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# Hospital-Based Influenza Vaccination of Children: An Opportunity to Prevent Subsequent Hospitalization

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## ABSTRACT

**OBJECTIVE.** We performed this study to determine the frequency of previous hospitalization among children hospitalized with influenza.

**METHODS.** The Pediatric Health Information System database (discharges that occurred between January 1, 2001, and December 31, 2006) was used to determine the proportion of children hospitalized with influenza or respiratory illness who had a previous hospitalization during the most recent influenza-vaccination season. Subjects included pediatric patients (through 18 years of age). The index hospitalization was defined as the first influenza or respiratory illness hospitalization for a child that occurred during the study period and between November 1 and April 30. A previous hospitalization during the most recent influenza-vaccination season was defined as a hospitalization for any reason in the 0.5 to 6 months before the index hospitalization but not before September 1 or on or after March 1.

**RESULTS.** Overall, 16% of children hospitalized with influenza and 12% of children hospitalized with influenza or a respiratory illness had a previous hospitalization during the most recent influenza-vaccination season. Approximately 23% of the children hospitalized with influenza and a comorbidity had a previous hospitalization during the most recent influenza-vaccination season.

**CONCLUSION.** Hospital-based programs for influenza vaccination have the potential to reach children at highest risk of influenza complications and to reduce the rates of pediatric hospitalization for treatment of influenza-related illness.

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### Key Words

influenza, child, vaccination

### Abbreviations

ICD-9-CM—*International Classification of Diseases, Ninth Revision, Clinical Modification*  
CI—confidence interval

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**T**HE CENTERS FOR Disease Control and Prevention recommends annual influenza vaccination for children >6 months of age with chronic medical conditions that place them at high risk for complications of influenza and for all children 6 to 59 months of age.<sup>1</sup> Currently, only 2% to 43% of children at high risk are estimated to be fully vaccinated against influenza.<sup>2-4</sup>

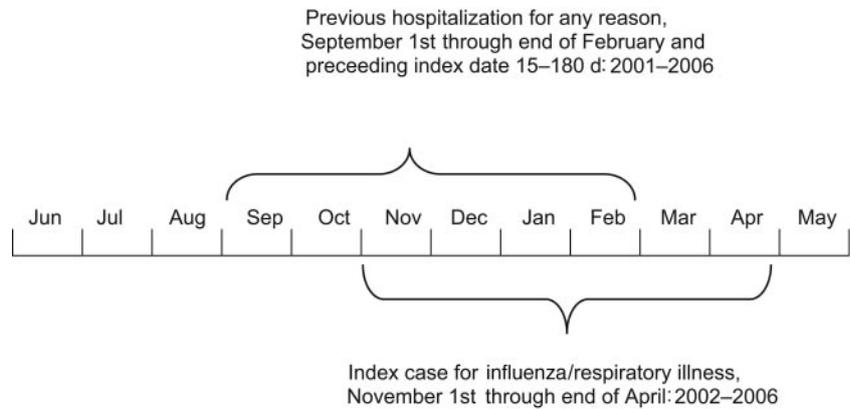
Previous studies of elderly patients hospitalized with influenza and other respiratory conditions demonstrated that a large proportion (38%–46%) of these patients were hospitalized during the most recent influenza-vaccination season.<sup>5,6</sup> Current recommendations aimed at increasing vaccination rates call for expanding access to influenza vaccine in health care settings and for using standing orders for adult patients.<sup>7,8</sup> Such programs have demonstrated success in adults.<sup>9,10</sup> Whether such programs have the potential to reduce hospitalizations for influenza-related illness in children (particularly those with comorbidities that predispose them to hospitalization) is not known. Our objective was to determine whether there is an opportunity for hospital-based influenza vaccination to prevent a substantial number of subsequent hospitalizations for influenza-related illness in pediatric patients.

