Clinical Infectious Diseases

MAJOR ARTICLE

Prevalence of Coronavirus Disease 2019 Infection and Outcomes Among Symptomatic Healthcare Workers in Seattle, Washington

Nandita S. Mani,[1,a] Jehan Z. Budak,[2,a] Kristine F. Lan,[2] Chloe Bryson-Cahn,[2] Allison Zelikoff,[3] Gwendolyn E.C. Barker,[4] Carolyn W. Grant,[5] Kristi Hart,[5] Carrie J. Barbee,[6] Marissa D. Sandoval,[6] Christine L. Dostal,[6] Maria Corcorran,[2] Hal M. Ungerleider,[7] Jeff O. Gates,[8] Svaya V. Olin,[9] Andrew Bryan,[10] Noah G. Hoffman,[10] Sara R. Marquis,[11] Michelle L. Harvey,[12] Keri Nasenbeny,[13] Kathleen Mertens,[14] Lisa D. Chew,[15] Alexander L. Greninger,[10,11] Keith R. Jerome,[10,11] Paul S. Pottinger,[2] Timothy H. Dellit,[2] Catherine Liu,[2,11] Steven A. Pergam,[2,11] Santiago Neme,[2] John B. Lynch,[2] H. Nina Kim,[2,16] and Seth A. Cohen[2]

[1]Department of Medicine, School of Medicine, University of Washington, Seattle, Washington, USA; [2]Division of Allergy and Infectious Diseases, Department of Medicine, University of Washington, Seattle, Washington, USA; [3]Population Health, Harborview Medical Center, Seattle, Washington, USA; [4]Allied Ambulatory Care Services, Harborview Medical Center, Seattle, Washington, USA; [5]Patient Care Services, University of Washington Medical Center–Northwest, Seattle, Washington, USA; [6]Harborview Medical Center, Seattle, Washington, USA; [7]Respiratory Therapy, University of Washington Medical Center–Northwest, Seattle, Washington, USA; [8]Employee Health, University of Washington Medical Center–Northwest, Seattle, Washington, USA; [9]Infection Prevention and Control, University of Washington Medical Center–Northwest, Seattle, Washington, USA; [10]Department of Laboratory Medicine, University of Washington Medical Center, Seattle, Washington, USA; [11]Vaccine and Infectious Disease Division, Fred Hutchinson Cancer Research Center, Seattle, Washington, USA; [12]Clinical Trials Office, University of Washington, Seattle, Washington, USA; [13]Patient Care Services, University of Washington Medical Center, Seattle, Washington, USA; [14]Primary Care and Population Health, Harborview Medical Center, Seattle, Washington, USA; [15]Division of General Internal Medicine, Department of Medicine, University of Washington, Seattle, Washington, USA; and [16]Allergy and Infectious Diseases/Department of Medicine Research Collaboratory, University of Washington, Seattle, Washington, USA

(See the Editorial Commentary by Bryant and Isaacs on pages 2708–9.)

Background. Healthcare workers (HCWs) who serve on the front lines of the coronavirus disease 2019 (COVID-19) pandemic have been at increased risk for infection due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in some settings. Healthcare-acquired infection has been reported in similar epidemics, but there are limited data on the prevalence of COVID-19 among HCWs and their associated clinical outcomes in the United States.

Methods. We established 2 high-throughput employee testing centers in Seattle, Washington, with drive-through and walk-through options for symptomatic employees in the University of Washington Medicine system and its affiliated organizations. Using data from these testing centers, we report the prevalence of SARS-CoV-2 infection among symptomatic employees and describe the clinical characteristics and outcomes among employees with COVID-19.

Results. Between 12 March 2020 and 23 April 2020, 3477 symptomatic employees were tested for COVID-19 at 2 employee testing centers; 185 (5.3%) employees tested positive for COVID-19. The prevalence of SARS-CoV-2 was similar when comparing frontline HCWs (5.2%) with nonfrontline staff (5.5%). Among 174 positive employees reached for follow-up at least 14 days after diagnosis, 6 reported COVID-related hospitalization; all recovered.

