N95 Decontamination & Reuse Webinar

Expanding PPE for the frontline
WEBINAR ETIQUETTE

❖ Foundation of love and respect
  - Respond kindly rather than react if you disagree
❖ It is everybody’s responsibility to keep ECHO a safe space
❖ Test your equipment ahead of time
❖ Introduce yourself before speaking
❖ Body signals can be distracting
❖ Avoid making noise (i.e. potato chips, shuffling papers, whispering, cell phones, loud bags, etc.)
❖ For questions during Q&A session use the “raise hand” function
WEBINAR ETIQUETTE

❖ Mute microphone when not speaking
  - Left bottom corner of your screen
❖ Remember to unmute before speaking
❖ Position webcam effectively to show your face if alone or to capture the whole group
❖ Have a light source from the front (Avoid being backlit)
❖ Test both audio and video
❖ Speak close to microphone
❖ IT issues? Send a message through chat/email.
N95DECON Consortium

- 105 scientists from 10 different institutions;
  - Unbiased, interdisciplinary, & no financial conflicts
  - PhDs, MDs, RNs, students
  - Evaluate existing literature on N95 decontamination methods

- Publish Technical Reports and Fact Sheets
- Coordinate and execute research

Method agnostic - We understand there is no single best solution

Independent - Entirely volunteer-based, not backed by any financial interest

Science-based - All information in our publications is subjected to rigorous review and debate

Learn more: https://N95DECON.org
What you will learn today -
Evidence and Implementation

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<th>CONSIDERATIONS</th>
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<td>● PPE for COVID-19</td>
<td>● UV-C</td>
<td>● Filtration Efficiency</td>
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<td>● What is an N95?</td>
<td>● Heat</td>
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<td>● Hazards</td>
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<td></td>
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Disclaimers: Data and experience pertains to NIOSH-certified N95 respirators only (NIOSH: The U.S. National Institute for Occupational Safety and Health). There may be variation between different mask manufacturers and models.
How can you protect yourself against COVID-19?

Dr. Ashley Styczynski MD, MPH
Infectious Disease Fellow, Fogarty Global Health Scholar
Stanford University
PPE is the last line of defense.

Most effective

Elimination
- Physically remove the hazard

Substitution
- Replace the hazard

Engineering controls
- Isolate people from the hazard

Administrative controls
- Change the way people work

Least effective

PPE
- Protect the worker with personal protective equipment
PPE depends on transmission.

- SARS-CoV2
- Symptomatic or asymptomatic individuals
- Nasal/oral secretions (coughing, sneezing, singing, talking)

- Infectious Agent
- Reservoir
- Portal of Entry
- Mode of Transmission

- Anyone
- Mucous membranes, respiratory tract

- Droplet
- Contact
- Aerosol
PPE depends on transmission.

<table>
<thead>
<tr>
<th>Potential route of exposure</th>
<th>Entry to cohort area, no patient contact</th>
<th>Direct contact with COVID patients</th>
<th>Aerosol-generating procedures</th>
<th>Cleaning COVID-affected areas</th>
<th>Lab technician</th>
<th>Visitors of COVID patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical mask</td>
<td>![Surgical mask] Droplet ✓</td>
<td>![Droplet] Droplet, contact ✓</td>
<td>![Aerosol, droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
</tr>
<tr>
<td>Gloves</td>
<td>![Gloves] Droplet ✓</td>
<td>![Droplet] Droplet, contact ✓</td>
<td>![Aerosol, droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
</tr>
<tr>
<td>Gown</td>
<td>![Gown] Droplet ✓</td>
<td>![Droplet] Droplet, contact ✓</td>
<td>![Aerosol, droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
</tr>
<tr>
<td>Eye/face protection</td>
<td>![Eye/face protection] Droplet ✓</td>
<td>![Droplet] Droplet, contact ✓</td>
<td>![Aerosol, droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
</tr>
<tr>
<td>N95/FFP2</td>
<td>![N95/FFP2] Droplet ✓</td>
<td>![Droplet] Droplet, contact ✓</td>
<td>![Aerosol, droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
<td>![Droplet, contact] Droplet, contact ✓</td>
</tr>
</tbody>
</table>
What is the evidence for PPE?

