

# Electrostatic Sprayer Efficacy for Personnel PPE Decontamination – Mannequin Tests

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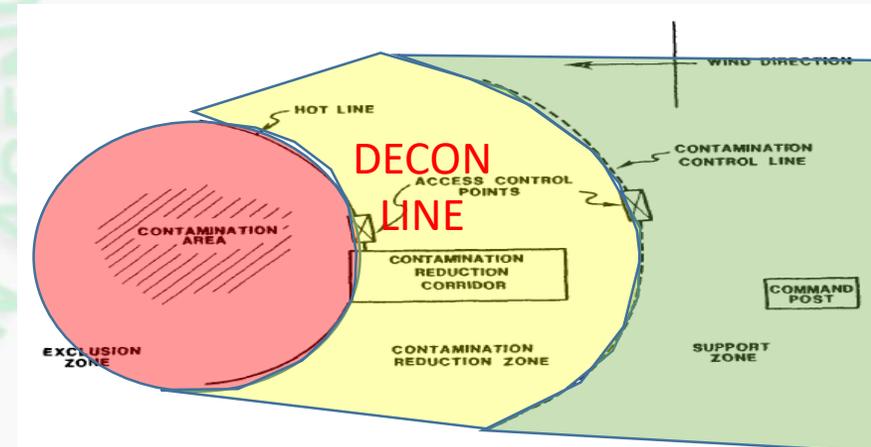
# Acknowledgements and Disclaimer

- EPA Team: Worth Calfee, Sang Don Lee, Leroy Mickelsen, Lukas Oudejans
- Jacobs Technology: Abderrahmane Touati, Rob Delafield, Denise Aslett, Ahmed Abdel-Hady

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# 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**)
  - 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



# Experimental Approach – Pilot Scale

- Spore Inoculation – aerosol and liquid
- Preparation of mannequin PPE ensembles
  - Nitrile gloves, Tychem<sup>®</sup> SL coveralls, Hazproof<sup>®</sup> boots (PVC), Powered-air purifying respirator (PAPR), and ChemTape<sup>®</sup>
- Contamination/inoculation of mannequins
  - *Bacillus atrophaeus var. globigii* (Bg)
  - Aerosol and liquid deposition ( $1 \times 10^7$  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:**
  - $\sim 10^7$  CFU *Bacillus atropeus* var. *globigii* (Bg)
    - 1) Aerosol Deposition
    - 2) Liquid Deposition
- **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



## Decontaminant

1:10 diluted  
bleach



# Electrostatic Sprayers



[Pic from www.electrostaticspraying.com](http://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
- 10 sec spray time
- 5 min contact
- Normal lab gloves

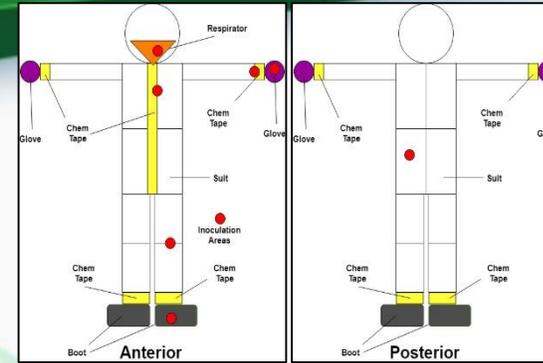
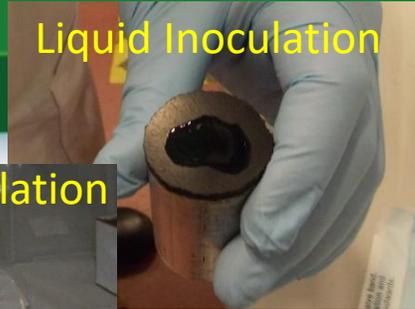


## Electrostatic Sprayer (ES)

- 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
- 30 sec spray time
- 5 min contact
- Anti-static gloves



# Testing Approach

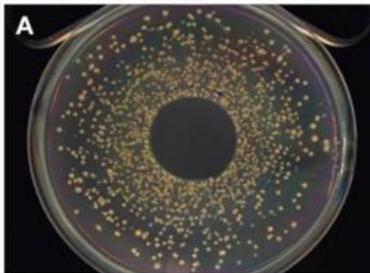


Inoculation of Test Mannequins and Controls

Decontamination with ES or TS



Culture Analysis



Sampling

- Surface
- Runoff
- Air

\*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)

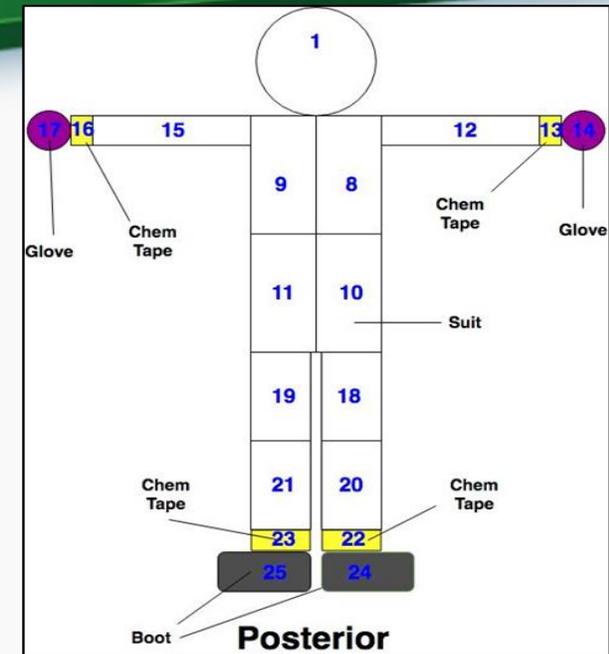
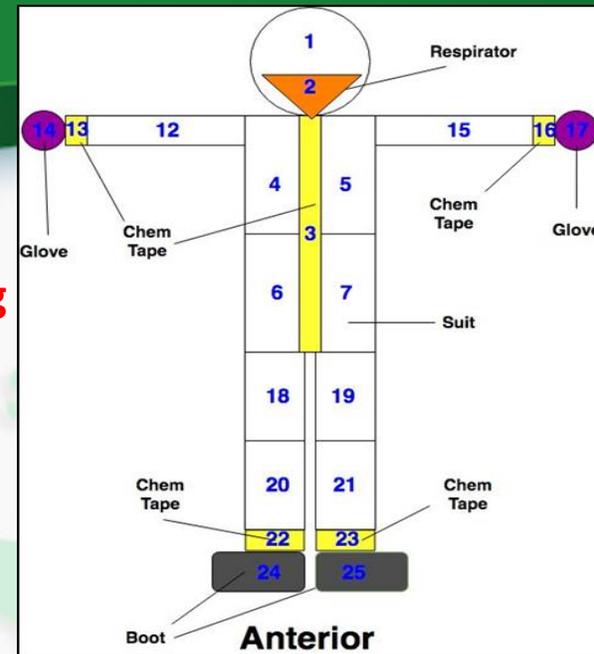
- Moistened polyester-rayon blend wipes used to wipe mannequin surfaces

### 2) Liquid Runoff Sampling

- Not able to immediately neutralize with STS

### 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



## Runoff



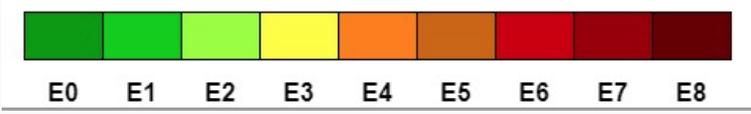
## Reaerosolization



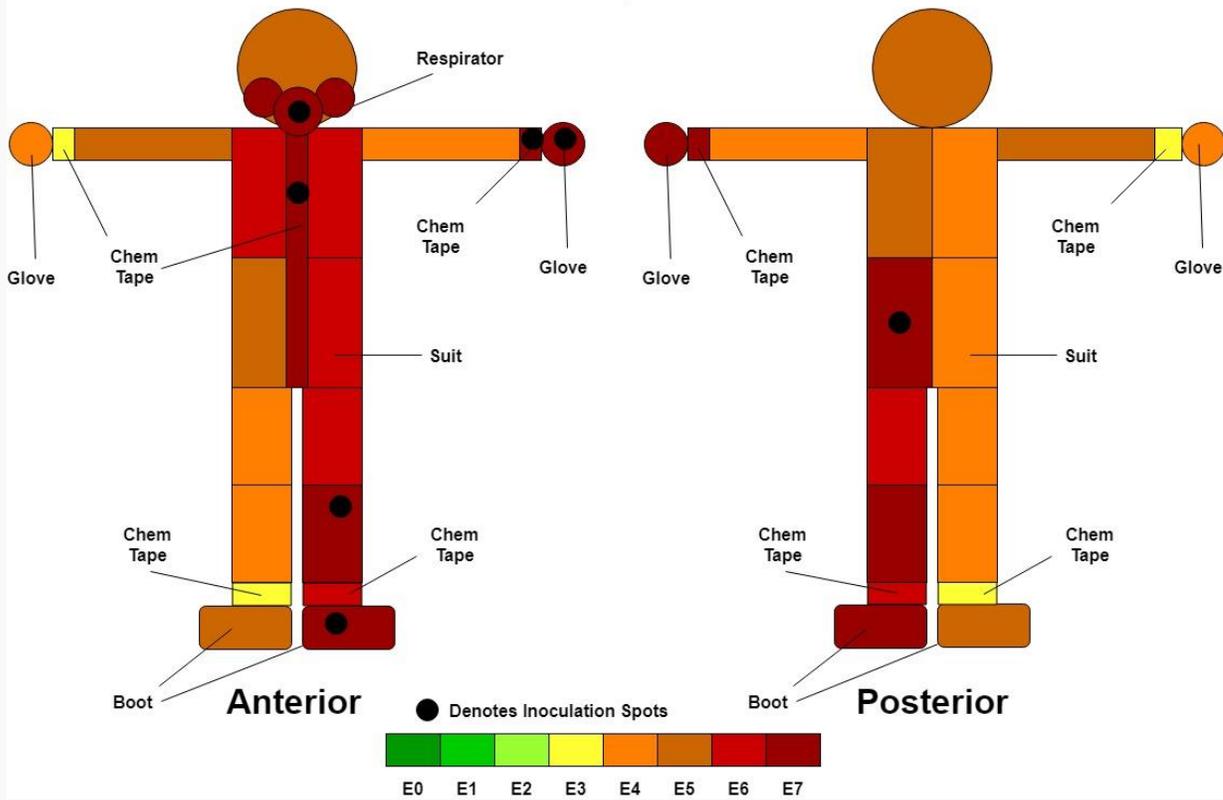
- Cross contamination was an issue during aerosol inoculation, less so for liquid inoculation
- Blanks, Positive Controls and Procedural Blanks were important for QA

