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ORIGINAL PAPER

Rural-Urban Disparities in HPV Vaccination Coverage Among Adolescents in the Central Part of the State of Illinois, USA

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Abstract

Human Papillomavirus (HPV) is associated with six cancers and widespread immunization with HPV vaccine could reduce the number of these cancers. Although HPV vaccination rates are available for the state of Illinois and the city of Chicago, data are limited for specific areas. We assessed rates of HPV vaccine initiation and completion among adolescents in central Illinois and identified factors associated with initiation and completion. This was a retrospective study of adolescents (aged 11–17) who receive care at the Southern Illinois University Medicine Department of Pediatrics. The outcome variables were HPV vaccination initiation (receipt of ≥ 1 dose) and completion (receipt of ≥ 2 or 3 doses, depending on age of initiation). Multivariable logistic regressions were used to identify factors associated with HPV vaccine uptake. A total of 9,351 adolescents were included in the study. Overall, HPV vaccine initiation was 46.2% and completion was 24.7%. In adjusted analyses, adolescents residing in rural areas were 38% and 24% less likely to initiate (aOR = 0.62; 95 CI: 0.54–0.72) and complete (aOR = 0.76; 95 CI: 0.65–0.88) the HPV vaccine compared with those residing in urban areas. Similarly, adolescents were less likely to initiate and complete the HPV vaccine if they were not update to date on the hepatitis A, meningococcal, or Tdap vaccinations. HPV vaccination rates in central Illinois were low, and far below the national average and the Illinois state average. Future directions should include interventions to increase HPV vaccine uptake, particularly in rural areas.

Keywords Human papillomavirus · HPV vaccination · rural/urban disparities · adolescents · Illinois

Introduction

The United States (US) is facing a crisis of human papillomavirus (HPV) infection. Currently, one in four people in the US – nearly 80 million – are infected with a least one type of HPV [1]. There are an estimated 14 million new cases of HPV infection each year in the country, and it is estimated that 80–90% of sexually active people will acquire HPV in their lifetime [2]. Oncogenic HPV infections contribute to virtually all cases of cervical, 90% of anal, 69% of vaginal, 60% of oropharyngeal, 51% of vulvar, and 40% of penile cancers [3] and second primary cancers [4, 5]. HPV infection is associated with nearly 39,000 cancer cases diagnosed in the US per year [1]. Between 2008 and 2012, approximately 6,070 cancers (including cervical, vaginal, vulvar, anal, penile, and oral cancers) were attributable to HPV infection in the state of Illinois [6]. Even though overall cancer incidence has been decreasing in the US, HPV-related oropharyngeal and anal cancers are some

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of the few cancers with increasing incidence [7, 8]. With these figures in mind, the use of routine HPV vaccination as prevention for adolescents is of vital importance.

The Advisory Committee on Immunization Practices (ACIP) recommends routine HPV vaccination for adolescents between 11 and 12 years of age [9, 10]. Catch-up vaccination is also recommended for both males and females aged 13–26 years and shared clinical decision making through age 45 [9, 10]. Despite the efficacy and safety of the HPV vaccine, uptake has been low compared to other routine vaccinations in adolescents and current rates fall short of the *Healthy People 2030* goal of 80% completion among adolescents aged 13–15 years old [11]. The 2020 National Immunization Survey – Teen reported that 75.1% of adolescents aged 13–17 years had received at least one dose of the HPV vaccine and 58.6% had completed the series – either 2 or 3 doses based on age of initiation [12]. As of 2020, HPV vaccination initiation and completion for the state of Illinois was 75.9% (86.3% in the City of Chicago and 73.7% for the rest of the state) and 63.1% (72.3% in the City of Chicago and 61.2% for the rest of the state) [12]. For rural areas, these rates may even be lower. Prior literature has found that HPV vaccination rates and the odds of initiation and completion among adolescents in rural communities were lower than their urban counterparts [13]. Although HPV vaccination rates are available for the state of Illinois and the city of Chicago [12], data are limited for specific areas of the state. With no data on HPV vaccination rates about adolescents in central Illinois, it is crucial to estimate vaccination rates so interventions may be implemented if necessary. This study aimed to quantify the rates of HPV vaccine initiation and completion in an academic medical center located in central Illinois and identify factors associated with vaccine initiation and completion.

