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ORIGINAL PAPER

The Use of Medical Claims Data for Identifying Missed Opportunities for HPV Immunization Among Privately Insured Adolescents in the State of Iowa

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Abstract

Background Rates of adolescent human papillomavirus (HPV) vaccination remain low, despite decades of safety and effectiveness data. We sought to quantify the extent of missed opportunities (MOs) for HPV vaccination among adolescents ages 11 to 13 in Iowa and compare the number of these MOs by gender and rurality.

Methods Medical claims data from a midwestern insurance provider were used to calculate total numbers of MOs for HPV vaccination for adolescents with continuous health insurance enrollment between ages 11 and 13 (n = 14,505). We divided MOs into several categories: total, among non-initiators, occurring before initiation, occurring after the first dose, and occurring between first and last dose. Finally, we used t-tests to perform subgroup comparisons (urban vs. rural; male vs. female).

Results Over half of adolescents failed to initiate vaccination by age 13. The majority of MOs occurred prior to initiation. Urban adolescents had more MOs than rural counterparts and males tended to have more MOs than females. Females experienced significantly fewer overall MOs than males 5.98 ($SD = 5.49$) compared to 6.18 ($SD = 6.04$) for males. Additionally, among non-initiators, urban females had significantly more MOs overall ($M = 7.13$; $SD = 6.41$) compared to rural females ($M = 6.58$; $SD = 5.51$).

Conclusions Results highlight the extent of MOs that occur at the critical time period between ages 11 and 13. A lack of opportunity was not the barrier to HPV vaccination, particularly among both males and urban adolescents. It will be critical for providers to use known strategies to reduce MOs and utilize all adolescent visits to ensure vaccination is completed by age 13.

Keywords HPV vaccination · Medical claims data · Adolescent health · Immunization

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Introduction

Despite the fact that three vaccines are routinely recommended for adolescents—the human papillomavirus (HPV) vaccine; the Tetanus, diphtheria, and pertussis (Tdap) vaccine, and the meningococcal disease (MenACWY) vaccine—significant gaps in coverage are observed comparing rates for HPV vaccine uptake to those of Tdap and MenACWY. Among 13- to 17-year-olds, 75% initiated the HPV vaccine series, compared with 90% and 89% receiving the Tdap and MenACWY vaccines, respectively [1]. This significant gap between the HPV vaccine and the other vaccines suggests that missed opportunities (MOs) may be a contributing factor. For the purposes of this study, we adapted our definition of MOs from one created for adult MOs for immunizations [2]. We defined MOs for HPV vaccination

as all healthcare visits (preventive and acute care) at which an eligible adolescent who is not fully vaccinated for HPV does not receive recommended vaccine doses.

While the concept of MOs is not new to the vaccination literature, it is understudied for HPV vaccination. These encounters represent critical opportunities for prevention of future disease or progression of current disease and have been measured in many areas of preventive care [3–6], including immunizations [2, 7–9]. Researchers have previously used both immunization registry data [8, 10] and electronic health record (EHR) data [11, 12] to explore MOs. While these data sources provide some insights into this issue, there are important considerations that limit utility for these types of analyses. Registry data is limited in its scope and does not include all types of healthcare visits and EHR data is restricted to a single clinic or, in some cases, a system of clinics.

Medical claims data can offer a nuanced understanding MOs as they provide information on all healthcare encounters that were billed for across both providers and healthcare systems. However, previous studies using claims data to assess MOs have either not used a definition of MOs inclusive of both preventive and acute care visits or limited their analyses to only female adolescents [7, 13]. Therefore, research that includes a more comprehensive definition of what constitutes a MO is needed to address gaps in knowledge about MOs. Given that data show that adolescents have more visits for non-preventive care than for preventive care [14], failing to use a comprehensive definition of MOs does not capture these potential opportunities. To advance our understanding of adolescent HPV vaccination, the primary aim of this analysis was to quantify the number of MOs for HPV vaccination that adolescents experienced between the ages of 11 and 13 using medical claims data. There are significant disparities in HPV initiation and completion rates by gender and rurality [1], thus a secondary aim was to conduct subgroup comparisons by gender and rurality.

