



# Burden of Healthcare-Associated Viral Respiratory Infections in Children's Hospitals

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**Objective.** Although healthcare-associated (HA) viral respiratory infections (VRIs) are common in pediatrics, no benchmark for comparison exists. We aimed to determine, compare, and assess determinants of unit-specific HA-VRI incidence rates in 2 children's hospitals.

**Methods.** This study was a retrospective comparison of prospective cohorts. The Montreal Children's Hospital and the Cohen Children's Medical Center of New York perform prospective surveillance for HA-VRI using standardized definitions that require the presence of symptoms compatible with VRI and virus detection. Cases detected between April 1, 2010, and March 31, 2013, were identified using surveillance databases. Annual incidence rates were calculated, and a generalized estimating equation model was used to assess determinants of HA-VRI rates.

**Results.** The overall HA-VRI rate during the 3-year study period was significantly higher at Montreal Children's Hospital than that at Cohen Children's Medical Center of New York (1.91 vs 0.80 per 1000 patient-days, respectively;  $P < .0001$ ). Overall, the HA-VRI incidence rate was lowest in the neonatal intensive care unit. Rates in the pediatric intensive care, oncology, and medical/surgical units were similar. The most common etiology of HA-VRI at both institutions was rhinovirus (49% of cases), followed by parainfluenza virus and respiratory syncytial virus. Hospitals with less than 50% single rooms had HA-VRI rates 1.33 (95% confidence interval, 1.29–1.37) times higher than hospitals with more than 50% single rooms for a given unit type.

**Conclusions.** HA-VRI rates were substantial but different among 2 children's hospitals. Future studies should examine the effect of HA-VRI and evaluate best practices for preventing such infections.

**Keywords.** healthcare associated; pediatrics; respiratory infection; viral infection.

## INTRODUCTION

Surveillance for healthcare-associated infections (HAIs) is now a mandatory requirement in many states and jurisdictions and allows for internal and external comparisons with benchmarks [1–9]. However, most programs focus on device- and procedure-associated infections, such as central line-associated bloodstream infection or surgical-site infection.

Although central line-associated bloodstream infections represent a major burden in pediatrics and have been a focus of infection-prevention efforts [1, 8], healthcare-associated (HA) viral respiratory tract infection (VRI) should not be overlooked. The availability of multiplex nucleic acid amplification tests that detect a panel of respiratory viruses has made laboratory-based surveillance of HA-VRIs feasible and less time-consuming. In

pediatric wards and hospitals, HA-VRI often mirrors community-acquired VRI in patients admitted for care. HA-VRIs represented 10% of HAIs in pediatric wards in a recent point-prevalence survey [8], whereas in another study, close to 20% of infants and toddlers admitted to a tertiary-care pediatric hospital had a virus detected in their nasopharyngeal specimen [10]. Although the overall burdens of HA-VRI and outbreaks of specific viruses were reported previously [11–19], benchmarks for comparison are not readily available. Our objective was to determine, compare, and assess determinants of unit-specific HA-VRI incidence rates in 2 children's hospitals.

## METHODS

### Study Setting and Population

Montreal Children's Hospital (MCH) (Quebec, Canada) is a 121-bed tertiary-care pediatric teaching hospital with a bone marrow transplant unit, a pediatric intensive care unit (PICU), a level-4 neonatal intensive care unit (NICU), a hematology/oncology ward, and general medical/surgical wards that serves the greater Montreal area (Table 1). Total hospital surveillance for all HAIs has been done prospectively and routinely since 1985 using standardized definitions from the National Healthcare Safety

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Network [20–23]. Laboratory testing is done for patients with new respiratory symptoms regardless of fever. The nursing teams flag patients with new-onset symptoms (fever, respiratory symptoms, wound discharge) on a standardized form during their daily rounds. Infection preventionists review laboratory data, new-symptom-onset forms, and medical records to determine the occurrence of HAI and complete a standardized case-report form. The infection-control physician adjudicates cases.

The Steven and Alexandra Cohen Children’s Medical Center (CCMC) of New York is a 171-bed tertiary-care pediatric teaching hospital with a bone marrow transplant unit, a PICU, a level-4 NICU, a hematology/oncology ward, and general medical/surgical wards (Table 1). Targeted HAI surveillance is done prospectively. Infection preventionists prospectively monitor patients for febrile and nonfebrile HA-VRI using laboratory detection-based surveillance.