### Interventions to reduce spread of respiratory viruses

<table>
<thead>
<tr>
<th>Intervention</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent hand washing*</td>
<td>0.54</td>
<td>0.44-0.67</td>
</tr>
<tr>
<td>Wearing mask*</td>
<td>0.32</td>
<td>0.26-0.39</td>
</tr>
<tr>
<td>Wearing N95 mask</td>
<td>0.17</td>
<td>0.07-0.43</td>
</tr>
<tr>
<td>Wearing gloves</td>
<td>0.32</td>
<td>0.23-0.45</td>
</tr>
<tr>
<td>Wearing gowns</td>
<td>0.33</td>
<td>0.24-0.45</td>
</tr>
<tr>
<td>Eye protection</td>
<td>0.1</td>
<td>0.05-0.17</td>
</tr>
<tr>
<td>Nose wash</td>
<td>0.3</td>
<td>0.16-0.57</td>
</tr>
</tbody>
</table>

More PPE does not mean more protection.

- Head coverings and shoe covers are not required for routine patient care
- Risk during doffing
Follow safe doffing practices.

1. Gloves
2. Face protection
3. Gown
4. Mask
5. Hand washing

Avoid touching the outside of the PPE!
What if I have limited PPE?

1. Extended use
1. Decontamination and reuse
1. Substitution
What if I have limited PPE?

Hand hygiene
Wash with soap and water or alcohol based hand rub

20–30 seconds
15–20 seconds

Risk factors for COVID-19 in healthcare workers

Suboptimal handwashing
RR 3.1 (1.4-6.7)

Improper PPE use
RR 2.8 (1.1-7.2)
What if I have limited PPE?

**Filtration efficiency of various materials by particle size**

- **N95 fitted**
  - >300 nm: 99.9%
  - <300 nm: 85.0%

- **N95 with gap**
  - >300 nm: 12.0%
  - <300 nm: 34.0%

- **Surgical mask**
  - >300 nm: 99.6%
  - <300 nm: 76.0%

- **Surgical mask with gap**
  - >300 nm: 44.0%
  - <300 nm: 50.0%

- **Cotton 600 TPI (1 layer)**
  - >300 nm: 79.0%
  - <300 nm: 82.0%

- **Cotton 600 TPI (2 layers)**
  - >300 nm: 98.4%
  - <300 nm: 99.5%

- **Cotton 80 TPI (t-shirt)**
  - >300 nm: 14.0%
  - <300 nm: 9.0%

- **Chiffon**
  - >300 nm: 73.0%
  - <300 nm: 67.0%

- **Flannel**
  - >300 nm: 44.0%
  - <300 nm: 57.0%

- **Silk**
  - >300 nm: 56.0%
  - <300 nm: 54.0%

- **Cotton 600 TPI/flannel**
  - >300 nm: 96.0%
  - <300 nm: 95.0%

- **Cotton/silk (2 layers)**
  - >300 nm: 98.5%
  - <300 nm: 94.0%

- **Cotton/chiffon (2 layers)**
  - >300 nm: 99.2%
  - <300 nm: 97.0%

---

**Mask**

- **N95/FFP2**
  - Extended use: 6 hours
  - Decontamination and reuse: Up next
  - Substitution: Surgical

- **Surgical**
  - Extended use: 6 hours
  - Decontamination and reuse: *Limited reuse
  - Substitution: Surgical

- **Cloth**
  - Extended use: 6 hours
  - Decontamination and reuse: *Limited reuse
  - Substitution: Cloth

Source: Konda A, et al. ACS Nano, April 2020
What if I have limited PPE?

- **Hand hygiene**
- **Mask**
- **Gloves**

**Extended use and decontamination:**
- Use alcohol hand rub up to 30 times

**Substitution:**
- Extended hand washing

*Use alcohol hand rub up to 30 times*
What if I have limited PPE?

