

COMMENTARY

RESPIRATORY PROTECTION CONSIDERATIONS FOR HEALTHCARE WORKERS DURING THE COVID-19 PANDEMIC

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The COVID-19 pandemic has resulted in a surge of patients that exceeds available human and physical resources in many settings, triggering the implementation of crisis standards of care. High-quality respiratory protection is essential to reduce exposure among healthcare workers, yet dire shortages of personal protective equipment in the United States threaten the health and safety of this essential workforce. In the context of rapidly changing conditions and incomplete data, this article outlines 3 important strategies to improve healthcare workers' respiratory protection. At a minimum, healthcare workers delivering care to patients with confirmed or suspected COVID-19 should wear N95 respirators and full-face shields. Several mechanisms exist to boost and protect the supply of N95 respirators, including rigorous decontamination protocols, invoking the Defense Production Act, expanded use of reusable elastomeric respirators, and repurposing industrial N95 respirators. Finally, homemade facial coverings do not protect healthcare workers and should be avoided. These strategies, coupled with longer-term strategies of investments in protective equipment research, infrastructure, and data systems, provide a framework to protect healthcare workers immediately and enhance preparedness efforts for future pandemics.

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THE HEALTH AND WELL-BEING of our healthcare workers determine our nation's health, security, and economic prosperity. In the United States, an alarming number of healthcare workers have been stricken by COVID-19. Across 10 states that conduct detailed track-

ing, healthcare workers comprise between 4.4% and 20% of diagnosed cases,¹ and across the globe, more than 100 healthcare workers have died from COVID-19.² Escalating infections and related fatalities of healthcare workers threaten the capacity of the US healthcare system to care for

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additional COVID-19 patients, as diagnoses increase at a staggering pace and trigger the implementation of crisis standards of care.³ This explosion is sending the care delivery system spiraling to unfathomable lows, with unknown consequences, especially since illness unrelated to COVID-19 marches on, often unattended. Also, families bear the brunt as healthcare workers fall ill.

Now is the time for action. COVID-19 transmission among healthcare workers *must* be contained; other countries have succeeded with aggressive measures, including meticulous respiratory protection.⁴ Respiratory protection is challenging today, partly due to unforgivable equipment shortages and sparse COVID-19-specific research data to inform infection control strategies. For example, the human infectious dose of SARS-CoV-2 and the modes of transmission are still unknown. A National Academy of Medicine rapid response report supports the possibility that SARS-CoV-2 could be spread via bioaerosol particles generated directly by patients' exhalation.⁵ This is in addition to the spread posited through close contact and droplet transmission, with fomite transmission likely.⁶

Respiratory protection is an essential component of risk reduction. An N95 respirator is designed to reduce workers' inhalation exposure to hazardous airborne particles, such as SARS-CoV-2. In contrast, a surgical mask does not protect healthcare workers from airborne hazards and is designed to protect others from the wearer's expired respiratory droplets. Masks may offer limited barrier protection from splashes and larger droplets.

As members of the 2018 National Academy of Medicine Study Committee on the Use of Elastomeric Respirators in Health Care,⁷ we were charged with exploring the feasibility of adopting reusable elastomeric respirators in a pandemic. Recently, 6 members of this committee voluntarily reconvened (without an official National Academy request) to review our original recommendations, meeting materials, and recent relevant published literature to respond to the urgent need to protect healthcare workers.

STRATEGIES TO IMPROVE RESPIRATORY PROTECTION

Drawing from our summary of the existing information and informed by our collective expertise, we posit 3 urgent strategies and 4 longer-term actions to adopt to protect healthcare workers from COVID-19 and future pandemics:

1. At a minimum, healthcare workers delivering care to patients with confirmed or suspected COVID-19 should wear N95 respirators and full-face shields. This recommendation is informed by the concerns for aerosol transmission reported by the National Academy of Medicine Rapid Response team cited above and by published data that document viral RNA airborne levels and detection on numerous surfaces, including ventilator registers.^{6,8} While

we await robust experimental studies specific to live SARS-CoV-2 virus, there is insufficient evidence to conclude that surgical masks provide adequate protection against this pathogen. We also urge that healthcare workers wear at least N95 respirators and full-face shields when working in high-risk settings, such as emergency departments, where notably ill patients may be infected with SARS-CoV-2 but not yet diagnosed. While N95 respirators will provide better protection compared to surgical masks for healthcare workers, it is unclear if the 95% protection level is adequate to prevent infection, as the infectious dose for humans remains unknown. Respirators with higher levels of protection, such as powered air-purifying respirators, may be needed to protect healthcare workers more fully, and this approach should be investigated.

