CUI

Reducing Airborne Risk by Air-based Manikin Chemical, Biological, and Radiological Surrogate Decontamination for the Arctic

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INTRODUCTION

Does individual exposure to combinations of ototoxic substances, continuous noise, and impulse noise differ in the development of hearing loss indicators?

- Air Force recommends high-volume, low-pressure water wash and disrobing for 90% reduction of Chemical/Biological/Radiological (CBR) personal contamination (USAF, 2021)
- Water-based decontamination (decon) impractical in Arctic environments
- Cold Region Expeditionary Medical Operations (CREMO) requires waterless CBR patient decon solution
- Project goal was to test non-water decon methods vs. 90% risk redux
- A commercial off-the-shelf (COTS) system exists which may provide a rapid acquisition option for ambulatory patients
- Design/test similar system for litter-bound patients
- ARCTIC Focus:
- Increased Temperatures in Region (Arctic Council, 2024)
- Increased shipping routes (Arctic Council, 2024)
- Increased Presence (Williams et al., 2023)
- Russia/China and US/NATO interest
- 2022 National Strategy for Arctic Region (White House, 2022)
- DoD Medical support needed, Russia potential CBRN threat (Hoetells, 2023)
- U.S. Army SBCCOM Guidelines (2002) for Cold Weather Decon Use friction (dry decon)
- High volume & low-pressure water at 95° F for 60 sec
- Shelter victims in heated enclosure
- Air-based decontamination:
- Dust exposure for workers (Cecala et al., 2007)
- Gunshot-residue-specific lead (Tsepelev, 2016)
- Respirable dust & dry aerosols (Slagley et al., 2017)
- Water-free alternative decon for particulate contamination (Alexander et al, 2020)
- Lab constructed air shower w/ liquid- & gas-phase contaminant (Li, 2014)

METHODS

High Throughput COTS Air Shower CBRN Patient Decontamination Effectiveness for Cold Region Expeditionary Medical Operations (CREMO)

Chemical, biological, and radiological contaminants (3)

Ambulatory vs. litter-bound patients (2)

Therefore (3 x 2) = 6 subtasks

A

B

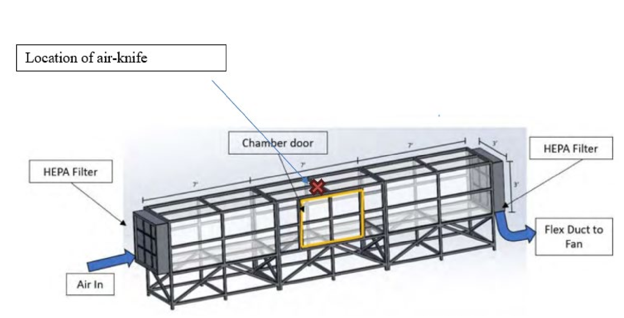


Figure 1: (A) COTS Air Shower for Ambulatory Patients; (B) Air Knife Chamber for Litter-bound Patients. (*Images property of USAF.*)

METHODS

Table 1: Chem/bio/rad surrogates

Agent type	Surrogate	Actual agent
Biological	1µm Polystyrene Latex (PSL) spheres	*B. Anthracis* spores
Radiological	Copper Oxide (CuO) (ρ=6.32 g/cc)	Sr-90 (ρ=5.11g/cc)
Chemical	Methyl Salicylate (MeS)	VX

- Manikins (NOT human subjects)
- Contaminate the manikin's uniform, then
  - No decon
  - Air shower decon
  - Other dry decon (HEPA Vac for B/R; absorbent for C)
- 10 trials each of 3 treatments
- Compare airborne inhalation risk

