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Evidence regarding the need for respiratory protection of healthcare workers responding to COVID-19 pandemic.

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We know from past pandemics that frontline healthcare workers have a high risk of exposure to infected patients. Historically and in the current pandemic there have been reports of large numbers of healthcare workers being infected and some deaths.[1] [2] [3] [4] [5] Protecting our healthcare workers is not only a moral imperative but essential to maintaining the necessary staff to provide patient care during this crisis. The reports cited also indicate that infected healthcare workers pose a significant risk of infection to patients, workers' family members, and the community.

Impact on Healthcare Workers [6] [2] [7] SARS 1, MERS, SARS 2 As of 3/16/2020		
SARS 1, 7/5/2003	**MERS, ongoing**	**SARS 2, ongoing**
1,769 cases 21% of all cases 5 deaths	415 cases 17% of all cases 137 deaths	China: 3,400 4% of all cases China: 22 deaths

Transmission of SARS CoV-2

There is mounting evidence that short term aerosol transmission may be a significant source of transmission for SARS CoV-2, particularly for healthcare and other workers who have close contact with infected people. From past outbreaks it has been established that corona viruses are transmitted via contact and droplet. But guidance from public health authorities on the issue of aerosol transmission is inconsistent and conflicting. An aerosol is a tiny droplet nuclei or particle suspended in air in the respirable size range containing infectious agents that remain infective over time and distance.[8] When a person breathes, coughs, or sneezes they emit droplets in a variety of sizes ranging from large to very small (sub-micron[1]). Contrary to popular belief, large particles that are 5 to 10 microns do NOT drop immediately to the ground but will remain airborne for several minutes.[9] Smaller droplets that are less than 5 microns will stay suspended in the air for many minutes or hours. All particles begin to evaporate because mucus is mainly composed of water, making the particles smaller and more likely to remain in the air. Emerging evidence from past and the current pandemic

[1] A micron is a millionth of a meter.

indicates that short range aerosol transmission of SARS CoV-2 is likely to have caused some of the healthcare worker infections.[10] [11] [12] [13] [14]

Airborne transmission is different from aerosol. It is defined as droplet nuclei suspended in air over long distances. The classic examples of airborne infectious diseases are tuberculosis and measles. The standard for worker protection in evaluating suspect or known cases of airborne diseases includes respiratory protection.[15]

The University of Nebraska Medicine that operates one of the nation's premier biocontainment units includes the use of respiratory protection in its infection control protocols for healthcare workers who evaluate and treat COVID-19 patients. In a new study the authors concluded, "Disease spread through both direct (droplet and person-to-person) as well as indirect contact (contaminated objects and airborne transmission) are indicated, supporting the use of airborne isolation precautions."[10]

In a research letter reviewing environmental sampling in a COVID-19 patient room in Singapore published in early March 2020 the authors reported " Swabs taken from the air exhaust outlets tested positive, suggesting that small virus-laden droplets may be displaced by airflows and deposited on equipment such as vents."[16]

In a pre-print of a study evaluating aerosol and surface stability of SARS-CoV-2 published March 13, 2020, the authors concluded, "Our results indicate that aerosol and fomite transmission of HCoV-19 is plausible, as the virus can remain viable in aerosols for multiple hours and on surfaces up to days."[17]

CDC Guidelines

Initially CDC guidelines for protection of healthcare workers included a minimum of an N95 air purifying respirator. However, in early March CDC changed its guidelines to allow for use of a surgical mask for evaluating suspect COVID-19 patients as well as providing care for them, during periods when respirators are in short supply.[18] The guidelines state that facilities should return to using N95s when the supply is restored. CDC has not provided a scientific justification for lowering the recommended level of protection for healthcare workers. Nor did they include any warning about the potential for aerosol transmission when using surgical masks. This defies the evidence from prior outbreaks where healthcare workers were infected, and some died. The World Health Organization also has adopted this lower standard of protection.[19]

Difference between surgical masks and respirators

A surgical mask does not provide a tight seal around the users face and therefore does NOT adequately protect healthcare workers from inhaling infectious material. Surgical masks are designed to protect patients' wounds from being contaminated by healthcare staff. They are also useful for stopping large particles. In contrast, respirators are certified by NIOSH to filter out sub-micron particles and provide a tight facial seal to protect the user.[20]

OSHA and Cal/OSHA

OSHA establishes and enforces occupational safety and health standards. OSHA's respiratory protection standard requires that employers must provide adequate respiratory protection when efforts to reduce respiratory hazards through other means are not adequate.

On March 23, 2020 OSHA published the following statement:

"When disposable N95 filtering facepiece respirators are "not available, consider using other respirators that provide greater protection and improve worker comfort. Other types of acceptable respirators include: a R/P95, N/R/P99, or N/R/P100 filtering facepiece respirator; an air-purifying elastomeric (e.g., half-face or full-face) respirator with appropriate lters or cartridges; powered air purifying respirator (PAPR) with high-ef ciency particulate arrestance (HEPA) lter; or supplied air respirator (SAR). See CDC/ NIOSH guidance for optimizing respirator supplies at:www.cdc.gov/coronavirus/2019-ncov/hcp/respirators-strategy."

