Although Virginia Commonwealth University Medical Center (VCUMC) minimized health care worker infections and exposures through the first and second waves of Covid-19, the arrival of the much larger third wave of Covid-19 sparked a substantial surge in cases. The third wave peaked among health care workers during the week of December 13, 2020, with 1% of the workforce (134 of 13,346 workers) testing positive for Covid-19. VCUMC implemented a bundle of intensified infection-control measures, augmented soon thereafter with the arrival of Covid-19 vaccines. These actions were associated with a tenfold reduction in weekly Covid-19 infections, which fell to 0.1% (13 of 13,346 workers) the week of January 31, 2021. Two weeks after the receipt of the first dose of a Covid-19 vaccine, the odds of laboratory-confirmed symptomatic Covid-19 health care worker infection declined by 98%. VCUMC’s experience demonstrates that reinforcing longstanding infection prevention strategies with additional measures can quickly control an outbreak of Covid-19 among health care personnel.

The Challenge

Much like severe acute respiratory syndrome (SARS), SARS-COV-2 poses a substantial infection-prevention challenge in health care systems, albeit on a larger scale.¹ During the first and second
waves of the Covid-19 pandemic in the spring and summer of 2020, Virginia Commonwealth University Medical Center (VCUMC), a 865-bed tertiary care academic medical center with >13,000 health care workers, successfully limited Covid-19 health care worker infection to levels lower than that in the general population of central Virginia. However, the third wave of Covid-19 led to a surge of health care worker infections, threatening the continuity of hospital operations (Figure 1).

FIGURE 1

**Graph Showing the Rates of Covid-19 at VCUMC and in Central Virginia Over Time.**

COVID-19 Infections, by week

During the first two waves, hospital leadership and the Hospital Infection Prevention Program team limited Covid-19 infections in health care workers through a robust mix of infection-control countermeasures. Interventions included designated staff for observation of donning and doffing personal protective equipment (PPE), requiring face shields when caring for Covid-19 patients, universal masking (using cloth, droplet, and N-95 masks), and designating green, yellow, and
red zones to indicate low, medium, and high exposure risks in different settings. Because of the limited supply of N-95 masks, health care workers only wore N-95 masks when caring for patients with suspected or confirmed Covid-19 who presented a risk of aerosolization (intubated patients, patients receiving nebulizers, etc.). The development of a novel and highly effective N-95 sterilization process allowed us to extend the use of our N-95 mask supply. A “Thumbs UP” campaign required all health care workers arriving for work to proactively communicate that they had no Covid-19 symptoms and were fit for duty by giving hospital security staff, positioned at hospital entrances, a thumbs-up signal while entering the building (Figure 2). Virtual town halls and email communications shared up-to-date information and guidance with staff.
The Goal

In November 2020, the third wave of Covid-19 reached Virginia. The rate of Covid-19 hospitalization accelerated following the Thanksgiving holiday. We soon noted an unprecedented rise in Covid-19 infections among health care workers, which threatened the sustainability of the medical center’s mission as Richmond’s safety-net hospital and one of the Commonwealth’s
leading referral centers. In response to these concerns, hospital leadership initiated deliberate and targeted infection-prevention countermeasures to limit transition within the health care setting.

The Execution

The Hospital Infection Prevention Program, Employee Health, and Covid Notification teams investigated the origin of health care worker infections to determine what specific interventions could stop workplace transmission. Contact investigators defined health care worker clusters as two or more laboratory-confirmed cases in one work area during a 14-day period. Beginning in January 2021, the definition evolved to two or more laboratory-confirmed cases in one work area, epidemiologically linked to VCUMC, during a 14-day period. Investigators reviewed approximately 40 clusters from December 2020 through early February 2021. Of the approximately 720 health care workers who were potentially exposed in these clusters, 572 received Covid-19 testing and 310 had a positive result.