Extended use: No limit
Decontamination: 70% alcohol, 0.5% chlorine
Substitution: Make your own face shield

Benefits of face shields:
- 76-97% reduction in contamination of masks
- 68-96% reduction in aerosol exposure
- 3-fold lower risk of SARS with face shield
- Reduced touching of face
- Can be locally produced
What if I have limited PPE?

**Gown**
- Extended use: Unless soiled
- Decontamination: Routine laundering
- Substitution: Lab coats, aprons

**Hand hygiene**

**Face Shield or Goggles**

**Mask**

**Gloves**
COVID-19 Protection
What type of PPE do I need?

Don't
Don't share masks, gowns, or gloves.
Don't
Don't touch outside of PPE if adjustments are needed; immediately perform hand hygiene.

Do
Remove and discard PPE if soiled, damaged, or hard to breath through.
Do
Use the highest appropriate PPE protection available to you.

Face Shield or Goggles
Use
For patient care and cleaning in COVID-19 wards.

Decontamination & reuse
Wearing a face shield with a mask increases respiratory protection and reduces external contamination of the mask.

Washing a face shield with a mask increases respiratory protection and reduces external contamination of the mask.

What if I don't have a face shield?
Face shields can be made out of common plastic materials such as soda bottles. Ensure the shield covers eyes, nose, and mouth and extends from ear to ear.

Hand Hygiene
Effective hand hygiene can prevent transmission even when gloves are not available.
Perform hand hygiene:
• before touching a patient
• before clean/aseptic procedures
• after body fluid exposure risk
• after touching a patient
• after touching patient surroundings
• before eating
• after using the bathroom

When gloves are worn, perform hand hygiene before and after glove use.

Wash with soap and water or alcohol-based hand rub
20–30 seconds
15–30 seconds

Mask
N95/FFP2
Use
For aerosol-generating procedures (intubation, CPR, collection of nasal or oral swabs, high-flow oxygenation invasive ventilation)

Reuse
Can be worn up to 6 hours and reused following decontamination if face seal is maintained and no obvious damage or difficulty breathing through mask. Perform hand hygiene after removal.

Surgical
Use
For patient care and cleaning in COVID-19 wards.

Reuse
Can be worn up to 6 hours and used to prevent droplet spray. Perform hand hygiene after removal.

Can I use a cloth mask?
For patient care only when surgical mask is not available. Use with face shield if possible. Also can be worn by patients and caregivers to reduce transmission. Wash or at least daily wash with soap and water. Dry before reusing.

Gown
Use
For patient care and cleaning in COVID-19 wards.

Decontamination & reuse
Remove gown when leaving patient care area. Launder reusable gowns when soiled and at least daily.

If gowns are not available, what else can I use?
• Laboratory coats
• Disposable aprons
• Layered clothing, preferably with long sleeves and closures that can be fastened

Gloves
Use
For patient care and cleaning in COVID-19 wards. Remove or decontaminate gloves before touching non-contaminated items (e.g., phones) and between patients. Perform hand hygiene immediately after removal.

Can I use hand sanitizer on my gloves?
If using foam or gel gloves, hand sanitizer can be used up to 30 times to decontaminate gloves if not visibly soiled or damaged.

Where can I get more information?
https://www.who.int/covid19/
Pause for Discussion

1. Are there other PPE shortages that have been challenging in your facility?

2. Any questions regarding the PPE needed for different types of patient care?
What is an N95 Respirator?

Kezi Cheng, PhD Student
NSF Materials Science Fellow
Harvard University
Types of Masks and Respirators (U.S.)