Methods

We used individual level data from a large midwestern insurance company for all analyses in this study. This dataset contained longitudinal, administrative claims data and enrollment periods from commercial enrollees. The data were split into two files: the membership enrollment file and the medical claims file. The membership enrollment file contains information on enrollees, including gender, city, state, and enrollment months, while the medical claims file contains information for unique visits including appropriate Current Procedural Terminology (CPT) or International Classification of Diseases (ICD) codes and information about providers. This study was determined not to be Human Subjects' Research by the University of Iowa Institutional Review Board.

Data Cleaning and Preparation

Only adolescents living in Iowa, born between 2001 and 2004, and with continuous insurance enrollment were included to ensure all HPV vaccinations and opportunities for vaccination were accurately captured. This resulted in a dataset containing information for 14,505 unique individuals. To determine HPV vaccine status, we used the CPT codes for HPV vaccines to determine the number of doses of the vaccine (0, 1, 2, or 3) an adolescent had received and when they had received them, including doses that were received prior to age 11 (as the vaccine can be administered as early as age 9). We then removed non-eligible claims using several exclusion criteria. Using a variable indicating place of service, claims that occurred outside the office setting (e.g., in-patient settings, extended care or nursing facilities, lab-visits, or ambulances) were excluded. Additionally, only claims that occurred between 2012 and 2017 were included in this analysis to cover the years during which adolescents in the sample were between ages 11 and 13. We used the city listed when the adolescent first entered the dataset to determine rurality. To be able to assign appropriate Rural Urban Community Area codes (RUCA), we cross-walked the adolescent's city with zip codes to assign each adolescent to a zip code and then used the dichotomous definition of zip code level RUCA codes to determine rurality [15]. Variables for gender and birth year were provided in the claims' data. Full variable definitions are outlined in Table 1.

Missed Opportunity Definition

To identify MOs, first any visits at which a vaccine would not be given due to moderate or severe illness were excluded, which is recommended by the Advisory Committee on Immunization Practices [16]. There is not a standard list of these illnesses, so we solicited input from three primary care physicians who are known HPV vaccine champions to review a list of 197 conditions and indicate at which types of visits they would not administer HPV vaccines. This list was created from a variable included in the data set that assigns the primary reason for the visit, a variable that is based on a review of diagnosis codes to produce clinically meaningful conditions. When two or more providers indicated they would not administer HPV vaccines at a certain visit type, visits for these reasons were then excluded. Further details of this process are available from the corresponding author upon request.

Table 1 Key variable definitions

Variable name	Variable definition
HPV vaccine	Identifies a dose of the HPV vaccine (Current Procedural Terminology codes 90,649, 90,650, 90,651)
Provider type	Includes: general practice, family practice, internal medicine, OB/GYN, pediatrics, a provider at a federally qualified health center, nurse practitioners, or physicians' assistants
Gender	Provided in member data file: male/female
Birth year	Provided in member data file: 2001–2004
Rurality	Determined by city in which the adolescent lived at the first time point they emerged in the dataset. City was cross-walked with zip codes to assign zip code-level Rural–Urban Commuting Area Codes [15]
Missed opportunity	A visit to a provider (belonging to one of the provider types listed in the "provider type" definition above") which an adolescent would be eligible to receive an HPV vaccine
Initiator	An adolescent with at least one dose of the HPV vaccine prior to age 13
Completer	An adolescent with three doses of the HPV vaccine by age 13

Using a previously developed definition [17], we eliminated claims from any provider who would not reasonably be expected to vaccinate adolescents. This primarily included specialists (e.g. cardiologists, oncologists) who may have adolescent patients, but would not be providing them preventive care like immunizations. Provider types considered to be "vaccinating providers" are listed in Table 1. Additionally, visits were eliminated to account for timing and proximity to when other HPV vaccinations were administered. We defined completion as three doses for the purposes of these analyses. For adolescents who completed the series, any visits after the third dose were eliminated. For adolescents with one or two doses, visits that fell prior to the time that the next shot in the series is recommended to be administered were excluded (within 28 days of the first shot and within 84 days of the second shot).

