Refillable and Reusable Dispensers: Bacterial Contamination and Risk Assessment

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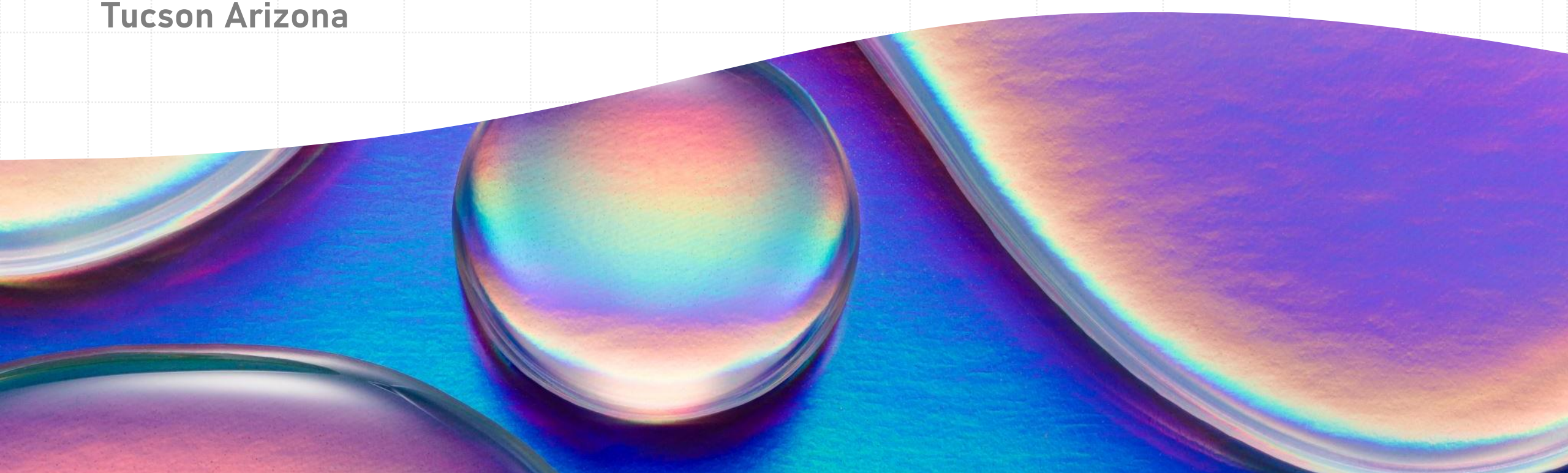
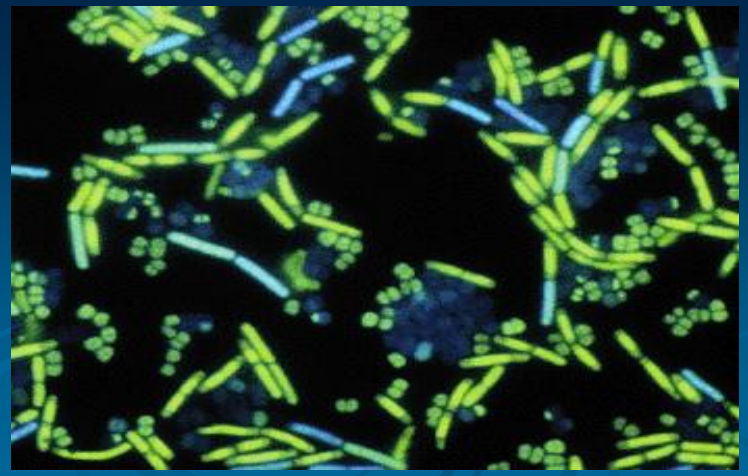


Liquid Soap Dispensers

Soap dispensers you would not want to use

Bacteria in Liquid Soap Dispensers – all are not the same

Total Number of Open Refillable Soap Samples	Number of Samples with Bacteria	Number of Samples with Coliforms (usually > 1,000,000/mL)
541	133 (25%)	87 (16%)



Frequency of Detection of Bacteria in Liquid Hand Soaps

Bacterial Species	Frequency of Detection
Klebsiella oxytoca	30
Klebsiella pneumoniae	29
Enterobacter aerogenes	13
Serratia marcescens	12
Pseudomonas aeruginosa	7
Citrobacter koseri / farmeri	3
Enterobacter cloacae	2
Enterobacter gergoviae	2
Serratia odorifera	1
Serratia liquefaciens	1
Pantoea spp.	1
Klebsiella ornithinolytica	1
Enterobacter spp.	1
Citrobacter freundii	1
Enterobacter sakazakii	1