- **Medical Masks**
  - (Cloth masks, molded medical masks)

- **Filtering Facepiece Respirator (FFR)**
  - (N95 and others: N99, N100, R95, P95, P100,)

- **Elastomeric Respirator**

- **Powered Air Purifying Respirator (PAPR)**
  - (SCBA, Supplied-air respirators)
International standards similar to N95

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<thead>
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<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Filter performance – (must be ≥ X% efficient)</td>
<td>≥ 95%</td>
<td>≥ 94%</td>
<td>≥ 95%</td>
<td>≥ 94%</td>
<td>≥ 94%</td>
<td>≥ 95%</td>
</tr>
<tr>
<td>Test agent</td>
<td>NaCl</td>
<td>NaCl and paraffin oil</td>
<td>NaCl</td>
<td>NaCl</td>
<td>NaCl and paraffin oil</td>
<td>NaCl</td>
</tr>
<tr>
<td>Flow rate</td>
<td>85 L/min</td>
<td>95 L/min</td>
<td>85 L/min</td>
<td>95 L/min</td>
<td>95 L/min</td>
<td>85 L/min</td>
</tr>
<tr>
<td>Total inward leakage (TIL)* – tested on human subjects each performing exercises</td>
<td>N/A</td>
<td>≤ 8% leakage (arithmetic mean)</td>
<td>≤ 8% leakage (arithmetic mean)</td>
<td>≤ 8% leakage (individual and arithmetic mean)</td>
<td>≤ 8% leakage (arithmetic mean)</td>
<td>Inward Leakage measured and included in User Instructions</td>
</tr>
<tr>
<td>Inhalation resistance – max pressure drop</td>
<td>≤ 343 Pa</td>
<td>≤ 70 Pa (at 30 L/min)</td>
<td>≤ 240 Pa (at 95 L/min)</td>
<td>≤ 500 Pa (clogging)</td>
<td>≤ 70 Pa (at 30 L/min)</td>
<td>≤ 240 Pa (at 95 L/min)</td>
</tr>
<tr>
<td>Flow rate</td>
<td>85 L/min</td>
<td>Varied – see above</td>
<td>85 L/min</td>
<td>Varied – see above</td>
<td>Varied – see above</td>
<td>40 L/min</td>
</tr>
<tr>
<td>Exhalation resistance - max pressure drop</td>
<td>≤ 245 Pa</td>
<td>≤ 300 Pa</td>
<td>≤ 250 Pa</td>
<td>≤ 120 Pa</td>
<td>≤ 300 Pa</td>
<td>≤ 70 Pa (w/valve)</td>
</tr>
</tbody>
</table>

USA: N95
Europe: FFP2
China: KN95
Australia: P2
Korea: Korea 1st Class
Japan: DS

https://multimedia.3m.com/mws/media/1791500O/comparison-ffp2-kn95-n95-filtering-facepiece-respirator-classes-tb.pdf
Updated FDA documents regarding N95 equivalents

1) May 7, 2020 FDA Reissue of April 3, 2020 EUA Non-NIOSH-Approved Disposable Filtering Facepiece Respirators Manufactured in China
   https://www.fda.gov/media/136664/download

2) May 7, 2020 Appendix A: Authorized Imported, Non-NIOSH Approved Respirators Manufactured in China
   https://www.fda.gov/media/136663/download

3) 03/28/20 EUA Imported, Non-NIOSH-Approved Disposable Filtering Facepiece Respirators https://www.fda.gov/media/136403/download

4) Counterfeit Respirators / Misrepresentation of NIOSH-Approval
   https://www.cdc.gov/niosh/npptl/usernotices/counterfeitResp.html
‘N95 Respirator’: What’s in a name?

● First letter:
  ○ ‘N’ = Non-oil resistant (‘R’ = Oil-Resistant, ‘P’ = Oil-Proof)

● Percent efficiency:
  ○ ‘95’ means 95% of particles filtered (tested at 0.3 μm diameter)
  ○ ‘100’ means > 99.7% filtered; ‘99’ is 99% filtered

● Type:
  ○ Respirator implies all inhaled air is filtered
  ○ ‘Mask’: implies a barrier which may not be sealed
  ○ ‘Surgical’: Provides a hydrophobic splash barrier
  ○ ‘PAPR’: Personal air purifying respirator
How does a N95 respirator work?

