



What's on the Surface Doesn't Stay on a Surface

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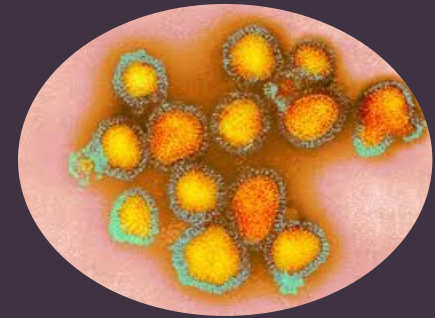
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Outline

- Importance of fomites in disease transmission
- Dynamics of resuspension of microbes into the air
- Resuspension of microbes by human activities (walking, sitting, etc.)
- -Examples of rapid movement of virus tracers in the built environment and impact of interventions
- -Risk assessment of fomite transmitted pathogen
- Mobile devices



Role of fomites in transmission of a disease



Pathogen falls on fomites
e.g. phone, computer

Person picks up pathogen
through contaminated fomite.

Person touches nose or eyes
with Contaminated fingers and
Becomes infected with pathogen.



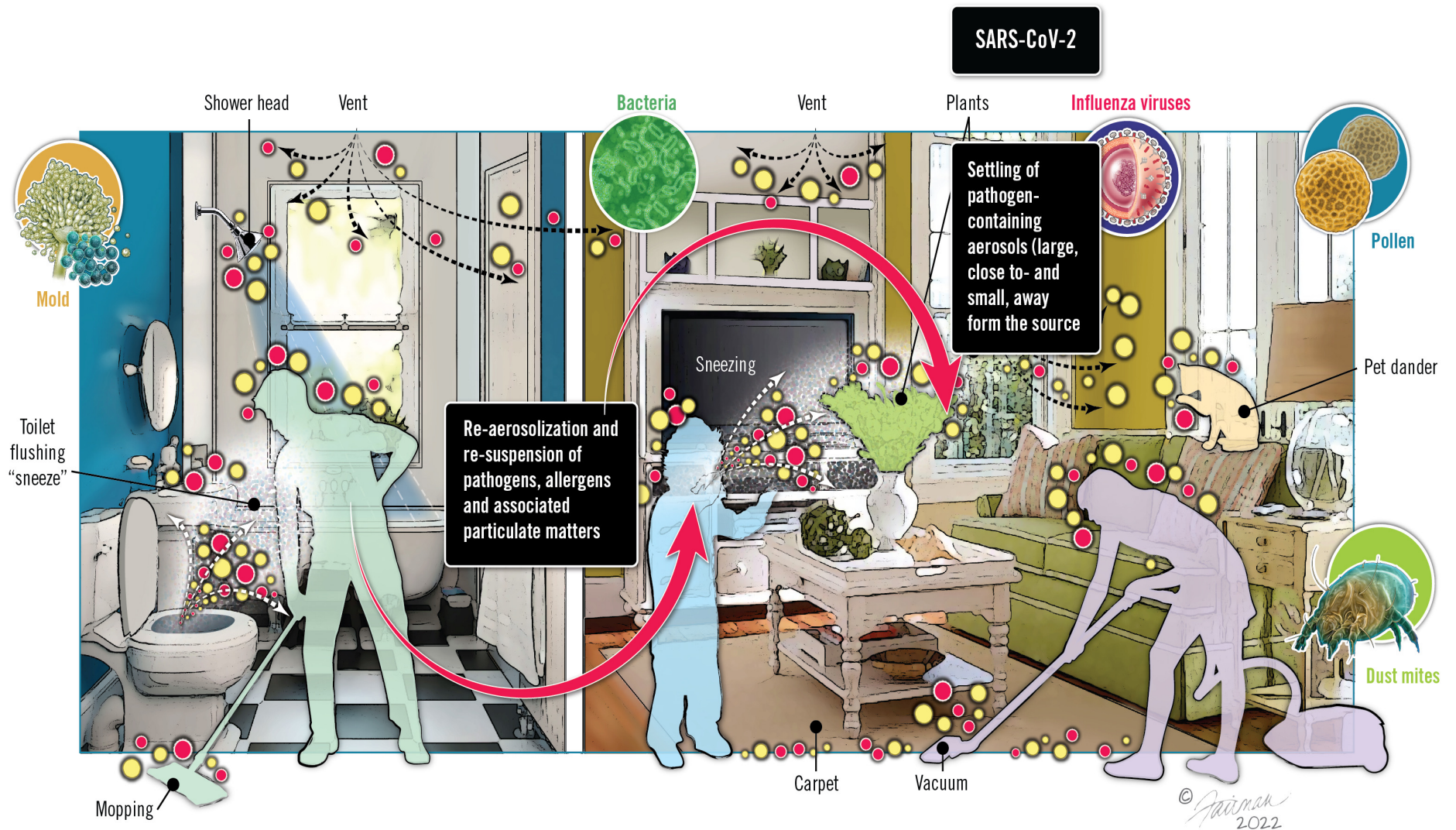
Sick person sneezes, coughs and pathogens
falls on fomite or get aerosolized.

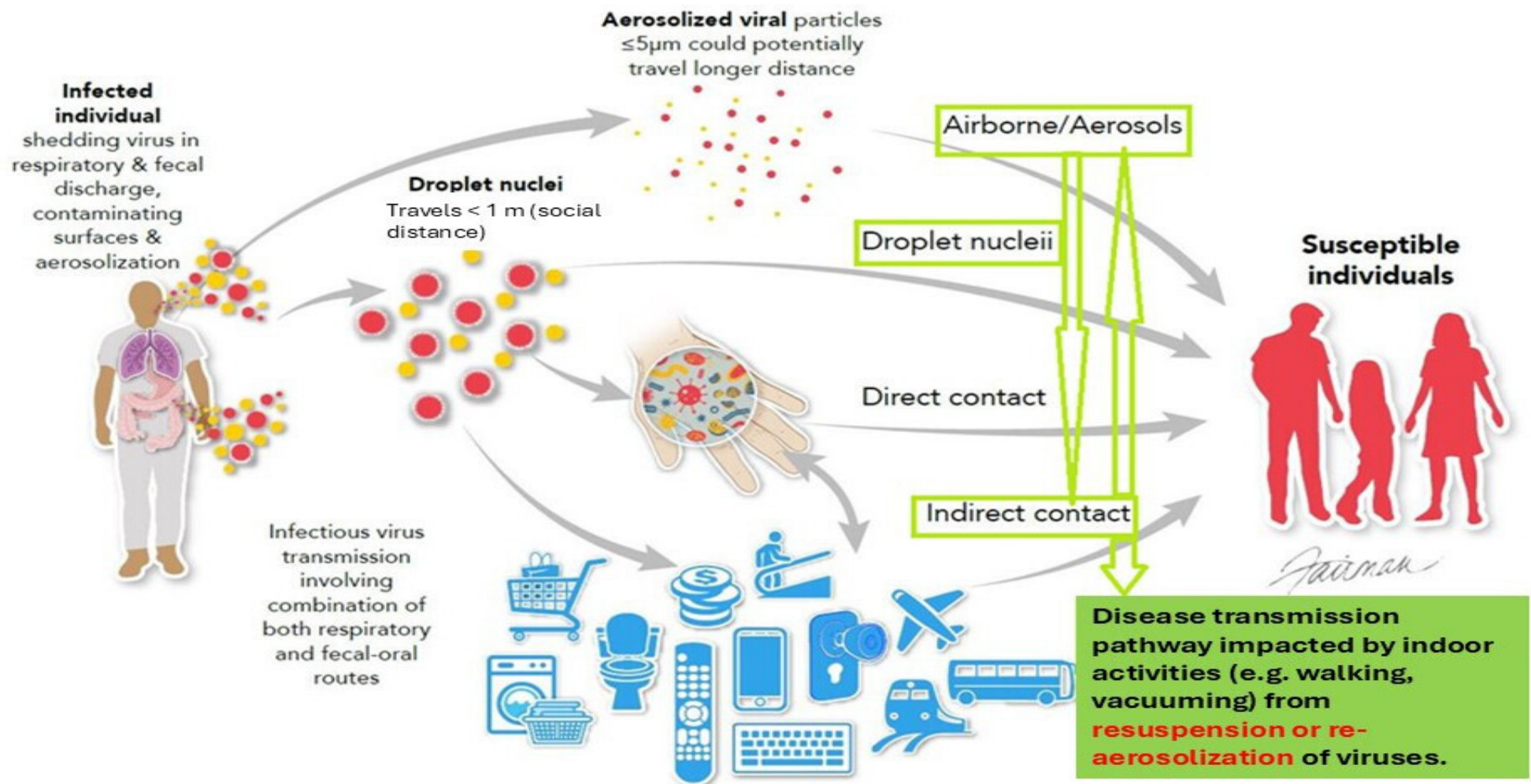


Diseases Spread Through Hand Contact on a rapid rate in the built environment

- Every three minutes, a child brings his/her hand to nose or mouth
- Every 60 seconds, a working adult touches as many as 30 objects