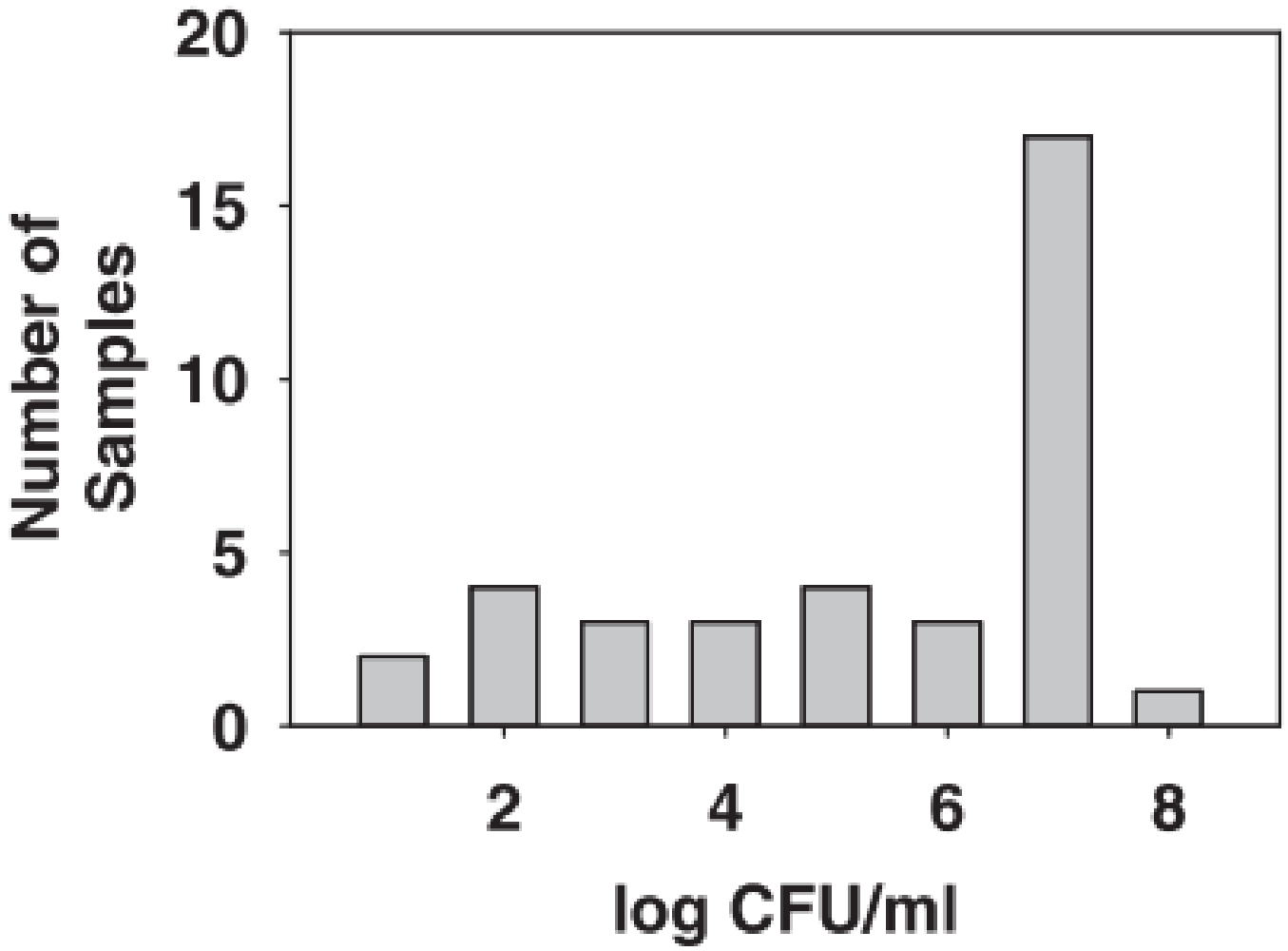
Chattman et al 2011

Identification of bacteria isolated from bulk-soap-refillable soap dispensers (Zapka et al 2011)

- Cirtobacter frundii
- Citrobacter youngae
- Providencia rettgeri
- Pseudomonas aeruginosa
- Pseudomonas fluorescents
- Serratia rubidara

. The distribution of microbial counts in contaminated soap samples.

Schaffner et al 2018



Fraction of samples containing detectable bacteria by soap color

Color	No. sampled	No. of times bacteria detected	% detected
Green	11	5	45.5
Clear	24	7	29.2
Orange	37	8	21.6
Pink	120	12	10.0
White	41	3	7.3
Blue	42	3	7.1
Yellow	16	0	0.0
Unknown	6	0	0.0

Schaffer et al 2018

Relationship between water activity and bacterial contamination of hand soap dispensers

The greater the water activity the more likely to be contaminated with bacteria (Schaffer et al 2018)

