COVID-19
Rapid Review

Friday, 10 April 2020

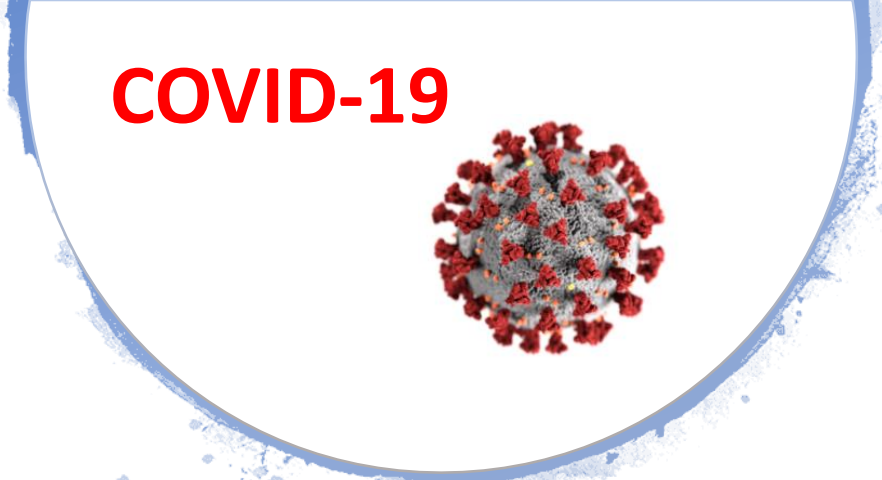
Review 3

The purpose of this regular review is to present COVID-19 related questions in Emergency Medicine

We accept that available literature on this topic in emergency medicine may be scarce and shared discussions of novel front line strategies may be a tool to augment our clinical practice and develop future policy

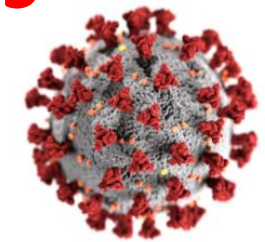
Topic:

Evidence for N95 extended use, re-use and decontamination



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COVID-19



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N95

EXTENDED USE, REUSE AND DECON SERIES

Personal protective equipment (PPE) shortages during the COVID-19 pandemic have led to discussions around reusing N95 respirators

Based on manufacturer recommendations, N95 respirators are designed for one-time use. Internal testing of various sterilising strategies has been performed by 3M, a major N95 respirator manufacturer and concluded that the company cannot endorse this practice.

The question remains whether it is acceptable, in times of austerity, to consider N95 respirator **extended use, reuse or decontamination strategies** based on individual clinical judgment and the institutional resources available.

Extended use = Contingency Strategy

Re-use = Crisis Strategy

Reprocessing/Decontamination = Crisis Strategy

It is essential that N95 respirator and surgical respirator usage be used in conjunction with a combination of IPC measures as laid out in the Western Cape Provincial PPE policy and it's use in isolation is futile.

We acknowledge that recommendations for N95 respirator usage must consider protection against additional airborne infectious agents other than SARS-COV-2. In South Africa, the TB burden of disease is significant and the reality, in clinical practice, is that N95 respirator may be worn more frequently than what has been recommended by the global and local scientific community as it relates to the COVID-19 PPE guidance

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Extended use = Contingency Strategy

The CDC reports that prolonged N95 respirator use can be safe for up to 8 hours and encourages each user to review each manufacturer's recommendations prior to following this strategy.

Re-use = Crisis Strategy

The number of times a respirator can safely be re-used depends on multiple factors

- whether the user was exposed to aerosolizing procedures
- how the respirator was stored
- whether the respirator was soiled

Assuming there is no soiling and minimal to no viral contamination to the outside of the respirator, the CDC suggests that respirators can be hung to dry or stored in a breathable container in between uses. This is based on evidence that coronaviruses lose their viability significantly after 72 hours. When planning to reuse a N95 respirator, removal should be done strictly avoiding contamination of the inside of the respirator during placement or removal (see below methods for donning and doffing).

Reprocessing/Decontamination = Crisis Strategy

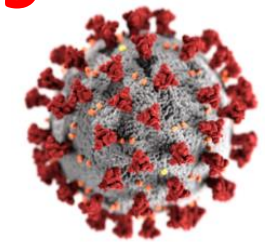
General principles of re-processing include:
The method must sufficiently inactivate the viral load on the respirator.
The respirator cannot be soiled (bodily fluids, makeup).
The filtration capacity and ionic charge must be preserved as much as possible.
The fit of the respirator cannot be compromised.

