COVID-19 Infections in Health Care Personnel by Source of Exposure and Correlation With Community Incidence

Elizabeth Wight, MD, Melanie Swift, MD, MPH, John C. O'Horo, MD, MPH, Caitlin Hainy, DNP, Robin Molella, MD, MPH, Allison Morrow, MPH, and Laura Breeher, MD, MPH

Objective: The aim of this study was to describe the rate of household, community, occupational, and travel-related COVID-19 infections among health care personnel (HCP). **Methods:** In a retrospective cohort study of 3694 HCP with COVID-19 infections from July 5 to December 19, 2020, we analyzed infection source data and rates, compared with local and state infection rates, and performed a correlation analysis. **Results:** Household (27.1%) and community (15.6%) exposures were the most common sources of infection. Occupational exposures accounted for 3.55% of HCP infections. Unattributable infections (no known exposure source) accounted for 53.1% and correlated with community rather than occupational exposure ($R = 0.99$ vs 0.78, $P < 0.01$). **Conclusions:** COVID-19 infections in this large HCP cohort correlated closely with infection rates in the community. The low incidence of occupational infections supports the effectiveness of institutional infection prevention and control measures.

Keywords: COVID-19, SARS-CoV-2, health care personnel, health care worker, occupational risk, infection prevention, infection source

H ealth care personnel (HCP) work on the front lines of the COVID-19 pandemic, caring directly for many patients including those with confirmed COVID-19 infection. They are at an increased risk of exposure to COVID-19 in the occupational setting[1–3]; however, limited data are available regarding occupational transmission and risk of infection. Risk of exposure for HCP was particularly high in the early phases of the pandemic when knowledge of pathogenicity, mode of transmission, and appropriate personal protective equipment were limited.[1,3] Appropriate and consistent use of personal protective equipment and hand hygiene have been proven to reduce occupational risk of COVID-19 among HCP and have been recommended by the World Health Organization.[4–6] At our institution, universal masking and use of protective safety eyewear were implemented in April 2020 along with robust contact tracing methods that were refined through the spring of 2020.

Beyond their occupational roles, HCP are members of families and communities and face potential exposure to COVID-19 in those settings as well. Little is currently known about the source of COVID-19 infections among HCP, although studies in the United States and internationally have suggested the risk of community and household exposures among HCP may be underappreciated.[7–9]

We examined COVID-19 infections, and source of exposure when ascertainable, for a cohort of HCP from a large tertiary care health care institution with multiple hospital and clinic locations in the Midwest. Occupational Health Services conducts exposure investigations and contact tracing for every confirmed case of COVID-19 among HCP and gathers information about exposure source. Occupational Health Services collaborates with Infection Prevention and Control to perform contact tracing when patient-to-HCP exposures occur. The contact tracing methods used have been previously described, including description of the risk assessment process.[10]

We aim to describe the rate of household, community, occupational, and travel-related COVID-19 infections among HCP employed at a large health care system and to correlate rates of infections lacking an identifiable exposure with rates of occupationally acquired infections and with non-HCP infection rates in the community.

METHODS

We conducted a retrospective cohort study of Mayo Clinic HCP (employee, contractor, volunteer, or student) working at the main Mayo Clinic campus in Rochester, Minnesota, or at Mayo Clinic Health System sites in Minnesota and Wisconsin with a documented positive molecular test for SARS-CoV-2. Occupational Health Services contacts each HCP identified as infected with COVID-19 to determine source of exposure. As part of the contact tracing process, a trained occupational health clinician evaluates each COVID-19–positive HCP to gather previous exposure incidents, symptom onset and communicable dates, work history, and possible close contacts. Information from the COVID-19–infected HCP was captured in a detailed self-assessment questionnaire, with telephone interviews to clarify answers or obtain missing information. Findings are stored in a centralized occupational health electronic database.

Infections were attributed to the most likely source of exposure at the time of the occupational health assessment, based on occupational exposure records and/or self-report of close contact with an individual who was communicable with COVID-19 during the 2 weeks before symptom onset (or test date if asymptomatic). Infections were attributed to a household exposure if the HCP reported shared living quarters with a communicable individual, to a community exposure if the HCP sustained a close contact with confirmed infection in the community, to a travel exposure if the HCP reported a close contact while traveling outside the community where they live or work, and to occupational exposure if the HCP sustained a Centers for Disease Control and Prevention–defined higher risk exposure at work in the previous 2 weeks. Infections without an identified likely source of exposure in the previous 2 weeks were classified as unattributable.