# “Preliminary” Results – Mannequin Decon QA Challenges

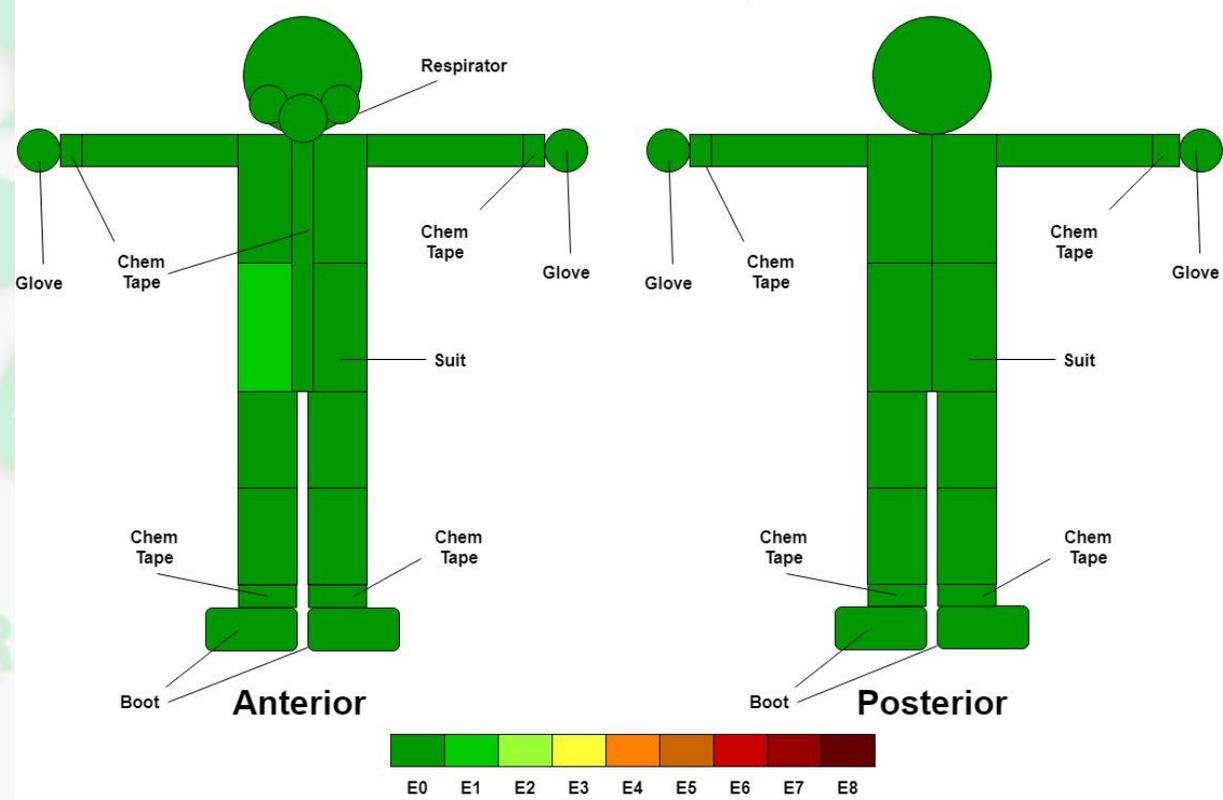
● Denotes Inoculation Spots



Electrostatic Sprayer 2 minute spray - Positive Control Mannequins



