



# Contaminated Air: The Invisible Threat to Patients and Staff

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Dr. Linda Lee, DrPH, MBA, CIC  
UV Angel, Chief Science and Medical Officer

# Presenter Introduction

UV Angel's technology is clinically based & back by science & engineering under the leadership of Dr. Linda Lee. Dr. Lee is a leading expert in environmental health science, with a specialty in the relationship of opportunistic environmental pathogens and disease transmission.

## Dr. Linda D Lee DrPH, MBA, CIC

UV Angel, Chief Medical Affairs & Science Officer

- Chief Medical Affairs and Science Officer, UV Angel
- MD Anderson Cancer Center, AVP Admin Facilities and Campus Operations
- CH2M Hill, Global Practice Director - focusing on complex environmental health, threat detection, mitigation and response and biological-chemical safety projects
- Founding member of Stericycle
- WM Healthcare Solutions, Director of Operations
- Faculty University of Texas Health and Science Center, School of Public Health
- ASHRAE Committee Member - Environmental Health, 185 UVC chair 185.3 in room air treatment
- American Hospital Association Speaker
- Speaker - SHEA, AIHce, IPAC-Canada, C. Diff Foundation, APIC, ASHRAE
- Awarded as a Top 25 Woman Leader in Health & Technology of 2022
- Published author - AHA



# Learning Objectives

|                 |   |
|-----------------|---|
| <b>Describe</b> | Describe the behavior of airborne microbes.   |
| <b>Align</b>    | Align technology implementation with regulatory needs.  |
| <b>Contrast</b> | Contrast episodic disinfection with continuous disinfection.  |
| <b>Evaluate</b> | Evaluate technologies designed to reduce airborne contamination and their application to high-risk areas. |

# Contaminated Air: The Invisible Threat.

What do we do about it?



# The Pandemic Reinforced Once Again:

- **Air Matters**
- **Infection Prevention Vs Infection Response**

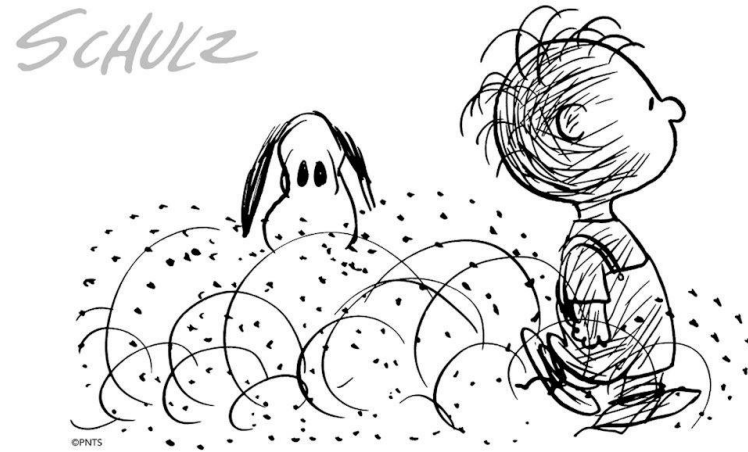
Emerging Threats  
Especially, H5-N1

Trifecta of respiratory diseases  
RSV  
Influenza  
Covid

The recent Covid-19 pandemic killing over **6,000,000** people globally

CDC expecting up to **400,000 flu hospitalizations** in 2022

# Contaminated Air: What is The Invisible Threat?



# People are the major source of contamination & transmission

Many Indoor Air Quality (IAQ) and surface related problems

- Foot traffic sends **100,000 particles** per step into the air
- Humans shed **37 million bacteria** per hour
- Study shows hospital room dirtiest 1.5 hrs after cleaning
- Pathogens **can travel on air to surfaces**; resulting in direct and indirect transmission

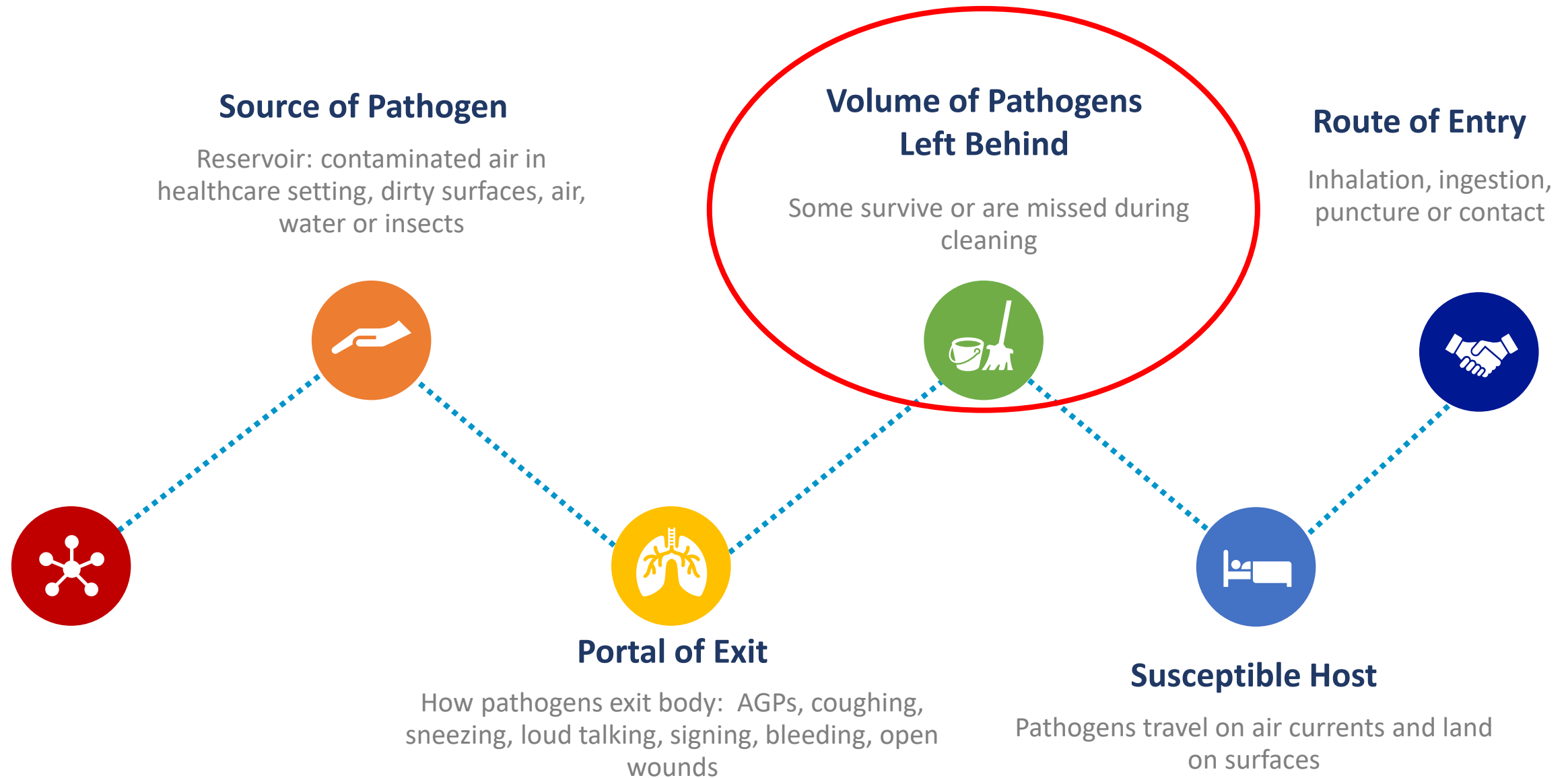


## Snow Globe Affect



What Goes Up Must Come Down

# Breaking the Chain of Airborne Transmission



# Pathogens Settle and Survive on Surfaces

## High-touch surfaces

### Pathogen Survival Rates

|                  |          |                   |
|------------------|----------|-------------------|
| C. difficile     | 200 days | <sup>2,7,8</sup>  |
| MRSA             | 300 days | <sup>1,5,10</sup> |
| VRE              | 200 days | <sup>2,3,4</sup>  |
| E. Coli          | 480 days | <sup>7,9</sup>    |
| Klebsiella       | 900 days | <sup>6,7</sup>    |
| Acinetobacter    | 300 days | <sup>7,11</sup>   |
| Mycobacterium TB | 120 days | <sup>7</sup>      |
| Candida albicans | 120 days | <sup>7</sup>      |

1. Beard-Pegler et al. 1988. *J Med Microbiol.* **26**:251-5.
2. BIOQUELL trials, unpublished data.
3. Bonilla et al. 1996. *Infect Cont Hosp Epidemiol.* **17**:770-2
4. Boyce. 2007. *J Hosp Infect.* **65**:50-4.
5. Duckworth and Jordens. 1990. *J Med Microbiol.* **32**:195-200.
6. French et al. 2004. *ICAAC.*
7. Kramer et al. 2006. *BMC Infect Dis.* **6**:130.
8. Otter and French. 2009. *J Clin Microbiol.* **47**:205-7.
9. Smith et al. 1996. *J Med.* **27**: 293-302.
10. Wagenvoort et al. 2000. *J Hosp Infect.* **45**:231-4.
11. Wagenvoort and Joosten. 2002. *J Hosp Infect.* **52**:226-7.



# Pathogens Settle and Survive on Surfaces

## Low-touch surfaces

### Pathogen Survival Rates

|                         |          |        |
|-------------------------|----------|--------|
| <i>C. difficile</i>     | 200 days | 2,7,8  |
| MRSA                    | 300 days | 1,5,10 |
| VRE                     | 200 days | 2,3,4  |
| <i>E. Coli</i>          | 480 days | 7,9    |
| <i>Klebsiella</i>       | 900 days | 6,7    |
| <i>Acinetobacter</i>    | 300 days | 7,11   |
| <i>Mycobacterium TB</i> | 120 days | 7      |
| <i>Candida albicans</i> | 120 days | 7      |



1. Beard-Pegler et al. 1988.. *J Med Microbiol.* **26**:251-5.
2. BIOQUELL trials, unpublished data.
3. Bonilla et al. 1996. *Infect Cont Hosp Epidemiol.* **17**:770-2
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# Prior Room Occupancy Increases Risk