Conclusions. During the study period, we observed that the prevalence of positive SARS-CoV-2 tests among symptomatic HCWs was comparable to that of symptomatic nonfrontline staff. Reliable and rapid access to testing for employees is essential to preserve the health, safety, and availability of the healthcare workforce during this pandemic and to facilitate the rapid return of SARS-CoV-2–negative employees to work.

Keywords. COVID-19; employee health; healthcare workers.

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes coronavirus disease 2019 (COVID-19), was declared a pandemic by the World Health Organization on 11 March 2020. It continues to disrupt life for millions around the globe [1]. The first case of COVID-19 in the United States was diagnosed in Washington State on 20 January in a traveler returning from Wuhan, China [2]. Subsequently, the greater Seattle area became the first recognized epicenter of the COVID-19 outbreak in the United States with more than 22 000 confirmed cases and 1100 deaths statewide as of 4 June [3].

During the 2003 severe acute respiratory syndrome (SARS) outbreak, healthcare workers (HCWs) were disproportionately affected, accounting for 21% of all cases due to documented nosocomial transmission [4–6]. SARS-CoV-2 has also caused significant morbidity and mortality among HCWs globally, particularly in China and Italy early in the outbreak [7–10]. As of 9 April, 9282 HCWs in the United States were confirmed to have COVID-19, as reported to the Centers for Disease Control (CDC) [11]. In the setting of widespread community

Received 13 May 2020; editorial decision 10 June 2020; accepted 11 June 2020; published online June 16, 2020.

[a]N. S. M. and J. Z. B. contributed equally to this work.

Correspondence: N. S. Mani, 12-CT, 325 9th Avenue, Seattle, WA 98104 (nsmani@uw.edu).

Clinical Infectious Diseases® 2020;71(10):2702–7

DOI: 10.1093/cid/ciaa761

transmission, HCWs are at risk for community acquisition as well as potential healthcare-acquired infection, making it difficult to discern their route of exposure. Multiple factors have been reported to contribute to the risk of infections in HCWs, including lack of awareness during the early weeks of the outbreak, inadequate personal protective equipment (PPE) supply and training, insufficient rapid diagnostic testing for COVID-19, long work hours in high-risk environments, and ongoing community spread and household exposures [12–14].

Early and high-throughput testing for SARS-CoV-2 among symptomatic employees is essential to prevent nosocomial transmission of COVID-19 to patients, minimize clusters among HCWs, and maintain staffing during the pandemic [15]. To that end, on 6 March, we implemented a drive-through testing center for employees across the University of Washington (UW) Medicine healthcare system. On 14 March, a second testing center opened to increase testing capacity.

Data on SARS-CoV-2 infections among HCWs in the United States and associated strategies to optimize their safety are urgently needed in order to prepare healthcare systems, assess the efficacy of infection prevention policies, and better understand the risk of COVID-19 transmission to HCWs [16]. Here, we describe the approach to establishing high-throughput employee testing centers, the prevalence of infections among symptomatic frontline vs nonfrontline staff, and clinical outcomes associated with COVID-19 in these employees.

METHODS

We established 2 employee testing centers in Seattle, Washington, one at the University of Washington Medical Center (UWMC)–Northwest Campus and the second at Harborview Medical Center (HMC), to serve employees of the UW Medicine healthcare system (UWMC Montlake and Northwest campuses, Harborview Medical Center, Valley Medical Center, and UW Neighborhood Clinics). In addition to UW Medicine employees, testing was offered to UW students, staff, and faculty and to employees from 2 affiliate organizations, Seattle Children's Hospital (SCH) and Seattle Cancer Care Alliance (SCCA). SCH and SCCA employees could obtain testing at their respective employee testing centers as well; data from SCH and SCCA testing sites are not included here. Clinic staffing and equipment at the 2 testing centers included in this study varied based on site (Supplementary Materials).

