
Tales of the Toilet
Presenter:
Charles P. Gerba, PhD
University of Arizona
Dept. of Environmental Science
Hosted by Martin Kiernan
www.webbertraining.com
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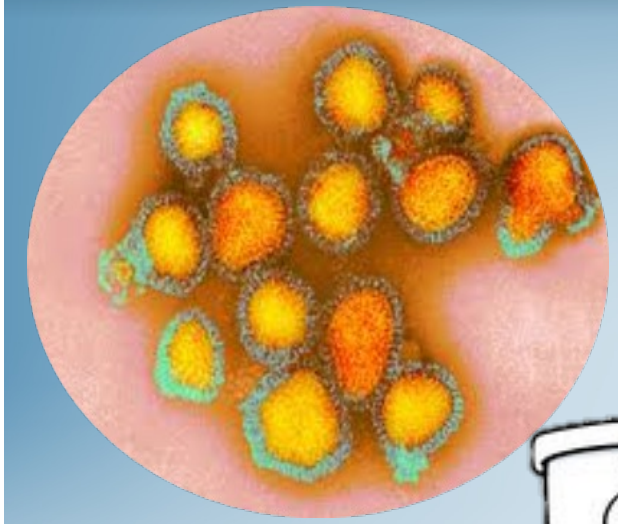
Disclosures

Charles P. Gerba

- I disclose personal financial relationships with commercial interests relevant to this educational activity within the past 12 months
- Reckitt – research grant to the Universality of Arizona

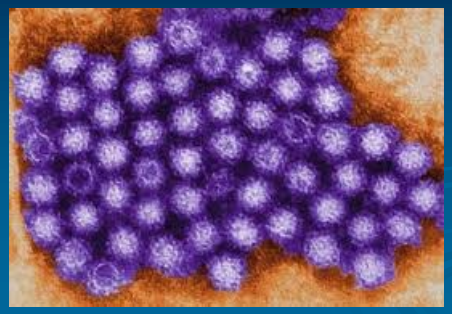
Learning Objectives



- 1. What are the most contaminated sites in the restroom
- 2. How to reduce toilet aerosol contamination
- 3. Optimal cleaning frequency to minimize contamination
- 4. Why both hand washing and hand sanitizer use are the best combination for controlling virus spread

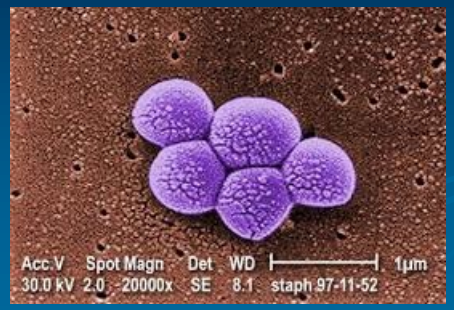
Microorganisms Associated with Outbreaks in Public Toilets

- *Shigella* – Diarrhea
- *Salmonella* – Diarrhea
- *Hepatitis A virus* – Liver Disease
- *Norovirus* – Vomiting and Diarrhea



Microorganisms Associated with Outbreaks in Public Toilets – Good Evidence

- SARS (Severe Acute Respiratory Syndrome)
- MRSA (Methicillin Resistant *Staph. aureus*)
- VRE (Vancomycin resistance enterococcus)
- *Clostridium difficile* – diarrhea
- Cholera



Concentration for pathogens and fecal bacteria in stools

Microorganism	Concentration/gram/ml	Reference
Coliforms	10^{7} - 10^{9}	Haas *et al.* 2014
Fecal coliforms	10^{6} - 10^{9}	Haas *et al.* 2014
Escherichia coli		
Salmonella	10^{4} - 10^{10}	Haas *et al.* 2014
Campylobacter jujeni		
E. coli 0157:H7		
Shigella	10^{5} – 10^{9}	Haas *et al.* 2014
Enterovirus	10^{3} - 10^{8}	Pepper *et al.* 2014
Hepatitis A	10^{8}	Pepper *et al.* 2014
Rotavirus	10^{10} - 10^{12}	Pepper *et al.* 2014
Norovirus	10^{10} - 10^{12}	Pepper *et al.* 2014
Adenovirus	10^{11}	Haas *et al.* 2014
SARS-CoV-2	10^{1}-10^{3}	Xiao *et al.* 2020
Cryptosporidium	10^{6} - 10^{7}	Pepper *et al.* 2014
Giardia	10^{1}-10^{6}	GWPP 2020
Ascaris	10^{4} - 10^{5}	Haas *et al.* 2014

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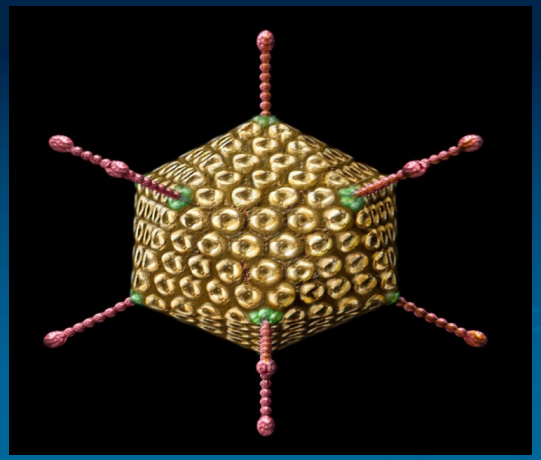
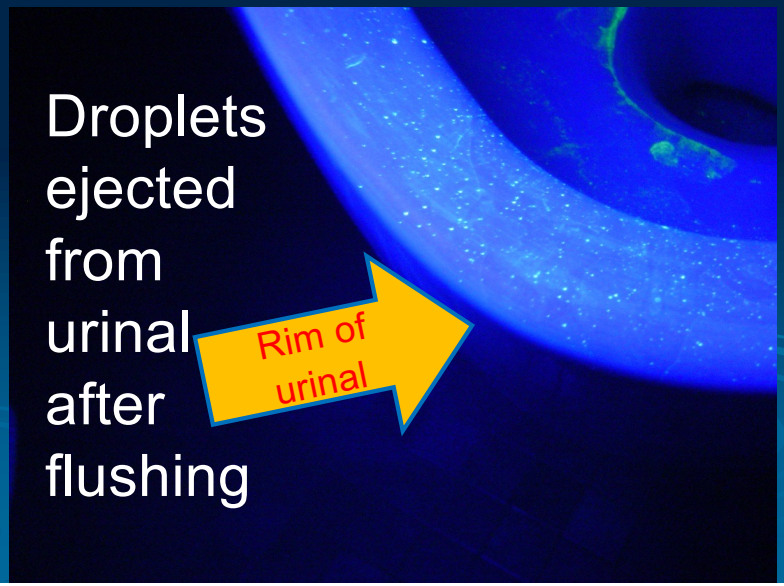
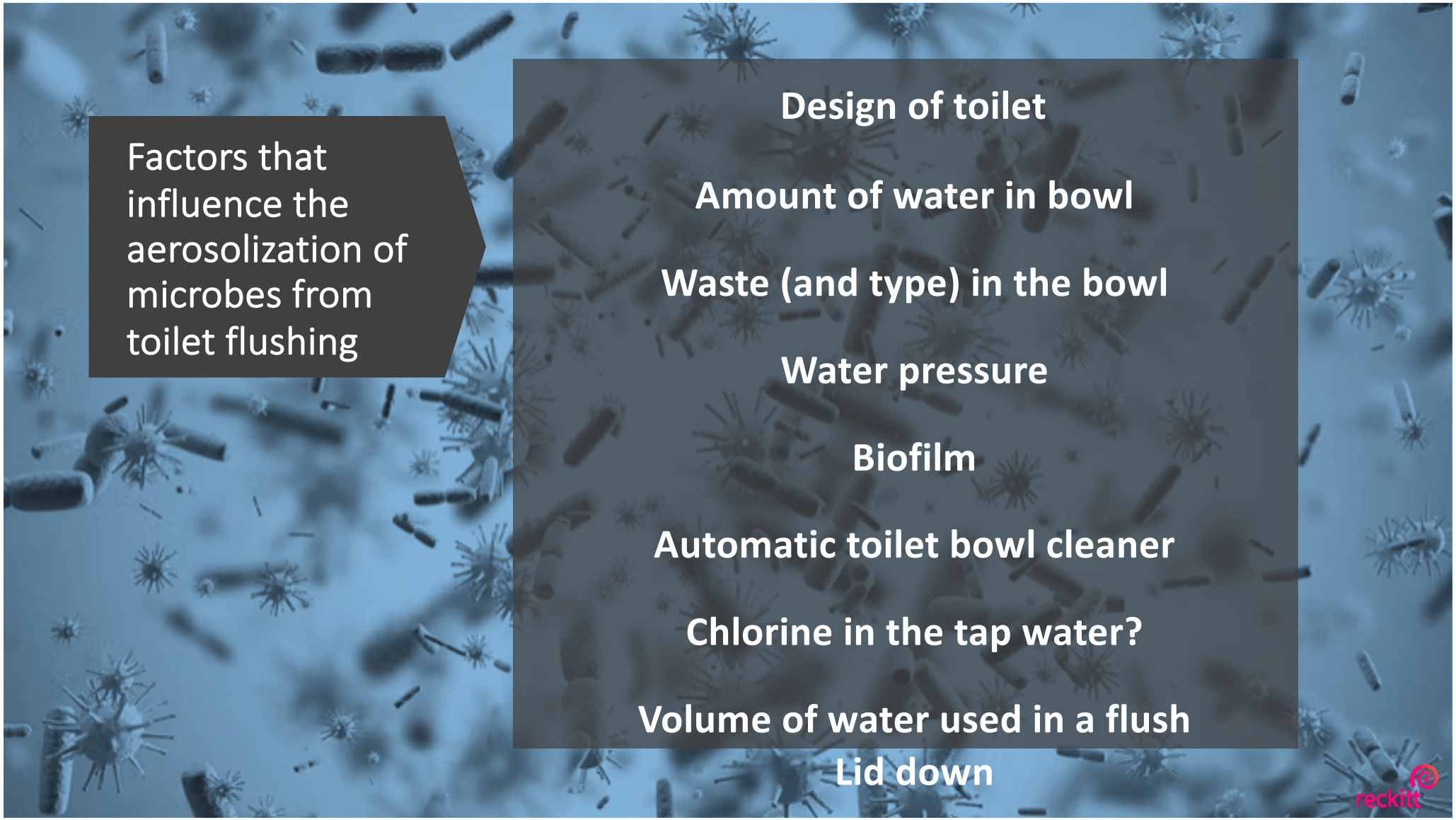
Urine is not Sterile!!!

Infectious viruses are often excreted in the urine during an infection.

