

Missed Opportunities for Influenza Vaccination Among Hospitalized Children With Influenza at a Tertiary Care Facility

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ABSTRACT

OBJECTIVES: To identify the extent and characteristics of missed opportunities for influenza vaccination among children hospitalized with influenza at a tertiary children's hospital.

METHODS: We conducted a retrospective cohort study of hospitalized patients with polymerase chain reaction–confirmed influenza admitted to Children's Hospital Colorado from 2010 to 2014. We reviewed medical records for vaccination status and previous visits. The primary outcome was the proportion of underimmunized patients hospitalized with influenza with at least 1 missed opportunity visit (visit before influenza diagnosis in which an eligible patient did not receive the influenza vaccine). The relationship between sociodemographic characteristics and the primary outcome were examined using χ^2 tests and nonparametric tests, and variables with $P < .2$ were entered into a multivariate logistic regression model.

RESULTS: Among 322 patients hospitalized with influenza, 199 (61%) were undervaccinated; 83 of 199 (42%) had at least 1 missed opportunity for influenza vaccination. Multivariate analysis demonstrated that high-risk status (adjusted odds ratio 6.9, 95% confidence interval 3.8–12.4) was associated with increased odds of having a missed opportunity visit. Most missed opportunity visits were to subspecialty clinics (42%), and most visits (71%) occurred from September to November.

CONCLUSIONS: More than 40% of hospitalizations for influenza in children are associated with at least 1 missed opportunity visit at a tertiary center. Our findings highlight the potential role of tertiary care institutions in increasing influenza vaccination rates among children.

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Dr Rao conceptualized and designed the study, contributed to the data collection and chart review, carried out the initial analyses, and drafted the initial manuscript; Dr Williams designed the data collection instruments, performed chart review, and critically reviewed the manuscript; Dr Torok carried out the statistical analyses and reviewed and revised the manuscript; Dr Cunningham performed chart review; Dr Glodè helped conceptualize the study and critically reviewed the manuscript; Dr Wilson helped conceptualize the study, helped design the study, and critically reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.



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Annual influenza vaccination is the most effective method for preventing influenza infection and reducing the risk for potentially severe complications.^{1,2} Despite recommendations from the Advisory Committee for Immunization Practices for universal influenza vaccination in 2010, immunization rates among children aged 6 months to 17 years remain low, ranging from 51% to 59% from 2010 to 2014.³ The American Academy of Pediatrics has emphasized that improving influenza vaccination rates among children at high risk and extending vaccination throughout the influenza season are 2 of its highest priorities.⁴

Previous studies have indicated that missed opportunities for influenza vaccination in the primary care setting are common,^{5–10} but the potential role for vaccination during pediatric inpatient and outpatient tertiary care visits has not been well studied. Studies of hospitalized adults demonstrate numerous missed opportunities for influenza vaccination, and poor documentation of vaccination status in the inpatient setting.^{11–14} Primary care providers face considerable challenges in vaccinating their patients against influenza, even before recommendations for universal vaccination.^{15,16} Therefore, addressing vaccination during tertiary visits could decrease the potential burden of these visits to primary care providers,¹⁷ while targeting patients at high risk of complications from influenza. Because influenza vaccination is required at least yearly, it is important to consider other opportunities to vaccinate against influenza. Previous studies indicate that primary care physicians would favor collaborative vaccine delivery.¹⁸ Increased vaccination rates can also help offset costs associated with influenza-related hospitalizations and outpatient and emergency department (ED) visits.

The study objectives were to determine the extent of missed opportunities in previous tertiary inpatient, ED, and outpatient care visits for influenza vaccination among inpatients with influenza, and explore patient- and visit-level characteristics among patients with missed opportunities for vaccination.