A N95 FFR **seals to the face** and **filters out at least 95%** of non-oil airborne particles.

Airflow

Harmful Particles
A N95 FFR seals to the face and filters out at least 95% of non-oil airborne particles.

1. SEAL TO FACE

Airflow

Harmful Particles

2. FILTER PARTICLES

Resilient shaping & support layers

Filtration Layer

Soft inner liner

Outer layer may be fluid resistant

Noseclip molds to fit nose

No airflow
An inadequate seal allows harmful particles to leak around the edge.

A poor seal could be caused by:
- Poor Fit
- Facial Hair
- Structural degradation

A tight seal to the face forces air through the filtration layer.

Users must check seal qualitatively for each use (seal check) and thoroughly once per year (fit test).

Filtration efficiency can be reduced by physical damage to the filter or a change in filter charge.

If fibers lose charge, particles can pass through to the user.

Typically non-woven, meltblown polypropylene electrets trap droplets by electrostatic charge. Pores larger than virus (breathable) still effective.

Images of filter layer:
- 80 μm

More about... Filtration

Fit

KEY FUNCTIONAL FEATURES

CAUTION!
Processes that damage filtration or fit are unsafe.
Healthcare vs. Non-Healthcare Features

Vented masks provide protection for the wearer, but **no protection for others**

- **N95 respirator for healthcare use**
- **N95 respirator with vent for industrial use (not for healthcare use)**

Vent allows **unfiltered** exhalation!
How to validate N95s in the lab

Counterfeit N95s can be identified by **quantitative testing** of filtration

Standard **NIOSH TSI 8130A** measures **filtration efficiency** (%)¹ and **pressure drop** (mm H2O)²

2. [https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4499853/](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4499853/)
Pause for Discussion

1. Is it necessary to determine particle filtration and fit post decontamination?

1. Because of the shortage of N95 respirators, now there are lots of KN95 masks, are these equivalent to N95 in terms of reuse & decontamination?

1. Is a reused fitted N95 mask, decontaminated or not, better than the use of a new one size fits all, non-fitted or poorly sealed N95?
N95 Fit & Appropriate Wear

Dr. Nichole Starr, MD, MPH
General Surgery Resident, University of California, San Francisco
Senior Fellow, Lifebox Foundation
N95 Fit Testing

- Model & size fit differently
- Required annual by OSHA (US)
- Emergency guidance March 2020
  - Only initial fit testing required
  - Annual fit testing suspended
- Uncommon in many settings

Fit testing procedure:

- Aerosol sprayed under hood
- User tastes sweet (saccharin) or bitter (bitrex) substance
- Process repeated while user wearing N95
- Position changes during test

- Fail fit test if user tastes aerosol substance
- After passing, user should wear same size/model

Proper Donning, Seal Check & Doffing of N95

1. N95 Donning
- Clean or gloved hands
- Cup mask & place over face
- Place upper strap on crown
- Place lower strap on neck
- Adjust to cover chin
- Press metal nosepiece to fit
- Perform seal check

2. N95 Seal Check
- Cup with clean or gloved hands
  - Negative Pressure Check
    - Inhale, mask seals to face without air intrusion
  - Positive Pressure Check
    - Exhale, no air escape around mask edges
    *Must cover exhalation valve

3. N95 Doffing
- Remove after exiting pt room
- Assume mask is contaminated
- Do not touch front of mask
- Remove lower strap first
- Remove upper strap
- Place in clean container
- Perform hand hygiene

https://workersafety.3m.com/importance-of-a-user-seal-check/
CDC recommends extended use/reuse due to COVID-related PPE shortage

- PPE conservation strategy also includes limiting N95 use to necessary personnel, and using alternative respirators when possible (e.g. PAPR)

Extended use: wearing same N95 respirator for extended period of time

- Patients with same pathogen or in same ward/hospital area

Reuse: using same N95 respirator for multiple patient encounters, donning and doffing N95 between encounters