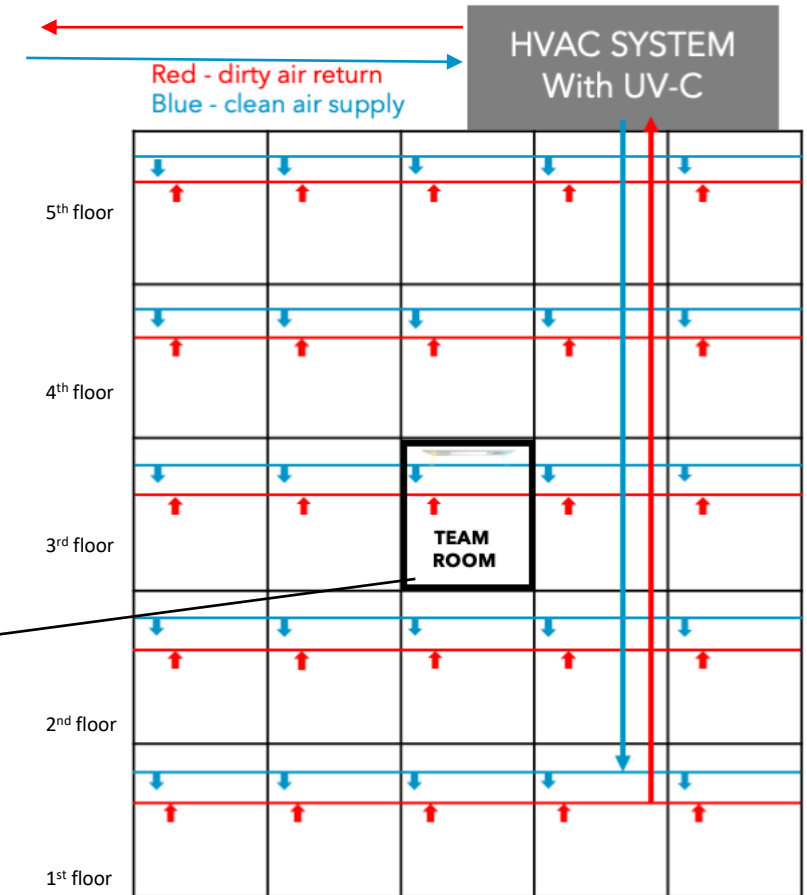
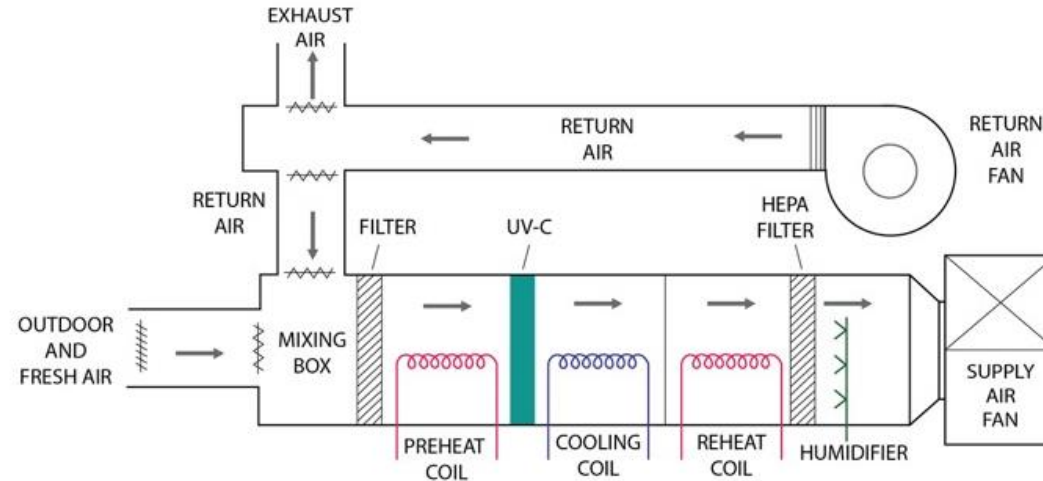
| Study                           | Healthcare associated pathogen                  | Likelihood of patient acquiring HAI based on prior room occupancy (comparing previously 'positive' room with a previously 'negative' room) |
|---------------------------------|---|--|
| Martinez 2003 <sup>7</sup>      | VRE – cultured within room                      | 2.6x   |
| Huang 2006 <sup>8</sup>         | VRE – prior room occupant                       | 1.6x   |
|                                 | MRSA – prior room occupant                      | 1.3x   |
| Drees 2008 <sup>9</sup>         | VRE – cultured within room                      | 1.9x   |
|                                 | VRE – prior room occupant                       | 2.2x   |
|                                 | VRE – prior room occupant in previous two weeks | 2.0x   |
| Shaughnessey 2008 <sup>10</sup> | <i>C. difficile</i> – prior room occupant       | 2.4x   |
|                                 | <i>A. baumannii</i> – prior room occupant       | 3.8x   |
| Nseir 2010 <sup>11</sup>        | <i>P. aeruginosa</i> – prior room occupant      | 2.1x   |

7. Matinez et al. 2003. *Arch Intern Med* 163: 1905-12.
8. Huang SS et al. 2006. *Arch Intern Med* 166: 1945-51.
9. Drees M et al. 2008. *Clin Infect Dis* 46: 678-85.
10. Shaughnessey M et al. 2008. Eval of hospital room assignment and acquisition of *C. diff* diarrhea (CDAD). In: Program and Abstracts of the 48<sup>th</sup> Annual Interscience Conf. ICCAAC / ISDA 46<sup>th</sup> Annual Meeting. Abstract 14194.
11. Nseir S et al. 2011. *Clin Microbiol Infect* 17: 1201-8.



# HVAC Purpose

HVAC system supplies air for entire building.  
Air travels from one source to reach all areas.



HVAC additions don't affect room level contamination which is directly correlated with the presence of people.

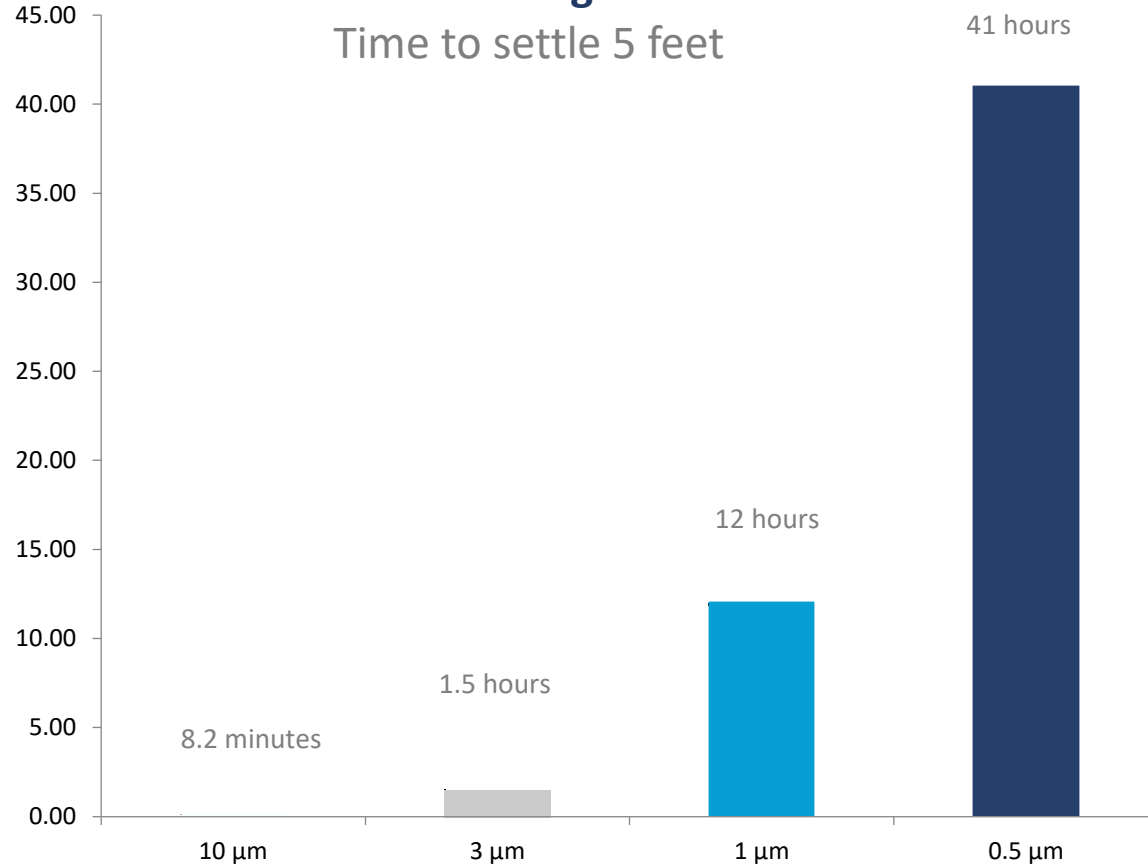
TEAM BREAK ROOM

The block contains a text box with the statement 'HVAC additions don't affect room level contamination which is directly correlated with the presence of people.' Below the text are icons of three people: a woman, a man, and a person in a wheelchair. To the right of these icons is the text 'TEAM BREAK ROOM' and an icon of a person sitting at a desk with a laptop.

*Remember – Conventional HVAC creates clean air going in, but it's the people who contaminate the space!*

# Particles float on air

**Particles Settling in Still Air**  
Time to settle 5 feet



| Microbe                         | Type     | Size - µm |
|---------------------------------|----------|-----------|
| Paravovirus B19                 | Virus    | 0.022     |
| Rhinovirus                      | Virus    | 0.023     |
| Coxsackievirus                  | Virus    | 0.027     |
| Norwalk virus                   | Virus    | 0.029     |
| Rubella virus                   | Virus    | 0.061     |
| Rotavirus                       | Virus    | 0.073     |
| Reovirus                        | Virus    | 0.075     |
| Adenovirus                      | Virus    | 0.079     |
| Influenza A virus               | Virus    | 0.098     |
| Coronavirus (SARS)              | Virus    | 0.110     |
| Measles virus                   | Virus    | 0.158     |
| Mumps virus                     | Virus    | 0.164     |
| VZV                             | Virus    | 0.173     |
| Mycoplasma pneumoniae           | Bacteria | 0.177     |
| RSV                             | Virus    | 0.190     |
| Parainfluenza virus             | Virus    | 0.194     |
| Bordetella pertussis            | Bacteria | 0.245     |
| Haemophilus influenzae          | Bacteria | 0.285     |
| Proteus mirabilis               | Bacteria | 0.494     |
| Pseudomonas aeruginosa          | Bacteria | 0.494     |
| Legionella pneumophila          | Bacteria | 0.520     |
| Serratia marcescens             | Bacteria | 0.632     |
| Mycobacterium tuberculosis      | Bacteria | 0.637     |
| Klebsiella pneumoniae           | Bacteria | 0.671     |
| Corynebacterium diphtheriae     | Bacteria | 0.698     |
| Streptococcus pneumoniae        | Bacteria | 0.707     |
| Neisseria meningitidis          | Bacteria | 0.775     |
| Staphylococcus aureus           | Bacteria | 0.866     |
| Staphylococcus epidermis        | Bacteria | 0.866     |
| Streptococcus pyogenes          | Bacteria | 0.894     |
| Clostridium perfringens spores  | Bacteria | 1.000     |
| Mycobacterium avium             | Bacteria | 1.118     |
| Nocardia asteroides             | Bacteria | 1.118     |
| Acinetobacter                   | Bacteria | 1.225     |
| Enterobacter cloacae            | Bacteria | 1.414     |
| Enterococcus                    | Bacteria | 1.414     |
| Haemophilus parainfluenzae      | Bacteria | 1.732     |
| Clostridium difficile spores    | Bacteria | 2.000     |
| Aspergillus spores              | Fungi    | 3.354     |
| Cryptococcus neoformans spores  | Fungi    | 4.899     |
| Rhizopus spores                 | Fungi    | 6.928     |
| Mucor spores                    | Fungi    | 7.071     |
| Fusarium spores                 | Fungi    | 11.225    |
| Blastomyces dermatitidis spores | Fungi    | 12.649    |

# Regulatory

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The intent of the presentation is to provide highlights and an overview of regulations/standards.. This presentation is not intended to supplement the requirements or be all-encompassing of the requirements of ASHRAE 241 or any other requirements by ASHRAE or authority having jurisdiction. It is also not intended to avoid or circumvent any health, safety, or comfort regulations required by an *authority having jurisdiction*. This presentation in no way is a substitute for a copy of the full ASHRAE standard.

**\*The opinions presented here are those of UV Angel and not specifically ASHRAE.**

# ASHRAE 170

## 2. SCOPE

2.1 The requirements in this standard apply to patient care areas, resident care areas, and related support areas within health care facilities.

2.2 This standard applies to new buildings, additions to existing buildings, and those alterations to existing buildings that are identified within this standard.

2.3 This standard considers chemical, physical, and biological contaminants that can affect the delivery of medical care to patients and residents; the convalescence of patients and residents; and the safety of patients, residents, health care workers, and visitors.

2.4 This standard establishes design requirements for temperature and humidity.

2.5 This standard establishes design requirements for odor control and asepsis.

2.6 This standard establishes design requirements for ventilation rates, including, but not limited to, outdoor air to serve health care facilities.

2.7 This standard does not establish comprehensive thermal comfort design requirements.

Requirement for:

**airborne infection isolation (All):** the isolation of patients infected with organisms spread by airborne droplet nuclei less than 5  $\mu$ m in diameter. For the purposes of this standard, the abbreviation "All" refers to the room that provides isolation. **Informative Note:** See FGI [2018a, 2018b, 2018c], CDC [2003], and CDC [2005] in Informative Appendix E.)

**airborne infection isolation (All) room:** a room that is designed according to the requirements of this standard and that is intended to provide airborne infection isolation.

**infection control risk assessment (ICRA):** a determination of the potential risk of transmission of various infectious agents in the facility, a classification of those risks, and a list of required practices for mitigating those risks during construction or renovation.