METHODS

Setting

We conducted a retrospective cohort study of patients with influenza admitted to Children's Hospital Colorado (CHCO) from December 1, 2010, to April 12, 2014. CHCO is an academic, tertiary care hospital serving Colorado and 6 surrounding states. CHCO primarily admits patients from the Denver metro area, which has a population of ~2.5 million people. The hospital (including affiliated sites) has ~500 inpatient beds, provides care at 6 satellite locations with an additional 135 beds, and for the year ending 2014, experienced ~19 000 inpatient admissions and 158 000 ED visits.

Study Design and Population

Our inclusion criteria were inpatients with influenza infection, defined as those with respiratory samples positive for influenza by real-time reverse transcriptase-polymerase chain reaction. At our institution, testing is at the discretion of the provider. Respiratory virus or influenza testing among patients admitted with a respiratory illness is ~50% to 60%, and of these, ~10% of patients admitted with testing available are positive for influenza (Internal unpublished data from the Department of Epidemiology, Children's Hospital Colorado, 2014–2015). Patients who were <6 months of age at the time of the diagnosis of influenza, who had unknown vaccination status, or had a known contraindication to the vaccine (previous severe allergic reaction to the vaccine or vaccine component) were excluded from the study. Using chart review, visits to CHCO before hospitalization during the same season were recorded for each patient from September to May, the months during which influenza vaccine was available. Visit location included outpatient subspecialty clinics, inpatient medical wards, inpatient medical subspecialty or surgical wards, primary care clinics, and allied health clinics. A visit included inpatient hospitalizations, surgical procedures, and outpatient clinics during which a patient was seen by a medical or allied health provider. A visit was excluded if it was a nurse-only or dental visit, had missing documentation regarding the nature of the visit, or was associated with an influenza-like illness within 7 days before the

hospitalization. In addition, only the first hospitalization for patients with repeated hospitalizations for influenza was included.

We determined the number of patients hospitalized with influenza who were undervaccinated. An undervaccinated individual was defined as unvaccinated or partially vaccinated for that season. A partially vaccinated individual was defined as a child aged 6 months to <9 years who required 2 influenza vaccinations within the same season but only received 1 vaccine.

Primary Outcome

The primary outcome was the proportion of undervaccinated inpatients with influenza with at least 1 missed opportunity for influenza vaccination. A missed opportunity was defined as a visit before the influenza diagnosis in which an eligible patient did not receive the influenza vaccine when it was available. The time period when vaccine was available was defined from September 1 to May 1, which is the usual influenza vaccine season. We confirmed with pharmacy records that influenza vaccine was indeed received by the institution before this time period for each season.

Immunization Status

Immunization status was determined from electronic medical record (EMR) chart review of the inpatient admission record (receipt of influenza vaccination needed to be specifically documented in the medical chart), as well as from the Colorado Immunization Information System (CIIS) registry also accessible from the EMR. The CIIS is a lifelong immunization record tracking system created under the Colorado Immunization Registry Act of 2007. Approximately 75% of practices in the state use the registry for vaccination documentation. Exploratory variables included patient demographics (age, sex, ethnicity, race, and insurance status), high-risk conditions and number of previous visits. Patients were classified as high risk if they had any comorbidity increasing their likelihood for complications from influenza, as defined by the Committee on Infectious Diseases, including chronic pulmonary conditions (including asthma), hemodynamically significant cardiac disease,

hemoglobinopathies, immunosuppressive disorders or therapy, chronic renal dysfunction, metabolic disease, neurologic disorders compromising respiratory function, and long-term aspirin therapy.¹⁹

We explored visit-level characteristics among patients with missed opportunities for influenza vaccination by collecting additional information: location, visit date and type (sick or well), whether influenza vaccination was administered during the visit, and whether influenza vaccination status was documented during the visit.

Clinical and demographic information pertaining to the patients' hospitalizations and previous visits were abstracted from the EMR. The data were managed with REDCap (Research Electronic Data Capture) tools hosted at the University of Colorado.²⁰ Approval was obtained from the Colorado Multiple Institutional Review Board.