Origins of Indoor Environment Bioaerosols

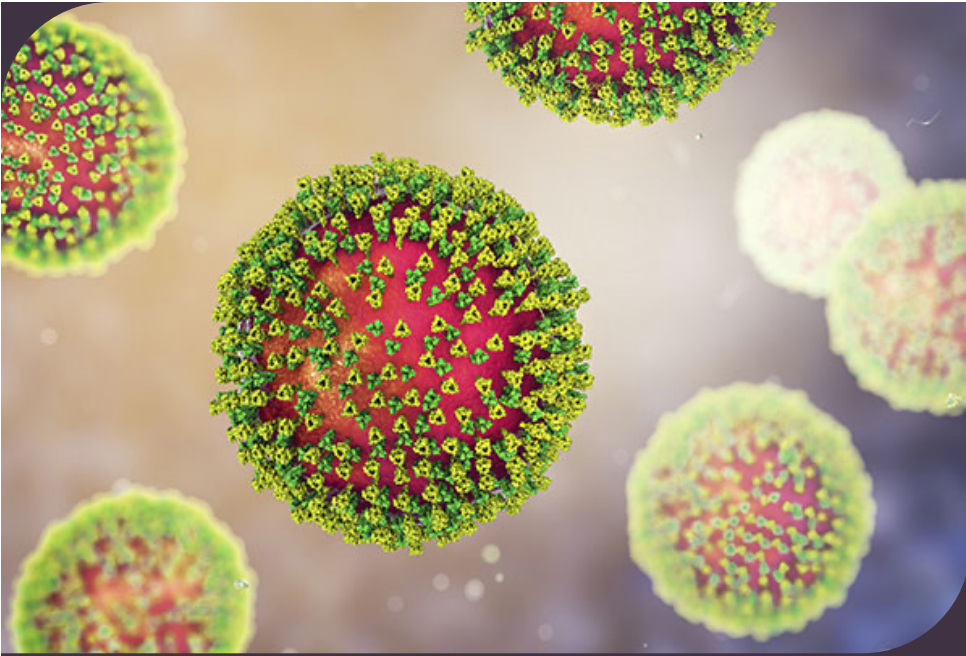
RESIDENTIAL HOMES: (MAJOR INDOOR SOURCES)

- human occupants
- pets
- house dust - microbes can accumulate and grow on dust particles, house dust is a potential source of bioaerosols
- Fungi (outdoor source)
- Heating
- ventilation and air-conditioning (HVAC) system.

HUMAN BODIES

- generate bioaerosols directly through activities:
 - talking,
 - sneezing,
 - coughing,
- Generate bioaerosols indirectly
 - washing,
 - flushing toilet,
 - Sweeping/vacuuming floor
 - walking





Airborne pathogen transmission

- **Airborne transmission of pathogens or disease is a known public health threat.**
- Indoor aerosols and viral droplet transmission risks are influenced by 4 factors:
 - 1) Aerosol or droplet properties.
 - 2) Indoor air flow
 - 3) Virus - specific factors
 - 4) Host – specific factors.

Re-aerosolized particles size

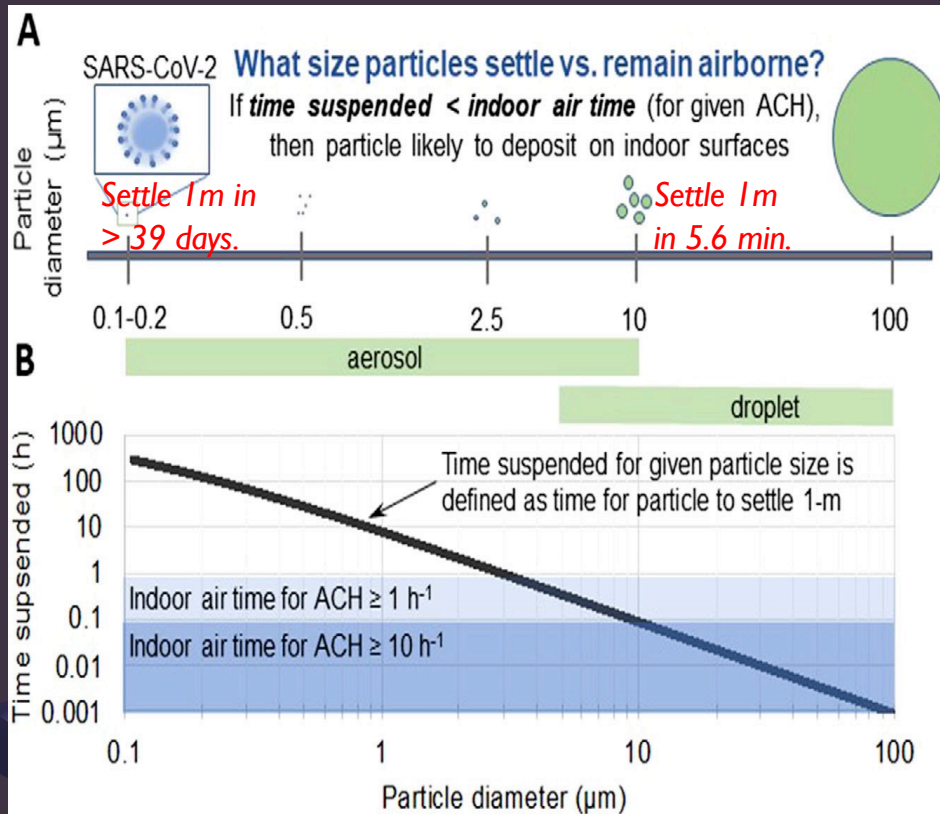


Figure: Kohanski et al . 2020

- Large droplet size >10 μm can travel short distances and deposit on surrounding surfaces in seconds or minutes.
 - Infection is possible after contact with contaminated surface and self inoculation of eyes, nose or mouth.
 - Particles/ droplet larger < 10 μm can deposit in the upper airway.
- Small particle size (< 2.5 μm) can stay aerosolized.
 - Particles can be inhaled and then cause infection or reinfection.
 - Can deposit in the lower airway (lung bronchial and alveoli).

Resuspension studies using bacterial virus MS2

Goal – to assess spread from one fomite to another

- MS2 same shape and size as rhinovirus (common cold virus) and norovirus
- Non-infectious to humans
- Has been used in many studies to trace virus movement in public facilities (hospitals, homes, offices)
- Contaminate fomite: carpet, Wood flooring, cotton curtain, plastic shower curtain, office chair and den/ living room chair.
- Settle plates to collect assess settling on others surfaces and transmission via fomites re-suspended virus after various activities (walking, vacuuming. and sitting).



Fine dust > 10 um

Shoes and Microbial Transport

- Germ viewpoint
 - Shoes are made for walking



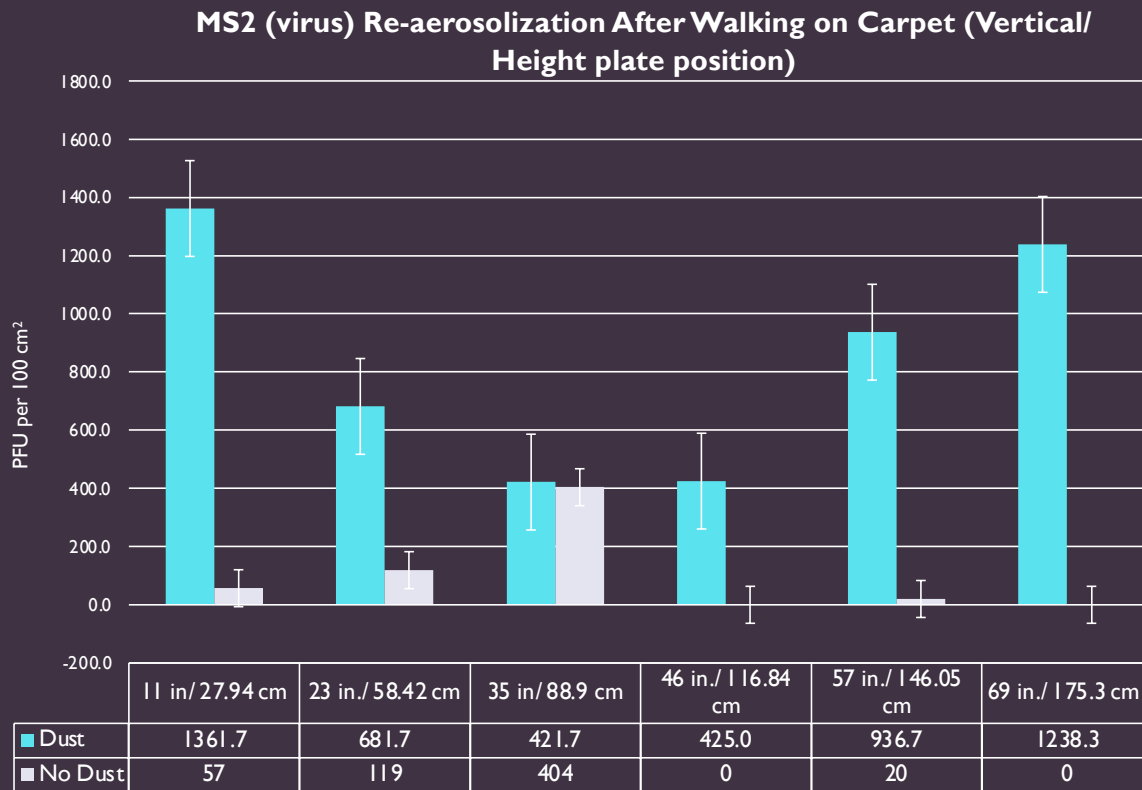
| Left Shoe | | Right Shoe | |
|-----------|---------------------|-------------------|--|
| 1 | 1,000 66,000,000 | 110 61,000,000 | |
| 2 | 400 68,000,000 | 10 27,000,000 | |
| 3 | 10 23,000,000 | 20 11,000,000 | |
| 4 | 240 27,000,000 | 90 17,000,000 | |
| 5 | 140 21,000,000 | 30 4,200,000 | |
| 6 | 100 15,000,000 | 640 2,600,000 | |

