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BRIEF REPORT

Impact of SARS-CoV-2 Prevention Measures on Non-SARS-CoV-2 Hospital-Onset Respiratory Viral Infections: An Incidence Trend Analysis From 2015–2023

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We reviewed hospital-onset respiratory viral infections, 2015–2023, in one hospital to determine whether Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) transmission prevention measures prevented non-SARS-CoV-2 respiratory viral infections. Masking, employee symptom attestations, and screening patients and visitors for symptoms were associated with a 44%–53% reduction in hospital-onset influenza and respiratory syncytial virus (RSV), accounting for changes in community incidence.

Keywords. viral transmission; masking; hospital-acquired infection; respiratory viral infections; infection prevention.

Nosocomial respiratory viral infections are a longstanding but underappreciated problem in hospitals. Hospital-acquired respiratory viral infections are associated with increased length-of-stay and high mortality rates, particularly in patients who are elderly, have compromised immune systems, or underlying heart and lung disease [1–3]. In response to the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) pandemic, hospitals implemented extensive infection prevention and control measures to reduce nosocomial transmission of SARS-CoV-2, including universal masking, employee attestations of health, visitor restrictions, and others. Mechanisms and risk factors for nosocomial transmission of respiratory viruses are similar for all viruses [4], raising the question of whether measures implemented to decrease nosocomial SARS-CoV-2 transmission also decreased the incidence of non-SARS-CoV-2 respiratory viral infections. We assessed for changes in the incidence of hospital-onset non-SARS-CoV-2 respiratory viral infections over 8 years in one hospital, comparing pre-pandemic, intra-pandemic, and post-acute-pandemic periods, accounting for changes in community incidence.

METHODS

We used data from Brigham and Woman's Hospital, an 803-bed academic hospital in Boston, Massachusetts. We assessed monthly counts of patients with incident positive influenza, parainfluenza, adenovirus, human metapneumovirus (HMPV), rhinovirus, and respiratory syncytial virus (RSV) polymerase chain reaction (PCR) or antigen tests between October 2015 and April 2023. Cases were categorized as community-onset if detected on hospital days 1–3 and hospital-onset if first detected on hospital day 4 or later.

We calculated the monthly frequency of hospital-onset respiratory viral infection per 1000 admissions. We then used an interrupted time-series analysis to assess for changes in the incidence of hospital-onset respiratory viral infections following the implementation of infection control measures to reduce in-hospital transmission of SARS-CoV-2 starting in March 2020. Measures that may have affected non-SARS-CoV-2 respiratory viral transmission included universal masking of patients and providers (with surgical masks), requiring employees to attest to lack of respiratory viral symptoms before each shift, visitor restrictions, and regularly screening patients for new respiratory viral symptoms. Influenza vaccines were required for all employees in all seasons. We limited the statistical assessment for changes in non-SARS-CoV-2 incidence rates to influenza and RSV because access to testing for these pathogens has been stable over time whereas testing for other respiratory viruses (HMPV, rhinovirus, parainfluenza, adenovirus) has increased due to a combination of greater awareness and the introduction of in-house multiplex PCR testing.

The incidence of hospital-acquired respiratory viral infections is closely associated with community incidence rates; we therefore adjusted monthly estimates of hospital-onset influenza and RSV using 1 of 2 different measures of community incidence rates: (1) the count of patients admitted with community-onset influenza or RSV, and (2) Centers for Disease Control and Prevention's (CDC's) weekly estimates of influenza-like-illness (ILI) activity for Massachusetts, expressed as the percentage of healthcare provider visits for ILI [5]. We divided the analysis into 3 periods: the pre-pandemic period (October 2015 to March 2020), the intra-pandemic period during which the community incidence of influenza and RSV was near zero (April

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2020 to August 2021), and the post-acute-pandemic period when the community incidence of influenza and RSV rose again (September 2021 to April 2023).

We fitted a Poisson regression model to analyze the log-transformed rate of the sum of hospital-onset influenza plus RSV per 1000 admissions, adjusting for: (1) community-acquired influenza and RSV admissions or ILI in separate models respectively, (2) changes in intra-pandemic levels and trends, (3) changes in post-acute-pandemic levels and trends, and (4) seasonality. We calculated relative rates of hospital-onset cases by predicting hospital-onset influenza and RSV counts from the adjusted models for each of the pre-, intra, and post-acute-pandemic periods, taking the average hospital-onset influenza plus RSV counts per period, and then dividing intra-pandemic versus pre-pandemic and post-acute-pandemic versus pre-pandemic predicted counts. We did a sensitivity analysis in which we defined hospital-onset cases as those detected on hospital day ≥5. Model fitting and inferences were performed in R version 4.1.2. Model details can be found in the Supplement. The study was approved with a waiver of informed consent by the Mass General Brigham Institutional Review Board.

