Use and Re-Use of Respirators Used Against Infectious Aerosols
Overview

- Review historical basis of respirator disinfection
- Review literature on microorganism viability and reaerosolization as it relates to respirator re-use
Respirator Contamination Concerns

- Originally
  - By the respirator wearer
  - Inside of respirator
- Recently
  - Exposure to bioaerosols
Solutions

- To prevent “spreading” disease from a respirator
- Personal use w/ cleaning as needed
- Multiple users
  - Cleaning and disinfection of before the respirator is reassigned
    - Replacement of filters
    - “Disposable” respirators
Recommendations from food service

- Hypochlorite solution (50 ppm, 2 min.)
- Aqueous iodine solution (50 ppm, 2 min.)
- Quaternary ammonium solution (200 ppm, 2 min.)
Concerns

• “Spreading” disease from handling a contaminated respirator
• Contamination of respirators by exposure to bioaerosols
  • Filter
  • Straps, valve covers, etc.
Contamination Concerns

- Dispose of respirator
- “Reusable” Respirator maintenance
  - Respirator handling
    - Touch
    - Reaerosolization
      - Degree of filter loading
      - Most work done with what might be considered to be “high” filter loading
Concerns continued

- Knowledge of how the disease is transmitted
- Survivability on respirator/respirator filter
  - Most work done with bacteria
  - Little or no work with viruses
Disinfectant

• Effective against the bioaerosol
• No harm to the wearer
• No harm to the respirator material
Infectious Aerosol
Requirements

• Handling precautions
• Cleaning and disinfection
• Storage
  • For infectious aerosols, plastic bag may not be best option
  • Paper bags have been used to let the respirator dry out
Re-use

- Re-use guidelines in NIOSH pub. # 96-101
  - For filter, based on loading
  - If no oil mist, limited by hygiene, damage, and breathing resistance
  - May be reused as long as respirator is functional
- Studies have shown:
  - Properly fitted filtering facepiece respirators may be reused several times during a day (AIHCE, 2001)
- Re-use may be more dependent upon infection control procedures
• WPF studies
• 4 separate situations indicate no significant differences in performance over the course of a shift
• No significant effect from:
  • redonning
  • slippage, change in fit
• Time of day or duration of use was not associated with a difference in performance
Brosseau et al., 1997

- Experimental concentrations were probably higher than those in work settings
- Results implied bacteria can remain viable on filters for several days
- Implications for reuse, handling and disposal of respirators
  - Training to recognize when exposures might require immediate disposal of respirators
Reponen et al., 1999

- *Mycobacterium smegmatis* (surrogate for MTB)
- “N95 respirators”
- Tested for survival 1 to 9 days after loading
- Bacteria unable to grow on filters
- Bacteria survived up to 3 days, even under ideal growth conditions
Wang et al., 1999

- Bacteria
  - *Pseudomonas fluorescens*
  - *Bacillus subtilis*
- NIOSH certified “polypropylene” respirator filters
- Bacteria were unable to grow
- Both bacteria survived
  - *P. fluorescens* < 3 days
  - *B. subtilis* > 13 days
- Suggests
  - Spore forming bacteria may have greater viability than vegetative bacteria
• TB simulant
• Tested 6 models of filtering facepiece respirators
• Stored at room temperature in a Zip-lok™ bag for 28 days
• No more viable organisms were recovered after day 7
• Internal contamination appeared from environmental bacteria thought to be due to handling (removal from bag to sample)
• Concluded that respirators may be reused over time with little risk over a week’s time of internal contamination provide the respirator is carefully handled and stored (handle by non-filter components)
Pasanen et al., 1993

- Loaded 2 High efficiency filters
  - 85% fiberglass, 15% cellulose
  - 15% fiberglass, 85% cellulose
- Loaded with microorganisms
  - Cow barn (8 hr/day, 2 weeks)
  - Waste water treatment plant (continuously for 1 week)
- Stored @ 98% RH, 35 days
- Attributed growth to storage in humid environment
• 2 High efficiency filters  
  • 85% fiberglass, 15% cellulose  
  • 15% fiberglass, 85% cellulose  
• Filters inoculated w/ *Stachybotrys atra*  
• Stored at 3 RH ranges, 78 – 100% for 86 days  
• *S. atra* grows and produces toxins on cellulose filters @ high RH conditions  
• Stated that these conditions probably do not occur during normal respirator use and storage
Re-aerosolization of Microorganisms

- The process by which any aerially deposited material can be re-suspended
  - High air flow back through the filter (cough or sneeze)
  - Handling
- Size of re-suspended particles may be different from that of the deposited particles
- 2 studies
Qian et al., 1997

- Measured reaerosolization of *M. tuberculosis* surrogates and other test particles
- 3 models of N95 respirators
- Re-entrainment air velocity 300 cm/sec
- Re-aerosolization into dry air significant only for larger test particles
- No re-aerosolization at RH levels > 35%
• Concluded that reaerosolization of collected TB bacteria and other particles < a few µm in size is insignificant at conditions encountered in respirator wear

• Speculated that conclusions were valid for other fibrous filters as well
Kennedy & Hinds, 2004

• Used 1µm PSL particles to simulate anthrax spores
• Measured release of particles from respirators dropped 3 feet onto a hard surface
• Two brands of N95 disposable respirators
• Conclusions
  • Small, but consistent fraction of 1 µm particles captured by a disposable respirator can be released into the air
  • Fraction release ranged from 0 to 0.5%
  • Suggests caution in handling and disposing of respirators contaminated with anthrax spores
Re-use

- Some bacteria and fungi can survive on respirator filters
- May be dependent on:
  - Organism
  - Filter material,
  - Storage conditions
- Unclear as to its implications on reuse and storage
  - Daily filter or respirator disposal
  - Knowledge of disease transmission for agent of interest
References