# Evaluation of an Electrostatic Sprayer for Personnel PPE Bio Decontamination

## Mannequin Tests

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# Acknowledgements and Disclaimer


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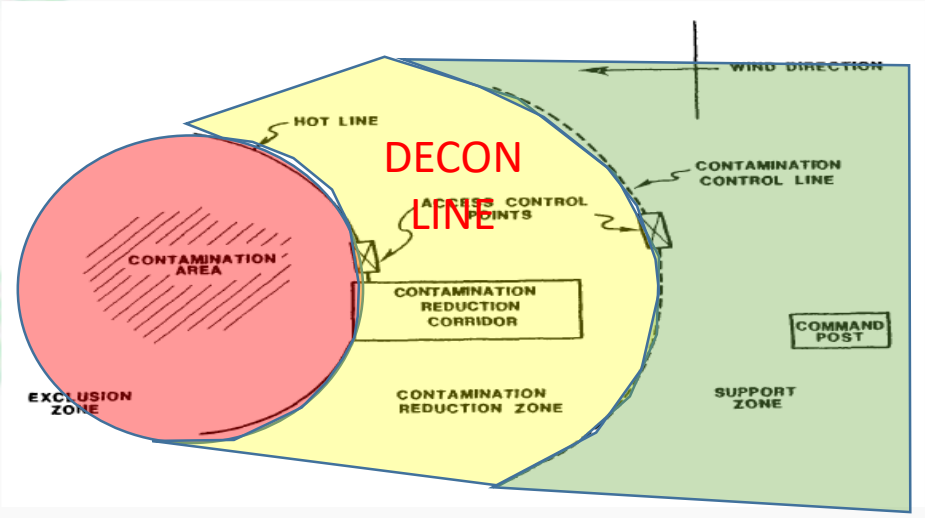
- Jacobs Technology: Abderrahmane Touati, Rob Delafield, Denise Aslett, Ahmed Abdel-Hady

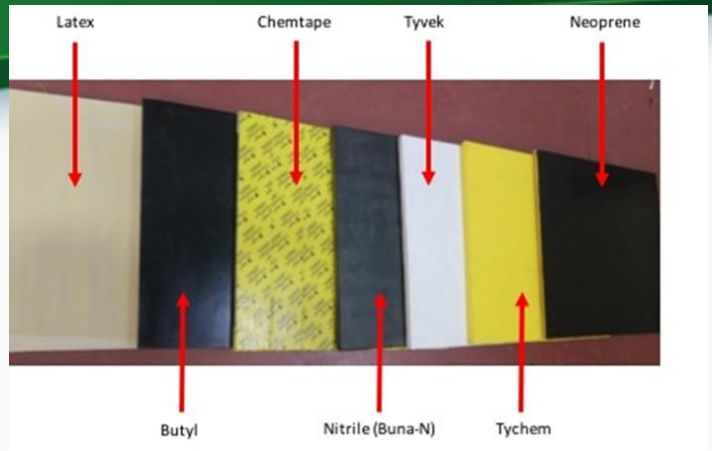
# Objectives

- Continue evaluation of EPA's internal personnel bio decontamination line protocol
- Evaluate decontamination (decon) efficacy of an electrostatic sprayer (ES) on personal protective equipment (PPE) and compare to traditional backpack sprayer (TS)
  - Bench-scale study (COMPLETED and PUBLISHED)
  - Pilot-scale study (CURRENT)
  - Field study to evaluate real-world application (PLANNED)
- Assess operational factors and reaerosolization
  - compare to current traditional sprayer

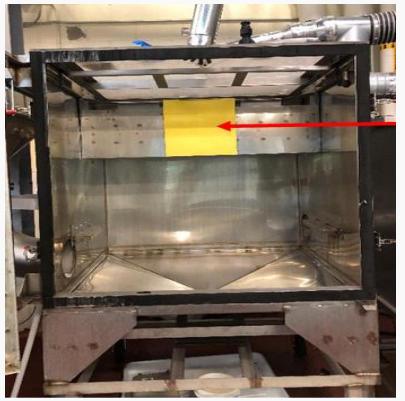



- **Goal** is to improve personnel bio decon procedure by evaluating efficacy, minimizing liquid waste, and reducing cross contamination

# Bench-Scale Study - Review




- Compared traditional backpack sprayer (TS) with Electrostatic sprayer (ES)
- Electrostatic sprayer performed well overall
  - Similar efficacy between ES and TS (both > 6 Log reduction)
  - 5-minute contact time was effective for inactivation
  - Less decontaminant used with ES
  - Much less runoff/washoff with ES, so less waste
  - Spores were transported off vertical coupons with TS, but formed a liquid film with ES
- ES demonstrated advantages which warrant further investigation

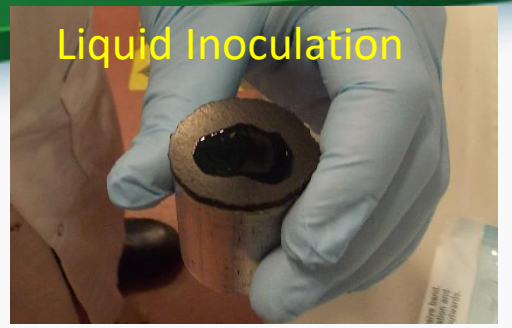


Archer, J., M. Karnik, A. Touati, D. Aslett, AND A. Abdel-Hady. Evaluation of Electrostatic Sprayers for Use in a Personnel Decontamination Line Protocol for Biological Contamination Incident Response Operations. U.S. Environmental Protection Agency, Washington, DC, **EPA/600/R-18/283, 2018**.

# Experimental Approach – Pilot Scale

- Spore Inoculation – aerosol and liquid
- Preparation of mannequin PPE ensembles
    - Nitrile gloves, Tychem® SL coveralls, Hazproof ® boots (PVC), Powered-air purifying respirator (PAPR), and ChemTape®
- Contamination/inoculation of mannequins
    - *Bacillus atrophaeus var. globigii (Bg)*
    - Aerosol and liquid deposition (1 X $10^7$ CFU) for comparison
- Application of decon procedure on mannequins
- Wipe Sampling, air sampling, collection of runoff, and culture analysis
- Determination of decon efficacy and reaerosolization

# Test Setup


- All materials sterilized prior to testing
- **Inoculation:**
  - ~$10^7$ CFU *Bacillus atropheus var. globigii (Bg)*
    1) Aerosol Deposition
    2) Liquid Deposition

**Decontaminant**
1:10 diluted bleach

- **Test Chamber - COMMANDER**
  - Located in RTP, NC
  - Internal dimensions: 2.7 m X 3.7 m X 3 m
  - Allows for support staff entry and containment
  - Negative pressure
  - Allows for internal release of bio agent and decon

# Electrostatic Sprayers

Pic from www.electrostaticspraying.com

- Commonly used in agricultural and healthcare industries
- Droplets are atomized and produce electrically-charged spray
- Can cover all surfaces through “wrap around” effect
- Increased deposition efficiency
  - Demonstrated more uniform distribution of liquid decontaminants on flat building materials (US EPA, 2015) and PPE-covered coupons (US EPA, 2018)
- Intended for light-duty, quick disinfection and sanitization applications
- Have been used in personnel decon lines

# Personnel Decon Sprayers "Tale of the Tape"

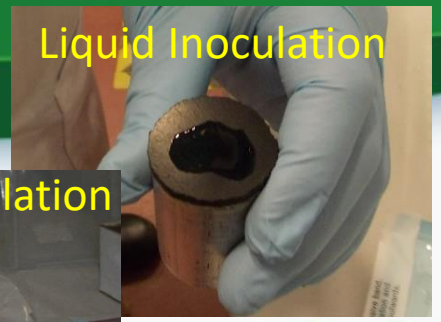
## Traditional Backpack Sprayer (TS)

