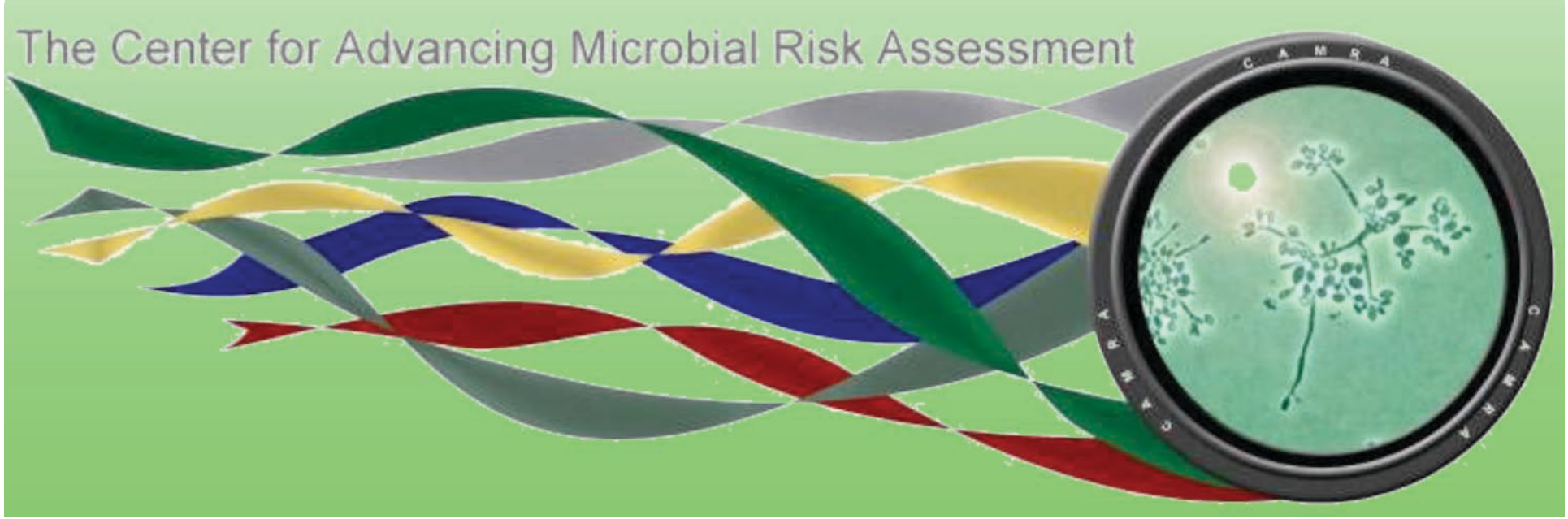
Factors Affecting Fomite Survival
and
The Future of Fomites

Ryan Sinclair M.P.H., Ph.D.



Introduction

Fomite Definition: any inanimate object capable of transmitting pathogens

- Global
  - Escalator hand rails, elevator buttons, restroom doorknobs, public phones
- Local
  - Kitchen sponge, computer, cutting board, etc.

Objective

- Discuss where most variability and uncertainty is.
- What drives the risk assessment?

Outline

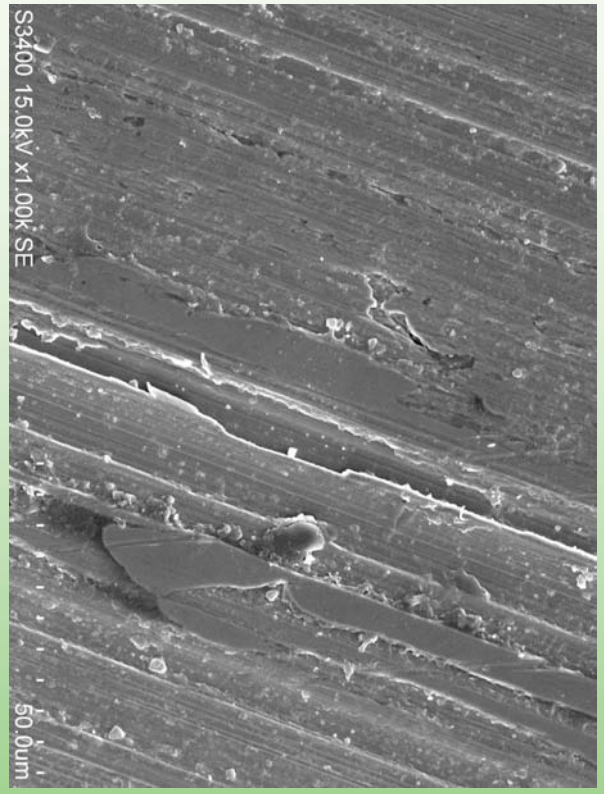
- **Work done at CAMRA institutions**
- Factors affecting survival
- Basic Model
- Needed studies

