

# Surface Disinfection in Health Care And Emerging Technologies

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## Disclosures

- Financial

Ms. Stewart is a Certified Industrial Hygienist and Healthcare Environmental Manager employed full-time by Kaiser Permanente as a Principal Consultant in the National Environmental, Health and Safety department and has no relevant financial interests in any of the content presented here.

- Non-financial

Ms. Stewart is a voluntary member of and active participant in several professional societies, among them the US Green Building Council, the American Society of Heating, Refrigeration and Air-conditioning Engineers and the American Industrial Hygiene Association. She is also a Fellow of AIHA.

# Agenda

Microbiome and biofilm

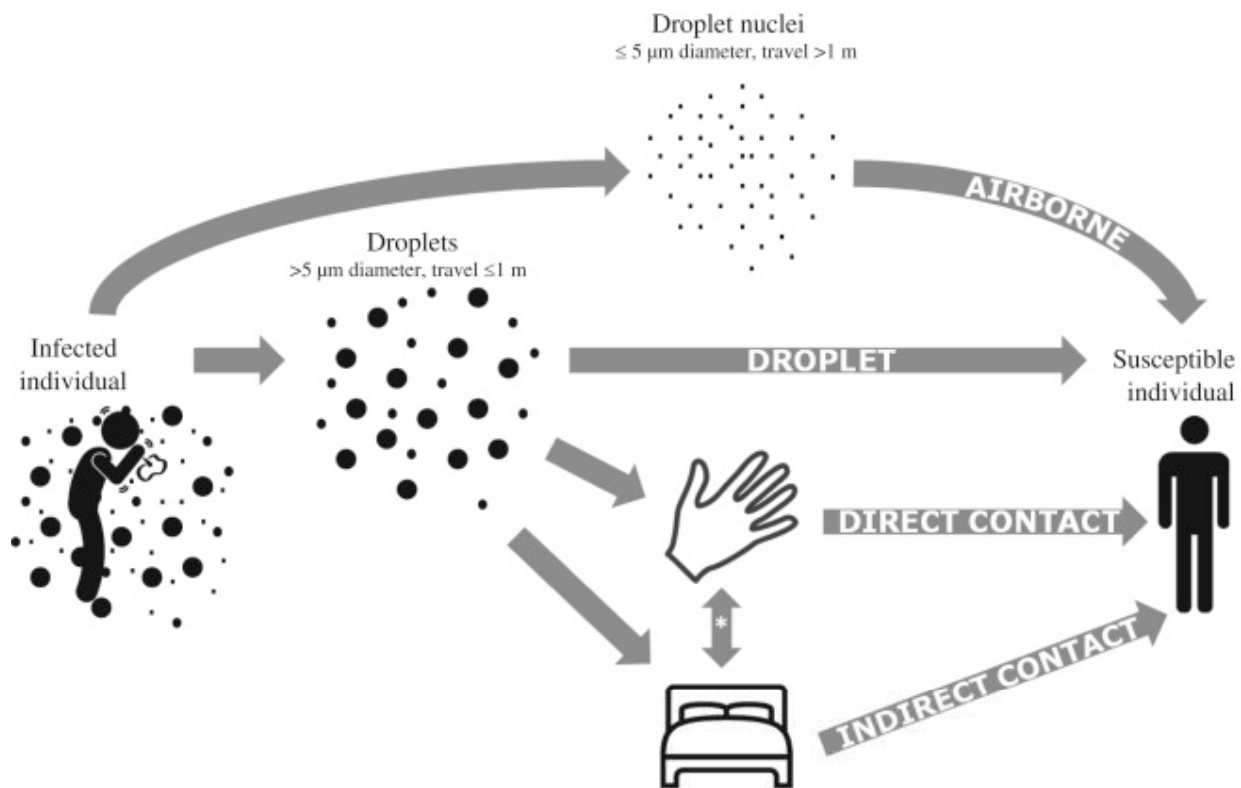
Current approaches to cleaning and disinfection