RESULTS

Across 8 years, we detected 436 hospital-onset respiratory viral infections. Most occurred during the fall-winter months of October to March (315/436, 72.2%). Hospital-onset cases were predominantly attributable to influenza (124/436, 28.4%), RSV (84/436, 19.3%), and rhinovirus (114/436, 26.1%) but HMPV (40/436, 9.2%), parainfluenza (52/436, 11.9%), and adenovirus (22/436, 5.0%) were also detected (Figure 1*A*). The incidence rate was highest in winter 2019/2020 (4.0 cases per 1000 admissions) and lowest in 2020/2021 (0.55 cases per 1000 admissions). On average, 14.9% of all respiratory viral infections among hospitalized patients during respiratory viral seasons (October to March) were hospital-onset, ranging from 9.8% in 2015/2016 to 20.9% in 2018/2019 and 20.2% in 2019/2020.

The incidence of hospital-onset influenza and RSV alone are shown in Figure 1*B* along with contemporaneous ILI rates. The intra-pandemic period was associated with a 100% decrease in hospital-onset influenza and RSV compared to the pre-pandemic period. The post-acute-pandemic period was associated with a 53% decrease in hospital-onset influenza and RSV compared to the pre-pandemic period when using influenza-like illness rates to adjust for community incidence (risk ratio [RR] 0.47, 95% confidence interval [CI] .14–.62, $P < .01$) and a 44% decrease in hospital-onset influenza and RSV versus the pre-pandemic period when using community-acquired influenza and RSV hospitalizations to adjust for community incidence (RR 0.56, 95% CI .14–.74, $P < .01$). Results were consistent in a sensitivity analysis in which hospital-onset was defined as hospital day ≥5 (RR 0.37, 95% CI .24–.72, $P < .01$ using influenza-like illness to adjust for community incidence and RR 0.43, 95% CI .28–.88, $P < .01$, using community-acquired influenza and RSV hospitalizations to adjust for community incidence).

DISCUSSION

Hospitals implemented multiple measures to decrease SARS-CoV-2 transmission during the pandemic including universal masking, employee attestations of health, and screening visitors and patients for respiratory viral symptoms. These measures were associated with decreases in nosocomial SARS-CoV-2 infections but could also have lowered transmission of other respiratory viruses given they too are mostly transmitted from the respiratory tract through the air to susceptible parties. On retrospective analysis of 8 years of data in 1 hospital, we found hospital-onset non-SARS-CoV-2 respiratory virus infections were common (>50/year), attributable to a wide array of viruses (only ∼50% were attributable to influenza or RSV), and that measures implemented to prevent SARS-CoV-2 transmission were associated with a 44%–53% reduction in hospital-onset influenza and RSV, accounting for season-to-season changes in community incidence.

Our findings mirror studies from before the pandemic that also reported masking healthcare workers was associated with substantial decreases in hospital-onset respiratory viral infections [6, 7]. Sung and colleagues reported that year-round masking in a hematopoietic stem cell transplant unit was associated with a 60% decrease in hospital-onset respiratory viral infections [6]. Ambrosch and colleagues reported that implementing a strict "mouth-nose protection" policy during influenza season was associated with a 60% reduction in nosocomial influenza cases and fewer nosocomial influenza deaths [7]. Other investigators reported even greater decreases in nosocomial influenza and RSV in the initial months of the SARS-CoV-2 pandemic following implementation of universal masking [8, 9] but did not account for the simultaneous dramatic drop in community cases [10, 11].

Our study echoes and amplifies these investigations by also reporting a 44%–53% decrease in the incidence of hospital-onset influenza and RSV following implementation of universal masking and other measures but extends these studies by adjusting for community incidence of respiratory viral infections using two independent measures (influenza-like illness and community-acquired influenza plus RSV hospitalizations).

A common finding across these studies is that masking healthcare workers is associated with reducing nosocomial respiratory viral infections by about half. This is consistent with laboratory studies suggesting that surgical masks reduce respiratory viral emissions by about 40%–60% [12, 13]. Decreases in viral emissions translate into less viral exposure and hence less risk of transmission. However, since surgical