## METHODS

### Data Source

The study protocol was reviewed and approved by the Children's Hospital and Regional Medical Center institutional review board. We used the Pediatric Health Information System database developed by the Child Health Corporation

**FIGURE 1**  
Hospital-based influenza vaccination Pediatric Health Information System sampling scheme and time frame.



of America, which includes demographic and diagnostic data on 42 freestanding, noncompeting, children's hospitals. The database includes diagnoses in *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) format. We used selected patient abstract and ICD-9-CM coding for hospitalizations with discharges that occurred between January 1, 2001, and December 31, 2006. More-detailed data were selected for a subanalysis that included diagnostic testing data from a subset of 38 hospitals with comprehensive transaction and utilization data.

### Patients

Our study included pediatric patients (through 18 years of age) with discharge codes for influenza (ICD-9-CM code 487.0, 487.1, or 487.8) between November 1 and April 30 in 2002–2006. In addition, because influenza often is not specifically diagnosed in children,<sup>11</sup> we evaluated ICD-9-CM codes that were previously validated to represent influenza-like illness most accurately, including ICD-9-CM code 079.99 (unspecified viral infection), code 382.9 (unspecified otitis media), codes 460, 461.9, 465.8, 465.9, and 466.0 (codes 460–466; various acute respiratory conditions), code 486 (pneumonia, organism unspecified), code 490 (bronchitis, not specified as acute or chronic), code 780.6 (fever), and code 786.2 (cough).<sup>12</sup> A group of patients with influenza diagnostic testing data was created as a subset of the aforementioned influenza discharges by using data from 38 hospitals with expanded transaction and utilization data. Diagnostic testing was defined on the basis of laboratory test codes, that is, code 364151 (influenza A and B antibody), code 364152 (influenza A and B antigen), code 364153 (influenza A/H5), code 364150 (influenza virus, unspecified), code 364159 (other specified influenza virus), code 364500 (other specified viral culture), code 364999 (other specified viruses), and code 364000 (viruses, unspecified). Comorbidities were defined on the basis of ICD-9-CM codes indicating patients at high risk for complications resulting from influenza.<sup>13</sup> An index hospitalization was defined as the first influenza or respiratory illness hospitalization for the child during the study period. However, we restricted the earliest index

date as January 1, 2002, to ensure that the database would include complete data for the previous 6 months.

### Outcomes

Previous hospitalization was defined as hospitalization for any reason occurring during the most recent influenza-vaccination season (September 1 through March 1) and in the 0.5 to 6 months before the index hospitalization (Fig 1). When multiple previous hospitalizations were documented, the earliest date was used to calculate the time interval between the index hospitalization and the previous hospitalization.

### Statistical Analyses

Descriptive analyses with univariate and bivariate frequencies were performed; 95% confidence intervals (CIs) were calculated for the proportions of patients hospitalized previously. All analyses were conducted by using Stata 9.2 software (Stata Corp, College Station, TX).

### RESULTS

We identified ~14 000 children hospitalized with influenza and 170 000 hospitalized with influenza or a respiratory illness during the study period (Table 1). Approximately 15% of those hospitalized with influenza and 21% of those hospitalized with influenza or a respiratory illness had a comorbidity associated with increased risk of complications resulting from influenza. Overall, 16% (95% CI: 15.4%–16.7%) of those with an influenza hospitalization and 12% (95% CI: 11.9%–12.3%) of those with an influenza or respiratory illness hospitalization had a previous hospitalization during the most recent influenza-vaccination season (Table 1). In total, 1624 children with an influenza-specific ICD-9-CM code and a charge for a viral test were identified. Of those 1624 children, 232 children (14.3%; 95% CI: 12.6%–16.1%) were identified as having a previous hospitalization during the most recent influenza-vaccination season.

Analyses with stratification according to comorbidity status and age were performed. Approximately 23% of children with an influenza hospitalization and a comor-