A questionnaire was created to collect and manage data through Research Electronic Data Capture, a secure web-based software platform hosted at UW [17]. The questionnaire served as the main portal for employees to request testing and was posted on a university website on 12 March. All employees who requested testing had to complete this survey. Employees were eligible for testing if they had any new symptoms concerning for SARS-CoV-2 infection including, but not limited to, fever, cough, shortness of breath, sore throat, fatigue, headache, anosmia, muscle aches, and diarrhea (Supplementary Materials). In addition to a symptom screen, basic demographic variables, and primary site of work, employees were asked whether they had face-to-face contact with patients, which was used to prioritize testing and determine if they were frontline HCWs. Employees were asked if they lived communally, which was not further defined. Asymptomatic employees were not offered testing at the testing center outside of outbreak investigations.

Staff were advised to remain home from work while awaiting test results. In accordance with CDC and Washington Department of Health guidelines at the time, UW Medicine sick policy required employees infected with COVID-19 to remain at home for at least 7 days from symptom onset and until they were asymptomatic for 72 hours, whichever was longer. Repeat testing was not required or routinely performed before returning to work. Employees who tested negative for SARS-CoV-2 were permitted to return to work after 24 hours of complete symptom resolution.

At this institution, PPE protocols for acute care patients with confirmed or suspected COVID-19 consist of standard/droplet/contact precautions (surgical mask, eye protection, gown, and gloves) while patients requiring intensive care unit (ICU) level care are placed in standard/airborne/contact precautions (powered air purifying or N95 respirator, eye protection, gown, and gloves) due to the potential for frequent aerosol-generating procedures. All staff members who don and doff PPE when caring for these patients are monitored by a trained observer to minimize breaches in precautions and HCW self-contamination. An optional extended use masking policy for staff was implemented on 1 April, and universal masking was implemented on 27 April.

Procedure

Staff at each testing site were trained to perform nasopharyngeal swab sampling. A flexible or standard synthetic fiber nasopharyngeal swab was inserted into the nostril for 2–3 seconds and rotated 360 degrees for 10–15 seconds. This technique was repeated in the contralateral nostril using the same swab. The swab was then placed into a sterile vial containing universal transport media. Samples were either taken to the laboratory within the hour or refrigerated until they could be transported for processing.

Testing and Results

Polymerase chain reaction testing was performed at the UW Virology Laboratory as previously described [18, 19]. Inconclusive results were initially reflexed to the Washington State Department of Health Laboratory for confirmatory testing until 30 March, after which inconclusive results were interpreted presumptively as positive and were no longer sent for confirmatory testing. During the study period, the turnaround time for laboratory results ranged from 6 to 10 hours.

Employees were able to access their results through a secure electronic medical record portal or through a quick response code reader. In addition, all employees were contacted by phone to notify them of their test result. Employees with a positive or inconclusive result received a second phone call from a trained healthcare provider who asked questions regarding infection prevention practices and gathered data on whether any exposures occurred at work or in the community. Another follow-up call was made after 14 days to all positive employees to ascertain whether the employee required hospitalization due to COVID-19, what level of hospital acuity had been required, and to assess the duration of their leave before returning to work. Up to 3 telephone call attempts were made for each employee, followed by an e-mail.

Study Sample and Statistical Analyses

All symptomatic employees who self-initiated and completed testing from 12 March to 23 April were included in the analysis. Frontline HCWs were defined as those who answered "yes" to whether they had face-to-face contact with patients. The primary outcome of interest was the prevalence of SARS-CoV-2 infection among symptomatic employees seeking testing, examined across time in an epidemic curve, stratified by frontline HCWs vs nonfrontline employees, and with 95% confidence intervals (CIs) for these rates. At 1 campus, asymptomatic screening of exposed staff was performed as part of 3 specific outbreak investigations during which there was concern for ongoing staff-to-staff transmission on the unit. Asymptomatic staff tested in the context of these clusters were not included in the primary analysis, as much of this evaluation was performed on the hospital unit rather than in the employee testing center. A secondary analysis was performed to calculate the prevalence of infection with a 95% CI of all HCWs, including those who underwent asymptomatic testing, to help estimate the impact of these investigations on the overall employee burden of COVID-19.