- Requires storage of N95 between patient encounters
- Proper storage and donning/doffing technique important due to risk of self-contamination
- Each don/doff cycle can impair mask fit

https://www.cdc.gov/niosh/topics/hcwcontrols/recommendedguidanceextuse.html
N95 Storage for Reuse: Do’s and Don’ts

**Do:**
- Encourage staff to save and reuse N95s
- Provide labeled, vented containers for storage
  - Take-out containers
  - Plastic food storage container with holes
  - Aeration necessary
  - These become contaminated

**Don’t:**
- Save and store heavily contaminated N95 (e.g. aerosol-generating procedures)
  - These should be immediately decontaminated
- Share N95 between users without decontamination
- Allow straps to touch front of used N95
- Use sealed plastic containers without air flow
Which N95s Can be Decontaminated?

**Do Decontaminate:**
- After aerosol-generating procedures in COVID+ patients
- After predetermined use period

**Don’t Decontaminate:**
- Soiling
- Deformation
- Broken Strap
- Tearing
- Nosepiece Detachment
- Nosepiece Fracture

[https://www.n95decon.org/example-processes#instructional-handouts](https://www.n95decon.org/example-processes#instructional-handouts)
Pause for Discussion

1. How is fit testing & seal check usually done in your facility? Any questions on how to perform these steps?
2. What strategies are you currently using for extending the life of N95 masks? Do you have questions about these?
3. Do you have any questions on which masks are and are not fit for decontamination & reuse?
N95 Decontamination Principles:
Filtration, Fit, Bioburden, Residue

Tyler Chen, PhD Student
Bioengineering Knight-Hennessy Scholar
Stanford University
Filtration, Fit, Bioburden, Residue

An effective decontamination method must...

- Preserve N95 filtration (>95% of particles)
- Preserve N95 fit (tight seal to face)
- Reduce bioburden (kill viruses and other pathogens)
- Not introduce additional hazards (e.g. hazardous residue)
N95 Performance: Filtration and Fit

The number of decontamination cycles before an N95 is damaged depends on the N95 model and the decontamination method. See www.n95decon.org/publications.

Even without decontamination, some N95 models lose proper fit (seal to face) after putting on mask 5 times, others lose fit after >15 times.¹ User seal check is crucial before each reuse!

¹(Bergman et al. 2012) http://dx.doi.org/10.1016/j.ajic.2011.05.003
Bioburden Reduction - Hierarchy

**High-level Disinfection:** > 6-log kill of spores (99.9999%)

**Minimum Viral Inactivation:** > 3-log kill of SARS-CoV-2 (99.9%)

FDA: “Enforcement Policy for Face Masks and Respirators During the Coronavirus Disease (COVID-19) Public Health Emergency (Revised)”
Methods NOT to Use

**Damages N95 filtration**
- Soap
- Alcohol
- Bleach Immersion
- Gamma Radiation

**Does not inactivate virus**
- Overnight Storage Time
- UV-A/B (e.g. Nail Salon)
- Sunlight

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**Dangerous to health**
Bringing potentially biohazardous masks home is highly dangerous and has significant contamination risk. Decontamination should occur only in secured environments. Bleach residue may also be hazardous.

n95decon.org/caution
N95 Decontamination Principles

- N95 filtration efficiency
- N95 fit
  - Highly method-dependent
- Bioburden inactivation/reduction
  - At least 3-log reduction of SARS-CoV-2
  - Preferably use sterilization methods with 6-log reduction of bacterial spores
- Minimize hazardous residues
  - Inhalation/contact hazard

Decontamination methods to be discussed today:

- Vaporized hydrogen peroxide
- UV-C germicidal irradiation
- Humid heat
- Time (wait and reuse)

Hydrogen peroxide vapor (HPV) can inactivate SARS-CoV-2 as well as bacterial spores and other pathogens.