To further confuse matters, the CDC guidelines refer to complying with the OSHA respiratory protection and PPE standards. A cogent argument can be made that hospitals following the CDC guideline allowing for use of surgical masks when evaluating or providing care for infected patients is in violation of OSHA requirements.

Recommended minimum protection

An example of the more protective measures used in China to prevent nosocomial transmission of SARS CoV-2 is in the chart below.[21] Note that it includes an N95 respirator for triage stations as well as rooms used for evaluating suspect patients and caring for confirmed patients. China has succeeded in suppressing the epidemic and its more protective approach for healthcare workers was a part of that success.

Nebraska Medicine operates one of the nations premier biocontainment units. They had the experience of providing care to Ebola patients. Their COVID-19 procedures include the use of N95s as the minimum respiratory protection for evaluating or providing care to COVID-19 patients. They also use negative pressure isolation rooms if they are

Table 2. Enhanced infection control measures to prevent nosocomial transmission of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in Hong Kong

	Caring for suspected or confirmed SARS-CoV-2 [a]	Triage station [b]	Aerosol generating procedures [c]	Other wards or patients areas [d]	Other area with no direct patient contact
Hand hygiene	Required	Required	Required	Required	Required
Choice of mask	N95 respirator	N95 respirator [e]	N95 respirator	Surgical mask	Surgical mask
Isolation gown	AAMI level 3 [f]	AAMI level 1 or 3 [f]	AAMI level 1 or 3 [f]	Standard precautions +/- transmission based precautions	Not required
Disposable gloves	Required	Risk assessment	Required		Not required
Eye protection	Goggles / face shield	Eye visor / goggles / face shield	Goggles / face shield		Not required
Hair cover	Optional	Optional	Optional		Not required

[a] suspected or confirmed case of novel coronavirus 2019 is cared in airborne infection isolation room; [b] including triage stations of emergency rooms and outpatient clinics; [c] aerosol generating procedures included endotracheal intubation, cardiopulmonary resuscitation, bronchoscopy, and open suction of respiratory tract, sputum induction, use of nebulizer therapy, non-invasive positive pressure ventilation, and high frequency oscillatory ventilation; [d] including outpatient clinics, radiological facilities, physiotherapy, occupation therapy, and day centers; [e] surgical mask could be used as an alternative based on risk assessment; [f] AMMI, Association for the Advancement of Medical Instrumentation PB70:2003 is to define the liquid barrier performance and classification of protective apparel and drapes intended for use in health care facilities (https://www.fda.gov/medical-devices/personal-protective-equipment-infection-control/medical-gowns); AAMI level 1 isolation gown is used when small amounts of fluid exposure is anticipated while AAMI level 3 isolation gown is used when large amounts of fluid exposure is anticipated;

available. For high risk aerosol producing procedures they use powered air purifying respirators, a higher level of protection.

OSHA's guidelines also call for use of negative pressure isolation rooms and respiratory protection. See: https://www.osha.gov/SLTC/covid-19/controlprevention.html#health

The National Academy of Science conducted a study and published Reusable Elastomeric Respirators in Health Care: Considerations for Routine and Surge Use (2019)[22] The study recommended expanding the use and research on reusable elastomeric respirators in healthcare. Reusable elastomeric respirators are an important option for facilities dealing with the COVID-19 crisis because they can be assigned to one individual healthcare workers, can be easily disinfected, maintained, and stored and provide an equivalent level of protection to an N95 disposable respirator.

Comparison with other CDC guidelines

CDC's guidelines for infection control for MERS states, "Respiratory Protection, Use respiratory protection (i.e., a respirator) that is at least as protective as a fit-tested NIOSH-certified disposable N95 filtering facepiece respirator upon entry to the patient room or care area."

CDC's guidelines for infection control for SARS-1 states, "Respiratory protection – Wear a NIOSH-certified N-95 filtering facepiece respirator for entering an AIIR or designated SARS patient-care area. If N-95 or higher level of respiratory protection is not available, then wear a snug-fitting surgical mask to prevent nose and mouth contact with large respiratory droplets."

Conclusion

Use of respiratory protection for suspect or confirmed cases of COVID-19 is warranted until such time that there is evidence that it is not aerosol transmissible. Negative pressure isolation rooms should be used, where available. CDC's guidelines are recommendations and minimum recommendations at that. The use of surgical masks when working near suspect or confirmed COVID-19 patients jeopardizes the wellbeing of healthcare workers and patients. An evidence-based precautionary response calls for use of N95 respirators, at a minimum. More protective respirators as recommended by OSHA and NIOSH should be used where available..

Hospitals should adopt and adapt the model policies and procedures developed by Nebraska Medicine: https://www.nebraskamed.com/for-providers/covid19

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