Minimal Population Prevalence and Mortality of Coronavirus Disease 2019 in Healthcare Personnel

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Among 3926 healthcare personnel in a multisite healthcare system, the minimal population prevalence of coronavirus disease 2019 (COVID-19) was 4.4% (bootstrap 95% confidence interval [CI], 3.7%–5.0%), and the infection fatality rate was 0.6% (bootstrap 95% CI, 0.0%–1.7%). Rates reflected both local community prevalence and hospital exposures but not specifically exposure on COVID-19 units.

**Keywords.** COVID-19; healthcare workers; seroprevalence.

Healthcare personnel (HCP) are at high risk for exposure to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [1, 2]. The rate of HCP infection is influenced by utilization of personal protective equipment (PPE), community prevalence, and availability of testing for both symptomatic and asymptomatic personnel [1, 2].

Polymerase chain reaction (PCR) testing diagnoses active infection; however, sensitivity varies in relation to viral load and timing of infection. In contrast, antibody testing is more sensitive than PCR in providing cumulative data on past infection, regardless of symptoms [3]. Studies using PCR [4, 5] or serology [6–8] have found rates in HCP ranging from 1% to 13.7%, with a recent report demonstrating that a large proportion of HCP are asymptomatic [8]. In this study, we use a combination of serology and PCR to estimate the minimal population prevalence and infection fatality rate (IFR) of coronavirus disease 2019 (COVID-19) for HCP in a multisite healthcare system located in communities with differing COVID-19 prevalence.

**METHODS**

**Population**

The VA Boston Healthcare System (VABHS) comprises 3 major campuses in eastern Massachusetts: West Roxbury, tertiary inpatient; Jamaica Plain, outpatient only; and Brockton, long-term care and inpatient mental health. During the period of study (February to June 2020), VABHS employed an average of 3926 HCP. Symptomatic HCP received rapid, onsite nasopharyngeal PCR testing. Asymptomatic HCP were tested in response to outbreaks on inpatient units, exposures at home or in the community, or as part of surveillance in VABHS long-term care units. The processes and policies for testing and PPE were the same across campuses; the COVID units used N95 masks consistent with Centers for Disease Control and Prevention guidance. Voluntary SARS-CoV-2 antibody testing was offered to all HCP and was completed in 1702 employees between May 1 and June 19, 2020. The HCP with positive serology also underwent PCR testing. All employees were tracked for COVID-19 diagnoses and outcomes including return to duty and mortality.

**Laboratory Methods**

The SARS-CoV-2 immunoglobulin (Ig)G antibody assay was performed onsite using an Abbott Architect i2000SR (Abbott Park, IL) automated analyzer and validated as previously described [9, 10]. This qualitative assay detects IgG antibodies to the nucleocapsid protein of SARS-CoV-2 with a sensitivity of 100.0% (95% confidence interval [CI], 95.8%–100.0%) and a specificity of 99.6% (95% CI, 99.0%–99.9%) [3]. Polymerase chain reaction was performed onsite using the Cepheid platform [10].

**Statistical Analysis**

We calculated both measured and population prevalence rates. Measured COVID-19 prevalence was calculated by dividing the unique number who tested positive using either serology or PCR by the number of unique employees who were tested. The minimal population prevalence was calculated by dividing the unique number who tested positive by 3926, the number of HCP in our system in May 2020. The IFR was calculated by dividing the number of deaths by the number of COVID-19 infections. The 95% CIs were calculated using 2500 bootstrap samples with replacement. Statistical associations were evaluated using χ² and Fishers exact test as indicated.

**Patient Consent Statement**

This study was classified by VABHS Institutional Review Board as quality improvement and exempt from review; as such, patient consent is not applicable.

**RESULTS**

A total of 2492 of 3926 (63.5%) unique HCP had COVID-19 testing performed. Among 1702 HCP tested for IgG
SARS-CoV-2 antibodies, 54 (3.2%; 95% CI, 2.5%–4.0%) were positive (Table 1). An additional 790 HCP only had PCR testing performed, and 116 of this subgroup were positive. Two additional HCP had a positive PCR and tested negative by serology, for a total of 118 positive PCR tests among HCP. The combined measured prevalence of HCP with positive serology or PCR (positive COVID-19 test) was 172 of 2492 (6.9%; 95% CI, 5.9%–7.9%). Among HCP who had both tests performed, 22 were positive by both PCR and serology and 2 were discordant (positive PCR with negative serology), as noted above.

