

Cleaning of Personal Protective Equipment and Laundry Contaminated by Viruses

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BACKGROUND

The COVID-19 pandemic illuminated gaps in viral disinfection data for personal protective equipment (PPE) and materials typically laundered at home. In response, EPA's Homeland Security Research Program (HSRP) launched research testing different disinfectants and cleaning methods' efficacy at reducing bacteriophages Phi6 and MS2 on different materials. HSRP is currently focused on expanding the laundering dataset for the general population in preparation for disease-causing incidences that require shelter-in-place and cleaning of clothing.

METHODS

Coupon Test Matrix

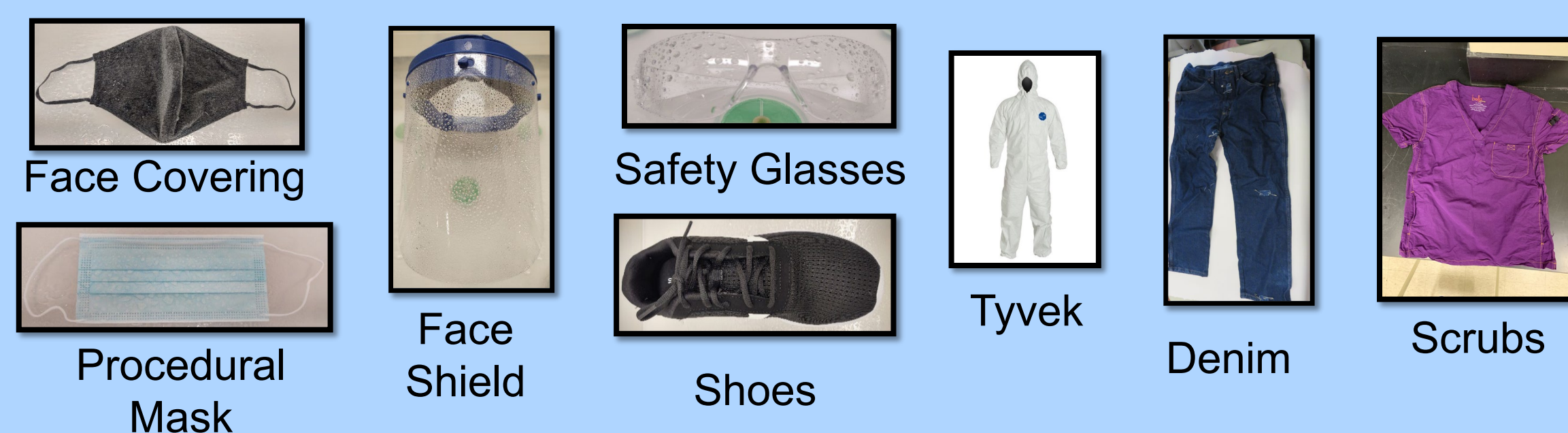
PPE Item	Cleaning method				
	LCHPV	Laundering	Bleach	IPA	QAC
Non-specialized Respiratory Protection					
Face covering	x	x	x	x	x
Procedural mask	x		x	x	x
Face and Eye Protection					
Face shield			x	x	x
Safety glasses			x	x	x
Specialized Body Protection					
Tyvek coveralls		x	x	x	x
Non-specialized Body Protection					
Medical scrubs		x			
Denim		x			
Shoes	x	x	x	x	x