- SHURFlo 4 ProPack Rechargeable Electric Back Pack Sprayer SRS-600 (Pentair-SHURFlo, Costa Mesa, CA)
- 996 mL/min
- Larger particle size
- Traditional spray nozzle – spray pattern can be adjusted
- 4 gal capacity
- 2 min spray time
- Normal lab gloves

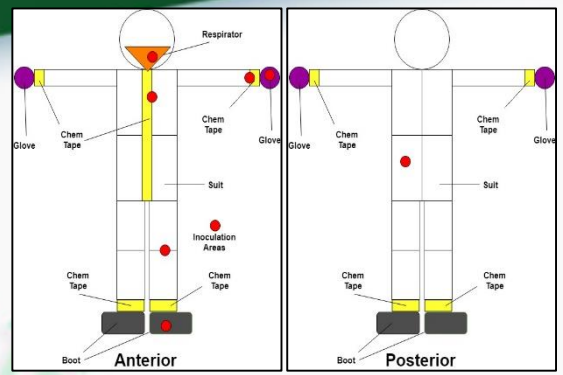

## Electrostatic Sprayer (ES)

- SC-ET HD electrostatic sprayer (Electrostatic Spraying Systems ESS, Watkinsville, GA)
- 62 mL/min
- Smaller particle size (40 um VMD)
- Electrostatic nozzle
- 1 gal capacity
- 2 or 4 min spray time
- Anti-static gloves

# Testing Approach







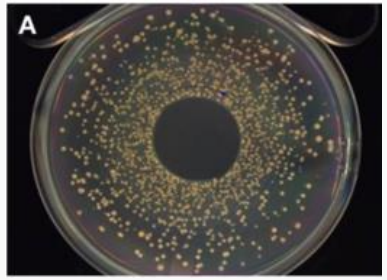

**Inoculation of Test Mannequins and Controls**

**Decontamination with ES or TS**

**Sampling**

- **Surface**
- **Runoff**
- **Air**

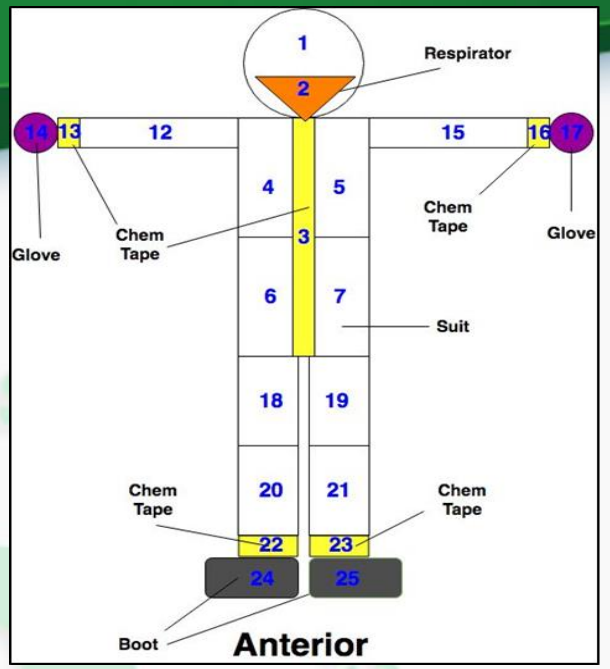
**Culture Analysis**

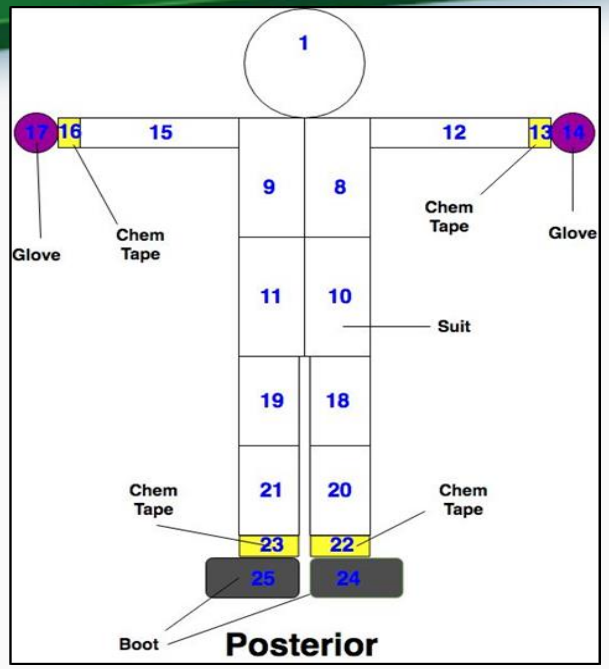



*Each individual experiment included negative control, procedural blank, positive control, inoculation control, triplicate DUMMIES, and DFU/runoff samples

# Sampling

**Wipe Sampling**



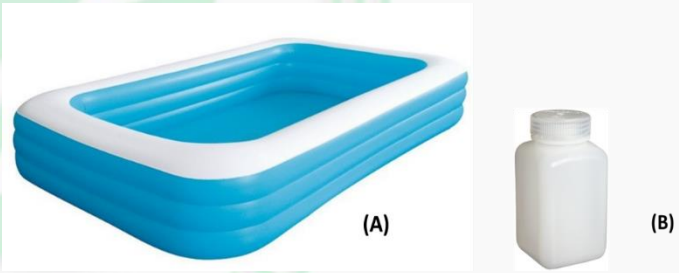

## 1) Surface Wipe Sampling

- Wipe sampling conducted following inoculation and decontaminant application (including 5-min contact time)
  - Moistened polyester-rayon blend wipes used to wipe mannequin surfaces

## 2) Liquid Runoff Sampling

- Not able to immediately neutralize with STS

**Runoff**




## 3) Air samples for reaerosolization

- Inside chamber with High Volume filter collection- Dry Filter Units (DFUs)
- DFUs collected samples during inoculation, decon, and sampling periods

**Reaerosolization**

- Cross contamination was an issue during aerosol inoculation, less so for liquid inoculation
- Blanks, Positive Controls and Procedural Blanks were important for QA