Bacteria (10^5)

Virus (10^7)

Movement of
organisms on
shoes during
walking –
keeping in step
with you

Vertical distribution of MS2 (virus) and **Dust** after **Walking** on Carpet



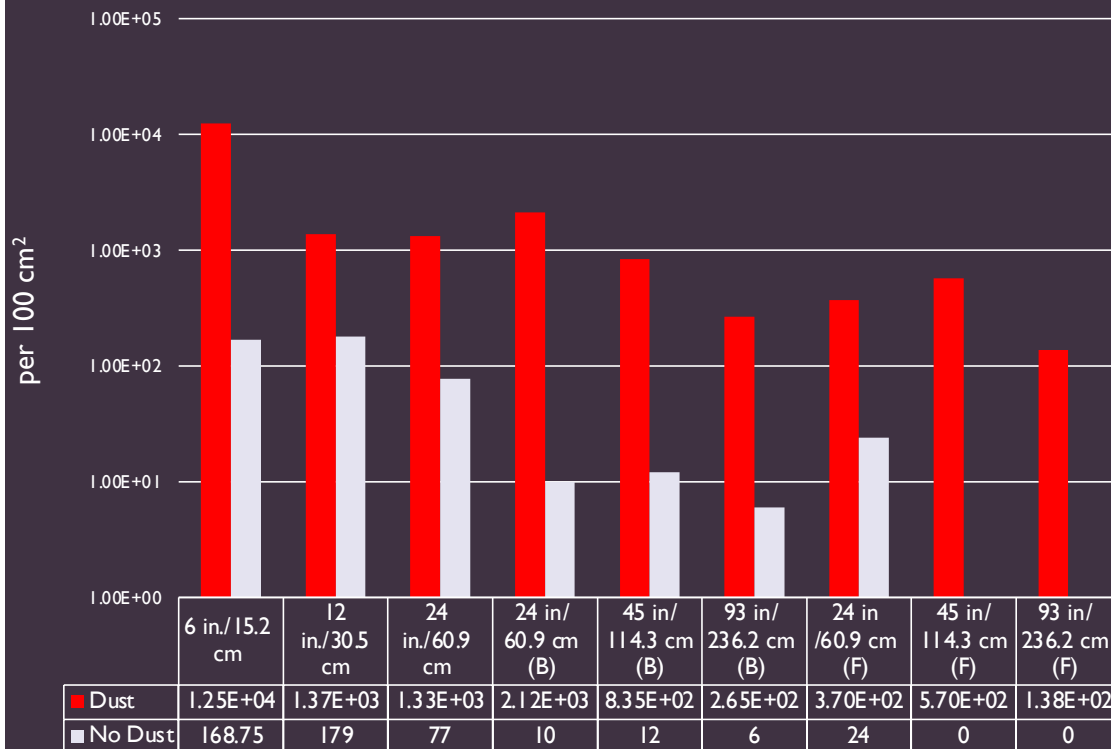
Experimental design:

- 1) Settle plates were positioned at different heights on the side of the carpet.
- 2) Two ml. of MS2 was added to the carpet, allowed to dry for 20 minutes .
- 3) Person was asked to walking in place 5 times, then leave the room.
- 4) Samples were collected from the settle plates after 1 hour and MS2 was quantified.

5) Conclusion – traveled to almost 6 feet into the air above the floor

Horizontal Distribution of MS2 (virus) and Dust after Walking on Carpet

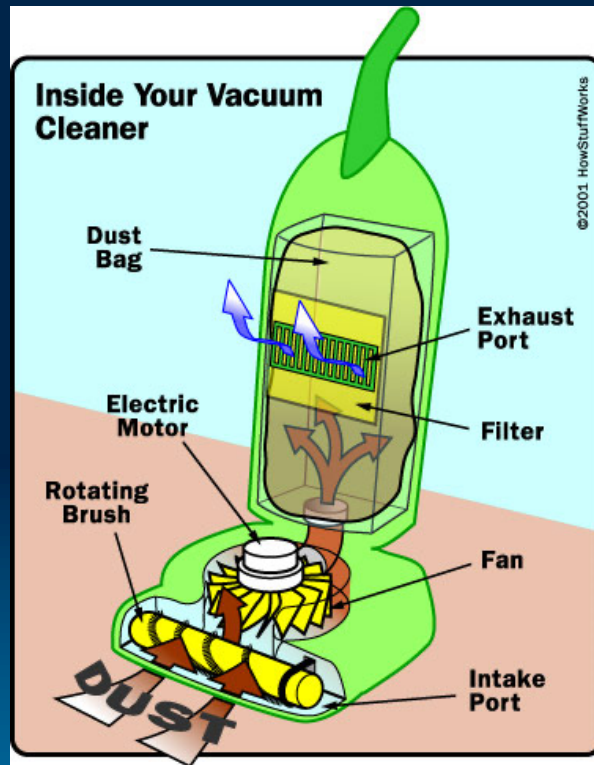
MS2 (virus) Resuspension After Walking on Carpet
(Horizontal & vertical settle plate position)



Dust has a major impact on resuspension

Horizontally to 7.5 ft. away from original site.

Vacuum Cleaners – Meals on Wheels for Bacteria



- Concentrate bacteria and food in one place
- *E. coli* detected on 50% of brushes
- *E. coli* and *Salmonella* grow in collection bag or container
- Wash your hands after emptying