2. Boost and protect the supply of N95 respirators for healthcare workers under the current crisis standard of care scenario. Several US locations now exceed healthcare system capacity, which compels the implementation of crisis standards of care. Alarmed and outraged by local and national reports of N95 respirator shortages,⁹ we outline efforts to boost and protect respiratory protection supplies for healthcare workers. These include:

- Expand research efforts to decontaminate used N95 respirators while preserving their protective features and avoiding degradation. In addition to the Centers for Disease Control and Prevention (CDC) Guidance of N95 reuse (which includes extending expiration dates), decontamination protocols, including hydrogen peroxide vapor, ultraviolet light, and heat, are promising strategies to preserve existing N95s.¹⁰⁻¹²
- The president should exercise authorities under the Defense Production Act to manufacture N95s and other protective equipment and distribute them to US healthcare workers. It is unlikely that new decontamination methods will be available soon and across all settings. Healthcare workers in less-resourced environments will remain at risk. The status quo is unacceptable and tragic. Therefore, N95 production must increase immediately. Equipment distribution plans must be transparent and informed by real-time demand. There is no time to spare to ensure the long-term health and economic vitality of our country and, indeed, the world.
- Consider adopting reusable half-facepiece elastomeric respirators.⁷ Commonly used in nuclear power and radiation industries, these respirators can be reused if a rigorous cleaning and disinfection protocol is in place. Elastomeric respirators are well-suited for units that care exclusively for COVID-19 patients. Given postponed elective procedures, central supply employees can be redirected to process and disinfect these respirators. One institution's protocol may be found in the appendix (see supplemental material at <https://www.liebertpub.com/doi/suppl/10.1089/hs.2020.0036>).

- Augment existing supply of N95 respirators from other sectors. During the pandemic, industrial N95 respirators can be used in place of surgical N95 respirators across healthcare settings, unless high-velocity blood spurts are possible.¹³

3. Homemade facial coverings offer no protection for healthcare workers. Numerous worrisome reports reveal that some healthcare settings have no respiratory protective equipment for front-line employees. The World Health Organization (WHO) discourages homemade facial coverings for healthcare workers.¹⁴ Bandanas and scarves are woefully inadequate, because of concerns for moisture and pathogen retention. In dire circumstances, certain materials and design principles may improve the performance of homemade facial coverings,^{15,16} but we emphasize that homemade facial coverings do not protect healthcare workers adequately against SARS-CoV-2. Institutions must relentlessly secure sufficient supplies of rigorously tested personal protective equipment. Our committee posited a comprehensive framework for optimal respiratory protection for healthcare workers.⁷

IMPROVING FUTURE PANDEMIC PREPAREDNESS

The 3 urgent strategies detailed above do not replace the essential steps necessary to strengthen our response to the next widespread infectious disease that will affect the United States. Regrettably, expert reports in 2006 and 2008 that detailed essential strategies to improve pandemic preparedness were not enacted.^{17,18} We cannot wait for the next pandemic to act. SARS-CoV-2 will be in our communities—nationally and internationally—for the foreseeable future, affecting vulnerable groups the most. These include older adults, children, individuals who are incarcerated or experience home insecurity, people with disabilities, and healthcare workers. To strengthen subsequent responses and to save lives, we recommend that the following actions commence immediately:

1. Substantial funding to develop and test better personal protective equipment specific to healthcare settings and ascertain exposure levels across settings and clinical procedures.^{19,20}
2. Reinvest in, monitor, and replenish the Strategic National Stockpile. Integrate these efforts with a reinvigorated Hospital Preparedness Program.²¹
3. Develop state-based data systems to track real-time demand and supply for essential healthcare equipment during surge situations.
4. Establish 50-state tracking of healthcare worker infections and mortality to monitor the impact of healthcare worker protection efforts.

CONCLUSIONS

The 3 urgent strategies, coupled with the 4 actions outlined above, would immediately strengthen protection to the estimated 18 million healthcare workers in the United States. These measures would also position the nation favorably for the next pandemic. In the past, our nation has faced catastrophic public health crises, only to emerge from them stronger in terms of research and clinical care. Previously, these advances expanded globally, resulting in improved health, prosperity, and safety. The same is possible from the COVID-19 pandemic, if health system leaders and policymakers understand “the fierce urgency of now” to protect healthcare workers and the American public from current and future threats.