Research at UA

Group 1 partners: Laboratory Research Survival Experiments

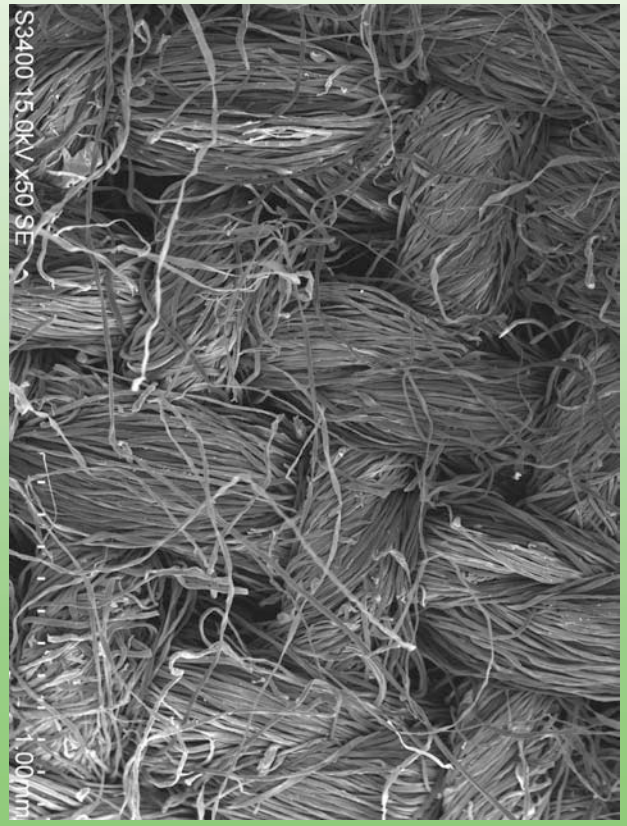
- University of Arizona
- Northern Arizona University
- Michigan State University