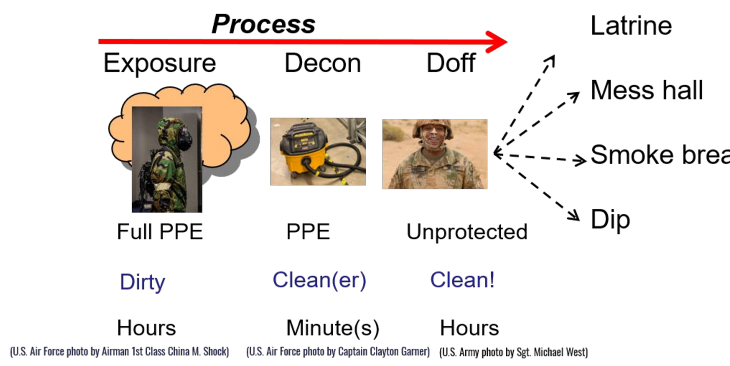


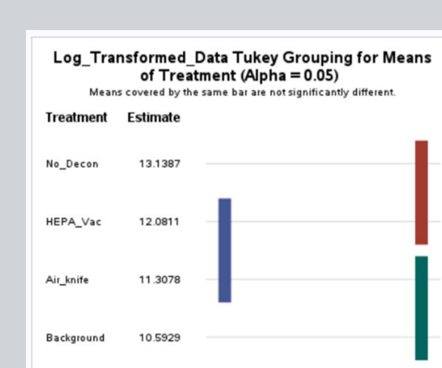
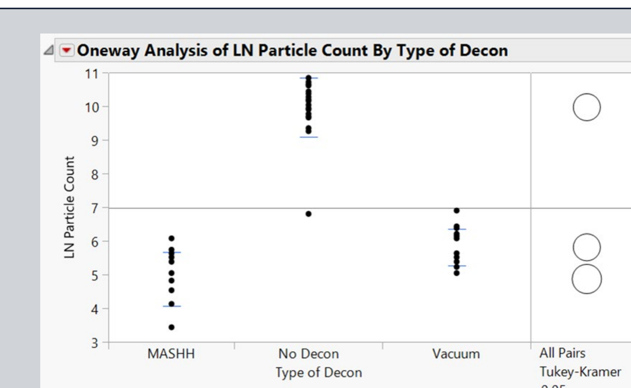
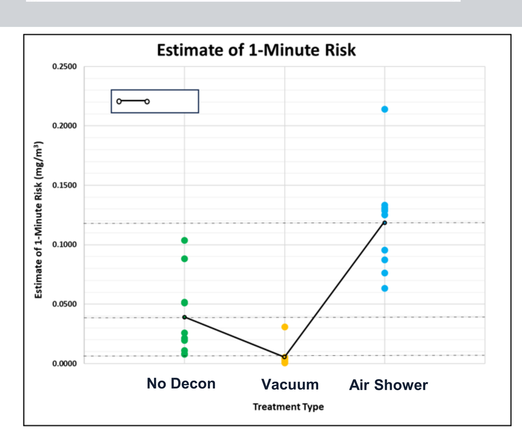
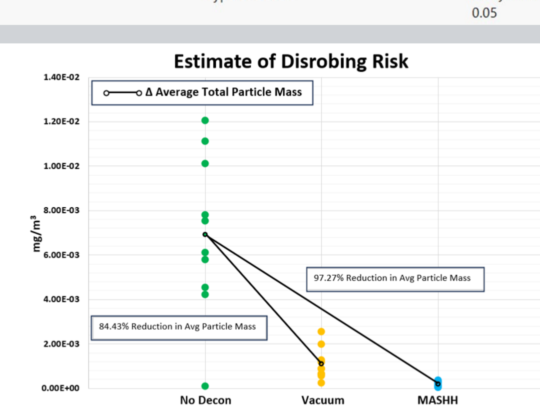
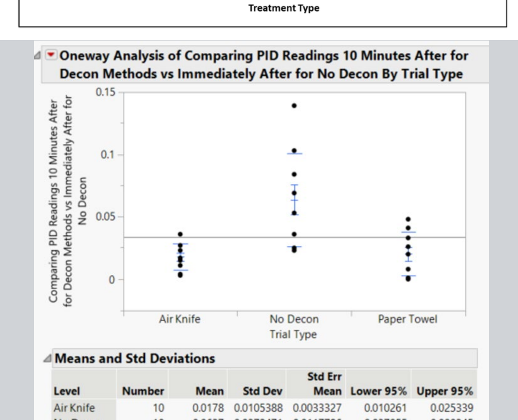
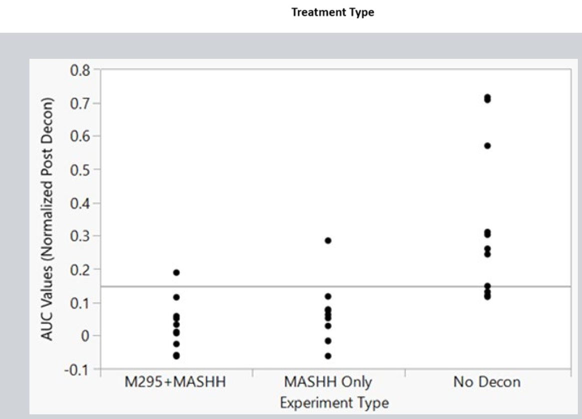
Figure 2: General Decon Process

