CONTAMINATED AIR:
The Invisible Threat to Patients and Healthcare Workers

Dr. Linda D. Lee, MBA

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LEARNING OBJECTIVES

- **Understand how air becomes contaminated in a hospital environment**
- **Explain how pathogenic particles travel on air currents**
- **Describe the dangers that pathogenic air particles pose to the patient and the healthcare worker**
- **Describe the relationship between positive and negative air pressure and how it affects the hospital environment**
- **Learn how ultraviolet light in the C spectrum (UV-C) air purification can reduce aerosols and minimize contamination on surrounding surfaces as a mitigation strategy.**

BIOGRAPHY

- Chief Medical Affairs and Science Officer, UV Angel
- Founding member of Stericycle
- MD Anderson Cancer Center, AVP Admin Facilities and Campus Operations
- Adjunct Faculty, UT Health School of Public Health, University of Houston, Walden University
- CH2M Hill, Global Public Health Director
- WM Healthcare Solutions, Director of Operations
- Speaker - SHEA, AIHce, IPAC-Canada, C. Diff Foundation, ASHAE, AHE, APIC
- Published author – AHA
- DrPH- The University of Texas Health Science Center Houston
- MS- University of Arkansas College of Engineering
- BS- Indiana State University Environmental Health Science

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Why we are here…

HEALTHCARE ASSOCIATED INFECTIONS: THE UNKNOWN KILLER

"CDC estimates that ***1 in 31*** hospital patients gets a HAI (an infection while being treated in a medical facility)."

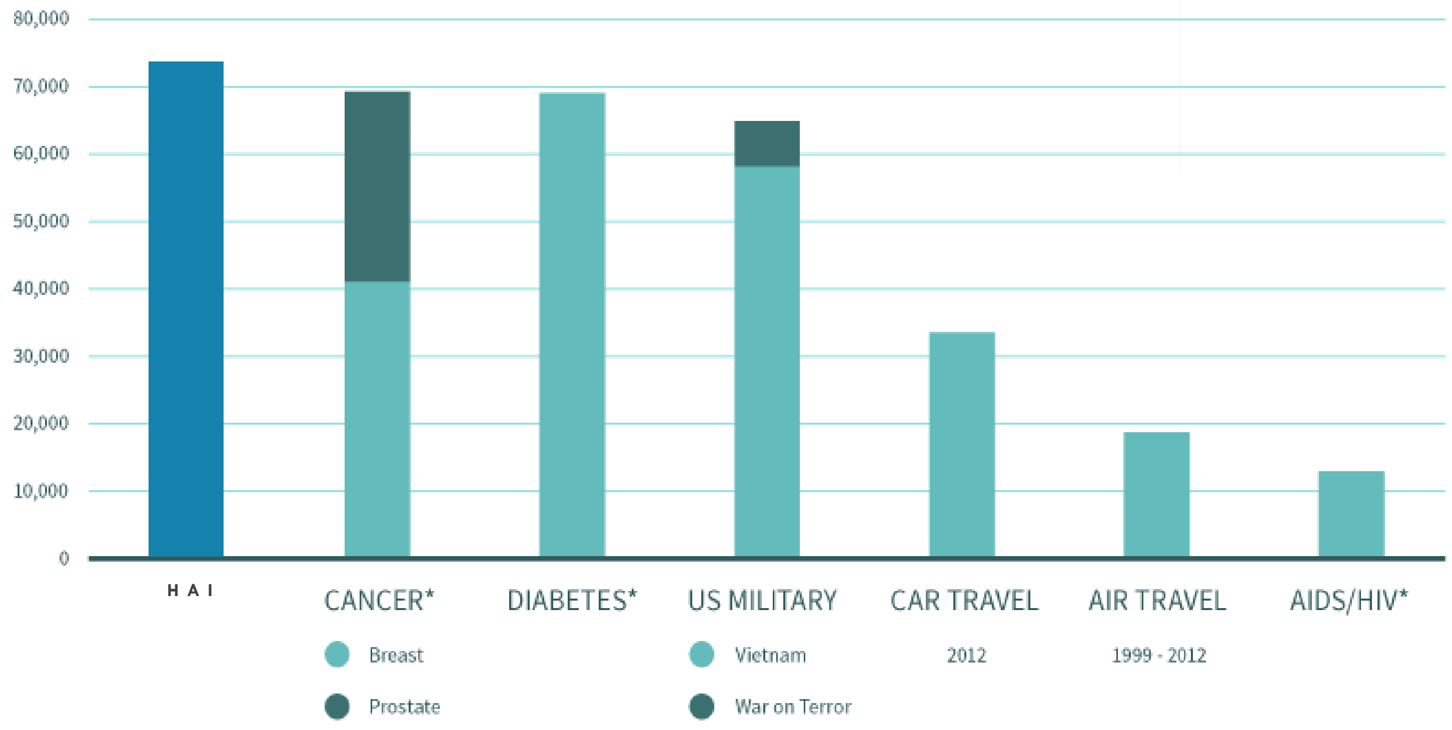
+720,000

US citizens that contract healthcare-associated infections annually

+72,000

US citizens that die from healthcare-associated infections annually

(Source: cdc.org)



PENALTIES AND COSTS

CMS - Centers for Medicare & Medicaid Services

$35-45 Billion	**Cost Annually Directly from Healthcare-associated infections (HAIs) in US** **(Source: cdc.org)**
$96-147 Billion	Total Cost Impact from direct, indirect, and nonmedical social costs of HAIs (Source: beckershospitalreview.com)
	Hospital-Acquired Condition Reduction Program Medicare payments are significantly reduced for the worst performing hospitals with regards to Hospital Acquired Conditions

Typical Excess Costs Per Patient of Common HAIs

CDI (Clostridium difficile Infection) • $11,000 • 3.3 extra days	VAP (Ventilator-Associated Pneumonia) • $40,000 • 13.1 extra days
SSI (Surgical Site Infections) • $20,800 • 23 extra days (w/ MRSA)	CLABSI (Central Line-associated Blood Stream Infection) • $45,800 • 15.7 extra days (MRSA)
CAUTI (Catheter-Associated Urinary Tract Infections) • $1,000 extra per patient	

DISEASE TRANSMISSION

Infectious Pathogen

Bacteria, Viruses, Fungus, Parasites

Source of Pathogen

Reservoir: dirty surfaces, air, water or insects

Portal of Exit

How pathogens exit body: coughing, bleeding, open wounds

Volume of Pathogens Left Behind

Some survive or are missed during cleaning

Susceptible Host

Pathogens travel on air currents and land on surfaces

Route of Entry

Ingestion, inhalation, puncture or contact

WHY IS THE AIR IMPORTANT?