UA: Fomites

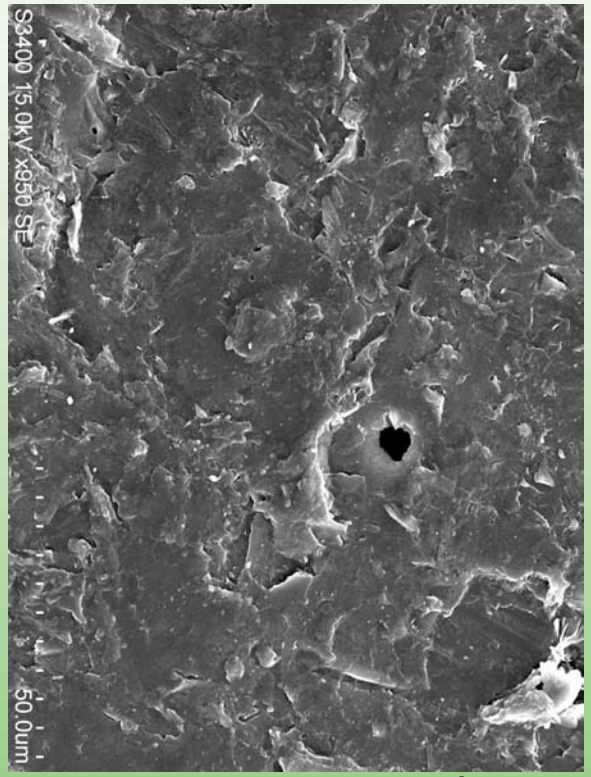


Stainless Steel

Type 304

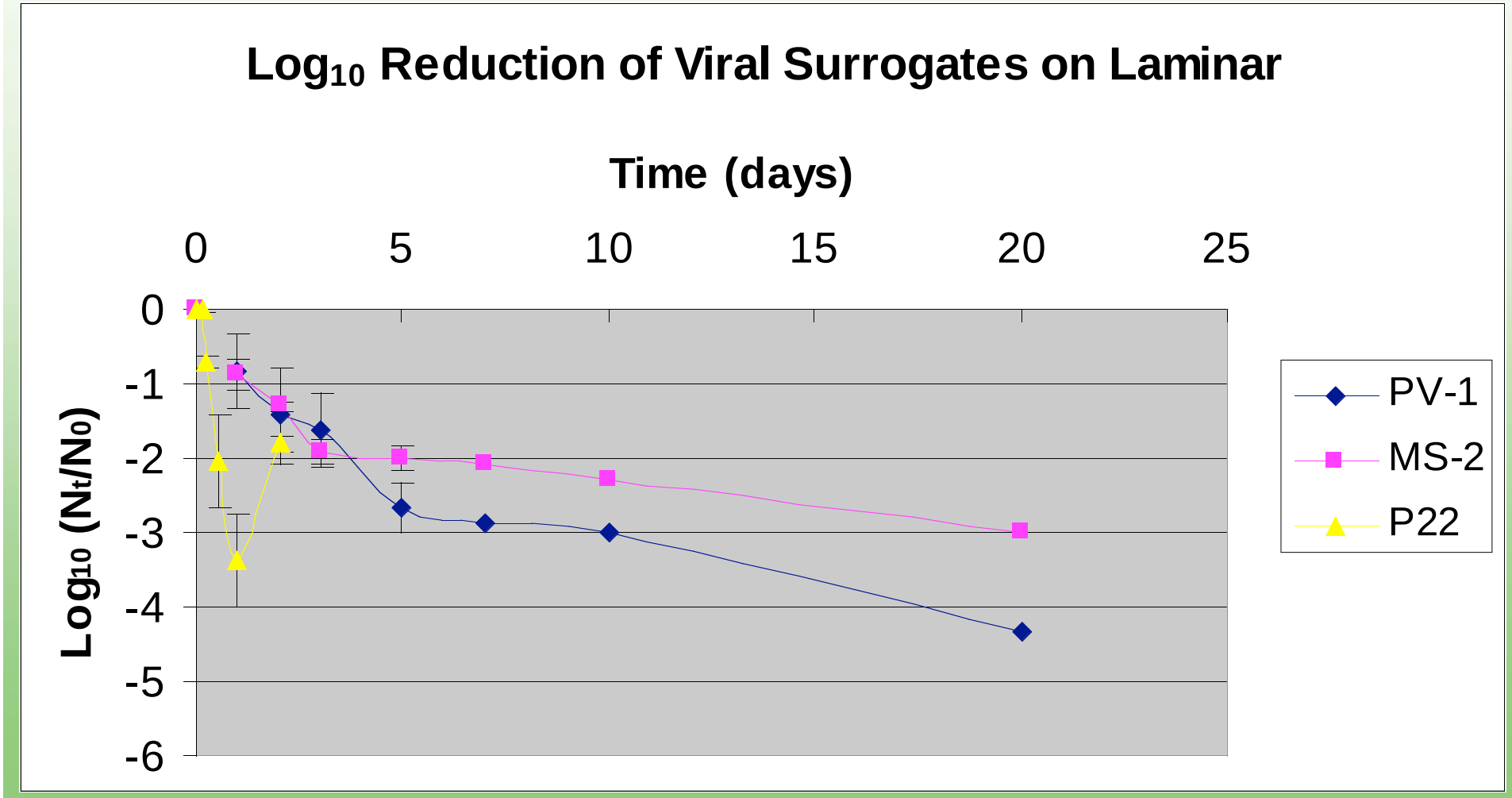


100% Cotton



Laminar

UA Results: PV, MS-2, P22



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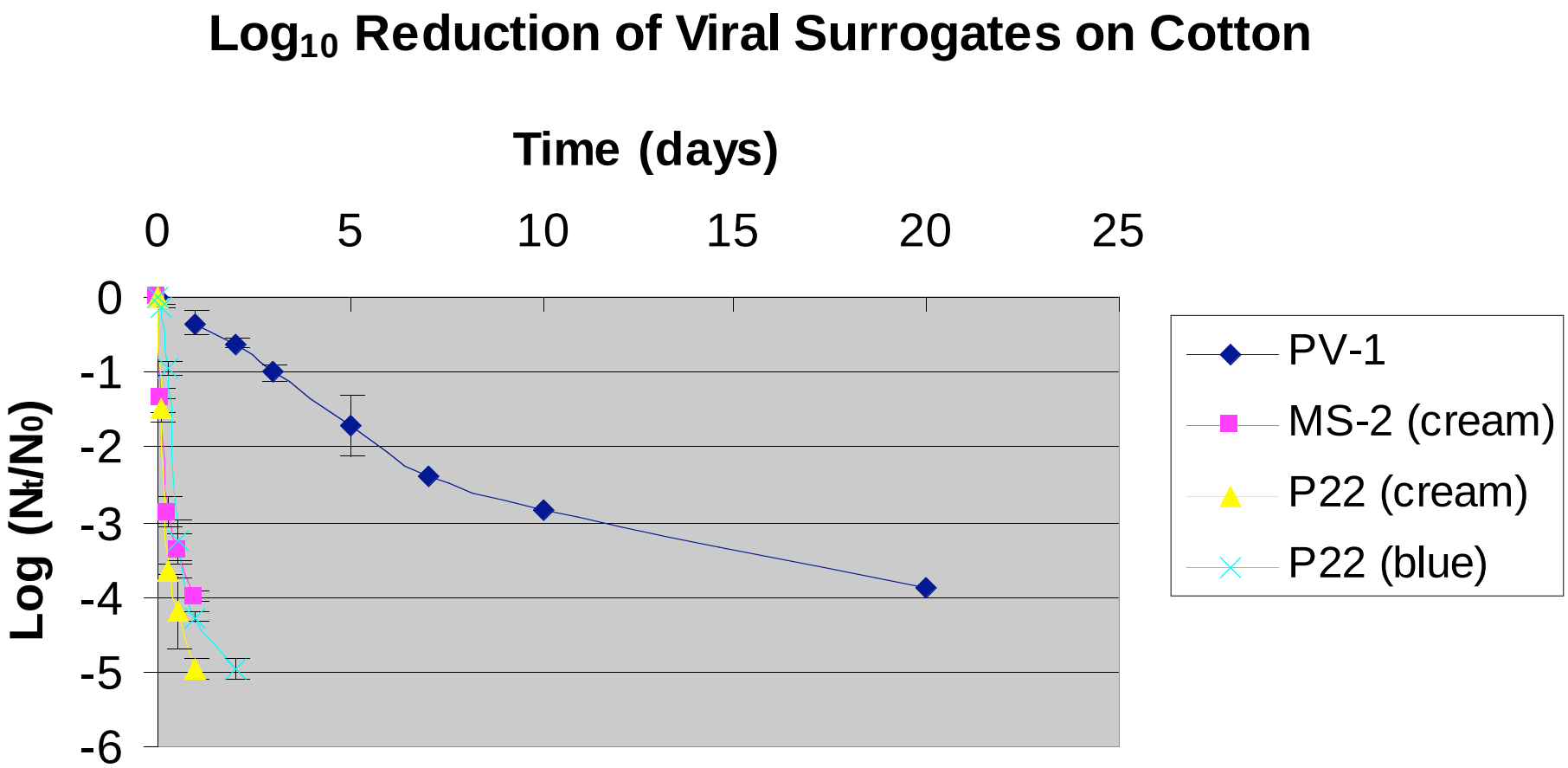