For the summary of baseline characteristics, symptoms, and clinical conditions, continuous variables were displayed as median values with simple ranges. Categorical variables were summarized as counts of all patients or a subset of evaluated patients with percentages. The χ^2 test was used as appropriate for comparison of features between positive and negative cases on a selected rather than wholesale basis to reduce the risk of false discovery rate. The proportion hospitalized (and 95% CI) was calculated as the number of employees reporting hospitalization among all who tested positive and responded to post-testing assessment. All analyses were conducted using R version 3.6.3.

The UW Institutional Review Board approved the study. Informed consent was waived for retrospective review of deidentified employee data.

RESULTS

A total of 3477 symptomatic employees were tested for COVID-19 from 12 March to 23 April with an average of 83 employees tested daily across both sites. Employees were scheduled in 5-minute intervals, and median turnaround time from survey submission to scheduled appointment time was 11 hours. During the study period, 185 staff members tested positive for COVID-19, yielding an overall prevalence of 5.3% (95% CI, 4.41–6.07). The cumulative incidence of positive SARS-CoV-2 tests increased over time as the epidemic spread in the Seattle area (Figure 1).

The median age of positive and negative employees was 40 and 39 years, respectively (Table 1). Staff who identified as male comprised a greater proportion of positive employees compared with all employees who were tested (38.4% vs 26.6%, $P < .001$). The proportion of employees who were immunocompromised or had chronic cardiac or pulmonary disease was similar among positive and negative employees. A total of 156 pregnant or breastfeeding employees were tested for COVID-19, with 7/156 (4.5%) testing positive.

Of employees who tested positive, the most common symptoms at the time of survey completion were fatigue (61.6%), headache (59.5%), cough (58.4%), muscle aches (54.1%), sore throat (50.8%), and fever (38.4%), as shown in Table 2. Positive cases were more likely to report fever ($P < .001$), myalgias/arthralgias ($P < .001$), and anosmia ($P < .001$) than those who tested negative. Additionally, though we intended to test only symptomatic individuals, a small number of asymptomatic employees were able to get tested. Of 185 positive employees, 5 reported none of the symptoms listed in Table 2.

Among all symptomatic employees, 2309 (66.4%) were identified as frontline HCWs. Demographic characteristics for frontline HCWs were similar to those of all employees (Supplementary Materials). The prevalence of SARS-CoV-2 infection among frontline and nonfrontline staff was 5.2% (95% CI, 4.33–6.15) and 5.5% (95% CI, 4.17–6.78), respectively, and epidemiologic curves were similar for these 2 groups over time (Figure 1). Among staff who underwent asymptomatic screening as part of outbreak investigations, 9 of 151 (6.0%) tested positive. Secondary analysis combining these staff with all symptomatic employees revealed a SARS-CoV-2 prevalence among frontline HCWs of 5.3% (95% CI, 4.42–6.21) and among all employees, 5.3% (95% CI, 4.45–6.08).

On follow-up assessment after at least 14 days from COVID-19 diagnosis, we were able to contact 174 (94.1%) of 185 employees who tested positive, and 6 (3.2%) reported hospitalization related to COVID-19 (95% CI, 1.11–6.98). Of these 6 employees, the median age was 49.5 years, 3 identified as male, and 3 identified as female. One employee required ICU admission; all employees recovered and were discharged from the hospital. Of the 174 employees reached via phone call for follow-up, 151