Example: Adenoviruses (diarrhea, respiratory infection:
67% of public restroom surfaces contaminated with adenoviruses
(Veranietal et al, 2014)






Factors that influence the aerosolization of microbes from toilet flushing
Design of toilet
Amount of water in bowl
Waste (and type) in the bowl
Water pressure
Biofilm
Automatic toilet bowl cleaner
Chlorine in the tap water?
Volume of water used in a flush
Lid down
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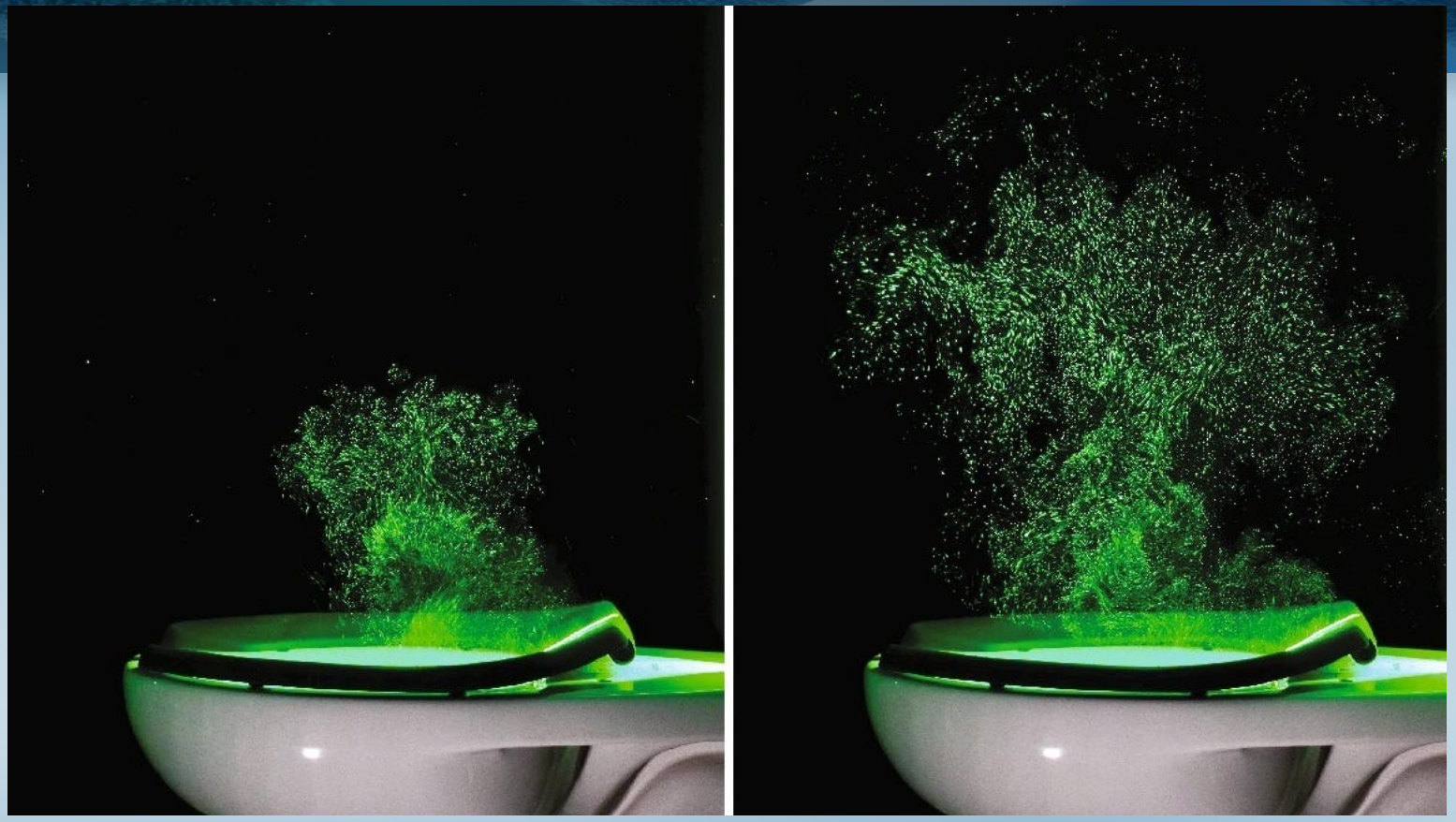
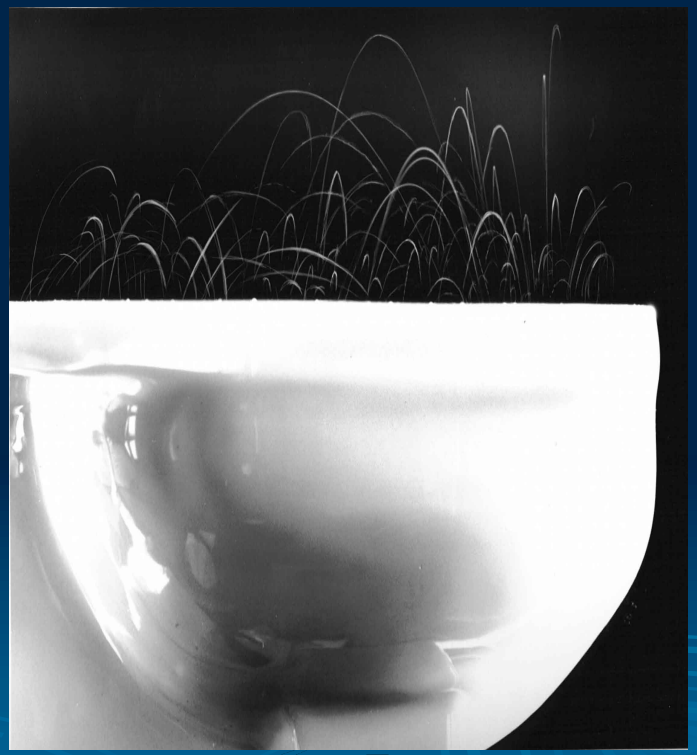
Why are we Focused on toilets?



Aerosols are Produced during Toilet Flushing

- Fecal bacteria and viruses are ejected from the toilet during flushing.
- The droplets settle out in the restroom contaminating the restroom with fecal microorganisms



Commodeograph

- Water sensitive paper held over toilet seat when flushed. Purple spots represent water droplets.

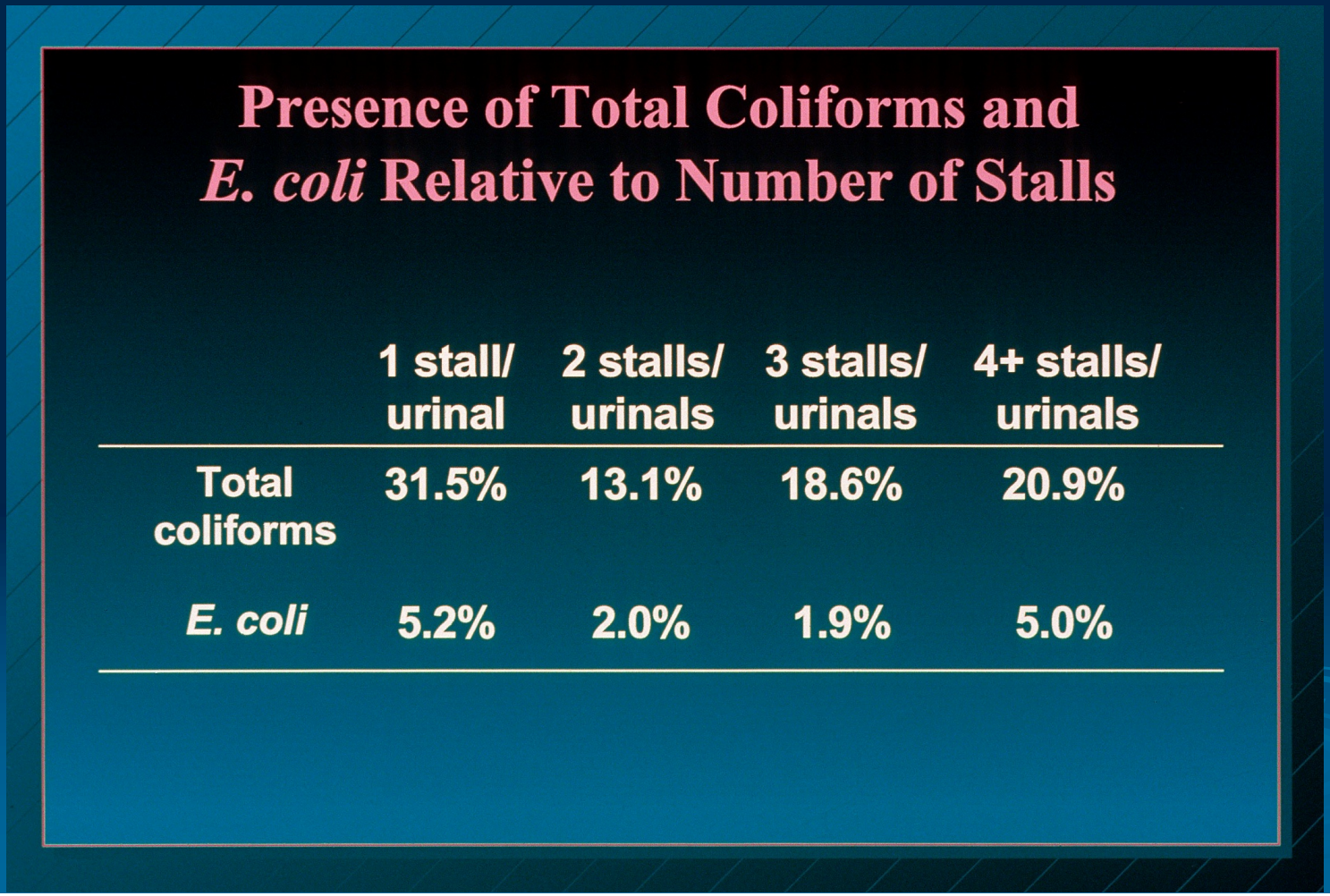
Coliform and *E. coli* Isolation from Public Restrooms (% of surfaces positive)

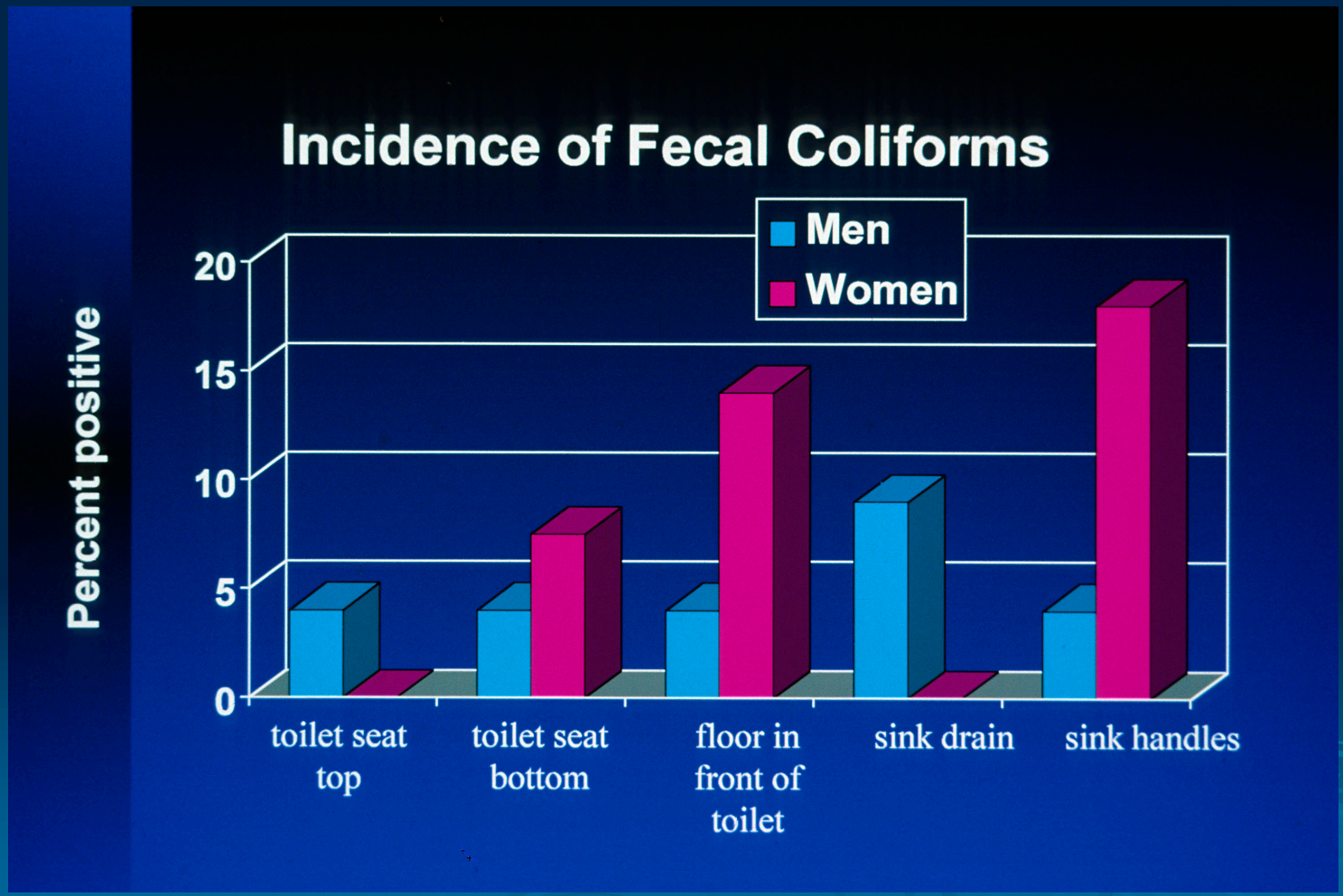
Location	Coliforms	*E. coli*
Airports	23.8	5.6
Fast Food Restaurants	21.9	1.5
Hospitals (Public Areas)	17.3	2.0
Overall	20.7	3.1