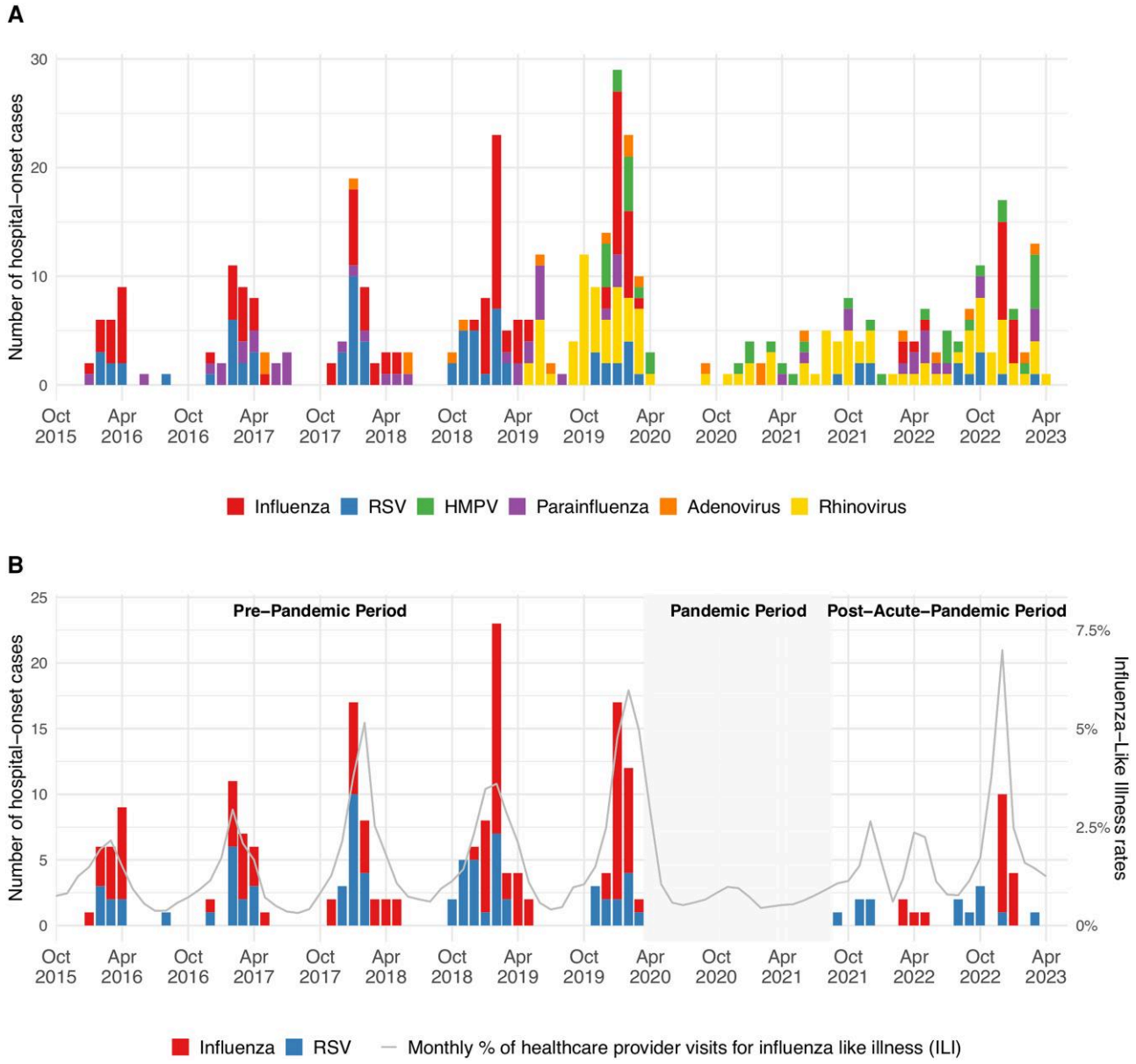

Figure 1. *A*, Number of hospital-onset respiratory viral infections between 2015–2023. *B*, Hospital-onset influenza and RSV cases with contemporaneous influenza-like illness rates.

masks do not completely eliminate viral emissions, residual transmissions are still possible [14, 15]. Respirators provide superior source control but are not commonly worn [16, 17]. Other potential explanations for residual hospital-onset infections despite masking include healthcare worker and visitor non-compliance with masking, transmission from unmasked roommates with undiagnosed infections, and delayed detection of community-acquired infections leading to misclassification as hospital-onset infections.

Our study has several limitations. First, we only included data from a single hospital, so our results may not be generalizable to other settings or populations. Second, patients may have been discharged before nosocomial respiratory infection was diagnosed, resulting in underdetection of hospital-acquired infections. Likewise, some cases of influenza and RSV are asymptomatic or minimally symptomatic so may not have prompted testing. Third, the threshold for testing for respiratory viruses has likely decreased over time due to greater awareness during the pandemic. This may have led us to underestimate the impact of SARS-CoV-2 prevention measures. Fourth, multiple measures were implemented to control SARS-CoV-2 in the study hospital making it difficult to elucidate which change or changes were most impactful. Fifth, the post-acute pandemic period was relatively brief and potentially atypical.