SURFACE CLEANING EFFORTS ARE NOT ENOUGH

Well-child visits account for 700,000+ new influenza cases costing $500m annually

2011 study of 150,000 people, 82% visited doctor or dentist prior to diagnosis, without visiting hospital

69% of infrequently touched (high-dust) surfaces positive for *C. difficile* in elderly ward

Is Alzheimer’s caused by fungus?

380,000 die in LTCF annually (CDC)

MRSA and C. difficile survive for months on surfaces

Airborne dispersion plays role in non-respiratory infections

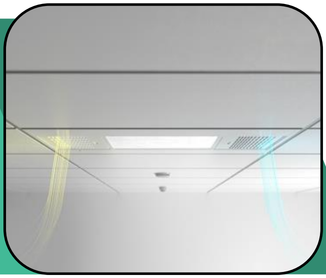
HIERARCHY OF CONTROLS

CDC, EPA, OSHA

ENGINEERING

UV Angel Air Handler,

UV Angel surface disinfection device



ADMINISTRATIVE

Surface cleaning, UV towers, hand hygiene, prevention/prophylaxis, UV Clean & Charge

PPE

Masks, gloves, protective equipment

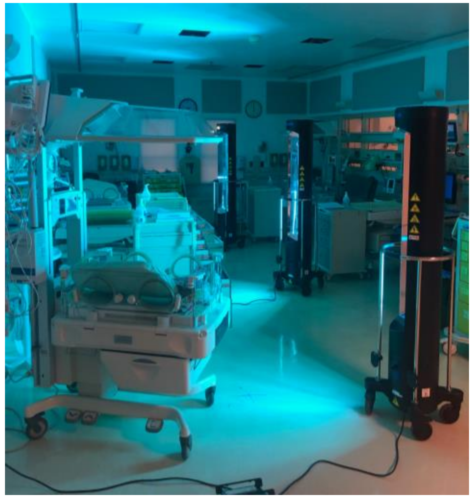
HEALTHCARE: PRIMARY CURRENT CLEANING PROCEDURES

Our workers clean… and clean… and clean…

HANDWASHING

CLEANING

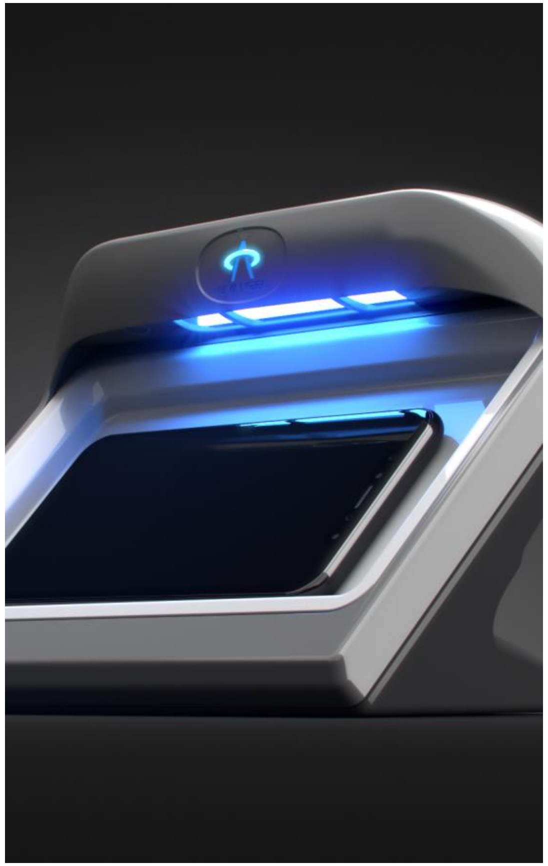
TERMINAL CLEANING



HIGH TOUCH SURFACES

TECHNOLOGY IS TAKING CHARGE

Portable Medical Carts



Mobile Disinfection

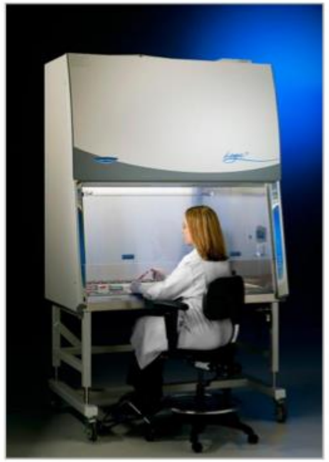
UV Air & Surface Disinfection

Integrated Technology

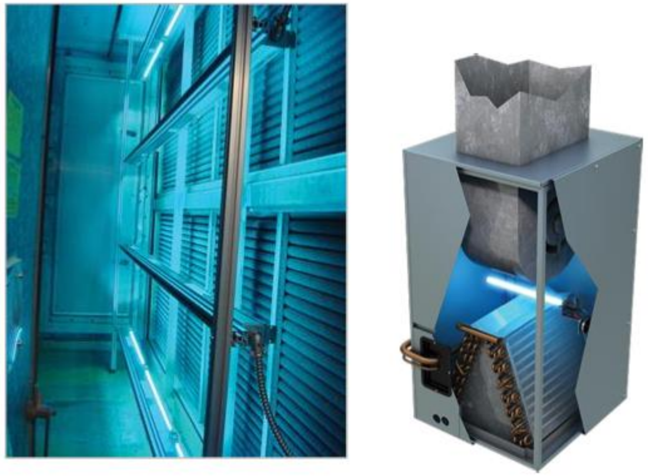
UV technology has a long history in healthcare.