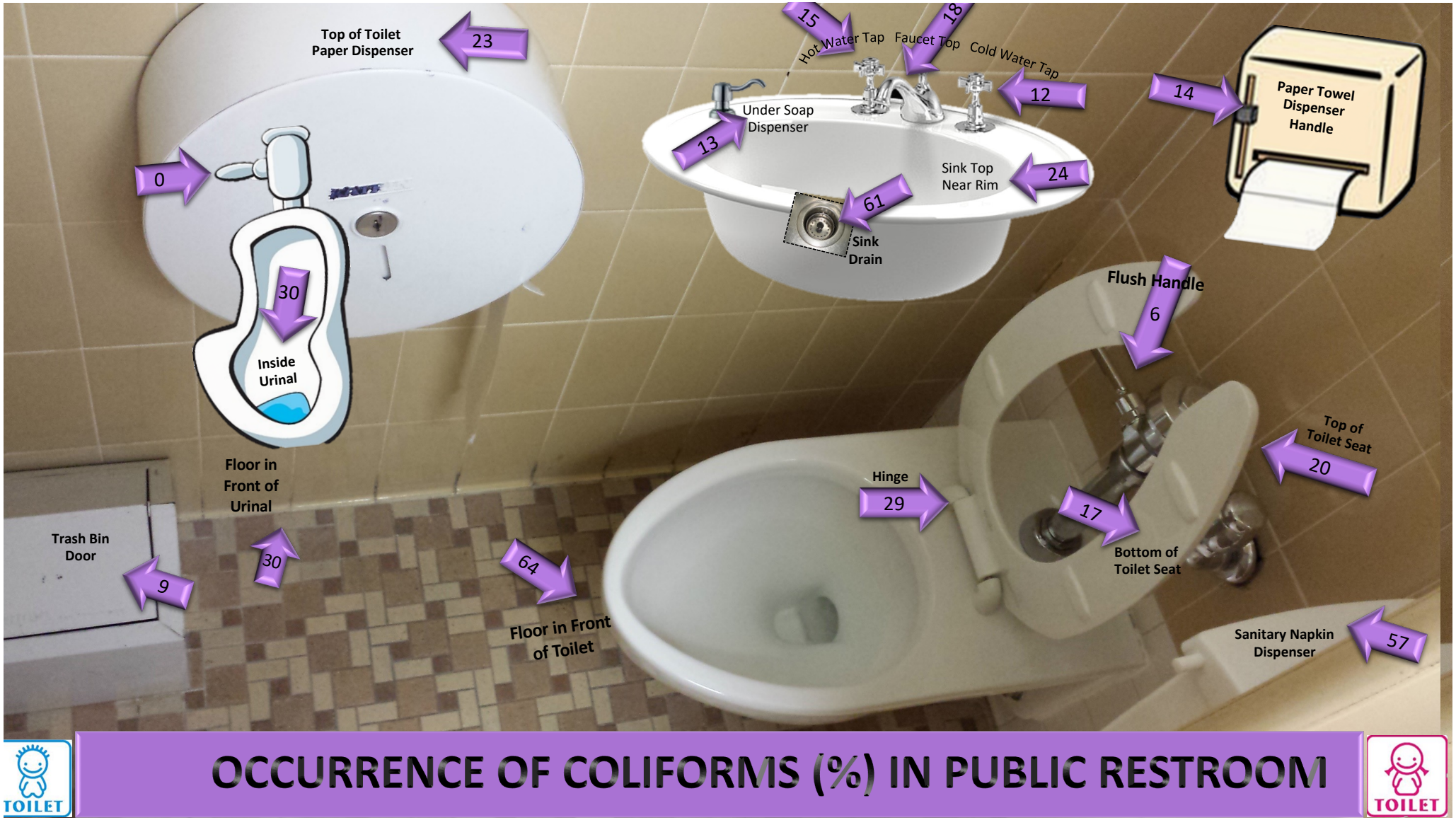
Coliform and *E.coli* in Public Restrooms

- Female restrooms were significantly more contaminated that men's restrooms
- The middle stall was more contaminated

Contamination related to number of stalls in restroom

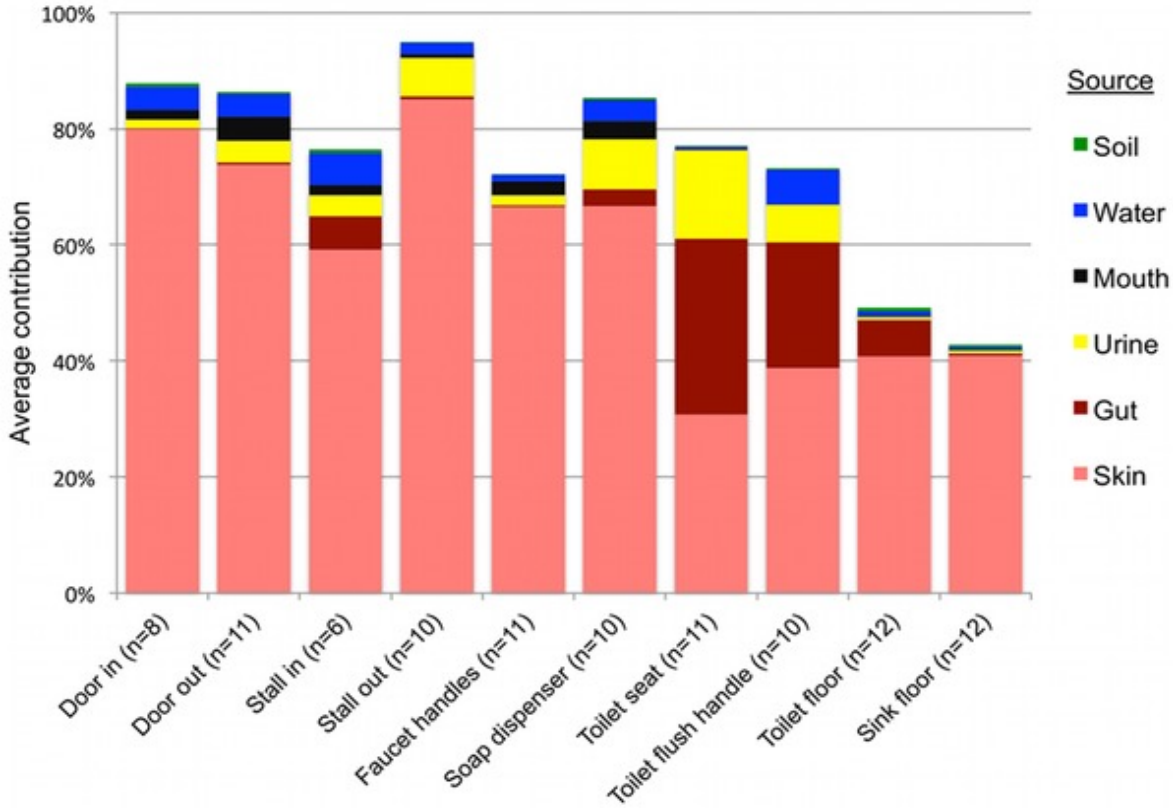



Incidence of Fecal Coliforms
Men
Women
Percent positive
20
15
10
5
0
toilet seat top
toilet seat bottom
floor in front of toilet
sink drain
sink handles



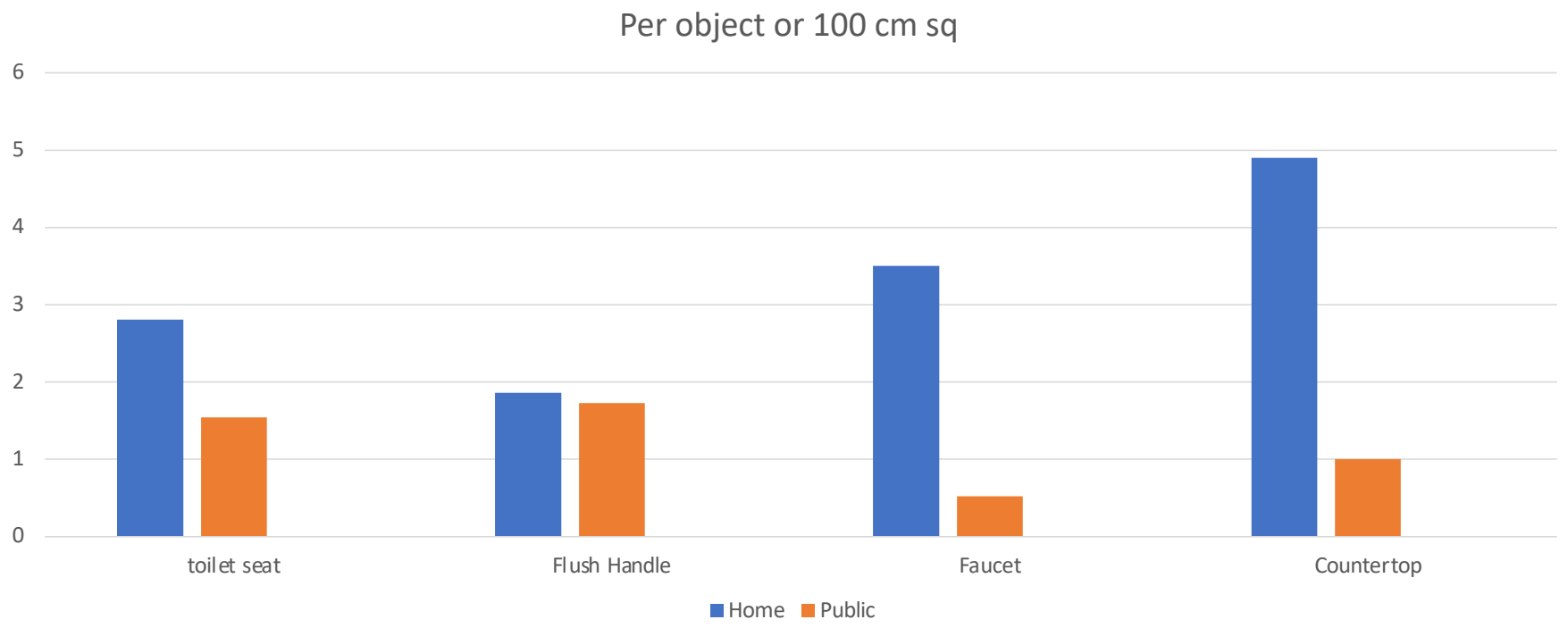
OCCURRENCE OF COLIFORMS (%) IN PUBLIC RESTROOM

Figure 4. Results of SourceTracker analysis showing the average contributions of different sources to the surface-associated bacterial communities in twelve public restrooms.