UA: Conclusions

Conclusions

- Surface type plays a large role with inactivation rates
- Cotton fabric has many factors influencing inactivation (color, treatment of material)
  - High variability between organisms
- Inactivation die-off is biphasic
  - Initial drying

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MINIREVIEWS

Persistence of Category A Select Agents in the Environment[▽]

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TABLE 5. Survival of category A biological agents on fomites

Disease and agent (exptl conditions, suspending medium [titer quantification])[a]	Initial titer	Fomite	Temp (°C)	rH (%)	T_{90}[b]	T_{99}	K_i	Reference
Tularemia								
Francisella tularensis (LVS in HIB [CFU/surface])	1.7×10^7	Metal	25	100	7.70	15.4	0.13	91
	1.0×10^7			65	15.1	30.2	0.07	
	7.0×10^6			10	87.6	175	0.01	
	3.5×10^6		37	100	2.22	4.43	0.46	
	4.0×10^6			80	2.60	5.21	0.38	
	2.3×10^6			65	2.68	5.37	0.37	
	3.1×10^6			55	3.98	7.96	0.25	
Plague								
Yersinia pestis A1122 (HIB with 1% peptone [CFU/surface])	1.2×10^6	Metal	11	30	22.4	44.7	0.04	91
	3.0×10^6		100	30	4.82	9.63	0.20	
	3.0×10^6		52	30	0.06	0.12	16.9	
	2.1×10^6		52	22	1.44	2.88	0.69	
Yersinia pestis A1122 (PB [CFU/surface])	1.5×10^6	Stainless steel	18–22	55	1.01	2.02	0.98	75
		Polyethylene			4.58	9.16	0.21	
		Glass			0.89	1.77	1.13	
		Paper			13.0	26.1	0.07	
Yersinia pestis Harbin (PB and HIB [CFU/surface])	2.8×10^6 in PB	Stainless steel	18–22	55	0.81	1.62	1.24	75
		Polyethylene			1.10	2.20	0.91	
		Glass			1.17	2.35	0.85	
		Paper			3.87	7.75	0.25	
	6.1×10^6 in HIB	Stainless steel	18–22	55	16.8	33.6	0.06	
		Polyethylene			15.0	30.1	0.06	
		Glass			13.6	27.2	0.07	
		Paper			23.6	47.2	0.04	

B. anthracis at NAU

- *B anthracis* on four surfaces: survival / persistence studies in BSL3
- Species -Ba, Bc, Bg, Bt
- Same Fomites – laminar ($2cm^2$), stainless steel, polystyrene (Petri dishes)
- Longer Time points – 2wks,4wks,2mth,5mth, 8mnt, 12mth, 16mth, 20mth

B. anthracis at NAU

Recent results:

24 hour studies

- 36% Recovery using Vortex method
- 90% Recovery using Swab method

- Ongoing survival studies over a two year period

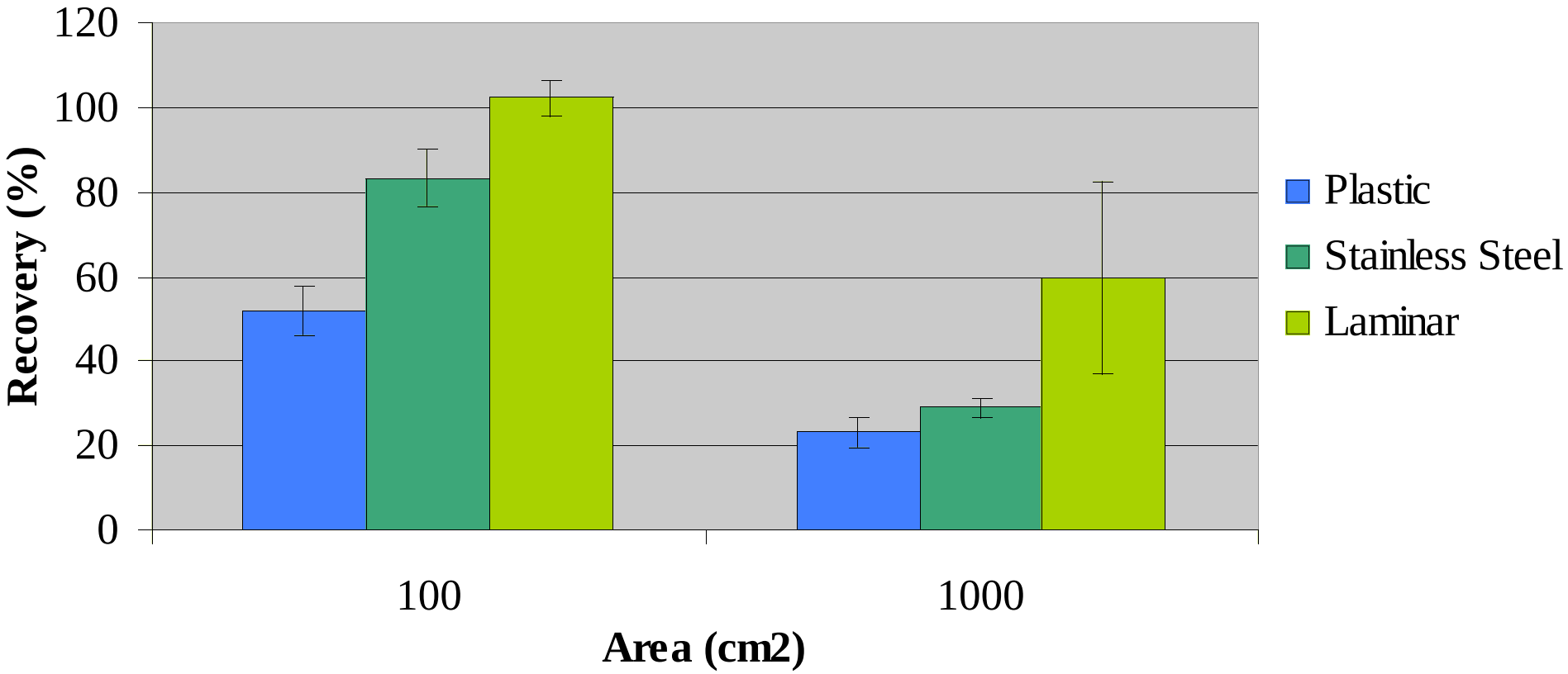
- Has a poster covering details

MSU study : *S. aureus, P22, Bt*

Evaluate

1. Recovery efficiency
   - Sampling tools
     - Culturable vs. molecular?
   - Fomite materials
   - Fomite surface areas relative to QMRA
2. Decay rates
   - Culture vs. molecular methods
3. Variability of methods (influence QMRA uncertainty)

MSU: P22 results



3 Universities: Overall Findings

- Greatest die-off rate within 24 hours
- Recovery efficiency related to surface area and fomite type
- Inactivation curves are biphasic