LCHPV = Low Concentration Hydrogen Peroxide Vapor

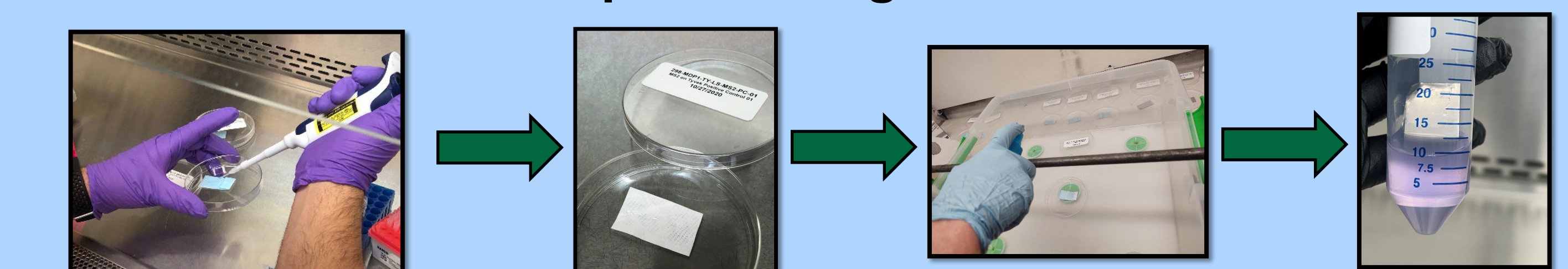
IPA = Isopropyl Alcohol Wipe

QAC = Quaternary Ammonium Compounds

Materials



Coupon Testing Process



PFU = plaque forming units

All tests included inoculation controls, positive controls, test samples and procedural blanks. Tests were first performed at bench-scale with small pieces of the PPE. For QAC and Laundering full-scale PPE items were also tested with small contaminated coupons pinned on.

Detailed steps are available in our publications:

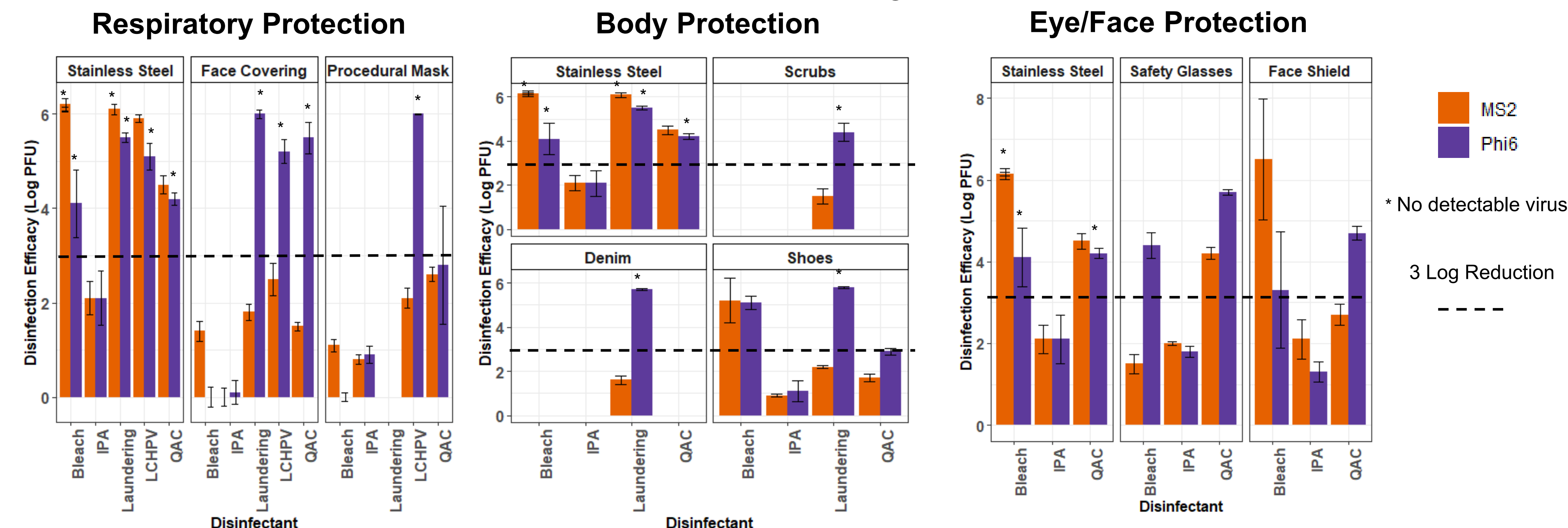
Archer, J., Mikelonis, A., Wyrzykowska-Ceradini, B., Morris, E., Sawyer, J., Chamberlain, T., ... & Touati, A. (2023). Evaluation of disinfection methods for personal protective equipment (PPE) items for reuse during a pandemic. *Plos one*, 18(7), e0287664. <https://doi.org/10.1371/journal.pone.0287664>