Secondary Aerolization of MS2 / Viruses Experimental Set-Up

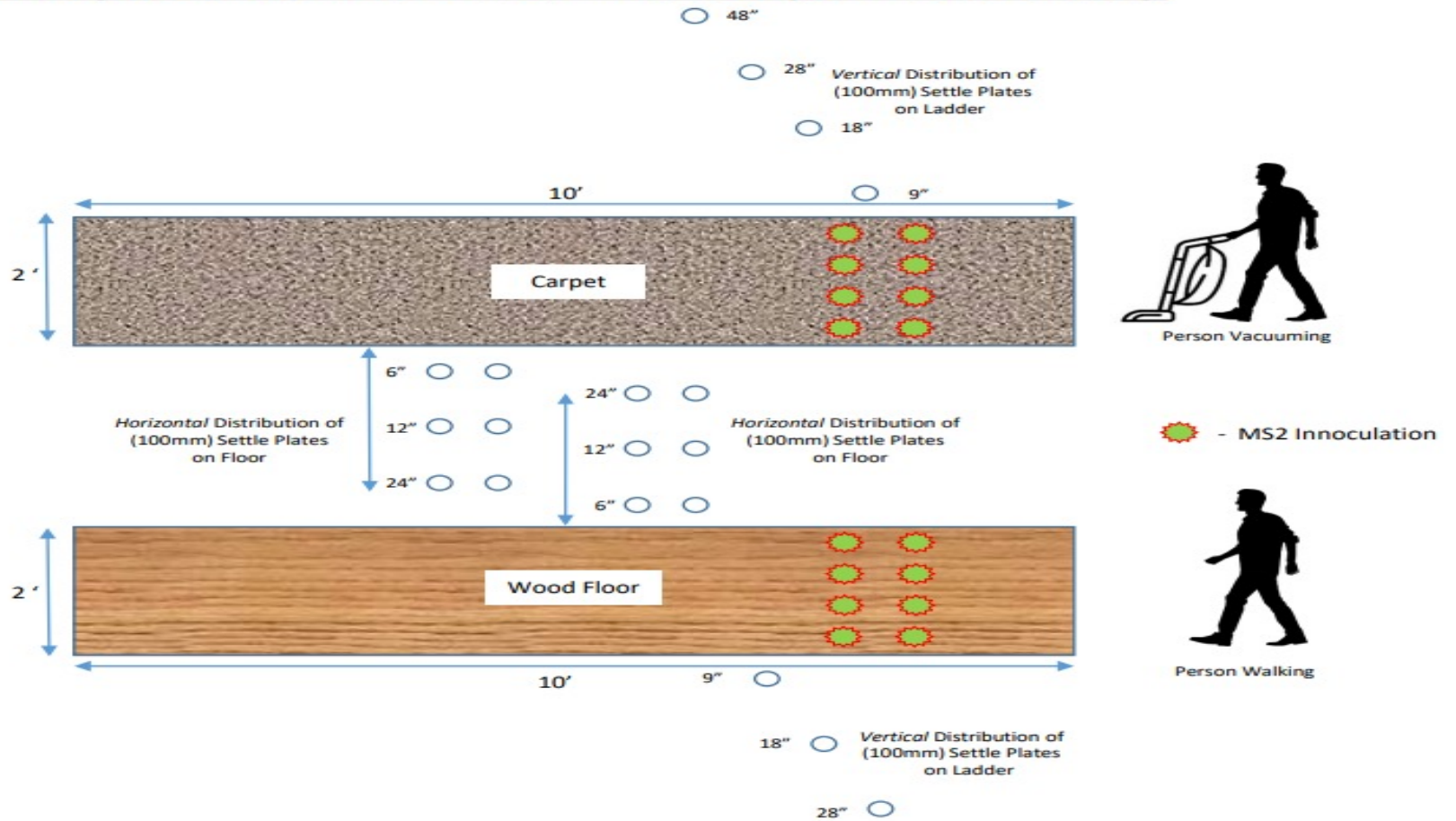
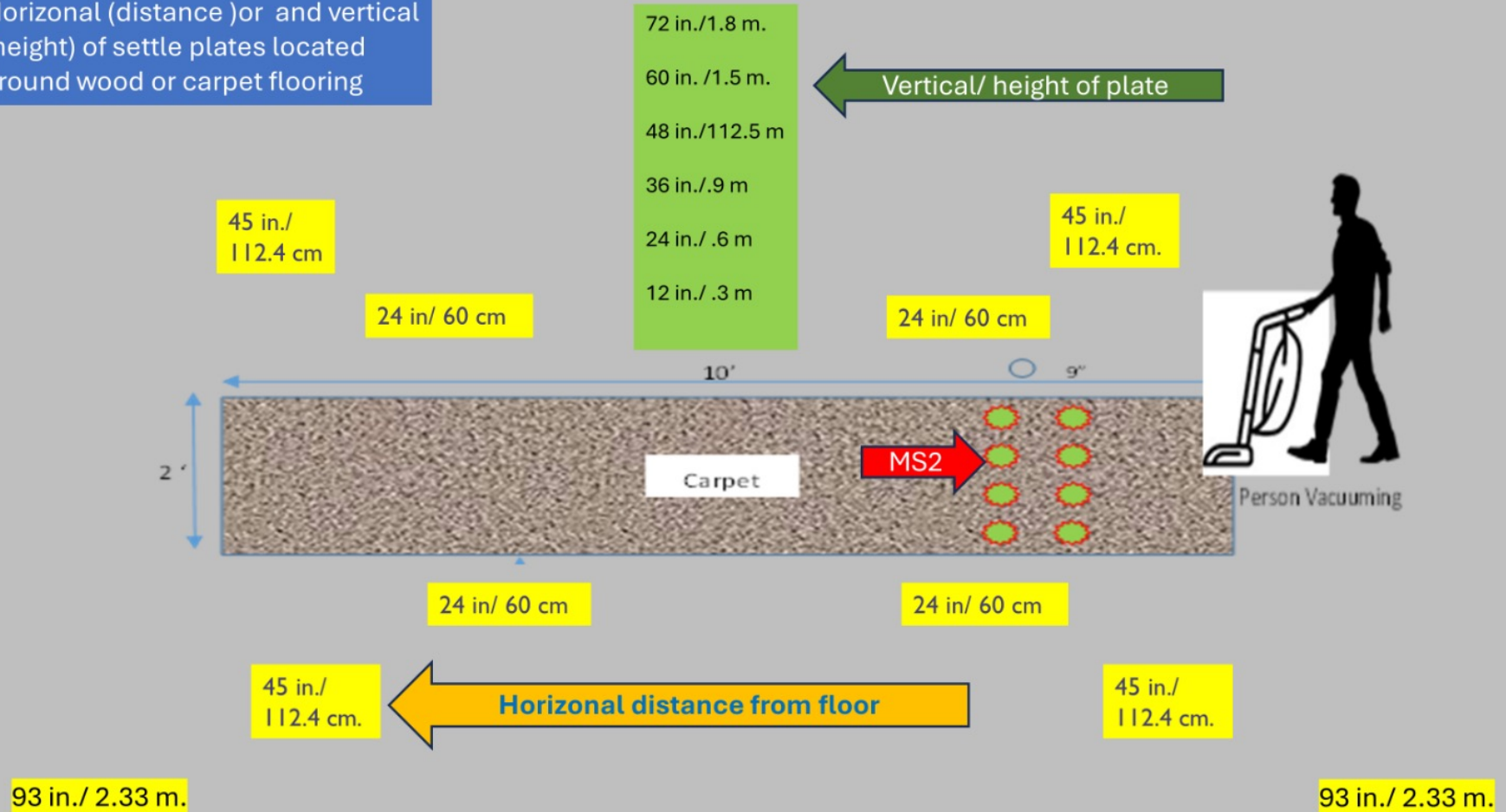


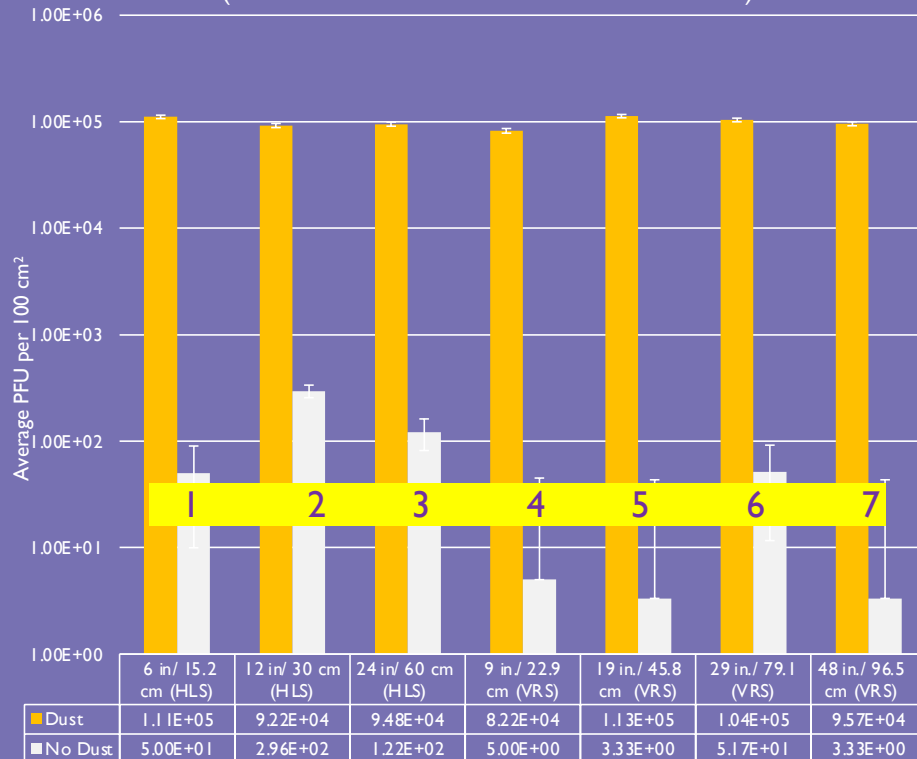
Illustration by Jeff Bliznick 2022

Horizontal (distance) or and vertical (height) of settle plates located around wood or carpet flooring



Vertical distribution of MS2 (virus) and Dust after Vacuuming Carpet

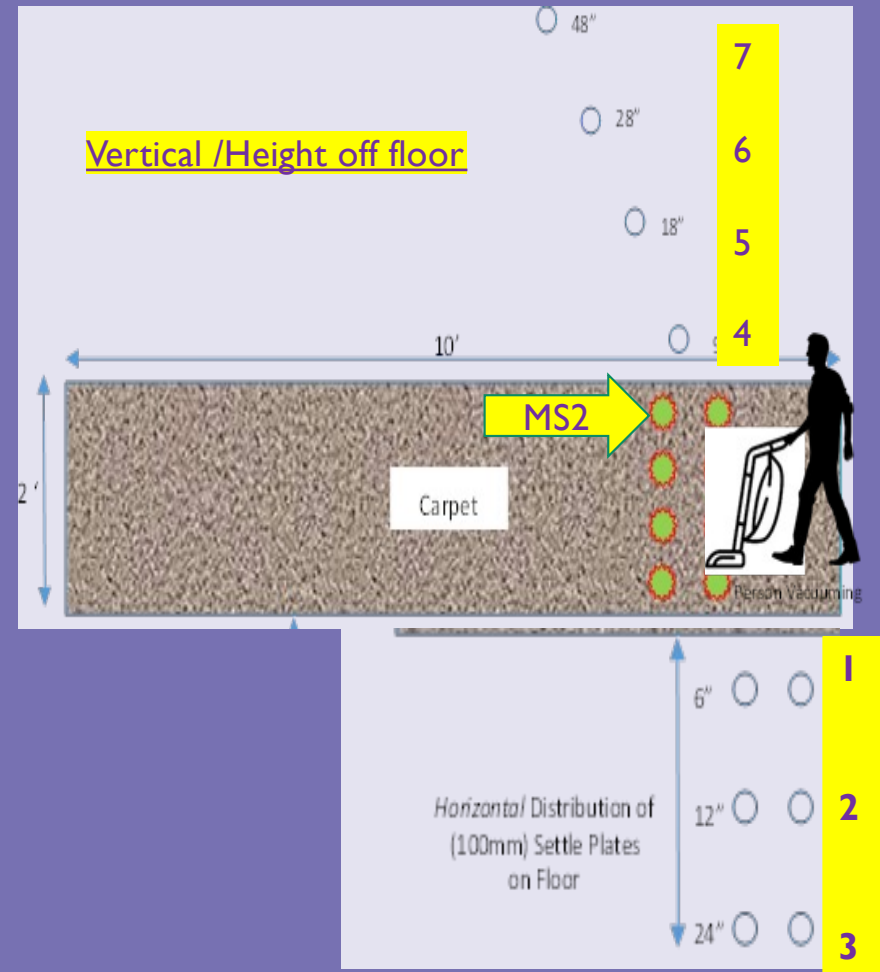
MS2 Re-aerosolization After Vacuuming Carpet
(Vertical & Horizontal Settle Plate Locations)



Number on bars correspond with # in diagram.