Could be a reflection of dilution of product conentrate

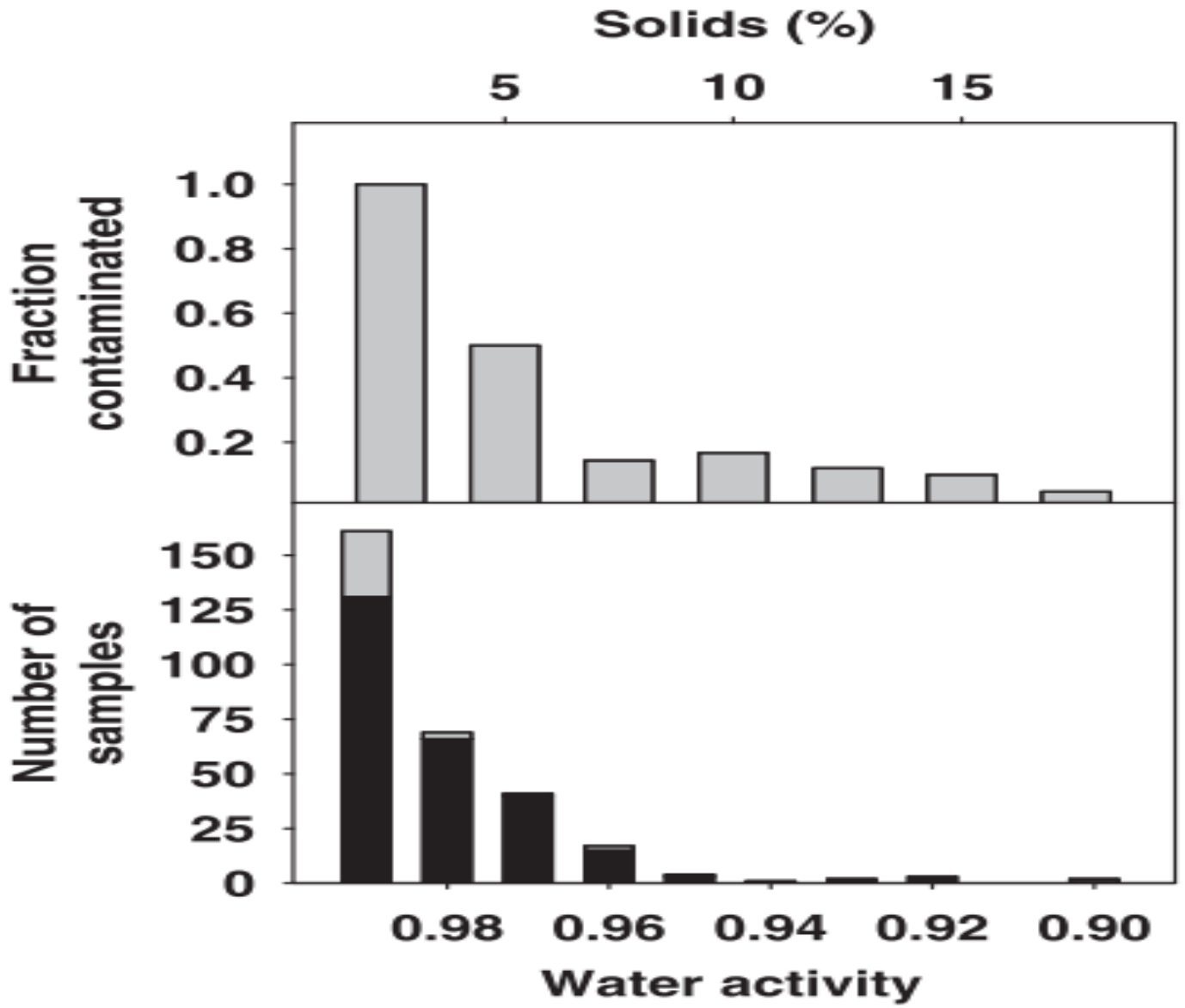
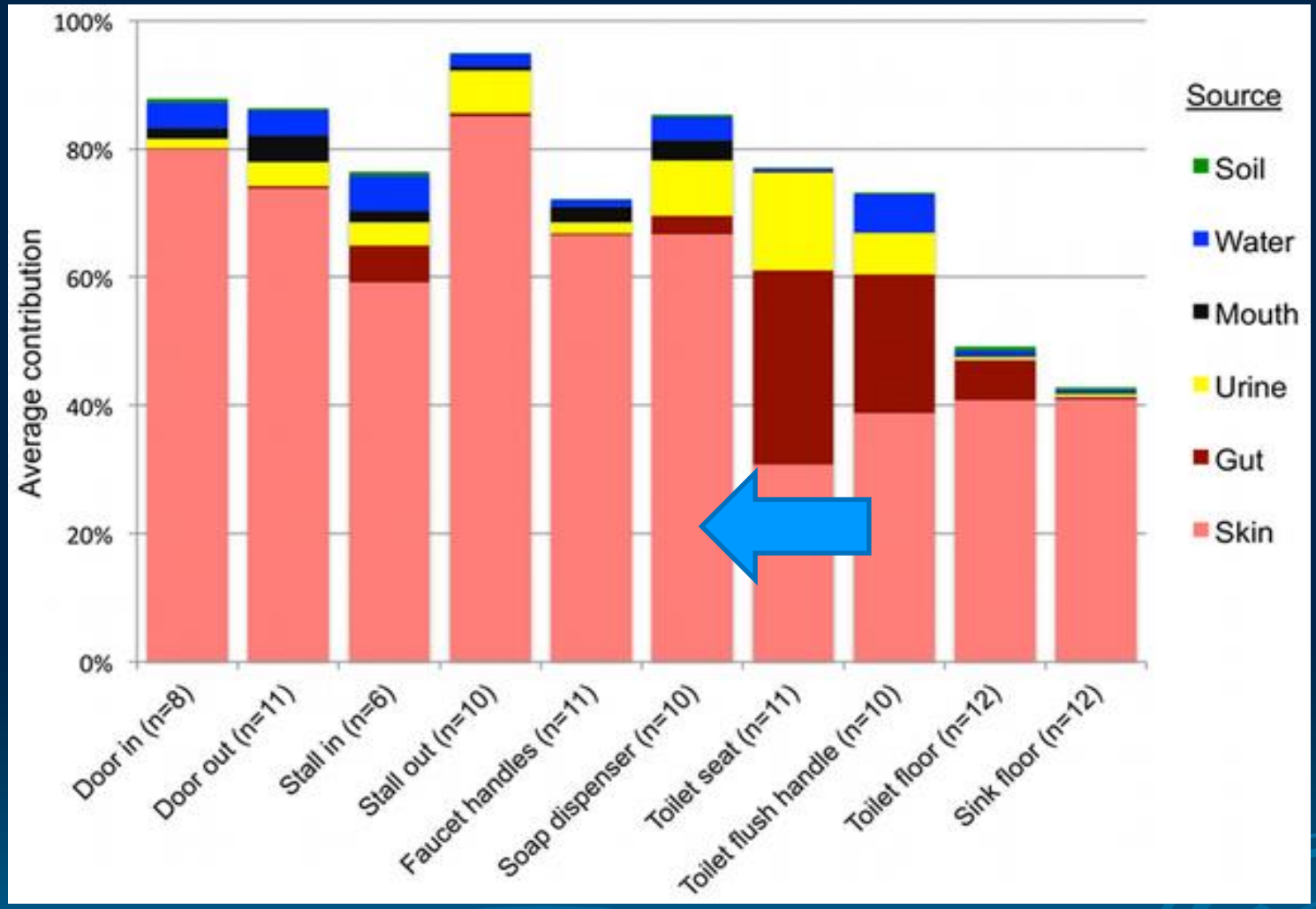


Figure 4. Results of SourceTracker analysis showing the average contributions of different sources to the surface-associated bacterial communities in twelve public restrooms.