Upper room air disinfection

UV “robots”



Biological safety cabinet



Air handlers & air conditioning units

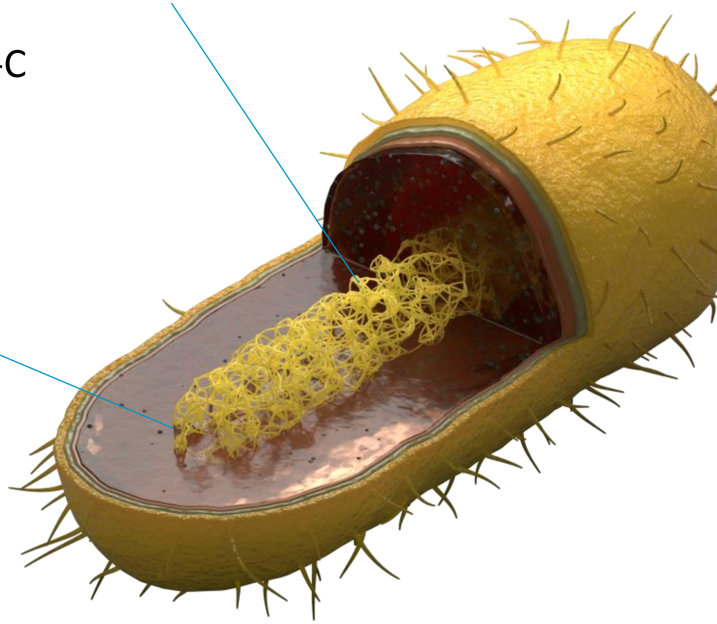
UV lamps in water treatment

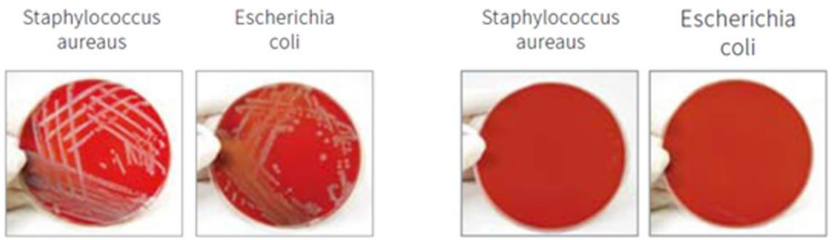
UV-C SURFACE AND AIR TREATMENT

- UV-C light provides rapid, effective inactivation of microorganisms through a physical process.
- When bacteria, viruses, and fungi are exposed to the germicidal wavelengths of UV light, they are rendered incapable of reproducing and infecting.

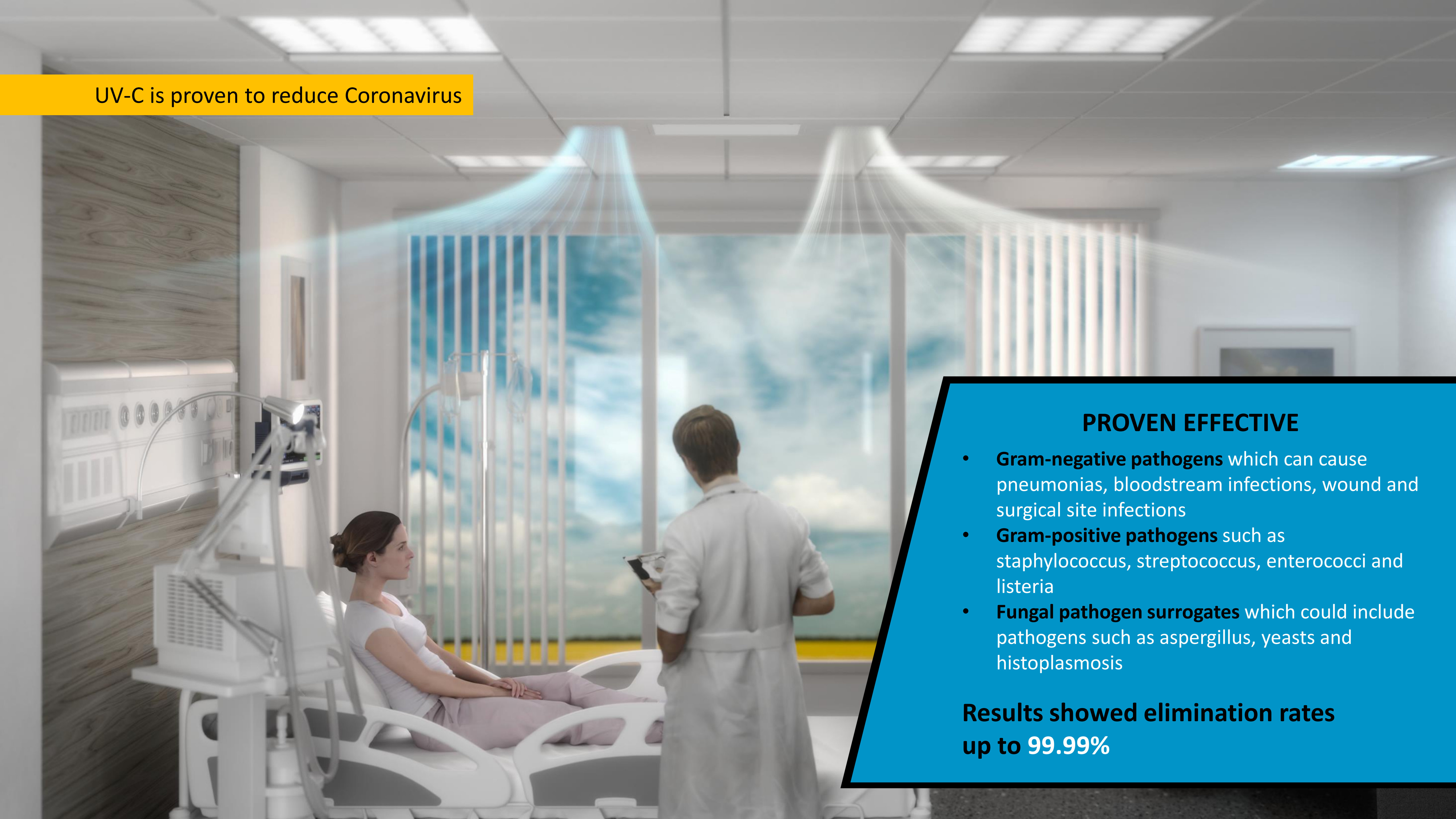
Before UV-C

After UV-C





Representation of found pathogens and disinfection



UV-C is proven to reduce Coronavirus

PROVEN EFFECTIVE

- **Gram-negative pathogens** which can cause pneumonias, bloodstream infections, wound and surgical site infections
- **Gram-positive pathogens** such as staphylococcus, streptococcus, enterococci and listeria
- **Fungal pathogen surrogates** which could include pathogens such as aspergillus, yeasts and histoplasmosis