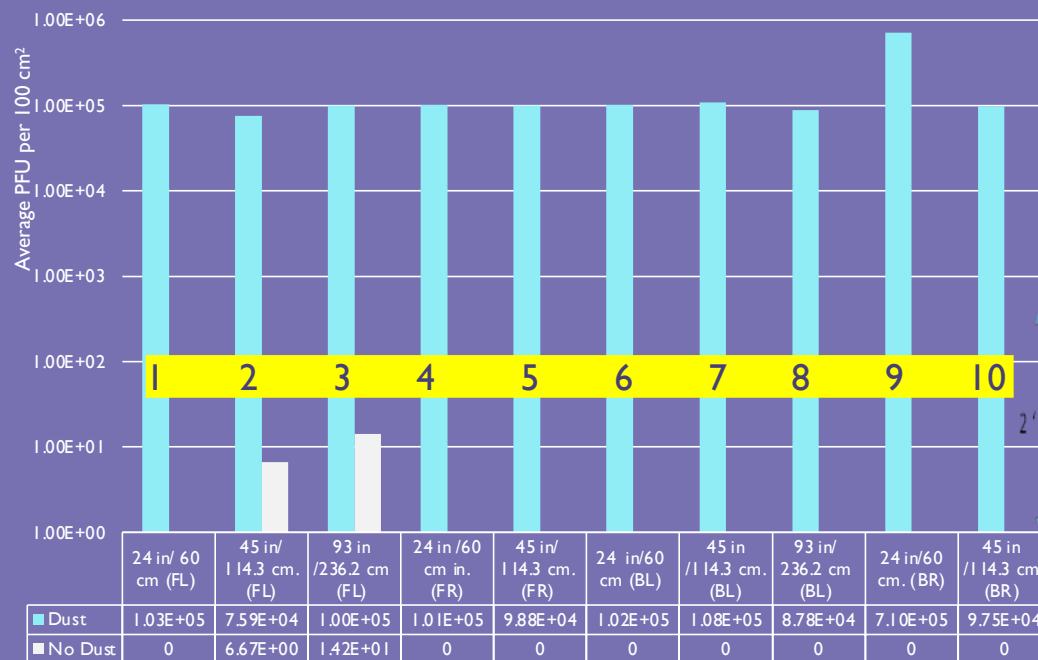
*Floor plates on the right side (RS) of the carpet.

** Vertical distance from floor/height on left side of carpet.



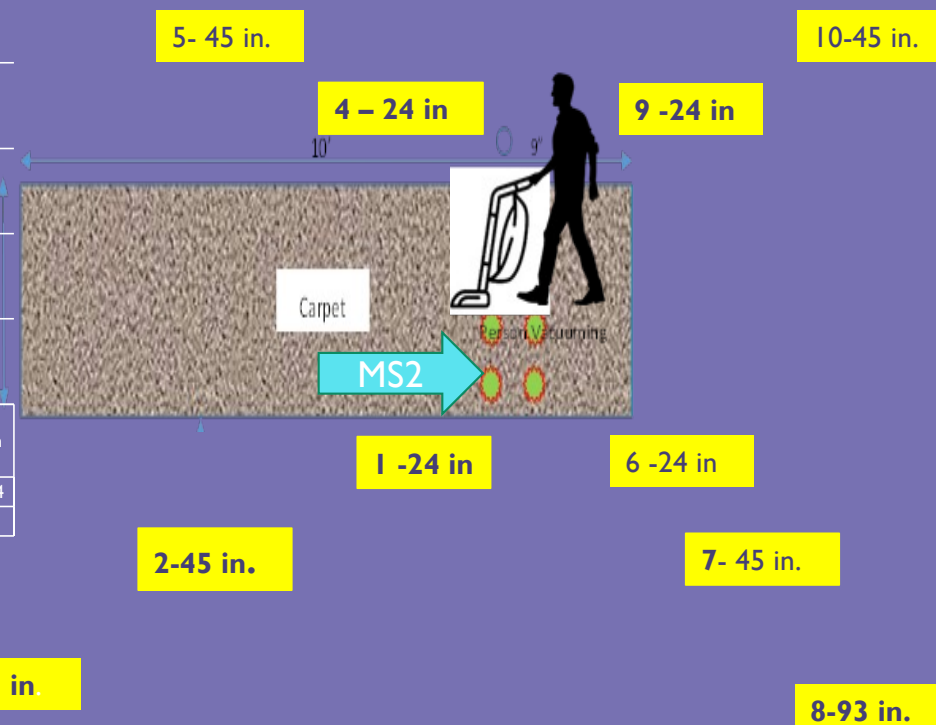
Horizontal Re-aerosolization of MS2 and Dust after Vacuuming Carpet

MS2 Re-aerosolization After Vacuuming Carpet (Floor Settle Plate Positions)



Number on bars correspond with number in diagram.

Front right (FR) & Front left (FL) - Floor plates in front or ahead of inoculated carpet.. Behind right (BR) & Behind Left - Floor plates behind inoculated carpet.



Re-aerosolization of MS2 Contaminated from Cotton Curtain – Experimental Design

*Ladder step
heights:*

69 in./ 175.3

cm

57 in./ 146.05

46 in./ 116.84

35 in./ 88.9

cm

23 in./ 58.42

11 in./ 27.94

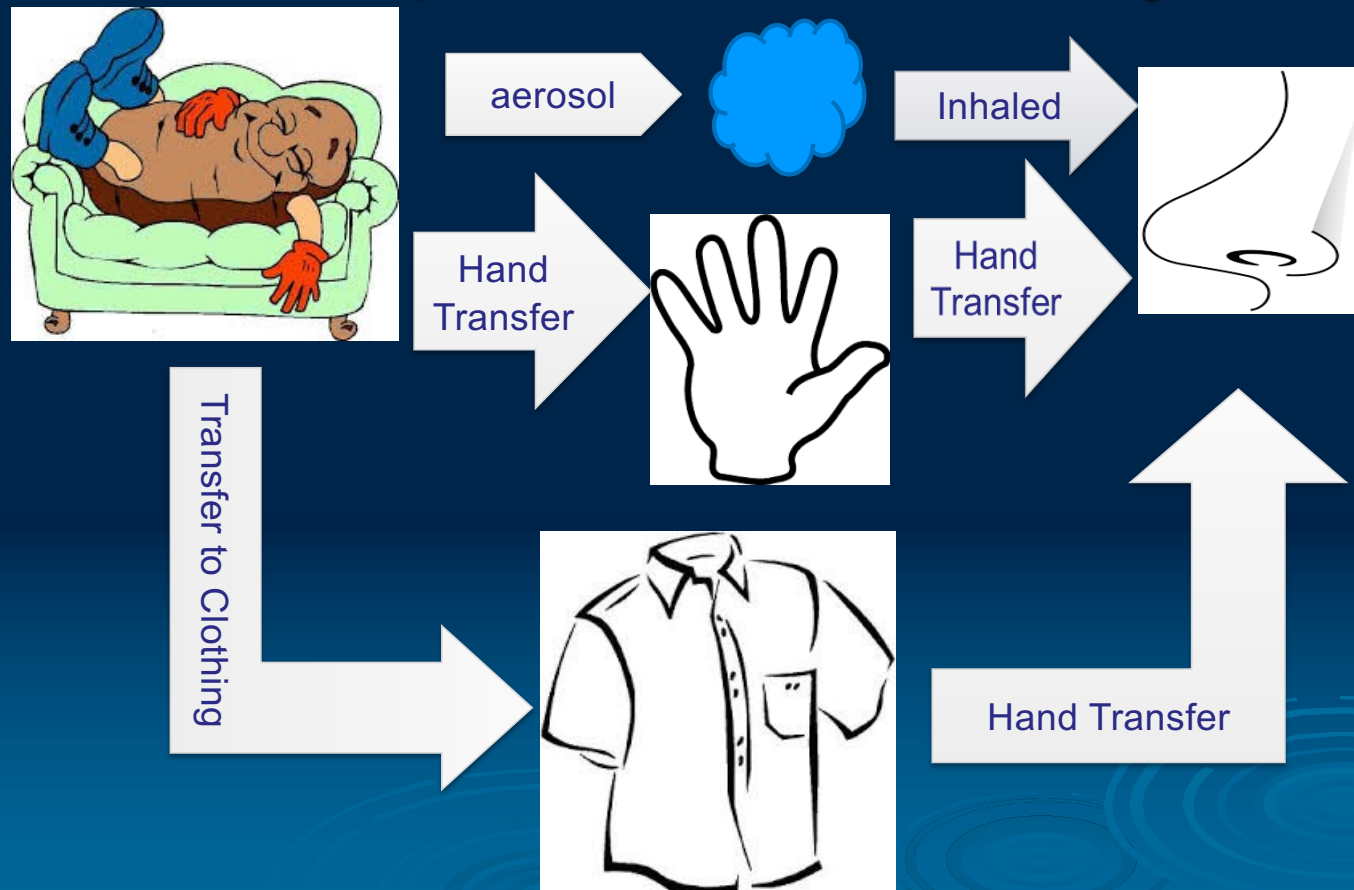


MS2 will be inoculated on the curtain within a 12 X 12 in square located 48 in. above the floor

Result: Virus detected on the floor 5 ft from the curtain and at 6 ft on the floor and and the person moving the curtain

Dangers of being a Couch Potato

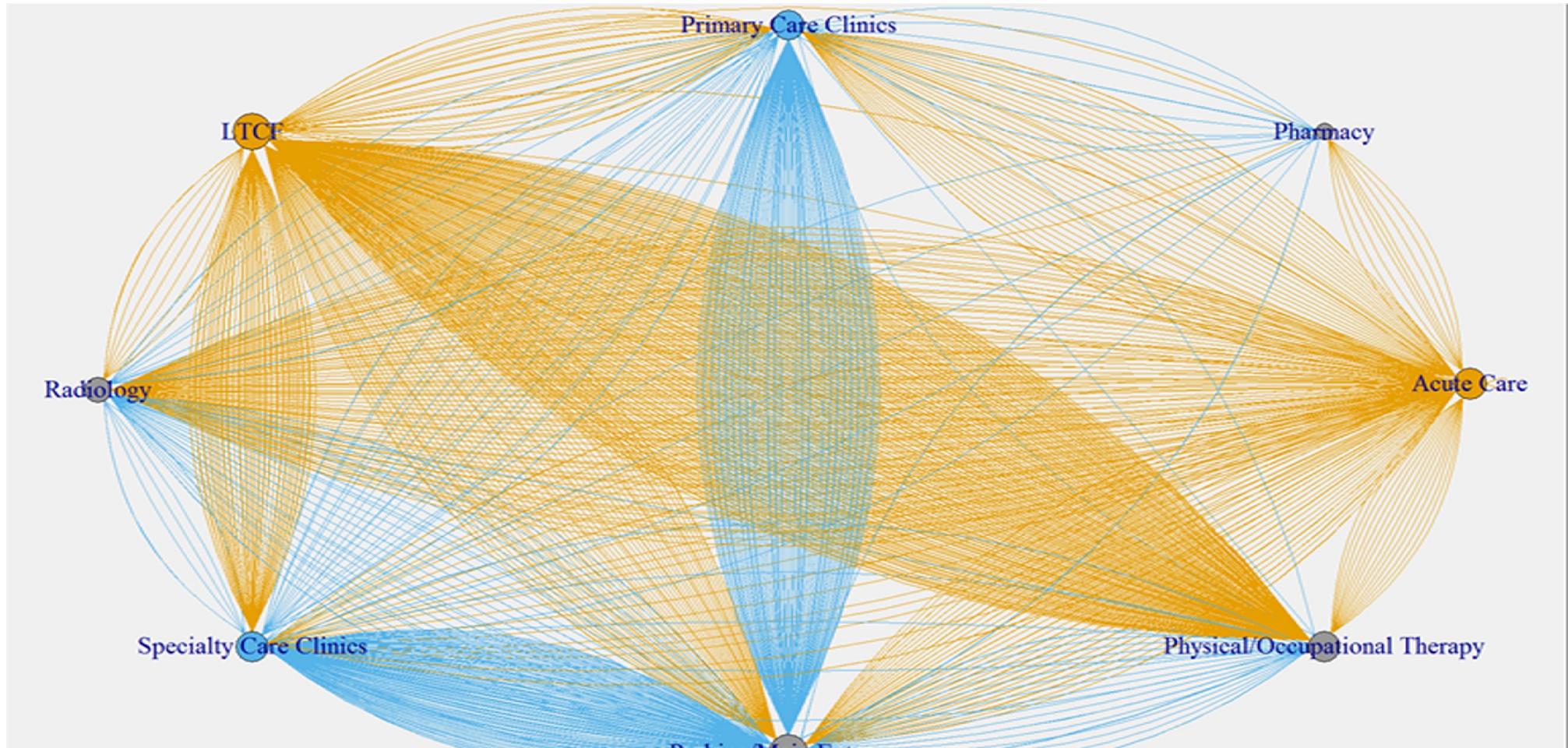
Routes of Germ Exposure – Fabrics – sitting on a chair



Mobile Devices



Network graph of wheelchair movement within the facility during 3-day period.
Jencson et al 2019 APIC



Transfer Efficiency of Human Coronavirus 229E From Fomites to Fingers

Type of fomite Makes A Difference

| Fomite/Surface | Mean % Transfer to Finger |
|------------------|---------------------------|
| Stainless Steel | 0.46 |
| Glass | 37 |
| Glazed Porcelain | 49 |
| Laminate | 7 |
| Formica | 25 |



Epidemiology vs QMRA

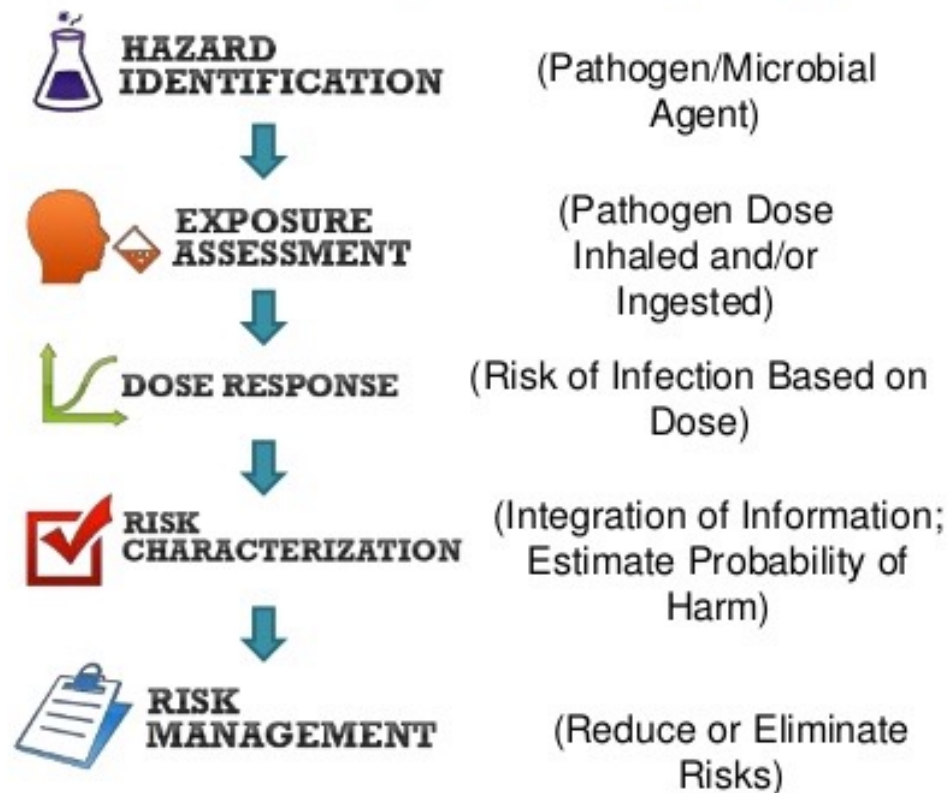
Epidemiology

- Difficult to isolate potentially many confounding factors
- Lacks precision
- Requires a large number of individuals
- Long observation time
- Can not see more than a 30 to 50% reduction in illness
- Difficult to do for specific pathogens (clinical specimens required)
- Costly

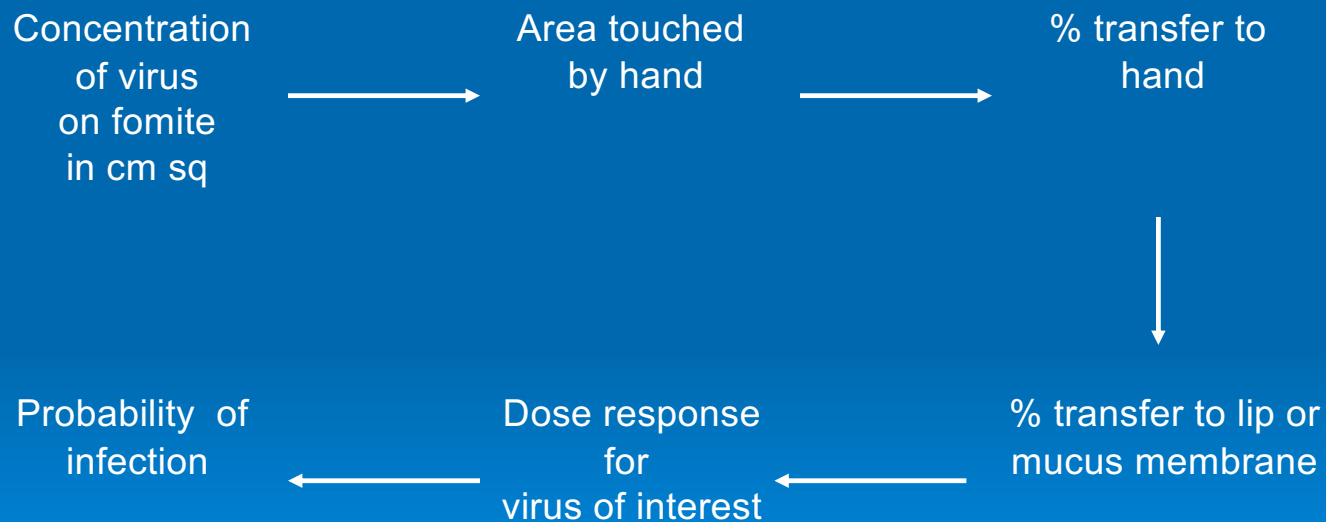
Risk Assessment

- Confounding factors can be controlled
- Good precision
- Small numbers of individuals needed (or none at all)
- Short observation time
- Can determine what is achievable in terms of reduction in risk of infection for a specific pathogen
- Can determine importance of specific exposure routes
- Far less costly