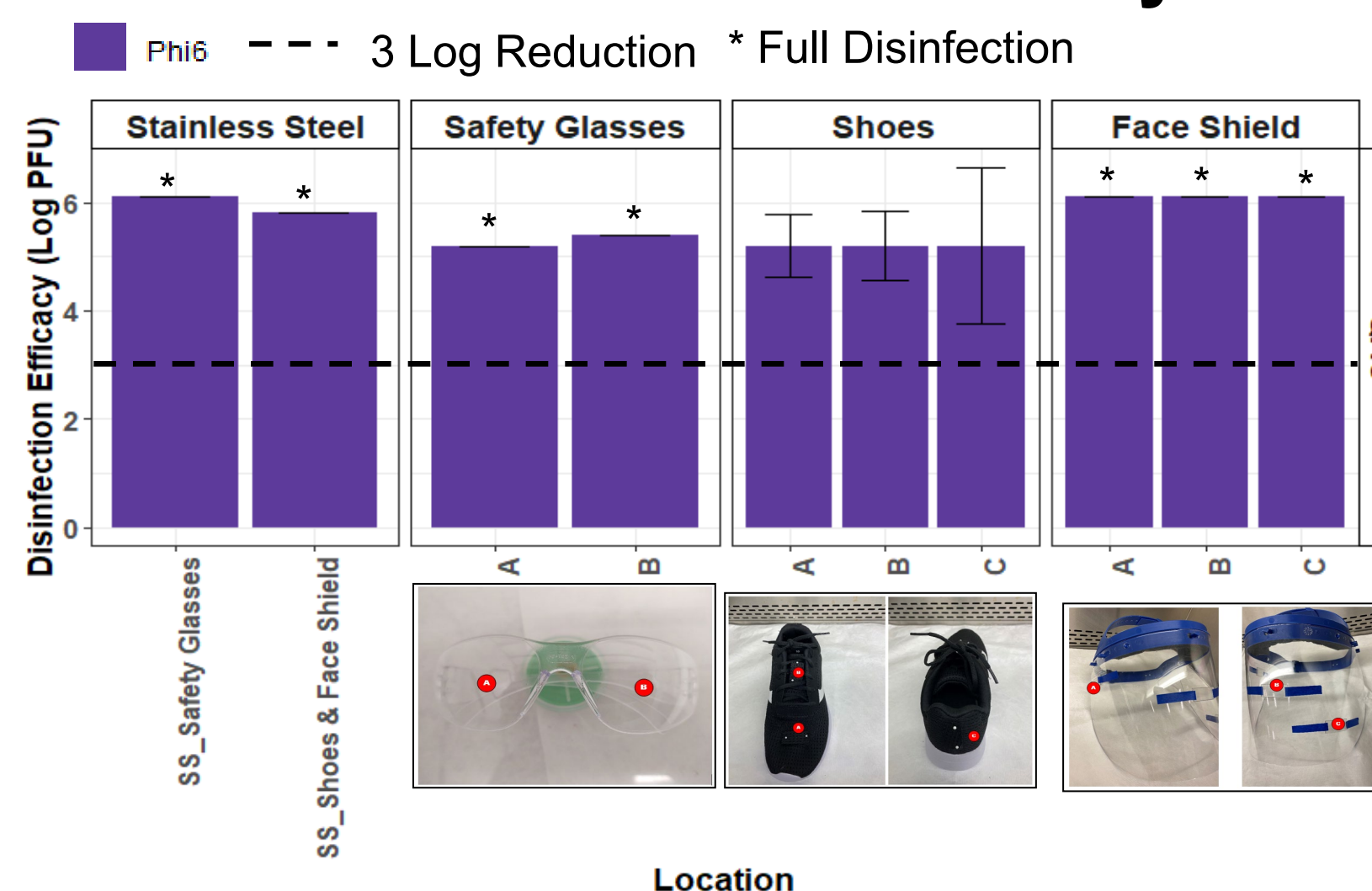
Mikelonis, A., Archer, J., Wyrzykowska-Ceradini, B., Morris, E., Sawyer, J., Chamberlain, T., ... & Touati, A. (2022). Determining Viral Disinfection Efficacy of Hot Water Laundering. *JoVE (Journal of Visualized Experiments)*, (184), e64164. <https://doi.org/10.3791/64164>