Decontamination methods that are currently generating discussion and interest are: **heat**,

ultraviolet C (UV-C) and

hydrogen peroxide vapor (HPV) treatments

COVID-19



N95

EXTENDED USE, REUSE AND DECON SERIES

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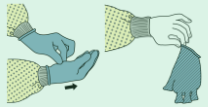
Extended use



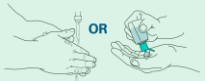
Prolong lifespan by using cleanable/disposable clear full face shield



Limit hand contact with respirator and only adjust with clean gloves



Remove gloves and discard



Perform hand hygiene



Donn clean gloves

DISCARD



If contact with any biohazardous fluid or solid particles



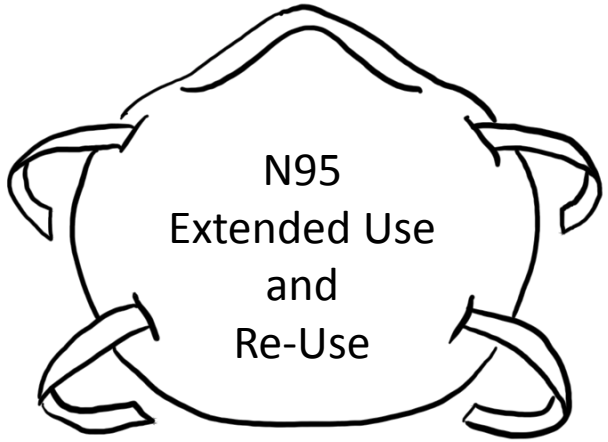
After any aerosol generating procedure including suctioning and intubation



After direct contact with a patient on contact precautions



Any visible tears or breaks in the respirator material



RISKS



Some respirators are strictly "single use only"



Most significant risk is from contact with contamination respirator surface



Contamination with other pathogens with prolonged environmental survival e.g. MRSA



Limited filter lifespan related to use conditions

Re-use (MAX 5)

DOFFING



Doff limited contact with front of respirator



Place into sealable paper bag, or breathable plastic container



Label bag

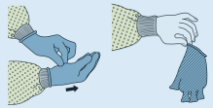


Perform hand hygiene

DONNING



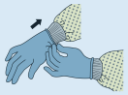
Remove from bag and apply respirator with gloves on. Adjust fit



Remove gloves and discard



Perform hand hygiene



Donn clean gloves

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Best practice is to use new N95s. Decontamination does not solve the PPE shortage crisis, and is an emergency practice to be considered during the COVID-19 pandemic. Efficacy and safety of N95 decontamination has not been fully characterized.

COVID N95 DECON & REUSE

HYDROGEN PEROXIDE VAPOR & HYDROGEN PEROXIDE GAS PLASMA

CORONAVIRUS INACTIVATION

Data not available for COVID-19 on N95s

\+ • Hydrogen peroxide inactivates viruses and highly-resistant bacterial spores[1,2]

N95 MASK INTEGRITY

\+ • HPV for up to 20 cycles does not degrade filter quality, straps, or fit for 3M 1860 N95s[2,3]

\+ • Low dose HPGP for 2 cycles does not degrade fit for 3M 8822 N95s[4]

— • High dose HPGP reduces filtration of 3M 1860 & KC PFR95 N95s[5]

KEY CONSIDERATIONS

Data from specific N95 models may not apply to other models

Trained personnel required - HPV and HPGP systems are dangerous

N95s should be isolated and returned to original user

N95 user seal check should be performed before each reuse

Correct machine settings must be confirmed

RISKS

Insufficient off-gas time and residue may pose a respiratory and skin hazard

Some HPGP protocols reduce filtration efficiency

Insufficient dosing may lead to insufficient decontamination

Hydrogen peroxide is a powerful oxidizer and presents a combustion and explosion risk

IMPLEMENTATION

Note: "VHP" and "HPV" are sometimes used interchangeably but can also refer to different techniques.