The last step was to split MOs into various categories based on when in the vaccine series they occurred. First, overall MOs were calculated, then the sample was split into non-initiators, initiators who did not complete the series, and completers. Total MOs were then calculated for non-initiators, which included all visits between ages 11 and 13. Among initiators, three separate categories of MOs were calculated: (1) prior to initiation, (2) after the first dose for non-completers (adolescents with either one or two doses of the vaccine), and (3) between first and last dose for completers.

Data Analysis

All analyses were completed using SAS 9.4 (SAS Institute, Cary, NC). We calculated frequencies and percentages for all categorical variables and means and standard deviations for continuous variables. All other analyses consisted of independent sample *t*-tests to compare differences in numbers of MOs between subgroups. We set the alpha level for all these pre-planned *t*-tests at 0.05.

Results

Study Population

Table 2 contains demographic information on adolescents included in this sample (n = 14,505) stratified by gender, rurality, and HPV vaccine initiation status. Just over half of the adolescents had a zip code in an urban area. Both initiation and completion rates were low in this population. For both males and females, the majority of the sample did not initiate the series by age 13 and only 16.8% of females and 11.4% of males completed the series (defined as three doses by age 13).

Missed Opportunities

Overall, adolescents experienced between 5 and 6 MOs between ages 11 to 13. For those who initiated the series, just over half of these MOs occurred prior to the first dose of the series. Once initiating the series, adolescents experienced, on average, less than two MOs. Among non-initiators, adolescents experienced approximately 7 MOs between ages 11 and 13.

In all MO categories, urban adolescents had a higher number of MOs compared to rural adolescents, though not all differences were statistically significant. Among females, overall, urban females who did not initiate the series had significantly more MOs than their rural counterparts (Table 3). Additionally, among those who completed the series, urban females had significantly more MOs between their first and last dose, compared to rural females. Among males, a significant difference for

Table 2 Demographic characteristics of sample (N = 14,505)

Female							
Birth Year	n	Urban n (%)	Rural n (%)	Non-initiators[a] n (%)	Initiators[b] n (%)	Completers[c] n (%)	Age at initiation Mean (SD)
2001	1957	991(50.6)	966(49.4)	1253(64.0)	427(21.8)	277(14.2)	12.55(0.71)
2002	1875	1001(53.4)	874(46.6)	1063(56.7)	517(27.6)	295(15.7)	12.26(0.72)
2003	1666	914(54.9)	752(45.1)	846(50.8)	497(29.8)	323(19.4)	12.27(0.72)
2004	1578	862(54.6)	716(45.4)	651(41.3)	637(40.4)	290(18.4)	12.21(0.71)
Total	7076	3768(53.3)	3308(46.8)	3813(53.9)	2078(29.4)	1185(16.8)	12.32(0.71)
Male							
2001	2041	1046(51.3)	995(48.8)	1526(74.8)	345(16.9)	170(2.3)	12.29(0.70)
2002	1927	1023(51.9)	949(48.1)	1339(67.9)	431(5.8)	202(10.2)	12.31(0.75)
2003	1736	922(53.1)	814(46.9)	1052(60.6)	436(25.1)	248(14.3)	12.30(0.72)
2004	1680	870(51.8)	810(48.2)	826(49.2)	624(37.1)	230(13.7)	12.28(0.74)
TOTAL	7429	3861(52.0)	3568(48.0)	4743(63.8)	1836(24.7)	850(11.4)	12.30(0.73)

[a]Non-initiator: adolescents with no doses in the HPV vaccine series by age 13

[b]Initiators: adolescents with one or two doses in the HPV vaccine series by age 13

[c]Completers: adolescents with three doses in the HPV vaccine series by age 13

Table 3 Missed Opportunities (MOs) for Female and Male Adolescents, Ages 11–13 (n = 14,505)