RESULTS

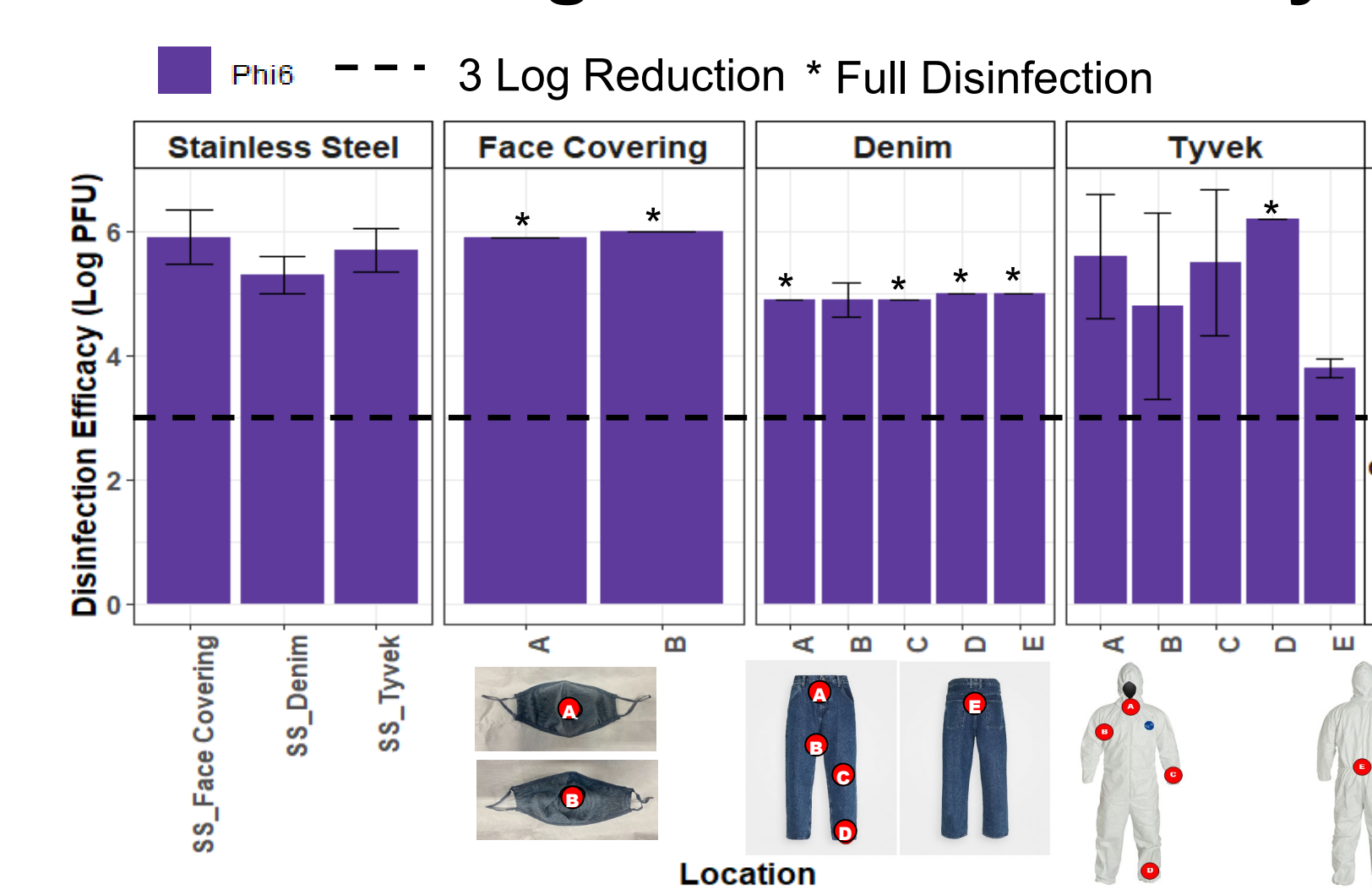
Coupon Efficacy



QAC Full-Scale Efficacy



Laundering Full-Scale Efficacy



DISCUSSION

Coupons

- None of the methods achieved 3 log reduction for MS2 contaminated respiratory protection, denim, or scrubs.
- Bleach had better efficacy on non-porous items.
- IPA showed limited effectiveness in wipe form compared to 3 Log reduction goal.
- Laundering (washing + drying) was effective for all items contaminated by Phi6, but only stainless-steel controls for MS2.
- LCHPV was effective against Phi6, but ineffective at test conditions for MS2.
- QAC was effective for three types of items, but residual odor may preclude use.