Statistical Analysis

The proportion of patients with influenza who were undervaccinated was calculated as the number of inpatients who were unimmunized or partially immunized

divided by the number of inpatients with laboratory-confirmed influenza during the study period. The primary outcome, proportion of underimmunized inpatients with influenza with at least 1 missed opportunity visit for influenza vaccination, was calculated as the number of undervaccinated inpatients with laboratory-confirmed influenza with at least 1 missed opportunity visit divided by the number of undervaccinated inpatients with laboratory-confirmed influenza who met our inclusion criteria at CHCO during the study period. For patient-level analyses, exploratory variables were examined using χ^2 and Wilcoxon rank sum tests to determine bivariable relationships between having had a missed influenza vaccination opportunity and demographics, timing of diagnosis and visit during the influenza season, number of visits before hospitalization and high-risk status. Variables with $P < .2$ were entered into a multivariate logistic regression model to identify patient-level characteristics that predict having a missed vaccination opportunity. Odds ratios and 95% confidence intervals were estimated and

results with $P < .05$ were considered statistically significant. Descriptive statistics were used to analyze visit-level characteristics. Data were exported to SAS software, version 9.3 (SAS Institute Inc, Cary, NC).

RESULTS

There were 389 patients representing 401 influenza-related hospitalizations during the study period. We excluded 45 patients who were under age 6 months, 17 patients with unknown vaccination status, and 5 patients with contraindication to receiving influenza vaccination, leaving a remaining 322 patients (Fig 1). Among 25 patients who were partially vaccinated, 8 patients were hospitalized before the due date for the second dose. Among patients eligible to receive the vaccine, vaccination status was not available in the CIRS registry for 17% of patients but was documented in admission records.

Among 322 inpatients with influenza with known vaccination status, 199 (61.8%) were undervaccinated; of these, 83 (41.7%) had at least 1 missed opportunity for influenza vaccination. The clinical characteristics of

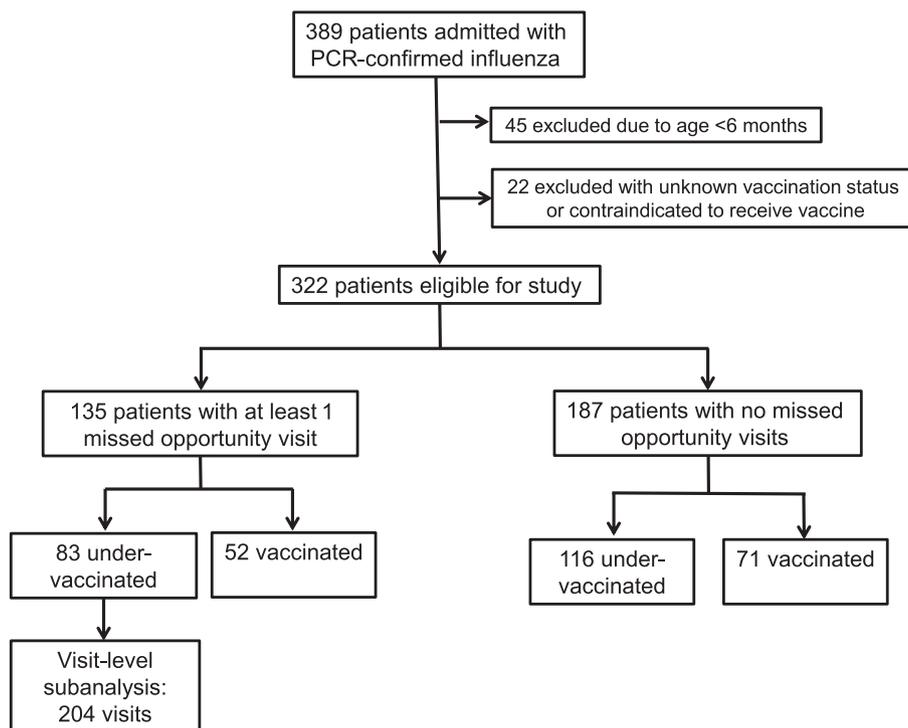


FIGURE 1 Flow diagram of participants in the study of missed opportunities for influenza vaccination among patients with influenza admitted to CHCO from 2010 to 2014. PCR, polymerase chain reaction.