Results showed elimination rates up to 99.99%

THE INVISIBLE THREAT

PRIOR ROOM OCCUPANCY INCREASES RISK

WHERE DID THE PATHOGENS COME FROM IN TERMINALLY CLEAN ROOM?

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	VRE – cultured within room	2.6x
Huang 2006	VRE – prior room occupant	1.6x
	MRSA – prior room occupant	1.3x
Drees 2008	VRE – cultured within room	1.9x
	VRE – prior room occupant	2.2x
	VRE – prior room occupant in previous 2 weeks	2.0x
Shaughnessy 2008	*C. difficile* – prior room occupant	2.4x
Nseir 2010	A. baumannii – prior room occupant	3.8x
	P. aeruginosa – prior room occupant	2.1x

Air Transports the Pathogens that Contaminate People and Surfaces

Up to 8 times

- Hospital air samples, on average, are up to 8 times more contaminated than surfaces

15 minutes

- MRSA counts remain elevated up to 15 minutes after bed making

69% Untouched

- A hospital study on C. diff showed 69% of untouched areas in a C. diff patient's room were contaminated

66% Reduced Contamination

- Hospital evidence shows reducing pathogens from the air can reduce surface contamination by as much as 66%

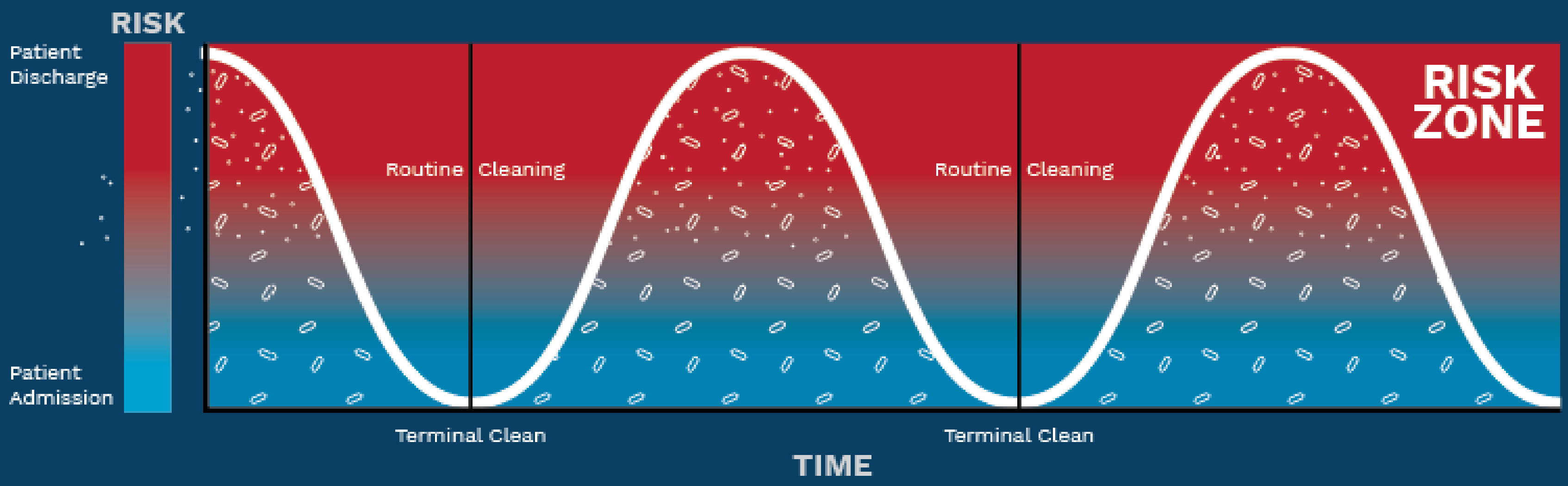
PATHOGEN SURVIVAL RATE

SOME PATHOGENS CAN HIDE FOR MONTHS

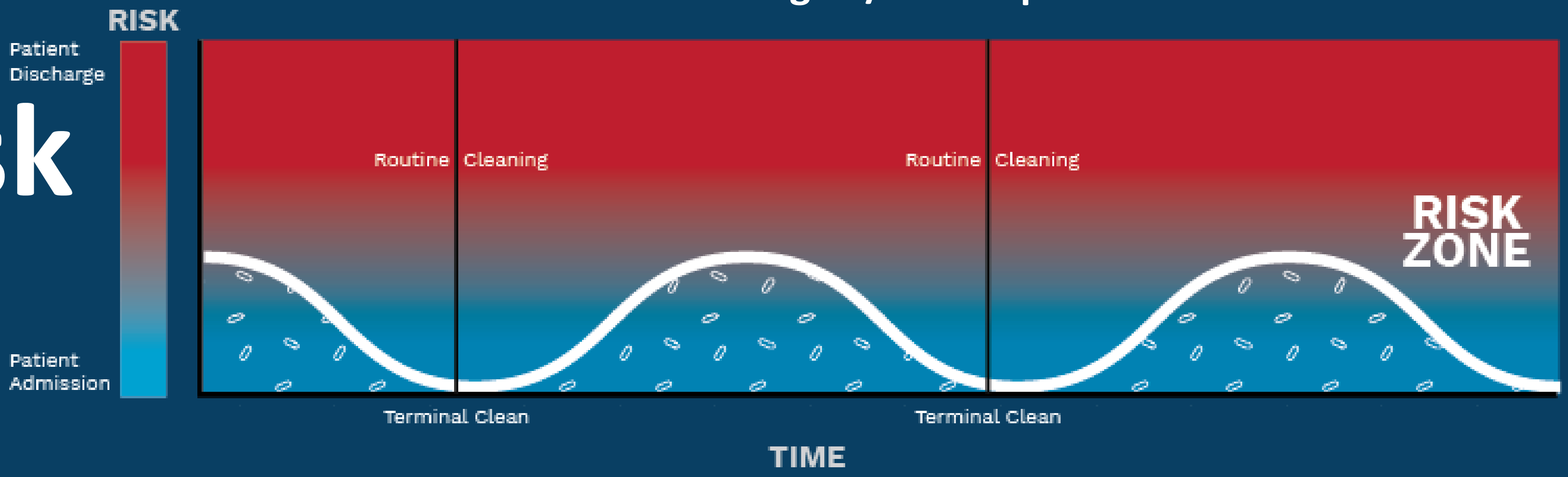
Organism	Survival period
Clostridium difficile	35- >200 days
Methicillin resistant Staphylococcus aureus (MRSA)	14- >300 days
Vancomycin-resistant enterococcus (VRE)	58- >200 days
Escherichia coli	>150- 480 days
Acinetobacter	150- >300 days
Klebsiella	>10- 900 days
Salmonella typhimurium	10 days- 4.2 years
Mycobacterium tuberculosis	120 days
Candida albicans	120 days
Most viruses from respiratory tract (eg: corona, coxsackie, influenza, SARS, rhino virus)	Few days
Viruses from the gastrointestinal tract (eg: astrovirus, HAV, polio- or rota virus)	60- 90 days
Blood-borne viruses (e.g.: HBV or HIV)	>7 days

Episodic Cleaning Protocols Have Inherent Risk

Before using 24/7 UV-C protocols



After using 24/7 UV-C protocols



HAZARDS OF SHARED MEDICAL EQUIPMENT

INCREASED RISK

- In 2017 AJIC study*, hospitalized patients had **1.4 interactions** per hour with medication carts that traveled between patient rooms.

