

**Association between Airborne Infection Isolation Room Utilization Rates and Healthcare Worker
COVID-19 Infections in Two Academic Hospitals**

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Abstract

We compared healthcare worker SARS-CoV-2 infection rates between March-August 2020 in two similar hospitals with high versus low airborne infection isolation room utilization rates but otherwise identical infection control policies. We found no difference in healthcare worker infection rates between the two hospitals nor between patient-facing vs non-patient-facing providers.

Key words: SARS-CoV-2, transmission, airborne infection isolation rooms

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Controversy persists regarding the roles of airborne infection isolation rooms (AIIRs) and respirators for managing patients with suspected or confirmed COVID-19. The U.S. Centers for Disease Control and Prevention (CDC) initially recommended AIIRs and respirators to care for all patients with suspected or confirmed COVID-19, but in the context of limited N95 respirator and AIIR supply modified their guidance to prioritize respirators and AIIRs for patients undergoing aerosol-generating procedures (AGPs); standard pressure rooms and surgical masks were designated acceptable alternatives for COVID-19 patients without AGPs. CDC has since reverted to recommending respirators to care for all patients with suspected or confirmed COVID-19 but continues to recommend reserving AIIRs for patients undergoing AGPs. AIIRs protect healthcare workers and other patients by minimizing the amount of virus-laden aerosols in a patient's room and limiting the escape of virus-laden aerosols outside a patient's room. To our knowledge, however, there are no comparative data on the impact of caring for COVID-19 patients in AIIRs vs standard rooms on healthcare worker infection rates. We therefore evaluated the association between AIIR utilization and healthcare worker infections in two similar academic medical centers with high versus low AIIR utilization rates.

Mass General Brigham (MGB) includes two major academic medical centers, Massachusetts General Hospital (MGH) and Brigham and Women's Hospital (BWH) in Boston, Massachusetts. MGH has a fixed and limited number of AIIRs. These were prioritized for COVID-19 patients undergoing AGPs. BWH by contrast converted multiple wards to negative pressure to care for COVID-19 patients, including those who did not require AGPs. Infection control policies for both hospitals were otherwise shared and identical. Universal masking was implemented on March 22. Neither hospital used HEPA filters in lieu of AIIRs.

We compared the rates and trajectories of healthcare worker infections between the two hospitals to assess the impact of differences in AIIR utilization rates on healthcare worker infections. We also took into consideration a change in respirator-use policy: MGB transiently stipulated that healthcare workers use surgical masks and eye protection to manage patients with suspected or confirmed COVID-19 and reserved respirators for AGPs. Starting April 10, 2020, however, MGB began recommending respirators for all COVID-19 care regardless of AGPs. We therefore incorporated an inflection point of April 10 into our analysis to assess the impact of the respirator policy change.

Methods

We calculated the percentage of days patients with confirmed COVID-19 were hospitalized in AIIRs versus standard pressure rooms for each hospital. We then calculated weekly incidence rates of COVID-19 infections amongst patient-facing (physicians, nurses, nurse assistants, physician assistants, rehabilitation services, respiratory therapists, and radiology technicians) versus non-patient-facing employees (administrators, financial services, food workers, information technology workers, maintenance workers, and researchers) from March 1, 2020 through August 21, 2020. Testing for COVID-19 was freely available during this period to all employees with any symptoms concerning for COVID-19, and beginning in early May, following any unprotected exposures.

We fit an interrupted time series to compare levels and trends in differences between patient-facing versus non-patient-facing infection rates between MGH and BWH. To control for changes in community incidence rates over time, we utilized the difference between weekly infection rates for patient-facing versus non-patient-facing employees at each hospital. We incorporated an inflection point of April 10 to assess whether the N95 policy change led to either a level change or trend

change in weekly infection rates. All models were fit using the "gls" function in the R package "nlme" (R version 4.0.3). The study was reviewed and approved by the MGB Institutional Review Board with a waiver of informed consent.

Results

During the study period, 1,938 COVID-19 patients were admitted to MGH (16,821 patient-days) and 1,142 to BWH (8,529 patient-days). COVID-19 patients admitted to MGH spent 3,626/16,821 (22%) patient-days in AIIRs and those admitted to BWH spent 8,157/8,529 (96%) patient-days in AIIRs.