Figure 3: U.S.G.I. Extreme Cold Weather System Gen III Waterproof Pants and Extreme Cold Weather N-3B Parka (Image property of USAF)

- Bio (Fluorescent PSL spheres): apply 10 mL with air brush, air sample with IOM inhalable samper, 25 mm PVC filter, fluorescent microscopy to estimate particle concentration
- Rad (CuO): Apply 27g with flour sifter or duster, air sample with optical particle counter (Aerotrak 9306, TSI, Inc., Shoreview, MN), background corrected
- Chem (MeS): Apply 8 µL with micropipet, air sample with photoionization detector (ppbRAE3000, Honeywell, Charlotte, NC)

RESULTS

Table 2: Combined results of residual airborne contamination (Images property of USAF)

Agent type	Litter-bound (MURPHEE)	Ambulatory (MASHH)
Bio (PSL)		
Rad (CuO)		
Chem (MeS)		

DISCLAIMER

RESULTS & DISCUSSION

Table 3: Reduction in airborne risk compared to the "no decon" treatment

Agent type	Litter-bound (MURPHEE)	Ambulatory (MASHH)
Bio (PSL)	MURPHEE: 91% (p<.05) HEPA Vac: 71% (p<.05)	MASHH: 99.4% (p<.001) HEPA Vac: 98.5% (p<.001)
Rad (CuO)	MURPHEE: Worse than no Decon (p<.0001) HEPA Vac: 86% (p=.0498)	MASHH: 97.3% (p<.05) HEPA Vac: 84.4% (p<.05)
Chem (MeS)	MURPHEE: 81% (p=.0009) MURPHEE+Paper Towel: 78% (p=.0015)	MASHH: 80.3% (p=.0024) MASHH+M295: 90.3% (p=.0011) *High RH, MASHH: 54%

- Bio: Dry air methods worked well for both patient types
- Rad: MASHH worked well, HEPA worked well but less so, litter-bound patients were problematic; air velocity at manikin ~ 1 m/s for MURPHEE vs. ~ 13 m/s for MASHH
- Chem: Dry air methods simply evacuated evaporated MeS from the chamber; did not eliminate hazard.
- NOT conducted at actual Arctic conditions
- Lack of temperature and humidity control (T & RH tracked and analyzed)

CONCLUSION

- Bio ≠ Rad ≠ Chem
- Generally, dry air decon methods reduce residual airborne risk by 70-90%
- 10-30% remaining in the air can still present a risk
- Automated systems tend to be faster, more expensive, and less variable
- Manual systems (HEPA Vac, absorbent) take longer and depend on individual motivation

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