**TABLE 1 Demographic and Clinical Information for Patients Hospitalized With Influenza or Respiratory Conditions Between 2002 and 2006**

|  | n (%)                                |   |
|--|--------------------------------------|---|
|  | Children Hospitalized With Influenza | Children Hospitalized With Influenza or Respiratory Illness |
| Total  | 13 875                               | 170 447   |
| Race   |                                      |   |
| White  | 8171 (58.9)                          | 104 044 (61.0)  |
| Black  | 3692 (26.6)                          | 41 843 (24.6)   |
| American Indian                                    | 75 (0.5)                             | 603 (0.4)   |
| Asian  | 285 (2.1)                            | 3492 (2.1)  |
| Other  | 931 (6.7)                            | 11 524 (6.8)  |
| Missing  | 721 (5.2)                            | 8941 (5.3)  |
| Ethnicity  |                                      |   |
| Hispanic   | 2683 (19.3)                          | 32 229 (18.9)   |
| Unknown  | 11 192 (80.7)                        | 138 218 (81.1)  |
| Age  |                                      |   |
| 0 to <6 mo   | 3697 (26.7)                          | 39 138 (23.0)   |
| 6 mo to <2 y                                       | 4094 (29.5)                          | 52 118 (30.6)   |
| 2 to <5 y  | 2703 (19.5)                          | 34 523 (20.3)   |
| 5 to 11 y  | 2067 (14.9)                          | 29 030 (17.0)   |
| 12 to 18 y   | 1314 (9.5)                           | 15 638 (9.2)  |
| Male gender  | 7868 (56.7)                          | 95 639 (55.5)   |
| Comorbidity  | 2014 (14.5)                          | 36 368 (21.3)   |
| Hospitalization during previous vaccination season | 2227 (16.1)                          | 20 630 (12.1)   |

bidity had a previous hospitalization during the most recent influenza-vaccination season, whereas 17% of children with an influenza or respiratory illness hospitalization and a comorbidity had a previous hospitalization (Table 2). Of children  $\geq 12$  years of age hospitalized with influenza, 23% had a previous hospitalization during the most recent influenza-vaccination season. More than 85% of the patients with a previous hospitalization had a period of  $\geq 4$  weeks between the index hospitalization and the previous hospitalization during the most recent influenza-vaccination season (Table 3).

## DISCUSSION

Using an administrative database representing 42 free-standing pediatric hospitals, we found that 12% to 16%

**TABLE 3 Time Between Hospitalization With Influenza or Respiratory Illness and Previous Hospitalization During the Most Recent Influenza Vaccination Season (Among Those With Previous Hospitalizations)**

|                      | Previous Hospitalizations for Children With Index Influenza Hospitalizations in 2001–2006 | Previous Hospitalizations for Children With Index Influenza or Respiratory Illness Hospitalizations in 2001–2006 |
|----------------------|---|--|
| Total, N             | 2227  | 20 630   |
| Time interval, n (%) |   |  |
| <4 wk                | 282 (12.7)  | 2335 (11.3)  |
| >4–12 wk             | 966 (43.4)  | 9682 (46.9)  |
| >3–6 mo              | 979 (44.0)  | 8613 (41.8)  |

of children hospitalized for treatment of influenza or a respiratory illness during influenza season had a previous hospitalization during the most recent influenza-vaccination season. Children with comorbidities had an even higher frequency of previous hospitalization; 23% of those hospitalized with influenza had a previous hospitalization during the most recent influenza-vaccination season.

Previous studies found that elderly adults hospitalized with influenza had a high frequency of previous hospitalization during the most recent influenza-vaccination season. A study performed in 1977, including 112 adults hospitalized with influenza, found that 38% were hospitalized previously in the same year and a little more than one half of those (21% of total) were hospitalized after October 1 (during influenza-vaccination season).<sup>5</sup> A subsequent, larger, population-based study demonstrated that 39% to 46% of elderly patients hospitalized for treatment of influenza-associated respiratory conditions had been discharged from the hospital during the most recent vaccination season.<sup>6</sup> In the same study, persons discharged with high-risk conditions during the vaccination season were at greater risk for hospitalization with influenza-associated respiratory conditions but were less likely to be vaccinated than were those at lower risk. These and other studies provide the rationale for the recommendation of the Centers for Disease Control and Prevention that unvaccinated patients “of all

