COVID-19 Evidence Service | **Addressing COVID-19 Face Mask Shortages [v1.1]**
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Please note: We do not advocate or advise specific treatments or approaches. The COVID-19 Evidence Service aims to share the best available evidence to address questions for clinical anesthesiologists and the anesthesiology community. We recommend that hospital policy and procedures be respected and adhered to.

What are good ways to address the shortage of face masks by anesthesiologists?

Stanford Learnly Anesthesiologist

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KEY TAKEAWAYS

- Frontline health care workers across the United States report shortages of PPE ranging from gloves, protective gowns, eye wear and face masks.
- It is unknown how wearing the same mask multiple times effects the fit of N95 masks [NIOSH]
- NIOSH states "there is no way of determining the maximum possible number of safe reuses for an N95 respirator as a generic number to be applied in all cases" and advise to "discard N95 respirators following use during aerosol generating procedures."
- Some methods of N95 mask disinfection can maintain filtration efficiency. Their effect on mask fit is unknown, and these methods are not approved by NIOSH.

RATIONALE

The current COVID-19 pandemic has highlighted global supply chain shortcomings in the US hospital delivery system, most notably personal protective equipment (PPE). Frontline health care workers across the United States report shortages of PPE ranging from gloves, protective gowns, eye wear and face masks.

The transmission of COVID-19 is thought to occur through respiratory droplets, and current CDC guidelines recommend the use of N95 masks for health care providers managing the care of patients infected with SARS-CoV-2 or persons under investigation (PUI) for COVID-19.

The global shortage of PPE in the setting of a viral pandemic has created potentially dangerous conditions for frontline healthcare workers lacking appropriate protection and their patients.

My hospital only provides N95 masks for PUI and COVID-19 positive patients. What is the chance that an asymptomatic person who has a negative COVID-19 history screening carries the SARS-CoV-2 virus? **Based on that chance, is wearing an N95 mask for all patients undergoing endotracheal intubation warranted?**

In COVID-19, "50-75% of 3000 positive cases in Vo, Italy were asymptomatic according to Professor Sergio Romagnani. Risk of exposure grows exponentially as noted through actual exposures (charted internationally) N95 masks are warranted and remain the standard of care. While CDC has relaxed standards of care, their evidence cites risks of self-inoculation, cross contamination and pathogen spreading through direct and indirect transmission.

CDC recommends Standard Precautions should be followed when caring for any patient, regardless of suspected or confirmed COVID-19. Doctors without borders report COVID-19 infected healthcare workers surge to 8% in Italy with 1700 healthcare workers infected and recent report suggest this is climbing to 8.3% where PPE shortages are widespread.

My hospital ran out of N95 and surgical masks. We want to make our own face masks from supplies we can purchase at local stores. **What appropriate replacement materials are suitable for face masks when no PPE is available?**

UNKNOWN: Nurses and other health care providers can "*use homemade masks (e.g., bandana, scarf) for care of patients with COVID-19*," according to CDC but in the next sentence admits protection capability is unknown. Alternatives are being fashioned from existing materials. Comparison study and graph where authors measured homemade mask ability to filter virus size particles.