\+ • CDC released guidance on HPV for decontaminating N95s[6]

\+ • HPV systems have recently received FDA authorization[7]

\+ • Processing procedures for HPV have been developed[8]

\+ • HPGP systems are under review by the FDA[9]

— • Systems and processes are complex and dangerous and require trained personnel

CONCLUSION

If implemented properly, and N95s are not soiled, it is likely that both HPV and HPGP machine-standard protocols inactivate SARS-CoV-2 and bacterial spores. HPGP and HPV are distinct processes; decontamination durations and maximum recommended reuse cycle recommendations are extremely different.

SUPPORTING RESEARCH [1] Heckert et al., 1997; [2] Battelle, 2016; [3] Schwartz 2020; [4] Dutch National Institute for Public Health and the Environment, 2020; [5] Bergman, 2010; [6] CDC, 2020; [7] Battelle, 2020; [8] Personal Communication, J. Yarwood, ASP

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COVID N95 DECON & REUSE

HEAT & HUMIDITY

CORONAVIRUS INACTIVATION

Data not available for COVID-19 on N95s

\+ • 60°C-75°C for 30min inactivates related coronaviruses in solution[1-5]

\+ • 70°C at 85% humidity for 30min inactivates H1N1 and H5N1 flu (non-coronavirus) on N95[6,7]

— • Method does NOT inactivate all bacterial or mold spores on N95

? • No data on heat inactivation of coronaviruses on N95s

N95 MASK INTEGRITY

\+ • N95 keeps filter performance at 5 cycles of 60°C heat, 80% humidity[8]

\+ • N95 shown to keep proper seal after 1 cycle at 65°C, 85% humidity[8]

— • Repeated thermal cycles may damage N95 fit and filtration[8,9]

? • Different N95 makes and models may respond differently to heat[8]

KEY CONSIDERATIONS

Data from tests on specific N95 models may not apply to other models

N95s should be isolated and returned to original user

N95 user seal check should be performed before each reuse

Temperature should be stable and uniform

RISKS

Untested protocol - virus may survive if temperature, humidity, or duration is too low

N95 fit and filtration may be damaged if the temperature is too high or after multiple cycles

N95 will NOT be sterilized by low heat and humidity

IMPLEMENTATION

\+ • CDC has released guidance on heat and humidity for decontaminating N95s[10]

\+ • Many devices can maintain 65-80°C, 50-85% humidity (warming cabinets, water baths, autoclaves, ovens)

? • Method has not been validated in an FDA-approved process

CONCLUSION

Heat and humidity for N95 decontamination is currently unproven for inactivation of SARS-CoV-2. Its use should be evaluated by relevant authorities. This is a low-cost technique that could be easy to implement in a wide range of settings. However, excessive thermal cycling may damage N95 fit and filtration. Moreover, this approach will NOT protect against all bacterial and mold co-infection risks. If risks are mitigated, this protocol merits future FDA feasibility studies.

SUPPORTING RESEARCH [1] Darnell et al., 2006; [2] Darnell & Taylor, 2004; [3] Rabenau et al., 2005; [4] Duan et al., 2003; [5] Pagat et al., 2007; [6] Heimbuch et al., 2011; [7] Lore et al. 2012; [8] 3M, 2020; [9] Viscusi et al., 2008; [10] CDC, 2020

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COVID N95 DECON & REUSE

UV-C

Use appropriate UV-C source

Use sensor to validate 1 J/cm^2 dose

Expose both sides of N95 mask

CORONAVIRUS INACTIVATION

Data not available for COVID-19

\+ • ≥1 J/cm^2 of UV-C inactivates viruses similar to SARS-CoV-2 on N95s[1,2,3]

\+ • ≥1J/cm^2 of UV-C kills *Bacillus subtilis* spores on N95s[4]

— • UV-C light may not reach inner N95 layers for all N95 models[5]

— • Straps may not be fully decontaminated by UV-C alone[1]

— • Shadowing blocks UV-C rays & can leave parts of N95 contaminated

N95 MASK INTEGRITY

\+ • N95 keeps fit and filter performance after 10-20 cycles of 1-1.2 J/cm^2 UV-C[2]

— • Some damage to N95 seen at high UV-C doses (≥120 J/cm^2)[6]

— • Strap and facepiece damage seen on some N95 models after UV-C[7]

KEY CONSIDERATIONS

Ensure accurate UV-C dose on front and back of N95

Measure dose at N95 surface with calibrated sensor

Keep N95s separate and return to original users

Perform user seal check before each reuse

Be aware that data from tests on specific N95 models may not apply to other models