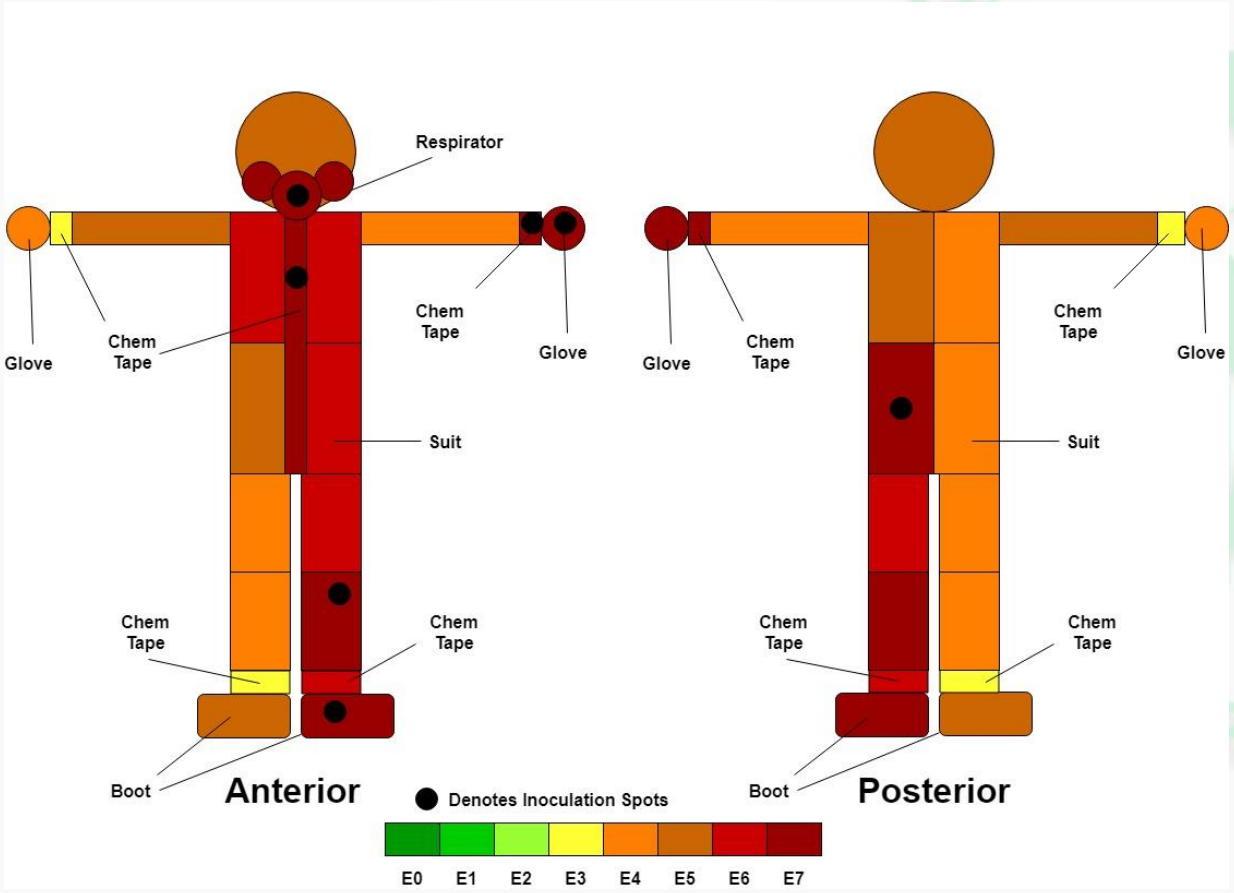
# Preliminary Results – Mannequin Decon

## QA Challenges

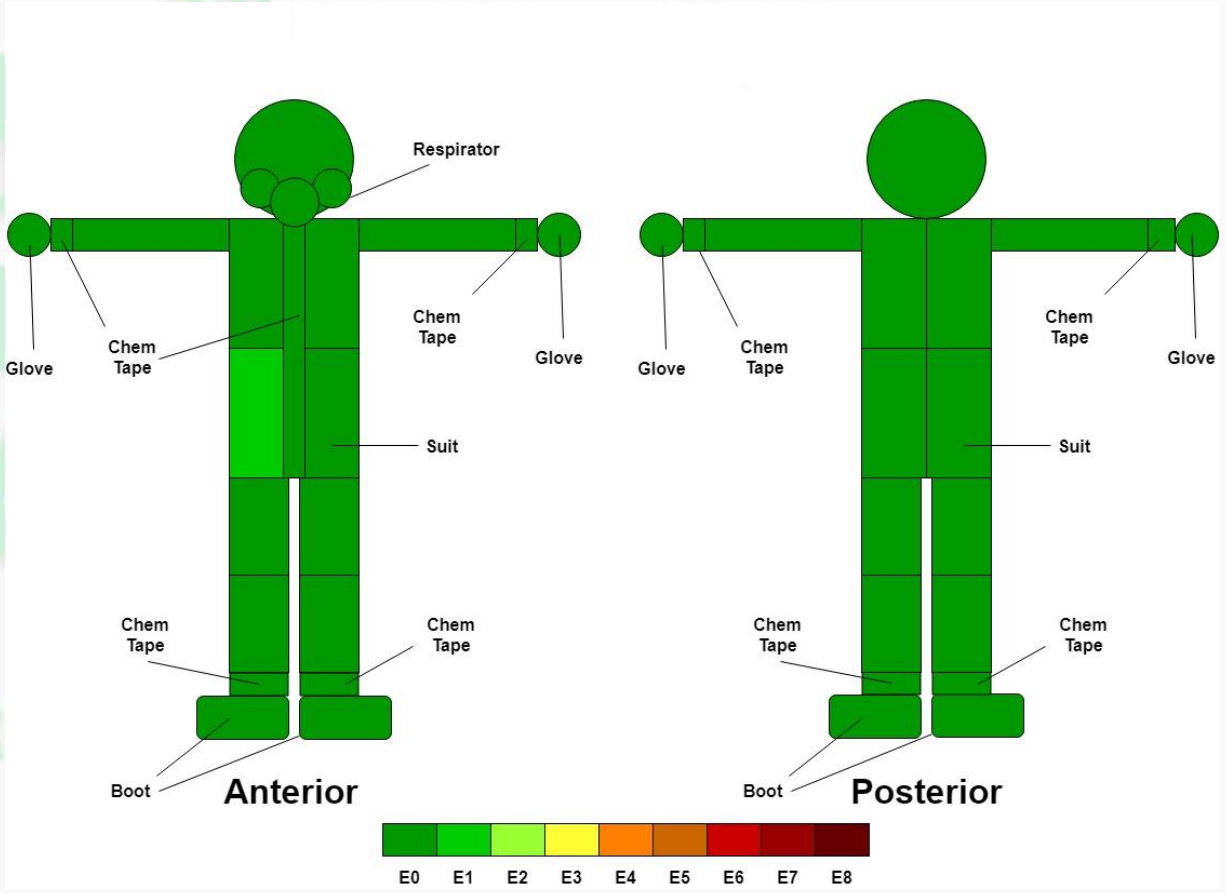
● Denotes Inoculation Spots

E0 E1 E2 E3 E4 E5 E6 E7 E8

**Positive Control**



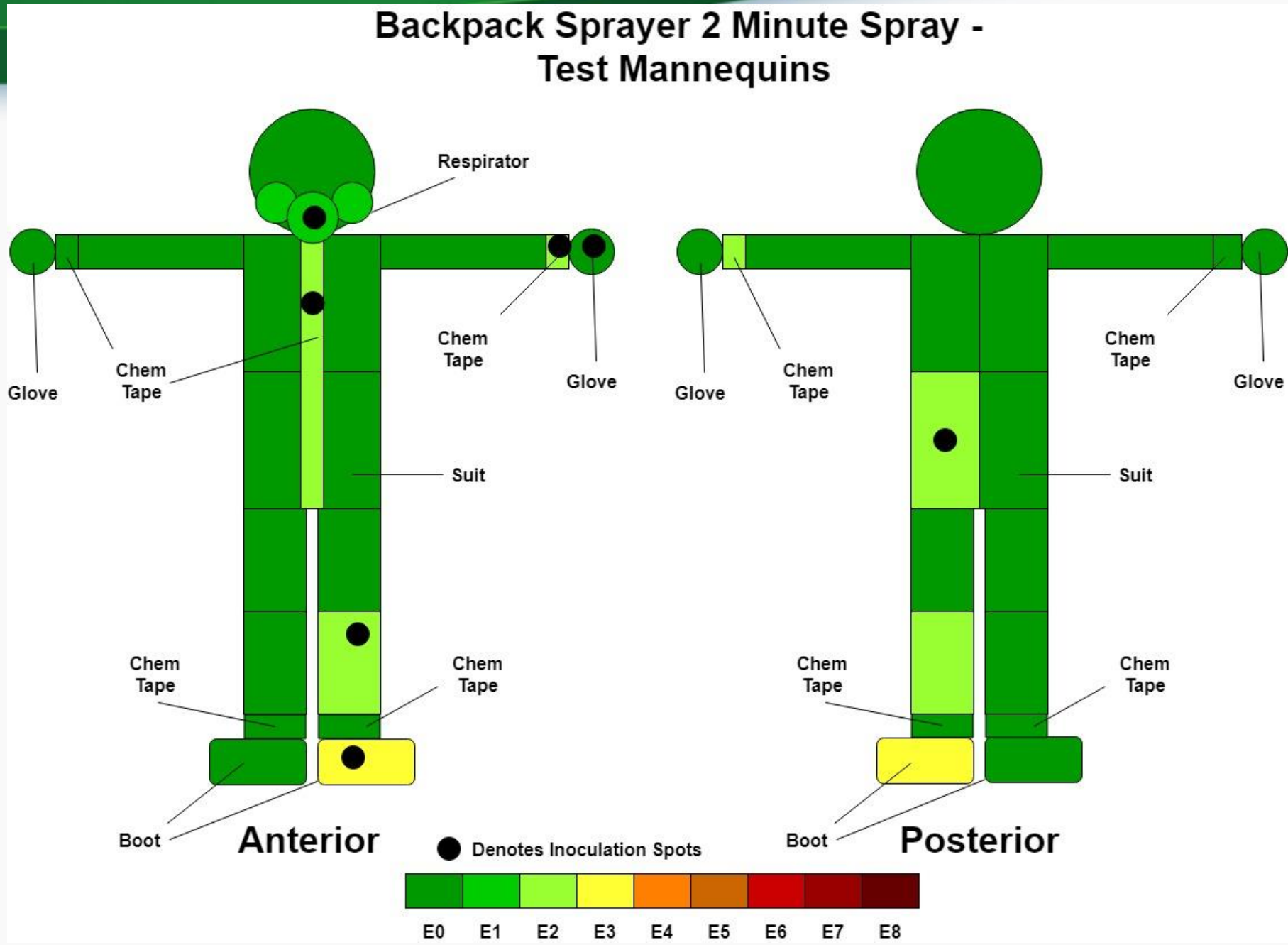