# ASHRAE 170 (Example of Requirements)

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**Table 7-1 Design Parameters—Inpatient Spaces**

| Function of Space (ee)   | Pressure Relationship to Adjacent Areas (n) | Minimum Outdoor ach | Minimum Total ach | All Room Air Exhausted Directly to Outdoors (j) | Air Recirculated by Means of Room Units (a) | Unoccupied Turndown | Minimum Filter Efficiencies (cc) | Design Relative Humidity (k), % | Design Temperature (l), °F/°C |
|--|---|---------------------|-------------------|---|---|---------------------|----------------------------------|---------------------------------|-------------------------------|
| <b>NURSING UNITS AND OTH &amp; ER PATIENT CARE AREAS</b>                     |   |                     |                   |   |   |                     |                                  |                                 |                               |
| All anteroom (FGI 2.1–2.4.2.3) (u)   | (e)   | NR                  | 10                | Yes   | No  | Yes                 | MERV-8                           | NR                              | NR                            |
| All room (FGI 2.1–2.4.2) (u)   | Negative                                    | 2                   | 12                | Yes   | No  | Yes                 | MERV-14                          | Max 60                          | 70–75/21–24                   |
| Cesarean Delivery room (FGI 2.2–2.9.11.1) (m), (o)                           | Positive                                    | 4                   | 20                | NR  | No  | Yes                 | MERV-16                          | 20–60                           | 68–75/20–24                   |
| Combination All/PE anteroom (FGI 2.2–2.2.4.5)                                | (e)   | NR                  | 10                | Yes   | No  | No                  | HEPA                             | NR                              | NR                            |
| Combination All/PE room (FGI 2.2–2.2.4.5)                                    | Positive                                    | 2                   | 12                | Yes   | No  | No                  | HEPA                             | Max 60                          | 70–75/21–24                   |
| Continued care nursery (FGI 2.2–2.10.3.2)                                    | N/R   | 2                   | 6                 | N/R   | No  | Yes                 | MERV-14                          | 30–60                           | 72–78/22–26                   |
| Critical care patient care station (FGI 2.2–2.6.2)                           | NR  | 2                   | 6                 | NR  | No  | Yes                 | MERV-14                          | 30–60                           | 70–75/21–24                   |
| Emergency department exam/treatment room (FGI 2.2–3.1.2.6 & 2.2–3.1.3.6) (p) | NR  | 2                   | 6                 | NR  | NR  | Yes (ff)            | MERV-14                          | Max 60                          | 70–75/21–24                   |
| Emergency department human decontamination (FGI 2.2–3.1.3.6[8])              | Negative                                    | 2                   | 12                | Yes   | No  | Yes (ff)            | MERV-14                          | NR                              | NR                            |
| Emergency department public waiting area (FGI 2.2–3.1.2.4 & 2.2–3.1.3.4)     | Negative                                    | 2                   | 12                | Yes (q)   | NR  | Yes (ff)            | MERV-8                           | Max 65                          | 70–75/21–24                   |
| Emergency department trauma/resuscitation room (FGI 2.2–3.1.3.6[4]) (c)      | Positive                                    | 3                   | 15                | NR  | No  | Yes                 | MERV-14                          | 20–60                           | 70–75/21–24                   |
| Emergency service triage area (FGI 2.2–3.1.3.3)                              | Negative                                    | 2                   | 12                | Yes (q)   | NR  | Yes (ff)            | MERV-8                           | Max 60                          | 70–75/21–24                   |
| Intermediate care patient room (FGI 2.2–2.5) (s)                             | NR  | 2                   | 6                 | NR  | NR  | Yes                 | MERV-14                          | Max 60                          | 70–75/21–24                   |
| Labor/delivery/recovery (LDR) (FGI 2.2–2.9.3) (s)                            | NR  | 2                   | 6                 | NR  | NR  | Yes                 | MERV-14                          | Max 60                          | 70–75/21–24                   |
| Labor/delivery/recovery/postpartum (LDRP) (FGI 2.2–2.9.3) (s)                | NR  | 2                   | 6                 | NR  | NR  | Yes                 | MERV-14                          | Max 60                          | 70–75/21–24                   |
| Laser eye room (FGI Table T2.2-1)  | Positive                                    | 3                   | 15                | NR  | No  | Yes                 | MERV-14                          | 20–60                           | 70–75/21–24                   |
| Neonatal intensive care (FGI 2.2–2.8)  | Positive                                    | 2                   | 6                 | NR  | No  | Yes                 | MERV-14                          | 30–60                           | 72–78/22–26                   |
| Newborn nursery (FGI 2.2–2.10.3.1)   | NR  | 2                   | 6                 | NR  | No  | Yes                 | MERV-14                          | 30–60                           | 72–78/22–26                   |
| Nourishment area or room (FGI 2.1–2.8.9)                                     | NR  | NR                  | 2                 | NR  | NR  | Yes                 | MERV-8                           | NR                              | NR                            |
| Nursery workroom (FGI 2.2–2.10.8.5)  | NR  | 2                   | 6                 | NR  | No  | Yes                 | MERV-8                           | Max 60                          | 72–78/22–26                   |
| Operating room (FGI 2.2–3.3.3) (m), (o)                                      | Positive                                    | 4                   | 20                | NR  | No  | Yes                 | MERV-16 (hh)                     | 20–60                           | 68–75/20–24                   |

**Informative Notes:** (1) NR = no requirement; (2) FGI paragraph numbers are shown in parentheses in the "Function of Space" column.

ANSI/ASHRAE/ASHE Standard 170-2021

# USP 797

USP 797 refers to chapter 797 “Pharmaceutical Compounding – Sterile Preparations” in the USP National Formulary. It is the first set of enforceable sterile compounding standards issued by the United States Pharmacopeia (USP).

It describes the guidelines, procedures and compliance requirements for compounding sterile preparations and sets the standards that apply to all settings in which sterile preparations are compounded.

USP applies to the compounding of both hazardous and non-hazardous drugs

## Prevent Patient Harm From

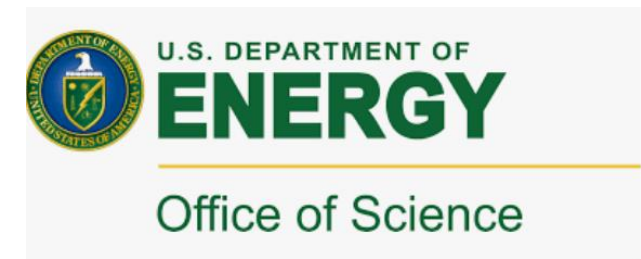
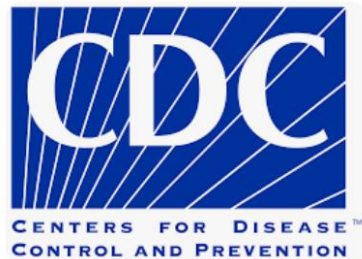
- Microbial contamination
- Excessive bacterial endotoxins
- Variability in the intended strength of correct ingredients
- Unintended chemical and physical contaminants
- Ingredients of inappropriate quality



# Clean Air Challenge

**“Clean Air in Buildings Challenge” from the group: the CDC, White House, EPA, and DOE.**

1. Optimize Fresh Air Ventilation
2. Enhance Air Filtration
3. UVGI



# ASHRAE 241 - Key Take Aways

Standard 241 is a companion standard to 62.1, 62.2, 170, and others.

First standard ventilation rates based on infectious aerosol modeling.

First ASHRAE standard on infectious aerosols

## Building Readiness Plan

Temporary isolation areas

Masking protocols

Risk models (known infectious)

Documentation of special operation procedures when in IRMM mode.

## Air Distribution

Select air cleaners appropriately for the type of air distribution pattern delivered by the ventilation system

Infectious aerosol modeling

There are no more air change per hour (ACH) numbers.

Don't throw away your clean air (Figure 6-1)



# ASHRAE 241 Key Take Aways (cont.)

## Air Cleaning

- Every cleaner must be rated and tested
- how air cleaners should be deployed
- testing air cleaners for performance and safety (specifically, hazards from air cleaner emissions – primary and secondary) and requirements for determining the contribution to meeting the required equivalent clean air target
- requirements for air cleaners are technology agnostic – they apply to all equally
- Consensus testing standards are referenced and methods for testing equipment not subject to existing standards are provided.

# ASHRAE 241 Key Take Aways (cont.)

- **Requirements for assessment, planning, operation, and maintenance**
  - defines the process for determining the need for upgrades and what upgrades should be selected, defining what special operating procedures are needed in IRMM
  - systems fail to perform not because of design flaws, but because they have not been maintained properly, new requirements for testing (to the extent possible) the installed performance of systems and provides informative guidance on how to do in-situ testing
- **Equivalent Clean Air Rate**
  - Key Performance target
  - Multiple options in each room
  - No room pressure requirements
  - There are no more air change per hour (ACH) numbers
- ASHRAE Standard 241 is a continuous maintenance standard.
- Changes are coming
- Adoption



# Equivalent Clean Airflow For Infection Risk Mitigation

Minimum *Equivalent Outdoor Airflow* per person for in Breathing Zone in IRMM Occupancy Category

| Occupancy category               | EOAi       |            |
|----------------------------------|------------|------------|
|                                  | CFM/person | L/s/person |
| <b>Correctional Facilities</b>   |            |            |
| Cell                             | 30         | 15         |
| Dayroom                          | 40         | 20         |
| <b>Commercial/Retail</b>         |            |            |
| Food & Beverage Facilities       | 60         | 30         |
| Gym                              | 80         | 40         |
| Office                           | 30         | 15         |
| Retail                           | 40         | 20         |
| Transportation Waiting           | 60         | 30         |
| <b>Educational Facilities</b>    |            |            |
| Classroom                        | 40         | 20         |
| Lecture Hall                     | 60         | 30         |
| <b>Industrial</b>                |            |            |
| Manufacturing                    | 50         | 25         |
| Sorting, Packing, Light Assembly | 20         | 10         |
| Warehouse                        | 20         | 10         |

| Occupancy category                                | EOAi       |            |
|---|------------|------------|
|   | CFM/person | L/s/person |
| <b>Healthcare</b>                                 |            |            |
| Exam Room   | 40         | 20         |
| Group Treatment Area                              | 70         | 35         |
| Patient Room                                      | 70         | 35         |
| Resident Room                                     | 50         | 25         |
| Waiting Room                                      | 90         | 45         |
| <b>Public Assembly/Sports &amp; Entertainment</b> |            |            |
| Auditorium  | 50         | 25         |
| Place of Religious Worship                        | 50         | 25         |
| Museum  | 60         | 30         |
| Convention  | 60         | 30         |
| Spectator Area                                    | 50         | 25         |
| Lobbies   | 50         | 25         |
| <b>Residential</b>                                |            |            |
| Common Space                                      | 50         | 25         |
| Dwelling Unit                                     | 30         | 15         |

