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County-level correlates of missed opportunities for HPV vaccination in Indiana: An environmental scan

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Abstract

Background: The goal of this study was to examine variability across the 92 Indiana counties in missed opportunities for HPV vaccination and to assess county-level correlates of missed opportunities.

Methods: The Indiana immunization registry provided county level data on 2017 missed opportunity rates for adolescents ages 11-18. A missed opportunity was an encounter when a patient eligible for HPV vaccination received one or more other recommended vaccines, but not HPV. Potential county-level correlates of missed opportunities included race, income, insurance

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Declaration of Competing Interest

Sharon Enuijoke has no interest to disclose.

Rivienne Shedd-Steele has no interest to disclose.

Joanne Daggy has no interest to disclose.

Heather Burney has no interest to disclose.

Lisa Robertson has no interest to disclose.

Katharine J. Head has no interest to disclose.

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status, population density, education, primary care providers per capita, smoking rates, mammography screening, diabetes monitoring, and Pap testing.

Results: The missed opportunity rate ranged from 31% to 85% across Indiana counties. Higher population density, mammography screening, income inequality, and diabetes monitoring were associated with fewer missed opportunities.

Conclusions: We found wide variability in missed opportunities across counties, which were associated with population density and county-level participation in other health-related behaviors

Keywords

Vaccination; HPV Vaccination; Health Status; Adolescence; Immunization Surveillance

Human papillomavirus (HPV) is the most common sexually transmitted infection in the United States. An estimated 14 million persons are newly infected every year. HPV is also the primary cause of genital warts and is a major contributing factor in at least six cancers: cervical, vulvar, vaginal, penile, anal, and oropharyngeal. [1]

Currently only one HPV vaccine, the 9-valent vaccine (9vHPV) is available in the U.S. and is licensed by the Food and Drug Administration (FDA) for use in males and females 9 through 45 years of age [2]. The Center for Disease Control's (CDC) Advisory Committee on Immunization Practices (ACIP) recently issued an updated set of recommendations for HPV vaccination.[3] The guidelines continue to indicate that HPV vaccine should be routinely administered to females and males ages 11 and 12 years and that vaccination can start as early as age 9 years. They also recommend routine catch-up vaccination for all females and males from ages 13 through 26 years, with a shared clinical decision-making approach recommended for individuals 27 through 45 years of age.[3] The ACIP currently recommends two doses of vaccine 6-12 months apart if the first dose is administered before age 15 years, with a three-dose recommendation for those who get the first dose at age 15 years or older. [4] The Healthy people 2020 goal is for 80% of adolescents to have completed their HPV vaccination series. In the United States, the HPV vaccination completion rate in 13-17 year olds is 51.1%, lagging behind the Healthy People 2020 goal. [5]

Although Indiana HPV vaccination rates have shown steady progress over the years, initiation of vaccination continues to lag in comparison to the national average. In 2017, when data for the current study were collected, Indiana had a 59.3% initiation rate among adolescents ages 13-17 years, ranking 40th in the United States.[6] In comparison, Indiana ranks in the top ten for administration of the tetanus, diphtheria, pertussis (Tdap; 93.1%) and meningococcal ACWY (MenACWY; 95%) vaccines. The discrepancies in vaccination rates between HPV and Tdap/MenACWY are significant, as Tdap and MenACWY are usually administered at 11-12 years of age, the same age that the ACIP recommends initiating HPV vaccination.[6] There could be several reasons for the discrepancies. For instance, Indiana code IC 20-34-4-2 mandates Hepatitis A, Tdap, and MenACWY for middle school entry (ISDH), but not HPV vaccine.[7] Another reason could be a weak recommendation (or no recommendation) for HPV vaccination from a health care provider (HCP).[8] A missed

opportunity is classified as a health care encounter when a patient eligible for HPV vaccination received one or more other recommended vaccinations, but not the HPV vaccine.[9]

Indiana is made up of 92 counties that vary greatly with respect to population density, access to healthcare, and other sociodemographic factors. A study of HPV vaccination rates across the state of Utah showed that there was substantial variability in missed opportunities, suggesting this may be the case for other states.[10] The purpose of the present study was to similarly document county level variability in missed opportunities for adolescent HPV vaccination in Indiana and to examine county level factors that may be associated with missed opportunities across the 92 counties. The findings from this study can provide important insight into different county characteristics associated with vaccination rates, which could be useful when developing geographically-targeted interventions to improve adolescent HPV vaccination rates.