During this period, 775 infections were documented amongst 40,312 employees, with infection rates amongst patient-facing employees of 2.0% (313/15,592) at MGH and 2.0% (189/9,393) at BWH versus 2.0% (165/8,076) for non-patient facing employees at MGH and 1.5% (108/7,251) at BWH.

The interrupted time series for differences in weekly infection rates between hospitals in patient-facing versus non-patient-facing employees is shown in the Figure. There were no significant differences between the two hospitals in weekly rates of patient-facing minus non-patient-facing employee infections. Implementation of the N95 respiratory policy on April 10 was not associated with either a level change or trend change in patient-facing minus non-patient-facing employee infection rates at either hospital.

Discussion

We did not detect significant differences in healthcare worker infection rates between two related hospitals with high versus low AIIR utilization rates for COVID-19 patients. This is an important finding since many hospitals, like BWH, deployed substantial resources to convert patient rooms to AIIRs.

The lack of association between AIIR utilization rates and healthcare worker infection rates likely reflects the critical roles of distance and ventilation in moderating SARS-CoV-2 transmission risk. AIIRs protect workers by decreasing the amount of virus-laden aerosols inside patient rooms and the amount escaping outside patient rooms. In practice, however, distance alone is associated with a near exponential decrease in transmission risk in well-ventilated spaces. In a study of train travelers, for example, passengers seated next to someone with occult COVID-19 had a 3.5% risk of infection, passengers two seats away had a 1.7% risk, and passengers three seats away had a 0.4% risk.[1] Distance decreases viral exposure by allowing aerosols to diffuse and dilute in the surrounding air. Good ventilation potentiates the decrease in viral exposure with distance by facilitating dilution. Contemporary clinical spaces are required to maintain a minimum of 6 air changes per hour; this is substantially higher than the ventilation rates associated with most reports of long-range transmission of SARS-CoV-2 and other airborne pathogens such as tuberculosis (typically 0-2 air changes per hour).[2-4] Good room ventilation likely helped protect healthcare workers inside and outside patient rooms by diluting virus-laden aerosols; and MGB's policy requiring N95 respirators for all COVID-19 care likely provided further protection to workers inside patients' rooms.

Our finding that shifting to N95 respirators for all COVID-19-care did not impact infection rates contrasts with the growing literature documenting the limited filtration efficiency of surgical masks, instances of SARS-CoV-2 transmission despite use of surgical masks, and case-control studies reporting N95s are more protective than surgical masks.[5-12] Anecdotally, however, we observed that many employees wore N95s even before the policy shift (this was permitted under an extended use policy when employees had other indications to wear an N95). This likely blunted our capacity to see an impact of the policy change. Our analysis is further limited by substantial point-to-point variability in the initial weeks of the study, likely reflecting limited testing availability early in the pandemic.

Our analysis is further confounded by the fact that most healthcare worker infections are acquired in the community and from non-clinical encounters rather than from direct COVID-19 care.[13-15] This adds substantial noise to population-level analyses of the impact of hospital policies on healthcare worker infections. Greater use of whole genome sequencing is needed to better connect healthcare worker infections to their sources and to filter out community-acquired cases when assessing the impacts of hospital policies. Investigations using this approach have confirmed intermittent transmissions to and from healthcare workers within healthcare facilities despite masks.[7, 8, 10, 14]

A further limitation is that we did not quantify patients' viral burdens and were unable to limit the analysis to just the specific healthcare workers who interacted with highly contagious patients. It is an irony of SARS-CoV-2 that the sickest patients may be the least contagious.[15, 16] This is because the most severe manifestations of SARS-CoV-2, such as ARDS, stroke, and myocarditis, are typically due to secondary inflammation rather than active viral replication. Instead, more than two-thirds of SARS-CoV-2 transmissions are attributable to asymptomatic and presymptomatic individuals.[17]

Paradoxically, this means that greater respiratory protection may be more impactful for interactions with patients and colleagues *without* known COVID-19 infection, when SARS-CoV-2 incidence rates are high, to protect against transmission from presymptomatic but highly contagious individuals.[18] The study was conducted when the ancestral strain of SARS-CoV-2 was circulating; it is unknown whether our findings will generalize to patients with more contagious variants. We relied on PCR testing alone to detect employee infections rather than serologic testing so may have missed some infections. Finally, increasing data suggest that most AGPs generate minimal aerosols, far less than coughing or labored breathing.[19] Allocating AIIRs for AGPs rather than for patients with high viral loads (\pm symptoms) may therefore obscure our capacity to determine their potential impact on preventing healthcare worker infections.