**Field Blank**



# Preliminary Results – Mannequin Decon

## Traditional Sprayer

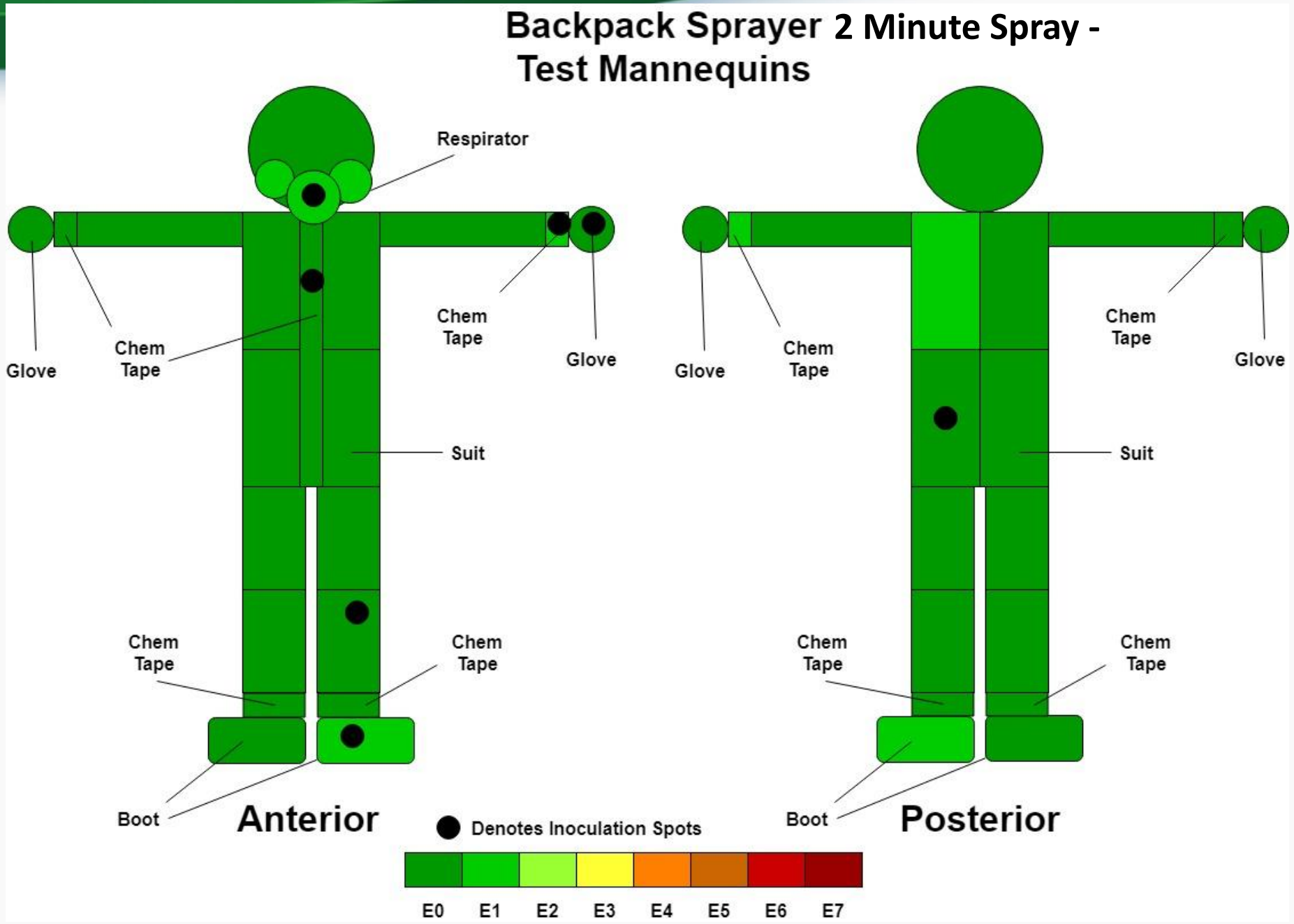
## Liquid Inoculation

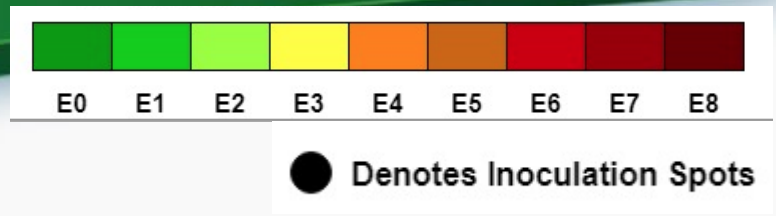


# Preliminary Results – Mannequin Decon

## Traditional