	Females (n = 7076)				Males (n = 7429)			
		Urban	Rural			Urban	Rural	
MO category	n	Mean (SD)	Mean (SD)	P value	n	Mean(SD)	Mean(SD)	P value
Total MOs	7076	6.09 (5.77)	5.85 (5.13)	.06	7429	6.26 (5.70)	6.10 (6.40)	.25
MOs for non-initiators	3813	7.13 (6.41)	6.58 (5.51)	.005	4743	6.76 (5.60)	6.41 (6.46)	.04
MOs prior to initiation	1898	3.65 (3.92)	3.56 (3.64)	.51	2686	4.09 (5.03)	4.05 (5.33)	.85
MOs after dose 1 for non-completers	2078	1.65 (2.68)	1.53 (2.32)	.26	1836	1.67 (2.69)	1.55 (2.45)	.32
MOs between first and last dose (completers)	1185	1.03 (1.84)	0.68 (1.14)	< .001	850	0.92 (1.45)	0.48 (1.00)	.49

Table 4 Comparing Missed Opportunities (MOs) Male and Female Adolescents, ages 11–13 (n = 14,505)

	Female		Male	
MO category	n	Mean (SD)	Mean (SD)	P value
MOs overall	14,505	5.98 (5.49)	6.18 (6.04)	.03
MOs for non-initiators	8556	6.84 (5.97)	6.58 (6.06)	.04
MOs prior to initiation	5949	3.62 (3.81)	4.07 (5.15)	< .0001
MOs after dose 1 for non-completers	3914	1.60 (2.53)	1.62 (2.59)	.83
MOs between first and last dose (completers)	2035	0.89 (1.61)	0.95 (1.72)	.39

non-initiators was also observed, again with urban males having significantly more MOs than rural males.

The comparison of males and females also revealed several important differences. Overall, females had significantly fewer MOs compared to males (Table 4). Among initiators, this same pattern held, with females having significantly fewer MOs compared to males. However, among non-initiators, females had significantly more MOs compared to males (Table 4).

Discussion

This study explored the extent of MOs for HPV vaccination among adolescents in Iowa, aged 11 to 13, finding that adolescents experienced approximately 6 MOs during this three year time period. Our findings indicate substantial opportunity to improve HPV vaccine delivery. While previous studies have explored MOs for HPV vaccination in more limited capacities [7, 8, 11–13], this study used medical claims data offering a fuller picture of healthcare utilization and a more comprehensive definition of MOs, which included both acute and preventive care visits. The results from this study provide important insights into the extent of MOs for HPV vaccination and when they occur.

In looking at the data overall, some clear patterns emerged. For males and females in both urban and rural areas, the total number of MOs ranged from about 6 to 7, with most of these MOs occurring either prior to initiation of the series or among non-initiators. The sheer number of MOs at earlier ages among adolescents in this sample suggest ample opportunities to improve HPV vaccine delivery by vaccinating earlier. There are several ways in which the results from this study are similar to what has been found in previous research on MOs for HPV vaccination. For example, two studies using immunization registry data found that many adolescents had MOs before initiation [8, 10]. Another study using medical claims data for females aged 11 to 26 found that their study population had a median of 13 MOs in that age range and that more than half of the sample had a MO that occurred at a non-vaccine visit [13].

An unexpected finding of the study presented here is that when significant differences were observed, rural adolescents tended to have fewer MOs than their urban counterparts. This finding is not consistent with existing MO literature. In an analysis of state immunization registry data, Kepka and colleagues found that rural adolescents were more likely to have MOs than urban ones, although they did not calculate the total number of MOs per adolescent [8]. One explanation for this could be that rural adolescents have more limited access to healthcare or quality healthcare [18], and simply have fewer visits overall, which would translate to fewer MOs. Another explanation could be attributed to having a usual source of care. Rural residents are more likely to have a usual source of care than those living in urban areas [19]. Several studies have found that having a usual source of care is associated with increased utilization of preventive health services [20, 21]. Thus, it is plausible that consistently seeing the same healthcare provider may decrease the number of MOs that rural adolescents experience.