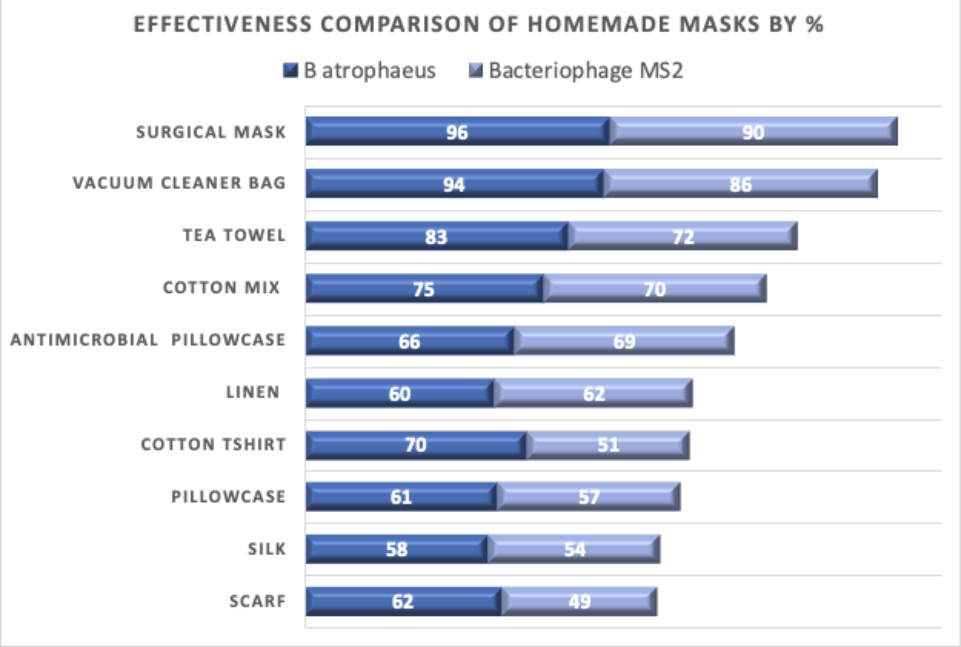

Table 1: **The mask effectiveness is offset by difficulty to breathe through the filter, vacuum bags were rated highly but the effort to breathe made it less secure.*

***Using inner filters such as feminine hygiene products for N95 masks is not recommended as N95 mask once contaminated retain 99.8% of pathogens*

****Other materials such as teabags which are antimicrobial might be used or layered with other materials*

Links to consider if you have to make a mask

- https://www.consumer.org.hk/ws_en/news/specials/2020/mask-diy-tips.html
- https://time.com/5805557/homemade-medical-face-mask-shortage/
- https://maidsailors.com/blog/how-to-make-a-surgical-mask/

Can N95 masks be reused multiple times and remain effective barrier protection for SARS-CoV-2?

Although this process is used according to CDC when there are PPE shortages it is not safe and there is no high-level evidence to indicate this is safe. We could find no reassuring statistics released by the CDV or others during other pandemics to show this is practice is safe and the barrier protection is shown to deteriorate with use and time.

Can N95 masks be autoclaved or sterilized by other means for safe reuse?

To be useful a decontamination method must eliminate the viral threat, be harmless to end-users, and retain respirator integrity.

N95 Mask UPDATE

4C Air confirmed all the proposed treatments have killed corona viruses. Labs have no way to test COVID-19 directly and as an accepted protocol, E. Coli is used for testing. We asked what methods can be used to decontaminate the facial mask for reuse safely and without loss to filtration efficiency. 4C Air confirms using 70 degree C hot air in an oven (typical kitchen-type of oven will do) for 30min, or hot water vapor are additional effective decontamination methods. Please see Table 2

Can Facial Masks be Disinfected for Re-use?

(Measurement results by 4C Air Inc.)

Samples	Meltblown fiber filtration media		Static-charged cotton		E. Coli. Disinfection Efficiency
	Filtration efficiency (%)	Pressure drop (Pa)	Filtration efficiency (%)	Pressure drop (Pa)	
70°C hot air in oven, 30min	96.60	8.00	70.16	4.67	>99%
UV light, 30min	95.50	7.00	77.72	6.00	>99%
75% alcohol, soaking and drying	56.33	7.67	29.24	5.33	>99%
Chlorine-based disinfection, 5min	73.11	9.00	57.33	7.00	>99%
Hot water vapor from boiling water, 10min	94.74	8.00	77.65	7.00	>99%
Initial samples before treatment	96.76	8.33	78.01	5.33	

Conclusions: DO NOT use alcohol and chlorine-based disinfection methods. These will remove the static charge in the microfibers in N95 facial masks, reducing filtration efficiency. In addition, chlorine also retains gas after de-contamination and these fumes may be harmful.

Table 2: Data supplied courtesy of Professor Yi Cui | Materials Science and Engineering, Stanford University and Professor Steven Chu | Physics and Molecular & Cellular Physiology, Stanford University on behalf of 4C Air Incorporated.

Viscusi and colleagues evaluated five decontamination methods for nine models of NIOSH-certified respirators (three models each of N95 FFRs, surgical N95 respirators, and P100 FFRs) N95 masks. They tested filtration performance and filter airflow resistance but not the viral threat.