Sprayer

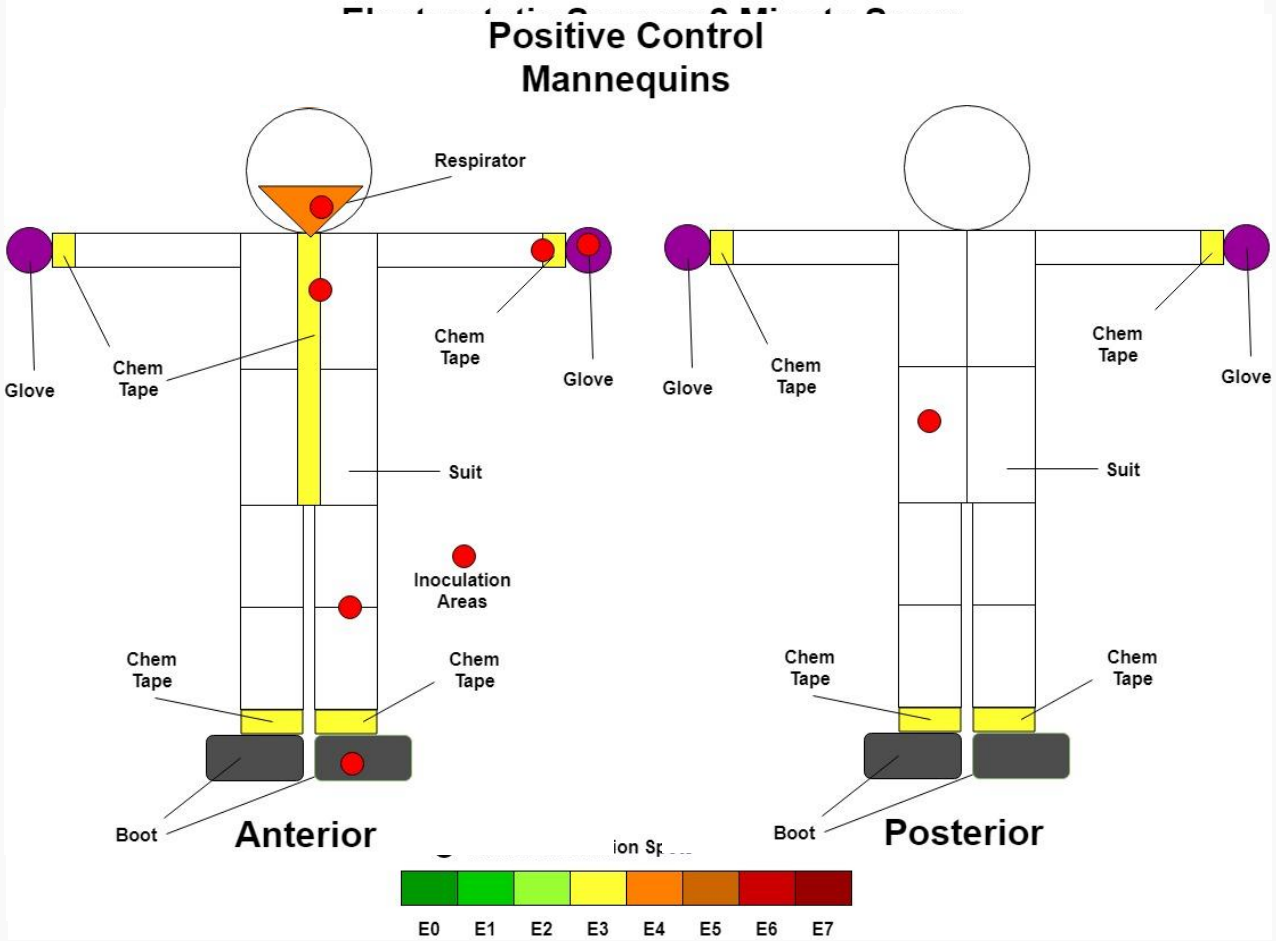
## Aerosol Inoculation

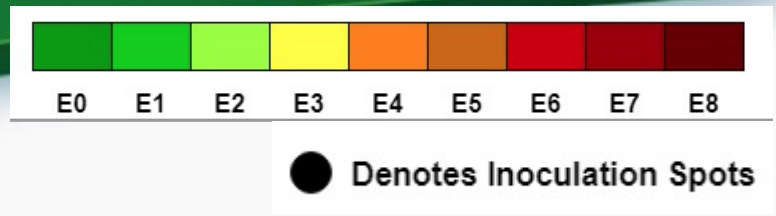





# Preliminary Results – Mannequin Decon

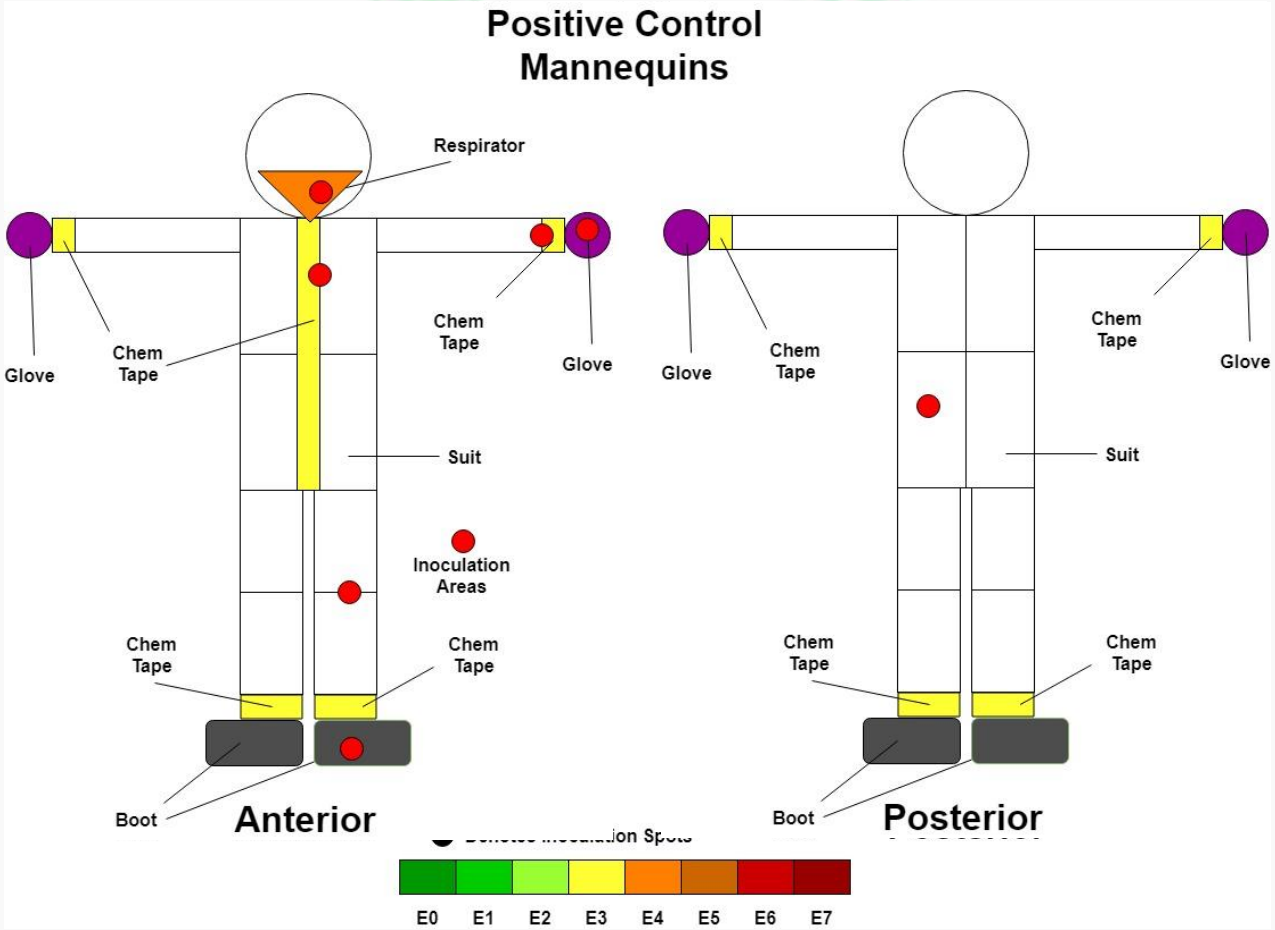
## Electrostatic Sprayer - Liquid Inoculation