UC Berkeley: Freq. of Contact

Hand-to-Face Contact Rate

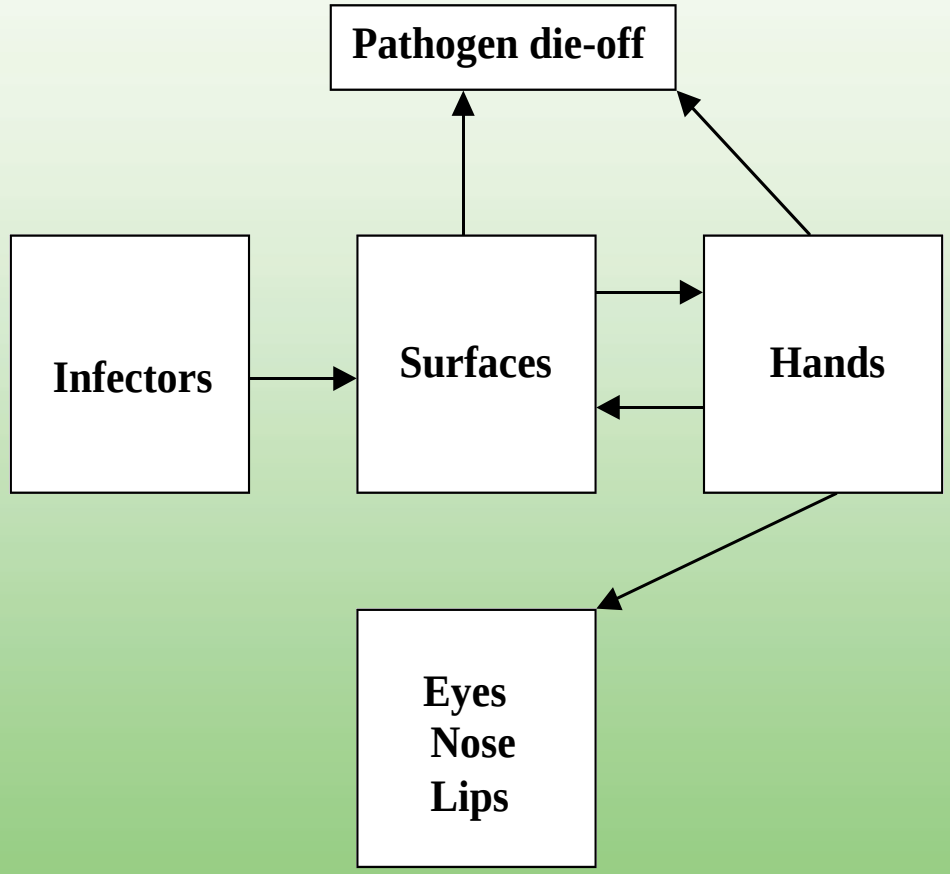
•We observed ten volunteers via digital camera for three hours each while they sat at a desk doing office work.

•The average contact rate for all facial targets was 16 per hour (range: 1 to 35 touches per hour, CV = 72%).

•As per hour averages, there were:

2.5 eye contacts
5 nostril contacts
8 lip contacts

Other ways to look at it

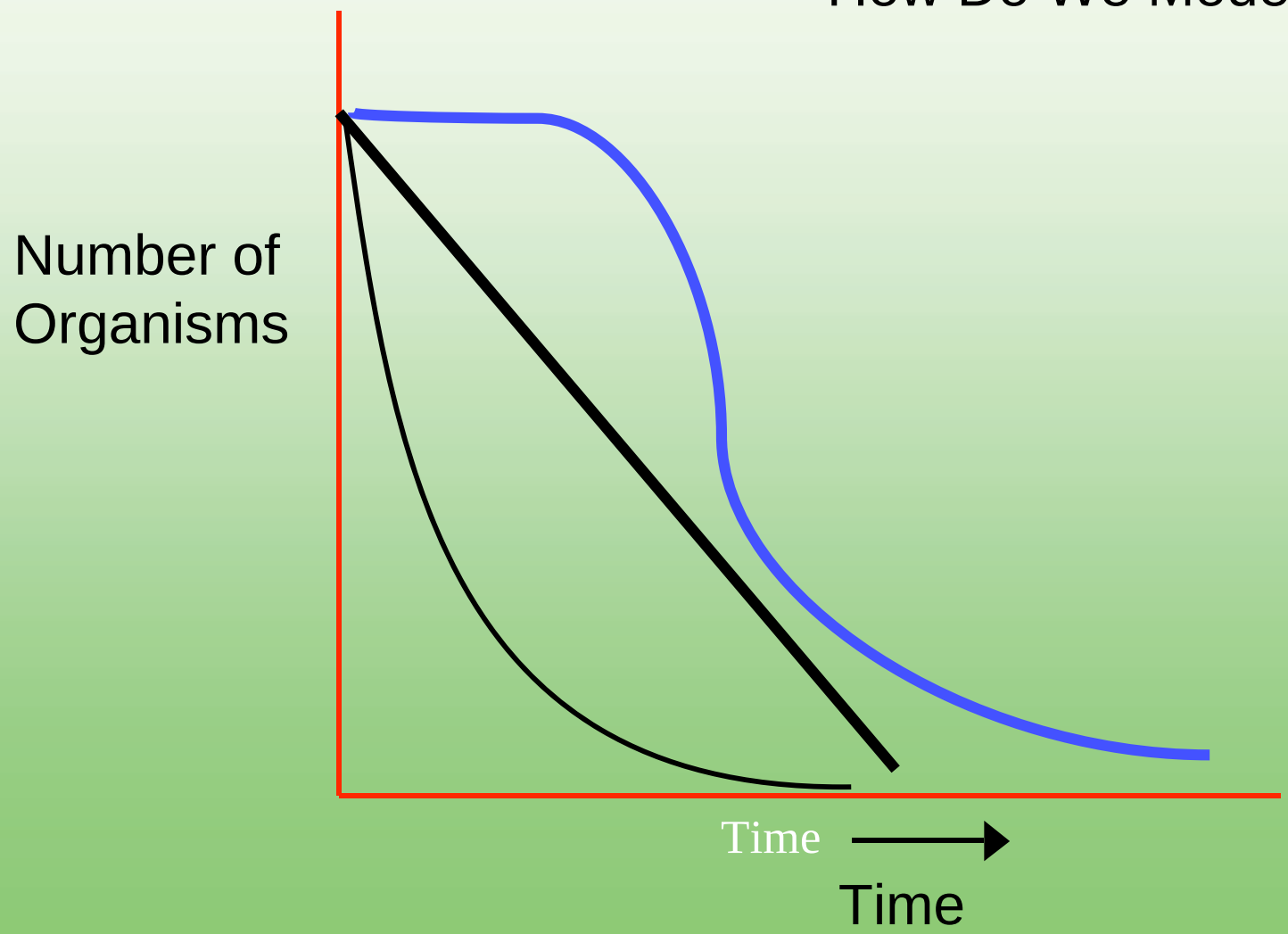


Outline

- Work done at CAMRA institutions
- **Factors affecting survival**
  - **Outcome of workshop discussions among the exposure (group 1, 2, 4) members**
- Basic Model
- Needed studies

Microbial Die-off (Inactivation)

How Do We Model This?



DIRECT CONTACT

Ranking of Factors Significant in Transmission of Enteric Pathogens by Direct Fomite Contact

Factor	**Relative Ranking**
Survival*	V>B>P
Contamination in Feces	V>=B>P
Infectivity	V>=P>B
Transferability (i.e. fomite to hand)	?

* Enteric bacteria may grow on certain fomites (I.e. sponges and dishcloths).

SURVIVAL OF FOMITES

Factors Controlling the Survival of Organisms on Surfaces

- Temperature
- Humidity
- Evaporation and Desiccation
- Light and Ultraviolet Radiation
- Chemical and Physical Properties of the Fomite
- Substance in Which the Organism is Suspended

Factors Controlling the Degree of Fomite Contamination

- Density of the population
- Incidence of infection in the population
- Concentration of the organism in the excretions or secretions
- The occurrence of the organism in both excretions and secretions
- Utilization of the fomite
- Sanitary habits of the population

MICROBIAL EXPOSURE

Factors Controlling Microbial Exposure by Fomites

- Degree of fomite contamination
- Degree of hand or mouth contact with the fomite
- Degree of hand and mouth contact by the individual
- Degree of commonality (I.e. how many persons touch the same object)
- Survival of the organism on the fomite
- Transferability (I.e. to what degree is the organism transferred from the fomite to the hand to the mouth)
- Potential for the growth of the organism (bacteria only)

MICROBIAL TRANS. ROUTES

Routes of Microbial Transmission by Fomites

- Feces or RS* --> Fomite --> Hand --> Mouth
- Feces or RS --> mouth
- Aerosol --> Fomite
- Food (water) --> Fomite
- Fomite --> Fomite
- Fomite --> Food**

* Respiratory Secretions

**Potential for re-growth of Bacteria

Outline

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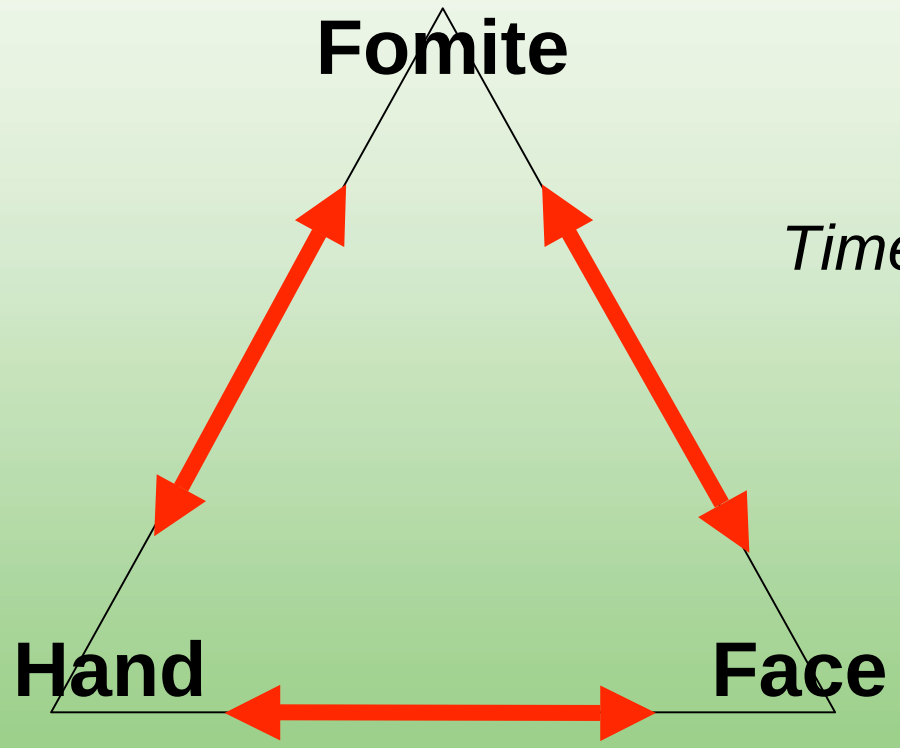
Models