Full-Scale

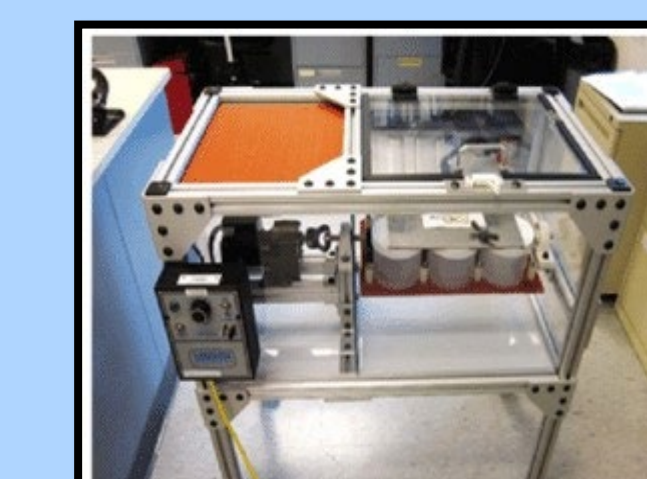
- For items tested, full-scale efficacy results was comparable to coupon results.
- For laundering there was more variation in results for Tyvek (perhaps due to size of the PPE item), but all replicates achieved 3 log disinfection efficacy.
- For QAC there was more variation in results for shoes, but all replicates achieved 3 log disinfection efficacy.

DISCLAIMER
The United States Environmental Protection Agency (EPA), through its Office of Research and Development, funded and managed the research described. This presentation was peer and administratively reviewed and has been approved for presentation as an Environmental Protection Agency document. It does not necessarily reflect the views of the Environmental Protection Agency. No official endorsement should be inferred. This presentation includes photographs of commercially available products. The photographs are included for purposes of illustration only and are not intended to imply that EPA approves or endorses the product or its manufacturer. EPA does not endorse the purchase or sale of any commercial products or services.

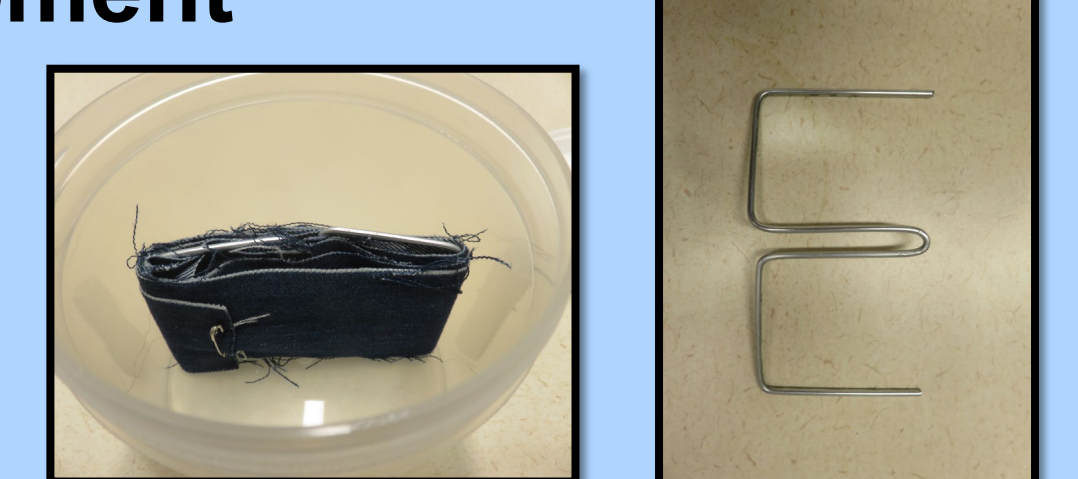
ONGOING LAUNDERING RESEARCH

While the research during the COVID-19 pandemic had a broad scope, laundering is the focus of current research. The project team is augmenting the laundering capabilities at EPA's Research Triangle Park campus by building a tumbler that allows for tests to be performed in line with EPA's Office of Chemical Safety and Pollution Prevention's Product Performance Test Guideline 810.2400 Disinfectants and Sanitizers for use on Fabrics and Textiles – Efficacy Data Recommendations. In recent years, these guidelines have been used to approve multiple laundering additives for sanitizing/disinfecting which will be tested in this work.