Problems with current approaches

Beneficial bacteria

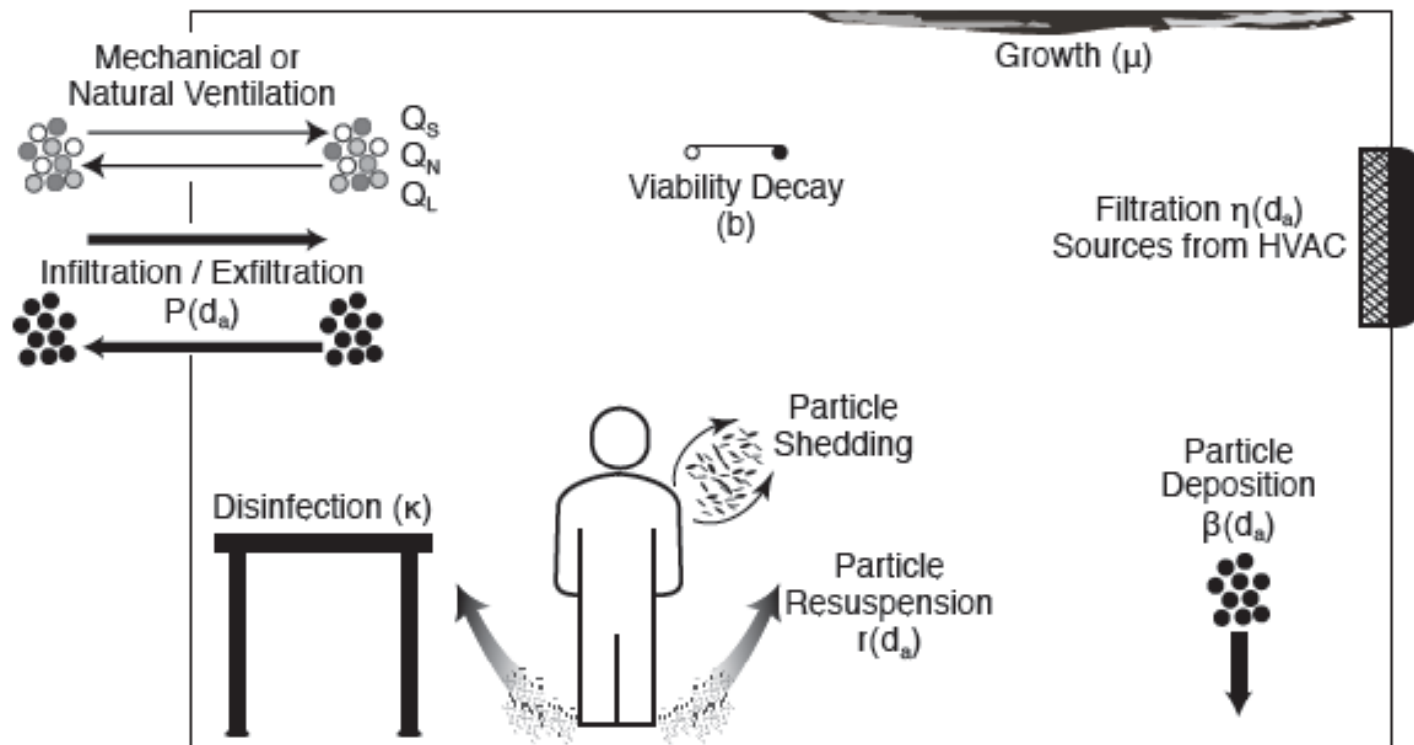
Applications and opportunities / emerging technologies

