Decline in SARS-CoV-2 Infections Among Healthcare Workers at Two Hospitals Following Rollout and Administration of mRNA Vaccines

Chanu Rhee MD MPH\textsuperscript{1,2}, Rui Wang PhD\textsuperscript{1,3}, Shangyuan Ye PhD\textsuperscript{1}, Meghan Baker MD, ScD\textsuperscript{1,2}, Diane Griesbach NP\textsuperscript{4}, Karl Laskowski MD MBA\textsuperscript{2}, Michael Klompas MD MPH\textsuperscript{1,2}, for the CDC Prevention Epicenters Program

1. Department of Population Medicine, Harvard Medical School / Harvard Pilgrim Health Care Institute, Boston, MA, USA
2. Department of Medicine, Brigham and Women’s Hospital, Boston, MA, USA
3. Department of Biostatistics, Harvard T.H. Chan School of Public Health, Boston, MA, USA
4. Occupational Health Services, Brigham and Women’s Hospital, Boston, MA, USA

Corresponding Author:
Chanu Rhee, MD, MPH (crhee@bwh.harvard.edu)
Address: Department of Population Medicine
Harvard Medical School and Harvard Pilgrim Health Care Institute
401 Park Drive, Suite 401
Boston, MA 02215, USA
Phone: 617-509-9987, Fax: 617-859-8112

Keywords: SARS-CoV-2; COVID-19; Vaccines; Healthcare Workers

© The Author(s) 2021. Published by Oxford University Press on behalf of Infectious Diseases Society of America.
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs licence (http://creativecommons.org/licenses/by-nc-nd/4.0/), which permits non-commercial reproduction and distribution of the work, in any medium, provided the original work is not altered or transformed in any way, and that the work is properly cited. For commercial re-use, please contact journals.permissions@oup.com
Dear Editor:

Two SARS-CoV-2 mRNA vaccines received FDA Emergency Use Authorization in December 2020 after showing 94-95% efficacy in phase 3 clinical trials.\textsuperscript{1,2} We evaluated trends in healthcare worker (HCW) SARS-CoV-2 infections before and after vaccine deployment at Brigham Health, an integrated healthcare system in Massachusetts that includes Brigham and Women’s Hospital (an 803-bed academic hospital) and Faulkner Hospital (a 162-bed community teaching hospital) and employs over 23,000 HCWs.

**METHODS**

Brigham Health began administering the BNT162b2 (Pfizer/BioNTech) vaccine on December 17 and mRNA-1273 (Moderna) vaccine on December 23. Vaccines were initially prioritized for emergency, inpatient, and ambulatory staff caring for suspected or confirmed Covid-19 patients. Access was expanded to include all staff working on-site within 3 weeks.

We compared weekly trends in HCW SARS-CoV-2 infections from October 5-January 31 to the 7-day average of new confirmed cases in Massachusetts\textsuperscript{5} and the hospitals’ 7-day average inpatient Covid-19 census. HCWs with any symptoms consistent with Covid-19 or unprotected exposures were required to undergo PCR testing; elective asymptomatic testing was also available at no cost. The hospitals’ Occupational Health Service interviewed all test-positive employees to assess symptoms and exposures. We compared trends in the pre-vaccine (October 5-January 3) vs post-vaccine period (January 4-31) by applying an interrupted time series model.
to weekly case counts (log-transformed) and comparing slopes between HCWs, Massachusetts cases, and inpatient Covid-19 census. We used January 4th as the inflection point to allow adequate time for a meaningful fraction of HCWs to be vaccinated and because the trials suggested vaccine efficacy after about 2 weeks. Analyses were done using R version 4.0.3 (R Foundation).

**Patient Consent Statement**

This study was approved by the Mass General Brigham Institutional Review Board. The need for written consent was waived as the data were collected for the purpose of hospital operations.

**RESULTS**

Between October 5-January 31, 1,004 HCWs tested positive for SARS-CoV-2. Weekly HCW infections increased from October through early January, closely mirroring trends in community and hospital cases (Figure). Of 23,329 HCWs, 7,542 (32%) received at least one vaccine dose by January 4th, 12,438 (53%) by January 18th, and 14,901 (64%) by January 31. After January 4th, there was a 33% weekly reduction in HCW infections from a peak of 116 to a low of 33 from January 25-31, while Massachusetts community cases and inpatient census declined more modestly (weekly reduction rate: 18% and 9%, respectively, p<0.001 for difference in both trends compared to HCW trends). HCWs underwent a mean 2,226 tests per week during the study period, including 2,852 per week from January 4-31. Overall, 824/1,004 HCWs...
(82%) were symptomatic when tested, including 610/760 (80.3%) in the Oct 5-Jan 3 period and 214/244 (87.7%) in the Jan 4-31 period.

Between January 4-31, 98/244 HCW infections (40%) were in vaccinated individuals; 74 (76%) occurred within 14 days of the first dose. Of the 24 vaccinated HCWs who tested positive >14 days after their first vaccine dose, 18 had symptoms at diagnosis while 6 were asymptomatic. Six of the vaccinated HCWs who tested positive did so ≥14 days after receiving the 2nd vaccine dose; 5/6 had symptoms at time of diagnosis. None of the vaccinated HCWs who tested positive were hospitalized at the time of interview by Occupational Health. Of the 14 samples with available PCR cycle threshold (Ct) values from the 24 HCWs who tested positive >14 days after the 1st vaccine dose, the median Ct value was 24.5 (IQR 20.9-26.8), compared to 21.8 (IQR-18.6-27.3) from the 109 samples with available Ct values from the other HCWs who tested positive after January 4th.