TRANSMISSION

- Patients frequently had direct or indirect interaction with medical equipment or other fomites that were shared with other patients.

PROOF

- Equipment was often found to be contaminated with healthcare-associated pathogens.
- **12%** of the cultures found MRSA, VRE or *C. difficile*.

"Our findings suggest that there is a need for protocols to ensure effective cleaning of shared portable equipment"

Suwantarat, et. al

*Nuntra Suwantarat, Laura A. Supple, Jennifer L. Cadnum, Thriveen Sankar, Curtis J. Donskey, Quantitative assessment of interactions between hospitalized patients and portable medical equipment and other fomites, *AJIC*, Volume 45, Issue 11, Pages 1276–1278

10 HOSPITAL SITE ANALYSIS, N=2,079

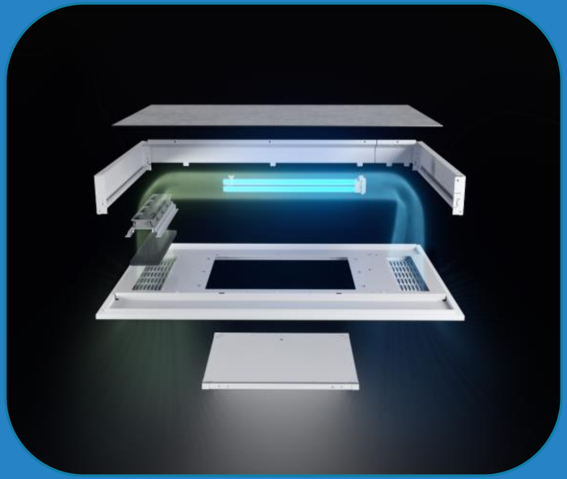
Of the 2,079 samples 1,464 samples were positive for clinically relevant organisms (70%) Below are the average CFU for the organisms tested. (hospital group no-pass policy greater than 10 CFU)

Organism	Average CFU
Total aerobes	111*
Staphylococcus aureus	34
Methicillin-resistant Staphylococcus aureus	35
Enterococcus	137
Vancomycin-resistant enterococcus	54
Gram-negative bacilli	196
Candida spp.	60
Clostridioides difficile	N/A
Too Numerous To Count (limit is 250 CFU) Gram Negative Enterococcus	38% (549) 199 42

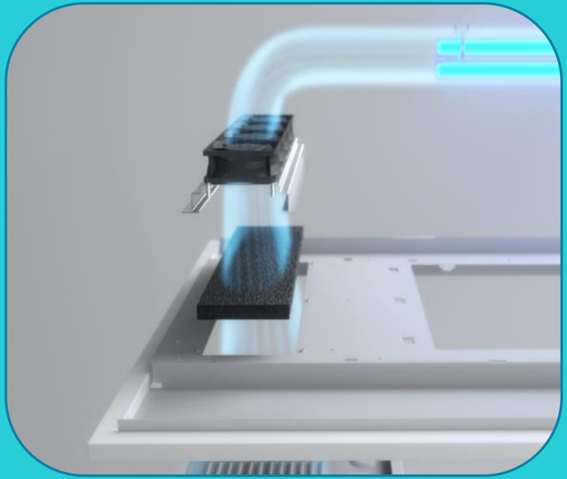
- All surfaces sampled; WOW Work Surfaces, WOW Keyboard, Wall Arm Keyboard, Nurse Station Keyboard, Patient Vitals Monitor, Pyxis Machines, IV Pumps
- Surface with the highest number of samples positive for HAI Bacteria: Nurse Keyboard (26%), WOW Work Surface (25%), Wow Keyboard (23%)
- Most contaminated surface by avg CFU'S: Pyxis Machine (171 CFU), WOW Work Surface (114 CFU), WOW Keyboard
- Most clinically relevant surface contamination by percent: Wall arm keyboard (86%), WOW Work Surfaces (79%)

HOW IN CEILING UV-C AIR PURIFICATION WORKS

Replaces conventional lighting systems so no staff intervention is required



A fully sealed UV-C chamber is enclosed above normal LED room lighting



Fans quietly draw air into the sealed UV-C chamber

WHERE CAN UV-C SOLUTIONS BE MOST EFFECTIVE IN A HOSPITAL?

