliminary results from this study were presented at the 40th North American Primary Care Research Group annual meeting; December 1–5, 2012; New Orleans, LA.

We wish to thank OCHIN and its member clinics for sharing electronic health record data with the authors.

Human Participant Protection

This study was exempted from review by the institutional review board at Oregon Health & Science University (IRB# 00007595).

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