Methods

Data collection

The Southern Illinois University School of Medicine Institutional Review Board approved this study. We performed a retrospective study of all adolescents (aged 11–17) who had received at least one dose of childhood recommended vaccines (hepatitis A, hepatitis B, measles, mumps, rubella [MMR], meningococcal, and tetanus, diphtheria, and pertussis [Tdap]) from January 1, 2015, to December 31, 2020, at the Southern Illinois University (SIU) Medicine, Department of Pediatrics, division of Pediatric Primary Care, located in Springfield, IL. The medical center is located in a small urban area and provides access to care for patients from surrounding rural counties. The medical center is also a Vaccines for Children (VFC) provider. Electronic medical records were reviewed, and the necessary data were extracted.

Measures

The outcome variables were HPV vaccine initiation and completion. Adolescents who had received at least one dose of the vaccine were deemed to have initiated the vaccination. In Fall of 2016, the ACIP stated that adolescents who initiated the vaccine at 9–14 years of age need only two doses received 6 months apart [14]. However, those who initiated the vaccine at the age of 15 years or older still need three doses [14]. Based on this recommendation, adolescents who initiated the vaccine before age 15 years and received at least two doses or initiated after age 15 years and received at least three doses were deemed to have completed the series. Independent variables were adolescent age in years, sex (male, female), race (White, Black/African American, other), insurance type (private, Medicaid), rural vs. urban status based on Rural-Urban Continuum codes (RUCCs; rural: RUCC = 4–7, urban: RUCC = 1–3) and a yes/no response to hepatitis A vaccine initiation and completion, hepatitis B vaccine initiation and completion, MMR vaccine initiation and completion, meningococcal vaccination, and Tdap vaccination.

Statistical Analysis

Descriptive characteristics were used to summarize the study sample, overall and stratified by HPV vaccine initiation and completion. Multivariable binary logistic regression models were used to examine the association between independent variables (age, sex, race, insurance type, rural/urban status, hepatitis A vaccine completion, hepatitis B vaccine completion, MMR vaccine completion, meningococcal vaccination, and Tdap vaccination) and HPV vaccine initiation and completion. Odds ratios and their associated 95% confidence intervals were reported for all variables. Statistical tests were two-tailed, and the significance level was set at $P < 0.05$. All analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

Results

A total of 9,351 adolescents were included in the study. There was an equal distribution of age, among females and males, 75.7% were of White race, 56.8% had private insurance and 71.9% resided in urban areas (Table 1). Most adolescents had initiated and completed the hepatitis A and hepatitis B vaccines. Similarly, the majority had initiated the

Table 1 Characteristics of adolescents included in the study (n = 9,351)

	Frequency (%)						
	Overall	**HPV vaccine initiation**		***P*-value**	**HPV vaccine completion**		***P*-value**
		Yes	***No***		***Yes***	***No***	
HPV vaccine initiation	4317 (46.2)						
Yes	5034 (53.8)						
No							
HPV vaccine completion	2313 (24.7)						
Yes	7038 (75.3)						
No							
Age (categorized)	2482 (26.5)	818 (33.0)	1664 (67.0)	< 0.0001	282 (11.4)	2200 (88.6)	< 0.0001
11–12	2712 (29.0)	1296 (47.8)	1416 (52.2)		877 (32.3)	1835 (67.7)	
13–14	4157 (44.5)	2203 (51.0)	1954 (47.0)		1154 (27.8)	3003 (72.2)	
≥ 15							
Sex	4649 (49.7)	2241 (48.2)	2408 (51.8)	< 0.0001	1213 (26.1)	3436 (73.9)	0.0025
Female	4702 (50.3)	2076 (44.1)	2626 (55.9)		1100 (23.4)	3602 (76.6)	
Male							
Race	7077 (75.7)	3238 (45.8)	3839 (54.2)	< 0.0001	1827 (25.8)	5250 (74.2)	< 0.0001
White	1302 (13.9)	738 (56.7)	564 (43.3)		328 (25.2)	974 (74.8)	
Black/African American	972 (10.4)	341 (35.1)	631 (64.9)		158 (16.3)	814 (83.7)	
Other							
Insurance	5311 (56.8)	2727 (51.3)	2584 (48.7)	< 0.0001	1631 (30.7)	3680 (69.3)	< 0.0001
Private	4040 (43.2)	1590 (39.4)	2450 (60.6)		682 (16.9)	3358 (83.1)	
Medicaid							
Rural-Urban status	6724 (71.9)	3631 (54.0)	3093 (46.0)	< 0.0001	1962 (29.2)	4762 (70.8)	< 0.0001
Urban	2627 (28.1)	686 (26.1)	1941 (73.9)		351 (13.4)	2515 (86.6)	
Rural							
Hepatitis A vaccine initiation	5542 (59.3)	3736 (67.4)	1806 (32.6)	< 0.0001	2078 (37.5)	3464 (62.5)	< 0.0001
Yes	3809 (40.7)	581 (15.3)	3228 (84.7)		235 (6.2)	3574 (93.8)	
No							
Hepatitis A vaccine completion	5077 (54.3)	3471 (68.4)	1606 (31.6)	< 0.0001	1984 (39.1)	3093 (60.9)	< 0.0001
Yes	4274 (45.7)	846 (19.8)	3428 (80.2)		329 (7.7)	3945 (92.3	
No							
Hepatitis B vaccine initiation	6822 (72.9)	4212 (61.7)	2610 (38.3)	< 0.0001	2291 (33.6)	4531 (66.4)	< 0.0001
Yes	2529 (27.1)	105 (4.2)	2424 (95.8)		22 (0.9)	2507 (99.1)	
No							
Hepatitis B vaccine completion	6689 (71.5)	4171 (62.4)	2518 (37.6)	< 0.0001	2275 (34.0)	4414 (66.0)	< 0.0001
Yes	2662 (28.5)	146 (5.5)	2516 (94.5)		38 (1.4)	2624 (98.6)	
No							
Meningococcal vaccine initiation	5612 (60.0)	4201 (74.9)	1411 (25.1)	< 0.0001	2295 (40.9)	3317 (59.1)	< 0.0001
Yes	3739 (40.0)	116 (3.1)	3623 (96.9)		18 (0.5)	3721 (99.5)	
No							
Meningococcal vaccine completion	851 (9.1)	714 (83.9)	137 (16.1)	< 0.0001	330 (38.8)	521 (61.2)	< 0.0001
Yes	8500 (90.9)	3603 (42.4)	4897 (57.6)		1983 (23.3)	6517 (76.7)	
No							
Measles, mumps, rubella (MMR) vaccine initiation	6780 (72.5)	4209 (62.1)	2571 (37.9)	< 0.0001	2292 (33.8)	4488 (66.2)	< 0.0001
Yes	2571 (27.5)	108 (4.2)	2463 (95.8)		21 (0.8)	2550 (99.2)	
No							
Measles, mumps, rubella (MMR) vaccine completion	6390 (68.3)	4084 (63.9)	2306 (36.1)	< 0.0001	2227 (34.9)	4163 (65.1)	< 0.0001
Yes	2961 (31.7)	233 (7.9)	2728 (92.1)		86 (2.9)	2875 (97.1)	
No							
Tetanus, diphtheria, and pertussis (Tdap) vaccination	5660 (60.5)	4219 (74.5)	1441 (25.5)	< 0.0001	2292 (40.5)	3368 (59.5)	< 0.0001
Yes	3691 (39.5)	98 (2.7)	3593 (97.3)		21 (0.6)	3670 (99.4)	
No							

meningococcal (60.0%), MMR (72.5%) and Tdap (60.5%) vaccines. Overall, vaccine initiation for HPV was 46.2% and completion was 24.7%. In the unadjusted analyses, there were significant differences between adolescents who had initiated and completed the HPV vaccine, and all independent variables (Table 1).

In the adjusted analyses (Table 2), older age was associated with increase odds of initiating (aOR = 1.19; 95 CI:

Table 2 Logistic regression models estimating HPV vaccination initiation and completion among adolescents (n = 9,351)

	Adjusted OR (95% CI)	
	HPV vaccine initiation	**HPV vaccine completion**
Age (continuous)	1.19 (1.15, 1.23)	1.10 (1.06, 1.13)
Sex	Reference	Reference
Female	0.75 (0.66, 0.85)	0.83 (0.75, 0.93)
Male		
Race	Reference	Reference
White	1.75 (1.43, 2.15)	0.94 (0.80, 1.11)
Black	0.92 (0.74, 1.14)	0.71 (0.58, 0.88)
Other		
Insurance	Reference	Reference
Private	1.10 (0.96, 1.26)	0.64 (0.56, 0.72)
Medicaid		
Rural-Urban status	Reference	Reference
Urban	0.62 (0.54, 0.72)	0.76 (0.65, 0.88)
Rural		
Hepatitis A completion	Reference	Reference
Yes	0.29 (0.25, 0.34)	0.33 (0.28, 0.38)
No		
Hepatitis B completion	Reference	Reference
Yes	0.99 (0.70, 1.39)	0.65 (0.43, 0.99)
No		
Measles, mumps, rubella (MMR) completion	Reference	Reference
Yes	1.15 (0.85, 1.55)	1.01 (0.74, 1.37)
No		
Meningococcal initiation	Reference	Reference
Yes	0.15 (0.10, 0.21)	0.06 (0.03, 0.12)
No		
Tetanus, diphtheria, and pertussis (Tdap)	Reference	Reference
Yes	0.09 (0.06, 0.13)	0.24 (0.12, 0.46)
No		