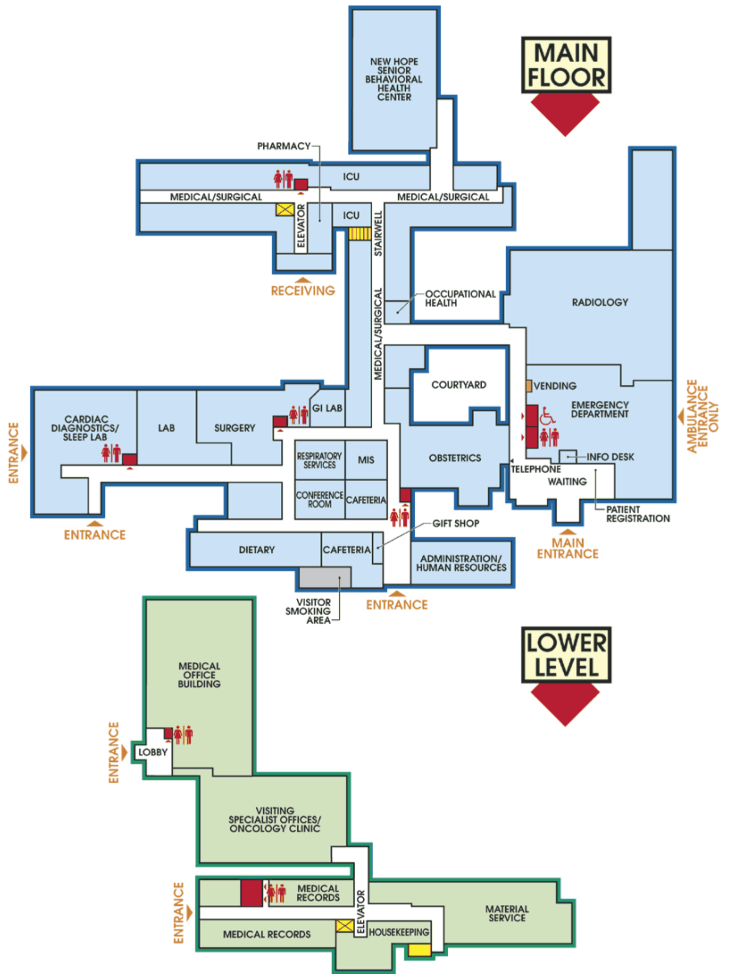
High risk patients
High contamination areas
High density locations

- ICU
- NICU
- PICU
- SCU
- Geriatric
- Oncology
- Hematology
- Burn units
- BMT units

- Bronchoscopy Suites
- Areas surrounding the ORs
- Decontamination rooms
- Employee break rooms
- Soiled utility rooms
- Isolation rooms
- Toilet rooms
- TB-Isolation

- Emergency Dept.
- Nurses stations
- Clinics
- Corridors

- Waiting rooms
- Central supply
- Sterile core
- PACU



Air Sampling Process

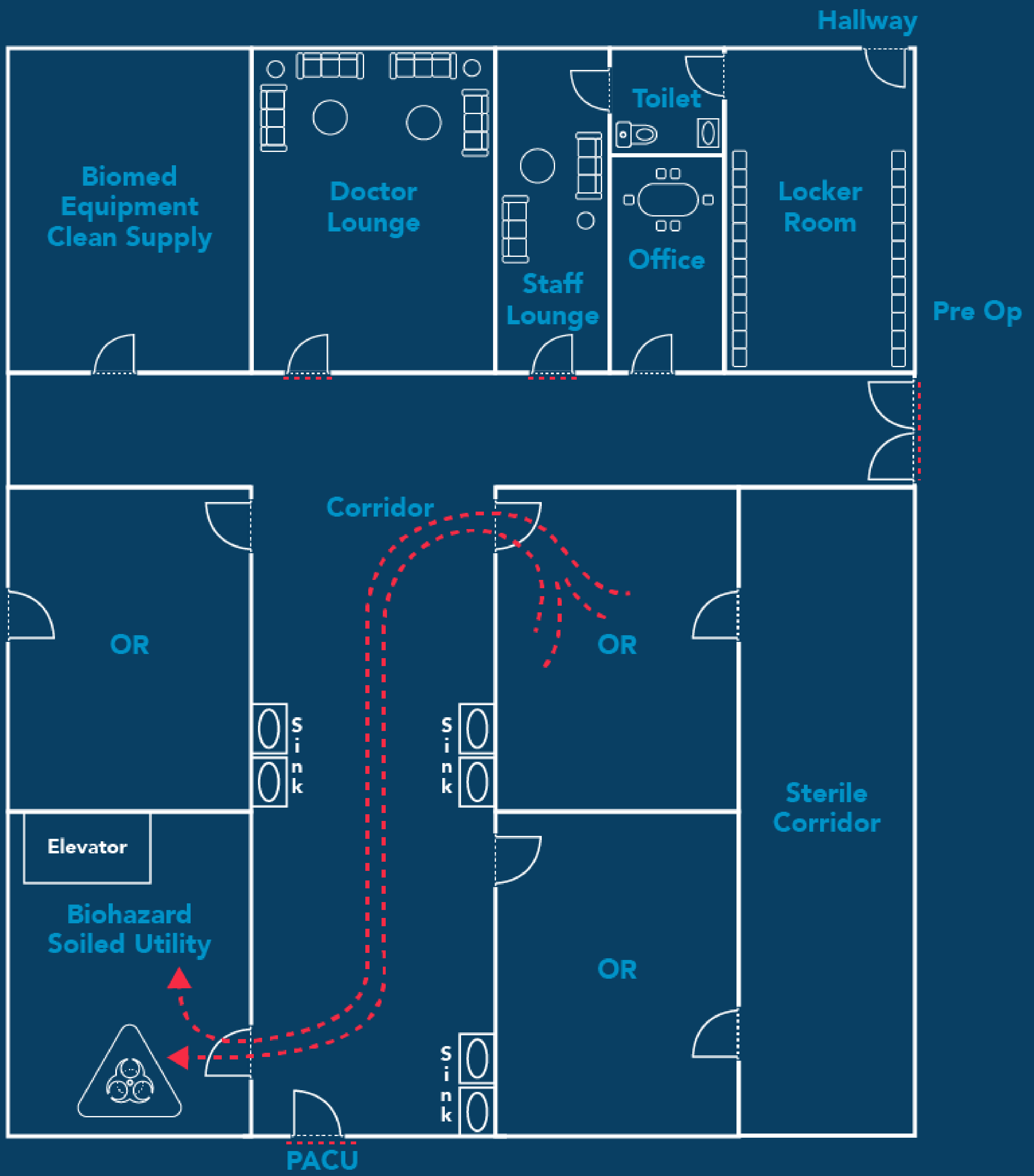
SAS 180 Sampler

Rodac Plates

Blood Agar Plates

Air Flow

The basis of design is not always operational reality

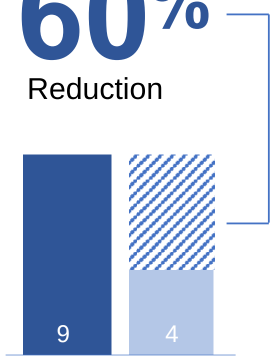


Infection Reduction Results, KY

Hospital ICU in KY, 12-month study

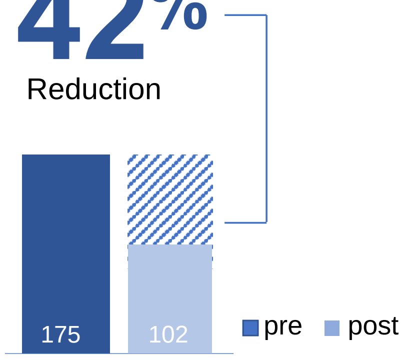
Infection Rate – All Infections

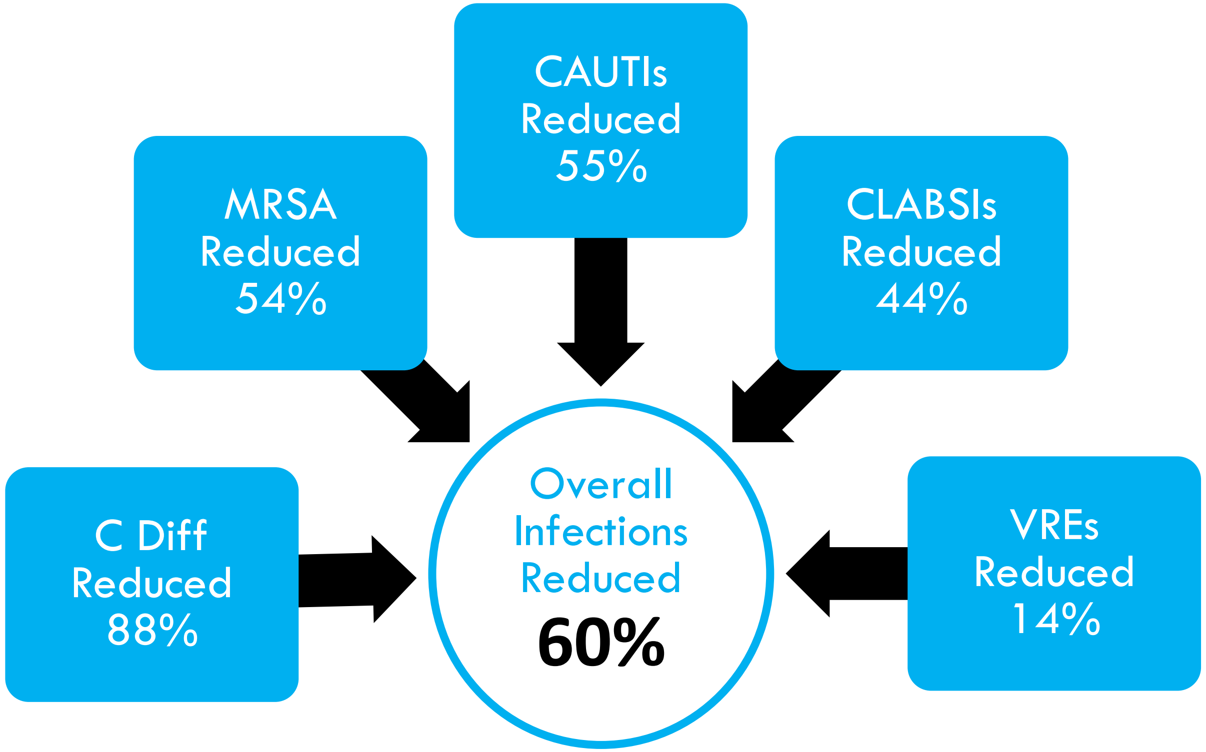
60% Reduction



Bacteria Air Sampling – Patient Rooms

42% Reduction





Staff reported that allergy symptoms and odors were minimized, and absenteeism was lowest where UV-C systems were installed

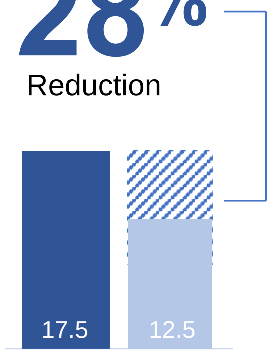
Tina Ethington, MSN, RN, CEN, NE-Bca et. al. Cleaning the Air with UV-C Lessened Contact Infections in an LTAC, AJIC, American Journal of Infection Control, reference number YMIC4661