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Determining which health care worker clusters were work-acquired required extensive interviewing of infected health care workers. Contact investigators determined that select outbreaks resulted from social gatherings among health care workers outside of the work environment. In addition, several infected health care workers lived together or vacationed together. Although most wave 1 and 2 cases were due to community transmission, contact investigators determined that the lack of social distancing among health care workers in workstations and break rooms was contributing to Covid-19 health care worker clusters beginning in December. The majority of hospital-based transmissions occurred in shared eating spaces, where health care workers were both without a mask and unable to socially distance. Adequate supplies of hand hygiene products, disinfectant wipes, and PPE were available, and proper air-handling and ventilation systems were functioning in Covid-19 cluster locations.

Increasing the social distance between health care workers was an important challenge. Beginning in early December 2020, members of the Hospital Infection Prevention Program team, the Plant Operations team, and the Safety team began to make multidisciplinary rounds to post clear signage with stringent occupancy limits in break rooms and work areas. Finding space that was close to work units but adequate for social distancing required creativity and flexibility from our health care workers. Some teams transitioned their daily safety huddles to virtual formats. Others began conducting virtual patient-care discussion rounds.

Environmental measures included reducing the number of chairs in workspaces and conference rooms, opening additional break rooms, and installing more Plexiglass barriers to separate staff working in close quarters (e.g., telemetry monitoring rooms). When possible, ancillary staff moved
charting areas away from clinical care areas, and large medical teams split into several workrooms to ensure safe social distancing. Cafeteria seating prohibited more than one person per table. Hospital leaders reemphasized the importance of virtual work for all eligible health care workers. The VCUMC communications team shared information about our surge plan deployment with the local newspaper in mid-December, allowing the public to understand the looming crisis that our facility was facing.

Hospital leaders disseminated surge plan guidance by reinstating virtual town halls and mass email communications on December 2. Anticipating the impending issuance of one or more emergency use authorizations (EUAs) for Covid-19 vaccines, we shared preliminary data on vaccine safety with our health care workers. The Food and Drug Administration (FDA) issued its first EUA on December 11, and the second EUA followed 1 week later. To limit community transmission in the hospital, the number of adult inpatient visitors decreased from two visitors to one on December 14. Updated protocols allowed health care workers who had been potentially exposed to Covid-19 to keep working while asymptomatic (unless the exposure occurred in the individual’s home) until they became symptomatic or tested positive.

As patient and health care worker infections continued to rise, we implemented the medical center’s surge plan beginning on December 15. Nurse clinicians (unit-based nurse leaders focused on education and professional development rather than on providing direct patient care) transitioned from their support roles to direct patient care roles, ambulatory nurses moved to support care in inpatient areas, and education/professional development staff pivoted to orienting reassigned staff. Non-nursing personnel assumed roles such as monitoring PPE donning and doffing. In addition, 40 agency nurses began temporary work on adult medical/surgical units.

We began administering Covid-19 vaccinations to health care workers on December 16. A nine-tiered approach enabled us to allocate vaccines equitably among the Phase-1a population as authorized by the Virginia Department of Health. Tiers 1–7 reflected our frontline providers and staff, and tiers 8–9 reflected nonclinical support services that were critical to hospital operations. To encourage vaccine acceptance, hospital leadership hosted six virtual panels, providing authoritative answers to questions regarding vaccine safety and effectiveness. Health care workers received daily emails reporting the number of their fellow health care workers vaccinated, along with videos of colleagues endorsing the vaccine, in the hope of reassuring vaccine-hesitant individuals.

“By February 6, 2021, 58 days into our health care worker vaccine campaign, 69% of health care workers had received at least their first dose of Covid-19 vaccine.”

Nevertheless, vaccine hesitancy continues. By February 6, 2021, 58 days into our health care worker vaccine campaign, 69% of health care workers had received at least their first dose of Covid-19 vaccine. Because of a decrease in health care worker appointments and a diminishing vaccine allocation from the state, formal vaccine clinics ended on February 12, but we will continue to offer vaccines through Employee Health until we are no longer able to do so (which will only occur if our
health care worker vaccine allotment stops). Although we hope to reach an uptake rate of ≥80%, we have no plans to mandate vaccination.