In summary, we document that infection control measures implemented to prevent SARS-CoV-2 transmission in hospitals were associated with a 44%–53% decrease in the incidence of non-SARS-CoV-2 viruses. These findings suggest the potential utility of requiring healthcare workers to wear masks or respirators, particularly during times of increased community transmission, in order to protect patients from the breadth of respiratory viral pathogens, in addition to SARS-CoV-2 [18].

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Notes

Acknowledgments. S. E. analyzed and interpreted the data, prepared figures, and wrote the first draft of the manuscript. T. C. conducted statistical analyses. V. V. obtained data for the project. M. B. and C. R. helped interpret results and provided significant input on the manuscript. M. K. conceived of the project, helped obtain data, helped write and revise the manuscript, and provided study supervision.

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

References

1. Javaid W, Ehni J, Gonzalez-Reiche AS, et al. Real-time investigation of a large nosocomial influenza A outbreak informed by genomic epidemiology. Clin Infect Dis **2021**; 73:e4375–83.
2. Begley KM, Monto AS, Lamerato LE, et al. Prevalence and clinical outcomes of respiratory syncytial virus versus influenza in adults hospitalized with acute respiratory illness from a prospective multicenter study. Clin Infect Dis **2023**; 76: 1980–8.
3. Tseng HF, Sy LS, Ackerson B, et al. Severe morbidity and short- and mid- to long-term mortality in older adults hospitalized with respiratory syncytial virus infection. J Infect Dis **2020**; 222:1298–310.
4. Klompas M, Milton DK, Rhee C, Baker MA, Leekha S. Current insights into respiratory virus transmission and potential implications for infection control programs: a narrative review. Ann Intern Med **2021**; 174:1710–8.
5. Centers for Disease Control and Prevention. National, regional, and state level outpatient illness and viral surveillance. Available at: https://gis.cdc.gov/grasp/fluview/fluportaldashboard.html. Accessed March 23.
6. Sung AD, Sung JAM, Thomas S, et al. Universal mask usage for reduction of respiratory viral infections after stem cell transplant: a prospective trial. Clin Infect Dis **2016**; 63:999–1006.
7. Ambrosch A, Luber D, Klawonn F, Kabesch M. A strict mask policy for hospital staff effectively prevents nosocomial influenza infections and mortality: monocentric data from five consecutive influenza seasons. J Hosp Infect **2022**; 121: 82–90.
8. Wong S-C, Lam GK-M, AuYeung CH-Y, et al. Absence of nosocomial influenza and respiratory syncytial virus infection in the coronavirus disease 2019 (COVID-19) era: implication of universal masking in hospitals. Infect Control Hosp Epidemiol **2021**; 42:218–21.
9. Wee LEI, Conceicao EP, Tan JY, et al. Unintended consequences of infection prevention and control measures during COVID-19 pandemic. Am J Infect Control **2021**; 49:469–77.
10. Chow EJ, Uyeki TM, Chu HY. The effects of the COVID-19 pandemic on community respiratory virus activity. Nat Rev Microbiol **2023**; 21:195–210.
11. Park S, Michelow IC, Choe YJ. Shifting patterns of respiratory virus activity following social distancing measures for coronavirus disease 2019 in South Korea. J Infect Dis **2021**; 224:1900–6.
12. Adenaiye OO, Lai J, Bueno de Mesquita PJ, et al. Infectious severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in exhaled aerosols and efficacy of masks during early mild infection. Clin Infect Dis **2022**; 75:e241–8.
13. Leung NHL, Chu DKW, Shiu EYC, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. Nat Med **2020**; 26:676–80.
14. Klompas M, Baker MA, Griesbach D, et al. Transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from asymptomatic and presymptomatic individuals in healthcare settings despite medical masks and eye protection. Clin Infect Dis **2021**; 73:1693–5.
15. Sickbert-Bennett EE, Samet JM, Clapp PW, et al. Filtration efficiency of hospital face mask alternatives available for use during the COVID-19 pandemic. JAMA Intern Med **2020**; 180:1607–12.
16. Kim M-C, Bae S, Kim JY, et al. Effectiveness of surgical, KF94, and N95 respirator masks in blocking SARS-CoV-2: a controlled comparison in 7 patients. Infect Dis (Lond) **2020**; 52:908–12.
17. Lawton T, Butler M, Peters C. Airborne protection for staff is associated with reduced hospital-acquired COVID-19 in English NHS trusts. J Hosp Infect **2022**; 120:81–4.
18. Klompas M, Baker MA, Rhee C, Baden LR. Strategic masking to protect patients from all respiratory viral infections. N Engl J Med **2023**; 389:4–6.