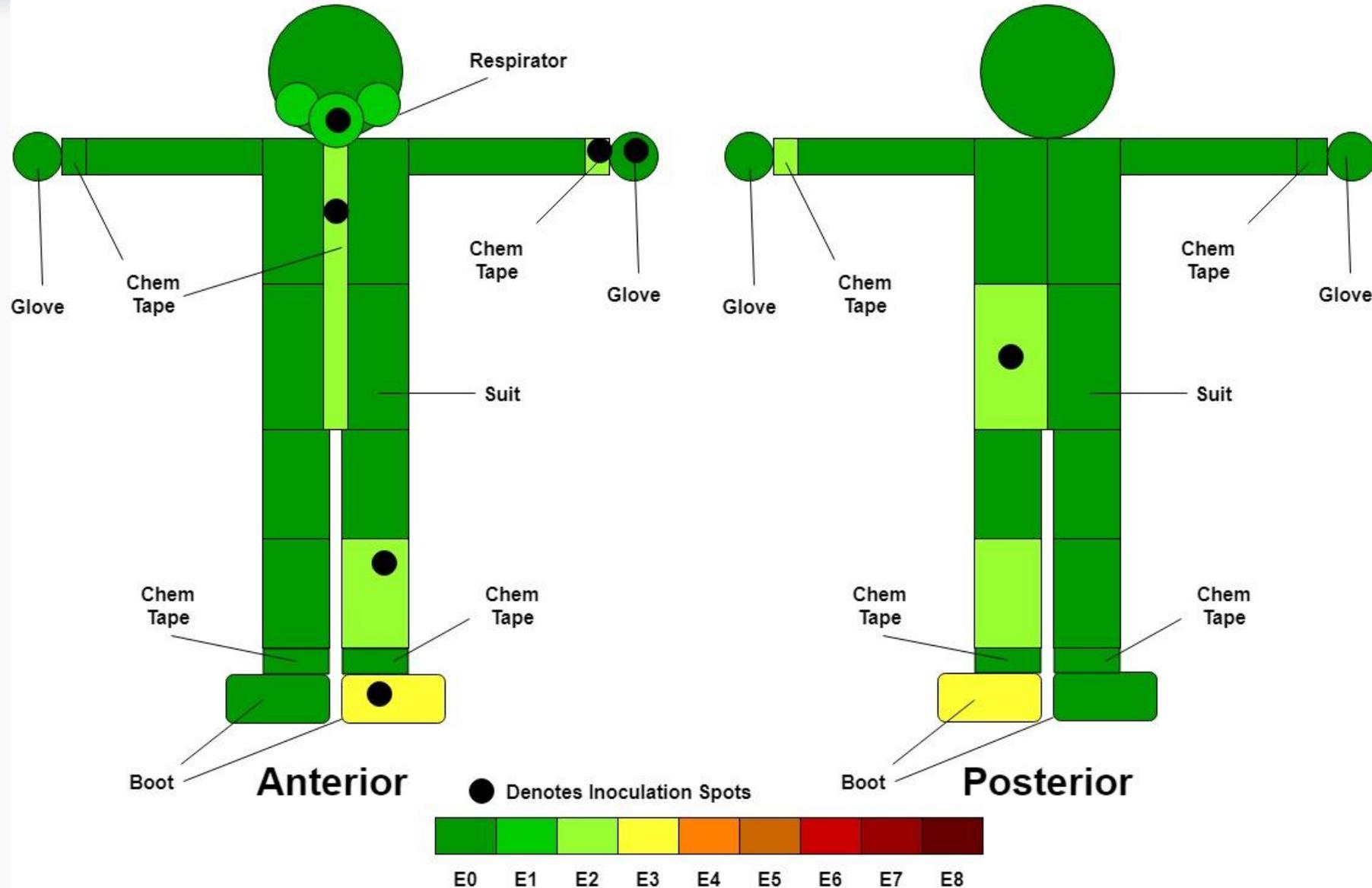
Electrostatic Sprayer 4 Minute Spray - Field Blank Mannequin



# “Preliminary” Results – Mannequin Decon

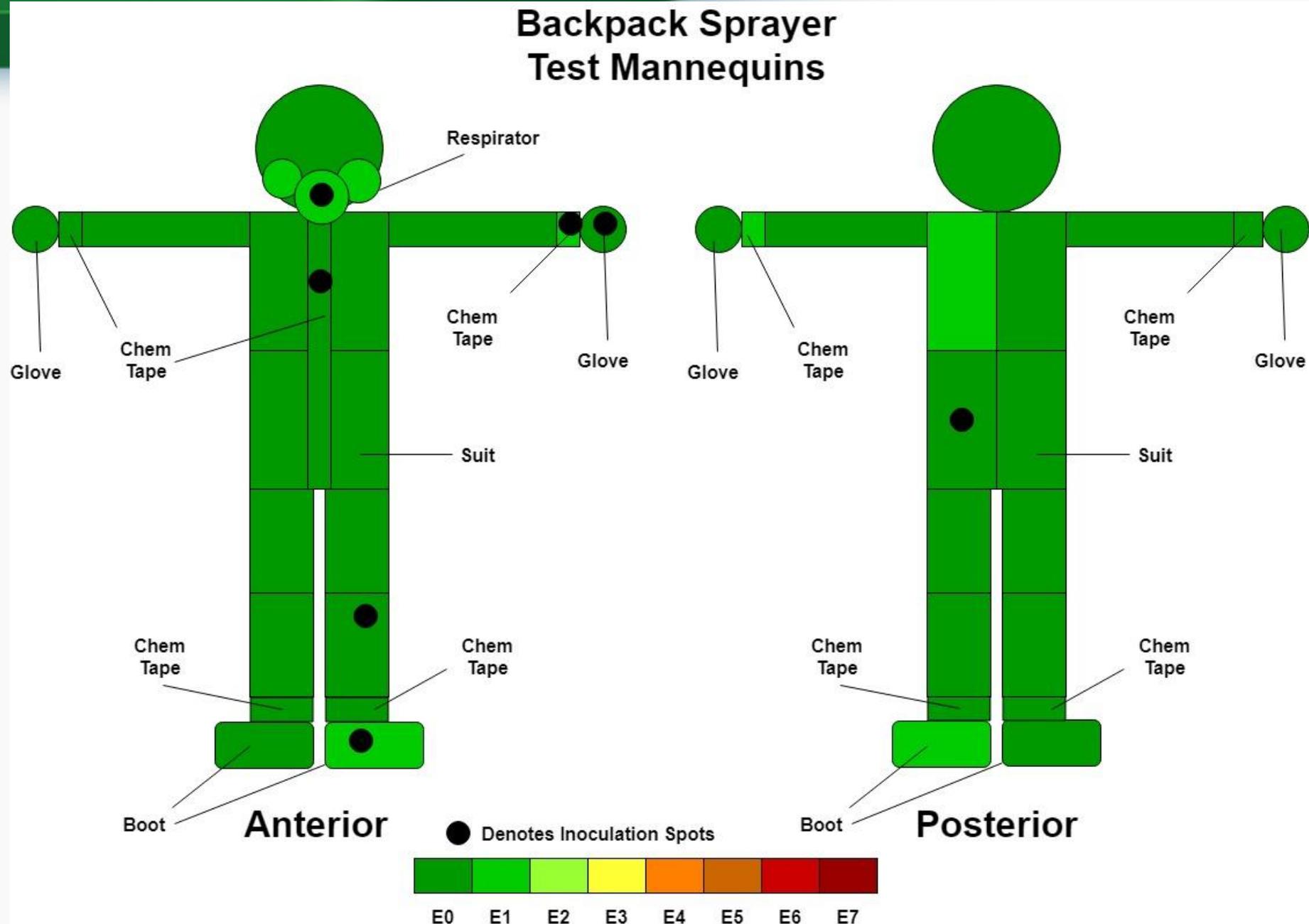
## Traditional Sprayer Liquid Inoculation