Updated Equipment



- ASTM E2274 compliant
- Holds 9 bottles
- Rotates at 60 RPM



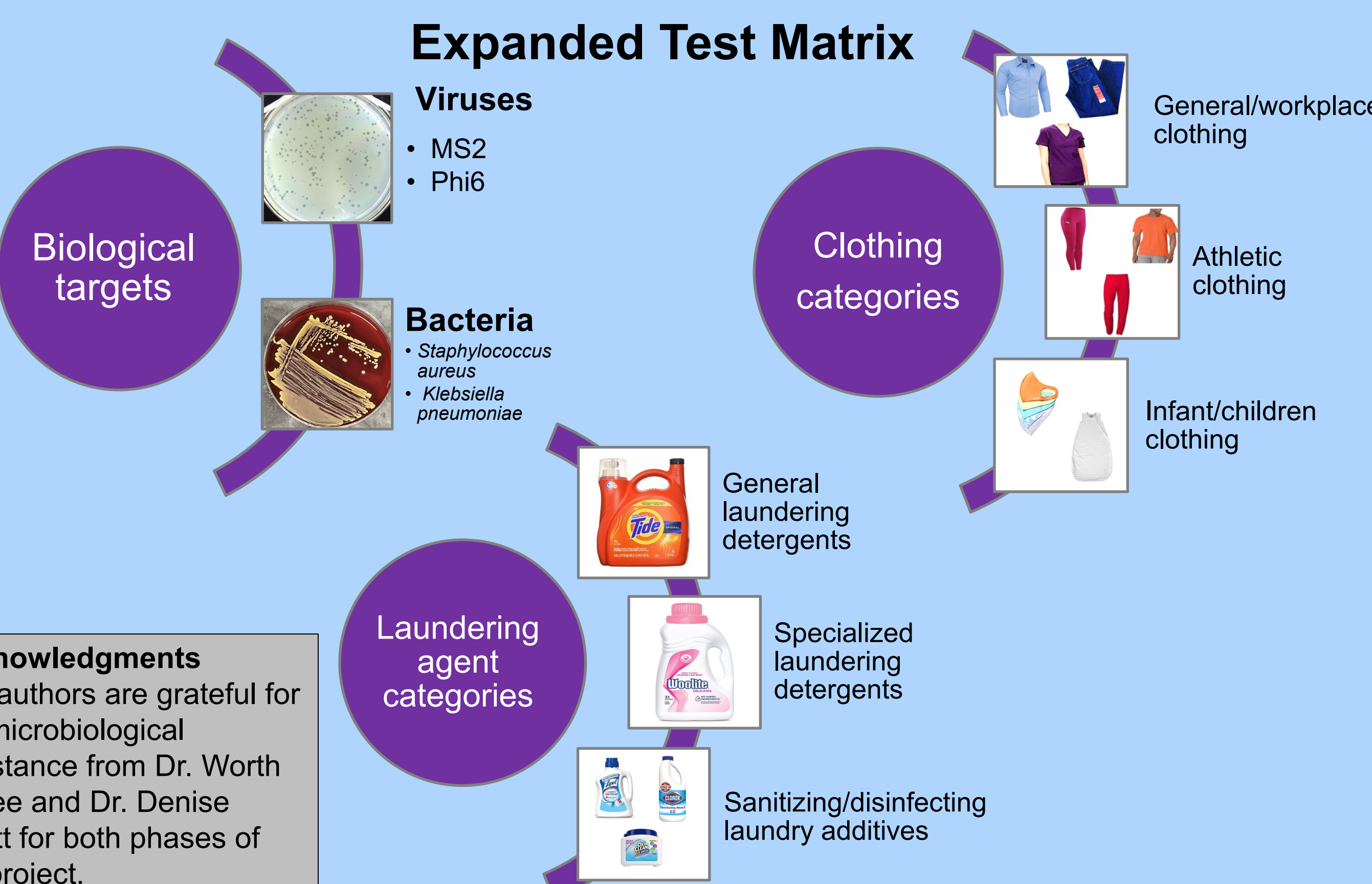
Spindles

Expanded Washing Procedures

- Baseline: 40 min 20 °C machine wash + 20 min rinse
- Hot water machine wash + machine rinse + hot machine drying
- Hot water machine wash + bleach sanitizing rinse + hot machine drying
- Warm/hot machine wash with OxiClean disinfecting/sanitizing addition + machine rinse + cool/hot machine drying
- Hot water machine wash + Lysol sanitizing addition + hot machine drying
- Bleach soak + hot water machine wash + rinse + hot machine drying
- OxiClean soak + warm water machine wash + rinse + cool air machine drying
- Cold water machine wash + machine rinse + cool air machine drying
- Cold water machine wash + machine rinse + air drying
- Water-only machine wash + no rinse + air drying
- Bleach soak + hand-rinse + air drying
- Cold hand wash + hand rinse + air drying



High efficiency washing machine ratio of wash solution to fabric



Acknowledgments
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*Tumbler Image from: Farcas, D., Blachere, F.M., Kashon, M.L. et al. Survival of *Staphylococcus aureus* on the outer shell of fire fighter turnout gear after sanitation in a commercial washer/extractor. *J Occup Med Toxicol* 14, 10 (2019). <https://doi.org/10.1186/s12995-019-0230-4>