patients by missed opportunity status are outlined in Table 1. Patients with at least 1 missed opportunity visit were more likely to have an underlying high-risk medical condition (84.4% vs 45.5%, $P < .0001$) and a greater number of high-risk conditions (1 vs 0, $P < .0001$) than those without at least 1 missed opportunity.

Patient-level multivariate analysis of the original cohort with vaccination dates available ($n = 311$), including those with no previous visits are shown in Table 2. High-

risk status (adjusted odds ratio 6.9, 95% confidence interval 3.8–12.4) was associated with increased odds of having a missed opportunity visit (Table 2). Visit-level data were obtained for 204 visits among 83 undervaccinated patients in the cohort who had at least 1 missed opportunity visit. Influenza vaccination status was documented in the visit note for 5% of visits. The majority (78%) of patients were considered high risk. Most missed opportunity visits were to subspecialty clinics (42%), followed by the ED or urgent

care (27%) and inpatient (subspecialty and general inpatient) wards (15%). Most visits among high-risk patients were at a subspecialty clinic, and most standard risk visits occurred in the ED or urgent care (Fig 2). The highest proportion of missed opportunities in this group occurred in the 2012–2013 influenza season (41%, $P < .0001$), and most visits (71%) among undervaccinated patients with at least 1 missed opportunity occurred early in the vaccination season from September through November.

TABLE 1 Clinical Characteristics of Children Hospitalized With Influenza at CHCO by Missed Opportunity Status From December 1, 2010, to April 12, 2014 ($N = 322$)

Variables	At Least 1 Missed Opportunity Visit	No Missed Opportunity Visit	P^a
	($n = 135$)	($n = 187$)	
Age category, y, n (%)			
<2.0	34 (25.2)	36 (19.3)	.06
>2.0–5.0	30 (22.2)	49 (26.2)	
>5.0–10.0	30 (22.2)	62 (33.2)	
>10.0	41 (30.4)	40 (21.4)	
Race/ethnicity, n (%)			
White	84 (62.2)	102 (54.5)	.28
African American	8 (5.9)	17 (9.1)	
Hispanic	21 (15.6)	25 (13.4)	
Other race	22 (16.3)	43 (23.0)	
Sex, n (%)			
Male	73 (54.1)	108 (57.8)	.51
Insurance, n (%), $n = 316$			
Private insurance ^b	47 (35.6)	81 (44.0)	.13
Medicaid/uninsured	85 (64.4)	103 (56.0)	
Timing of influenza diagnosis, n (%), $n = 317$			
Early: September–November	13 (9.9)	11 (5.9)	.18
Late: December–April	118 (90.1)	175 (94.1)	
High-risk status, n (%)			
Yes	114 (84.4)	85 (45.5)	<.0001
No	21 (15.6)	102 (54.5)	
Timing of initial visit, n (%), ($n = 172$)			
Early: September–November	110 (83.3)	30 (75)	.25
Late: December–April	22 (16.7)	10 (25)	
No. of high-risk conditions, median (IQR)	1 (1–)	0 (0–1)	<.0001 ^c
No. of previous visits, median (IQR), $n = 175^d$	4 (2–7)	3 (1–4)	<.15 ^c
No. of d between last visit and diagnosis, median (IQR), $n = 175^d$	35 (15–77)	25 (5.5–59)	.06

IQR, interquartile range.

^a Pearson's χ^2 test unless otherwise specified.

^b Private insurance: health maintenance organization, Kaiser, preferred provider organization, private payer.