### Backpack Sprayer 2 Minute Spray - Test Mannequins



# “Preliminary” Results – Mannequin Decon

## Traditional Sprayer Aerosol Inoculation

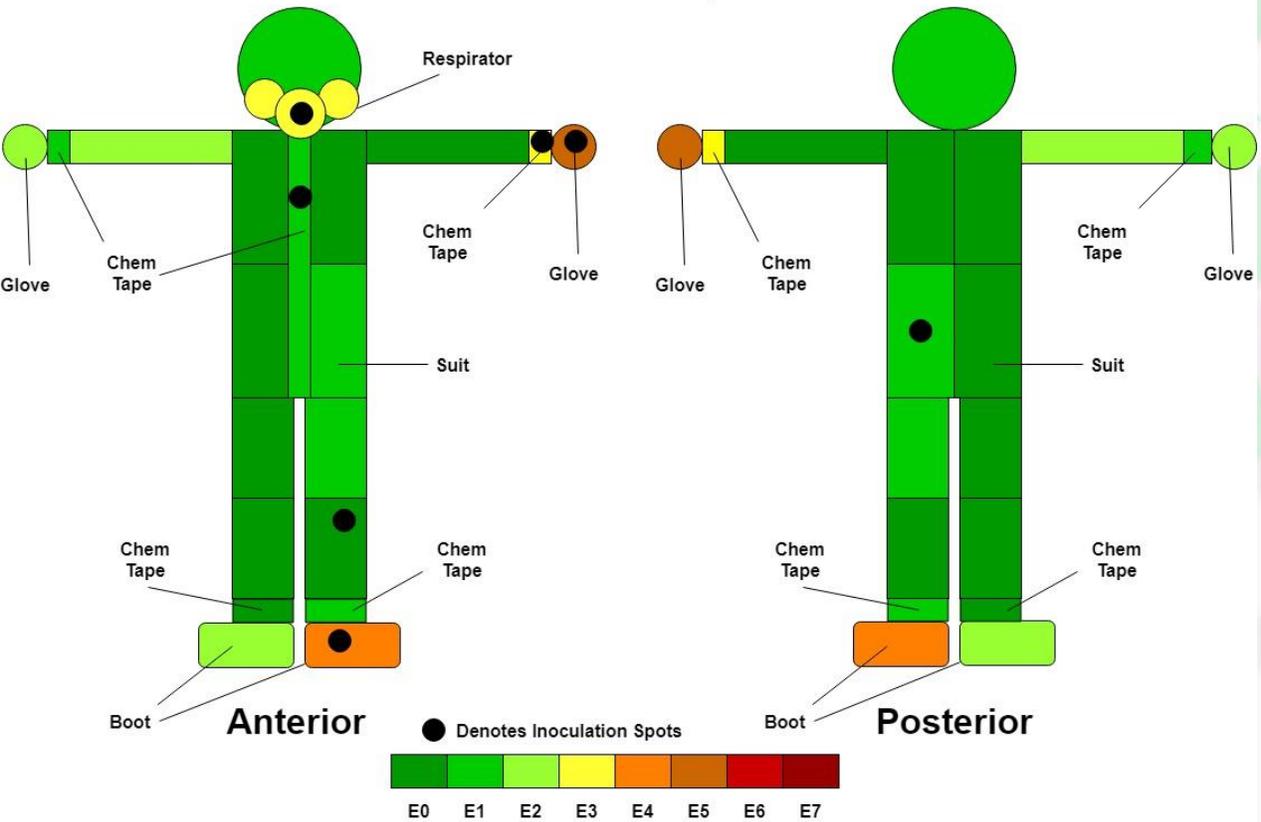




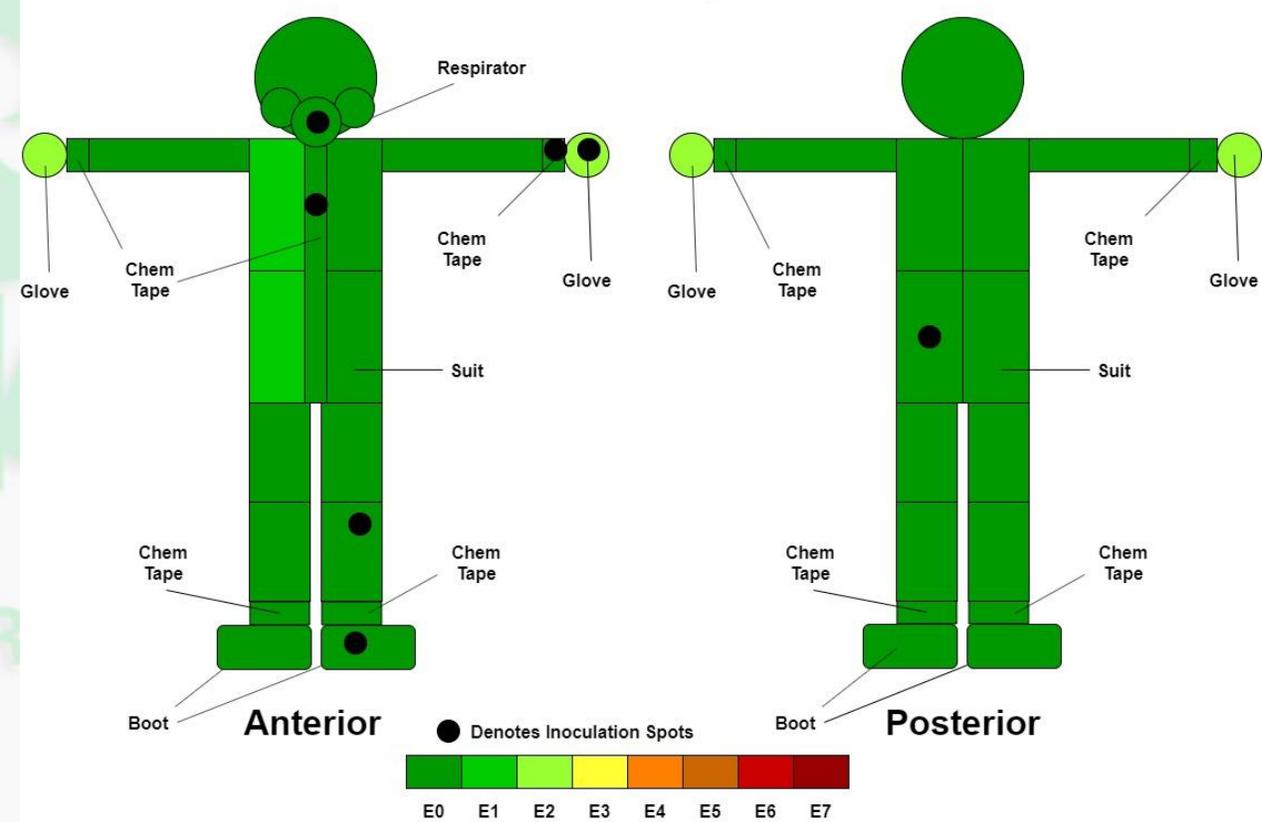
● Denotes Inoculation Spots

# “Preliminary” Results – Mannequin Decon Electrostatic Sprayer - Aerosol Inoculation

Electrostatic Sprayer 2 Minute Spray -  
Test Mannequins



Dry Deposition Electrostatic Sprayer 4 Minute Spray -  