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

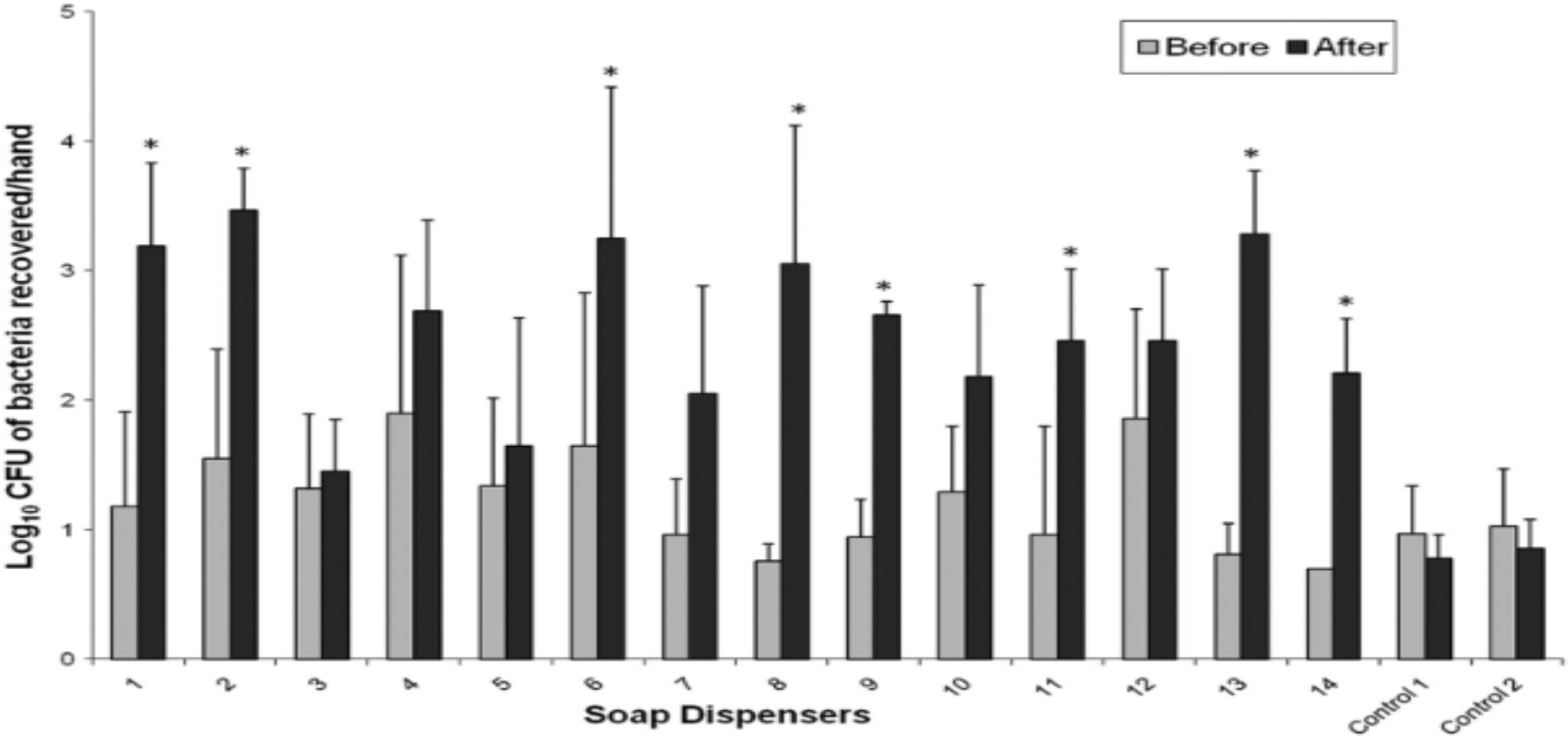
No bacterial contamination was found in soap dispensed from sealed systems

E. coli in Liquid Hand dispensers

- 25% of bacterial contaminated liquid soap dispensers contained *E. coli*
- Some of the bacteria remain on the hands after washing with contaminated soap

Red dots are bacteria

Gram-negative bacteria from hands of school children and staff before after washing with contained bulk soap dispenser (Zapka et al 2011). More bacteria on hands after washing with contaminated soap



Occurrence of Bacteria in Liquid Hand Soap From Refillable Dispensers

Location	# of Liquid Soap Samples	# > 500 CFU/mL	# Containing Coliform Bacteria	% of Samples With HPC > 500 CFU/mL	% of Samples Containing Coliform Bacteria
Total	541	134	86	24.8	15.9
Sink area	428	83	56	19.4	13.1
Shower area	113	51	30	45.1	26.5

Chattman et al 2011

Antibiotic Resistant Bacteria in Soap Dspensers

- 23 samples contained vancomycin-resistant organisms.
- Seven of these were also resistant to ampicillin, and two of those, in turn, were resistant to gentamicin.
- One sample contained an organism resistant to vancomycin, ampicillin, gentamicin, and ciprofloxacin (antibiotic resistance data not

- (Schaffner et al 2018)

Does Handwashing Spread Microbes?

Sample Location	Automatic Faucet*	Manual Faucet*
Faucet	180,000	570
Countertop	103,000	57
Wall behind sink	58,000	330
Sink Bowl	20,800,000	71,600,000
Hand after washing	180,000	95,000

-Add ~10^9 MS-2 virus to hands before washing – males only
*Number of viruses as plaque forming units per 100 sq. cm

Shampoo, Conditioner and Body Wash Dispensers

Gram-Positive Bacteria Isolated from spout of Shampoo and Body Wash Dispensers

Shampoo Dispensers

- Paenibacillus shunpengi (spore former)
- Staphylococcus spp.
- Bacillus spp.
- Micrococcus spp.

Body Wash Dispensers

- Staphylococcus spp.
- Bacillus subtills
- Bacillus filamentosus
- Aerococcus spp (cause urinary tract infections)
- Bacillus firmus
- Micrococcus spp.
- Bacillus pumuli
- Staphylococcus haemolyticus (urinary, wound, and eye infections)

Gram-Positive Bacteria Isolated from spout of Shampoo and Body Wash Dispensers

- Range of Gram-positive bacteria when detected
- 3,333 to 66,700 per mL

- *Bacillus firmis* and *Staphylococcus spp. d*etected resistant to the antibiotics Oxacillin and Erythromycin

Bacterial Outbreaks from Soap Dispensers have been Documented by *Staph., Pseudomonas* and *Serratia spp.*

OPEN ACCESS Freely available online

PLoS one

Molecular Epidemiology of a *Pseudomonas aeruginosa* Hospital Outbreak Driven by a Contaminated Disinfectant-Soap Dispenser

Simone Lanini[1]*, Silvia D'Arezzo[1], Vincenzo Puro[1], Lorena Martini[1], Francesco Imperi[2], Pierluca Piselli[1], Marco Montanaro[3], Simonetta Paoletti[3], Paolo Visca[2], Giuseppe Ippolito[1]

1 National Institute for Infectious Diseases "Lazzaro Spallanzani", I.R.C.C.S., Rome, Italy, 2 Department of Biology, University "Roma Tre", Rome, Italy, 3 UOC Ematologia Azienda Unità Sanitaria Locale di Viterbo, Viterbo, Italy

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Türk Hijyen ve Deneysel Biyoloji Dergisi

Analysis of nosocomial outbreak caused by contamined liquid hand soaps: A single-center study

ELSEVIER

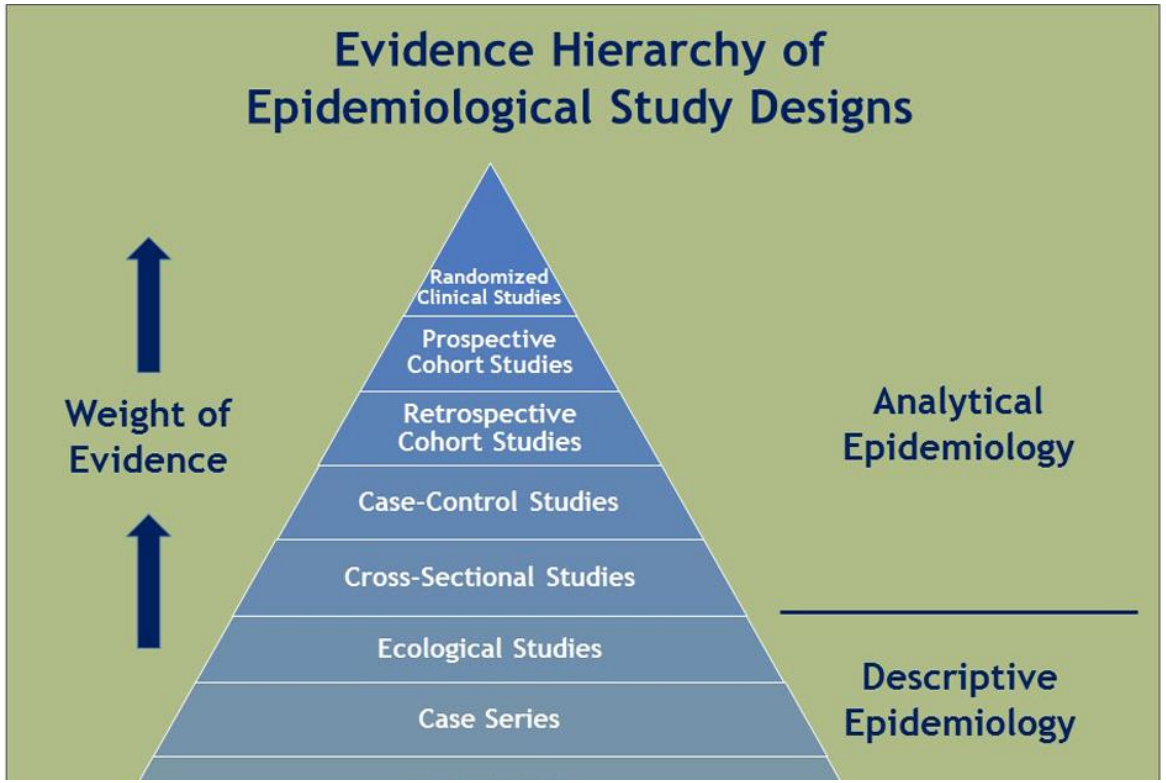
Journal of Hospital Infection

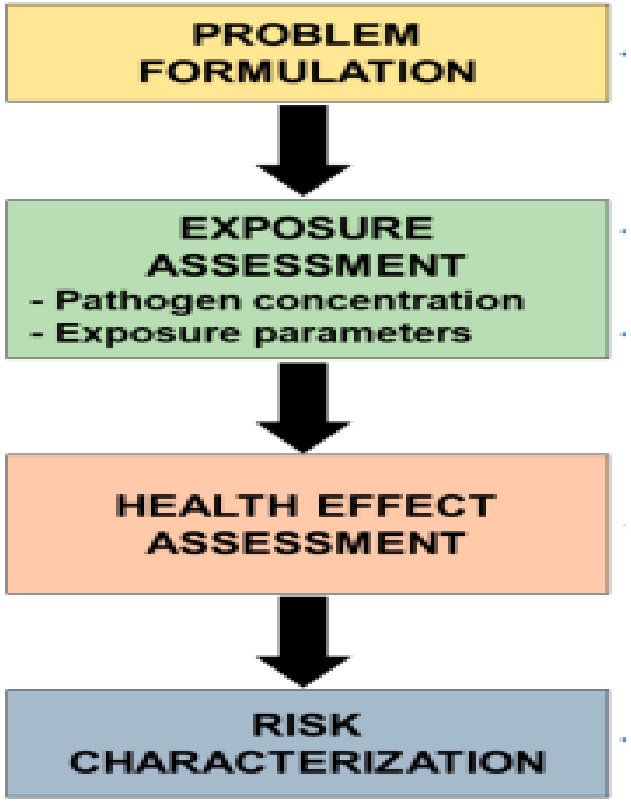
Volume 72, Issue 1, May 2009, Pages 17-22

Outbreak of *Serratia marcescens* in a neonatal intensive care unit: contaminated unmedicated liquid soap and risk factors

S. Buffet-Bataillon [a], V. Rabier [b], P. Bétrémieux [b], A. Beuchée [b], M. Bauer [a], P. Pladys [b], E. Le Gall [b], M. Cormier [a c], A. Jolivet-Gougeon [c]

So what are the Risks of infection from bacteria in soap/ shampoo or body wash dispensers





Intervention Studies

Epidemiology

- Difficult to isolate potentially a large number of 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

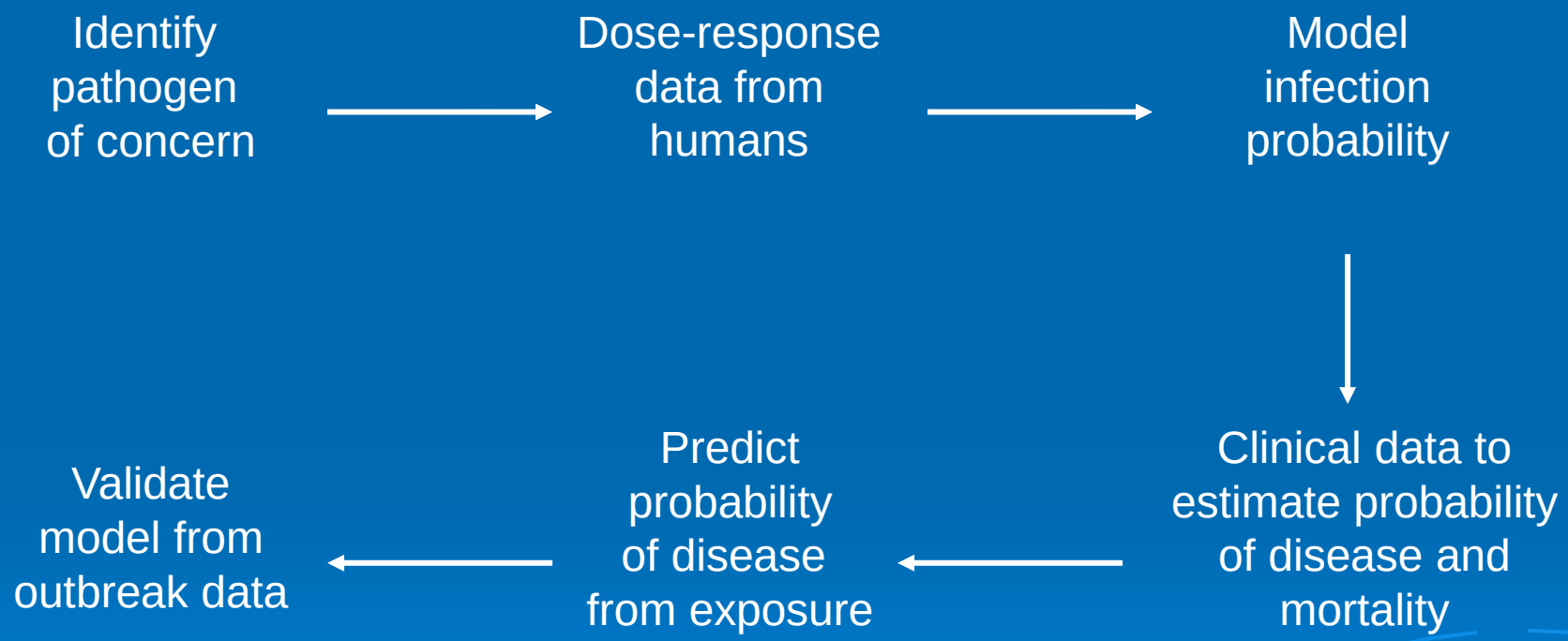
- Confounding factors can be controlled
- Good precision
- Small numbers of individuals needed (or none at all)
- Short observation time
- Can determine what is achievable in terms of reduction in risk of infection for a specific pathogen
- Can determine importance of specific exposure routes
- Far less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