The five methods for decontamination were bleach, ethylene oxide (EtO), microwave oven irradiation, ultraviolet germicidal irradiation (UVGI), and hydrogen peroxide (vaporized and liquid forms).

Filter aerosol penetration values were maintained for the five methods (less than the National Institute for Occupational Safety and Health (NIOSH) certification criteria). Authors found decontamination using an autoclave, 160C dry heat, 70% isopropyl alcohol, and soap and water (20-min soak) caused significant degradation to filtration efficiency. Airflow resistance remained constant except in the case of the masks melted by the microwave which obviously could not be tested. Lindsley et al, 2015 report material strength of N95s can degrade with UVGI.

In summary bleach and microwaves were failures at point of care because the bleach gases (skin and respiratory irritants) remained after multiple strategies were used to remove them, the microwave melted the masks and soaking them first led to reduced filtration. EtO, UVGI, and hydrogen peroxide decontamination were safe and effective in the models tested but it is not known if they would retain filtration, material strength, and airflow integrity with repeated use. EtO, UVGI, and hydrogen peroxide limitations include time from decontamination to reuse and available space and materials to decontaminate in an OR setting. **70C /158F heating in a kitchen-type of oven for 30min, or hot water vapor from boiling water for 10 min, are additional effective decontamination methods.**

Can electrolyzed water kill SARS-CoV-2 and be used to treat PPE for reuse

Electrolysed water EOW, ECA is produced by the electrolysis of water containing dissolved sodium chloride (salt). This electrolysis produces a slightly corrosive solution of hypochlorous acid and sodium hydroxide. The resulting water can be used as a disinfectant. It can kill some viruses in 5 seconds if used immediately and within 5 minutes if used within 48 hours of production. One challenge is that it weakens when it is in contact with proteins such as body fluids, like blood, mucous, stool or vomit. The other challenge is that at least one manufacturer will void the warranty if electrolysed water is used on their equipment due to corrosive activity. Electrolyzed water loses its potency over time (> 48 hours) and needs frequent monitoring to maintain correct potency. [Source Unimoto and Colleagues].

For testing, the balance between strength of the solution, corrosion and neutralization through contact with bodily fluids such as those found on soiled PPE equipment would need to be tested. There are patents in place and Vietnam private industry is apparently using this method we could find no evidence of evidence based testing with COVID-19.

My hospital has a severe shortage of N95 masks. We are being asked to reuse the masks for multiple patients and for an entire day. **What are the potential harms of reusing N95 masks when deployed for use as barrier protection against SARS-CoV-2?**

Extended use and reuse of respirators might conserve limited supplies of disposable N95 respirators but at what cost?

CONTACT TRANSMISSION through direct contact with others as well as through indirect contact by touching and contaminating surfaces that are then touched by other people. Inadvertent **SECONDARY EXPOSURES** can also occur if any user is infectious (symptomatic or asymptomatic) This happens most often through touching the surface of the contaminated respirator. For example, one study found nurses average 25 touches per shift to face, eyes or respirator during extended use causing **SELF-INOCULATION**. ~99.8% Respiratory pathogens remain trapped for extended periods on contaminated respirators. **CROSS CONTAMINATION** can occur via co-infected patients who harbor common pathogens (e.g., methicillin-resistant Staphylococcus aureas, vancomycin-resistant enterococci, Clostridium difficile, norovirus, etc.).

Other risks include breakdown of **RESPIRATOR FIT**, **PROTECTIVE MATERIALS/FILTER** and increased risk of transmission through **TRAPPED PATHOGENS** or touch each time the mask is put on or removed. Continuous use of the mask can lead to **SKIN IRRITATION** and breakdown thus increasing vulnerability and pathogen transmission. In addition, when masks must be reused health care providers may neglect **HYDRATION** as time may not be available between patients for the additional precautions needed to remove and then re-wear the respirator. [Source NIOSH Pandemic planning]

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DISCLAIMER: the article has not been peer-reviewed; it should not replace individual clinical judgement and the sources cited should be checked. The views expressed in this commentary represent the views of the authors and not necessarily those of the Stanford University School of Medicine. The views are not a substitute for professional medical advice.

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COMPETING INTERESTS
AP and LC have no competing interests to declare

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