## What are we solving for?



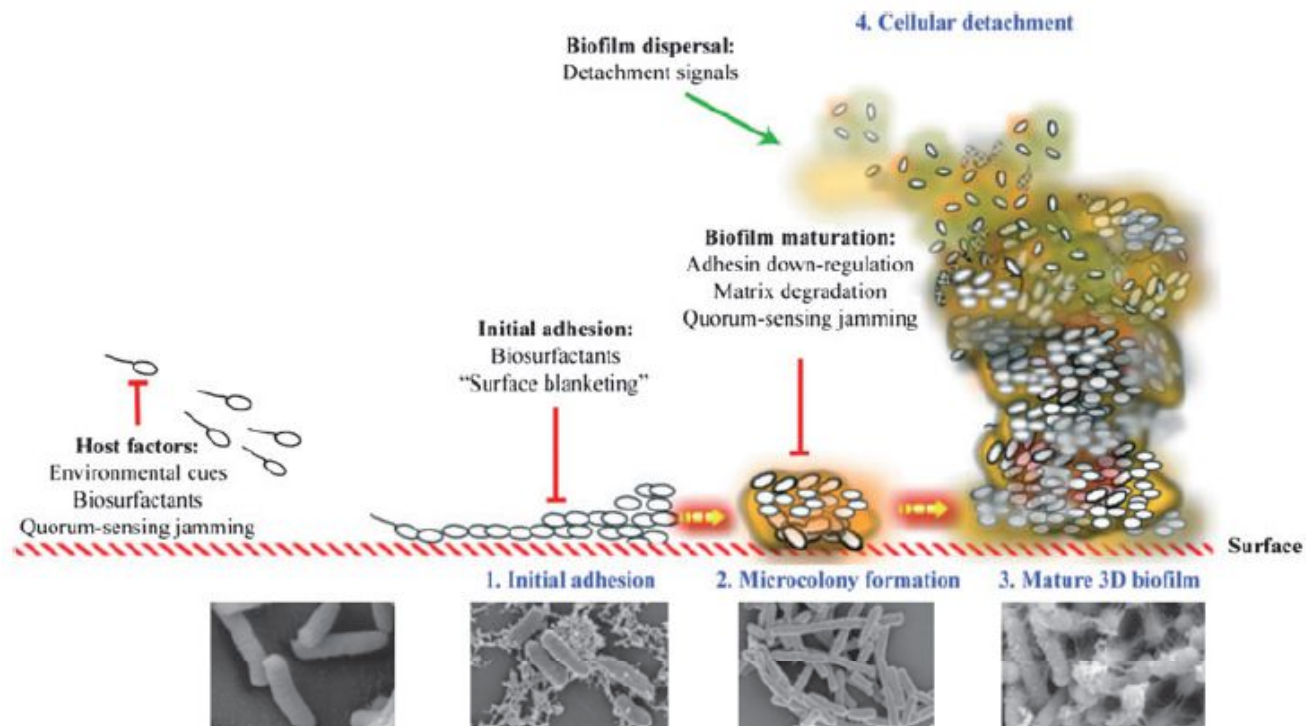
\* Transmission routes involving a combination of hand & surface = indirect contact.

## Processes acting on the microbiome



National Academy of Sciences, *Microbiomes of the Built Environment: A Research Agenda for Indoor Microbiology, Human Health and Buildings*, 2017 p207.