- ***Survival*** *at three nodes*
  - *Surface*
  - *On hand*
  - *In person*

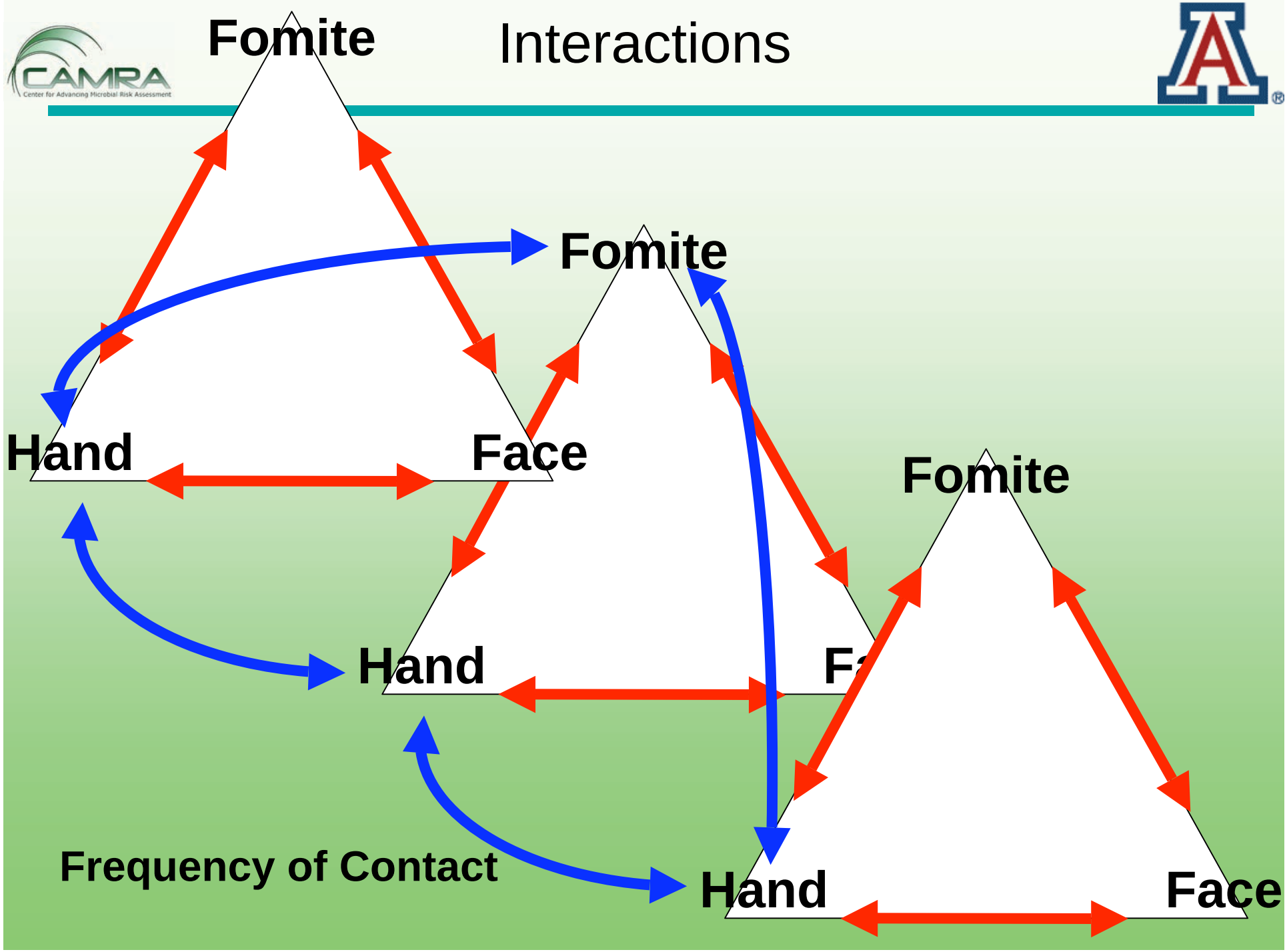
- ***Transfer*** *from any node*



Time and frequency

- *Different hands/face/fomites*

Interactions



Logical Exposure Factors

- pathogen concentration on surfaces
  - (deposition and die-off)
- rate of hand contact with surfaces
  - (% pathogens transferred to hands)
- pathogen die-off rate on hands
  - transfer rate back to surfaces
- rate of hand contact with facial targets
  - fraction of pathogens transferred to targets

Outline

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- Basic Model
- **Needed studies**

Planned Studies

Areas being investigated

- Transferability studies
  - Fomite to hand is important (artificial skin)
- Frequency of contact studies
  - (observational)
- Survival of additional agents on fomites
  - Surrogates and select agents
- Comparison of QMRA with norovirus outbreaks.
  - Concentration of agents on fomites is known

Research Sponsors and Major Collaborators

Homeland Security

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY