



Short Report

Healthcare-associated viral respiratory infections in paediatric intensive care unit settings: More than just a sneeze

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SUMMARY

Healthcare-associated infections (HAIs) affect patient health. Patients with Paediatric Intensive Care Unit (PICU) acquired viral respiratory infections had longer use of respiratory support. We found it's uncommon in ICUs to have high risk HAIs. RSV, parainfluenza, and hMPV are the most common, and 1/3 of patients required escalation in respiratory support and/or escalation in antibiotics. All patients had underlying comorbidities. In our series there were two deaths within 2 weeks of infection.

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Introduction

Hospital-acquired infections exert considerable pressure on patient health and are tracked closely by Infection Prevention (IP) departments. Most attention is directed to hospital-acquired blood stream infections [1] as well as ventilator associated pneumonias [2]. Hospital acquired blood stream infections increase crude mortality [2] as well as overall cost by \$40,000/patient [3]. Hospital-acquired viral respiratory infections in the Paediatric Intensive Care Unit (PICU) have potential to increase length of stay, all-cause mortality, and cost but have not been as well studied. The prolonged time of viral

shedding may increase the likelihood of hospital transmission to patients and staff.

Viral infections are common in the paediatric population, with healthy children often only requiring supportive treatment. A problem arises when PICU patients, who are considered medically fragile at baseline, acquire common viruses during hospital admission. Research demonstrates that patients with PICU associated respiratory viral infections have greater duration of intubation and respiratory support [4]. One European hospital demonstrated that after RSV, human metapneumovirus (hMPV) is most prevalent [5].

There is a body of evidence that characterizes the effects of RSV, rotavirus, and bloodstream infections on hospital stay. However, there is limited evidence evaluating the effects of other viruses. Our aims are to determine if there are factors that increase the likelihood of hospital-acquired viral respiratory infections. Also, if there is a specific subgroup of

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patients that is more likely to acquire a specific virus. Lastly, to evaluate the need for additional workup and treatment of patients that likely have a viral infection. Closing this gap in knowledge will allow providers to better understand the implications of acquiring these type of hospital acquired infections (HAIs).

Methods

Children's Health Orange County (CHOC) is a 334-bed, tertiary care center located in Southern California. A retrospective cohort study was completed. Potential charts were identified from a pre-established database of patients generated by the IP department between the fiscal years (FY) of 2005–2020. Patients were included in this database by the following criteria: 1. Patients between 0-21 years of age admitted to CHOC. 2. Patients diagnosed with a new respiratory viral infection by viral culture, viral respiratory panel, or viral polymerase chain reaction ≥ 48 -hours after admission (different diagnostic modalities available during this time-frame). Influenza A/B, RSV, adenovirus, parainfluenza, and hMPV, were included because these viruses are most likely to require hospitalization, have protracted clinical courses, or be associated with bacterial superinfections. Additionally, cases of hospitalised influenza and RSV are tracked by public health agencies annually. We excluded rhino/enteroviruses

because they are ubiquitous and normally do not result in hospitalization. Patients are admitted to the CHOC ICUs if they require significant respiratory support via high flow nasal cannula or mechanical ventilation. Additionally, patients are admitted to the ICU if they require observations of vital signs more frequently than every four hours, monitoring for shock, or administration of certain intravenous medication.

The control group size was determined by completion of a power analysis and needed to be a 2:1 ratio to the case group. Potential charts were queried from Cerner's database of patients between 0-21 years of age admitted to CHOC's ICUs between the fiscal years of 2005 to present. Patients were excluded from the control group if they were included in the case group database. These patients were admitted to the PICU for post-operative monitoring or because they required nursing care that is not offered on our medical surgical floors.

Patients were categorized according to underlying pathology. Increased respiratory support was defined as any increase from a patient's baseline ± 24 hours of viral diagnosis. Antibiotic escalation was initiation of antimicrobial therapy or broadening the spectrum for ≥ 2 days ± 24 hours of viral diagnosis. Statistics were completed in cooperation with UCI Biostatistics, Epidemiology, and Research Design Unit utilizing two sample t-test and Fisher exact tests.