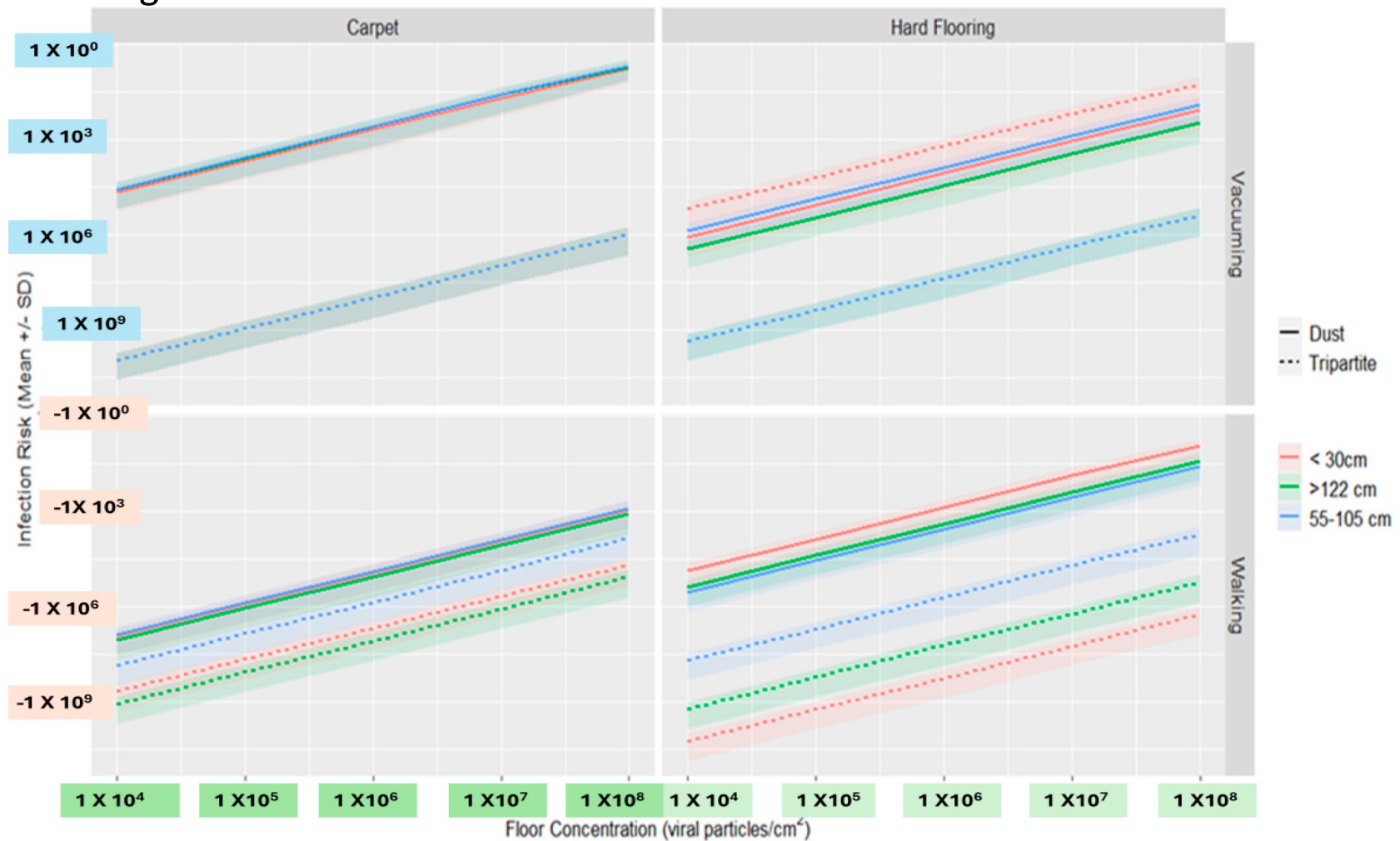
Quantitative Microbial Risk Assessment (QMRA) Approach



Quantitative Microbial Risk Assessment – Infection Risk from Touching a Fomite



Risk of infection from norovirus by touching different surfaces after resuspension and contaminating a fomite which is touched



How fast does a microbe move in the indoor environment?



Quat Wipe / Hand Sanitizer Intervention

In an Office Building

- Add a bacterial virus to the entrance door handle of an office building with 80 persons
- Collect samples after 2, 4 and 7 hours of fomites and hands