The minimal population prevalence estimate for COVID-19 was 172 of 3926 (4.4%; 95% CI, 3.7%–5.1%) (Table 1). One HCP died of COVID-19; all others recovered within the study period. The IFR was 1 of 172 (0.6%; 95% CI, 0.0%–1.7%).

Population prevalence by demographic was estimated by dividing the number of positive COVID-19 tests by the total population for each demographic (Table 1). The prevalence of positive COVID-19 tests was significantly higher in females (5.1%) than in males (3.2%) \( (P = .003) \). Race data were not available for PCR results; however, the seroprevalance was significantly higher in black HCP (2.5%) than in white HCP (0.6%; \( P < .001 \)). There was no difference in prevalence in clinical staff (4.2%) compared with nonclinical staff (3.5%). Among clinical HCP, the prevalence of COVID-19 was significantly higher in nursing staff (8.5%) than in provider staff (2.6%; \( P < .001 \)). Among nursing staff from the tertiary care campus, the prevalence was not higher for those on COVID-19 units compared to those on non-COVID-19 units (18 of 222 [8.9%] vs 21 of 202 [10.45%]; \( P = .41 \)).

Community prevalence data as of June 11, 2020 were available from PCR testing by the Boston Public Health Commission and MA Department of Public Health [11, 12]. Coronavirus disease 2019 prevalence was similar among HCP working at the Brockton campus, located in a higher-prevalence community (4.7% in HCP; 4.1% in community), and those working at the West Roxbury campus, located in a lower-prevalence community (4.6% in HCP; 1.6% in community). Prevalence was lowest at the Jamaica Plain campus and mirrored the community rates (1.8% in HCP; 1.7% in community).

**DISCUSSION**

There is an urgent need to understand the epidemiology of COVID-19 infection among healthcare workers to optimize prevention efforts and allocation of scarce resources. Utilizing a combination of antibody and PCR testing in over 50% of our workforce, we demonstrate that the overall prevalence of COVID-19 exposure in our multisite healthcare system was similar among clinical and nonclinical staff, likely reflecting a significant contribution of community transmission in both groups.

Our minimal population COVID-19 prevalence of 4.4% is comparable to that reported in Belgian HCP from a single-site tertiary care center [6]. This rate is lower than that reported by Northwell Health in New York City, a region with a much higher community rate than the greater Boston area [7]. The association between community prevalence and HCP COVID-19 rates is also apparent in our diverse campuses. Prevalence among HCP from our Jamaica Plain campus, where there was no tertiary COVID-19 care, was

| Characteristics | Total Population | IgG Total Tested | IgG Pos | Unique PCR Positive | IgG Pos Plus Unique PCR Pos | Minimal Population Prevalence (IgG and PCR) |
|-----------------|-----------------|-----------------|--------|---------------------|---------------------------|-----------------------------------------|
| Number          | 3926            | 1702            | 54 (3.2%) (CI, 2.5%–4.0%) | 118 | 172 | 4.4% (CI, 3.7%–5.0%) |
| Age (mean)      | 46.0            | 44.7            | 45.0   | 44.9                |                           |                                         |
| Gender          |                 |                 |        |                     |                           |                                         |
| Male            | 1492            | 535             | 10 (1.8) | 37 | 47 | 3.2% |
| Female          | 2434            | 1167            | 44 (3.8%) | 81 | 125 | 5.1% |
| Clinical Role*  |                 |                 |        |                     |                           |                                         |
| Clinical        | 2964            | 1097            | 37 (3.4%) | 86 | 123 | 4.2% |
| Nonclinical     | 1409            | 605             | 17 (2.8%) | 32 | 49 | 3.5% |
| Profession      |                 |                 |        |                     |                           |                                         |
| Nursing staff   | 1111            | 586             | 27 (4.6%) | 67 | 94 | 8.5% |
| Provider        | 381             | 366             | 6 (1.6%) | 4 | 10 | 2.6% |
| Nursing Staff Work Unit† | | | | | | |
| COVID-19        | 222             | 18              | 8.9%   | | | |
| Non-COVID-19    | 202             | 21              | 10.5%  | | | |

Abbreviations: CI, confidence interval; COVID-19, coronavirus disease 2019; HCP, healthcare personnel; IgG, immunoglobulin G; PCR, polymerase chain reaction; Pos, positive.