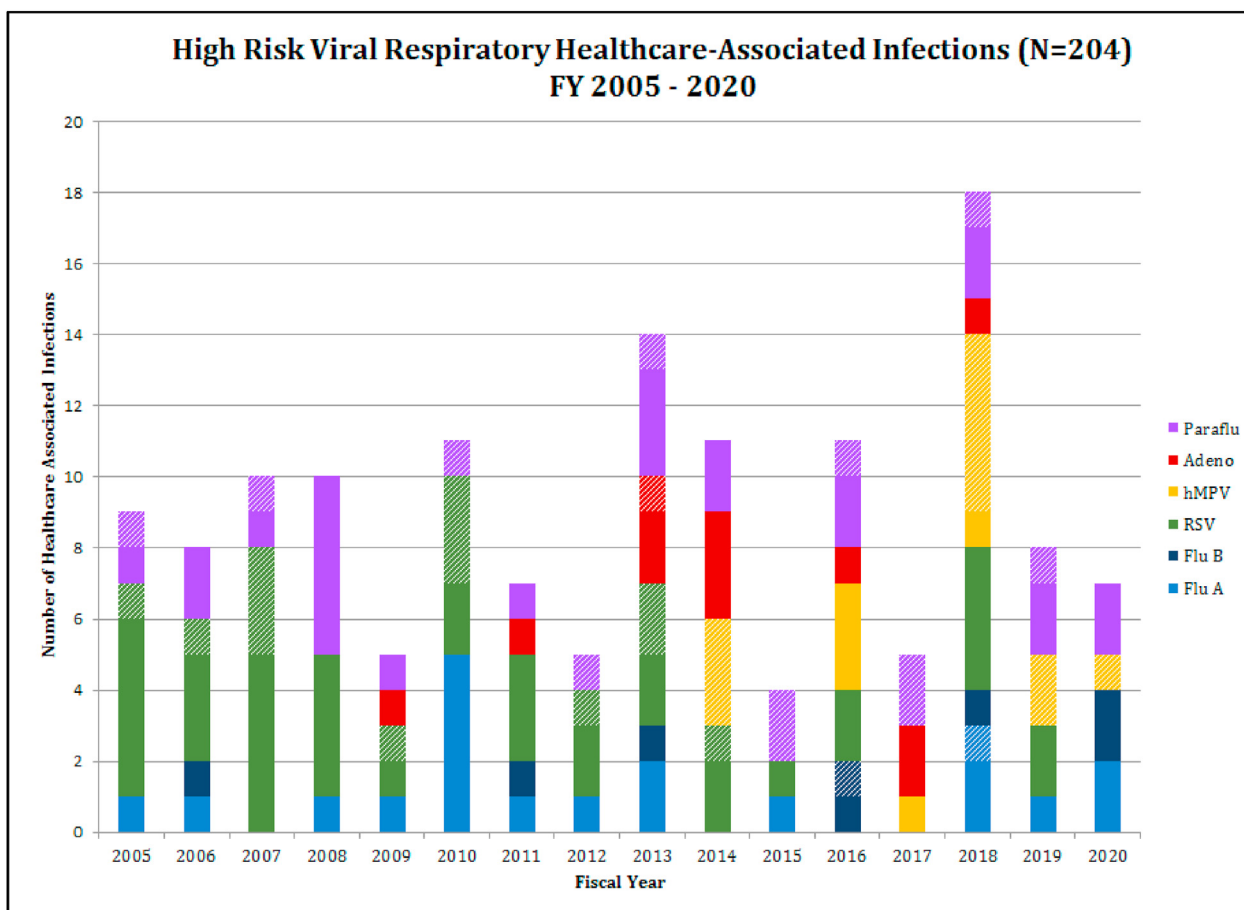


Figure 1. High risk viral respiratory healthcare-associated infections in a children's hospital between fiscal years 2005 to 2020. Total viruses are indicated by the bar for the year. The subset of viruses that were acquired in an ICU are indicated with cross hatching.

Table I

Demographics table. Patients with a cardiovascular comorbidity were more likely to require an increase in respiratory support than those without ($P = 0.1617$). The same can be said of those with a pulmonary comorbidity when compared to those without ($P = 0.1013$)

	Control group	Case group	P-value
N	88	39	
Gender			
Male	48	20	
Female	40	19	
Average age (months)	43.1	40.9	
Length of Stay (LOS) (days)	4.8	56.9	<0.0001
Virus			
RSV		12	
Parainfluenza		12	
Adenovirus		11	
hMPV		1	
FluA/B		3	
Season			
Spring	24	13	
Summer	12	5	
Fall	10	3	
Winter	42	18	
Comorbidities			
None	28	0	
Structural cardiac	35	15	0.1617
Oncologic	0	8	
Pulmonary	0	6	0.1013
Neurologic	9	4	
Mixed	15	6	
Respiratory support		24	
Average length (days)	0	12.6	<0.0001