RISKS

Residual contamination may remain on N95 straps and may need to be separately wiped with disinfectant

Consumer UV products are not recommended for N95 decontamination

If UV-C source is underpowered, decontamination timescales may be infeasible

UV-C may not decontaminate N95 straps or eliminate risk of bacterial co-infection

Makeup and sunscreen on N95 may reduce decontamination efficacy

IMPLEMENTATION

\+ • Reference documents from University of Nebraska Medical Center[8] for implementation

? • Validate each UV-C source and protocol with a UV-C sensor to ensure adequate dose for decontamination at the N95 surface

CONCLUSION

If implemented properly using sensors to ensure ≥1J/cm^2 UV-C dose to the N95, this method likely inactivates SARS-CoV-2; however, this has not yet been confirmed directly with SARS-CoV-2. This method may protect against some bacterial co-infection risks but not all.

SUPPORTING RESEARCH [1] Mills et al., 2018; [2] Heimbuch & Harnish, 2019; [3] Lore et al., 2012; [4] Lin et al., 2018; [5] Fisher and Shaffer, 2010; [6] Lindsley et al., 2015; [7] Personal Safety Division, 3M, 2020; [8] Lowe et al., 2020

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TAP/CLICK ON THE INDIVIDUAL IMAGE TO DOWNLOAD PDF

N95 Decontamination	COVID Activity	Respirator Integrity	Risks	Key points
Hydrogen Peroxide Vapour	HPV **inactivates** viruses and some highly-resistant bacterial spores on N95	No fit, strap, or fit degradation after **20 cycles** (3M)	Skin and respiratory hazard of **low off-gas time** **Combustion and explosion** risk **Insufficient dose** can be ineffective	Data may not be transferable to all N95 brands Requires **training** and machine **calibration** Some **FDA approved** HPV systems Systems are **complex** and potentially **dangerous** N95 should be returned to original user
Humidity and Heat	**60C – 75C for 30min** inactivates coronaviruses in solution **70C at 85% humidity for 30min** inactivates H1N1 and H5N1 Does not inactivate all bacterial or mold spores	Filter performance preserved for **5 cycles** at 60C, 80% humidity Seal maintained after 1 cycle Different respirators may react to heat differently	Protocol not validated Virus may survive if temp, humidity, duration **not optimal** Filter may be damaged if thermal **energy too high**	Data may not be transferable to all N95 brands Temperature should be **stable and uniform** Systems are **complex** and potentially **dangerous** N95 should be returned to original user
Ultraviolet C	>1 J/cm2 of UVC • inactivates similar viruses to SARS-CoV-2 on N95 • kills Bacillis subtilis spores on N95 May not reach inner layers of respirator Shadowing blocks UVC rays and can leave some areas contaminated	Filter performance maintained >10-20 cycles Damage noted at high doses (>120J/cm2) Some damage may be noted on facepiece / straps on some models	Straps may not be fully decontaminated Consumer UV products not recommended Risk of underpowered UV-C May not eliminate risk of bacterial co-infection	Data may not be transferable to all N95 brands Dose on front and back Measure dose with sensor N95 should be returned to original user

RESOURCES (CLICK ON ICON TO OPEN)

N95DECON

3M Science. Applied to Life.™
Technical Bulletin

CDC
Strategies for Optimizing the Supply of N95 Respirators
Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

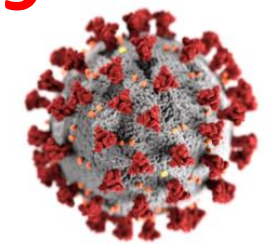
CDC
Decontamination and Reuse of Filtering Facepiece Respirators
Centers for Disease Control and Prevention
CDC 24/7: Saving Lives, Protecting People™

Stanford MEDICINE | Anesthesia Informatics and Media Lab

learnly

COVID-19 Evidence Service | **Addressing COVID-19 Face Mask Shortages [v1.1]**
Updated March 22, 2020