Test Mannequins



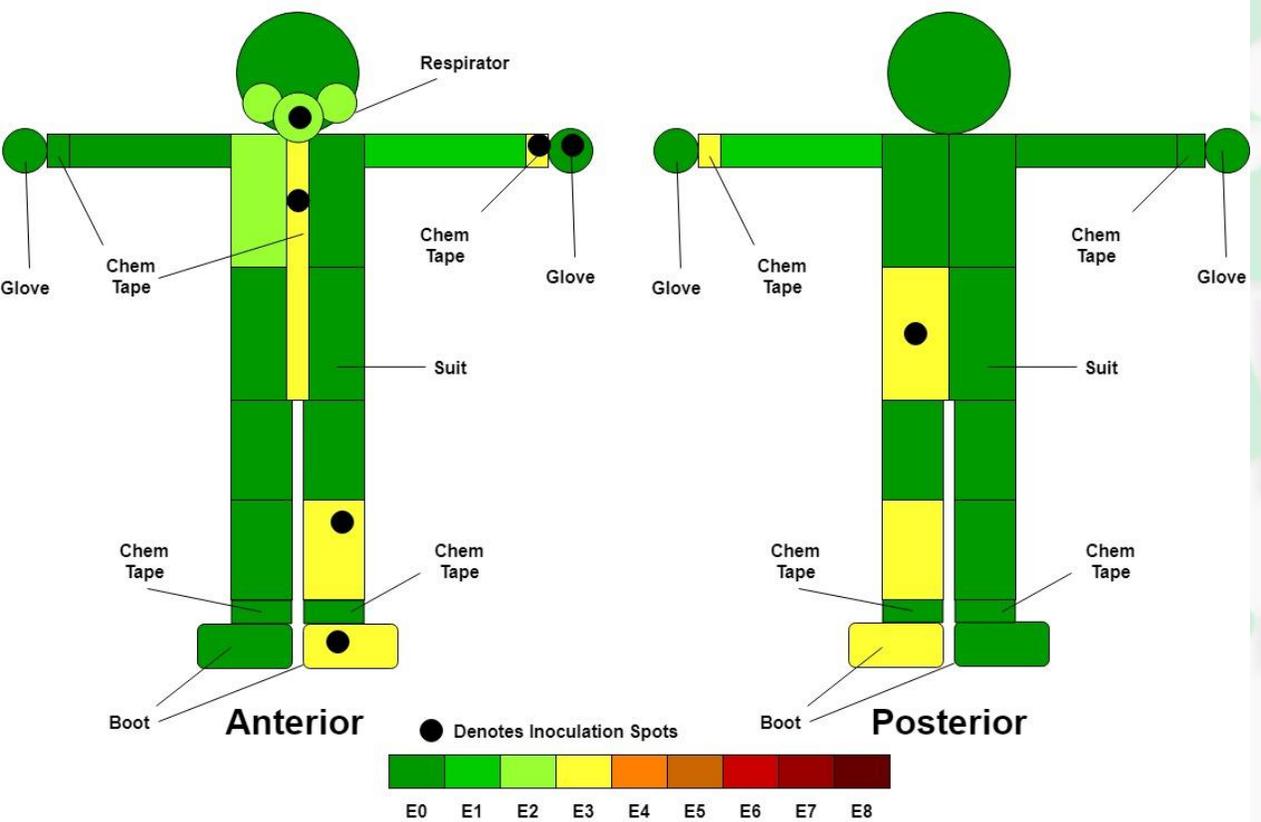


● Denotes Inoculation Spots

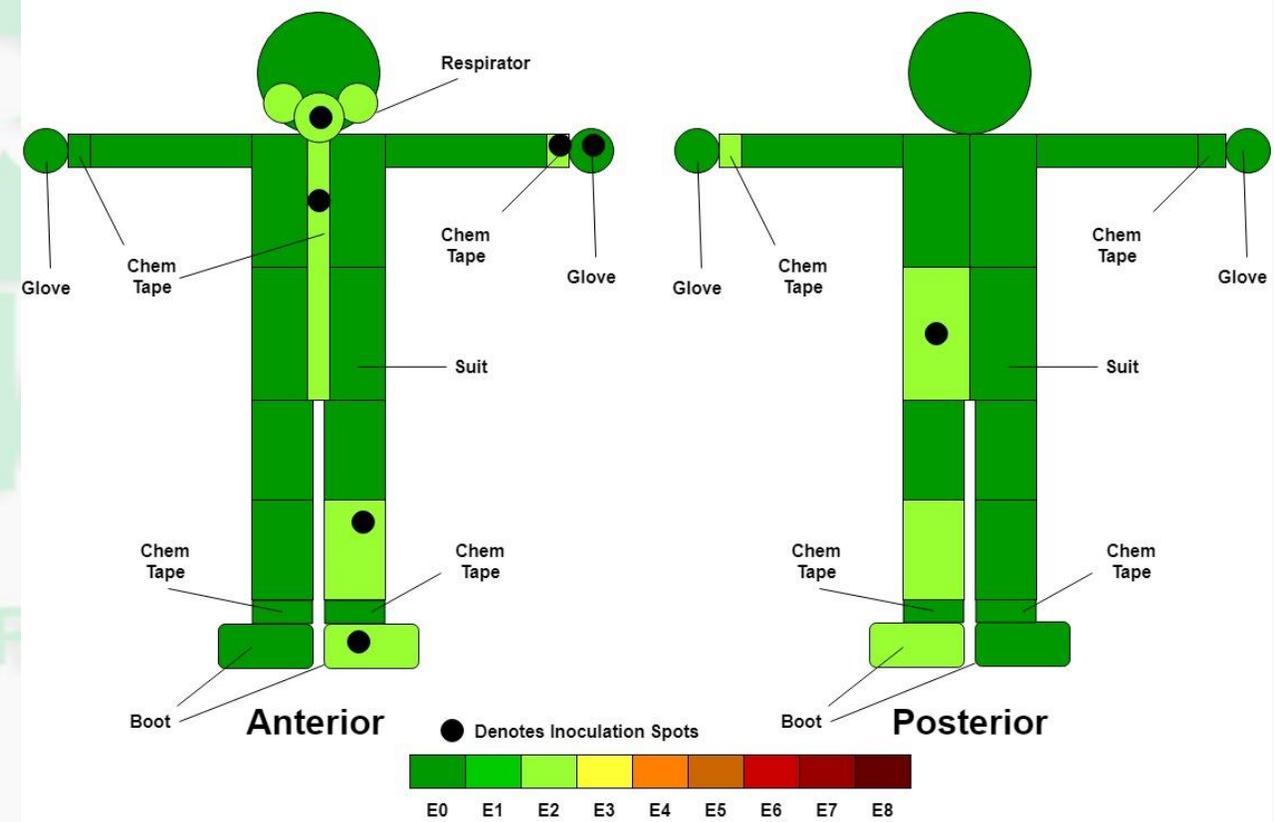
# Results – Mannequin Decon

## Electrostatic Sprayer - Liquid Inoculation

Electrostatic Sprayer 2 Minute Spray - Test Mannequins



Electrostatic Sprayer 4 Minute Spray - Test Mannequins



# Results – Mannequin Decon

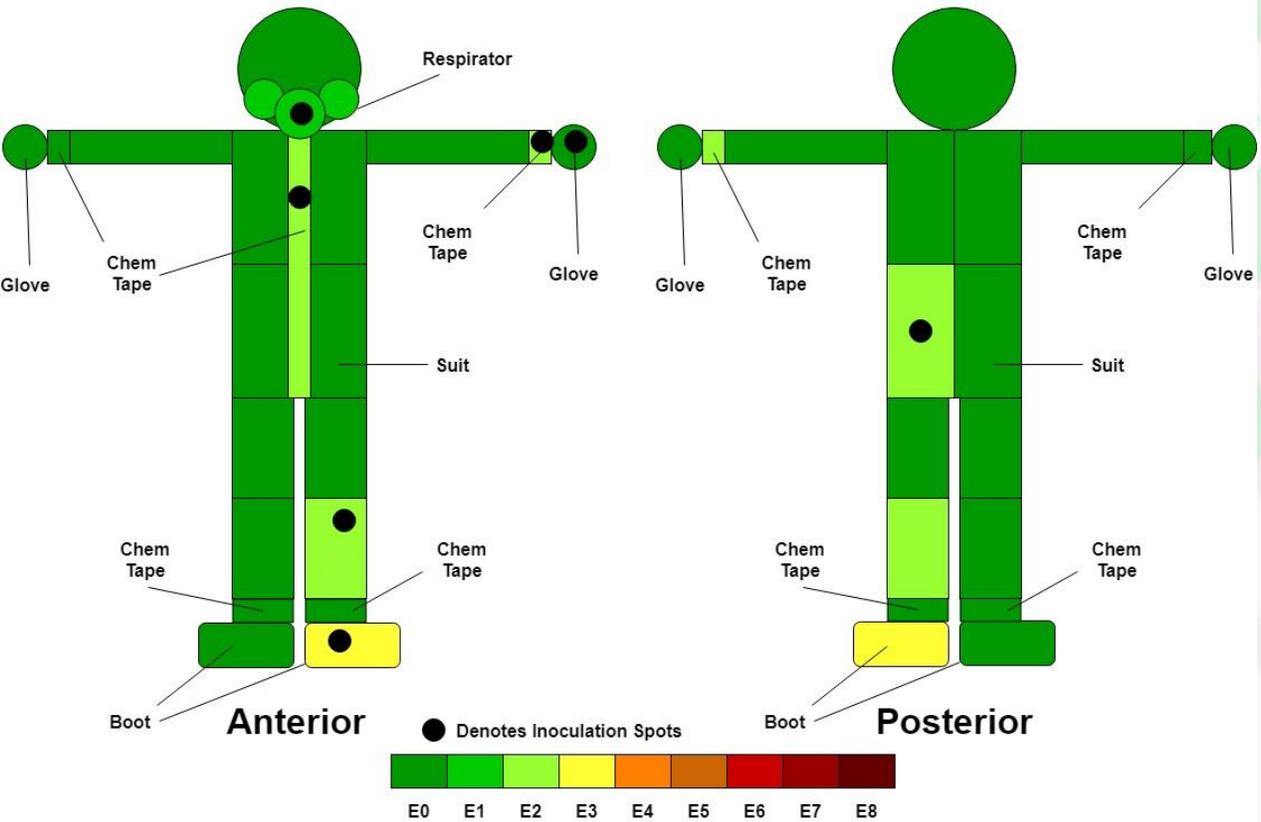
## Traditional (TS) vs Electrostatic (ES)