In sum, we found no association between large differences in AIIR utilization rates and healthcare worker infection rates. Further studies using more refined methods to differentiate workplace transmissions from community-acquired infections are warranted. Further data will also be required to determine if our findings hold true when managing patients with more contagious variants.

NOTES

Funding: This work was supported by the Centers for Disease Control and Prevention (6U54CK000484-04-02). Dr. Ochoa reports a grant awarded to Harvard Pilgrim Health Care (their institution). Dr. Baker reports receiving grant CDC RFA-CK-16-004 to fund study.

Conflicts of Interest: Dr. Klompas and Dr. Rhee have received royalties from UpToDate for chapters on unrelated topics. Dr. Klompas reports support to their institution from AHRQ and Massachusetts Department of Public Health, outside the conduct of the study. Dr. Ochoa reports support from National Institutes of Health (grants) and Massachusetts Department of Public Health (contract) to their institution.

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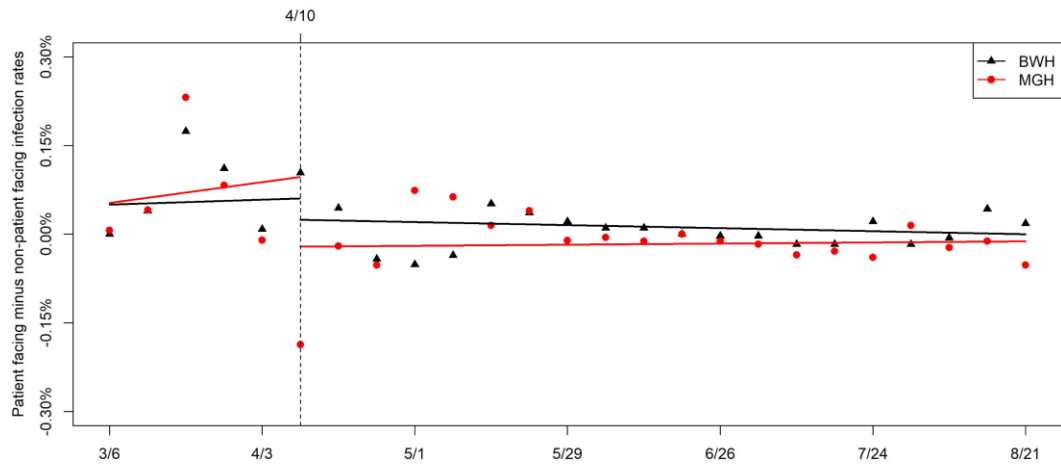
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Figure Legend.

Time series analysis of differences in weekly patient-facing vs non-patient-facing employee infection rates in hospitals with high versus low airborne infection isolation room utilization rates (Brigham and Women's Hospital, BWH, 96% utilization rate vs Massachusetts General Hospital, MGH, 22% utilization rate). April 10 corresponds to the date of the policy change to require N95s for all routine COVID-19 care. Prior to April 9th, surgical masks were used for routine care and N95s were only required for aerosol-generating procedures.

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Figure 1



<i>Patient facing minus non-patient facing infection rates</i>	BWH		MGH		BWH vs MGH	
	$\hat{\beta}$	P	$\hat{\beta}$	P	$\hat{\beta}$	P
Initial level	0.0494	0.20	0.0563	0.34	0.0029	0.97
Trend before April 10	0.0073	0.63	0.0083	0.71	0.0067	0.81
Level change after April 10	-0.0670	0.23	-0.1201	0.14	-0.0818	0.40
Trend change after April 10	-0.0083	0.59	-0.0077	0.59	-0.0049	0.86

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