NOTES: Provider = physician, dentist, physician assistant, nurse practitioner, clinical pharmacist, clinical psychologist. Nursing staff = licensed practical nurse, registered nurse, nursing assistant.

*The designation of clinical and nonclinical was derived from a somewhat larger database that included both permanent and temporary employees.

†Work Unit comparison limited to nursing staff in tertiary care campus.
comparable to the local community rates. The much higher prevalence in HCP at our Brockton campus, another site without tertiary COVID-19 care, reflected the comparatively higher community prevalence for the Brockton community. Prevalence for HCP at our West Roxbury campus, the tertiary care site, was higher than for the West Roxbury community, but lower than the 9% seroprevalence for nearby Boston neighborhoods [13]. Taken together, these variations between campuses within the same healthcare system suggest that COVID-19 prevalence among HCP reflects exposure both in and outside of the healthcare setting, including the communities in which they live and work. Indeed, the prevalence among black HCP was much higher than in white HCP, consistent with community prevalence data [12].

Coronavirus disease 2019 was more prevalent in nursing staff than in providers. This difference cannot be attributed solely to the greater proximity and more prolonged exposure of nursing staff to patients. Coronavirus disease 2019 prevalence was similar for nursing staff working on COVID-19 units and on non-COVID-19 units in our tertiary care campus, suggesting that properly deployed PPE and rapid testing and isolation of positive HCP significantly mitigated the risk of SARS-CoV-2 transmission. Because of their work flow and the physical layout of their working and break areas, nursing staff also have closer proximity and more prolonged exposure to each other at nursing stations and in breakrooms compared with providers. These spaces might facilitate both community and hospital-based transmission of SARS-CoV-2 [14]. It is also possible that nursing staff on COVID-19 units were more meticulous than those on non-COVID-19 units in preventing exposure at home and in the community. Indeed, some isolated themselves from their families while they worked in COVID-19 units. Hence, COVID-19 prevalence in HCP might be mitigated through heightened attention to distancing, masking, and hand hygiene outside of COVID-19 units, particularly in shared spaces and in the community.

Another unique aspect of our work was the ability to do a robust calculation of the IFR. This metric has been assessed for large populations but is not readily available for HCP in a setting with extensive testing and close follow-up for outcomes. Our estimate of 0.6% is on the low end of the 0.5%–1.0% range reported across studies of the general population [15]. However, these rates vary by sample size, approach, age distribution, country, and demographics. There is little published on IFRs in HCPs, and our combined analysis of serology and PCR testing captures both symptomatic and asymptomatic infection, generating a more robust denominator.

CONCLUSIONS

Our study has several limitations. Slightly less than 50% of our HCP had antibody studies, and there may be selection bias related to PCR testing of primarily symptomatic or exposed employees. However, the same biases existed across our campuses and in the community; thus, the relative comparisons of community to healthcare rates are valid. In addition, PCR testing was required for any symptomatic or exposed employee, and test results from outside facilities were systematically recorded as part of our return to work protocol. Severe acute respiratory syndrome coronavirus 2 antibodies may diminish over time, [16] so we may have missed some asymptomatic cases with rapidly waning antibody levels. However, our antibody testing was performed within 1 month of our surge, minimizing this risk. Hence, we robustly captured both asymptomatic and symptomatic infections and have calculated a minimal population prevalence, unadjusted for false positives. The true population prevalence is likely higher, because our calculation excluded asymptomatic cases in the untested population.

Overall, our data support the association between HCP prevalence and community prevalence and the lack of association with working on COVID-19 units. These findings underscore the importance of adherence to prevention measures both in shared hospital areas, such as work units and breakrooms, and in the community.

Acknowledgments

Potential conflicts of interest. K. G. is a shareholder in Abbott Pharmaceutical and serves as a consultant for QIAGEN and First Light Diagnostics. 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.

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