Flores GE, Bates ST, Knights D, Lauber CL, et al. (2011) Microbial Biogeography of Public Restroom Surfaces. PLoS ONE 6(11): e28132. doi:10.1371/journal.pone.0028132
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0028132

E. coli: Home vs Public Toilets
(Geometric average)

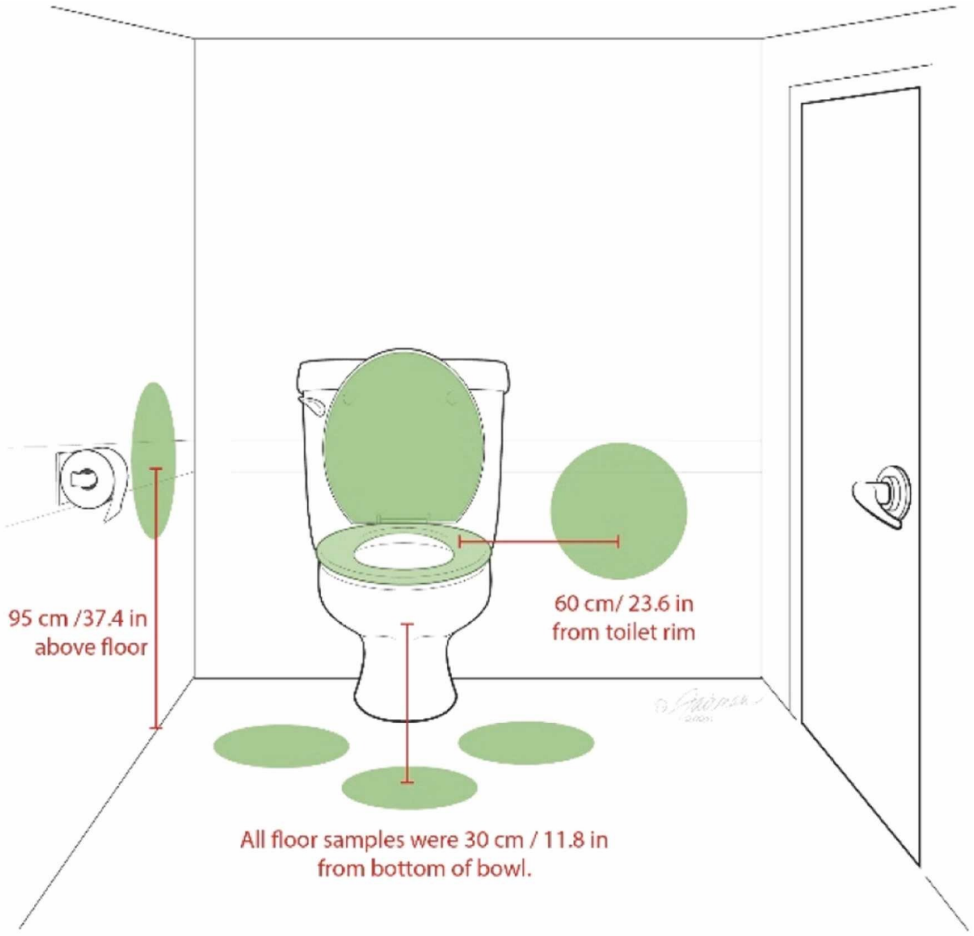


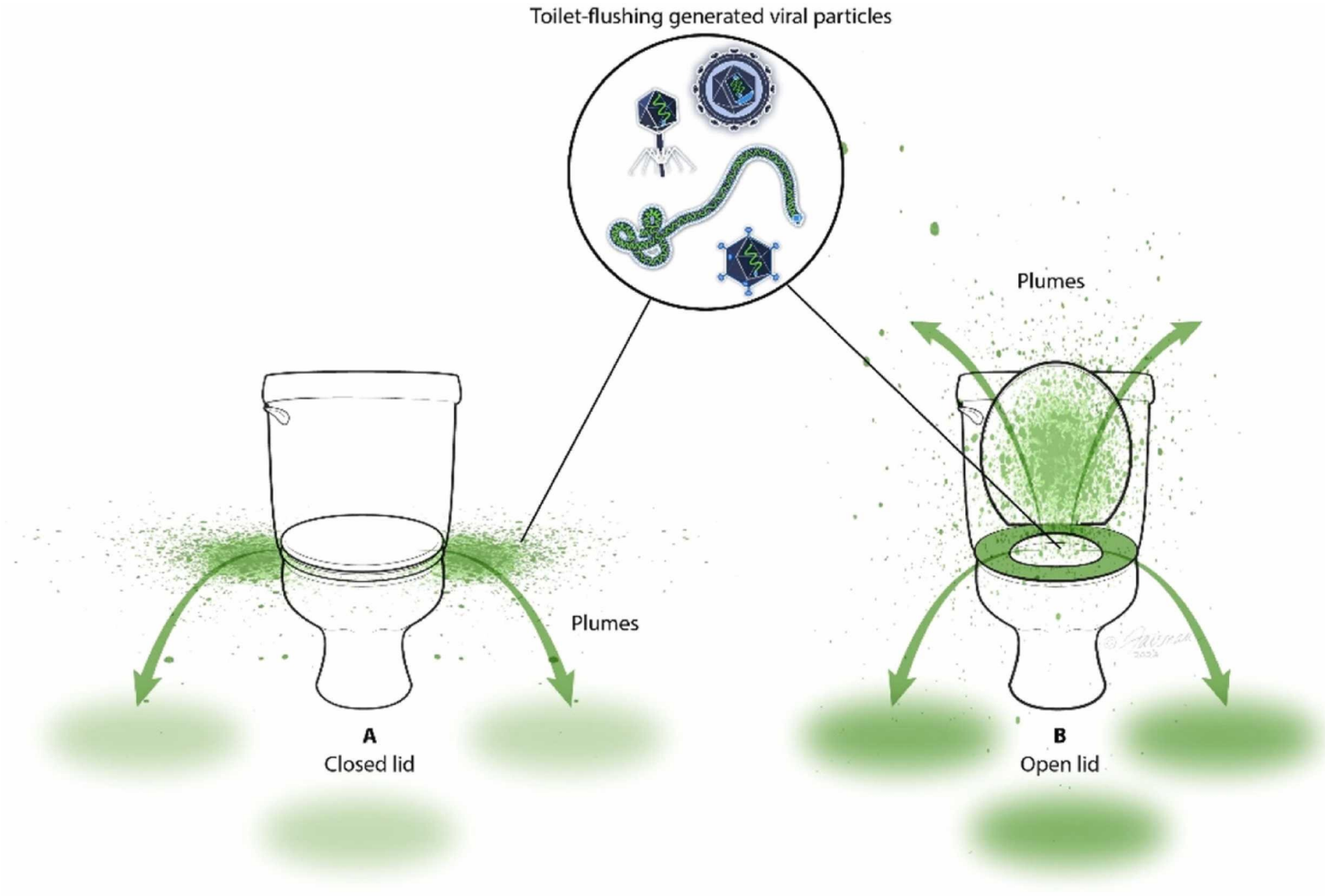
Objectives:

- Determine impact of lid closure on fomite contamination in the restroom

- Determine impact of cleaning toilet with and with out a disinfectant cleaner

Fomite Sample Locations in Restroom




Toilet-flushing generated viral particles
Plumes
Plumes
A
Closed lid
B
Open lid

Impact of home toilet lid position prior to flushing on MS2 virus contamination of toilet surfaces

Lid Position	Toilet Lid PFU/ 100 cm^2		Toilet Seat PFU/100 cm^2	
	Top	Bottom	Top	Bottom
Up	1.70	1.70	6.80	7.85
Down	1.72	1.65	5.62	7.62

10^{14} PFU added to bowl before flush

Note: no statistical difference on contamination with lip up or down

Viral spread from Restroom

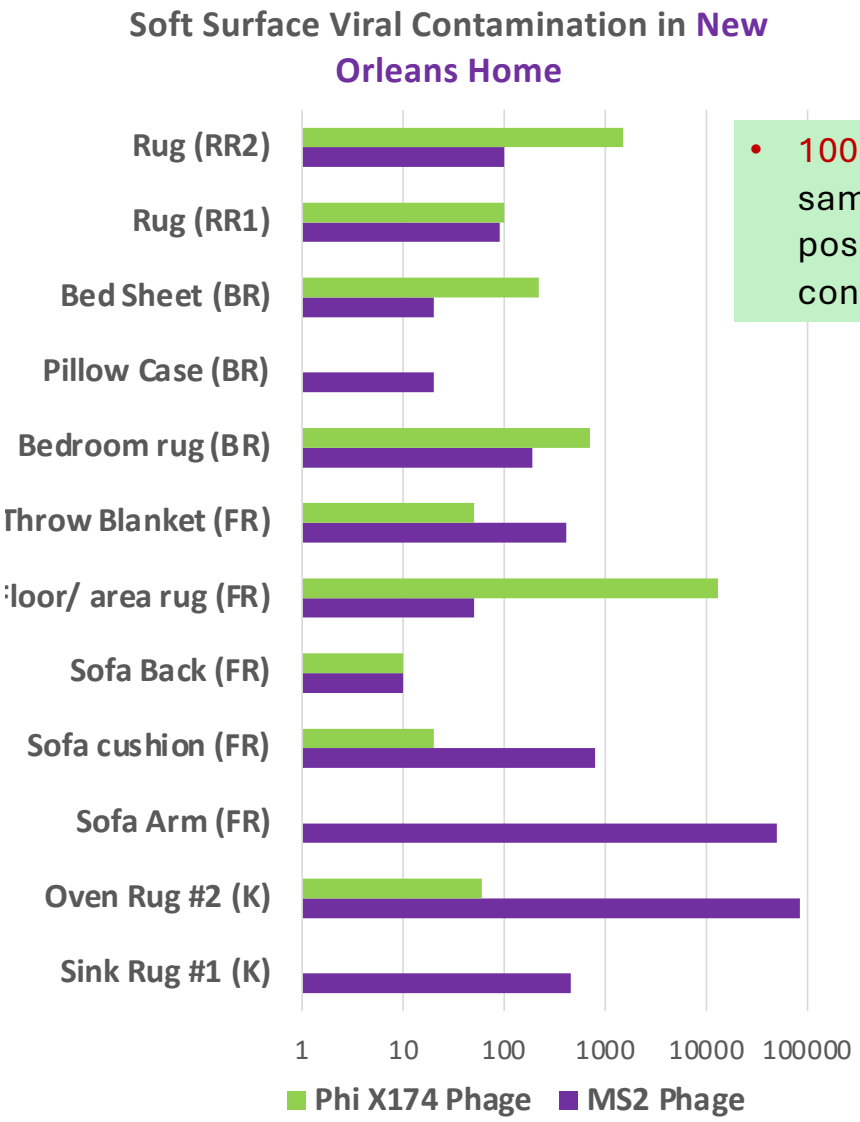
1) door handle, sink handle, toilet handle in Restrooms were contaminated with bacteriophage MS2

2) Occupants were asked not to clean the restroom or home surfaces for 24 hours.

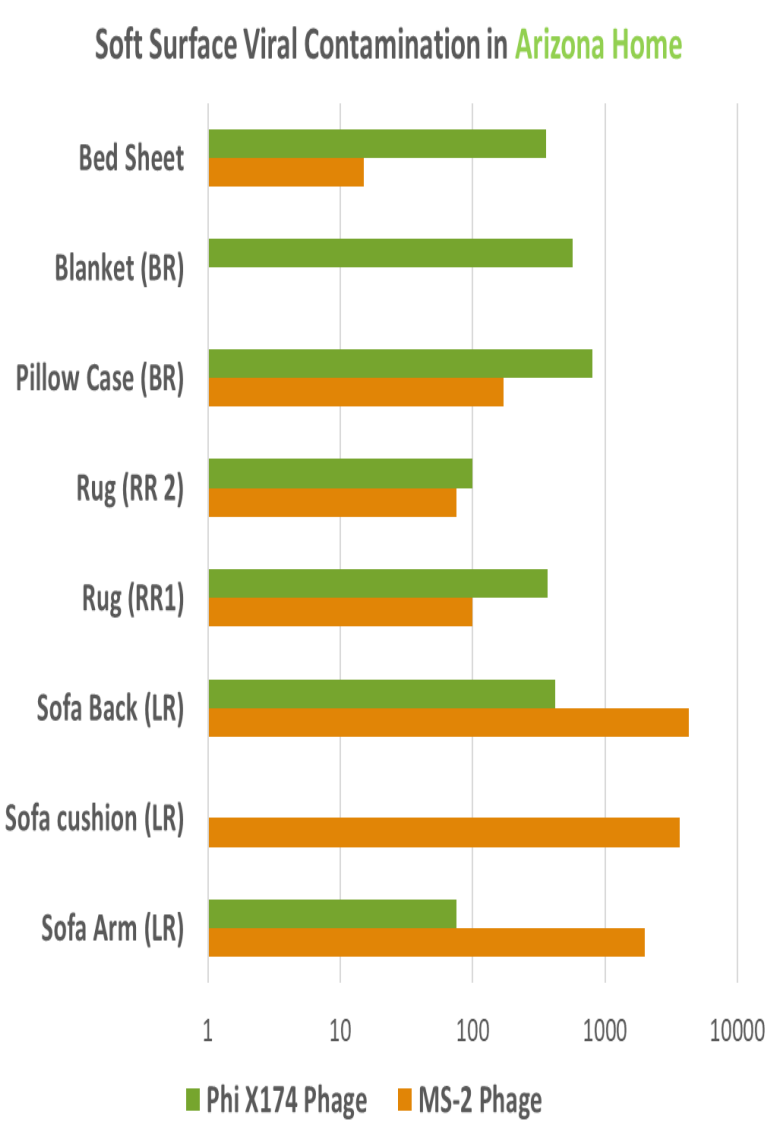
3) Occupants did not know which surfaces were contained with virus.

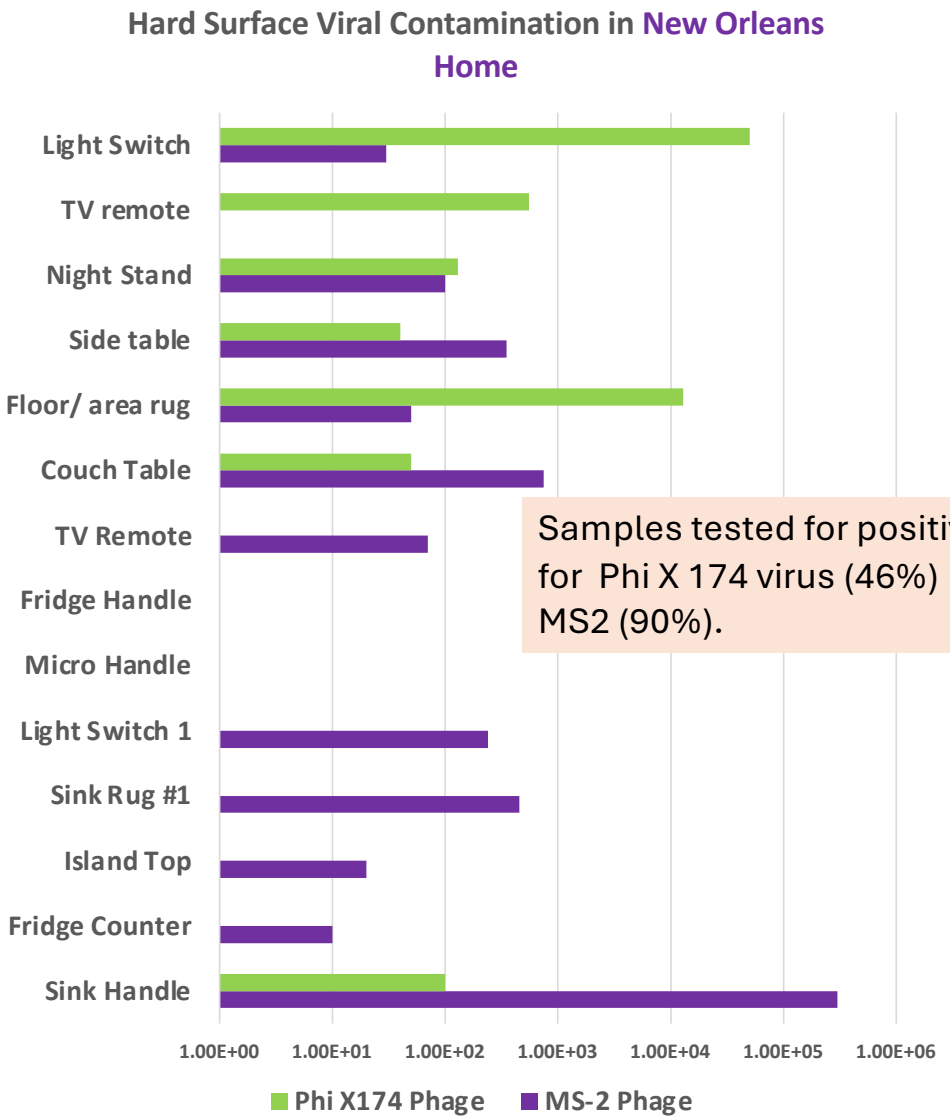
4) They were asked to continue their normal activities.

5) Home samples of both soft and hard surfaces were collected after 24 hrs.

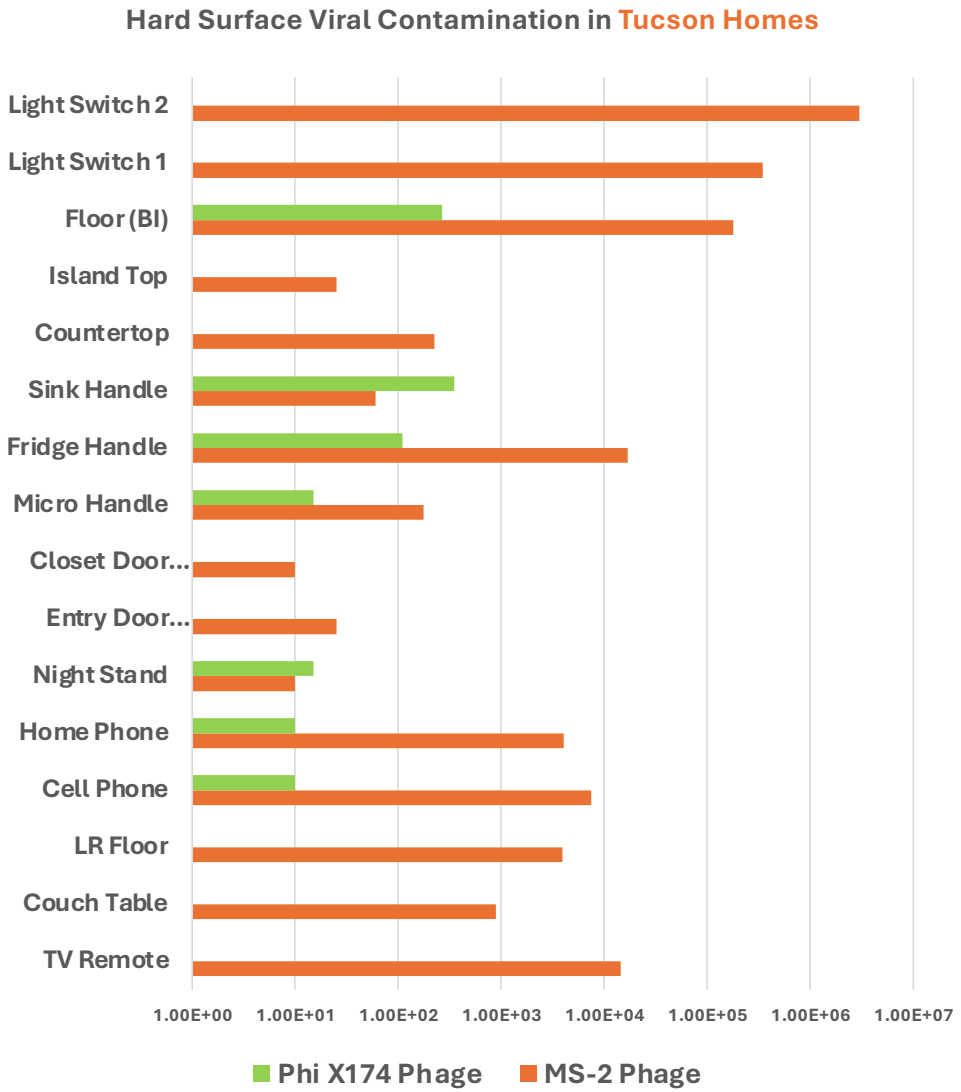


- 100% of all soft surfaces sampled (20 total) tested positive for MS2 after contamination of restroom.





Samples tested for positive for Phi X 174 virus (46%) and MS2 (90%).

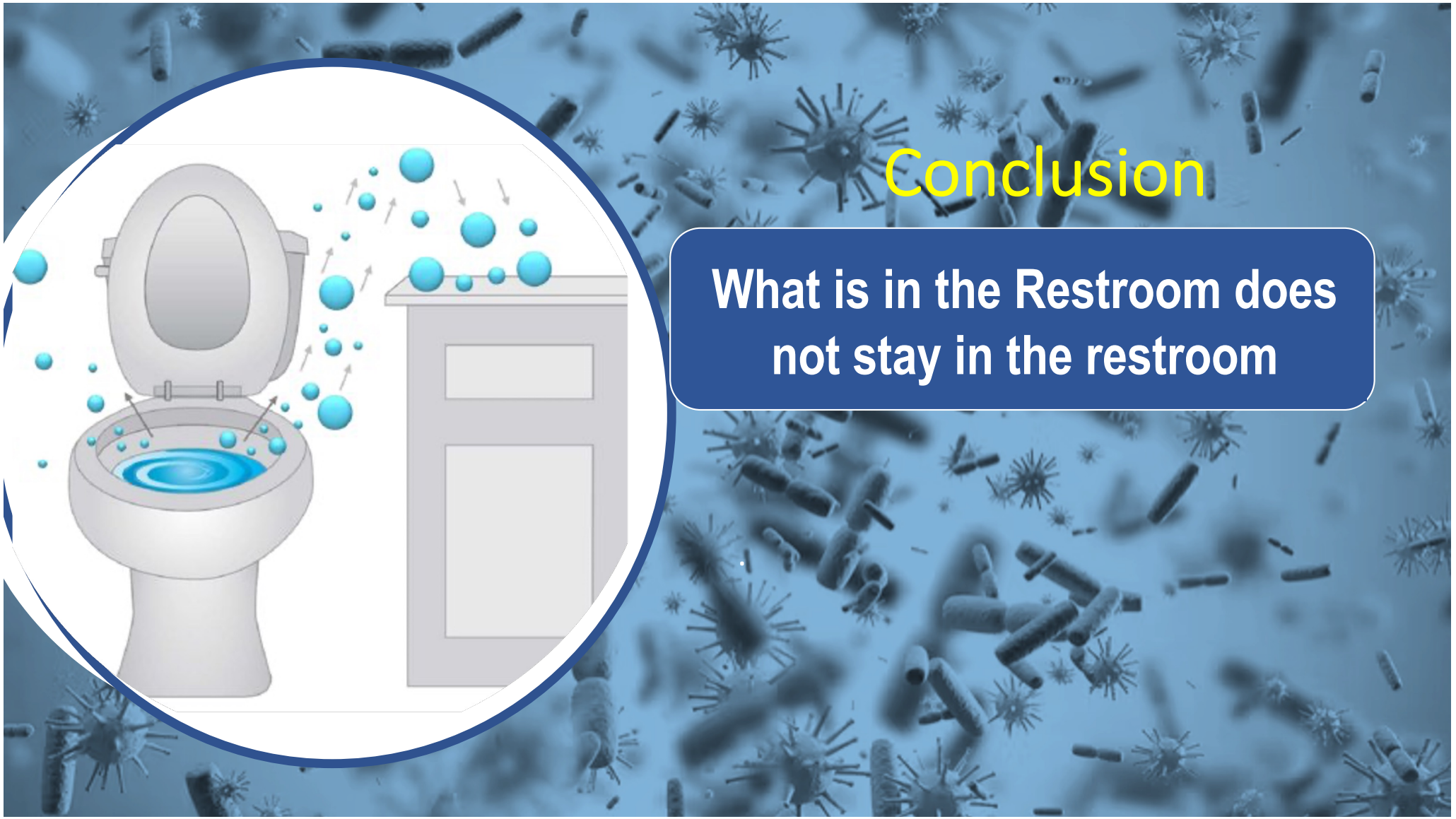


Hospital Waiting Room Restroom

MS-2 virus added to the entrance to the restroom door handle.

Within 4 hours:
Virtually all the surfaces become contaminated. In the restroom and –

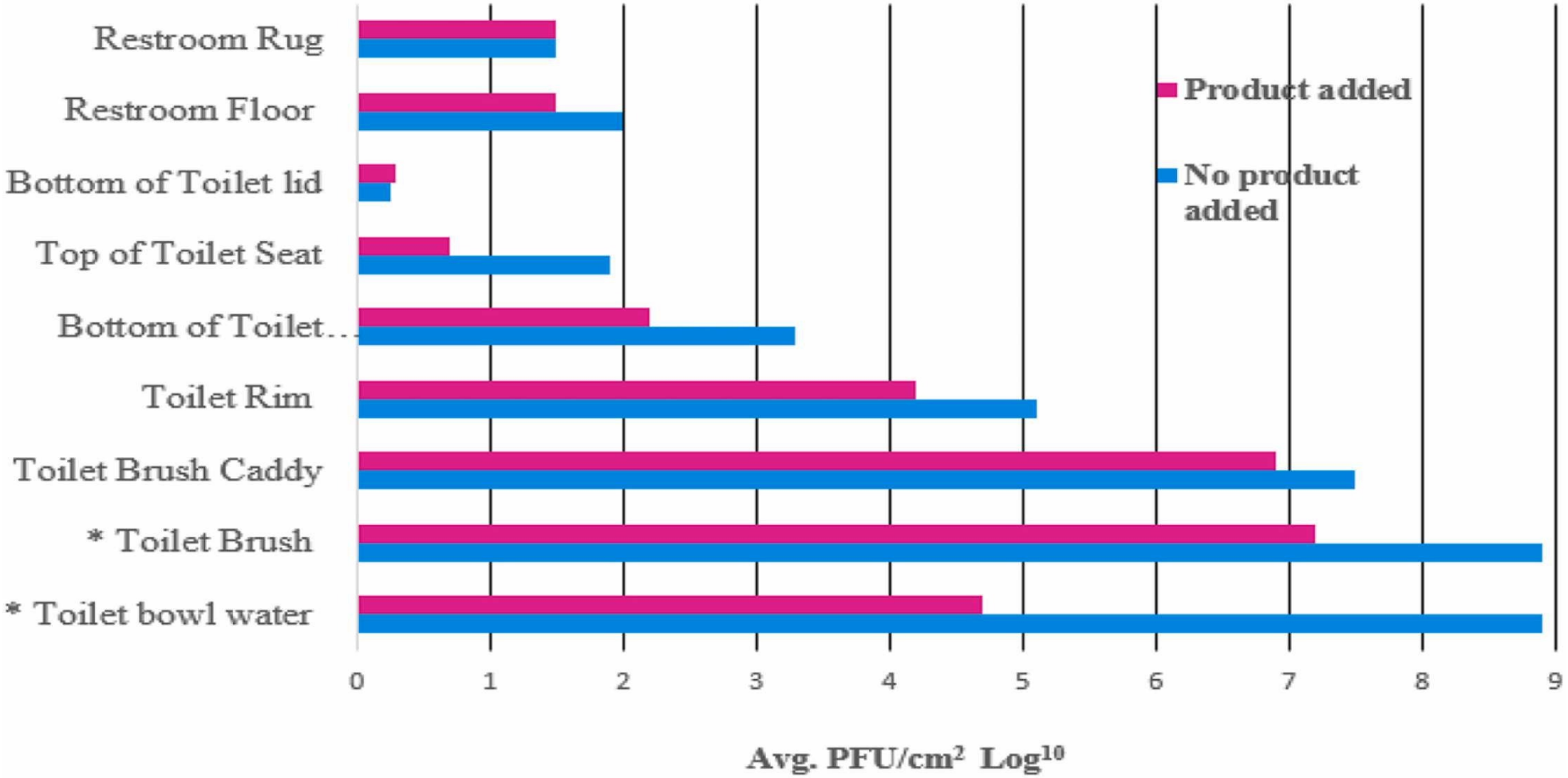
*Nearby nursing station
*chairs in the patient waiting room

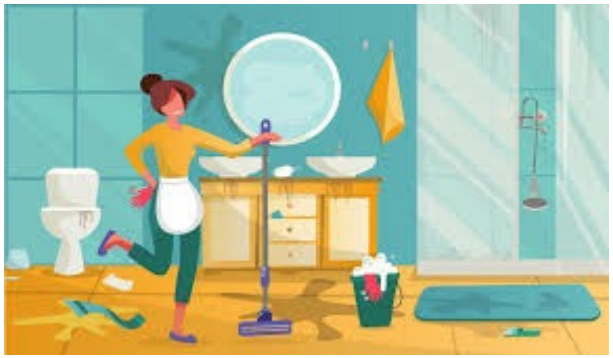

Conclusion
What is in the Restroom does not stay in the restroom

What is the Optimal Cleaning Frequency for a home Restroom?

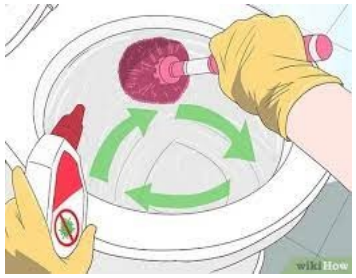
- Compared using one product vs. multiple products.
- Cleaning frequency
  - Every 1, 2, 3 and 7 days.
- Measured total bacteria, *E. coli*/coliform levels as reference for fecal contamination.

Impact of toilet bowl cleaning with and without a disinfectant product on virus contamination of restroom



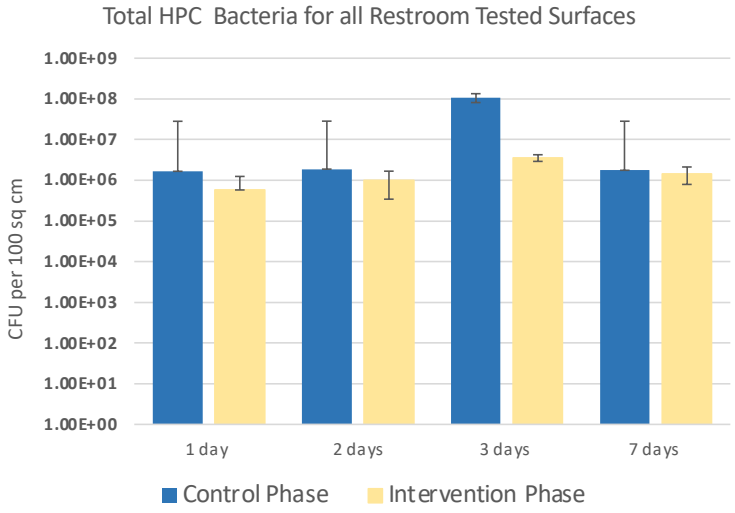


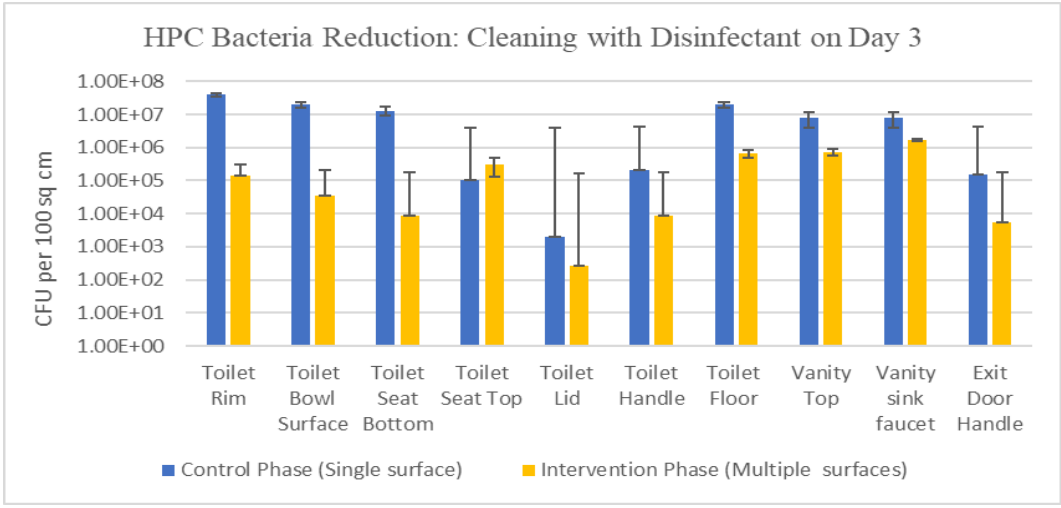
94.5% risk reduction



99.7% reduction risk reduction – 2X per week

For optimal microbe reduction, use multiple disinfectants to clean multiple bathroom surfaces twice a week.





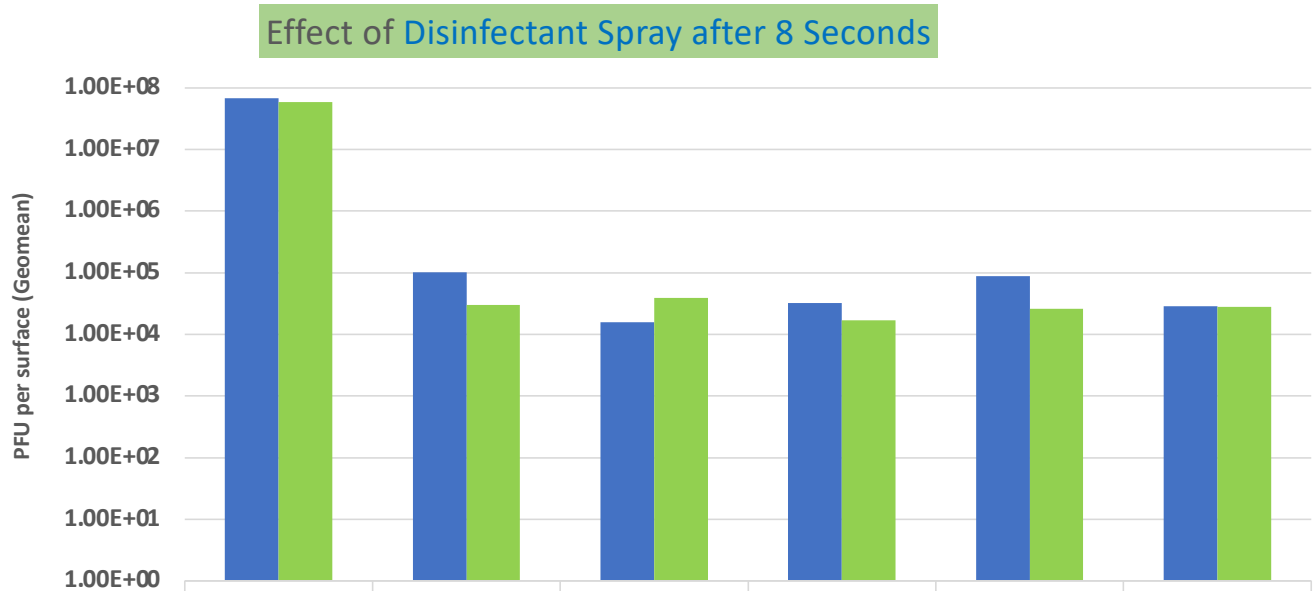
Risk of norovirus infection after cleaning twice a week with Bundle approach of cleaning products

Site	One touch event		Percent reduction in risk
	Before*	After**	After bundle use
Vanity countertop	1.14×10^{-1}	$\leq3.30\times10^{-4}$	≥99.7
Toilet seat	5.8×10^{-3}	$<3.30\times10^{-4}$	≥94.3

Assessment of Aerosol Spray sanitizer

- MS2 virus was added to the toilet bowl water,
  - toilet was flushed,
  - and Air Sanitizing Spray product was used per instructions.
    - (spray for 30 or 8 seconds then, close bathroom door and leave spray for 12 mins.).
- 15 minutes post spray all samples were collected using a sponge stick from restroom surfaces.