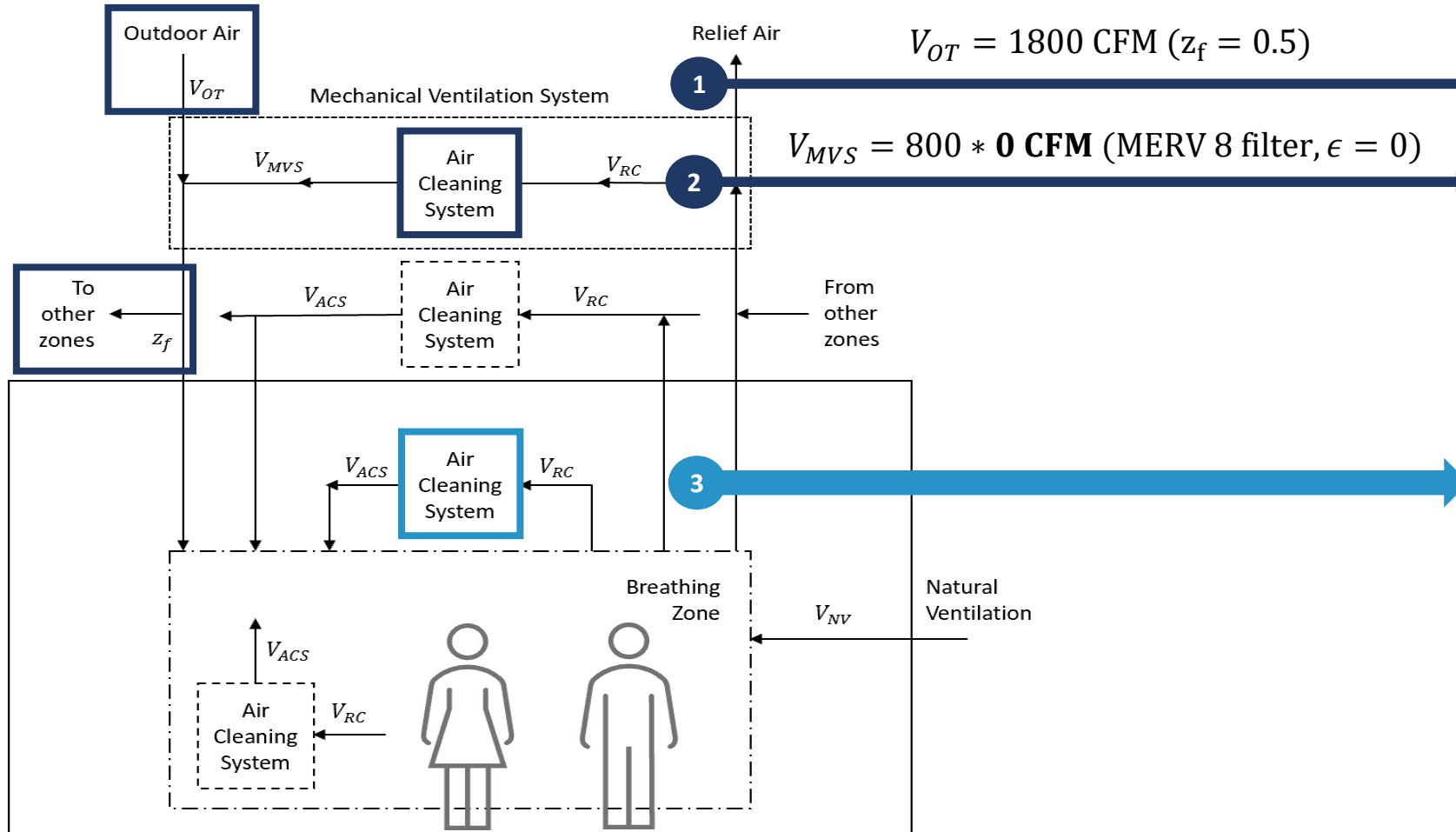
# EQ Clean Airflow For IRMM

## ER Waiting Room

Example: 30 people

- 90 cfm per person (IRMM) = 2,700 cfm Total

1. Mechanical HVAC
2. In Duct
3. In Room



Outside Air  
0.5 x 1800=900

Recirculated Clean Air = 0

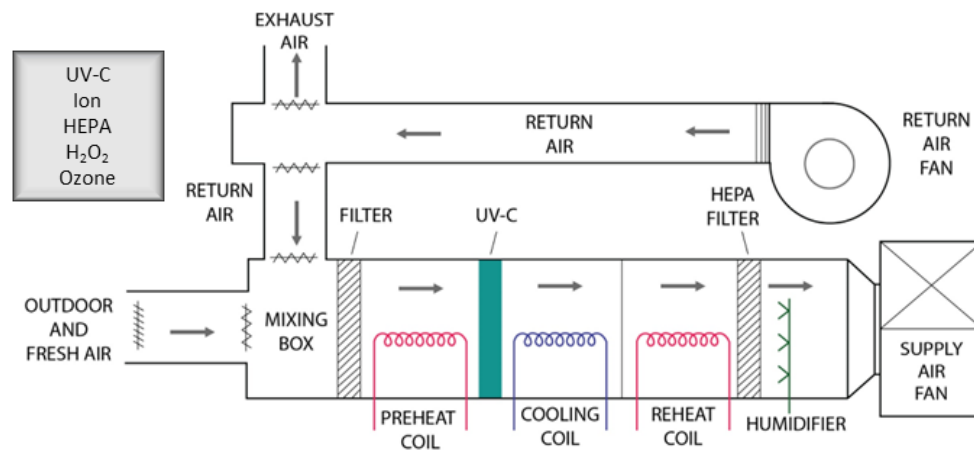
In Room = 2,000 cfm

Total = 2,900 cfm

# ASHRAE Standard 62.1

“ASHRAE has determined that HVAC ventilation rates in commercial buildings, **do not address transmission of airborne viruses, bacteria, and other infectious contagions**”

Building HVAC systems supply air for entire building and air travels from one source to reach ALL areas. The systems are not designed to destroy pathogens at the occupied room level



# Engineering Controls

## Episodic vs Continuous

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SOLUTION

# Engineered Source - Control

Engineering Controls – by design protect people by automatically eliminating hazards or reduce exposure to hazards, without human intervention. At UV Angel we focus on the development of intelligent automated engineered-controls for infection prevention & control



The most effective protection measures are listed in the table to the right (from most effective to least effective). In most cases, a combination of control measures will be necessary to protect workers from exposure to SARS-CoV-2. Engineering controls reduce exposure to hazards without relying on worker behavior and can be the most cost-effective solution to implement.



Recommends using ultraviolet germicidal irradiation (UVGI) as a supplement to help inactivate the virus.



Strongly recommend; good evidence –Upper-room UVGI as a supplement to supply airflow

MOST EFFECTIVE

Engineering Controls  
**Active, Upper Room UVGI**

Administrative Controls

Personal Protective Equipment (PPE)

LEAST EFFECTIVE

# Important Decision Criteria

Environmental Mitigation Approach:

**ADDITIVE vs SUBTRACTIVE**

Upper Room Applications:

**ACTIVE vs PASSIVE**

UV-C Wavelengths for Occupied Spaces:

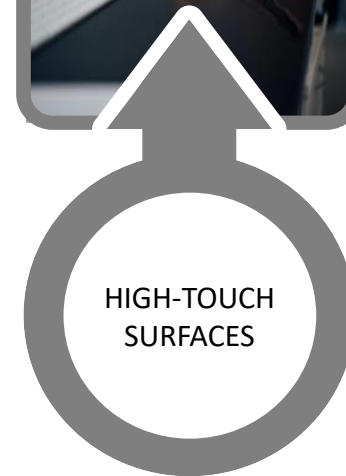
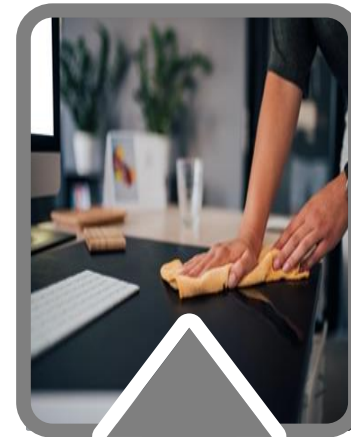
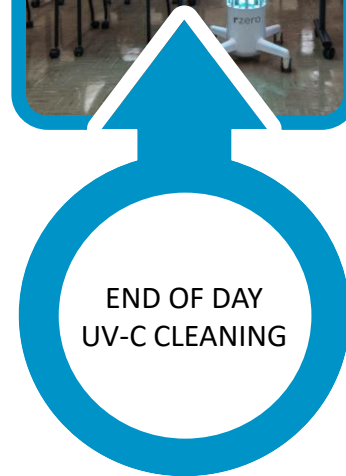
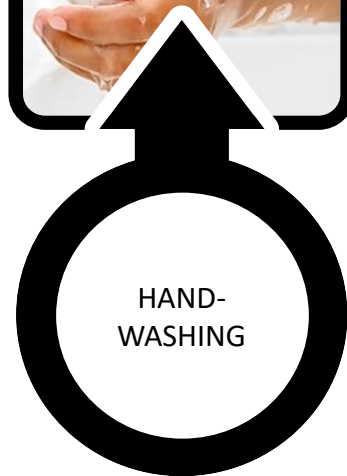
**SHIELDED UVC 254 vs UNSHIELDED UVC 222**

# Episodic Routine Controls – Use a Layered Approach – Continuous Automated

Cleaning typically happens when people are not present...

Yet people are the major source of disease transmission and contamination...

The room environment gets contaminated again after the people re-occupy the space...



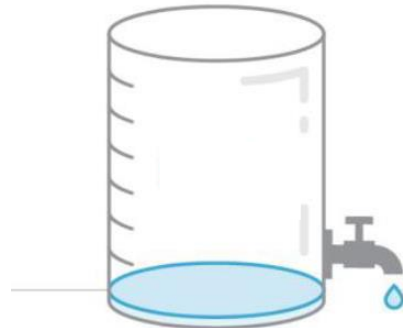
**EPISODIC CLEANING – EVEN WITH BEST INTENT ERRORS EXIST**

# The laboratory vs. the real world + continuous treatment

## Laboratory Versus Real-World Settings

“A person typically sheds some **37 million bacteria** into the surrounding air or onto surfaces touched.”

Kills 99.99%?  
Small Snapshot



**Treatment technology** in  
a lab setting

Constant Loading



Hospital without  
continuous treatment  
technology

Continuous Cleaning =  
Continuous Reduction



Hospital with continuous  
treatment technology

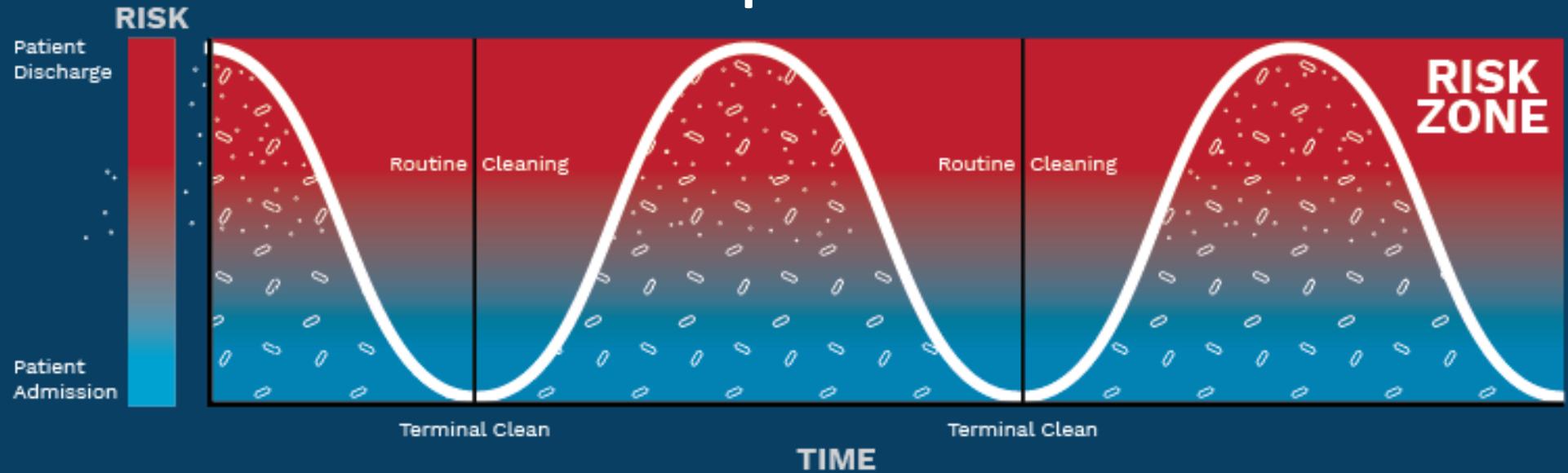
# Why should you be concerned

- Often good to visualize this to truly understand – but essentially if I have 10,000 E.coli – after using a product there should be roughly 1 left.
- Now – Given the fact that E.coli has a doubling time (1 -> 2, 2->4) of 20 minutes. That 1 E.coli that survived that initial volley of germicidal will become 2.1 million in 7 hours. After just one more hour it becomes 16.8 million strong.<sup>1</sup>
- We apply our device that's "99.99%" effective – and now we've brought the load down from 2.2 billion to 220,000 colony forming units.
- So, while 99.99% is very good – it's important understand it's application in microbiology as the 99.xx% term is thrown around quite a bit.

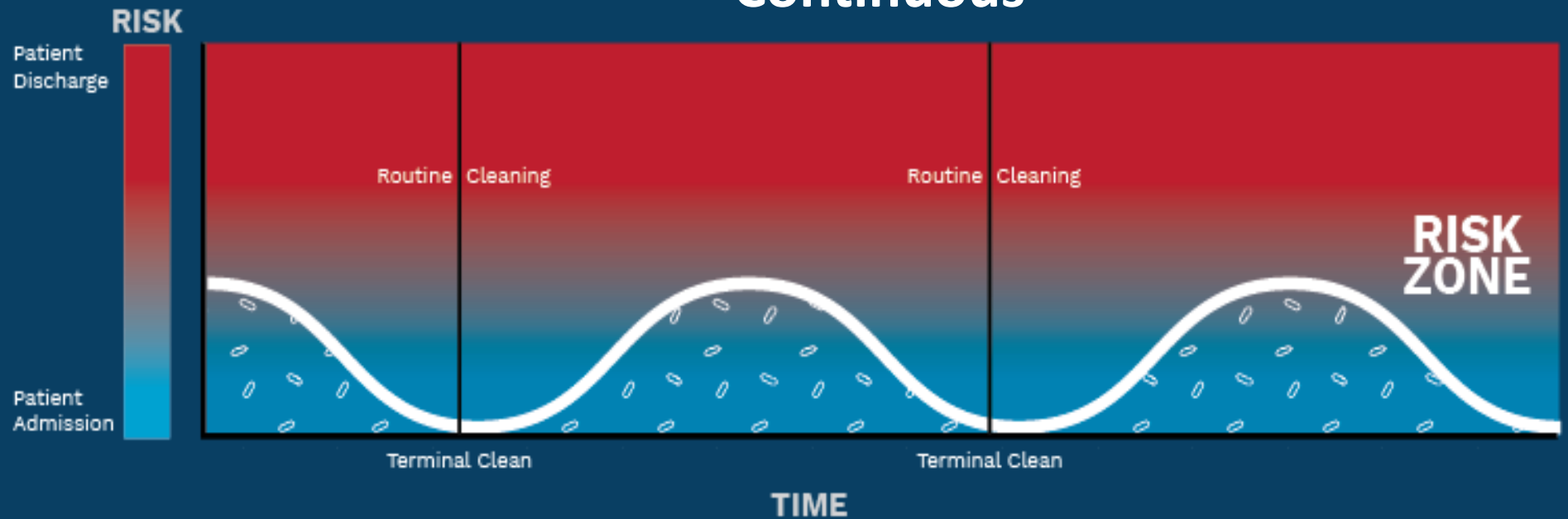
1. <https://microbiologysociety.org/why-microbiology-matters/what-is-microbiology/bacteria.html> Compliments of Nicholas Unger, Intertek

# Episodic Cleaning Protocols Have Inherent Risk

## Episodic



## Continuous



# What Air and Surface Environmental Sampling Tells Us

THE INVISIBLE THREAT



CONTAMINATED AIR



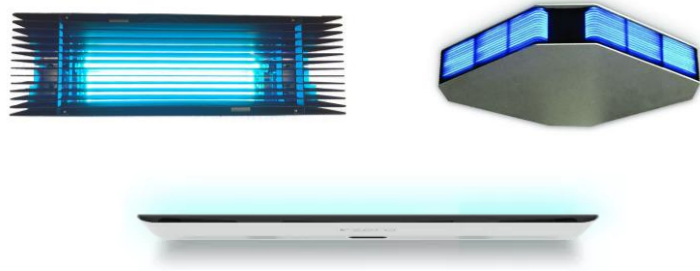
What to do about it?

Active Upper-Room UVGI Technology

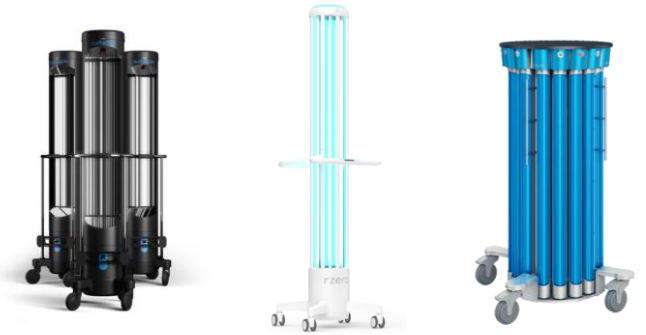
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# UVGI Disinfection Products

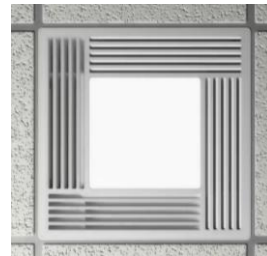
Passive Upper Room UV



Whole Room Surface (Episodic)



Active Upper Room UVGI



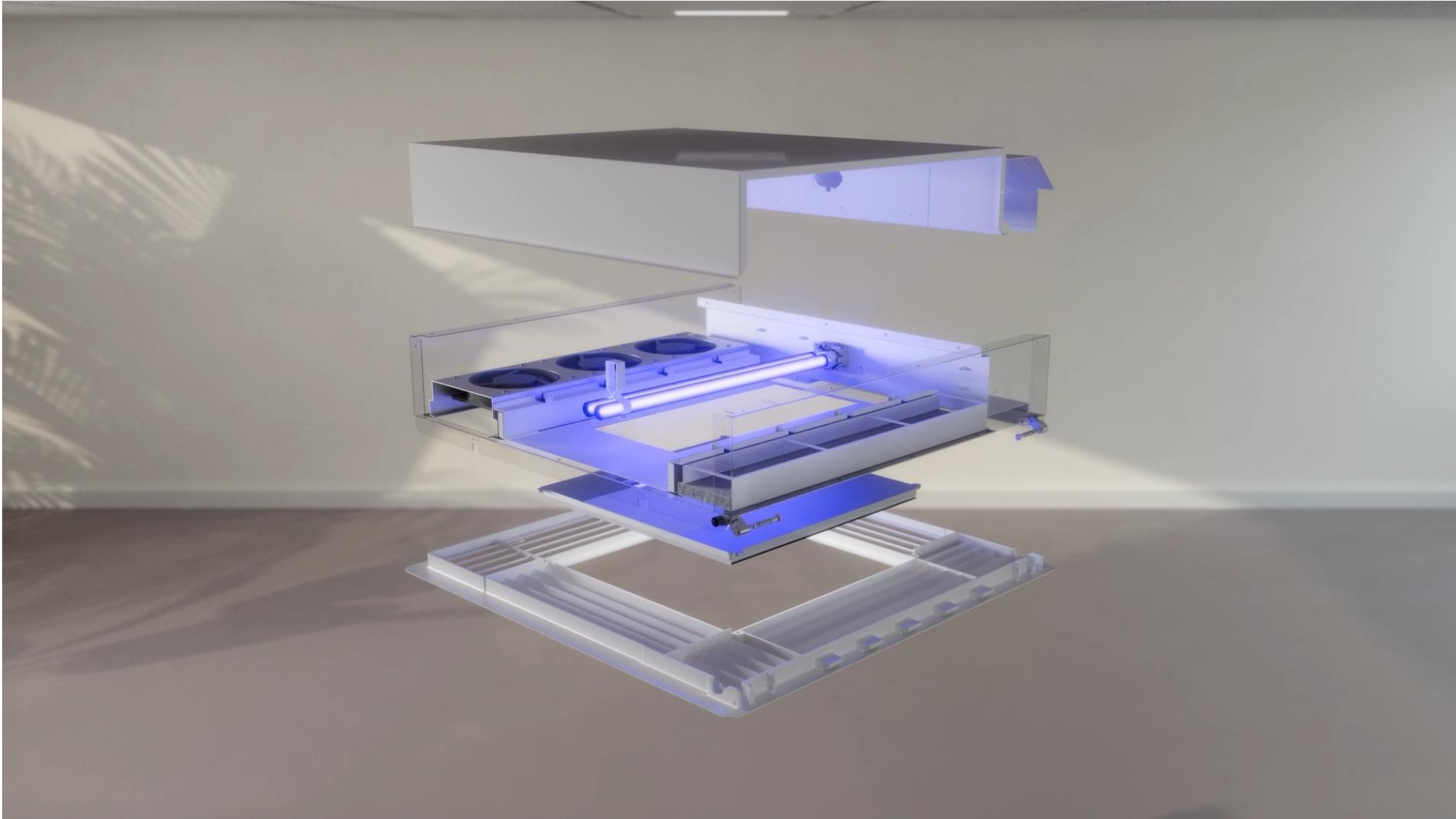
Passive Surface (222)



HVAC Air Handler



## Active Upper Room UVGI



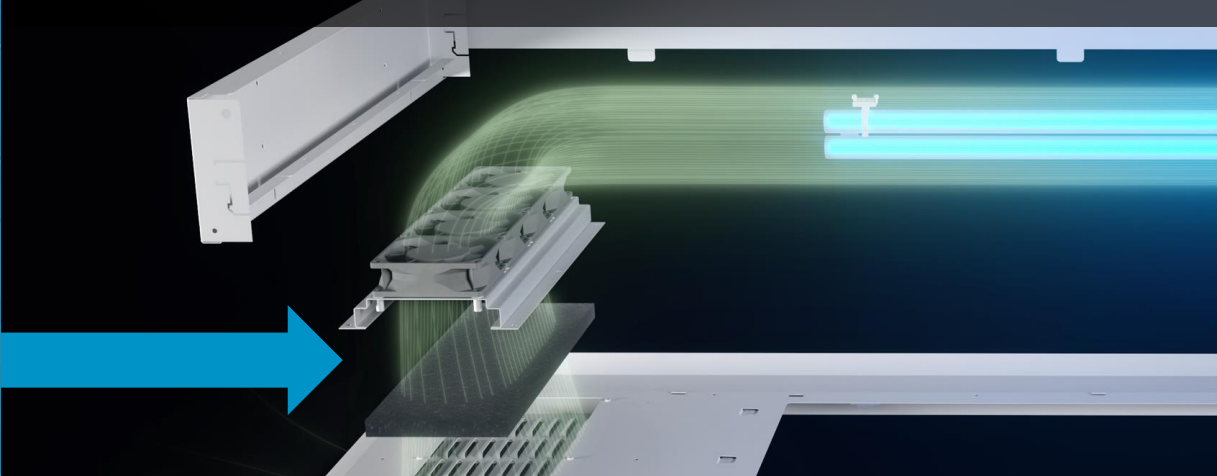
1

OPERATING SEPARATE FROM HVAC - ROOM AIR IS ACTIVELY DRAWN IN WITH FANS INTO THE SEALED UPPER ROOM UVGI DISENFECTION CHAMBER



2

VIRUSES, BACTERIA, FUNGI/MOLD (PATHOGENS) ARE CONTINUOUSLY 24X7-365 DRAWN IN BY ACTIVE FAN TECHNOLOGY THROUGH A FILTER TO THE UVGI LAMP



## HOW IT WORKS

4

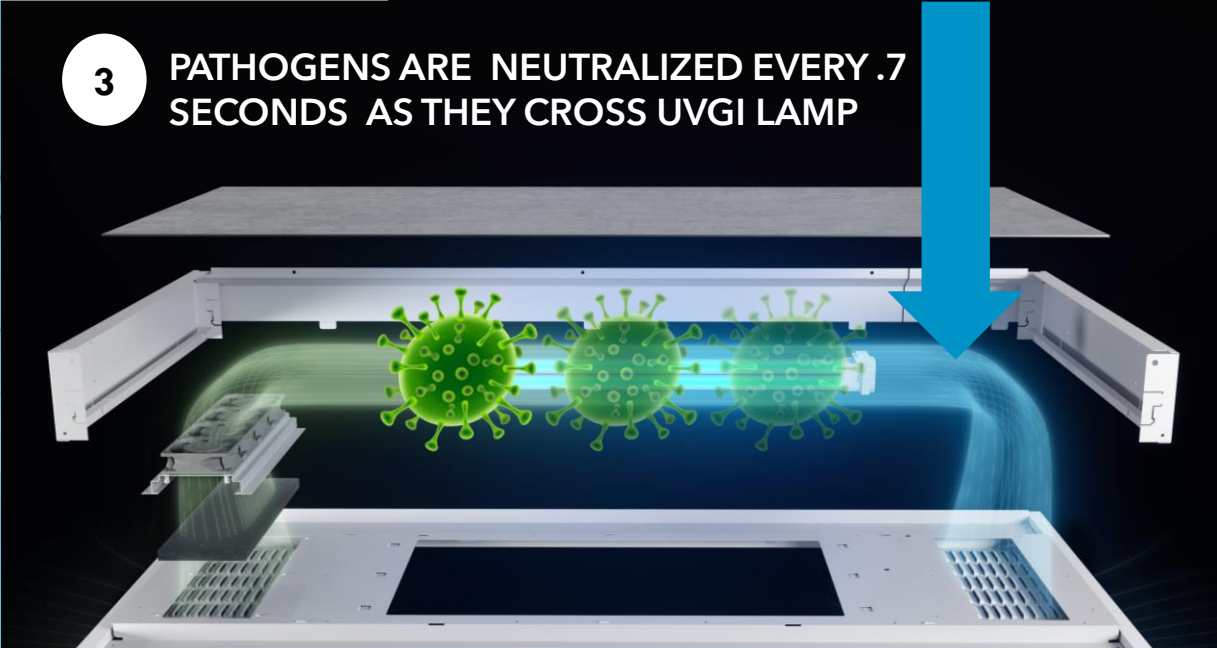
CLEAN, DISENFECTED AIR IS GENTLY RETURNED BACK TO THE ROOM



84,000 TIMES A DAY HIGH-INTENSITY UVGI IS DISENFECTING ROOM AIR FROM VIRUSES, BACTERIA, FUNGI/MOLD

3

PATHOGENS ARE NEUTRALIZED EVERY .7 SECONDS AS THEY CROSS UVGI LAMP



# How to Evaluate Technologies

---

# Good Science Should Drive Clarity

## The Importance of Technology Due Diligence



1. Review results that should include *independent third-party laboratory studies*
2. Review *company and user testimonial testing documentation of use in real-world* applications
3. Review results that should include *peer-reviewed published studies* that show the effectiveness of actual use cases

## Get The Facts – Step 1

Test conclusively support that Active Upper Room UVGI treats bacteria fungus and viruses in the air, including:

*Gram negative and gram-positive bacteria, fungal pathogens and viral surrogates and SARS CoV2. Active Upper Room UVGI results show elimination rates up to 99.9%.*

# Company Information and Additional Information

**Table 4: Combined UV + Filter Removal Rates**

| Microbe                     | Type         | Size<br>µm  | Filter<br>% | UV Rate<br>% | Total<br>%    |
|-----------------------------|--------------|-------------|-------------|--------------|---------------|
| Acinetobacter               | Bacteria     | 1.225       | 21          | 100          | 100.00        |
| Adenovirus                  | Virus        | 0.079       | 9           | 100          | 100.00        |
| Aeromonas                   | Bacteria     | 2.098       | 35          | 100          | 100.00        |
| Aspergillus                 | Fungi        | 3.354       | 45          | 93           | 96.30         |
| Bacillus anthracis          | Bacteria     | 1.118       | 19          | 61           | 68.20         |
| Bacteroides fragilis        | Bacteria     | 3.162       | 44          | 100          | 100.00        |
| Blastomyces dermatitidis    | Fungi        | 12.649      | 50          | 99           | 99.65         |
| Bordetella pertussis        | Bacteria     | 0.245       | 4           | 100          | 100.00        |
| Burkholderia cenocepacia    | Bacteria     | 0.707       | 11          | 100          | 100.00        |
| Burkholderia mallei         | Bacteria     | 0.674       | 10          | 100          | 100.00        |
| Burkholderia pseudomallei   | Bacteria     | 0.494       | 7           | 100          | 100.00        |
| Candida albicans            | Fungi        | 4.899       | 49          | 79           | 89.19         |
| Candia auris                | Fungi        | 4.899       | 49          | 75           | 87.31         |
| Chlamydia pneumoniae        | Bacteria     | 0.548       | 8           | 100          | 100.00        |
| Chlamydomydia psittaci      | Bacteria     | 0.283       | 4           | 100          | 100.00        |
| Cladosporium                | Fungi        | 8.062       | 50          | 98           | 98.75         |
| Clostridium botulinum       | Bacteria     | 1.975       | 33          | 100          | 100.00        |
| Clostridium difficile       | Bacteria     | 2           | 34          | 100          | 100.00        |
| Clostridium perfringens     | Bacteria     | 5           | 49          | 100          | 100.00        |
| <b>Coronavirus (Wuhan)</b>  | <b>Virus</b> | <b>0.11</b> | <b>6</b>    | <b>100</b>   | <b>100.00</b> |
| Corynebacterium diphtheriae | Bacteria     | 0.698       | 10          | 100          | 100.00        |
| Coxsackievirus              | Virus        | 0.027       | 19          | 100          | 100.00        |
| Cryptococcus neoformans     | Fungi        | 4.899       | 49          | 99           | 99.67         |
| Curvularia lunata           | Fungi        | 11.619      | 50          | 71           | 85.57         |
| Ebola virus                 | Virus        | 0.09        | 8           | 100          | 100.00        |
| Echovirus                   | Virus        | 0.024       | 20          | 100          | 99.89         |
| E. coli                     | Virus        | 0.5         | 7           | 100          | 100.00        |
| Enterobacter cloacae        | Bacteria     | 1.414       | 24          | 100          | 100.00        |
| Enterococcus                | Bacteria     | 1.414       | 24          | 100          | 100.00        |
| Enterococcus faecalis       | Bacteria     | 0.707       | 11          | 100          | 100.00        |
| Francisella tularensis      | Bacteria     | 0.2         | 4           | 91           | 91.49         |
| Fusarium                    | Fungi        | 11.225      | 50          | 92           | 96.23         |
| Haemophilus influenzae      | Bacteria     | 0.285       | 4           | 100          | 100.00        |
| Haemophilus parainfluenzae  | Bacteria     | 1.732       | 30          | 100          | 99.99         |
| Hantaan virus               | Virus        | 0.096       | 7           | 100          | 100.00        |
| Helicobacter pylori         | Bacteria     | 2.1         | 35          | 100          | 100.00        |
| Histoplasma capsulatum      | Fungi        | 2.236       | 36          | 99           | 99.56         |
| Influenza A virus           | Virus        | 0.098       | 7           | 100          | 100.00        |
| Junin virus                 | Virus        | 0.122       | 6           | 100          | 100.00        |
| Klebsiella pneumoniae       | Bacteria     | 0.671       | 10          | 100          | 100.00        |
| Lassa virus                 | Virus        | 0.122       | 6           | 100          | 100.00        |
| LCV                         | Virus        | 0.087       | 8           | 100          | 100.00        |
| Legionella pneumophila      | Bacteria     | 0.52        | 7           | 100          | 100.00        |
| Listeria monocytogenes      | Bacteria     | 0.707       | 11          | 99           | 98.98         |

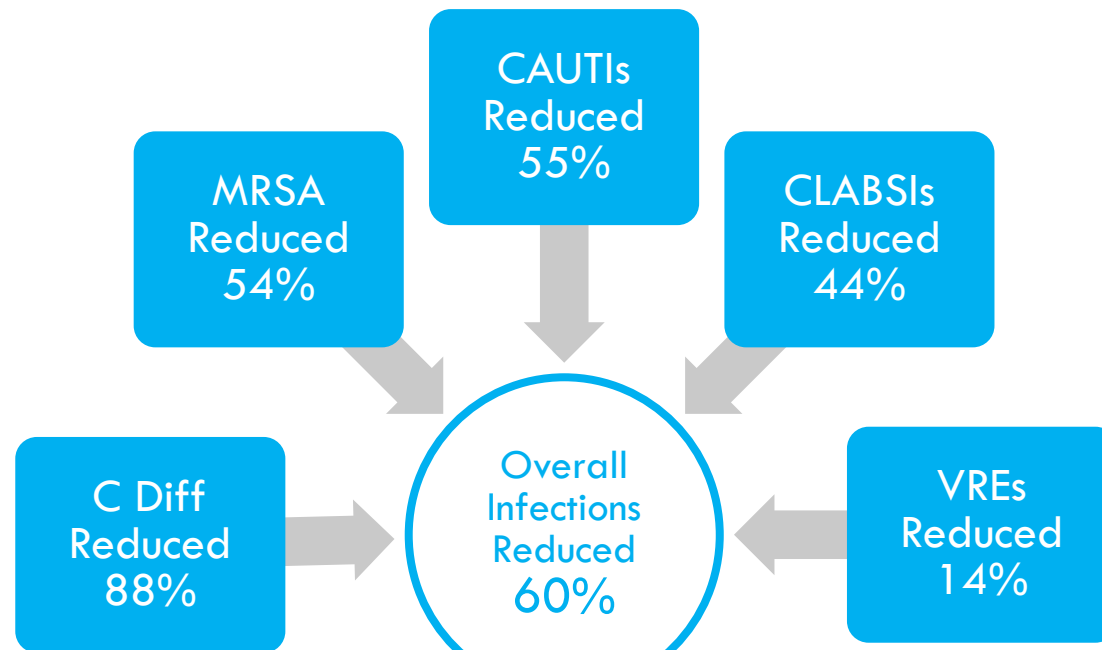
**Table 4: Combined UV + Filter Removal Rates**

| Microbe                    | Type     | Size<br>µm | Filter<br>% | UV Rate<br>% | Total<br>% |
|----------------------------|----------|------------|-------------|--------------|------------|
| Marburg virus              | Virus    | 0.039      | 15          | 100          | 100.00     |
| Measles virus              | Virus    | 0.158      | 5           | 100          | 100.00     |
| MERS virus                 | Virus    | 0.11       | 6           | 89           | 90         |
| Mucor                      | Fungi    | 7.071      | 50          | 95           | 98         |
| Mumps virus                | Virus    | 0.164      | 5           | 100          | 100        |
| Mycobacterium avium        | Bacteria | 1.118      | 19          | 100          | 100        |
| Mycobacterium kansasii     | Bacteria | 1.118      | 19          | 100          | 100        |
| Mycobacterium tuberculosis | Bacteria | 0.637      | 9           | 100          | 100        |
| Mycoplasma pneumoniae      | Bacteria | 0.177      | 5           | 100          | 100        |
| Neisseria meningitidis     | Bacteria | 0.775      | 12          | 100          | 100        |
| Nocardia asteroides        | Bacteria | 1.118      | 19          | 100          | 100        |
| Norwalk virus              | Virus    | 0.029      | 18          | 97           | 98         |
| Parainfluenza virus        | Virus    | 0.194      | 4           | 100          | 100        |
| Parvovirus B19             | Virus    | 0.022      | 21          | 100          | 100        |
| Penicillium                | Fungi    | 3.262      | 44          | 60           | 78         |
| Proteus mirabilis          | Bacteria | 0.494      | 7           | 100          | 100        |
| Pseudomonas aeruginosa     | Bacteria | 0.494      | 7           | 100          | 100        |
| Reovirus                   | Virus    | 0.075      | 9           | 99           | 99         |
| RSV                        | Virus    | 0.19       | 5           | 100          | 100        |
| Rhinovirus                 | Virus    | 0.023      | 21          | 99           | 99         |
| Rhizopus                   | Fungi    | 6.928      | 50          | 93           | 96         |
| Rickettsia prowazeki       | Bacteria | 0.6        | 9           | 100          | 100        |
| Rotavirus                  | Virus    | 0.073      | 9           | 100          | 100        |
| Rubella virus              | Virus    | 0.061      | 11          | 67           | 71         |
| Salmonella typhi           | Bacteria | 0.806      | 13          | 100          | 100        |
| SARS virus                 | Virus    | 0.11       | 6           | 100          | 100        |
| Serratia marcescens        | Bacteria | 0.632      | 9           | 100          | 100        |
| Stachybotrys chartarum     | Fungi    | 5.623      | 49          | 12           | 55         |
| Staphylococcus aureus      | Bacteria | 0.866      | 14          | 100          | 100        |
| Staphylococcus epidermis   | Bacteria | 0.866      | 14          | 100          | 100        |
| Streptococcus pneumoniae   | Bacteria | 0.707      | 11          | 77           | 80         |
| Streptococcus pyogenes     | Bacteria | 0.894      | 14          | 100          | 100        |
| Trichophyton               | Fungi    | 4.899      | 49          | 71           | 85         |
| Ustilago                   | Fungi    | 5.916      | 50          | 46           | 73         |
| VZV                        | Virus    | 0.173      | 5           | 100          | 100        |
| Yersinia pestis            | Virus    | 0.707      | 11          | 100          | 100        |

# AIR: PUBLISHED DATA

## Study Departments – Pharmacy, OR, ICU, Nursing Home VU, Outpatient Clinic

Infection Reduction Results - Hospital ICU, KY



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Journal homepage: www.ajicjournal.org

Major Article

Cleaning the air with ultraviolet germicidal irradiation lessened contact infections in a long-term acute care hospital

Tina Ethington MSN, RN, CEN, NE-BC<sup>a</sup>, Sherry Newsome BSN, RN, MBA/MNA<sup>a</sup>, Jerri Waugh BSN, RN, MBA/MHA<sup>a</sup>, Linda D. Lee DrPH, MBA<sup>b,c</sup>

<sup>a</sup> Frazier Hospital, Louisville, KY  
<sup>b</sup> American Green Technology, South Bend, IN

**Background:** This study was designed to determine whether removing bacteria from the air with ultraviolet germicidal irradiation (UV-C) at the room level would reduce infection rates.  
**Methods:** We measured infection data for 12 months before and after UV-C installation in the special care unit (SCU) of a long-term acute care hospital. All patients admitted to the SCU during the study time frame were included. Microbiologic impact of sampling was completed in August 2015. Standardized UV-C units were installed in 16 patient rooms. Air before and after the installation was collected for 12 months.

Emerging Technologies

Surface and air: What impact does UV-C at the room level have on airborne and surface bacteria?

Linda D. Lee, DrPH, MBA, Executive Vice President and Chief Science Officer, Valspar

Corresponding Author:  
Dr. Linda Lee, American Green Technology, 52120 Bona Vista Blvd, South Bend, IN 46707

Conflict of interest:  
Dr. Lee is employed by Valspar, which provided the UV-C technology used in this study.

**Background:** Ultraviolet methods have been published to highlight the germicidal oxidant effect.

**Abstract:** Short wave ultraviolet light (UV-C) is known to have the ability to render bacteria inert. We theorized that using UV-C would not only lower the amount of bacteria circulating in the air, but also lower the amount of bacteria found on surfaces. Methods: We set up test beds at three hospitals (Texas, Nevada, and Massachusetts) where we tested air and surface for bacteria the room level, and then tested air and surface again.  
**Results:** In all cases, airborne bacteria were reduced between 79 and 91% over pre-installation values. Most surfaces also showed a decrease in bacterial load, with a reduction of up to 98%.

**Conclusion:** The data indicate that using active UV-C technology at the room level not only reduces the bacteria in the air and on an hospital's surface, but also improves the UV-C technology's impact on air quality.

**Keywords:** UV-C, airborne bacteria

**Introduction:** An early publication on the effectiveness of ultraviolet light on bacteria is from 1877, when two British scientists noticed that "Rabies" isolation, when placed in lead-covered test tubes, grew innumerable bacteria, while the same solution in unshielded test tubes placed in sunlight, did not (1). Since then, many studies have demonstrated that UV rays are a powerful way to render bacteria inert, beginning with Chlorobacterium in 1922 (2) and Staph in 1939 (3). It has been known for decades that many diseases, such as tuberculosis and influenza, are spread via airborne and/or droplet transmission. More recently studies have shown that pathogens thought to be spread through direct contact can also become aerosolized. Robert et al. demonstrated that Clostridium difficile (C diff) spores could be disseminated through the air (4) as did Bost et al. (5). Li et al. reviewed 40 studies to show a strong association between building ventilation and the transmission of airborne disease (6). James et al. wrote annually, but with a higher focus on hospital acquired infection (HAI), including methicillin-resistant Staphylococcus aureus (MRSA) (7). Nazarioff et al. discussed the role of bacterial dynamics layout on how the airflow in a space moves particulate matter, including microbes (8).

Knowing that disease could be spread through the air, and that short-wave ultraviolet (UV-C) can render pathogens inert, it is logical that the medical community would turn to UV-C to reduce the amount of bacteria circulating in the air. Borden and Cotton discussed how UV distribution works in general (9) and Boyce discussed specific technologies for using UV-C in hospitals (10). Ritala et al. studied how UV eliminate bacteria (11). Over the decades, several air developed. These methods include water filtration system, using it in a stand-alone, mobile product. It recommended UV, in terms of effect also each one has drawbacks, in the case of the mobile unit, this requirement that the space to provided an excellent historical p et al. considered that ultraviolet g useful addition to the disinfection The potential for surfaces to be despite standard cleaning methods that an important source of air activity, such as entering a room, from surfaces (14). Our study was of using UV-C at the room level o air, and whether clearing the air surface bacteria.

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Brief Report

Effectiveness of a shielded ultraviolet C air disinfection system in an inpatient pharmacy of a tertiary care children's hospital

Douglas W. Kane, MD, Cynthia Finley, BRT, Diane Brown, BRT

**Background:** The use of a shielded ultraviolet C (UV-C) air disinfection system in an inpatient pharmacy of a tertiary care children's hospital was evaluated. Methods: A long-term care ventilator unit was installed in an environment with comparatively high concentrations of MRSA and C. difficile. Inpatient rooms where patients had symptomatic C. difficile were also included. UV-C devices were installed and control locations were monitored to evaluate the effectiveness of UV-C air disinfection in reducing air and surface microbial contamination in inpatient clinical areas where immunocompromised children are encountered was not proven.

**Conclusions:** There were no obvious statistically significant differences in the air and surface culture results between test locations where UV-C devices were installed and control locations. The effectiveness of UV-C air disinfection in reducing air and surface microbial contamination in inpatient clinical areas where immunocompromised children are encountered was not proven.

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Emerging Technologies

UV-C light and infection rate in a long term care ventilator unit

Douglas W. Kane, MD, Cynthia Finley, BRT, Diane Brown, BRT

**Background:** The use of a shielded ultraviolet C (UV-C) air disinfection system in an inpatient pharmacy of a tertiary care children's hospital was evaluated. Methods: A long-term care ventilator unit was installed in an environment with comparatively high concentrations of MRSA and C. difficile. Inpatient rooms where patients had symptomatic C. difficile were also included. UV-C devices were installed and control locations were monitored to evaluate the effectiveness of UV-C air disinfection in reducing air and surface microbial contamination in inpatient clinical areas where immunocompromised children are encountered was not proven.

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Major Article

Effect of a shielded continuous ultraviolet-C air disinfection device on reduction of air and surface microbial contamination in a pediatric oncology outpatient care unit

Hana Hakim MD, MS, CIC<sup>a,b,c</sup>, Craig Gilliam BS, CIC, FAPIC<sup>b</sup>, Li Tang PhD<sup>c</sup>, Jiahui Xu MSPH<sup>d</sup>, Linda D. Lee DrPH, MBA<sup>e</sup>

<sup>a</sup>Department of Pediatric Hematology, St. Jude Children's Research Hospital, Memphis, TN  
<sup>b</sup>Department of Pediatric Hematology and Control, St. Jude Children's Research Hospital, Memphis, TN  
<sup>c</sup>Department of Epidemiology, St. Jude Children's Research Hospital, Memphis, TN  
<sup>d</sup>Linda D. Lee Healthcare Consultants, LLC, Austin, TX

**Background:** For a clean hospital environment, we evaluated whether ultraviolet C (UV-C) air disinfection devices in a pediatric oncology outpatient care unit could reduce air and surface microbial contamination. Methods: A pre- and post-intervention study compared 6 test locations, where continuous shielded UV-C air disinfection devices were installed, with 10 control locations without UV-C. Pre- and post-intervention air and surface samples were collected for bacterial and fungal cultures. Prevalence changes in colony forming unit (CFU) counts in test and control locations were compared.  
**Results:** Mean bacterial CFU count per cubic meter air and per surface contact plate decreased by 27% (P = .02) and 17% (P = .01), respectively, in test locations compared to 40% (P = .004) and 30% (P = .000) reductions in control locations. Mean fungal CFU count per cubic meter air and per surface contact plate increased by 14% (P = .15) and 10% (P = .04), respectively, in test locations compared to 24% (P = .004) and 21% (P = .04) increases in control locations.  
**Conclusions:** There were no obvious statistically significant differences in the air and surface culture results between test locations where UV-C devices were installed and control locations. The effectiveness of UV-C air disinfection in reducing air and surface microbial contamination in outpatient clinical areas where immunocompromised children are encountered was not proven.

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**Background:** A clean protective environment is especially important in immunocompromised patient care areas. Pediatric oncology patients are at an increased risk for acquisition of infections, not only in the inpatient care settings but also in outpatient settings, where most health care delivery including chemotherapy infusions occur. To protect immunocompromised patients, our pediatric oncology center has actively sought ways to reduce the burden of pathogens, including airborne transmission of infections.

The effectiveness of germicidal ultraviolet-C (UV-C) light irradiation has been demonstrated for the disinfection of water and air-handling systems in the food industry, and for laboratory disinfection, among other uses.<sup>1-11</sup> Over the past decades, UV-C light technology has been increasingly used in health care settings as a tool to prevent infections by disinfecting the hospital environments, including surfaces, water, and air. Recent studies demonstrated the effectiveness of UV-C light in environmental disinfection and a reduction in the acquisition cycle processing and culture.

**Methods:** Environmental studies were conducted in Massachusetts Hospital A), an inpatient unit in Texas (Hospital B), and an acute care unit in Massachusetts (Hospital C). In each case, the study was designed to determine whether removing bacteria from the air with ultraviolet germicidal irradiation (UV-C) at the room level would reduce infection rates. We measured infection data for 12 months before and after UV-C installation in the special care unit (SCU) of a long-term acute care hospital. All patients admitted to the SCU during the study time frame were included. Microbiologic impact of sampling was completed in August 2015. Standardized UV-C units were installed in 16 patient rooms. Air before and after the installation was collected for 12 months.

**Results:** In all cases, airborne bacteria were reduced between 79 and 91% over pre-installation values. Most surfaces also showed a decrease in bacterial load, with a reduction of up to 98%.

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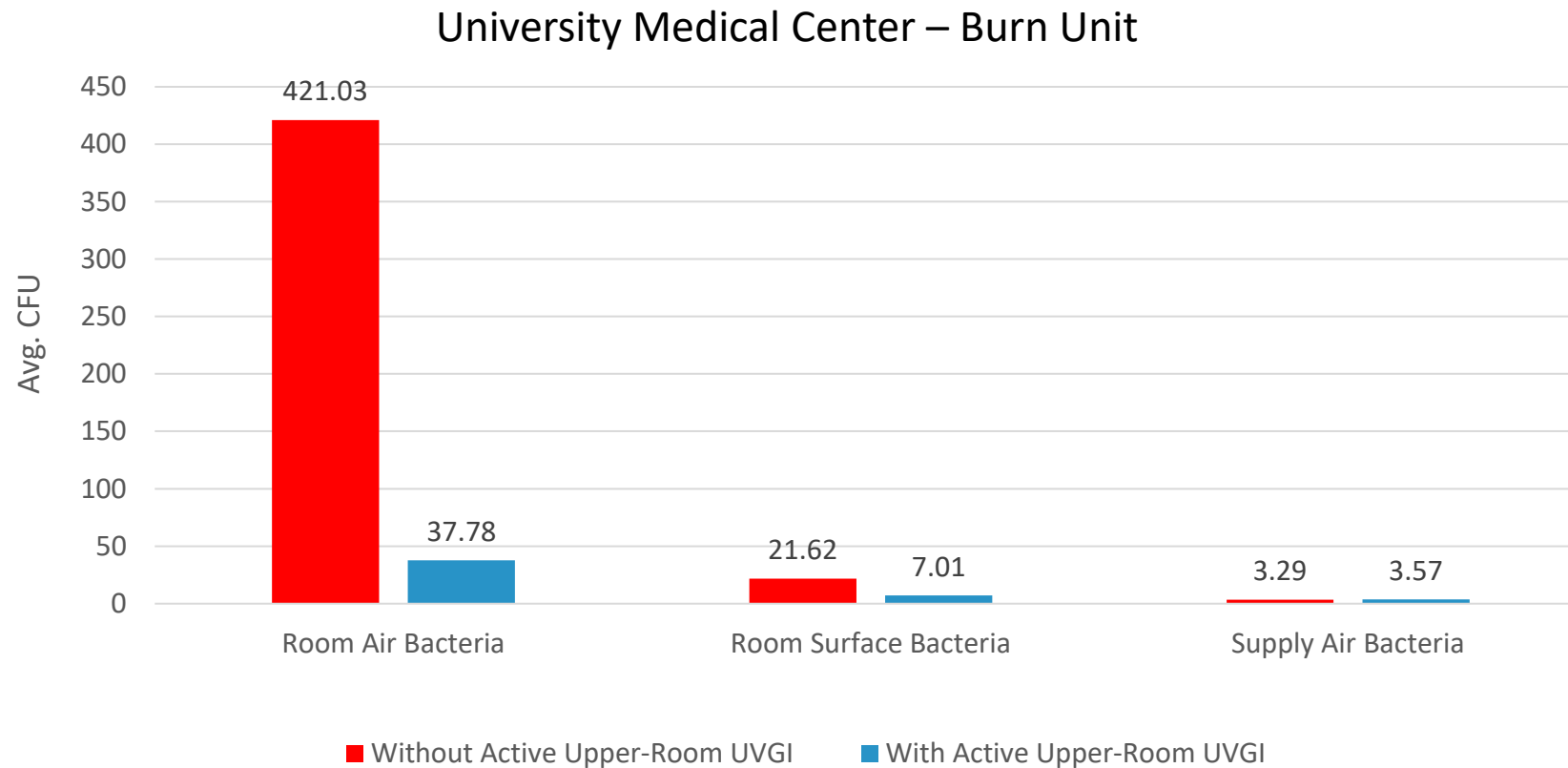
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Knowing that disease could be spread through the air, and that short-wave ultraviolet (UV-C) can render pathogens inert, it is logical that the medical community would turn to UV-C to reduce the amount of bacteria circulating in the air. Borden and Cotton discussed how UV distribution works in general (9) and Boyce discussed specific technologies for using UV-C in hospitals (10). Ritala et al. studied how UV eliminate bacteria (11). Over the decades, several air developed. These methods include water filtration system, using it in a stand-alone, mobile product. It recommended UV, in terms of effect also each one has drawbacks, in the case of the mobile unit, this requirement that the space to provided an excellent historical p et al. considered that ultraviolet g useful addition to the disinfection The potential for surfaces to be despite standard cleaning methods that an important source of air activity, such as entering a room, from surfaces (14). Our study was of using UV-C at the room level o air, and whether clearing the air surface bacteria.

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# Pre & Post Testing Study Summary



91% overall reduction of Room Air Bacteria.

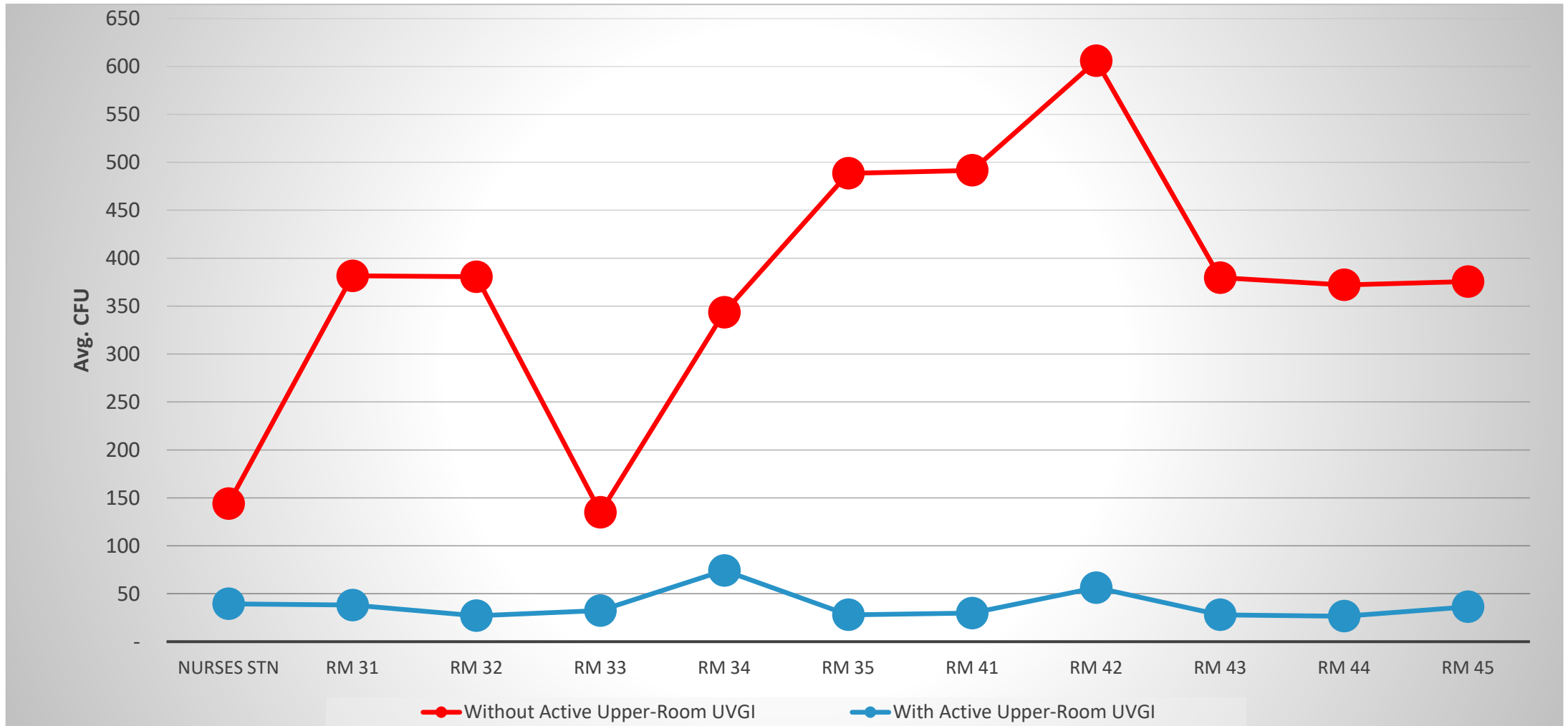
68% overall reduction of Room Surface Bacteria.

Virtually no change in bacteria counts in air supplied to the room.

\*The Air, Surface and Supply Bacteria is reported in CFU's.

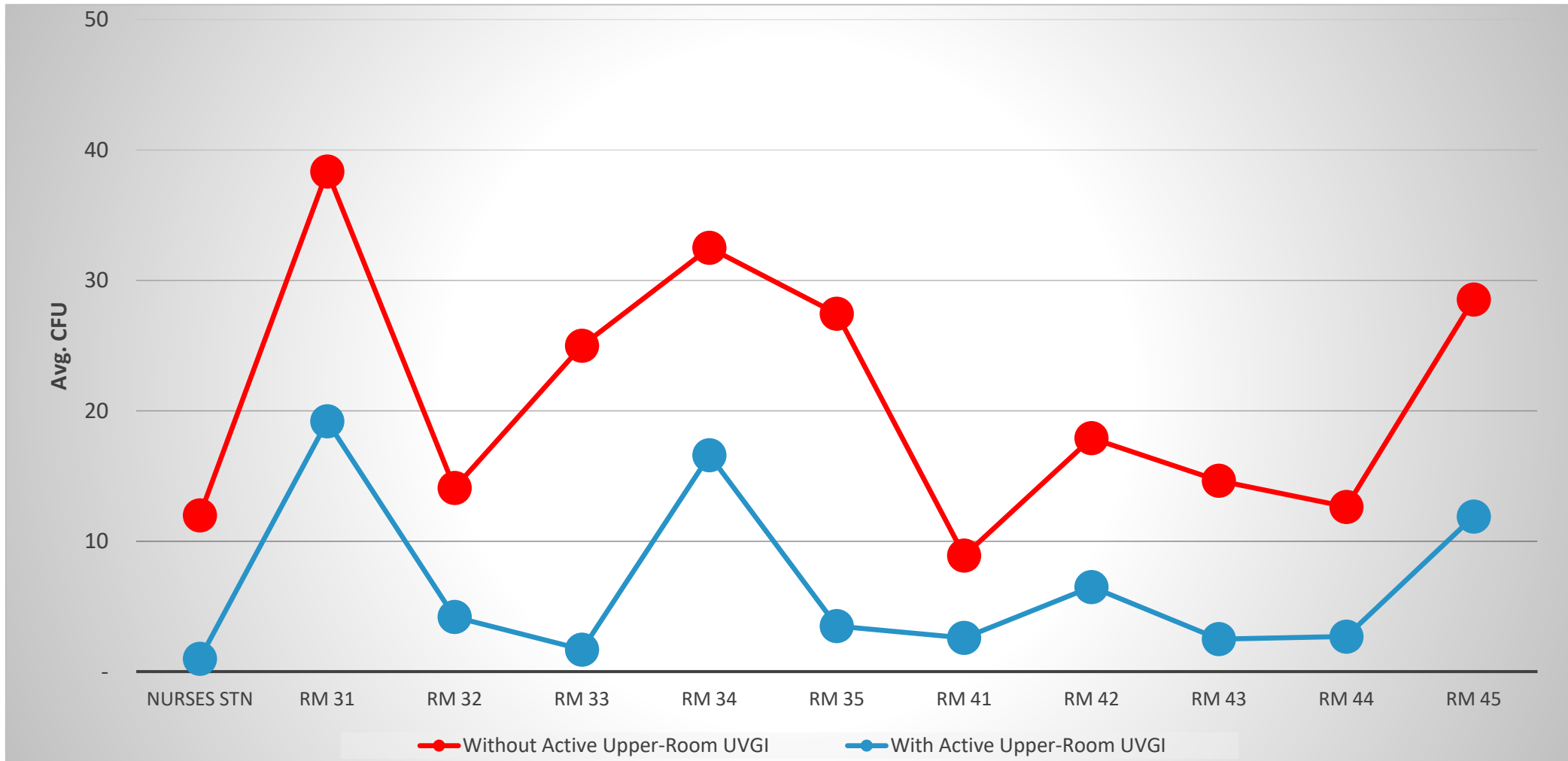
# Pre & Post Testing Study Summary

Average Room Air Bacteria CFU counts – comparing pre and post installation sampling



# Pre & Post Testing Study Summary

Average Room Surface Bacteria CFU counts – comparing pre and post installation sampling



# Lebanon VAMC Technology Study

| Table 2 - Infection Rates | Avg Rate |
|---------------------------|----------|
| No Mitigation             | 2.58     |
| Device #1 GUV             | 1.67     |
| Device #2 405 nm          | 3.22     |

| Table 3 - Infection Rate Comparison | % Change in Infection Rates |
|-------------------------------------|-----------------------------|
| No Mitigation v GUV                 | 35% decrease                |
| GUV v 405 nm                        | 88% increase                |
| no mitigation v 405nm               | 23% increase                |

## **Theresa Haley**

*Director, Infection Prevention*

Lebanon VA Medical Center

*Lead for Infection Control, Veterans Integration Service, VISN 4*

# Learning Objectives



**Describe**

Describe the behavior of airborne microbes.



**Align**

Align technology implementation with regulatory needs.



**Contrast**

Contrast episodic disinfection with continuous disinfection.



**Evaluate**

Evaluate technologies designed to reduce airborne contamination and their application to high-risk areas.

# QUESTION & ANSWER