# Biofilms



## Current approaches

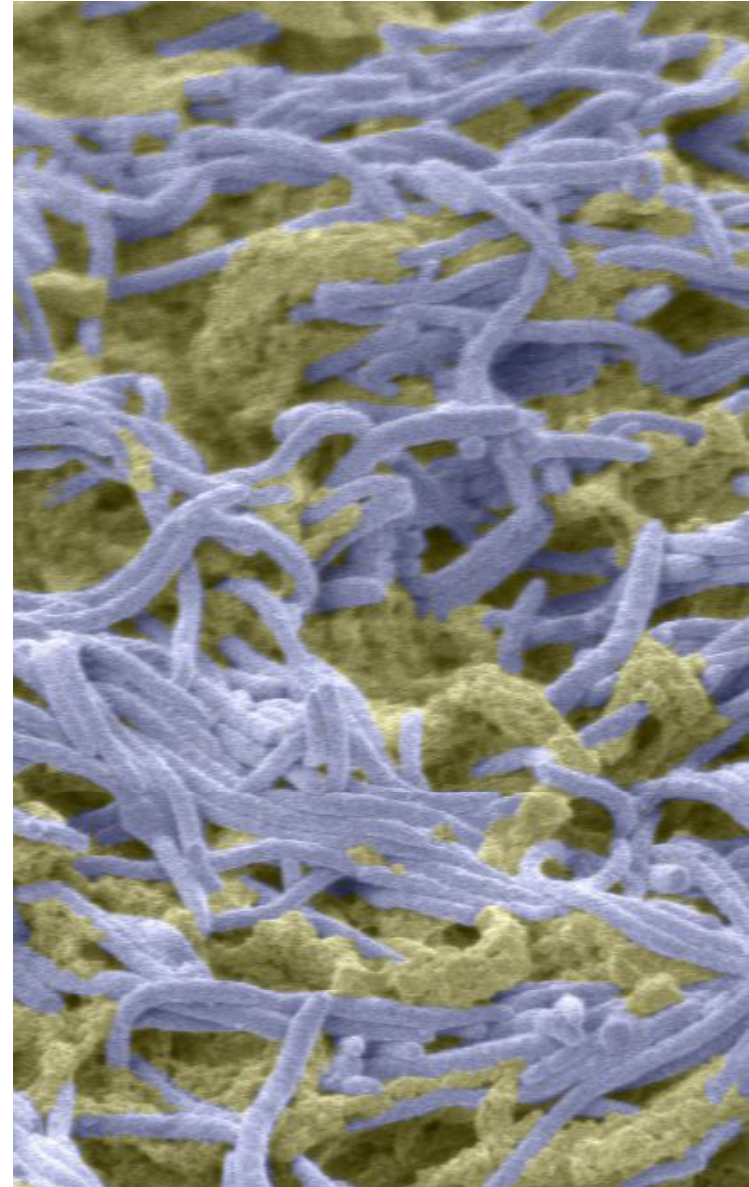
- Broad-spectrum antimicrobials
  - Bleach
  - Hydrogen peroxide (HP) / peracetic acid (PAA)
- Pulsed UV-C
- Chemical fogging (HP or ClO<sub>2</sub>)
- Surface selection





## Problems with the current approaches

- Disinfectant and antibiotic / disinfectant resistance
- Pathogen bounce-back
- Work-related asthma (WRA)
- Environmental fate





## Work-related asthma

- Not just Environmental Services aides
  - 10-23% adult-onset cases from cleaning products
    - 20% from direct contact
    - 80% from bystander exposure
- Method of application, duration of tasks
  - Spraying vs. wiping
  - Ventilation
  - Room size
  - Personal factors
- Medical burden



## Emerging alternative approaches

- Probiotic cleaners
- Blue-violet visible light LED
- Photocatalytic oxidation titanium dioxide-coated HEPA filters
- Copper-impregnated polymers
- Hypochlorous acid



## U.S. Environmental Protection Agency

- Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)
  - Antimicrobial pesticides for hospital surfaces
  - Public health claims
- Pesticide **device** vs. **product**
  - **Pesticide Product** - contains a **substance or mixture** of substances that is intended to destroy, repel, prevent or mitigate (lessen the severity of) a pest. This includes substances that attract pests to lessen their impact, for example by attracting pests to a trap.
    - How Regulated: Must be **registered** unless it qualifies for an exemption.
  - **Pesticide Device** - works by **physical means** (such as electricity, light or mechanics) and does not contain a substance or mixture of substances to perform its intended pesticidal purpose.
    - How Regulated: We do not require registration for these. However, these **devices are regulated** in that “false or misleading claims” cannot be made about the effectiveness of devices. If a manufacturer is making claims about a device, they should have scientific data to back up the claims.
    - Some devices are not regulated. For example, any device that depends more upon the performance of the user than the performance of the device itself to be effective (such as a fly swatter) is not regulated. Also, traps for vertebrate animals are not regulated.

## Public health claims

- **Disinfectant** – A substance, or mixture of substances, that destroys or irreversibly inactivates bacteria, fungi and viruses, but not necessarily bacterial spores, in the inanimate environment. EPA registers three types of disinfectants based on the type of efficacy data submitted: Limited, General (or Broad-spectrum), and Hospital.
  - **Limited** - A disinfectant that is effective against only a specific major group of microorganisms (such as gram-positive [e.g., *Staphylococcus aureus*] or gram-negative [e.g., *Salmonella enterica*] bacteria) is considered to be a limited disinfectant.
  - **General or Broad-spectrum** – A disinfectant that is effective against both gram-positive and gram-negative bacteria (*Staphylococcus aureus* and *Salmonella enterica*) is considered to be a general or broad spectrum disinfectant. General or broad spectrum disinfectants have a wide variety of uses in residential, commercial, institutional, and other sites.
  - **Hospital** - A disinfectant that is a general or broad-spectrum disinfectant and also is effective against the nosocomial bacterial pathogen *Pseudomonas aeruginosa* is a Hospital disinfectant. These disinfectants are generally for use in hospitals, clinics, dental offices, or other health care related facilities.

## Design for the Environment (DfE)

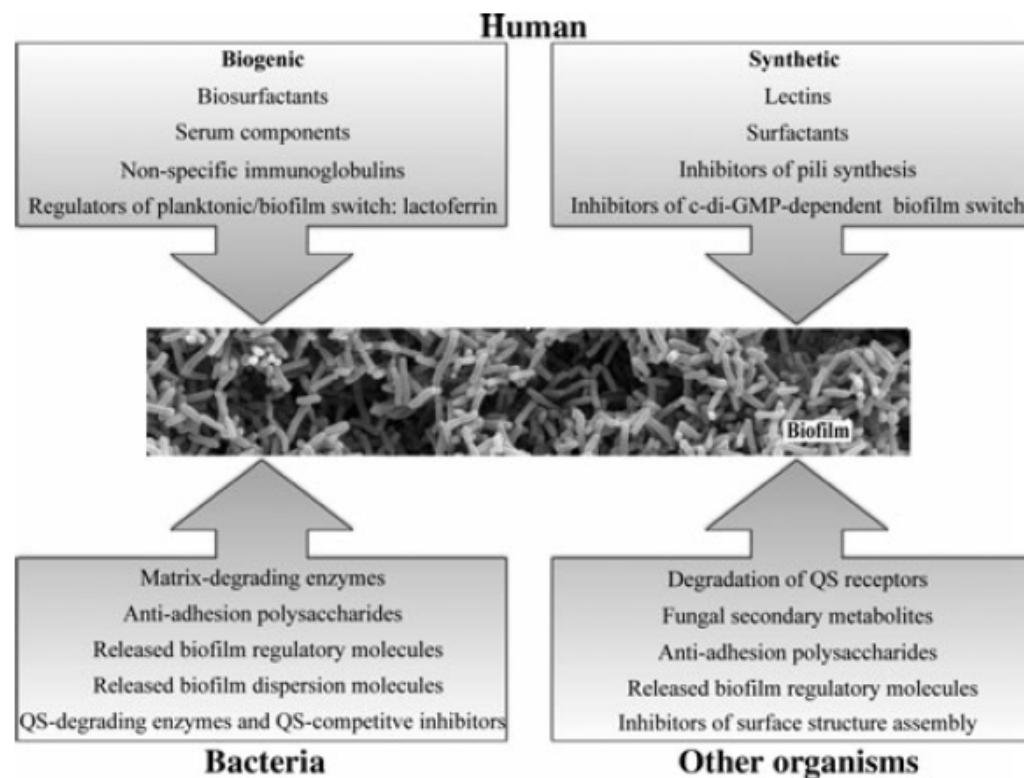
- Pesticide
- Biopesticide
  - Biochemical
  - Microbial
  - Plant-incorporated protectant
- Not clear if can be used in hospital environment