Quantitative Microbial Risk Assessment is an approach that allows the expression of risks in a quantitative fashion in terms of infection, illness, or mortality from microbial pathogens

First used by the U. S. Environmental Protection Agency to set guidelines for the treatment of drinking water

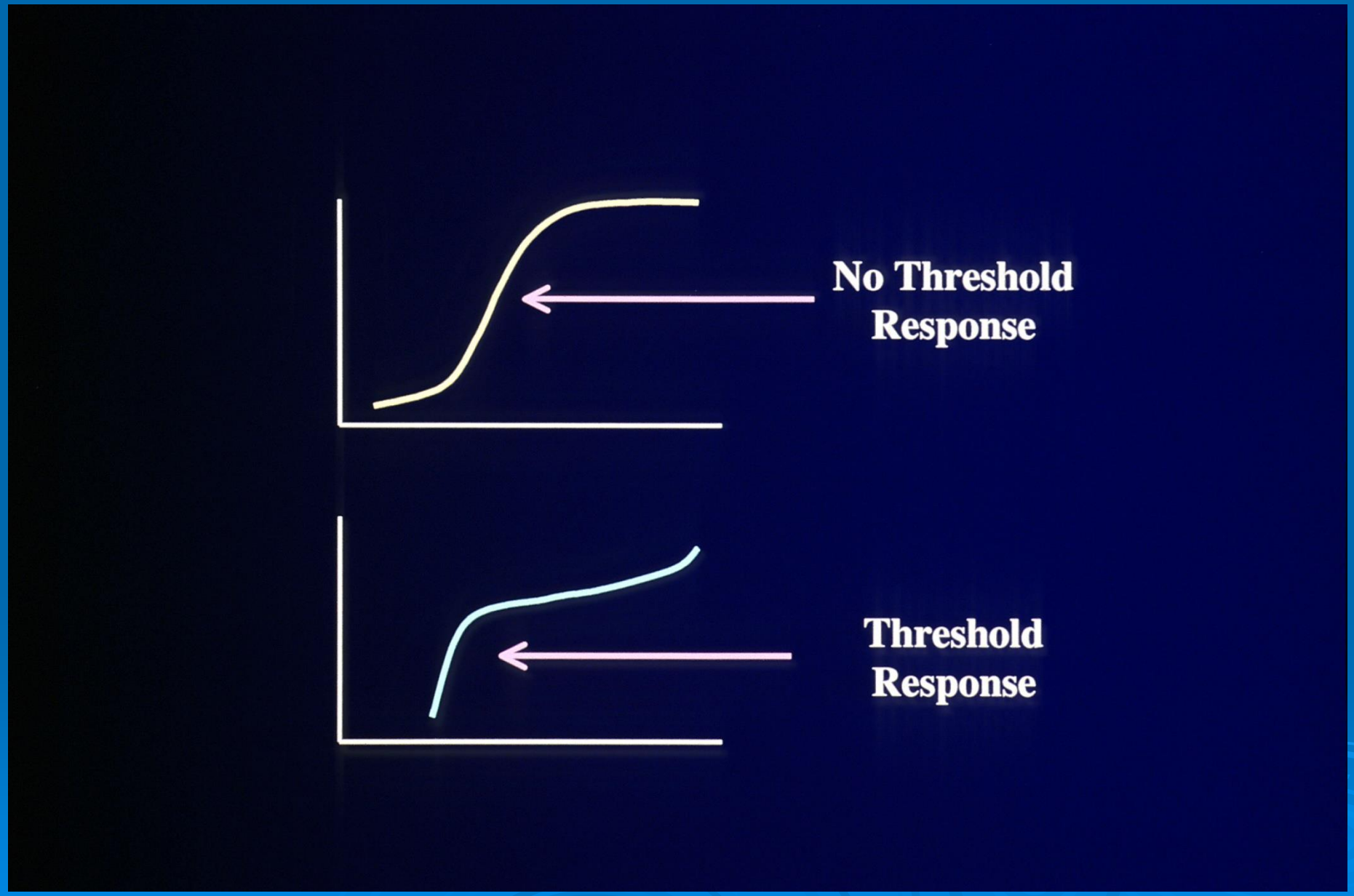
Goal is to reduce the risk of infection to 1:10,000 per year or 1,1,000,000 per day or event

Quantitative Microbial Risk Assessment



Four Basic Steps in Risk Assessment

- Hazard Identification - identifying the contaminate (i.e., *Pseudomonas*)
- Dose-Response Assessment - relationship between concentration of and the probability of infection
  - Data may come from human/animal feeding studies or outbreaks


No Threshold
Response
Threshold
Response

Dose Response Models for Microorganisms

Beta-Poisson
(Simple log-normal)

$$P = 1 - \left(1 + \frac{N}{\beta}\right)^{-\alpha}$$

Exponential

$$P = 1 - \exp(-rN)$$

P = Probability of infection from a single exposure
N = Number of organisms ingested
α and β = parameters characterizing the host-organism interaction
r= fraction of the ingested organisms that survive to initiate infections