First place virus
detected is the
coffee break room



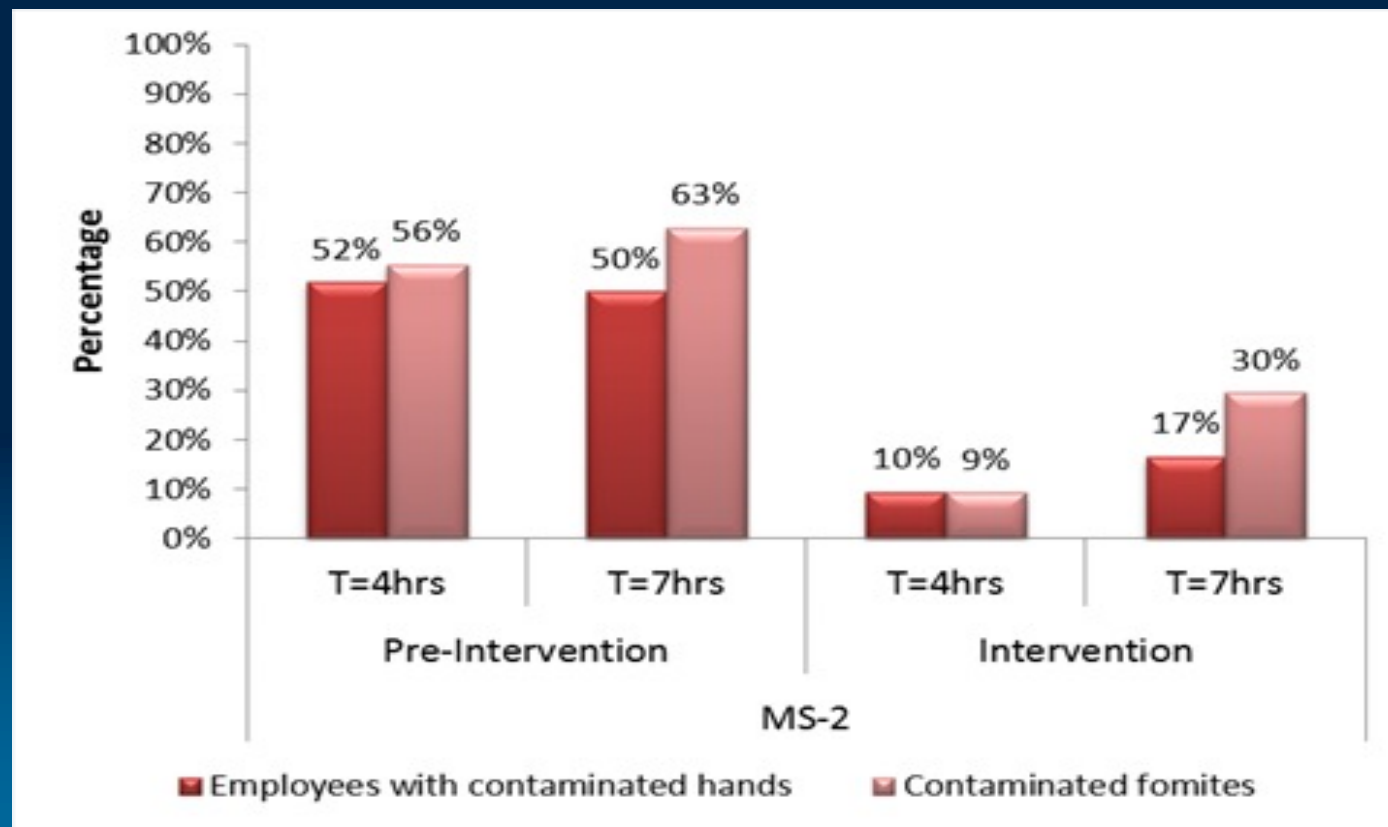
Intervention

+ hygiene
education

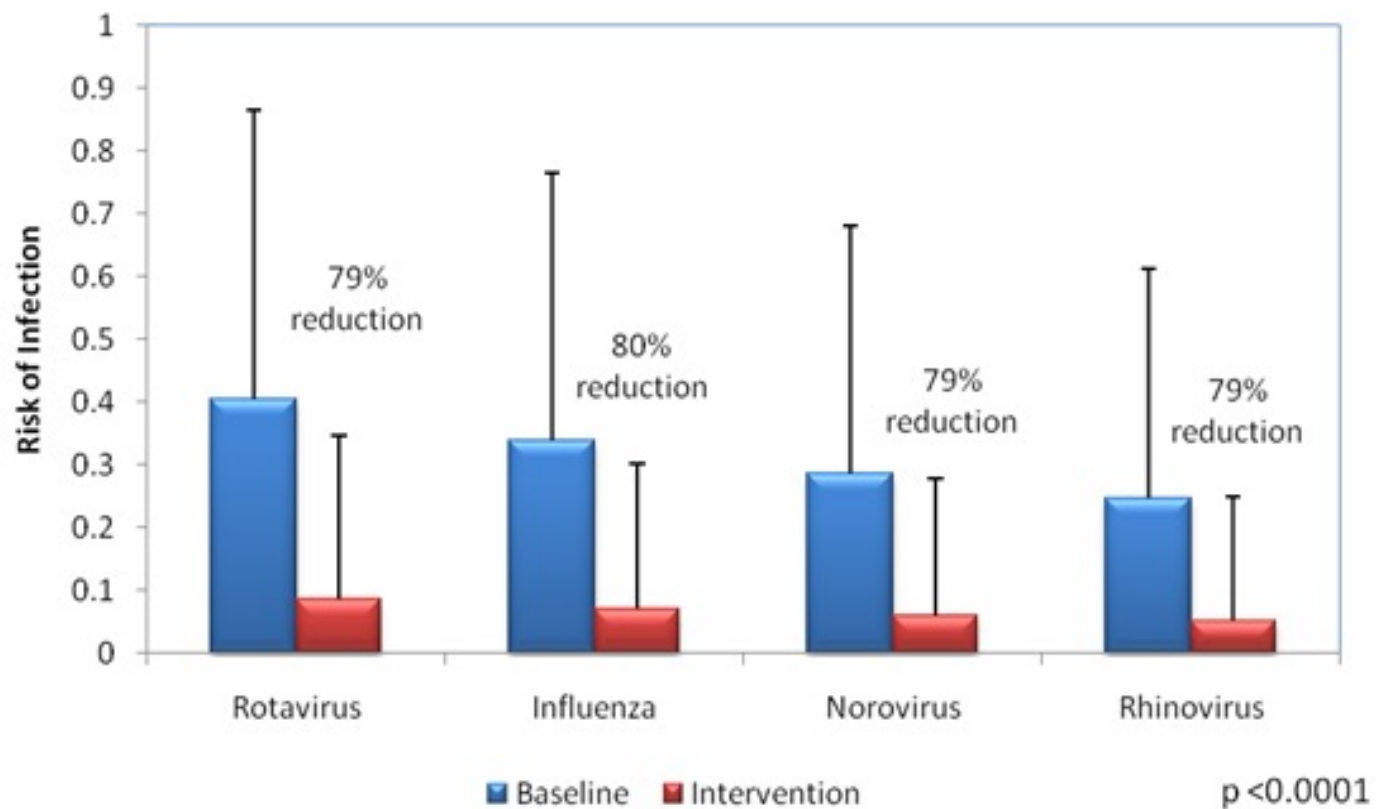


52% of 80 employee's agreed to participate

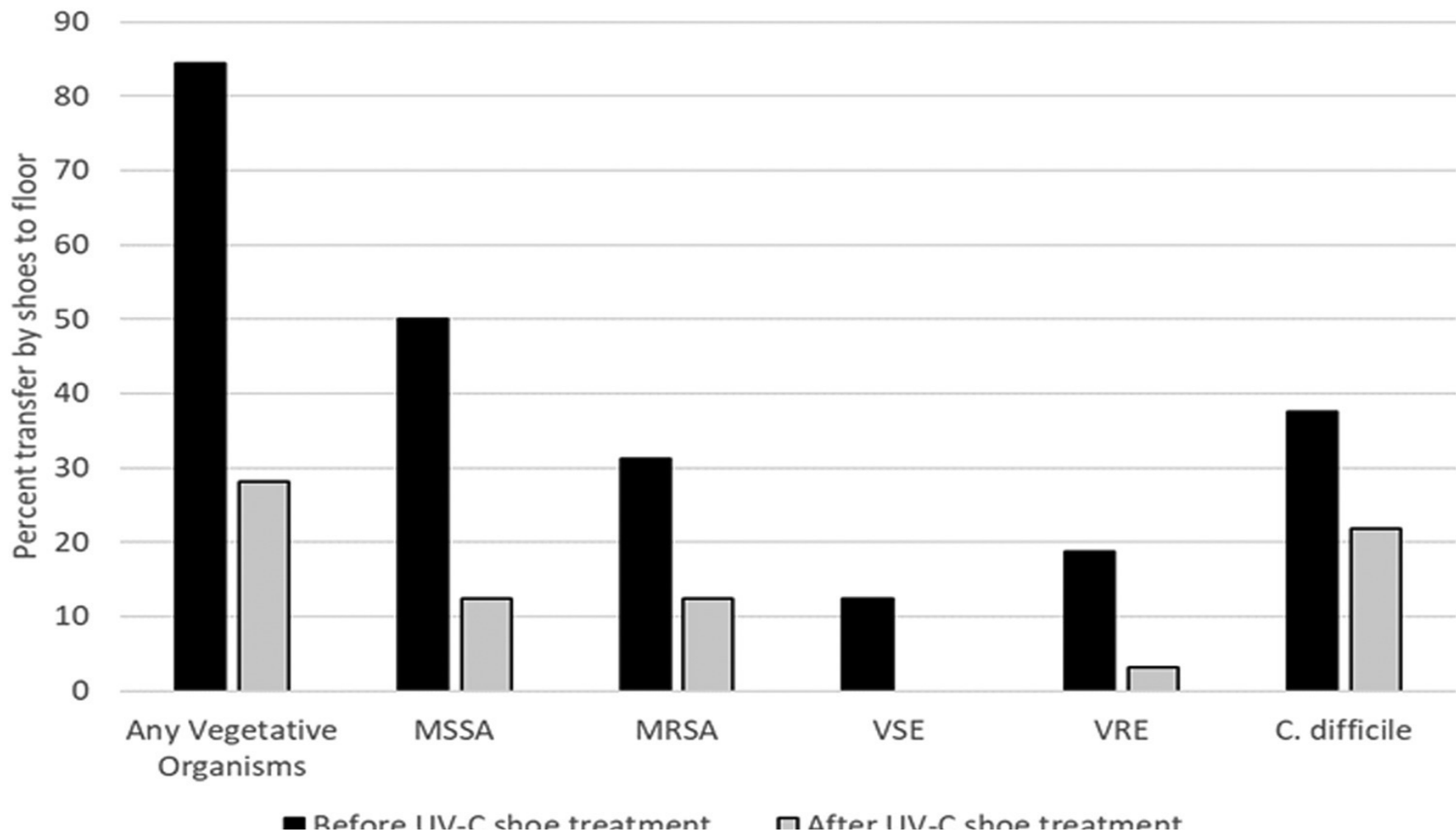
Impact of intervention on Occurrence of Virus on Employee's Hands



Probability of Infection



Percent transfer of pathogens from shoes of personnel to floors in patient rooms before versus after ultraviolet-C (UV-C) treatment of shoes. Donskey 2023. AJIC.



Virus Tracer Studies of Hygiene Interventions

| Environment/Location | Purpose/product | Outcome | Reference |
|-------------------------|---|---|--|
| Office building | Hand sanitizer/disinfecting wipes | Reduced probability of infection by 77% by rhino and rotavirus | Reynolds, Beamer, et al. 2016. Arch Env Occ Hlth |
| Hotel/Conference Center | Hand sanitizer/disinfectant products for cleaning staff | Reduced spread of virus between rooms by cleaning staff by 87% | Sifuentes, Koenig et al., 2014. Food Env Virol |
| Nursing home | Hand sanitizer | Reduce spread of virus between patient rooms by >99% | Sassi, Sifuentes, et al., 2015. Am J Infect Contr |
| Home | Hand sanitizer | Use of hand sanitizer reduced the probability of infection by 47% to 98%. | Tamimi, Maxwell et al., 2015. Epidemiol Infect |
| Home | Bleach | Reduced probability of infection by Salmonella in kitchen sponge by 99% | Chaidez, Soto-Beltran et al., 2014. Let Appl Microbiol |
| EMS response | H2O2wipes | Reduced spread of virus among EMS vehicle and equipment surfaces by 16% | Valdez et al., 2015. Am J Infect Contr |

Conclusions

- Movement of pathogens in the built environment is very dynamic
- Activities such as walking, sitting, vacuuming, moving equipment, using a cell phone and materials result in resuspension of pathogens
- Interventions such as hand sanitizer, disinfecting wipes, disinfectants reduce the spread of pathogens in the built environment.

Questions?



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Clean Hospitals Day
20 October 2026

Improving environmental hygiene practices

Clean Hospitals Day is celebrated each year on the 20th of October to raise global awareness of healthcare environmental hygiene (EH) and increase engagement of healthcare facilities (HCFs) around the world.

The theme for Clean Hospitals Day

2025 is "Human Factors and
Collaboration"

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With Prof. John Dunne, UK

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