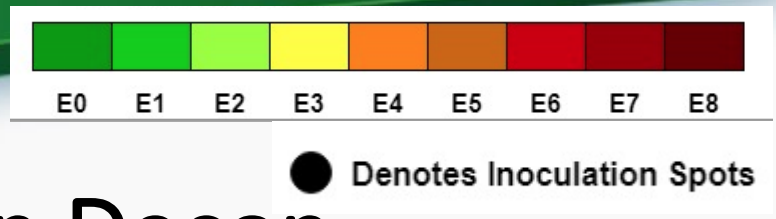





# Preliminary Results – Mannequin Decon

## Electrostatic Sprayer - Aerosol Inoculation

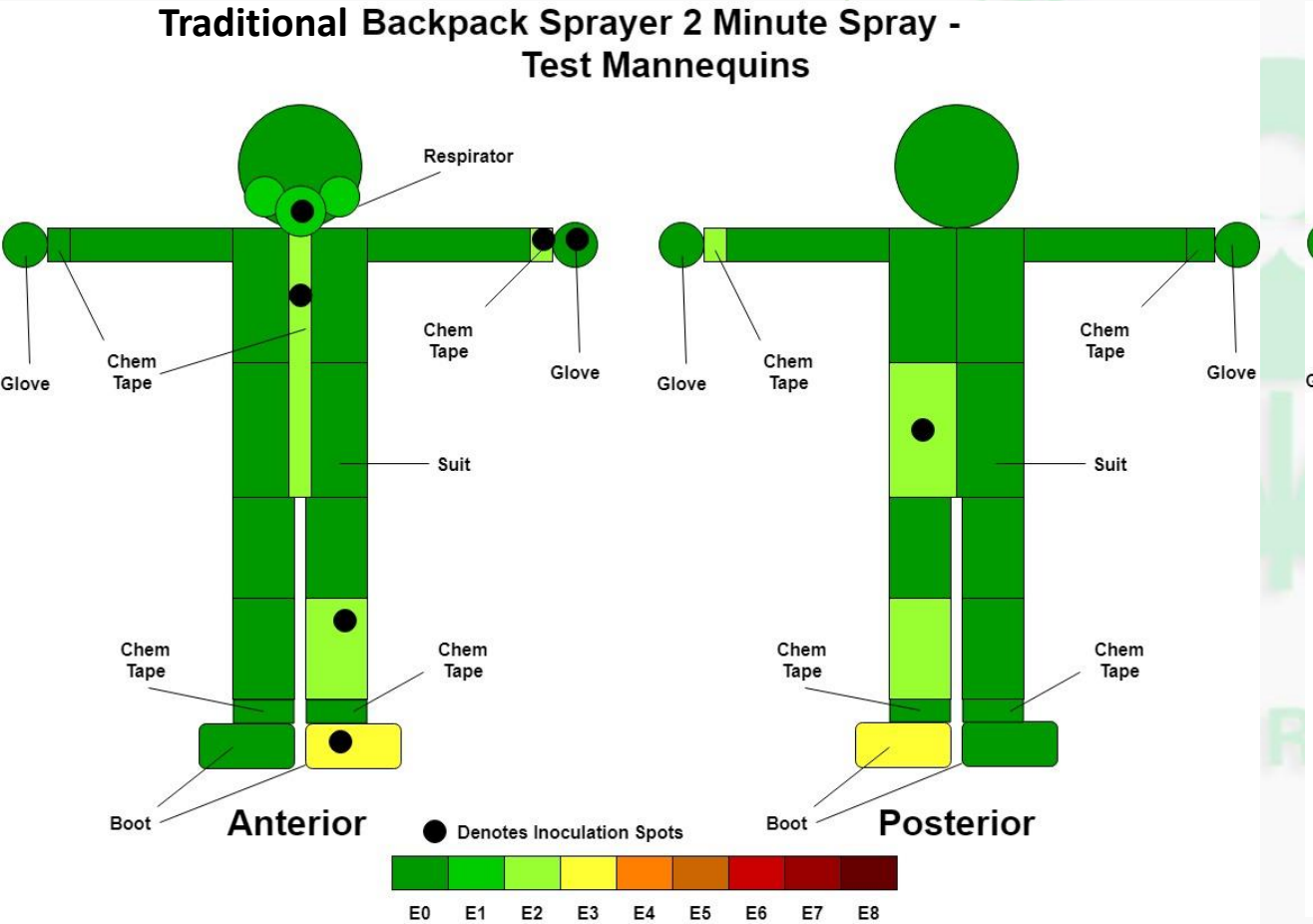


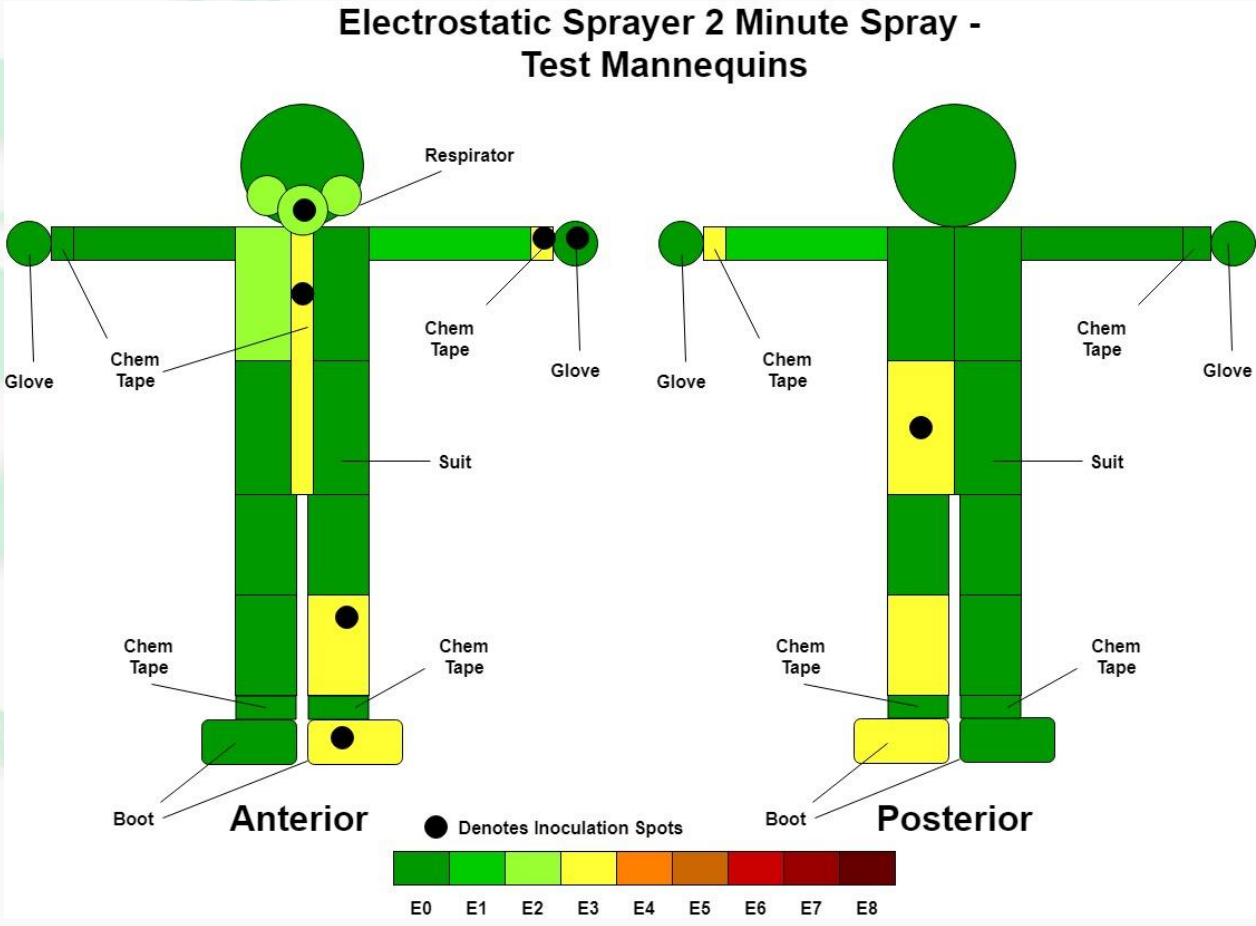


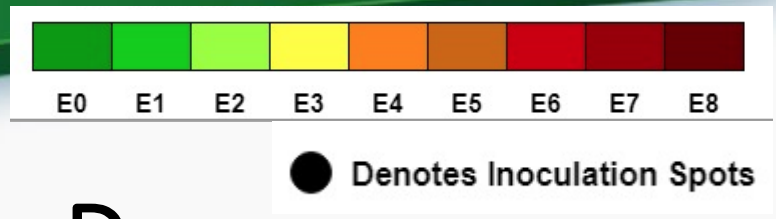

# Preliminary Results – Mannequin Decon

## Traditional (TS) vs Electrostatic (ES)

## Liquid Inoculation – 2 min



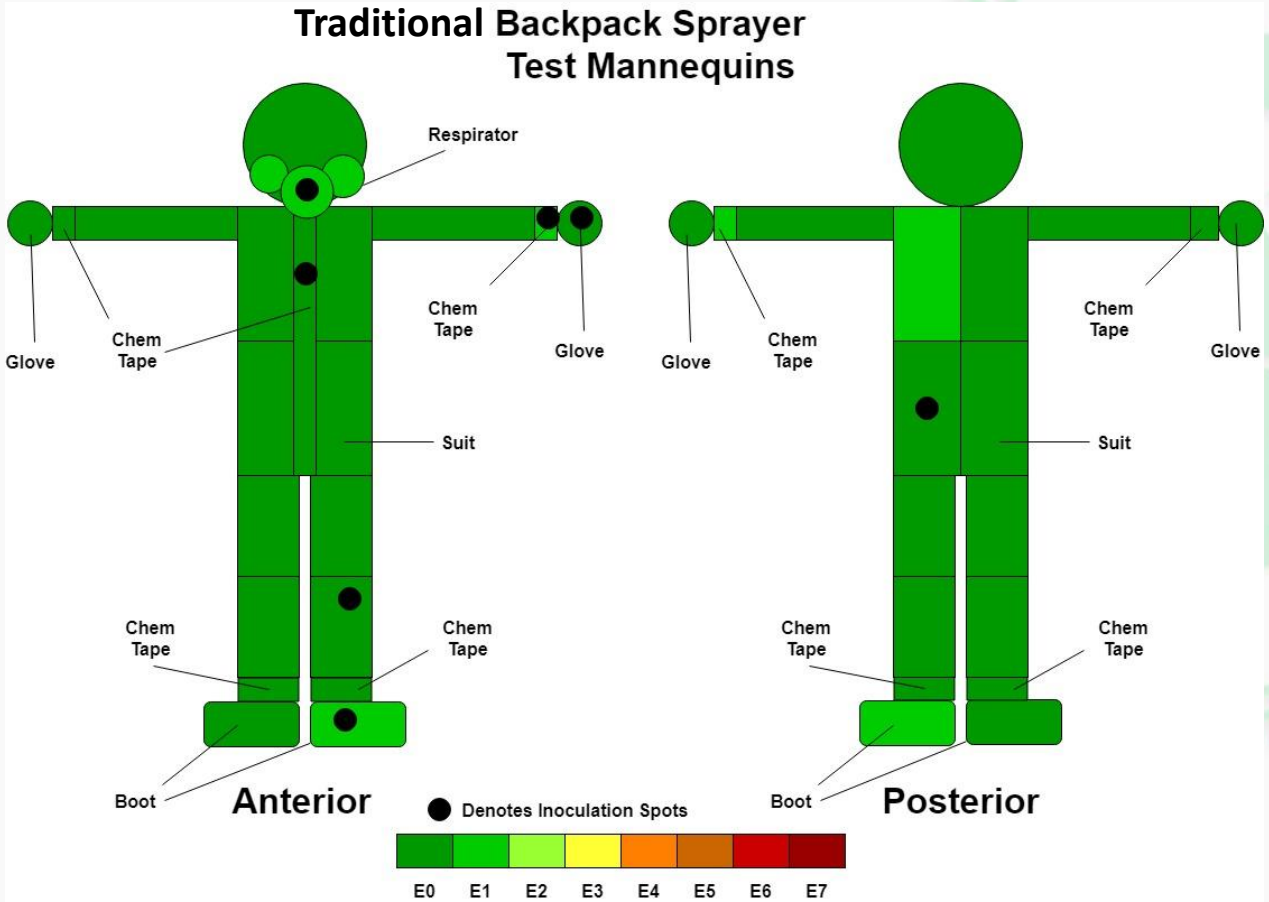



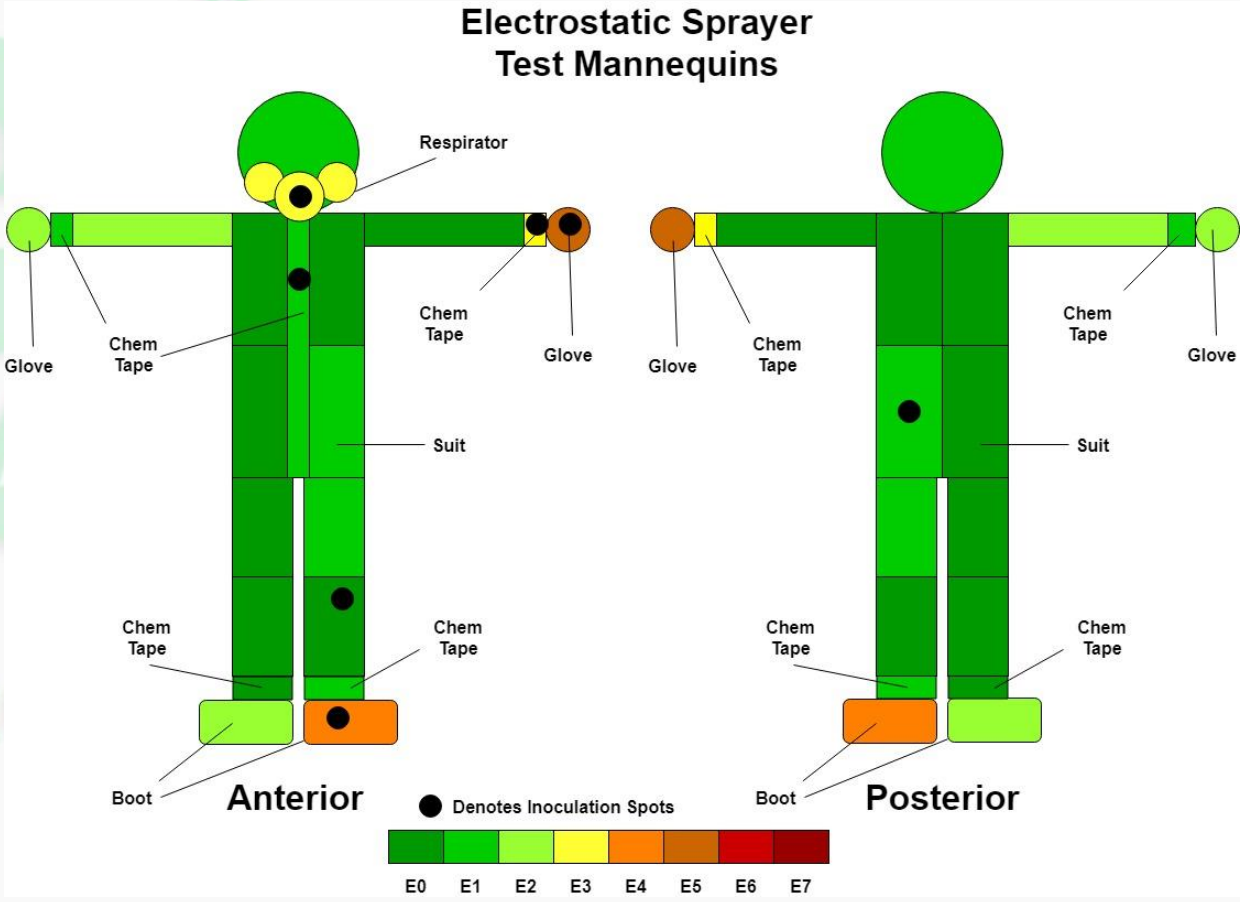



# Preliminary Results – Mannequin Decon

## TS vs ES

## Aerosol Inoculation – 2 min



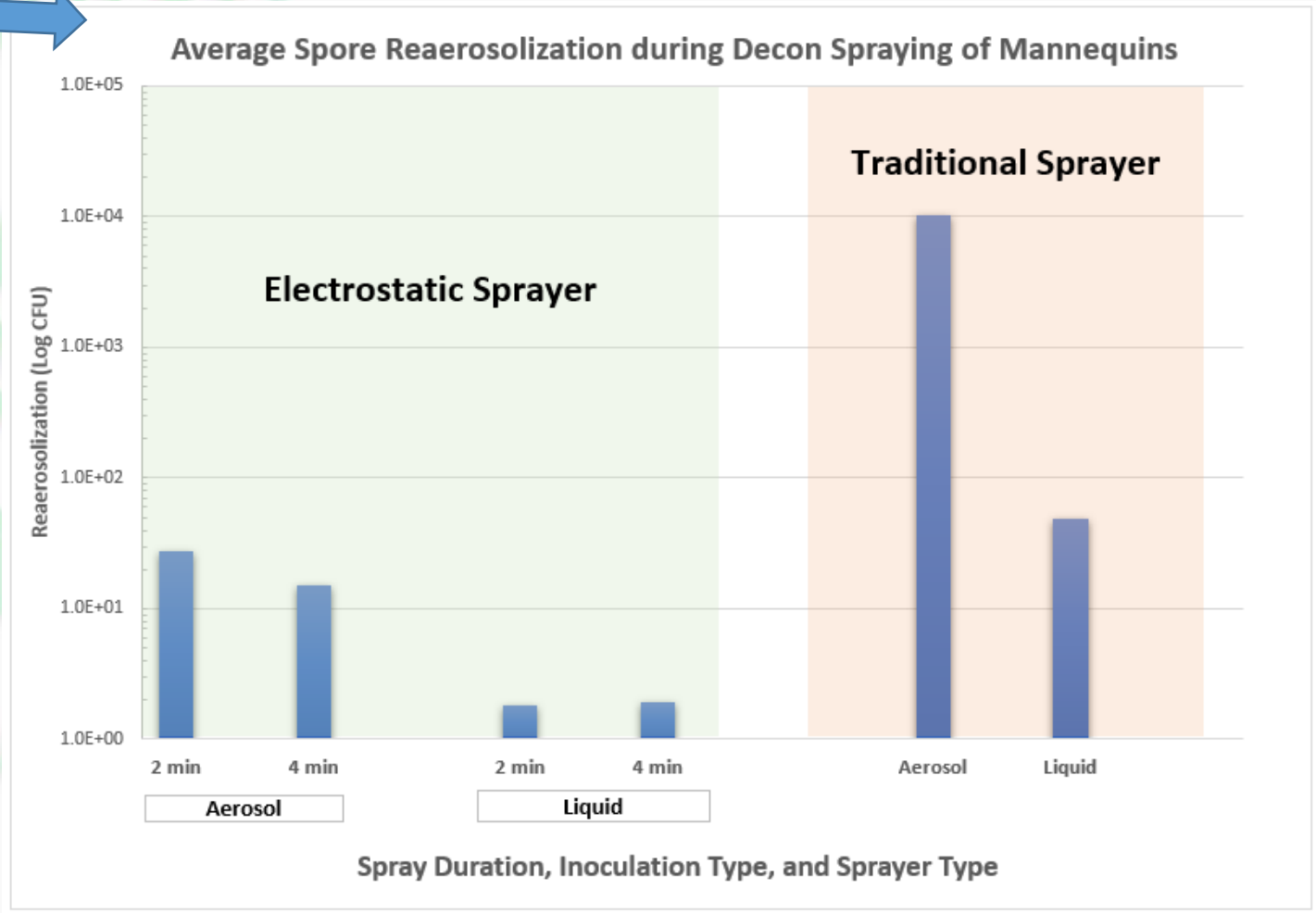
# Preliminary Results – Fate and Transport

## Reaerosolization

- High volume air sampling conducted during inoculation, sampling and decon spraying
- Reaerosolization observed 3 orders of magnitude higher for traditional sprayer type during decon