**DISCUSSION**

Our study mirrors other data on the real-world impact of the mRNA vaccines, including in the general population in Israel, and HCWs in the United Kingdom and United States.3-8 Our analysis adds insight into the timeline after vaccine roll-out before which a substantial decline on infection rates is likely to be seen, and also underscores the fact that infections can still commonly happen within the first few weeks of vaccination and, occasionally thereafter, in fully vaccinated individuals as well.

Limitations of our study include the focus on two hospitals alone, incomplete vaccine uptake by staff, and insufficient time for all HCWs to receive two doses. The observation that a higher proportion of HCWs tested positive while symptomatic in the
post vs pre-vaccination period also suggests that there may have been changes in HCW's propensity to get tested following vaccination. The reasons underlying the decline in community infections in the post-vaccination period are unclear but similar trends were seen nationally and are unlikely to be due to vaccination given <10% of the population had been vaccinated by the end of January.

In summary, we observed a substantial decline in SARS-CoV-2 infections amongst HCWs approximately 3-4 weeks after rollout of the mRNA vaccines. HCW infection counts decreased at a significantly greater rate than concurrent declines in community and hospital infections. After vaccinations began, most infections occurred in unvaccinated individuals; the vaccinated HCWs who did test positive tended to do so within 2 weeks of their first vaccine dose. At the same time, a relatively small number of HCWs tested positive after 1 and even 2 doses of the vaccine. While these results suggest that widespread vaccinations will have a substantial impact on SARS-CoV-2 infection rates amongst HCWs and in the community, they also indicate that breakthrough infections do occur and thus underscore the need for ongoing vigilance and adherence to safe practices.
ACKNOWLEDGEMENTS

**Funding Sources:** This work was funded by the Centers for Disease Control and Prevention (6U54CK000484-04-02).

**Role of the Funder / Sponsor:** Members of the Centers for Disease Control and Prevention, who are co-authors on this study, contributed to the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, and approval of the manuscript; and decision to submit the manuscript for publication.

**Conflicts of Interest:** Drs. Rhee and Klompas have received royalties from UpToDate, Inc. for writings on unrelated topics. None of the authors have any conflicts of interest to disclose.
REFERENCES

1. Polack FP, Thomas SJ, Kitchin N, et al. Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine. *N Engl J Med.* 2020;383(27):2603-2615.

2. Baden LR, El Sahly HM, Essink B, et al. Efficacy and Safety of the mRNA-1273 SARS-CoV-2 Vaccine. *N Engl J Med.* 2020.

3. Dagan N, Barad R, Kepten E, et al. BNT162b2 mRNA Covid-19 Vaccine in a Nationwide Mass Vaccination Setting. *N Engl J Med.* 2021.

4. Hall VJ, Foulkes S, Saei A, et al. Effectiveness of BNT162b2 mRNA Vaccine Against Infection and COVID-19 Vaccine Coverage in Healthcare Workers in England, Multicentre Prospective Cohort Study (the SIREN Study) (Posted Feb 22, 2021). [https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3790399](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3790399). Accessed Feb 26, 2021.

5. Thompson MG, Burgess JL, Naleway AL, et al. Interim Estimates of Vaccine Effectiveness of BNT162b2 and mRNA-1273 COVID-19 Vaccines in Preventing SARS-CoV-2 Infection Among Health Care Personnel, First Responders, and Other Essential and Frontline Workers - Eight U.S. Locations, December 2020-March 2021. *MMWR Morb Mortal Wkly Rep.* 2021;70(13):495-500.

6. Daniel W, Nivet M, Warner J, Podolsky DK. Early Evidence of the Effect of SARS-CoV-2 Vaccine at One Medical Center. *N Engl J Med.* 2021.

7. Keehner J, Horton LE, Pfeffer MA, et al. SARS-CoV-2 Infection after Vaccination in Health Care Workers in California. *N Engl J Med.* 2021.

8. Benenson S, Oster Y, Cohen MJ, Nir-Paz R. BNT162b2 mRNA Covid-19 Vaccine Effectiveness among Health Care Workers. *N Engl J Med.* 2021.
FIGURE LEGEND

Figure. Trends in weekly healthcare worker SARS-CoV-2 infections vs community infections and inpatient Covid-19 census

Weekly healthcare worker (HCW) infections refer to the total number of PCR-confirmed infections during the listed date and the preceding 6 days (primary y-axis). The 7-day average inpatient Covid-19 census denotes the average of the daily number of inpatients at both hospitals who have PCR-confirmed infection and had not yet met criteria for discontinuing transmission-based precautions on the listed date and the prior 6 days (primary y-axis). Massachusetts (MA) 7-day average of new cases denotes the average of molecular test-confirmed cases during the listed date and the prior 6 days (secondary y-axis). The infection point (January 4th) was chosen to allow adequate time for a meaningful fraction of HCWs to be vaccinated after the roll-out on December 17th and because the trials suggested vaccine efficacy after about 2 weeks. The proportion of HCWs vaccinated at various timepoints was as follows: 32% received 1 dose by January 4th, 53% received 1 dose (10% received 2 doses) by January 18th, and 64% received 1 dose (30% received 2 doses) by January 31st.
Figure 1

Figure. Trends in weekly healthcare worker SARS-CoV-2 infections vs community infections and inpatient Covid-19 census.