### Study Design and Definitions

Infection prevention and control (IPAC) surveillance databases were used to identify HA-VRI that occurred between April 1, 2010, and March 31, 2013, in either of the 2 hospitals. Patient-days were defined as the total number of days that patients spent on a given unit and were calculated on an annual basis. In both hospitals, HAIs were attributed to the unit to which the patient was admitted at the time of transmission on the basis of definitions (Table 2). An HA-VRI with an onset of symptoms after hospital discharge would be detected and included only for patients who presented to the emergency department or were readmitted for VRI and tested.

At MCH, an HA-VRI was defined as onset of symptoms after a minimum number of days after admission to hospital (etiology dependent) (Table 2) with at least 2 of the following

clinical findings: new onset of fever (temperature of >38.5°C rectally), sore throat, nasal discharge or stuffiness, cough, hoarseness, and/or pharyngeal erythema or purulent exudate in the throat, except for intubated patients and those with chronic respiratory disease in whom a change in consistency or quantity of respiratory secretions was required to be identified as HA-VRI. For patients aged <1 year, fever could be replaced by hypothermia (rectal temperature of <37°C), apnea, or bradycardia. Moreover, symptoms needed to be present for ≥24 hours with at least 1 of the following: (1) virus cultured from a respiratory tract site, (2) positive results for nucleic acid amplification test on respiratory secretions, and/or (3) physician diagnosis of respiratory tract infection. HA-VRI with negative viral identification or that were not tested were classified as syndromic cases and excluded from the pooled analysis. Even if the index patient was a parent or sibling, we considered the infection to be healthcare associated.

At the CCMC, an HA-VRI was defined as a new-onset fever and/or respiratory symptoms that were not present at admission, after a minimum number of days after admission to hospital (etiology dependent) (Table 2), and a positive result on a nucleic acid amplification test for a viral respiratory pathogen on respiratory secretions. Syndromic surveillance was not performed.

### Laboratory Testing

Both hospitals used a multiplex nucleic acid amplification test for respiratory virus detection on nasopharyngeal swabs or aspirates. The MCH used an in-house assay that detects adenovirus, human metapneumovirus (hMPV), influenza A and B viruses, parainfluenza virus (PIV) types 1, 2, and 3, respiratory syncytial virus (RSV), enterovirus, rhinovirus, and coronaviruses 229E and OC43. The lower limit of detection of the

**Table 1. Hospital Bed Configurations**

Hospital Ward	Beds in CCMC (n [%])				Beds in MCH (n [%])			
	Total	Single	Double	Multiple	Total	Single	Double	Multiple
PICU	28	20 (71)	0	8 (28) (two 4-bed rooms)	12	4 (33)	0	8 (66) (one 8-bed room)
NICU	57	0	24 (42)	20 (35) (five 4-bed-bed rooms) 7 (12) (one 7-bed room) 6 (10) (one 6-bed room)	24	0	0	20 (83) (two 10-bed rooms) 4 (17) (one 4-bed room)
H/Onc	18	2 (11)	16 (89)	0	9	9 (100)	0	0
BMT	4	4 (100)	0	0	3	3 (100)	0	0
Med/Surg	64	12 (19)	40 (63)	4 (6) (one 4-bed rooms) 8 (12) (one 8 bed-bed room)	73	6 (8)	59 (81)	8 (11) (two 4-bed rooms)
Total	171	38 (22)	80 (47)	53 (31)	121	22 (18)	59 (49)	40 (33)

Abbreviations: BMT, bone marrow transplant; CCMC, Cohen Children’s Medical Center; H/Onc, hematology/oncology; MCH, Montreal Children’s Hospital; Med/Surg, medical/surgical; PICU, pediatric intensive care unit; NICU, neonatal intensive care unit.

**Table 2. Criteria for Classifying a Respiratory Viral Infection as Healthcare Associated**

Respiratory Virus	Minimum Duration of Hospitalization Before Onset of Symptoms to Classify as Nosocomial (Days)	
	CCMC	MCH
Adenovirus	3	3
Human metapneumovirus	4	3
Influenza A and B	2	1
Parainfluenza virus	3	2
Respiratory syncytial virus	3	4
Rhinovirus	3	2

Abbreviations: CCMC, Cohen Children's Medical Center of New York; MCH, Montreal Children's Hospital.

in-house assay is 10 to 100 copies of influenza A and 100 to 1000 viral copies of all other viruses targeted in the panel. The field sensitivity is 95% compared to culture. The specificity is 85% for enterovirus and 100% for all other viruses in the panel.