Data collection and abstraction was conducted via electronic occupational health data system for all Mayo Clinic HCP in the Midwest with record of confirmed COVID-19 infection from July 5, 2020, through December 19, 2020. We intentionally excluded data before July fifth to align with the addition of questions regarding exposure source into all index case assessments and interviews. We excluded data after December 19, 2020, to avoid confounding by implementation of COVID-19 vaccination, which became available to HCP at that time but was not initially available to the general public.
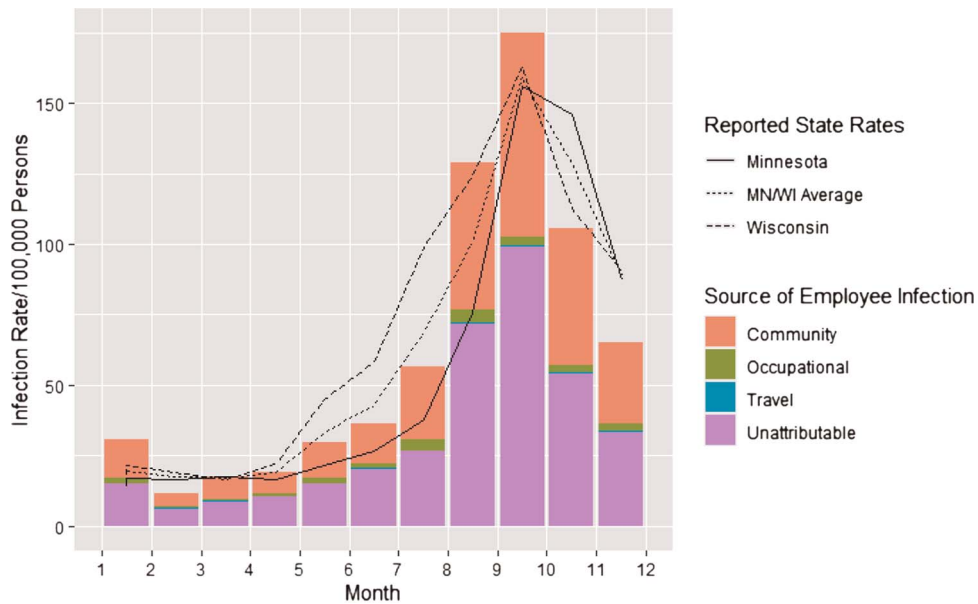
FIGURE 1. Health care personnel exposure source type per 10,000 employees among 12 two-week periods from July to December 2020. Note that dates of periods for each period 1 through 12 in 2020 are included in Table 1. Infection rates plotted with rates from Olmsted County, Minnesota, Wisconsin, and Minnesota/Wisconsin average. Data follow closely with average of Minnesota/Wisconsin rates.

Data on community incidence rates were obtained from the COVID-19 Data Repository by the Center for Systems Science and Engineering at Johns Hopkins University.[11] For ease of assessment and comparison with county and state infection data, dates were separated into 12 two-week blocks. Data are presented as cases per 10,000 HCP.

Statistical analysis was conducted using RStudio software (PBC, Boston, Mass). Correlation analysis and comparisons of correlations used the *R* statistic and Fisher's *Z* procedure using the cocor package (v1.1-3).[12]

This study was reviewed by the Mayo Clinic Institutional Review Board and deemed exempt.

RESULTS

Among a total of 54,636 HCP working at Mayo Clinic in Rochester and the Mayo Clinic Health System sites in Minnesota and Wisconsin, 3694 (6.8%) HCP were given a diagnosis of a COVID-19 infection between July 5, 2020, and December 19, 2020. Rates of infection per 10,000 HCP varied during our study time frame and were consistent with national and regional surges in the COVID-19 pandemic. Rates of infection among HCP correlated with state rates from Minnesota and Wisconsin (Fig. 1).

Household and community exposures were the most common attributable sources of HCP infection, representing 27.1% and 15.6% of cases, respectively. Occupational exposures accounted for 3.55% of infections. Furthermore, 53.1% of infections had no identifiable exposure source and were categorized as unattributable (Fig. 1).

Occupational exposures were highest in August, September, and October 2020 but remained lower than other identifiable sources. Between 3.85% and 8.1% of exposures were attributed to an occupational source during this period (Table 1). During a surge from late October through early December, occupational exposures accounted for between 1.88% and 3.56% of all employee infections (Table 1).

We noted an increase in the number and proportion of household exposures in late November and early December, and anecdotal accounts reported many of these were related to holiday gatherings. Exposures related to travel were uncommon, representing 0.59% of all infections (Table 1). Travel-related infections remained low throughout the study time frame with a relative increase in late summer and to a lesser degree around Thanksgiving Day.

To assess whether unattributable source infections may represent an unrecognized source of occupational exposure, a correlation analysis was conducted comparing unattributable exposures with known occupational and community exposure-related infections. Unattributable exposures correlated more closely with known community-acquired infection than with known occupational infection ($R = 0.99$ vs 0.78, $P < 0.01$).