^c Wilcoxon rank sum test.

^d Among patients with at least 1 previous visit.

DISCUSSION

Our study demonstrates that >40% of hospitalizations for influenza in children are associated with at least 1 missed opportunity visit at a tertiary center. The majority of missed opportunity visits occurred early during the influenza vaccination season, and the most common missed opportunity visit was to a subspecialty clinic. These data support a

TABLE 2 Multivariate Analysis for Having a Missed Opportunity Visit at CHCO Among Inpatients With Influenza From December 1, 2010, to April 12, 2014 ($N = 311$)

	Adjusted OR (95% CI)
Age group, y	
<2.0	1.5 (0.7–3.2)
>2.0–5.0	0.9 (0.4–1.8)
>5.0–10.0	0.6 (0.3–1.1)
>10.0	Ref
Insurance	
Private insurance ^a	Ref
Medicaid/uninsured	1.4 (0.8–2.4)
Health status	
Low risk	Ref
High risk	6.9 (3.8–12.4)
Timing of diagnosis	
Early (1 September–30 November)	Ref
Late (1 December–30 April)	0.5 (0.2–1.3)

Controlling for age group, risk status, insurance status, number of visits, timing of first visit, and timing of diagnosis.

^a Private insurance: health maintenance organization, Kaiser, preferred provider organization, private payer.

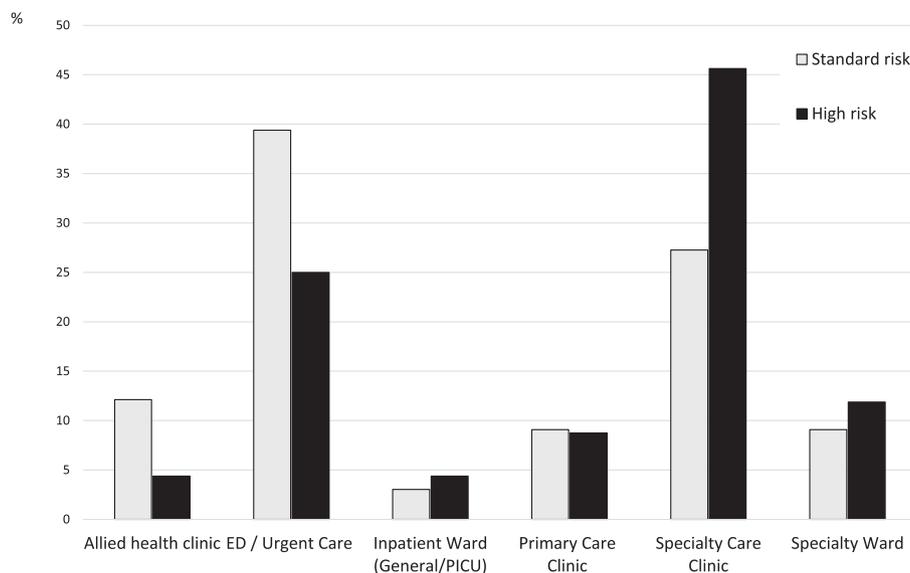


FIGURE 2 Location of missed opportunity visits among undervaccinated patients with influenza with at least 1 missed opportunity visit admitted to CHCO from 2010 to 2014 stratified by risk type. Graph showing breakdown of high-risk and standard-risk patients by visit location, $N = 193$. Visit type is listed on the x axis, percentage of visits on the y axis.

potential role for tertiary care institutions to provide influenza vaccination during inpatient and outpatient visits.

The extent and timing of missed opportunities shown in our study are similar to other studies conducted in the primary care setting, which demonstrate that missed opportunities for influenza vaccination are abundant.^{5,7,8} Given that the majority of visits occurred before the onset of the typical influenza season, vaccination during tertiary care visits may facilitate earlier vaccination, consistent with the Advisory Committee on Immunization Practices recommendations.