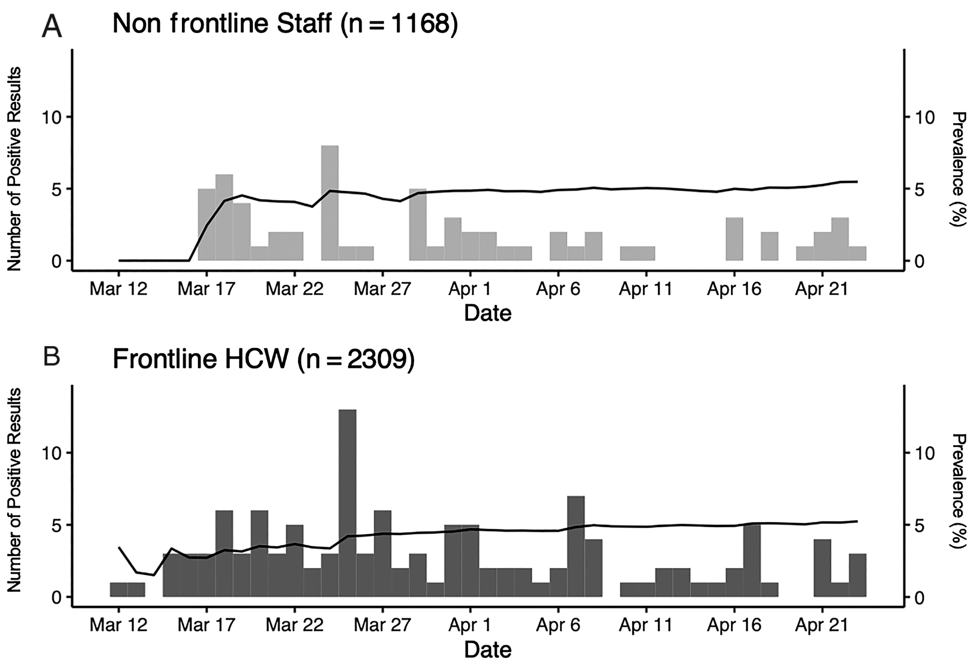

Figure 1. Prevalence of coronavirus 2019 between 12 March 2020 and 23 April 2020. Abbreviation: HCW, healthcare worker.

had already returned to work, and the median duration of their leave was 14 days (interquartile range, 8.5).

DISCUSSION

Rapid access to SARS-CoV-2 testing is crucial for symptomatic HCWs, both to confirm the diagnosis and to ensure a safe and timely return to work. Sick policies and testing strategies for HCWs are essential pillars of infection prevention and control efforts to prevent nosocomial transmission of infection and to limit critical staff shortages during a time of unprecedented need. Accessible testing also serves to strengthen employee trust in their workplace and reduce fear and anxiety surrounding contracting the virus or transmitting to patients and family members [20]. Supporting the mental health and emotional well-being of HCWs during any pandemic is key to preserving workforce morale, confidence, and availability [21].

We successfully implemented high-throughput drive-through and walk-through employee testing for COVID-19 at a large multihospital academic medical center that employs approximately 26 000 individuals. During the study period, we found that 5.3% of symptomatic employees were positive for COVID-19 compared with 10.3% of patients (n = 17 681) tested for SARS-CoV-2 within the UW Medicine system during the study period. This difference may be attributable to a relatively lower threshold to perform SARS-CoV-2 tests in HCWs, which may have led to higher sampling of minimally symptomatic workers compared with the general public, particularly in the earlier weeks of the epidemic when testing was limited and individuals

Table 1. Staff Demographics in Total and Stratified by Test Result

Demographics	COVID-19 Negative n = 3292	COVID-19 Positive n = 185	All Employees n = 3477
Age (n = 3465), y			
Median (range)	39 (19–88)	40 (21–72)	39 (19–88)
Gender (n = 3475)			
Female	2436 (74%)	114 (61.6%)	2550 (73.4%)
Male	854 (26%)	71 (38.4%)	925 (26.6%)
Type of staff member (n = 3477)			
Frontline healthcare worker	2188 (66.5%)	121 (65.4%)	2309 (66.4%)
Nonfrontline staff	1104 (33.5%)	64 (34.6%)	1168 (33.6%)
Living situation (n = 3308)			
Communal	751 (24%)	46 (26.4%)	797 (24.1%)
Noncommunal	2383 (76%)	128 (73.6%)	2511 (75.9%)

Abbreviation: COVID-19, coronavirus disease 2019.