The CCMC used a commercial multiplex nucleic acid amplification test (xTAG respiratory viral panel [Luminex]) that detects the same viruses as the MCH assay, except it does not detect coronavirus and does not differentiate between enterovirus and rhinovirus; a supplemental nucleic acid amplification test was used to differentiate enterovirus from rhinovirus.

### Infection Prevention and Control Practices

#### Isolation Practices

At the MCH, patients with clinical symptoms compatible with respiratory infection were placed on droplet and contact precautions year-round, regardless of etiology. Precautions were continued for the duration of symptoms.

At the CCMC, during the respiratory illness season (ie, December through April), isolation precautions included droplet and contact precautions for symptomatic patients while respiratory viral pathogen tests were pending; from May through November, contact precautions alone were implemented for such patients. At the discretion of the patient's nurse, supplemental precautions might have been discontinued for patients with results negative for respiratory viral pathogens. Except for the NICU, in which contact precautions were used, the following precautions were used for specific respiratory viral pathogens: droplet and contact precautions for adenovirus, droplet precautions for influenza virus, contact precautions for hMPV, PIV, and RSV, and standard precautions for rhinovirus. Precautions were continued for the duration of symptoms.

#### Visitation Policy

The MCH had a written policy that required sick persons to refrain from visiting. This policy was rarely enforced. There was no age restriction for visitors, except for the NICU, where the NICU staff required that children not be allowed to visit.

The CCMC had a written policy that restricted visitation from children (other than siblings) younger than 12 years and persons with a contagious disease and required screening of visitors on arrival to a hospital unit. However, this policy was not enforced. A health screening was performed on siblings who visited the NICU.

In each hospital, the bedside nurse had the primary responsibility for screening visitors, and all staff who were ill with respiratory symptoms were instructed to stay home.

#### Adherence to Infection-Prevention Practices

Between January 2011 and March 2013 at the CCMC, hand-hygiene audits of all persons entering a patient's room were performed and tabulated on a monthly basis.

#### Ethics

The MCH Research Ethics Board and the North Shore-LIJ Health System Institutional Review Board approved the study.

#### Statistical Analysis

We calculated the overall HA-VRI rates per 1000 patient-days ( $[\text{number of HA-VRI episodes}/\text{number of patient-days}] \times 1000$ ) and 95% confidence intervals (CIs) using Poisson regression. Virus- and unit-specific incidence rates were calculated also. Patients with an HA-VRI caused by coronavirus and those who tested negative for respiratory viruses (syndromic) were excluded from the pooled analysis. Only cases of HA-VRI that occurred in admitted patients were systematically captured.

We used a generalized-estimating-equation model to account for correlation of rates within a hospital, given that policies are hospital-wide educational activities (PROC GENMOD; Poisson distribution; link = log), and to assess determinants of HA-VRI rates in a multivariable regression model. Variables included in the model were hospital site, units with a proportion of single rooms <50%, and unit type. Statistical significance was determined using 2-sided *P* values ( $P < .05$ ). All statistical analyses were performed using SAS 9.3 (SAS Institute, Cary, NC).

### RESULTS

During the 3-year study period, the mean (range) annual patient-days at the CCMC and MCH were 46 529 (45 787–47 816) and 36 815 (37 983–39 577), respectively, for annual average patient-days per available bed of 272 and 304, respectively. The overall HA-VRI rate for the 6 virus groups studied in the 3-year study period was significantly higher at MCH than at the CCMC (1.91 vs 0.80 per 1000 patient-days, respectively;  $P < .0001$ ). At the CCMC, the unit with the lowest HA-VRI incidence rate was the NICU, whereas at MCH, the hematology/oncology ward had the lowest rate. Overall, the HA-VRI incidence rate was the lowest in the NICU. The rank orders of identified viral pathogens were similar at both hospitals. The

**Table 3. Numbers and Rates of Healthcare-Associated Viral Respiratory Infections (per 1000 Patient-Days) According to Virus and Hospital Unit**