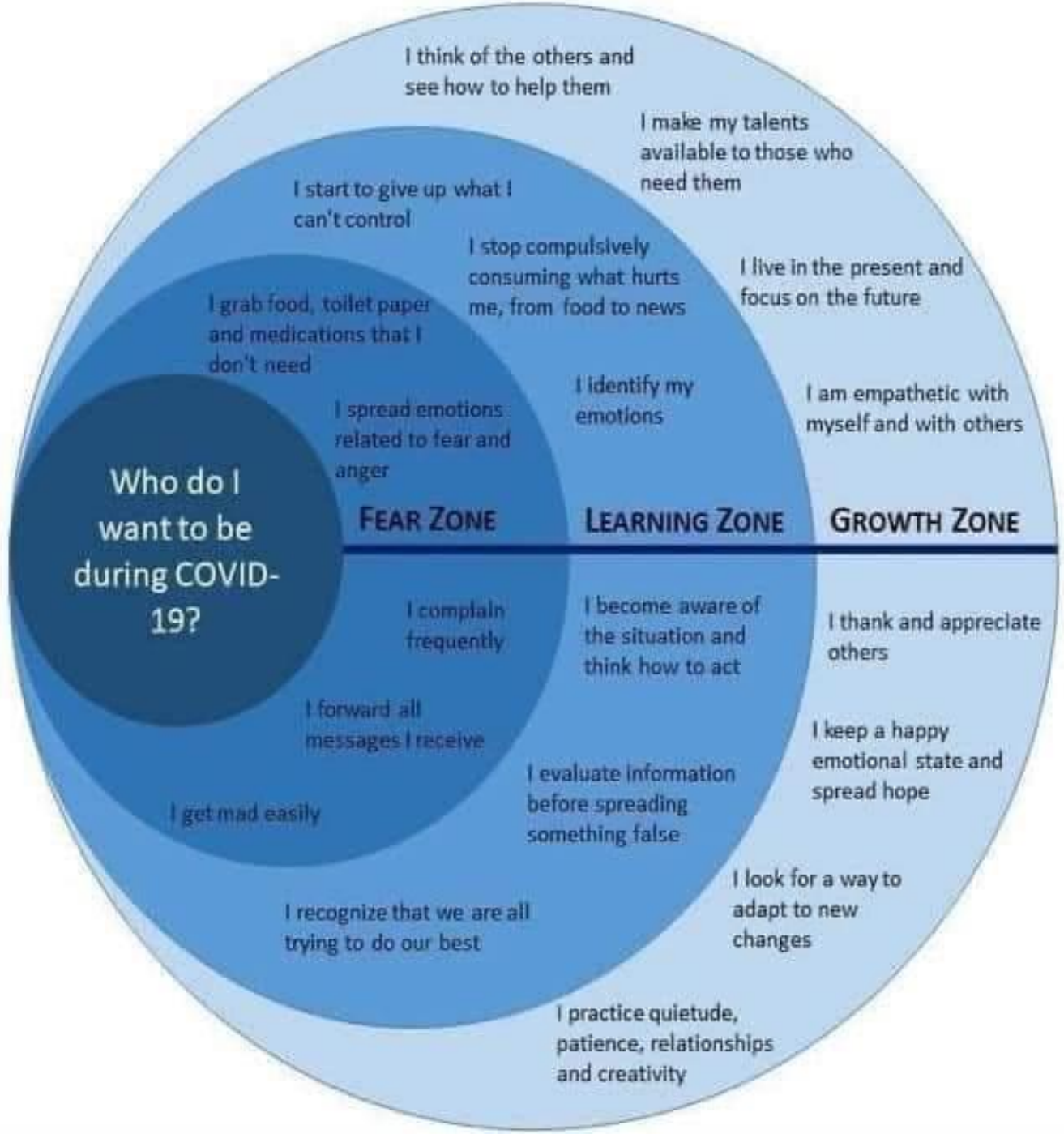
COVID-19



N95

EXTENDED USE, REUSE AND DECON SERIES

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I think of the others and see how to help them
I make my talents available to those who need them
I start to give up what I can't control
I stop compulsively consuming what hurts me, from food to news
I live in the present and focus on the future
I grab food, toilet paper and medications that I don't need
I identify my emotions
I am empathetic with myself and with others
I spread emotions related to fear and anger
Who do I want to be during COVID-19?
FEAR ZONE
LEARNING ZONE
GROWTH ZONE
I complain frequently
I become aware of the situation and think how to act
I thank and appreciate others
I forward all messages I receive
I keep a happy emotional state and spread hope
I evaluate information before spreading something false
I get mad easily
I look for a way to adapt to new changes
I recognize that we are all trying to do our best
I practice quietude, patience, relationships and creativity