Infections attributable to a known community exposure demonstrated a high degree of correlation with infection rates in the

TABLE 1. Percentage of HCP Infections by Source of Exposure per 2-Week Block

Dates	7/5–18	7/19–8/1	8/2–15	8/16–8/29	8/30–9/12	9/13–26	9/27–10/10	10/11–24	10/25–11/7	11/8–21	11/22–12/5	12/6–19	
Period	1	2	3	4	5	6	7	8	9	10	11	12	Total
Community	21.1	16.7	12.9	23.7	12.5	15.3	14.1	19.3	16.6	14.1	16.5	11.0	15.6
Unattributable	47.7	50.0	53.2	47.4	53.9	50.3	55.1	47.1	55.8	56.6	51.1	51.1	53.1
Household	26.6	25.0	24.2	22.7	27.9	27.6	24.2	26.8	23.7	27.1	29.5	33.7	27.1
Occupational	4.6	6.7	8.1	4.1	3.8	6.2	4.6	6.8	3.6	1.9	2.4	3.4	3.6
Travel	0.0	1.6	1.6	2.1	1.9	0.6	2.0	0.0	0.3	0.3	0.5	0.8	0.6

Dates for each period are displayed as month/day in the year 2020. HCP, health care personnel.

TABLE 2. Correlation Among Exposure Types With Geographic Location and Community and Occupational Exposures

	Olmsted County Infection Rate	Average of MN/WI Infection Rate	HCP Community Source	HCP Occupational Source
HCP community source	0.93	0.98	1	0.803119
HCP occupational source	0.61	0.77	0.803119	1
Travel source	0.55	0.49	0.427677	0.126898
Unattributable source	0.90	0.95	0.990206	0.783506

Unattributable exposure correlates well with community activity, whereas occupational exposure had a much weaker association.
HCP, health care personnel; MN, Minnesota; WI, Wisconsin.

surrounding community. Known occupational infection rates showed a much weaker correlation with community infection rates (Table 2).

DISCUSSION

Although unrecognized occupational exposure poses an important theoretical risk to HCP working on campus, our data suggest that in the absence of an identifiable source, COVID-19 infections in this large HCP cohort correlated most closely with infection rates among the general public in the region. Identifiable occupational exposures accounted for a small percentage of HCP infections and fluctuated little over the course of observation despite large changes in community rates of COVID-19. The overall low incidence of occupational infections reflects the effectiveness of institutional infection prevention and control measures, such as patient screening, universal masking, and use of appropriate personal protective equipment during patient care.

Of the major exposure source categories, occupational exposures often had the strongest corroborating data because Occupational Health Services had access to COVID-19 test results for patients and other employees and thus could confirm the communicability of the infectious source. Infections that cannot be attributed to a known source must be examined as a potential signal of unrecognized occupational exposures or ineffective safety procedures. We found that these unattributable infections correlated highly with community rates but not with known occupational infections. Although this is indirect evidence, it provides some reassurance that unattributable infections did not represent unchecked transmission within health care facilities. During a regional surge, as number of cases increased and community spread became more prevalent, the number of unattributable HCP infections also increased. In contrast, unattributable cases had a much weaker association with occupational rates, suggesting that these cases are more likely to be community-acquired versus occupationally acquired infections.

Both unattributable infections and those known to be due to a community exposure correlated closely with regional infection rates in Olmsted County (site of the main Mayo Clinic campus in Rochester) and in the states of Minnesota and Wisconsin. Increased community infection rates in the Midwest correlated with a shift in weather when gatherings were no longer possible outdoors. Indoor unmasked gatherings likely contributed to exposures. Travel-related infection rates remained low, although notably work-related travel was restricted, and public health authorities advised against unnecessary travel throughout the study period. In addition, travel-related exposures may be undercounted because of increased likelihood of a known community or household exposure during the same periods when community transmission was high.

Strengths of this study include a large HCP cohort, with systematic identification and evaluation of new COVID-19 infections through a centralized process. Use of standardized index case assessments, contact tracing, and data collection minimized the risk of ascertainment, measurement, and recall bias. The geographic region of the cohort allowed for comparison with community COVID-19 infection rates during the period, and the study period excluded the possibility

of confounding because of differential rates of vaccination among groups and regions. The study period predated emergence of new variants of concern. This has the advantage of avoiding confounding by geographic differences in variant behavior and transmissibility and allows direct comparison of infection rates in HCP and in the general public, which should be generalizable regardless of circulating strain.

This study is also subject to some limitations. There is a potential for measurement bias, because attribution of infection to household, community, or travel exposures could not be verified by occupational health services with corroborating information, whereas occupational exposures could more often be confirmed. It is possible some unattributable infections were actually acquired through unrecognized occupational exposure; however, the strong correlation of unattributable infections with state and regional community infection rates and their lack of correlation with occupational infection rates argue against a significant effect of unrecognized occupational exposures. Because the cohort worked for the same health system with similar infection control processes at all sites, findings may not be generalizable to all HCP across the United States. The addition of primary and booster vaccination may reduce the magnitude of differences in rate of infection by different sources of exposure, and differential rates of vaccine uptake by HCP and the general public will affect their respective infection rates.

Health care personnel are at risk of COVID-19 infection because of exposures at work, at home, in the community, and on their travels. Although often keenly aware of occupational risks, HCP may let down their guard in nonoccupational settings where exposure risk, although less obvious, may in fact be greater. We must remain diligent in implementing workplace protections for HCP, including education about community risk, because they are more likely to contract COVID-19 infection outside work. This study supports the effectiveness of workplace infection control measures in health care facilities and underscores the importance of strong public health measures to prevent community transmission to protect the general public as well as the health care workforce.

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