EXPOSURE

ROUTE

Inhalation, ingestion, dermal

CONCENTRATION OF PATHOGEN

Organisms per ml in the soap

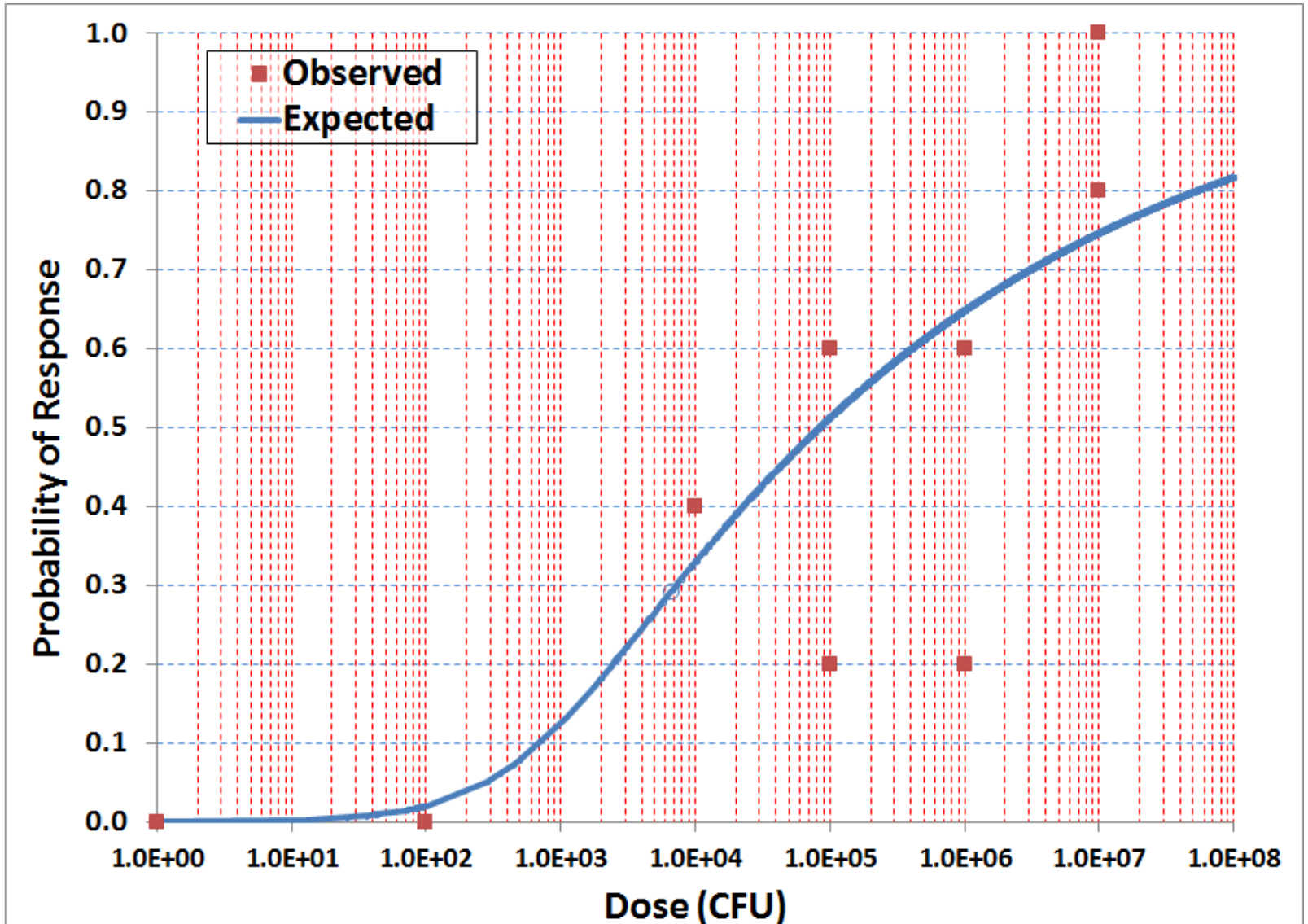
DURATION

One event, multiple events

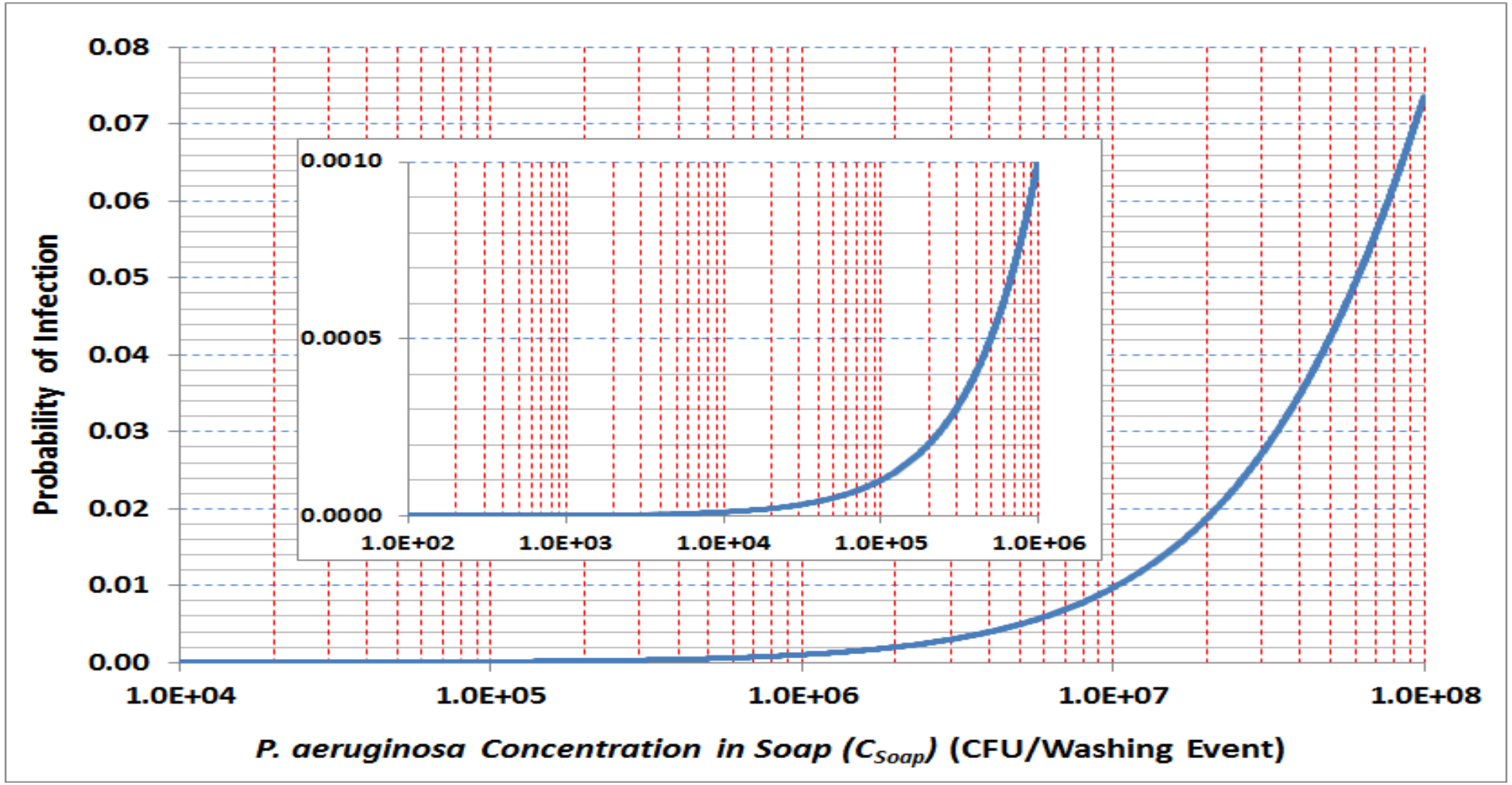
Exposure Routes for Soaps

- Wounds (cuts, scratches)
- Eye contact
- Mucus membranes
- Inhalation

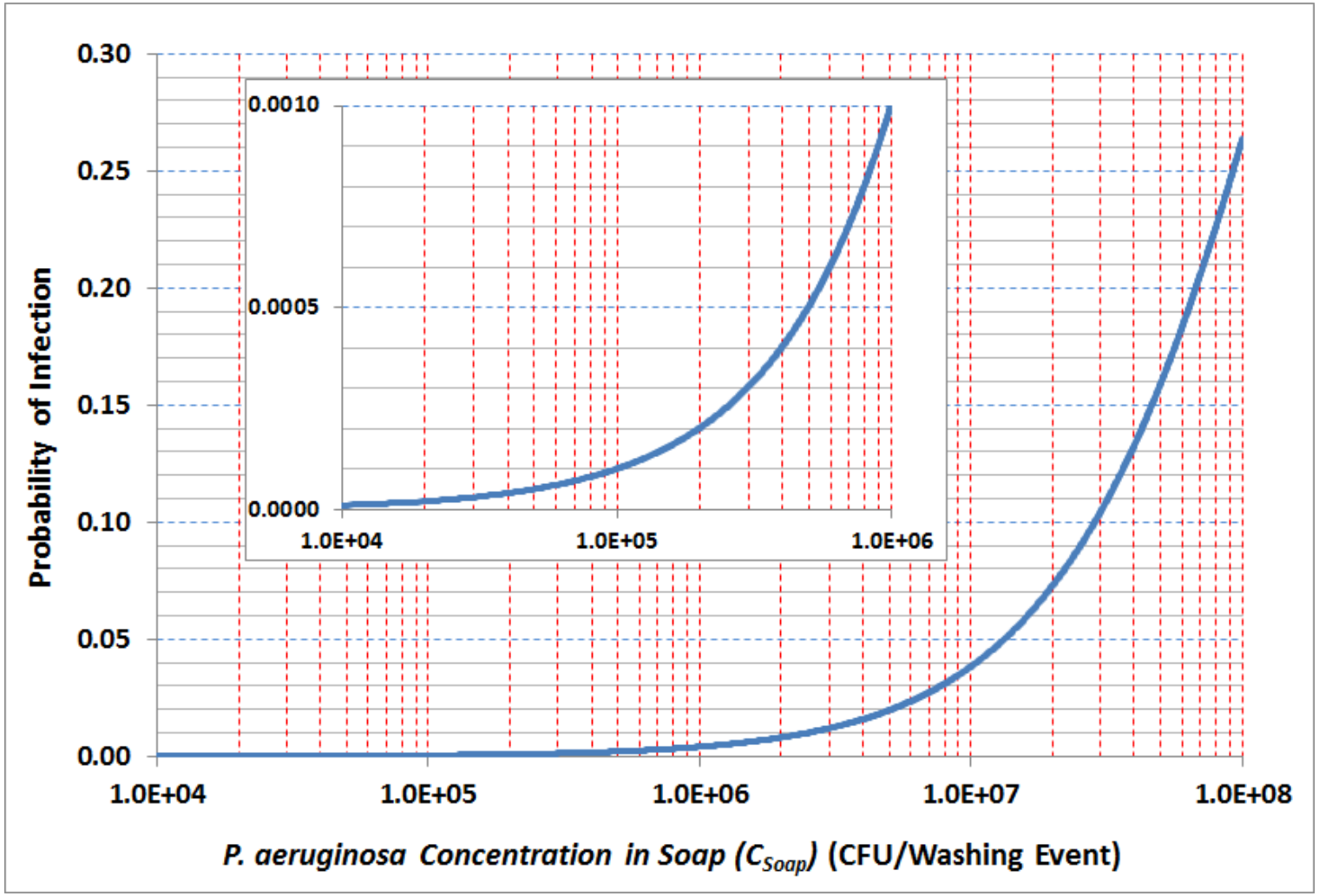
beta-Poisson dose-response curve that can be used to determine the probability of *P. aeruginosa* infection. (based on placement of contact lenses contaminated with *P. aeruginosa* – Lawin-Brussel et al 1993



Probability of eye infection with different concentrations of *P. aeruginosa* on the hand resulting from to one touch of eye



Probability of eye infection with *P. aeruginosa* due to 4 touches of eye



Take Homes

- Refillable dispensers present a risk of infection to susceptible individuals when high concentrations of bacteria are present
- High concentrations of bacteria occur in 13 to 26% of all soap dispensers used in public facilities
- Concentrated soap products should not be diluted beyond manufactures recommendation
- Non-refillable dispensers present little or no risk
- If possible, guidance should be developed for maintenance of refillable dispensers – but evidence is needed on effectiveness