Table 2. Clinical Characteristics and Health Conditions of Staff in Total and Stratified by Test Result

Symptoms and Health Conditions	COVID-19 Negative n = 3292 (%)	COVID-19 Positive n = 185 (%)	All Employees n = 3477 (%)
Symptom (n = 3477)			
Fever	549 (16.7)	71 (38.4)	620 (17.8)
Cough	1952 (59.3)	108 (58.4)	2060 (59.2)
Difficulty breathing	537 (16.3)	24 (13)	561 (16.1)
Sore throat	2066 (62.8)	94 (50.8)	2160 (62.1)
Fatigue/malaise	1649 (50.1)	114 (61.6)	1763 (50.7)
Headache	1790 (54.4)	110 (59.5)	1900 (54.6)
Muscle aches/pain	1111 (33.7)	100 (54.1)	1211 (34.8)
Nausea/vomiting	355 (10.8)	14 (7.6)	369 (10.6)
Diarrhea	482 (14.6)	24 (13)	506 (14.6)
Lack of smell (anosmia)	92 (2.8)	27 (14.6)	119 (3.4)
Other	679 (20.6)	35 (18.9)	714 (20.5)
Chronic health condition (n = 3477)			
Health condition[a]	416 (12.6)	23 (12.4)	439 (12.6)
Pregnant or breastfeeding (n = 3386)			
Yes	149 (4.6)	7 (4)	156 (4.6)
No	3062 (95.4)	168 (96)	3230 (95.4)

Abbreviation: COVID-19, coronavirus disease 2019.

[a]Chronic cardiac, pulmonary, or immune compromising health condition.

in the community with mild disease were not yet eligible for testing. Notably, there was no significant difference in prevalence of infection between frontline HCWs and nonfrontline staff. We suspect that early in the local epidemic, community transmission played a significant role in illness among HCWs. Determination of healthcare-acquired vs community-acquired infection fell outside the scope of this study.

Our cohort was predominantly young and healthy, which is consistent with national data on HCWs with COVID-19 [11]. We observed a wide range of presenting symptoms among employees. A similar range of symptoms was reported among a smaller cohort of positive HCWs in King County, Washington, emphasizing the importance of the expanded symptom screening criteria beyond fever, cough, and shortness of breath [22]. A small proportion of HCWs with COVID-19 required hospitalization in the 14 days following their diagnosis, with no deaths reported during this time, though 1 person required ICU-level care. Given that employees negative for SARS-CoV-2 were permitted to return to work after 24 hours of symptom resolution and that >95% of symptomatic employees tested negative, access to testing facilitated a more rapid return to work.

In the weeks after the first recognized case of COVID-19 in the United States was identified in Washington State, the governor declared a state of emergency on 29 February, instituted a statewide ban on gatherings of 250 people or more on 13 March, and issued a statewide stay-at-home order on 23 March [23, 24]. In addition, local testing through the UW Virology Laboratory was readily available on 2 March, which was earlier than in many other states, allowing for rapid expansion of patient and employee testing as laboratory capacity and nasopharyngeal swab availability allowed. These early measures may also have helped minimize the spread of COVID-19 within our community and inside these hospitals.

The prevalence of SARS-CoV-2 infection among HCWs can inform infection prevention policies within healthcare systems, including PPE, particularly if patient-to-HCW transmission is suspected despite PPE use. The similar proportion of positive tests between frontline and nonfrontline staff may support the current PPE protocols in place at our institution.

Although this is a large, representative sample, our study had limitations. The definition we used for frontline healthcare worker is broad. While a wide range of staff might indicate having "face-to-face contact" with patients, individual risk for exposure may markedly differ. Second, as testing was selectively restricted to employees who had symptoms, the proportion of positive tests reported here may not reflect the true prevalence of infection within the overall employee population. Testing criteria expanded over the course of the study as laboratory capacity increased, with high priority initially given to employees with more severe symptoms. Theoretically, this could have enriched our prevalence estimates during the first week of our study; however, this effect was not seen. Anosmia was added as a screening symptom later in the study period, and estimates related to this symptom should be interpreted carefully. In addition, we cannot ascertain whether infection was acquired in the community or in the healthcare setting. Statewide measures, including stay-at-home orders, had concurrent impacts on community transmission and overall incidence in our state. As Washington residents increasingly sheltered in place, the study population may not have remained consistent throughout the study period. For example, UW Medicine staff with office-based jobs began to telecommute; similarly, clinical rotations were cancelled for all medical students during this time.