The Effect of Hard Surface *Disinfectant Spray* on Virus Cross-contamination of Restroom Surfaces Post-flushing

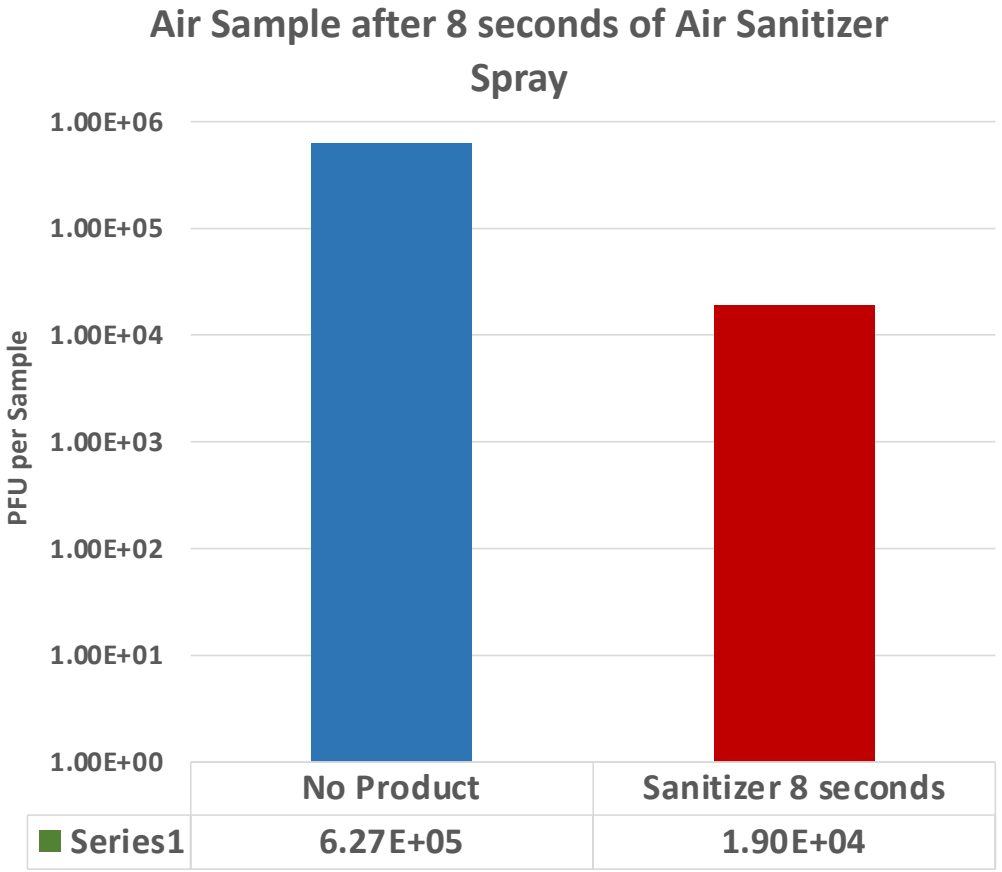


	Toilet seat	Toilet Floor	Toilet Handle	Vanity Top Left	Vanity Top Right	Corner Shelf
No Product	6.77E+07	1.02E+05	1.58E+04	3.21E+04	8.82E+04	2.89E+04
LDS	5.96E+07	3.00E+04	3.90E+04	1.70E+04	2.60E+04	2.80E+04

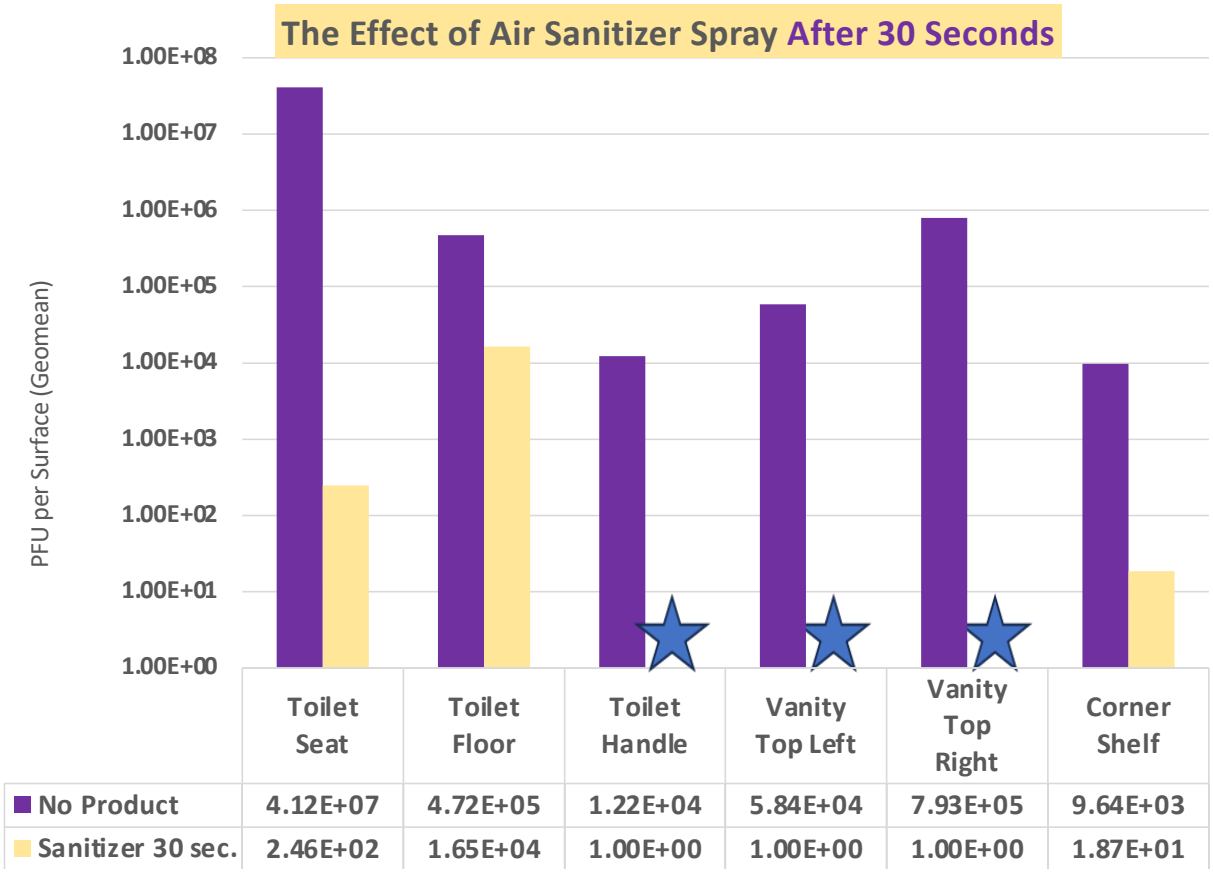
Very little or no reduction in contamination after spraying with a hard surface disinfectant Spray

Effect of *Air Sanitizer* Spray on Air Contamination (Anderson sampler) after 8 seconds

- *Air Sanitizer* Spray reduced restroom air contamination of MS2 virus by > 95% after 8 second spray.



The Effect of *Air Sanitizer* Spray on Virus -Cross-contamination of Restroom Surfaces Post-flushing



Air sanitizer Spray reduced surface virus contamination of bathroom surfaces by **99 to > 99.999% or a 1-5 log reduction of viruses using 30 second spray time.**

A significant difference of (p=.00378) was found between product use and no use.