Caution: Hydrogen peroxide will react with cellulose, and should not be used with cellulose-containing N95 respirators. See N95DECON technical report on Hydrogen Peroxide for a list of compatible N95 respirators.


https://www.n95decon.org/hydrogen-peroxide

** = not peer-reviewed
## Method Summary: Hydrogen Peroxide (H$_2$O$_2$)

### Bioburden Reduction
- If properly executed, vaporized H$_2$O$_2$ may inactivate viruses and bacterial spores by >6-log.
- Biological or chemical indicator should be included for each cycle.

### N95 Performance
- N95 fit and filtration preserved for up to 20 cycles.
- H$_2$O$_2$ is not compatible with N95s containing cellulose.
- Check cycle # allowed for specific method.

### Other Concerns
- Use machine-specific methods approved for N95 decontamination.
- Ensure proper aeration time of N95 before reuse.
- 6% liquid hydrogen peroxide may be accessible, but has not been validated for aeration time or viral inactivation.

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### Implementation Criteria

- Safety-trained personnel
- Machine-specific protocols (check FDA site)
- For whole room set-up, check hospital protocols (see N95Decon.org) and checklist:
  
  [Visit NIST website for more information](https://www.nist.gov/services-resources/software/tool-evaluation-vaporized-hydrogen-peroxide-disinfection-n95-masks-small)

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See [n95decon.org/hydrogen-peroxide](http://n95decon.org/hydrogen-peroxide) for a more complete report of the evidence for and cautions of this method.
UV-C Decon Depends on Wavelength

UV-C inactivates pathogens by damaging their genomic material. (DNA, RNA: max UV absorption at 260 nm)

UV-A: not germicidal
UV-B: minimally germicidal
Germicidal
UV-C
Ozone-generating UV

254 nm UV-C lamp peak

Germicidal action
Wavelength


https://www.n95decon.org/uvc
N95DECON Method: Ultraviolet-C (UV-C)

CORONAVIRUS INACTIVATION

- ≥1.0 J/cm² of UV-C inactivates coronaviruses similar to SARS-CoV-2 on N95 FFRs¹,²,³
- ≥1.0 J/cm² of UV-C yields 2-log reduction of viable B. subtilis spores on N95 FFRs⁴
- UV-C light may not reach inner N95 layers for all N95 models⁵
- Elastic straps require additional chemical disinfection¹
- Shadows can block UV-C rays & can leave parts of N95 contaminated

* ≥ 3-log inactivation

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N95 INTEGRITY

- N95 keeps fit and filter performance after 10-20 cycles of 1.0-1.2 J/cm² UV-C²,⁶
- Each don/doff can reduce N95 fit; some models fit unacceptably after 5 don/doff cycles⁹
- Some damage to N95 seen at high UV-C doses (≥120 J/cm²)⁶
- Strap and facepiece damage seen on some N95 models after UV-C⁷,²²


** = not peer-reviewed

https://www.n95decon.org/uvc
Method Summary: UV-C

Bioburden Reduction
If all surfaces exposed to $\geq 1 \text{J/cm}^2$, likely to sufficiently inactivate SARS-CoV-2

Bioburden reduction depends on N95 model

Straps require secondary decontamination

May NOT inactivate all other pathogens $\rightarrow$ return each N95 to original user

See n95decon.org/uvc for a more complete report of the evidence for and cautions of this method

N95 Performance
Filtration and fit preserved for 10-20 cycles at $1 \text{J/cm}^2$

on several N95 models

UV-C causes material degradation at higher doses of $\sim 100 \text{J/cm}^2$

Other Concerns
UV-C can cause eye and skin damage

Home UV is NOT effective

Sunlight is NOT effective

UV-C lamps can produce ozone

Implementation Criteria:
$\geq 1 \text{J/cm}^2$ UV-C on all N95 surfaces

Dose validation with UV-C specific sensor
N95DECON Method: Humid Heat

Heat + Time + Humidity = Viral Inactivation

Risk of reduced viral inactivation

50 °C
Hot tap water

Target range
70-85... °C

Target Relative Humidity 50-85%

Target Time >1 hour

Risk of N95 damage

100 °C
Water boils


https://www.n95decon.org/heat
N95DECON Method: Humid Heat

**CORONAVIRUS INACTIVATION**
- 70°C dry heat for 60min inactivated* SARS-CoV-2 on N95 under lab conditions¹
- 50–85% humidity enhances inactivation of flu virus (non-CoV) on N95 and metal²⁻⁴
- Real-world conditions (e.g. saliva, mucus droplets) may require higher temperature, humidity, or longer time.
- SARS-CoV-2 NOT inactivated by 70°C dry heat for 30min (on N95) and 60min (on metal)¹
- Method does NOT inactivate all bacterial or mold spores on N95⁵

* ≈ 3-log inactivation

**N95 MASK INTEGRITY**
- Several 3M N95 models (1860, 8210, 8210+) keep fit and filtration for multiple 30min cycles at 70–85°C and >50% humidity⁶,⁷
- Many models (e.g. 3M 8200, 3M 8511) keep fit performance for multiple 30min cycles at 75°C dry heat⁸,⁹
- Each N95 model responds differently to heat; many have not been tested with the heating conditions above¹,¹⁰
- Repeated thermal cycles may damage N95 fit and filtration¹,¹⁰,¹¹


** = not peer-reviewed

https://www.n95decon.org/heat
Method Summary: Heat and Humidity

Bioburden Reduction
Promising conditions for SARS-CoV-2 inactivation on N95 FFR are likely to be 70-85°C, humidity >50%, for >60 minutes, but data is limited. May NOT inactivate all other pathogens.

N95 Performance
Many common N95 models retain fit and filtration after 5 cycles at 85°C and 80% humidity, 30 minutes.

Other
N95 put inside container; container into oven; can add water for moisture; target 5 cycles max.
Calibrate and monitor heat and humidity, no direct exposure to heating element.
Not yet validated in an FDA-approved process.

Implementation Criteria
Temperature Range 70-85°C
Possible Humidity Range 50-80% RH
Target Duration Range >1hr
Other temperatures/humidities under study

n95decon.org/heat updated regularly, active research, new results coming

https://www.n95decon.org/heat
N95DECON Method: Wait and Reuse

**CORONAVIRUS INACTIVATION**

- SARS-CoV-2 on the surface of an N95 FFR slowly becomes inactive over time
- **Storage at room temperature (22°C, 40-65% humidity) for 7 days is expected to significantly reduce risk of exposure to SARS-CoV-2 via a re-used N95 FFR**[^1][^2][^3][^4]
- Storage at temperatures below 22°C could significantly increase the appropriate waiting time[^2]
- There is an urgent need for more experimentation to provide clearer guidance
- **The time to reduce infection risk is expected to be extremely sensitive to initial viral load, N95 FFR material[^1][^2], storage temperature[^2], and humidity[^4]**

**Takeaways:**

- Insufficient data, **only use if there is no other choice** for decontamination
- Room temperature storage in a clean, breathable container for 7 days may adequately inactivate SARS-CoV-2 on an N95
- Overnight storage is **NOT** sufficient
- Does **NOT** protect against bacteria or mold
- Return N95 to original user

Pause for Discussion

1. Are your facilities currently practicing PPE decontamination? What materials, procedures, and resources do you have access to?

2. Are you experiencing any barriers in PPE decontamination? If so, are there questions about these barriers we can address?

3. Have you received any support or resources from international or national organizations that might be helpful to others?
If you have more questions following this session, we have created a WhatsApp chat group for sharing relevant information about caring for COVID-19 patients.

Please join us!
Thank you! Contact Us

https://www.n95decon.org/
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@N95Decon

- CDC Guidance on extended use and limited reuse of N95 FFR
  https://www.cdc.gov/niosh/topics/hcwcontrols/recommendedguidanceextuse.html
- CDC Guidance on N95 FFR Decontamination
- Greater Boston Pandemic Fabrication Team: https://www.panfab.org/
- Recorded ACOEM Webinars on COVID-19
  https://acoem.org/Learning/Webinars