REFERENCES

1. Galvin G. The great unknown: how many health care workers have coronavirus? *US News and World Report* April 3, 2020. <https://www.usnews.com/news/national-news/articles/2020-04-03/how-many-health-care-workers-have-coronavirus>. Accessed April 17, 2020.
2. Kim S. Over 100 doctors and nurses have died combating coronavirus across the world. *Newsweek* April 3, 2020. <https://www.newsweek.com/coronavirus-deaths-infections-doctors-nurses-healthcare-workers-medical-staff-1496056>. Accessed April 17, 2020.
3. Institute of Medicine; Board on Health Sciences Policy; Committee on Guidance for Establishing Standards of Care for Use in Disaster Situations; Hanfling D, Altevogt BM, Viswanathan K, Gostin LO, eds. *Crisis Standards of Care*. Washington, DC: National Academies Press; 2012.
4. Wang X, Pan Z, Cheng Z. Association between 2019-nCoV transmission and N95 respirator use. *J Hosp Infect* 2020; 105(2020):104–105.
5. National Research Council. *Rapid Expert Consultation on the Possibility of Bioaerosol Spread of SARS-CoV-2 for the COVID-19 Pandemic (April 1, 2020)*. Washington, DC: National Academies Press; 2020.
6. Santarpia JL, Rivera DN, Herrera V, et al. Transmission potential of SARS-CoV-2 in viral shedding observed at the University of Nebraska Medical Center. medRxiv 2020; 2020.03.23.20039446. <http://medrxiv.org/content/early/2020/03/26/2020.03.23.20039446.1.abstract>
7. National Academies of Science Engineering and Medicine; Clever LH, Rogers BME, Yost OC, Liverman CT, eds. *Reusable Elastomeric Respirators in Health Care: Considerations for Routine and Surge Use*. Washington, DC: National Academies Press; 2019.
8. Ong SWX, Tan YK, Chia PY, et al. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA* 2020; 323(16):1610–1612.
9. Kamerow D. Covid-19: the crisis of personal protective equipment in the US. *BMJ* 2020;369:m1367.

10. Lowe JJ, Paladino KD, Farke JD, et al. *N95 Filtering Facemask Respirator Ultraviolet Germicidal Irradiation (UVGI) Process for Decontamination and Reuse*. Omaha: Nebraska Medicine; 2020. <https://www.nebraskamed.com/sites/default/files/documents/covid-19/n-95-decon-process.pdf>
11. Centers for Disease Control and Prevention. Decontamination and reuse of filtering facepiece respirators. Reviewed April 9, 2020 <https://www.cdc.gov/coronavirus/2019-ncov/hcp/ppe-strategy/decontamination-reuse-respirators.html>. Accessed April 17, 2020.
12. Chin AWH, Chu JTS, Perera MRA, et al. Stability of SARS-CoV-2 in different environmental conditions. *Lancet Microbe* 2020 Apr 2. <https://linkinghub.elsevier.com/retrieve/pii/S2666524720300033>. Accessed April 17, 2020.
13. US Food and Drug Administration. Emergency use authorization. <https://www.fda.gov/emergency-preparedness-and-response/mcm-legal-regulatory-and-policy-framework/emergency-use-authorization#covidppe>. Accessed April 17, 2020.
14. World Health Organization (WHO). *Advice on the Use of Masks in the Context of COVID-19: Interim Guidance, April 6, 2020*. Geneva: WHO; 2020. Accessed April 17, 2020. <https://apps.who.int/iris/handle/10665/331693>
15. Lee BY. Making an N95 mask for COVID-19 coronavirus? What you need to know. *Forbes* March 29, 2020. <https://www.forbes.com/sites/brucelee/2020/03/29/making-an-n95-mask-for-covid-19-coronavirus-what-you-need-to-know/#261a8d974989>. Accessed April 17, 2020.
16. Robertson P. What are the best materials for making DIY face masks? *Smart Air*. March 8, 2020. <https://smartairfilters.com/en/blog/best-materials-make-diy-face-mask-virus/>. Accessed April 17, 2020.
17. Institute of Medicine; Goldfrank LR, Liverman CT, eds. *Preparing for an Influenza Pandemic: Personal Protective Equipment for Healthcare Workers*. Washington, DC: National Academies Press; 2008.
18. Institute of Medicine. *Reusability of Facemasks During an Influenza Pandemic: Facing the Flu*. Washington, DC: National Academies Press; 2006.
19. Mason DJ, Friesse CR. Protecting health care workers against COVID-19—and being prepared for future pandemics. *JAMA Health Forum* March 19, 2020. <https://jamanetwork.com/channels/health-forum/fullarticle/2763478>. Accessed April 17, 2020.
20. Friesse CR. Time to meaningfully invest in health care worker safety. *The Hill* April 7, 2020. <https://thehill.com/opinion/healthcare/491593-time-to-meaningfully-invest-in-health-care-worker-safety>. Accessed April 17, 2020.
21. Medcalf S, Roy S, Bekmuratova S, et al. From silos to coalitions: the evolution of the US Hospital Preparedness Program. *J Emerg Manag* 2020;18(2):163-169.

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