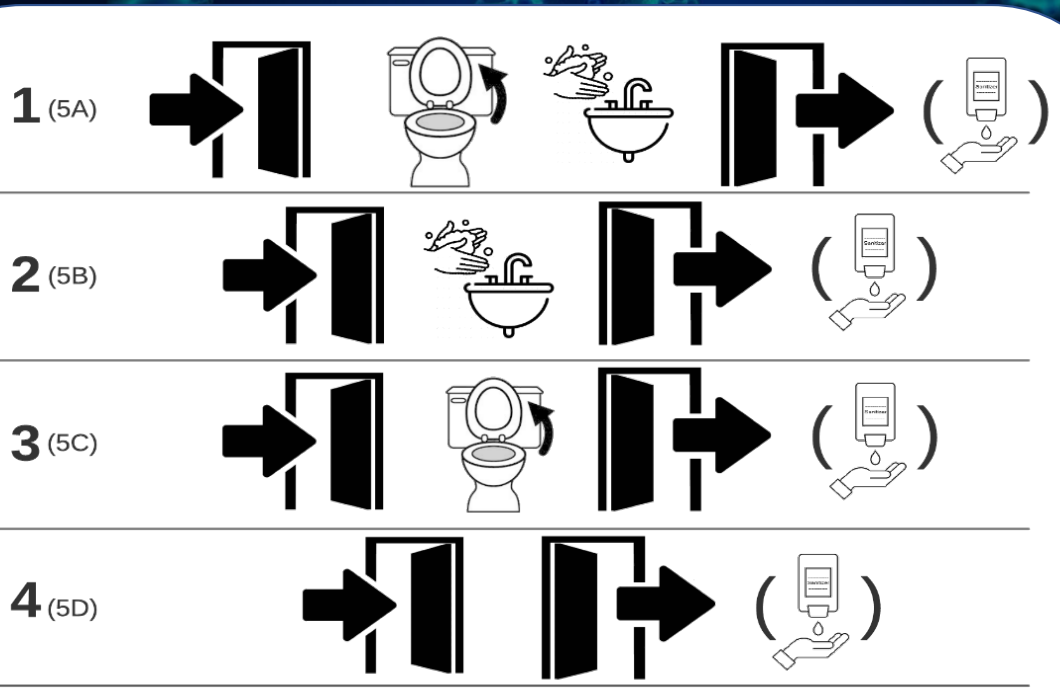
★ *Below limit of detection.*

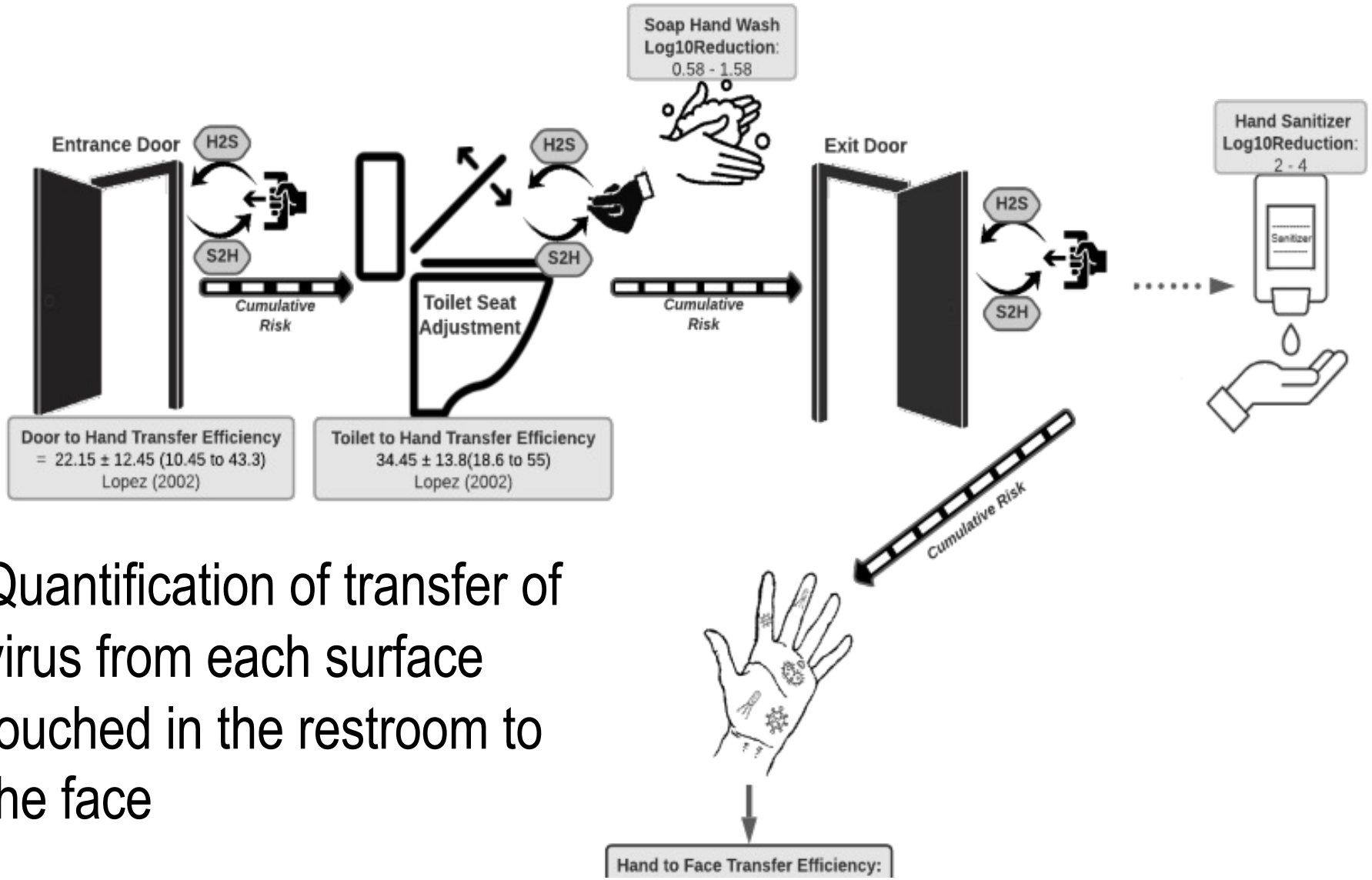
Toilet seat – 99.999% reduction
Toilet floor- >95 % reduction
Toilet Handle - >99.99%
Vanity Top (left & right side) - > 99.99%.
Corner shelf - 99.5%


Quantifying the risk of infection from norovirus from restroom use
Use quantitative microbial risk assessment Models to
. determine the risk from different scenarios of restroom use

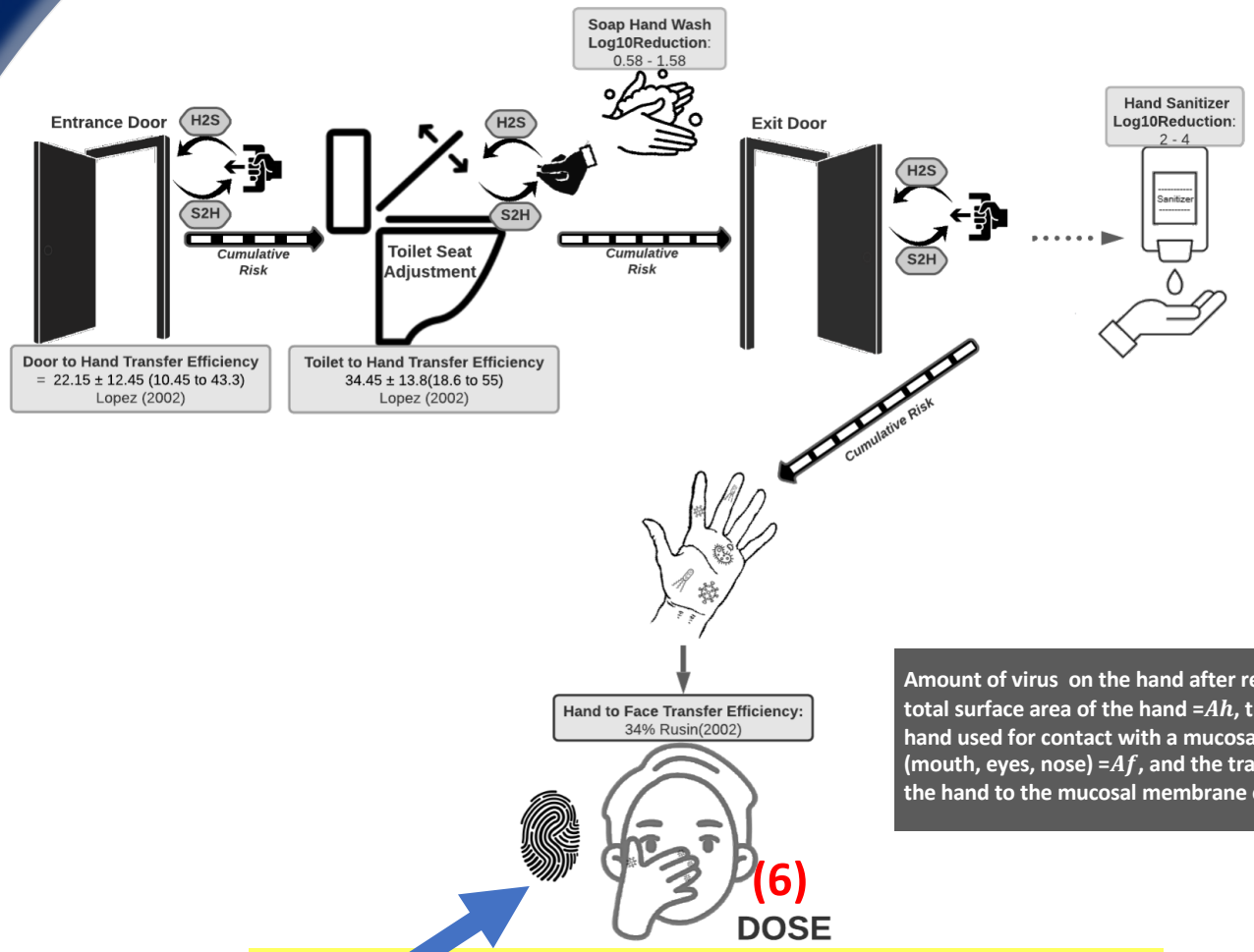
Restroom use

Exposure Scenarios



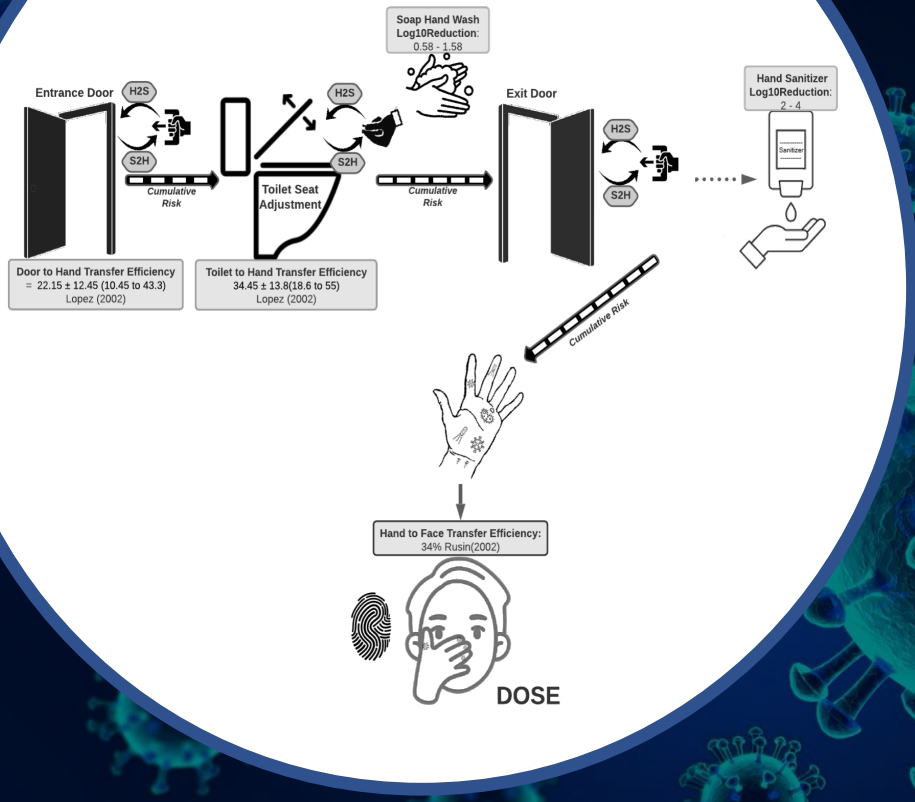


Quantification of transfer of virus from each surface touched in the restroom to the face



Amount of virus on the hand after restroom use= HC total surface area of the hand =Ah, the fraction of the hand used for contact with a mucosal membrane (mouth, eyes, nose) =Af, and the transfer efficiency for the hand to the mucosal membrane contact = TEh2f.

$$T_{FC \rightarrow D} = HC * TEh2f * Af * Ah \qquad (6)$$



Conclusions

- Adjustment of the toilet seat and exit door handle have the highest risk of infection highest risk of infection.
- **Hand washing and alcohol gel sanitizer in combination are needed to reduce the risk from norovirus infection to 99.9%**

Conclusions

- Closure of toilet lid had no significant impact of viral contamination of the toilet seat, lid or surrounding areas (floor, walls)
- Cleaning the toilet bowel with a brush resulted in contamination of the toilet seat, lid or surrounding areas (floor, walls)
- Contamination was reduced if a disinfectant was used during toilet bowl cleaning
- Use on an air sanitizer spray after toilet flushing reduces contamination throughout the restroom

Conclusions

- Optimal cleaning/disinfection of restroom in the home is twice a week using both bowl cleaner and surface disinfectants
- Handwashing plus hand sanitizer are needed to reduce risk of norovirus transmission by 99.9%

Questions?

COMING SOON ... NEW AND IMPROVED

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2025 Teleclass Education Topics

(most of them at least ... a few are yet to confirm)

FEBRUARY

6 ... Policy and Practice for Environmentally Sustainable Products in Healthcare: Joining the Dots
With Prof. Mahmood Bhutta, UK

13 ... Food Safety of Fresh Produce: An Old Food Safety Problem Nut With New Solutions
With Prof. Keith Warriner, Canada

19 ... The Art of IV Line Care
With Claire Rickard

20 ... To aeruginosa or Not to aeruginosa: How Significant are Pseudomonads in Waterborne Healthcare Infections
With Prof. Helen Rickard and Prof. Elaine Cloutman-Green, UK

MARCH

4 ... Preventing MRSA Bacteraemia: An Achievable Outcome Even in High Endemic Hospitals
With Prof. Michael Borg, Malta

13 ... The Next Pandemic - Are We Prepared?
With Prof. Michael Klompas, US

20 ... Frugal Innovation for Low-Resource Settings
With Prof. Davide Piaggio, UK

APRIL

3 ... Assessment of Mould Remediation in a Healthcare Setting Following Extensive Flooding
With Manjula Meda, UK

10 ... Use of Artificial Intelligence for Healthcare-Associated Infection Surveillance
With Prof. Ruth Carrico, US

22 ... Cost Analysis of a Hand Hygiene Improvement Strategy in Long-Term Care Facilities
With Dr. Anja Haenen, Netherlands

30 ... The Impact of Sink Removal and Other Water-Free Interventions in Intensive Care Units on Water-Borne Healthcare-Associated Infections
With Jia Ming Low, Singapore

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