On December 21, we mandated the wearing of level-3 masks while working in any clinical facility and the wearing of face shields during all direct patient encounters. Cloth masks were prohibited. Phased reductions of elective surgical and nonsurgical procedures, diagnostic testing, and in-person ambulatory care visits also went into effect on December 21. To remind our health care workers of the value of basic countermeasures, we launched a “Practice the 5 Ws Everywhere” campaign. The 5 Ws include: Wearing a mask, Washing hands, Watching your distance, Waiting until after the holidays to host or attend gatherings, and Whacking Covid-19 by getting vaccinated as soon as possible.9 To reduce presenteeism,10 hospital leaders consistently discouraged health care workers from coming to work when sick. On December 29, we reinstated the “Thumbs UP” requirement, along with temperature checks at the entry points of all VCUHS buildings. To emphasize the importance of the campaign, senior health system leaders greeted health care workers coming to work for morning and evening shifts.

On January 7, 2021, we imposed full visitor restrictions with some exceptions (e.g., one adult companion was allowed for patients in labor, pediatric patients, and some patients receiving end-of-life care). Through strategic supply chain management, we secured additional N-95 masks and began transitioning to them in late January. Increased health care worker fit-testing for N-95 masks was promptly instituted. Elimination of green (low-risk) zones on January 25 communicated to our staff that all inpatient hospital settings were either yellow (moderate-risk) or red (high-risk) zones, thereby reinforcing the requirement of a level-3 mask at a minimum unless direct patient care necessitated the use of an N-95 mask. On February 3, we implemented an “Ask to Mask” campaign, which asks patients to wear a mask inside their room when the care team is present and asks both patients and their visitors (when allowed) to wear a mask during the entirety of the visit (Table 1).

### Table 1. Covid-19 Infection Prevention Measures by Week

| Week                  | Interventions                                                                 |
|-----------------------|-------------------------------------------------------------------------------|
| December 13–19        | • Adult inpatient visitors decreased from two to one                           |
|                       | • Potentially Covid-19–exposed health care workers allowed to work if asymptomatic |
|                       | • Staffing surge plans implemented                                             |
|                       | • First health care workers vaccinated                                         |
| December 20–26        | • Minimum of level-3 masks (all health care workers working on site) and face shields (all health care workers providing patient care) mandated |
|                       | • Phased reductions of elective surgical and nonsurgical procedures, diagnostic testing, and in-person ambulatory care |
|                       | • 5 Ws Campaign                                                               |
| December 27–January 2 | • “Thumbs UP” and health care worker temperature checks required                |
| January 3–9           | • Full visitor restrictions (exceptions for pediatrics, labor and delivery, some end-of-life care) |
| January 10–16         | • No additional infection-prevention interventions made                         |
| January 17–23         | • No additional infection-prevention interventions made                         |
| January 24–30         | • Securement of additional N-95 masks                                         |
|                       | • Elimination of green (low-risk) zones within facility                       |
| January 31–February 6 | • Fit Testing for new N-95 masks begins                                       |
|                       | • “Ask to Mask” campaign                                                      |

Source: The authors.
The Team

Controlling the surge of Covid-19 health care worker infections required multilevel collaboration. Hospital leaders set the goal and the tone of our institution’s response to the Covid-19 surge. The Healthcare Infection Prevention Program team planned and enacted the infection-prevention measures throughout the hospital and worked with Plant Operations and the Safety Department to physically redesign spaces to allow for social distancing. Information Technology (IT) services set up additional computers in conference rooms and other locations so that appropriate spacing could occur during clinician documentation. Hospital Administration collaborated with Employee Health, Nursing Education and Professional Development, Pharmacy, Communications, Human Resources, Supply Chain, and IT to enact a rapid and safe vaccination plan. Volunteer nurses from nonclinical roles and supplemental staffing opted to vaccinate their fellow health care workers.

Metrics of Success

Within 8 weeks after the initiation of the multifaceted infection-control response and voluntary Covid-19 vaccination campaign, we witnessed a tenfold reduction of Covid-19 infections among health care workers.11 This decrease occurred despite sustained community transmission, new cases, and hospitalized patients remaining at peak levels from mid-December 2020 through January 2021.12 Covid-19 infections among health care workers peaked during the week of December 13, 2020, when approximately 1% of our workforce (134 of 13,346 workers) tested positive, and decreased to approximately 0.1% (13 of 13,346 workers) during the week of January 31, 2021 (Figure 1).