  - Likely due to pressure and volume of water sprayed
- Potential for migration of spores from PPE

## Runoff

- No measurable runoff liquid with ES
- Avg runoff volume with TS was ~ 1 liter for 2-min spray time (**50% of spray volume**)
  - Minimal spores detected in runoff – no immediate neutralization as in coupon study



# Summary of Results – Mannequin Testing

- Both types of decon sprayers achieved high decon efficacy for PPE-covered mannequins
- Some hot spots remained on PPE with both sprayer types in “hard-to-reach areas” – more hot spots with ES (inoculation locations)
- ES performed well but had a few hot spots (spore clumping) at wrinkles in PPE material
  - Still at least 3-4 log reduction at “hot spots” (2 min)
  - Increasing spray time from 2 min to 4 min decreased hot spot concentration post-decon
- **Reaerosolization** with traditional sprayer was several orders of magnitude higher than electrostatic sprayer ($10^4$ vs minimal spores)
- **Runoff** from TS was ~ 1 liter (50% spray volume) vs no measurable runoff from ES
- ES reduces reaerosolization and aqueous waste, but spray coverage is important

# Next Steps

- Complete pilot scale efficacy tests and investigate additional decontaminants/electrostatic sprayer systems
- Calculate time and cost considerations of electrostatic sprayer vs traditional wet sprayer methods
- Optimize personnel decon procedures
- Scale up to automated field deployable unit for bio decon
  - Eliminate manual spraying
- Determine if automated electrostatic sprayer unit is operationally feasible
  - Field study – test efficacy and evaluate cross contamination

# Contact Info

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