Results

During FY 2005–2020 there were 204 viral respiratory HAIs (VR-HAIs): 143 high risk VR-HAIs (HR-VR-HAIs) (70%), of which, 39 (19.1%) were found in ICUs (Figure 1), the control group was comprised of 88 patients. Basic demographic data is shown in Table I. Of those patients the average length of stay (LOS) for the case group was 56.9 days vs 4.8 days ($P < 0.0001$) in the control group. Patients in the case group had a LOS of 34.3 days prior to positive viral testing and a LOS of 22.7 days subsequent to positive viral testing. Out of the four seasons 46.2% (18) of the patients who acquired viral infections were admitted in winter, followed by spring 33.3% (13), with the remainder admitted in summer and fall 20.5% (8). Most of the HR-VR-HAIs were acquired in spring 43.5% (17), followed by winter 33.3% (13), then summer 15.4%, and fall 7.7% (3) with no statistical significance associated with seasonality. Most HR-VR-HAIs were RSV, Parainfluenza, and hMPV (Figure 2a); patients were more likely to acquire parainfluenza in the spring and RSV in the winter.

All 39 patients in the case group had underlying comorbidities. Fifteen of 39 (38.5%) had structural cardiac disease, 8/39 (20.5%) had underlying oncologic conditions, seven of whom

were immunosuppressed. Six of 39 (15.4%) had pulmonary disease and another 6/39 had mixed comorbidities. The remaining 4/39 (10.3%) had neurologic disease. Within the control group 28 (32%) were previously healthy, 35 (40%) has structural cardiac disease, no patients had pulmonary or oncologic disease, 9/88 (10.2%) had neurologic disease, and the remaining 15/88 (17%) had other comorbidities (Figure 2b). Twenty-four of 39 patients (61.5%) required an increase in respiratory support, with the average duration being 12.6 days versus no increase in support in the control group ($P < 0.0001$). Within the case group, patients with cardiovascular comorbidity were more likely to require an increase in respiratory support than those without ($P = 0.1617$). The same can be said of those with a pulmonary comorbidity when compared to those without ($P = 0.1013$).

Thirteen of 39 (33%) patients had escalation of antibiotics, two were justified by a positive blood culture. Another four were febrile neutropenic patients. The remaining seven had unclear reasons for escalation and four of the patients were treated for ≥ 5 days. Two of 39 expired within 2 weeks of acquisition.

Discussion

Respiratory viral infections typically require only supportive care in the outpatient setting, but the impact of these as HAI in the paediatric ICU population is not well defined. In our retrospective cohort study, we found a statistically significant difference in LOS of 56.9 days in the case group versus 4.8 days in the control group. It is unclear whether LOS resulted in increased risk of viral acquisition or if the hospital acquisition of a virus increased patient LOS. Prolonged LOS in the hospital offers more opportunity for visitors (and possibly staff) to transmit viral respiratory infections to patients. Conversely, acquisition of a respiratory viral infection in an already compromised child may prolong hospital stay to monitor fever or respiratory status. The substantially increased LOS prior to testing positive for a hospital acquired infection is a potential factor in overall virus acquisition.

A confounding factor linked to LOS is the underlying pathology of the patients. In the case group, none of the patients were previously healthy, whereas 1/4 of the control group had no comorbidities. In the United Kingdom, a PICU found that there was a significant difference in LOS in patients with one chronic condition versus those without [8]. Furthermore, the LOS increased with the number of chronic health conditions [6]. Other research demonstrates that while those with chronic conditions are more likely to be admitted to the hospital with increased LOS, it is particularly the socio-economically disadvantaged [7].

It is logical that patients in the case group would have a longer duration of escalation in respiratory support. Of note both those with cardiovascular and pulmonary comorbidities were more likely to require an increase in respiratory support as compared to other pathologies. Although the P -values are not statistically significant, the trend is meaningful. This is not surprising, as those with cardiac or pulmonary comorbidities have decreased respiratory reserve. We were unable to assess the likelihood of respiratory support from a previously healthy patient, as there were none in the case group.