Within 8 weeks after the initiation of the multifaceted infection-control response and voluntary Covid-19 vaccination campaign, we witnessed a tenfold reduction of Covid-19 infections among health care workers.”

From December 16, 2020 through February 6, 2021, 9,181 health care workers (69%) received their first dose of a Covid-19 vaccine. Noting the tenfold Covid-19 infection reduction among health care workers, we performed an odds ratio (OR) calculation to determine vaccine effectiveness (i.e., “the proportionate reduction in disease among the vaccinated group”13). Vaccine effectiveness is calculated using observational data in non-randomized settings in order to determine the reduction of disease burden among vaccinated people.14 We defined Covid-19 vaccine effectiveness as the prevention of laboratory-confirmed Covid-19 infection in individuals with Covid-19 symptoms. We compared the incidence of Covid-19 infections in vaccinated health care workers at 14 days after the first vaccine dose with that in unvaccinated health care workers (including those vaccinated <14 days prior to testing positive) (Table 2). The odds ratio of health care worker Covid-19 infection among the vaccinated individuals was 0.02 (95% confidence interval, 0.015 to 0.033), suggesting a 98% decrease in the odds of infection.
We did not adjust for any factors associated with vaccine receptiveness (e.g., individuals who choose to be vaccinated may also be individuals who practice Covid-19 precautions more diligently) and its possible effect on the OR. Data regarding which health care workers opted not to receive the vaccine or regarding risk factors for Covid-19 infections are not available. Given the nature of overlapping time lines between infection prevention interventions and vaccination efforts, we are unable to assess the individual impact of each component; thus, our estimate of VE and the odds reduction may be inflated by the additional interventions. Covid-19–positive individuals who had no symptoms may not have been tested, which could lead to misclassification of individuals as Covid-19–negative.

Lessons Learned

Health care systems that are faced with a surge in health care worker Covid-19 infections must rapidly intensify infection-control countermeasures. Although our organization’s infection-prevention protocols were successful in preventing health care worker–related spread during the first 9 months of the pandemic, they were not sufficient to contain Covid-19 infection during the third wave of the pandemic. Although it is impossible to quantify the extent to which vaccination and the individual infection-control interventions contributed to the tenfold reduction in the weekly incidence of health care worker Covid-19 infections, the downward trend began 2 weeks prior to when the protective effect of the vaccine was anticipated. This finding suggests that both pharmacological and non-pharmacological countermeasures were rapidly effective when SARS-CoV-2 transmission was high both in the community and in the health care setting. Our surge response was guided by previous publications, and the present report adds to the growing body of literature on the prevention of Covid-19 infection in health care workers. Health care systems that are faced with a surge of Covid-19 infections or an alternative respiratory virus in their workforce should simultaneously enhance infection-prevention measures and aggressively vaccinate health care workers to decrease transmission in the health care setting.

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Table 2. Risk of Covid-19 HCW infection in Vaccinated vs. Unvaccinated Health Care Workers *

|                   | Covid-19–Positive (N = 526) | Covid-19–Negative / Unknown (N = 12,820) |
|-------------------|-------------------------------|-----------------------------------------|
| Vaccinated†       | 27 (5.1%)                     | 9,101 (71.0%)                           |
| Unvaccinated‡     | 499 (94.9%)                   | 3,719 (29.0%)                           |

*The values are given as the number of health care workers. †A vaccinated health care worker is defined as an individual who received their first Covid-19 vaccine ≥14 days prior to testing positive. ‡An unvaccinated health care worker is defined as an individual who never received a Covid-19 vaccine OR an individual who received their first Covid-19 vaccine <14 days prior to the date of a positive test. Source: The authors.
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Acknowledgements

We would like to thank Dr. Le Kang, PhD, Associate Professor, Department of Biostatistics at VCU, for his support of this case study.

Disclosures: Rachel Pryor, Kaila Cooper, Amy Britton, Nikki Meador, Michelle Doll, Emily J. Godbout, Michael P. Stevens, and Gonzalo Bearman have nothing to disclose.

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