MATERIALS AND METHODS

This study examined missed opportunities across Indiana's 92 counties for initiating HPV vaccination amongst adolescents 11-18 years of age during the 2017 calendar year. We included age 18 as the upper limit, because the Vaccines for Children (VFC) program covers vaccination through age 18 years. The data were extracted from the Indiana State Department of Health (ISDH) Indiana Immunization Information System (IIS), also known as CHIRP (Children and Hoosier Immunization Registry Program). The Indiana University Institution Review Board made the determination that this study was exempt from review.

MEASURES

The outcome variable of interest, a missed opportunity for HPV vaccination during the 2017 calendar year, was defined as a clinical visit during which an HPV-vaccine-eligible adolescent between the ages of 11-18 received one or more vaccines (i.e., Tdap, MenACWY, Hepatitis A), but not the first dose of HPV vaccine. Since the influenza vaccine is seasonal, receipt of the influenza vaccine was not counted as a missed opportunity. We retrieved county-level adolescent immunization data from CHIRP, which is a secure web-based immunization registry program that permanently stores immunizations records. It is administered by the ISDH, which mandates that all immunization providers enter vaccine administration information for all individuals under the age of 19. No patient-level information (other than age group) or information on race/ethnicity was available through the CHIRP database.

We derived county-specific socio-demographic and health data from two sources: the 2010 U.S Census (<https://www.census.gov/programs-surveys/decennial-census/decade.2010.html>) and the 2018 County Health Rankings report (<https://www.countyhealthrankings.org/>), a program supported by the Robert Wood Johnson Foundation. From the measures available, we selected measures that focused on sociodemographic characteristics and health-related factors, including population density per square mile, percentage rural, primary care providers and mental health providers per capita, dental providers per capita, race, rates of

mammography screening (i.e., percentage of female Medicare enrollees ages 67-69 that receive mammography screening), median household income, income inequality, diabetes monitoring (i.e., percentage of Medicare enrollees with diabetes ages 65-75 that receive HbA1c monitoring), rates of smoking, and parental education. See Table one for a complete list of measures and the source of each measure. Although the mammography screening and diabetes monitoring measures involve older populations, we included them as variables that might indirectly reflect county-level access to care and utilization of health resources.

STATISTICAL METHODS

Descriptive statistics were reported for all covariates and outcomes at the county level. County-level variables considered as potential covariates in this analysis include population density per square quarter mile, percentage of individuals with certain educational attainment levels (i.e., less than a high school diploma, only a high school diploma, some college, or Bachelor's degree or higher), percentage of smokers, percentage of women with mammography screening, median household income, percentage of racial groups (i.e., African Americans, Hispanics, Non-Hispanic Whites), percentage of the county that is rural, income inequality ratio, dentists per capita, mental health providers per capita, percentage of individuals who engage in diabetes monitoring, and total number of primary care providers per 100,000.

Generalized linear mixed models (GLMM) with a binomial distribution and logit link were used to determine county-level covariates that were independently associated with the proportion of missed opportunities for HPV vaccination, while adjusting for the patient-level covariate of age group (11-12 years old vs 13-18 years old). [11] A random intercept for county was included to account for correlation of outcomes from patients in the same county.

For model-building univariable GLMMs were fit, which included age group and each candidate covariate. Odds ratios and associated 95% confidence intervals are reported. Covariates significant at the 0.05 level in univariable models were then included in a multivariable model. The intraclass correlation (ICC) of the outcome was estimated from a model which included only the county-level random intercept and from the full model. From the estimates of the ICC the percent of variability in the county-level proportions of missed opportunities explained by the patient age group and county-level covariates was estimated.

To determine if the effect of the important county-level covariates differed by age group, all two-way interactions between age group and the county-level covariates were then included in the model. The logistic regression model with the final selected county-level covariates was then fit separately by age-group. Odds ratios and the associated 95% profile-likelihood confidence intervals are reported. All analysis was conducted with SAS V9.4 (Cary, NC).

RESULTS

Descriptive statistics of the 92 counties in Indiana is outlined in Table 1. Table 2 provides summary statistics for the proportion of missed opportunities for HPV vaccination for the state of Indiana. There were significant missed opportunities, with 33% of counties having

greater than 66% missed opportunities for receiving HPV vaccination. The mean proportion of missed opportunities for adolescents' ages 11-18 years was 60%, with 57% missed opportunities in the 11-12 age group and 61% missed opportunities in the 13-18 age group (Table 2). The proportion of missed opportunity was significantly higher in children 13-18 years of age vs 11-12 years of age, OR = 1.12, 95% CI = [1.10, 1.14], p-value < 0.0001. From the logistic regression models adjusting for only age group (Table 3), increases in population density (p=.02), mammography screening (p<.0001), income inequality (p=.03), and diabetes monitoring (p=.0006) are significantly associated with less missed opportunities.

Based on the intraclass correlation (ICC) of the intercept-only model (ICC = .07), 7% of the variability in missed opportunities was due to variability between counties. From the full model including interaction terms (ICC = 0.052), only 5.2% of the total variability was due to variability between counties, thus patient age group and county-level factors explained 25.7% of the county-level variability in missed opportunities. The addition of the interaction terms provided an improved model fit compared to the model including only main effects based on the likelihood ratio test (p < 0.0001), thus the effect of these county-level factors on missed opportunities varied by age group.

From the final logistic regression model (Table 4), the two-way interaction terms between each of the four factors and age group were all statistically significant (all p < 0.01). Thus, a separate logistic regression model was fit to each age group including the main effects of population density, mammography screening, income inequality, and diabetes monitoring. For both age groups, lower population density, lower income inequality ratio, and lower percentage of individuals who engage in diabetes monitoring were associated with higher risk of missed opportunities. The odds ratio for population density was smaller for the 13-18 year-old age group indicating a more pronounced association for this age group, whereas the association of income inequality ratio and diabetes monitoring was less pronounced in the 13-18-year-old age group (see Table 5).

For the 13-18 year-old age group, a higher percentage of women with mammography screening was associated with lower risk of a missed opportunity (OR = 0.90, 95% CI = [0.89, 0.92]) which is what we would expect. However, for the 11-12 year-old group, the association was reversed (OR = 1.04, 95% CI = [1.01, 1.07]). In univariable results for the 11-12 year old group, we found that mammography screening was in the direction we would expect (OR = 0.95, 95% CI = [0.92, 0.98]) but not when including the three variables of population density, income inequality ratio, and diabetes monitoring. Thus, we ran additional logistic regression models for this age group by examining the inclusion of each of these variables one at a time with mammography screening. We found that if diabetes monitoring only is included, mammography screening is no longer statistically significant (OR = 1.00, 95% CI = [0.96, 1.03], p-value = 0.766). Thus, mammography screening and diabetes monitoring are highly related in this age group.

DISCUSSION

The findings from this study indicate wide variability in missed opportunities for HPV vaccination across the 92 counties in Indiana, results similar to those reported by Kepka et al., who found extensive missed opportunities across Utah. [10] Although Indiana does not require HPV vaccine for entry into middle school (6th grade), it does require students to receive Tdap, MenACWY, and Hepatitis A vaccines. Therefore, there should be ample opportunities to improve HPV vaccine delivery at the appropriate target age of 11-12 years old.

Keeping in mind that we were only looking at county-level factors, the association between increased mammography screening and diabetes monitoring with less missed opportunities, particularly in the older age group, may reflect county-level issues related to engagement with, and orientation to, health. Even though health care providers per capita was not related to missed opportunities, in sparsely populated counties, it may nonetheless be challenging to access health care. In support of this idea is the finding that counties with lower population density had higher missed opportunities, a result also reflected in NIS-Teen data [5], which show lower vaccine coverage in rural vs. urban areas.

Although 2018 National Immunization Survey-Teen data have shown racial/ethnic disparities in HPV vaccinations (NIS-Teen Supplementary Table 1) [5], this study did not find variability in missed opportunities related to race/ethnicity, which may simply be a reflection of the fact that our analyses could only consider race as a county-level variable (e.g., percentage of African Americans). A lower missed opportunity rate was associated with greater income inequality, which might be attributed to income inequality being higher in urban areas.[12]

The findings from this study are consistent with the framework of Bronfenbrenner's Social-Ecological Model, which considers how factors at the community and societal level can influence relationship-level factors and individual behaviors.[13] We found, for instance, that county-level measures (e.g., population density and engagement in mammography screening) were associated with missed opportunities for HPV vaccination. Although parental beliefs and health care provider recommendation are strong proximal determinants of HPV vaccination, findings from this study suggest that it may be important to consider the ways in which these proximal factors influence, and are influenced by, larger community characteristics.

A strength of this study was the availability of comprehensive vaccination data from the Indiana IIS, which mandates that all vaccine providers submit vaccination records for all persons under 19 years of age. These data enabled us to accurately assess missed opportunities for HPV vaccination at the county level. A limitation of this study was the focus on a single state in the U.S., which limits generalizability of the results to other states. Also, we were constrained by the availability of only county level data, which necessarily limited our ability to identify a full range of potential correlates of missed opportunities. Furthermore, we were not able to obtain a county-level breakdown of missed opportunities

by race or gender. Finally, we could not track follow-up data for individual adolescents to determine if they had received HPV vaccine at a separate clinical visit.

CONCLUSION

This study evaluated missed opportunities for adolescent HPV vaccination across the 92 counties in Indiana. We found wide variability in missed opportunities from county to county, which were associated with population density and county-level participation in other health related behaviors. Findings suggest that interventions designed to improve HPV vaccine coverage may need to consider and target smaller geographic areas. The use of the IIS data set can help identify counties that have high missed opportunities for HPV vaccination, therefore indicating a need for a deeper understanding of the barriers present in each of those counties. This study also reinforces the need to address rural-urban disparities and suggests there is a need to better understand the difference across counties in orientation towards health and access to healthcare.

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Table 1

Descriptive statistics for county-level variables (N = 92).

Variable	Mean $\pm$ Standard Deviation
Population 2010 Census	70.476 $\pm$ 116.748
Density Per Square Mile 2010 Census	11.1 $\pm$ 17.60
Percentage with Less than HS Diploma	12.7 $\pm$ 4.03
Percentage with HS Diploma	39.8 $\pm$ 6.21
Percentage with Some College	28.9 $\pm$ 2.81
Percentage with Bachelors or More	18.7 $\pm$ 8.02
Percentage of Smokers	19.7 $\pm$ 1.95
Percentage with Mammography Screening	60.2 $\pm$ 5.92
Median Household Income (\$)	52,606 $\pm$ 8,525.2
Percentage of African Americans	2.8 $\pm$ 4.46
Percentage of Hispanics	4.0 $\pm$ 3.51
Percentage of Non-Hispanic Whites	90.6 $\pm$ 7.72
Percentage of Rural	54.5 $\pm$ 26.91
Income Inequality Ratio	4.0 $\pm$ 0.47
Dentists Per Capita	39 $\pm$ 17.2
Mental Health Providers Per Capita	87 $\pm$ 71.7
Diabetes Monitoring	85 $\pm$ 6.7
Tout PCP Rate per 100,000	102 $\pm$ 46.3

Table 2

The proportion of missed opportunities summarized across counties by age group.

	Mean $\pm$ Standard Deviation (N = 92)	Median (25th–75th Percentile)	Minimum	Maximum
Missed Opportunities 11–12 Years	0.56 $\pm$ 0.13	0.55 (0.46–0.65)	27%	94%
Missed Opportunities 13–18 Years	0.61 $\pm$ 0.11	0.61 (0.51–0.68)	31%	84%
Missed Opportunities 11–18 Years	0.60 $\pm$ 0.11	0.60 (0.51–0.67)	31%	85%

Table 3

Logistic regression with each effect and age group only.

Effect	Unit Increase	Odds Ratio, 95% CI	p-value	p < 0.05
Density Per Square Mile 2010 Census	100	0.51 [0.29, 0.91]	0.023	*
Percentage with HS Diploma	10	0.91 [0.77, 1.08]	0.275	
Percentage with Some College	10	1.42 [0.99, 2.04]	0.057	
Percentage with Mammography Screening	10	0.72 [0.61, 0.84]	<0.0001	*
Median Household Income (thousands)	10	1.03 [0.91, 1.16]	0.638	
Percentage of African Americans	10	0.84 [0.67, 1.06]	0.142	
Percentage of Hispanics	10	1.01 [0.75, 1.36]	0.926	
Percentage of Non-Hispanic Whites	10	1.10 [0.96, 1.26]	0.161	
Percentage of Rural	10	1.04 [1.00, 1.08]	0.063	
Income Inequality Ratio	1	0.79 [0.64, 0.98]	0.034	*
Dentists Per Capita	10	0.95 [0.90, 1.01]	0.112	
Mental Health Providers Per Capita	10	0.99 [0.98, 1.01]	0.210	
Diabetes Monitoring	10	0.77 [0.66, 0.89]	0.001	*
Total PCP Rate per 100,000	10	0.98 [0.96, 1.00]	0.093	

* Indicates a statistically significant effect.

Table 4

Final multivariable logistic regression model with age interaction terms.

Effect	Estimate	SE	Num DF	Den DF	F Value	p-value
Intercept	4.221	0.805	-	-	-	-
Age Group (13–18)	-0.344	0.209	1	85	2.72	0.103
Density Per Square Mile	-0.001	0.003	1	85	0.58	0.450
Percent Mammography Screening	-0.010	0.008	1	85	4.20	0.043
Income Inequality Ratio	-0.334	0.105	1	85	5.17	0.026
Diabetes Monitoring	-0.024	0.007	1	85	8.48	0.005
Density Per Square Mile * Age Group (13–18)	-0.003	0.0002	1	85	158.92	<0.0001
Percent Mammography * Age Group (13–18)	-0.013	0.002	1	85	53.68	<0.0001
Income Inequality Ratio * Age Group (13–18)	0.198	0.019	1	85	109.37	<0.0001
Diabetes Monitoring * Age Group (13–18)	0.007	0.002	1	85	9.53	0.003

Table 5

Multivariable logistic regression separately by age group (N = 92).

Effect	Unit Increase	Age Group (11–12)			Age Group (13–18)		
		Odds Ratio	95% CI	p-value	Odds Ratio	95% CI	p-value
Density Per Square Mile	100	0.79	[0.76, 0.82]	<0.0001	0.60	[0.59, 0.61]	0.023
Percent Mammography Screening	10	1.04	[1.01, 1.07]	0.021	0.90	[0.89, 0.92]	<0.0001
Income Inequality Ratio	1	0.71	[0.69, 0.74]	<0.0001	0.88	[0.87, 0.89]	<0.0001
Diabetes Monitoring	10	0.72	[0.69, 0.75]	<0.0001	0.77	[0.76, 0.78]	<0.0001