**TABLE 2 Previous Hospitalization During the Most Recent Vaccination Season, According to Age and Comorbidity, for Children Hospitalized With Influenza or Respiratory Illness**

|              | Previous Hospitalization, n (%)      |                    |                       |   |                     |                        |
|--------------|--------------------------------------|--------------------|-----------------------|---|---------------------|------------------------|
|              | Children Hospitalized With Influenza |                    |                       | Children Hospitalized With Influenza or Respiratory Illness |                     |                        |
|              | Yes<br>(n = 2227)                    | No<br>(n = 11 648) | Total<br>(N = 13 875) | Yes<br>(n = 20 630)   | No<br>(n = 149 817) | Total<br>(N = 170 447) |
| Age          |                                      |                    |                       |   |                     |                        |
| 0 to <6 mo   | 415 (11.2)                           | 3282 (88.8)        | 3697                  | 3964 (10.1)   | 35 174 (89.9)       | 39 138                 |
| 6 mo to <2 y | 729 (17.8)                           | 3365 (82.2)        | 4094                  | 5876 (11.3)   | 46 242 (88.7)       | 52 110                 |
| 2 to <5 y    | 410 (15.2)                           | 2293 (84.8)        | 2703                  | 3657 (10.6)   | 30 866 (89.4)       | 34 523                 |
| 5 to 11 y    | 367 (17.8)                           | 1700 (82.2)        | 2067                  | 3863 (13.3)   | 25 167 (86.7)       | 29 030                 |
| 12 to 18 y   | 306 (23.3)                           | 1008 (76.7)        | 1314                  | 3270 (20.9)   | 12 368 (79.0)       | 15 638                 |
| Comorbidity  | 467 (23.2)                           | 1547 (76.8)        | 2014                  | 6303 (17.3)   | 30 065 (82.7)       | 36 368                 |

ages (including children) with high-risk conditions and persons aged 6 months to 4 years or  $\geq 50$  years who are hospitalized at any time, beginning from the time vaccine becomes available for the upcoming season and continuing through the season, should be offered and strongly encouraged to receive influenza vaccine before they are discharged.<sup>1</sup> The Centers for Disease Control and Prevention also recommend that use of standing orders to offer influenza vaccination to all hospitalized persons be considered.<sup>1</sup> Use of standing orders has been shown to increase vaccination rates for hospitalized adults.<sup>14,15</sup> We are not aware of previously published studies addressing these issues for children.

Although clinicians have been challenged by recommendations calling for vaccination of all children 6 to 59 months of age, especially given the requirement for 2 vaccinations in the first year of vaccination, rates of influenza vaccination for children at high risk for complications remain unacceptably low. Coverage for the 2004/2005 influenza season among children 2 to 17 years of age with asthma was estimated to be 29%.<sup>3</sup> Coverage during the 2005/2006 influenza season for children 6 to 23 months of age was estimated to be 6.6% to 60% for  $\geq 1$  dose and 2.3% to 43% for  $\geq 2$  doses (fully vaccinated) at Centers for Disease Control and Prevention sentinel sites.<sup>2</sup> Implementation of influenza-vaccine recommendations in recent years has likely been hampered by disruption of vaccine supplies, concerns about thimerosal, and confusion about population priorities for immunization. With increasing availability of vaccine and evidence of vaccine effectiveness in this age group,<sup>16</sup> clinicians and institutions caring for children must develop innovative measures to increase annual influenza vaccination rates, particularly for children at high risk for complications because of their age or medical condition. Consistent with Centers for Disease Control and Prevention recommendations, pediatric institutions should also consider programs aimed at vaccinating household contacts of patients at high-risk, especially those of children  $< 6$  months of age, because such children are too young to receive vaccination themselves.

This study has limitations that warrant mention. The frequency of previous hospitalization might have been underestimated, because patients hospitalized with influenza might have had a previous hospitalization at a different hospital during influenza-vaccination season. In addition, we did not determine whether hospital-based influenza-vaccination programs were being implemented at the study hospitals, and we were unable to assess vaccination rates accurately from the Pediatric Health Information System database because many hospitalized children qualify for state or federally funded vaccines, which would not be billed for by hospitals.

Despite these limitations, we suggest that an important implication can be drawn from our findings. Given the large proportion of children hospitalized for treatment of influenza-related illnesses who had a previous hospitalization during the most recent influenza-vaccination season, hospital-based programs for influenza vaccination have the potential to reach those at

highest risk for complications from influenza and to reduce the rates of hospitalization of children for treatment of influenza.

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