Our study demonstrated that the most common missed opportunity visit was to a subspecialty clinic, and highlights the potential role for influenza vaccination strategies in this setting. These visits provide an opportunity to target high-risk patients, who represent the majority of patients seen at the subspecialty clinics at our institution. Subspecialist physicians may perceive that vaccination is the role of primary care physicians,²¹ which may explain why a lower proportion of subspecialists recommend influenza vaccination compared with primary care providers.²² These beliefs in turn influence

decisions of subspecialty practices to supply vaccine and develop protocols to provide vaccination. In addition, documentation of immunization status was quite uncommon in this setting. Subspecialty immunization at the tertiary care level could take advantage of existing infrastructure within the organization to implement modalities that have been shown to be beneficial in increasing immunization rates. Such strategies include the following: prompts in the electronic medical record to facilitate screening and documentation; provision of education to nursing medical staff, patients, and families regarding the importance of vaccination and surveillance; and provider incentives.^{23–26} Despite the perceived feasibility of vaccination due to many of these features in existence in many institutions, a high proportion of missed opportunities remain^{27–29}; a multifaceted approach may be necessary.

After subspecialty clinic visits, ED or urgent care visits and inpatient admissions represented the next most common missed opportunities for vaccination. Pediatric data regarding the practice of influenza immunization during hospitalization and ED visits are limited.^{30–33} Several studies of adult inpatients show that unvaccinated elderly patients experience numerous

missed opportunities for vaccination and that several barriers exist, such as poor vaccination documentation in the inpatient setting.^{11–13} Pediatric inpatient vaccination presents its own set of unique challenges. For example, patients who are frequently hospitalized are more likely to miss primary care visits when immunizations are due.³⁰ Influenza vaccination status is less likely to be ascertained during sick visits,⁷ and vaccination may not be considered a high priority. Exploration of barriers to influenza immunization in the tertiary care setting is the subject of further study.

There are multiple limitations to our study. Our study cohort included only hospitalized patients with laboratory-confirmed influenza to capture patients with the most accurate influenza vaccine documentation. However, this may have biased our results toward a higher proportion of patients with underlying comorbidities, who are more likely to seek care at subspecialty clinics, have a greater number of hospitalizations, and have more urgent care visits. Another limitation was the retrospective nature of the study, which may result in inaccurate immunization status by relying on parent recall during admission or incomplete vaccination data in GISS. To minimize the potential for inaccurate influenza

vaccination status, we considered a patient immunized against influenza only if it was specifically documented in the chart or located within the CIIS registry, and we excluded patients with an unknown vaccination status from analysis. We were also not able to obtain data regarding vaccine refusal due to lack of documentation in the medical record. In addition, data regarding appropriate screening for influenza vaccination status may be incomplete because screening may have occurred during the visit without being documented in the medical record. Nursing visits were excluded from our data because standing orders were not in widespread use during the study period but would be important to explore further because of the potential for increased influenza vaccination rates using nurse-initiated orders. Finally, we were not able to assess the full spectrum of missed opportunities, including outpatient visits at nonaffiliated sites, because this was beyond the scope of our study.

Strengths of our study are the inclusion of patients over several influenza seasons to account for seasonal variations in influenza severity that may affect vaccination rates. We did not include data from the 2009 pandemic year because this unusually severe season may skew the data due to a difference in the number of sick visits and influenza immunization rates. In addition, we selected our study period to start after recommendations for universal influenza vaccination for all children 6 months of age and older were made, thus achieving a more uniform study population.

CONCLUSIONS

More than 40% of hospitalizations for influenza in children are associated with at least 1 missed opportunity visit at a tertiary center. Influenza vaccination should be provided at the earliest opportunity, including subspecialty clinics, ED visits, and inpatient admissions. Tertiary care institutions have an opportunity to increase influenza vaccination rates and thus minimize the burden of influenza-related disease, hospitalization rates, and length of stay and reduce health care costs.

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