In contrast, frontline HCWs continued to come to work, placing them at ongoing risk for community as well as nosocomial transmission. Last, the actual prevalence of SARS-CoV-2 infection may be higher than reported here, as these data do not include routine screening in asymptomatic or presymptomatic HCWs. While 9 staff were identified as positive following asymptomatic unit-based testing in the context of outbreak investigations, we do not know what proportion of these went on to develop symptoms and would have eventually been identified through traditional symptom screening. Future studies using serologic tests may be useful to understand the true prevalence in this population.

CONCLUSIONS

We present a representative sample of 3477 symptomatic employees of a large healthcare system who underwent nasopharyngeal testing for SARS-CoV-2 and observed a prevalence of 5.3% over the first several weeks of the epidemic compared with 10.3% of all patients tested within the UW Medicine system during the same time period. Among 185 positive employees, 6 reported hospitalization. Rapid and high-throughput testing of HCWs for COVID-19 is feasible using drive-through and walk-through testing clinic models and facilitated the rapid return of SARS-CoV-2–negative HCWs to work.

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. The authors greatly appreciate the time and effort of volunteers within the Division of Allergy and Infectious Diseases at the University of Washington. They also recognize the dedication of healthcare workers, first responders, and frontline employees in the fight against coronavirus 2019.

Financial support. M. C. is supported by a training grant from the National Institute of Diabetes and Digestive and Kidney Diseases (5T32DK007742-22).