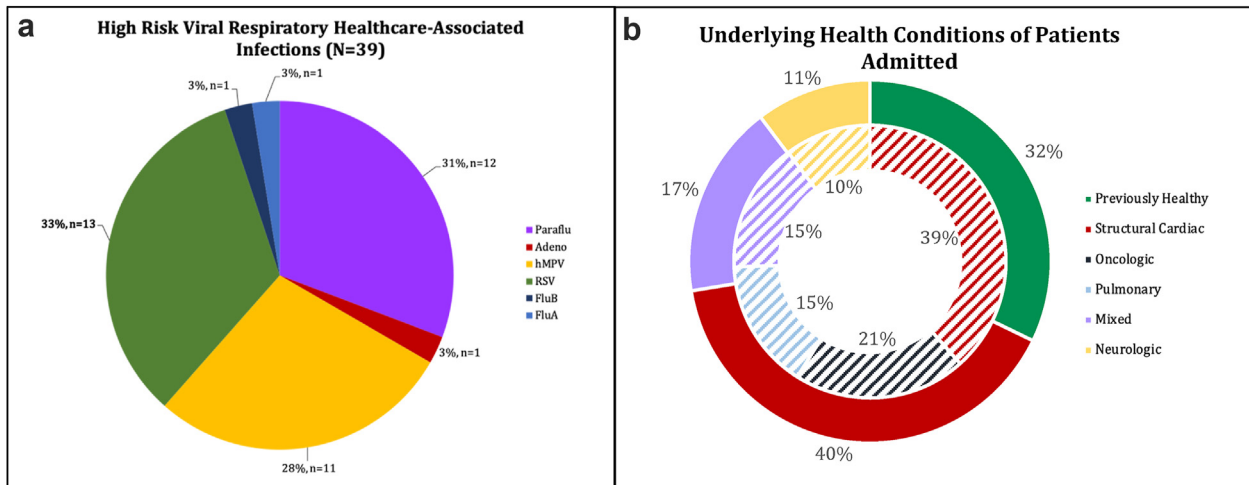


Figure 2. a) High risk viral respiratory healthcare-associated Infections (parainfluenza, adenovirus, human metapneumovirus, respiratory syncytial virus, and influenza A/B) in an ICU between fiscal years 2005 to 2020. (b) Underlying health conditions of patients admitted to an ICU between fiscal years 2005 to 2020. The case group is indicated with crosshatching and the control group with solid segments.

One would presume that those in the case group required more antimicrobial therapy, due to the increased LOS as well as comorbidities. However, having a viral aetiology for decompensation allowed providers to discontinue antimicrobials in otherwise medically complex children. The ability to run a viral PCR panel has allowed providers to exercise greater antibiotic stewardship. There were two deaths in the case group which occurred within two weeks of viral diagnosis. In this medically complex group, it is difficult to ascertain the effect of the HR-VR-HAI on outcome.

This study's generalizability is limited due to the small convenience sample at a single center as well as limited to high-risk respiratory viruses. Additionally, the data for the sample was obtained and analyzed prior to the COVID-19 pandemic and implementation of mandatory masking throughout hospitals. However, we can extrapolate some of what we have learned in the COVID-19 pandemic. Mask mandates, social distancing, improved ventilation, and better attention to hand hygiene, have decreased not only transmission of COVID-19 in schools and communities, but these measures have decreased community transmission, hospitalizations, and deaths due to other viral respiratory infections, such as influenza [8,9]. In the hospital setting, universal masking, strict avoidance of unnecessary staff and visitors, and more rigorous attention to hand hygiene during the pandemic period would be expected to decrease HAI viral respiratory infections [10].

Conclusions

It is uncommon in ICUs to have HR-VR-HAI. RSV, parainfluenza, and hMPV are the most common. In our study, all affected patients had underlying comorbidities, and 1/3 of patients required escalation in respiratory support and/or escalation in antibiotics. Further work should be done to establish a link between acquisition of a high-risk virus in hospital and LOS, morbidity, and financial cost. This analysis was prior to SARS-CoV-2 pandemic measures which have decreased community viral respiratory infections, and hopefully all HAI viral respiratory infections.

CRedit authorship contribution statement

Kelly Feldman: Conceptualization, Methodology, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization.

Wendi Gornick: Investigation, Data Curation, Writing - Review & Editing.

Beth Huff: Investigation, Data Curation.

Jasjit Singh: Conceptualization, Methodology, Writing - Review & Editing, Supervision.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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