Virus or Hospital Unit	CCMC		MCH		Overall Rate (95% CI)
	n <sup>a</sup>	Rate (95% CI)	n	Rate (95% CI)	
Respiratory virus	1				
Adenovirus	7	0.05 (0.01–0.09)	20	0.18 (0.10–0.26)	0.11 (0.07–0.15)
hMPV	7	0.05 (0.01–0.09)	9	0.08 (0.03–0.13)	0.06 (0.04–0.10)
Influenza A/B	7	0.05 (0.01–0.09)	12	0.11 (0.05–0.17)	0.08 (0.05–0.12)
PIV	23	0.16 (0.10–0.23)	38	0.34 (0.23–0.45)	0.24 (0.19–0.31)
RSV	17	0.12 (0.06–0.18)	28	0.25 (0.16–0.35)	0.18 (0.13–0.24)
Rhinovirus <sup>b</sup>	51	0.49 (0.35–0.62)	104	0.94 (0.76–1.12)	0.72 (0.61–0.83)
Coronavirus	NA	—	15	0.14 (0.07–0.20)	—
Syndromic	NA	—	11	0.10 (0.04–0.16)	—
Unit					
PICU	20	1.47 (1.00–2.09)	17	1.67 (0.97–2.68)	1.54 (1.13–2.04)
NICU	5	0.23 (0.12–0.42)	31	1.37 (0.93–1.95)	0.60 (0.44–0.82)
Med/Surg	33	0.69 (0.49–0.95)	152	2.22 (1.88–2.61)	1.55 (1.34–1.79)
H/Onc	28	1.84 (1.27–2.59)	11	1.17 (0.59–2.10)	1.61 (1.17–2.16)
Total	112	0.80 (0.66–0.97)	211	1.91 (1.66–2.19)	1.29 (1.15–1.44)

Abbreviations: CCMC, Cohen Children's Medical Center; CI, confidence interval; hMPV, human metapneumovirus; MCH, Montreal Children's Hospital; NA, not applicable; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit; PIV, parainfluenza virus; RSV, respiratory syncytial virus; Med/Surg, medical/surgical; H/Onc, hematology/oncology.

<sup>a</sup>Number of episodes during 36-month study period.

<sup>b</sup>Rhinovirus was detected in the last 3 months of the first year at the CCMC; the denominator used was 105 043 patient-days.

most commonly identified viral pathogen in both hospitals was rhinovirus, followed by PIV and RSV (Table 3). In the PICU, the viral pathogen with the highest incidence rate was rhinovirus, followed by adenovirus in both hospitals, whereas on the hematology/oncology wards, the incidence rate of rhinovirus was followed by that of PIV (Table 4).

At the CCMC, the monthly rate of adherence to hand-hygiene practices was 94.4% (range, 86.0%–98.2%), assessed with a mean of 160 observations per month.

#### Proportion of Single Rooms

Adjusting for unit type (PICU vs NICU vs medical/surgical vs hematology/oncology) and taking into account the correlation of HA-VRI rates within a hospital, having less than 50% single rooms in a given unit was associated statistically significantly with a higher rate of HA-VRI. The model predicted that units

with less than 50% single rooms have 1.33 (95% CI, 1.29–1.37) times higher HA-VRI rates than units with at least 50% single rooms, regardless of unit type (Table 5). There was no single room in any of the NICUs.

#### DISCUSSION

Our data show that HA-VRI are common HAIs in pediatric hospitals, and the overall incidence rate of laboratory-confirmed HA-VRI in our population was 1.29 per 1000 patient-days (95% CI, 1.15–1.44 per 1000 patient-days). This incidence rate is the same order of magnitude or higher than published rates of HA bloodstream infections: between 0.67 and 0.84 per 1000 patient-days for the same time period in hospitals of the University of North Carolina [24] and 0.51 and 0.65 per 1000 patient-days in 2014 in 2 pediatric hospitals [25, 26].

**Table 4. Incidence Rates (per 1000 Patient-Days) of Healthcare-Associated Viral Respiratory Infection According to Virus and Hospital Unit**

Virus	Cohen Children's Medical Center				Montreal Children's Hospital			
	PICU	NICU	Med/Surg	H/Onc	PICU	NICU	Med/Surg	H/Onc
Adenovirus	0.19 <sup>a</sup>	0	0.04	0.06	0.49 <sup>a</sup>	0	0.22	0
hMPV	0.10	0	0.06	0.11	0.10	0.10 <sup>a</sup>	0.09	0
Influenza A/B	0.05	0	0.02	0.06	0	0	0.16	0
PIV	0.14	0.06 <sup>a</sup>	0.21 <sup>b</sup>	0.34 <sup>a</sup>	0.30	0.04	0.45 <sup>a</sup>	0.32 <sup>a</sup>
RSV	0.10	0.02	0.17 <sup>a</sup>	0.28	0.20	0.04	0.34	0.21
Rhinovirus	0.90 <sup>b</sup>	0.15 <sup>b</sup>	0.15	0.95 <sup>b</sup>	0.59 <sup>b</sup>	1.15 <sup>b</sup>	0.97 <sup>b</sup>	0.64 <sup>b</sup>
Total	1.47	0.23	0.69	1.84	1.67	1.37	2.22	1.17

Abbreviations: H/Onc, hematology/oncology ward; Med/Surg, medical/surgical ward; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit.

<sup>a</sup>Respiratory virus with second highest incidence for a given unit type.

<sup>b</sup>Respiratory virus with highest incidence for a given unit type.

**Table 5. Determinants of Healthcare-Associated Viral Respiratory Infection Rates According to Multivariable Analysis**

Parameter	Estimate	95% CI	P Value
Fewer than 50% single rooms	1.33	1.29–1.37	<.0001
Hospital unit			
PICU	1.04	1.03–1.05	<.0001
NICU	0.47	0.16–1.38	.17
Med/Surg	0.85	0.37–1.94	.70
H/Onc	Reference	—	—

Abbreviations: CI, confidence interval; H/Onc, hematology/oncology unit; Med/Surg, medical/surgical ward; NICU, neonatal intensive care unit; PICU, pediatric intensive care unit.

The Canadian Nosocomial Infection Surveillance Program [27] reported results of a prospective surveillance of febrile respiratory illnesses that was performed between January and April 2005 in 8 acute-care pediatric hospitals across Canada. Their overall bacterial and viral hospital-acquired febrile respiratory infection incidence rate was 0.97 per 1000 patient-days (95% CI, 0.78–1.18 per 1000 patient-days), and a viral pathogen was isolated from 79.5% (70 of 88) of the patients tested. This rate was lower than the currently reported incidence rates. These differences might be explained by differences in the number of hospital days before the onset of symptoms required by the HA-VRI definition and the fact that our study included all VRIs, not only febrile HA-VRIs. Moreover, nucleic acid amplification tests were used in our study rather than viral culture or an antigen-detection test, which are known to be less sensitive [28, 29].

The lowest HA-VRI incidence rates were found in the NICU. Other types of units had similar rates. It is possible that visitor restrictions contributed to this difference, but another contributor might be the fact that the reservoir of patients with (mainly community-acquired) VRI is likely lowest in the NICU compared to other units, thus decreasing the risk of nosocomial transmission. It is also interesting to note that units with less than 50% single rooms had higher HA-VRI rates when we adjusted for confounders and accounted for correlation of data within a hospital. A 50% cutoff was chosen because healthcare workers who evaluated the impact of 100% single rooms in new facilities considered the ideal room mix on a ward to be 50% single-bed rooms and 50% multiple-beds room [30]. However, this should not be translated to mean that, regardless of the unit type or category, a higher proportion of single rooms would correlate with a lower HA-VRI rate. For instance, the proportion of single rooms was 0% in both NICUs in our study, yet these NICUs had the lowest overall HA-VRI rates. Although single-patient rooms are the goal in most new hospital designs, no evidence-based consensus currently exists on the efficacy of that setup in preventing the acquisition of HA multidrug-resistant organisms transmitted by direct or indirect contact (e.g., methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant *Enterococcus* and *Clostridium difficile*). Teltsch et al [31] found that changing

the ICU layout from multibed rooms to single rooms decreased the multidrug-resistant organism acquisition rate by 54% (95% CI, 29%–70%), but Ellison et al [32] did not find any difference associated with a similar change in layout on a general internal medicine ward. Organisms acquired through direct or indirect contact are also transmitted on healthcare workers' hands, shared equipment, and fomites; therefore, single rooms might not be sufficient to prevent nosocomial acquisition in the absence of diligent hand hygiene and housekeeping. Similar to multidrug-resistant HA organisms, HA-VRIs are transmitted by direct and indirect contact and also via droplets; therefore, single rooms might be more efficacious in preventing HA-VRI transmission through decreased crowding.

Rhinovirus was the most frequently identified virus in cases of HA-VRI in both hospitals (48% [155 of 323] of all HA-VRIs) for all but 1 unit type; the overall incidence rate was 0.72 per 1000 patient-days (95% CI, 0.61–0.83 per 1000 patient-days). Previous studies reported that the proportion of community-acquired acute respiratory infections caused by rhinovirus was, on average, 20% in children who required hospital admission [33, 34]. However, for children with a more severe presentation who required admission to the PICU for community-acquired lower respiratory tract infection and in whom a virus was identified, rhinovirus represented the etiological agent in 49% of the cases [35]. However, given the prolonged shedding of rhinovirus and its detection with nucleic acid amplification-based testing, it is difficult to tease out the proportion of positive tests that are clinically significant and the etiological role of rhinovirus in community- and healthcare-acquired respiratory infections. For instance, in an adult cohort of patients who presented with acute respiratory infection, rhinovirus was identified by polymerase chain reaction in 18% (444 of 2485) of the cases, and prolonged shedding was identified in 35% of the patients [36]. In a case-control study, rhinovirus was associated with community-acquired pneumonia in adults (adjusted odds ratio, 13.4 [95% CI, 3.04–59.1]) but not in children (adjusted odds ratio, 1.13 [95% CI, 0.84–1.51]) [34]. Management guidelines for febrile infants aged less than 90 days of life who present to the emergency department have recommended that the presence of rhinovirus in a nasopharyngeal specimen be disregarded and that these patients be managed as if they were respiratory virus negative because the presence of rhinovirus does not seem to decrease the likelihood of severe bacterial infection [37]. In the current study, although some patients with HA rhinovirus had a negative respiratory polymerase chain reaction result on hospital admission, the high prevalence of rhinovirus should be interpreted with caution.

Other viruses usually associated with HA-VRI, such as RSV, PIV, and influenza, accounted for 14% (45), 19% (61), and 6% (19) of isolated viruses, respectively. Our results are similar to those from a prospective surveillance for HA febrile respiratory infection in pediatric hospitals; RSV was identified in 25%



(38 of 153), PIV in 7% (11 of 153), and influenza in 11% (17 of 153) of cases of febrile HA-VRI [27].

### Limitations

Our study had several limitations that could explain the difference in HA-VRI rates between the 2 participating hospitals. First, no standardized definition for HA-VRI currently exists, and the IPAC services at each hospital used slightly different criteria. However, although the surveillance definitions differed slightly, both of them required a new onset of similar symptoms, and 1 definition (MCH) was more precise as to what was considered a respiratory symptom, which made it more operational and less subject to interpretation. Second, minimum durations of hospitalization before the onset of symptoms required to classify an infection as nosocomial were based on published incubation periods for each virus type; these durations were similar but not identical between hospitals and generally were at the lower end of the range for each virus type. These definitions were designed to be sensitive for the detection of HAIs and possible outbreaks. However, a potential exists for misclassification of some community-acquired infections as HAI. Third, the surveillance procedures for HA-VRI differed; 1 hospital was more aggressive in actively finding cases (including syndromic surveillance for which viral testing was either negative or not requested), whereas the other hospital was using a surveillance system that was laboratory based, which again potentially explains the difference in rates. This difference in case findings, however, is the Achilles's heel of all surveillance programs. Fourth, the case mix of patients in both hospitals also differed; chronically ventilator-dependent patients who attended out-of-hospital daycare were accounted for in HAI surveillance at the MCH. IPAC guidelines for additional precautions and visitation policies also differed. Last, another limitation to our study was that the detection of HA-VRI that manifested after hospital discharge was incomplete, because no systematic surveillance for HA-VRI is performed after discharge. The only children with HA-VRI with symptom onset after hospital discharge who were likely to be identified were those who presented to the emergency department or were readmitted because of a VRI.

Future studies should examine the effect of HA-VRI and evaluate best practices for preventing such infections, including compliance to influenza vaccination of patients and healthcare workers. The effects of viral testing, visitation policies, personnel work policy with regard to acute respiratory illness, and the proportion of single-patient rooms for given units on HA-VRI rates should be evaluated also.

### Notes

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**Author contributions.** Dr Quach contributed to study design and design of the data-collection instrument, supervised data collection for her site,

performed the data analysis, wrote the manuscript, and approved the final manuscript as submitted; Dr Shah contributed to study design, designed the data-collection instrument, performed the data collection for her site, and critically reviewed and approved the final manuscript as submitted; and Dr Rubin conceptualized the study, supervised the data collection for his site, and critically reviewed and approved the final manuscript as submitted.

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All authors have submitted the ICMJE Form for Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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