Potential conflicts of interest. A. L. G. reports personal fees from Abbott Molecular outside the submitted work. S. A. P. reports grant support from Global Life Technologies, Inc, participates in research trials with Chimerix, Inc, and has participated in research with Merck & Co. He is currently participating in a clinical trial sponsored by the National Institute of Allergy and Infectious Diseases (NIAID; U01-AI132004); vaccines for that trial are provided by Sanofi-Aventis. K. J. reports grants from the National Institutes of Health NIAID and consulting fees from Morgan Stanley during the conduct of the study. All other authors report no potential conflicts. 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. World Health Organization. WHO director-general's opening remarks at the media briefing on COVID-19. 11 March **2020**. Available at: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020. Accessed 5 May 2020.
2. Holshue ML, DeBolt C, Lindquist S, et al. First case of 2019 novel coronavirus in the United States. N Engl J Med **2020**; 382:929–36.
3. Washington State Department of Health. 2019 novel coronavirus outbreak (COVID-19). Available at: https://www.doh.wa.gov/Emergencies/Coronavirus. Accessed 5 June 2020.
4. World Health Organization. Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003. Available at: https://www.who.int/csr/sars/country/table2004_04_21/en/. Accessed 5 May 2020.
5. Schwartz J, King CC, Yen MY. Protecting healthcare workers during the coronavirus disease 2019 (COVID-19) outbreak: lessons from Taiwan's severe acute respiratory syndrome response. Clin Infect Dis **2020**; 71:858–60.
6. Yen MY, Lin YE, Lee CH, et al. Taiwan's traffic control bundle and the elimination of nosocomial severe acute respiratory syndrome among healthcare workers. J Hosp Infect **2011**; 77:332–7.
7. Alice SU. Doctors and nurses fighting coronavirus in China die of both infection and fatigue. Los Angeles Times. 25 February **2020**. Available at: https://www.latimes.com/world-nation/story/2020-02-25/doctors-fighting-coronavirus-in-china-die-of-both-infection-and-fatigue. Accessed 5 May 2020.
8. Anelli F, Leoni G, Monaco R, et al. Italian doctors call for protecting healthcare workers and boosting community surveillance during covid-19 outbreak. BMJ **2020**; 368:m1254.
9. Zhan M, Qin Y, Xue X, Zhu S. Death from Covid-19 of 23 health care workers in China. N Engl J Med **2020**:NEJMc2005696. doi:10.1056/NEJMc2005696.
10. Chou R, Dana T, Buckley DI, Selph S, Fu R, Totten AM. Epidemiology of and risk factors for coronavirus infection in healthcare workers: a living rapid review. Ann Intern Med **2020**. doi:10.7326/M20-1632.
11. CDC COVID-19 Response Team, Burrer SL, et al. Characteristics of health care personnel with COVID-19—United States, February 12–April 9, 2020. MMWR Morb Mortal Wkly Rep **2020**; 69:477–81. doi:10.15585/mmwr.mm6915e6.
12. Zhou P, Huang Z, Xiao Y, Huang X, Fan XG. Protecting Chinese healthcare workers while combating the 2019 novel coronavirus. Infect Control Hosp Epidemiol **2020**:1–4. doi:10.1017/ice.2020.60.
13. Wang J, Zhou M, Liu F. Reasons for healthcare workers becoming infected with novel coronavirus disease 2019 (COVID-19) in China. J Hosp Infect **2020**:S0195670120301018. doi:10.1016/j.jhin.2020.03.002.
14. Ran L, Chen X, Wang Y, Wu W, Zhang L, Tan X. Risk factors of healthcare workers with corona virus disease 2019: a retrospective cohort study in a designated hospital of Wuhan in China. Clin Infect Dis **2020**; 71:2218–21.
15. Centers for Diseases Control and Prevention. Priorities for testing patients with suspected COVID-19 infection. Available at: https://www.cdc.gov/coronavirus/2019-ncov/downloads/priority-testing-patients.pdf. Accessed 5 May 2020.
16. Bellisle M. States lack key data on virus cases among medical workers. Associated Press. 5 April **2020**. Available at: https://apnews.com/2f5b20bf9da0c7dbefac8e91769cfe08. Accessed 5 May 2020.
17. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform **2009**; 42:377–81.
18. Bhatraju PK, Ghassemieh BJ, Nichols M, et al. Covid-19 in critically ill patients in the Seattle region—case series. N Engl J Med **2020**:NEJMoa2004500. doi:10.1056/NEJMoa2004500.
19. Lieberman JA, Pepper G, Naccache SN, Huang ML, Jerome KR, Greninger AL. Comparison of commercially available and laboratory developed assays for in vitro detection of SARS-CoV-2 in clinical laboratories. J Clin Microbiol **2020**:JCM.00821-20. doi: 10.1128/JCM.00821-20.
20. Shanafelt T, Ripp J, Trockel M. Understanding and addressing sources of anxiety among health care professionals during the COVID-19 pandemic. JAMA **2020**. doi:10.1001/jama.2020.5893.
21. Adams JG, Walls RM. Supporting the health care workforce during the COVID-19 global epidemic. JAMA **2020**. doi:10.1001/jama.2020.3972.
22. Chow EJ, Schwartz NG, Tobolowsky FA, et al. Symptom screening at illness onset of health care personnel with SARS-CoV-2 infection in King County, Washington. JAMA **2020**. doi:10.1001/jama.2020.6637.
23. Klemko R. Seattle area used early social distancing, testing, to help begin flattening the coronavirus curve. Washington Post. 9 April **2020**. Available at: https://www.washingtonpost.com/national/coronavirus-seattle-flattening-curve/2020/04/09/7313b3c0-7689-11ea-85cb-8670579b863d_story.html. Accessed 5 May 2020.
24. Washington State Governor's Office. Inslee announces statewide school closures, expansion of limits on large gatherings. 13 March **2020**. Available at: https://www.governor.wa.gov/news-media/inslee-announces-statewide-school-closures-expansion-limits-large-gatherings. Accessed 5 May 2020.