### Liquid Inoculation – 2 min

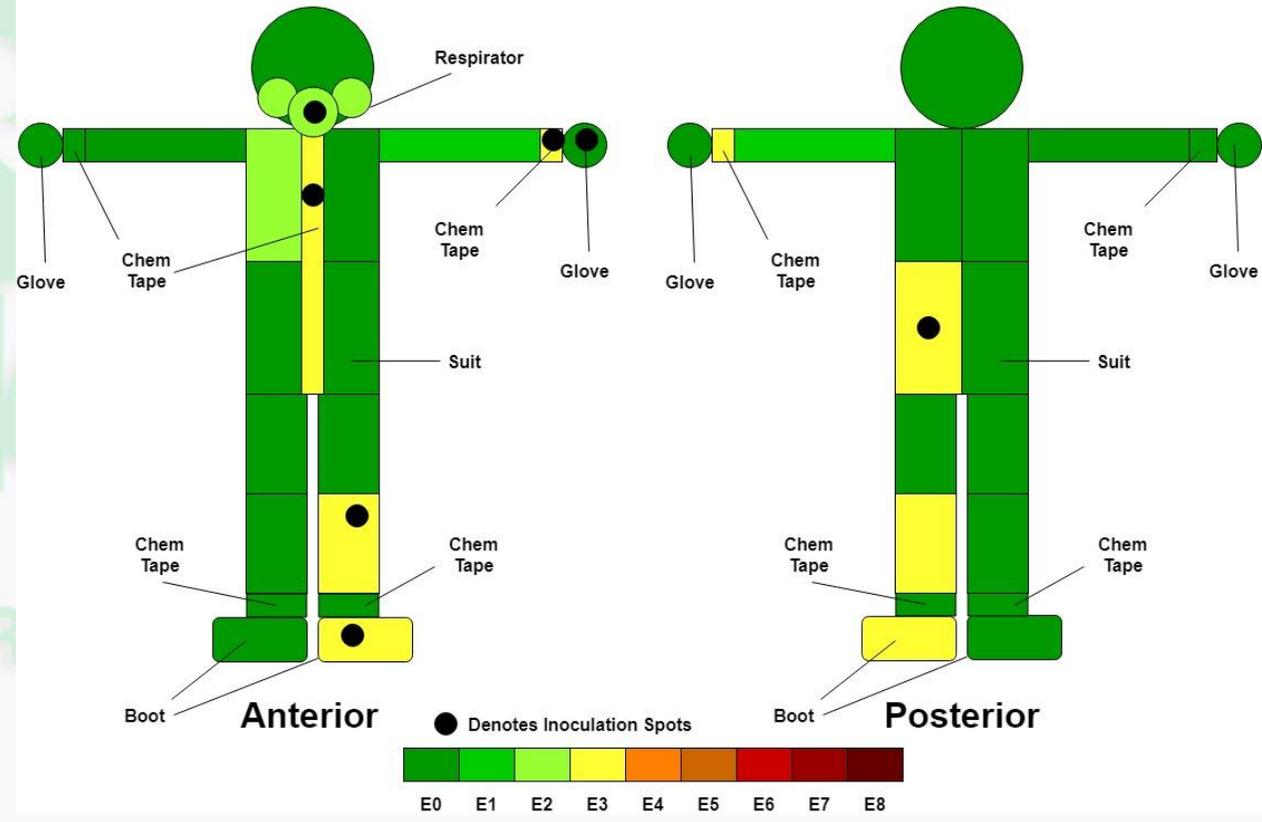


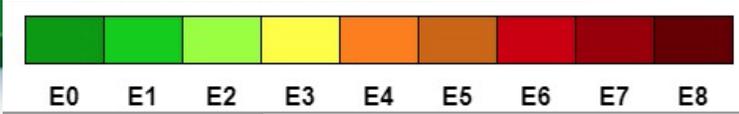
● Denotes Inoculation Spots

Traditional Backpack Sprayer 2 Minute Spray -  
Test Mannequins



Electrostatic Sprayer 2 Minute Spray -  
Test Mannequins





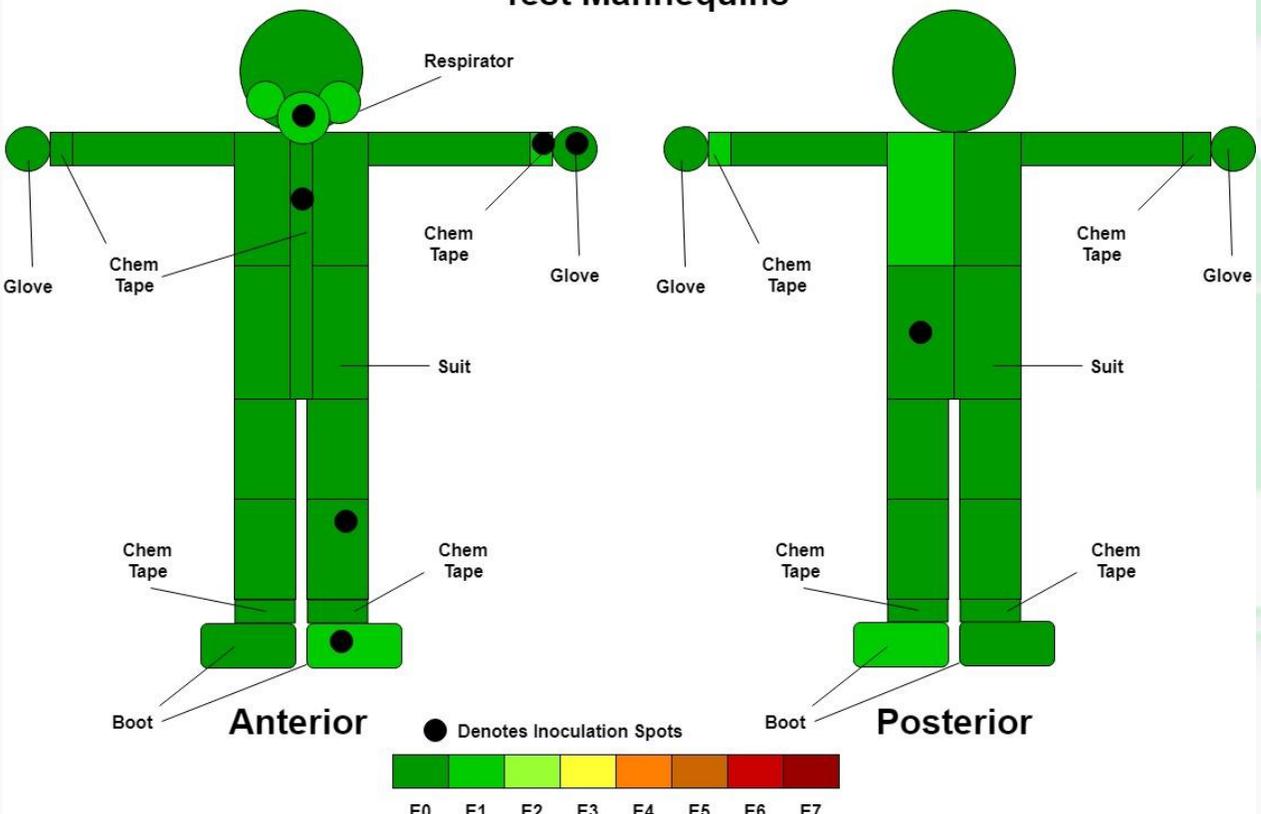
● Denotes Inoculation Spots

# Results – Mannequin Decon

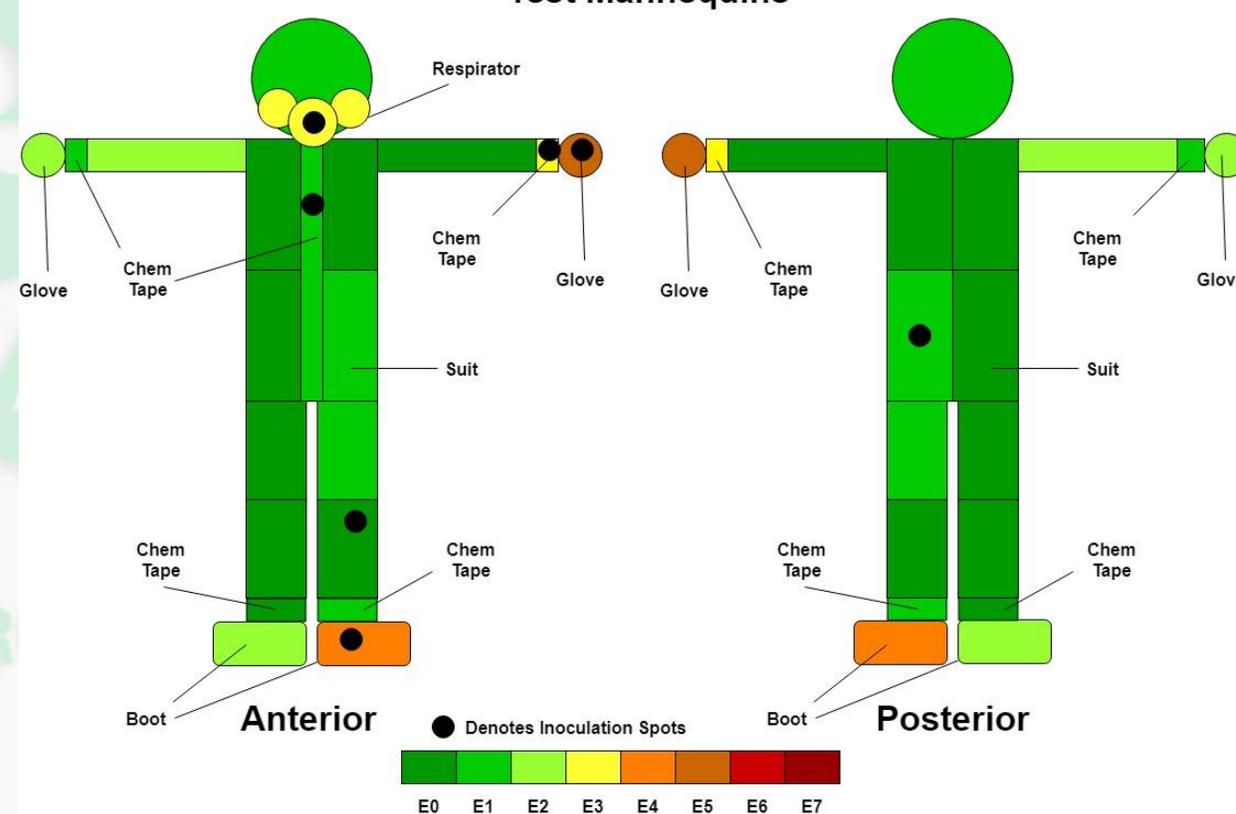
## TS vs ES

### Aerosol Inoculation – 2 min

**Traditional Backpack Sprayer  
Test Mannequins**



**Electrostatic Sprayer  
Test Mannequins**



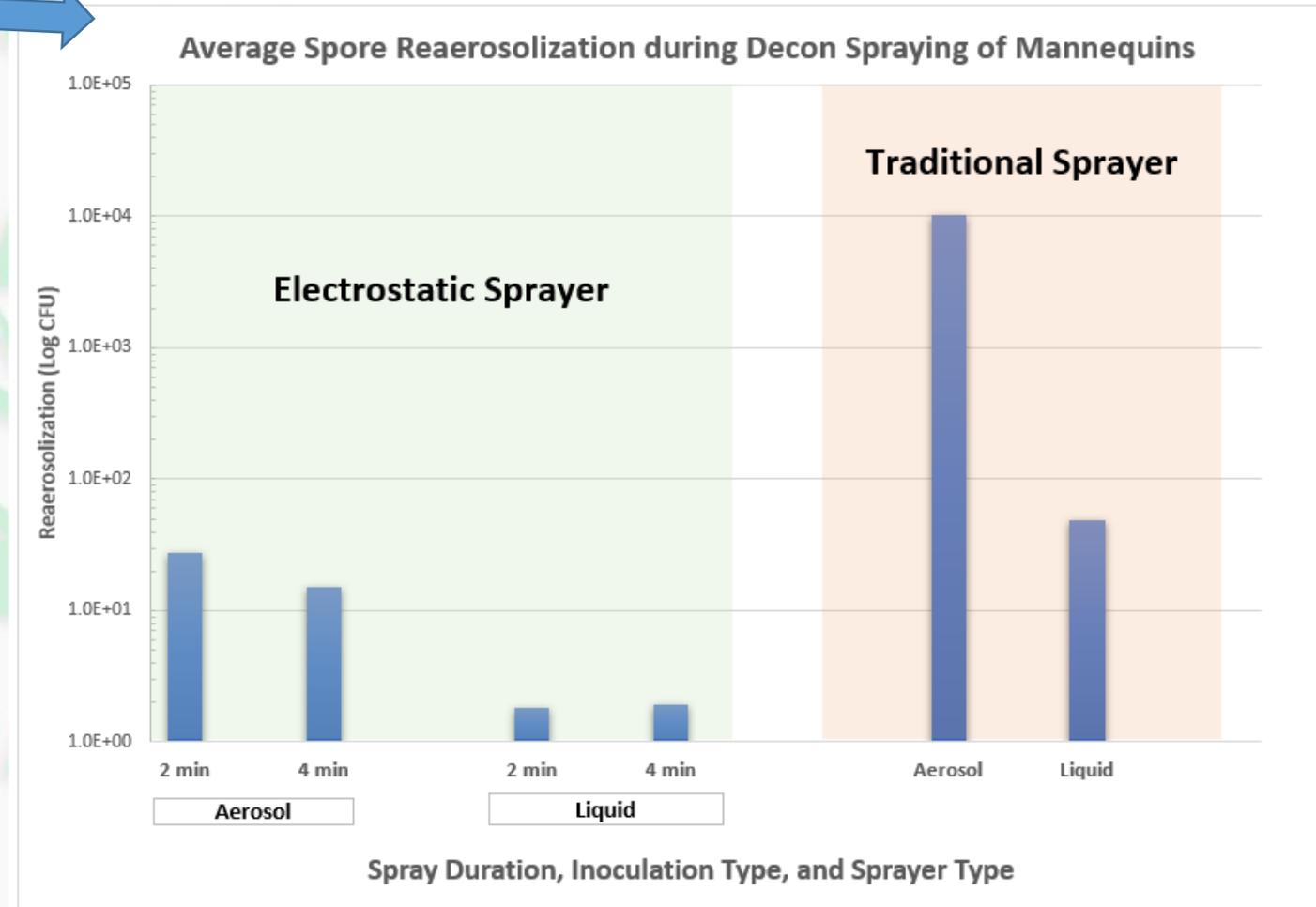
# “Preliminary” Results – Fate and Transport

## 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
  - Minimal spores detected in runoff – no immediate neutralization as in coupon study



# Summary of Results – Mannequin Testing

- Both types of decon sprayers (ES and TS) 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
- ES performed well, but had a few “hot spots” without full decon, due to creasing in PPE material
  - Increasing spray time from 2 min to 4 min reduced hot spots post-decon for ES
- **Reaerosolization** with traditional sprayer was several orders of magnitude higher than electrostatic sprayer ( $10^4$  vs minimal spores)
- **Runoff** from TS was ~ 1 liter 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
- 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 cross contamination

# Contact Info

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