<https://www.epa.gov/saferchoice/design-environment-safer-detergents-stewardship-initiative>

<https://cleangredients.org/>



## Beneficial bacterium



## Mechanisms

- Prevent adhesion
- Blanketing
- Biosurfactant production
- Inhibition
  - Downregulating
  - Jamming
- Matrix inhibition
  - Degradation of polysaccharide, nucleic acid, or protein components
- Biofilm dispersion
- Cross-kingdom antibiofilm
- Biofilm-specific antiadhesion molecules
- Biofilm self-inhibition



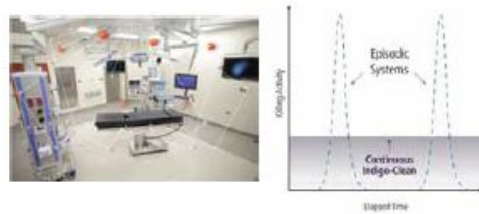
## Applications and Opportunities

- Probiotic surface cleaners
  - Proven extended reductions in pathogens colonized on surfaces
  - Clinical effectiveness in reducing HAIs
    - 60% by one estimate
- Probiotic air / water treatments
- EPA registration in USA
  - To register or not to register...

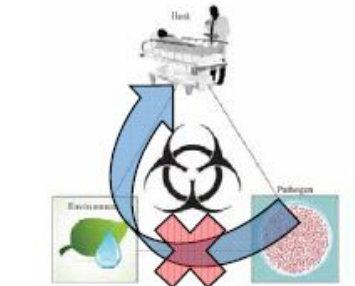
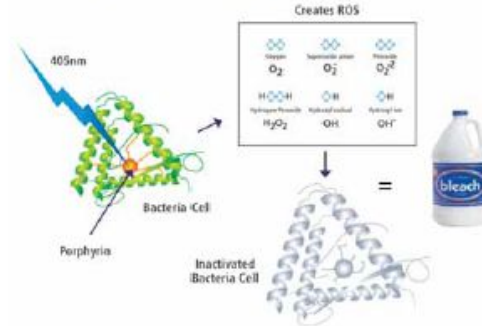


# Blue-violet visible light

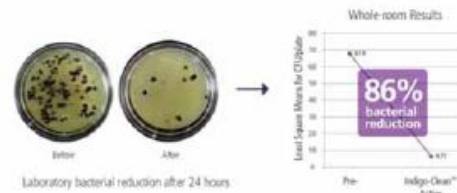
1. Continuous, automatic, safe system creates hostile environment for bacteria



2. Environment creates Reactive Oxygen Species within bacteria causing inactivation



3. Pathogen inactivation breaks the environmental chain of infection



4. Measured bacterial reduction\*

\*Maclean M., et. al. Environmental decontamination of a hospital isolation room using high-intensity narrow-spectrum light. *J. Hosp. Infection* Vol. 76, pp. 247-251 (2010)

## Titanium dioxide photocatalytic oxidation

- Augmented by silver ions
- UVA-LED, UV-C or Visible light catalyzer
- High relative humidity (60-70% RH) to achieve peak effectiveness
- ASHRAE 52.2 and 145.2 do not address microbial contaminants
- No standard efficiency rating due to differences in matrix and irradiation dose



## Copper-impregnated copolymers

- Solid surfaces
- Injection molded
- Public health claim
- HAI reduction published AJIC 2016 44 1565-71
- Copper tolerance vs. resistance



## Hypochlorous acid

- NaDCC and surfactants
- Sporicidal in four minutes contact
- 4x available chlorine vs. bleach
- 24 hour – 3 day effectiveness (test strips)
- pH = 5.5 - 6.5 tablet