1.15–1.23) and completing (aOR = 1.10; 95 CI: 1.06–1.13) the HPV vaccination. However, males were less likely to initiate (aOR = 0.75; 95 CI: 0.66–0.85) and complete (aOR = 0.83; 95 CI: 0.75–0.93) the HPV vaccine series compared with females. Adolescents residing in rural areas were 38% and 24% less likely to initiate (aOR = 0.62; 95 CI: 0.54–0.72) and complete (aOR = 0.76; 95 CI: 0.65–0.88) the HPV vaccine respectively compared with those residing in urban areas. Adolescents were less likely to initiate the HPV vaccine if they were not up to date on the hepatitis A (aOR = 0.29; 95 CI: 0.25–0.34), meningococcal (aOR = 0.15; 95 CI: 0.10–0.21) and Tdap (aOR = 0.09; 95 CI: 0.06–0.13) vaccines. Similarly, adolescents were less likely to complete the HPV vaccine if they were not up to date on the hepatitis A (aOR = 0.33; 95 CI: 0.28–0.38), meningococcal (aOR = 0.06; 95 CI: 0.03–0.12) and Tdap (aOR = 0.24; 95 CI: 0.12–0.46) vaccines.

Discussion

The increase in life expectancy in the 20th century is largely due to improvement in child health care especially curing or preventing infections [15]. Currently in United States, the recommendations focus on 17 vaccine-preventable diseases. This study assessed HPV vaccination rates of adolescents in a central Illinois urban county and surrounding rural areas. We found that adolescents in our study had substantially lower HPV vaccination rates than the national average (initiation: 46.2% vs. 75.1%%) and (completion: 24.7% vs. 58.6%) [12]. The vaccination rates in our study were also lower than the average for the state of Illinois [12]. Additionally, adolescents who resided in rural areas and/or had not completed other adolescent immunizations had lower HPV vaccination rates than their urban counterparts and those who had completed their childhood vaccinations, respectively. Findings suggest the continued need for HPV vaccination interventions, particularly in clinics serving patients residing in rural areas.

We found that compared to adolescents residing in urban counties, those residing in rural counties were less likely to initiate and complete the HPV vaccine series. This finding was consistent with other studies that have reported similar findings [13]. There are many theories on the reasons for differences in vaccination rates between rural and urban areas, however, it is likely due to multiple factors including cost, access to health care, transportation barriers, and parental concerns about vaccines for preventing sexually transmitted illnesses [16–18]. The reduction in number of doses require to complete the vaccination might help increase completion

rates as it will reduce some of the barriers like transportation issues and access to care.

Moreover, adolescents who had not completed hepatitis A, meningococcal, or Tdap vaccines were less likely to initiate and complete the HPV vaccination compared to those that were up to date on those vaccinations. This means adolescents are not receiving all the necessary vaccinations that are recommended, including those required for school (meningococcal and Tdap). It should be noted that HPV and hepatitis A are not required for school. This could be due to lack of parental acceptance of vaccines in general and/or provider recommendation of vaccines including the HPV vaccine. Healthcare providers should take every visit as an opportunity to recommend all the childhood vaccinations for patients who are not up to date.

This study has some limitations. First, this study analyzed data from one academic medical center and therefore may not be representative of other areas in the state and nationally. Second, as with many observational studies, there are other variables we could not adjust for such as provider recommendation that could have affected our findings. Third, no causal inference could be made about the findings since this was a cross-sectional study.

Conclusion

We found that HPV vaccination rates among adolescents in central Illinois were very low, and far below the national average as well as the state of Illinois average. In addition, we found that adolescents residing in rural counties were less likely to initiate and complete the HPV vaccine series compared to their urban counterparts. Similarly, adolescents who had not completed other childhood vaccinations (Hep A, Tdap) were less likely to initiate and complete the HPV vaccination compared to those who had completed the series.

Authors' Contributions All authors contributed to the conceptualization and design of the study, data analysis, interpretation of findings, and manuscript drafting and revisions. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Data Availability (Data Transparency) Analytic data will be provided by corresponding author upon request.

Declarations

Conflicts of Interest/Competing Interests All authors report no conflicts of interest.

Ethics Approval Southern Illinois University Institutional Review Board approved this study.

Consent to Participate Since this was a retrospective chart review, informed consent was waived by IRB.

Consent for Publication Not applicable.

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