Administering HPV vaccines during all visits at which adolescents are eligible could significantly increase vaccination rates and there are evidence-based interventions that could help clinics and providers to do so [22, 23]. The focus of this work should be on adolescent populations given that the vaccine is most effective when completed prior to an adolescent's 13th birthday. In this sample, by the age of 13, less than one-fifth of adolescents had completed the series. Recently, the recommendation for the HPV vaccine has changed to be a two-dose series, with limited evidence finding a single dose to be sufficient [24]. However, many adolescents in this sample did not initiate the series by age 13, indicating that even with the change to a two-dose series, MOs are still a substantial problem. Vaccinating at younger ages is proven to lead to on-time completion of the series and result in stronger protection against HPV-related cancers [25, 26]. Thus, while these adolescents may have been vaccinated in their later teenage years, this is not the ideal circumstance and could have been prevented given that they were seen by providers many times.

Strengths and Limitations

The primary strength of this study is the use of medical claims data. While immunization registries, EHR data, and national surveys provide a broad picture of the vaccination landscape, medical claims data provides individual-level information that captures all billed-for medical encounters. Another strength of this study is the incorporation of physicians' feedback to form the definition of MOs. Their input increases the likelihood that these results can directly inform clinical practice. Despite these strengths, there are some limitations to acknowledge. First, the inclusion criteria may limit the generalizability of these results. The sample was limited to adolescents living in Iowa with continuous insurance enrollment with a particular insurance provider, therefore, this sample may not be representative of adolescents who have gaps in their healthcare coverage or have other types of health insurance (e.g. public insurance). Secondly, a limitation inherent in all medical claims data is the lack of information about other contextual factors of an encounter with a provider. Relevant to this analysis, claims data does not provide information on whether the HPV vaccine was recommended by the provider or if the vaccine was refused by the parent. Thirdly, it is possible that adolescents received HPV vaccinations not paid for by this insurance provider (e.g. paid for by the Vaccines for Children program) and those would not be captured in this analysis. While this is a concern, due to our inclusion criteria of continuous enrollment, it is likely that there would be few vaccines paid for outside of this insurance provider. Finally, it is important to recognize that while there were statistically significant subgroup differences, we did not assess their clinical significance. Our results show that both rural and female adolescents tend to have fewer MOs, suggesting that providers and researchers may want to focus on urban or male adolescents in particular.

Conclusions

Overall, results from this analysis indicate that MOs are a widespread problem, and along with data from other studies [8, 12, 13], suggest that this is not unique to this population of adolescents. In addition to the importance of knowing overall vaccination rates, understanding when adolescents are not being vaccinated is equally, if not more important in efforts to improve vaccine delivery. Results from this analysis indicate a lot of opportunity for improvement and have important implications for providers serving adolescent populations, as well as researchers working in the field of adolescent immunization. Providers could be taking greater advantage of all adolescent visits as opportunities to vaccinate. This is particularly important in light of the COVID-19 pandemic, during which we have observed drastic drops in all adolescent vaccination [27]. Given that many adolescents included in this analysis had upwards of 6 clinic visits during the critical age of 11 to 13, increased attention to implementing provider-focused interventions that can help encourage vaccination during every visit is needed to reduce MOs and make up for the low vaccination rates in the past two years due to the ongoing pandemic.

Authors Contributions Dr. Ryan conceptualized and designed the study, carried out the analysis, drafted the initial manuscript and reviewed and revised the manuscript. Askelson, Ashida, Gilbert, Charlton, and Scherer provided feedback on design of the study and data analysis and reviewed and revised all drafts of the manuscript. Ms. Kahl assisted with data analysis and reviewed all drafts of the manuscript.

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Data Availability Proprietary data was used for this analysis and thus not available to the public.

Code Availability Upon request.

Declarations

Conflict of interest Authors have no conflicts of interest to declare.

Ethical Approval The University of Iowa determined that this was not human subjects' research.

Consent to Participate N/A.

Consent for Publication N/A.

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