Infection Reduction Results, TN

18 patient vent unit in TN, six-month study

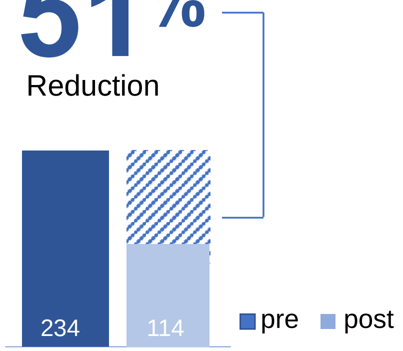
Infection Rate –
All Infections

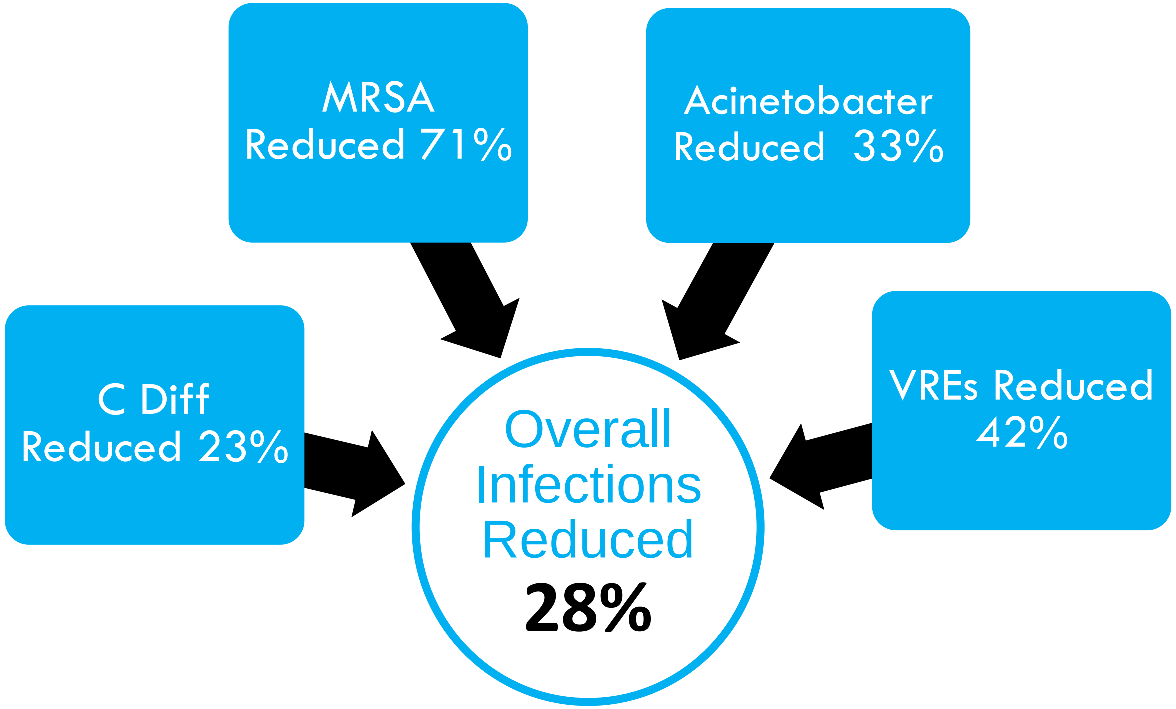
28%
Reduction



Bacteria Air Sampling –
Patient Rooms

51%
Reduction

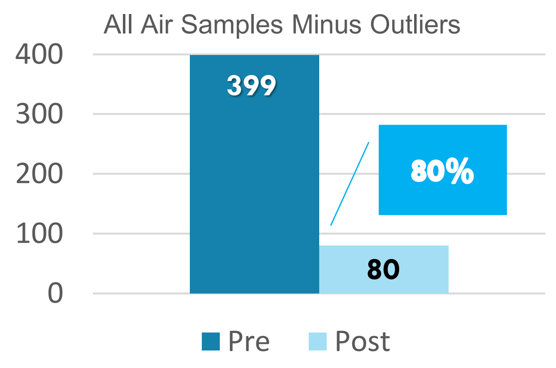


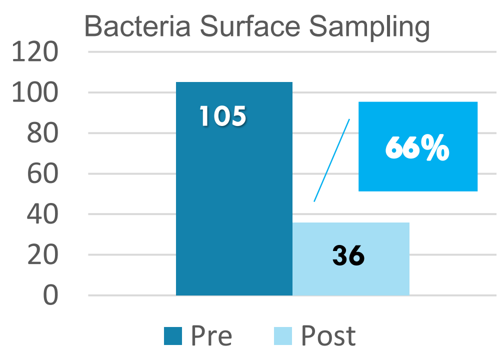


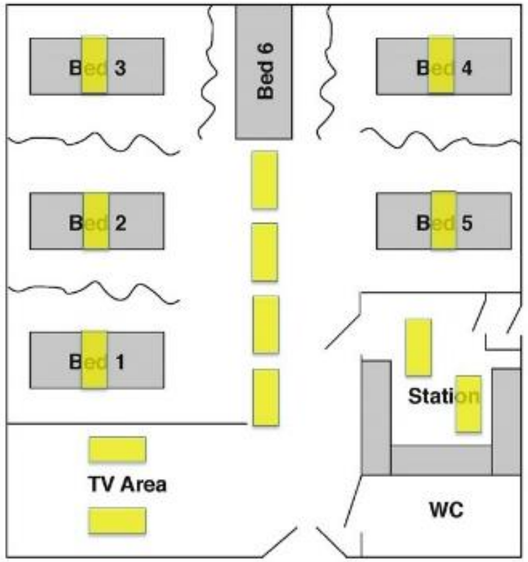
Nurses and staff report odors were reduced and the air felt cleaner and fresher

Kane, Douglas, MD, UV-C Light and Infection Rate in a Long Term Care Ventilator Unit, Canadian Journal of Infection Control, in press

Acute Care Hospital, ED-Psychiatric Holding, Las Vegas







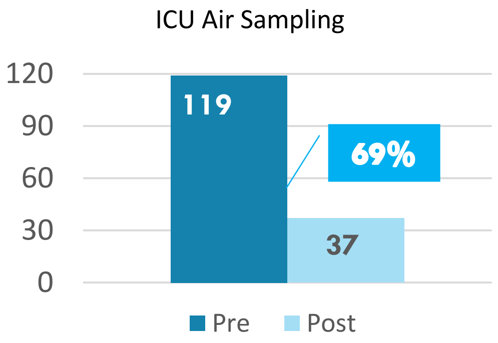
All units of measure are in colony forming units (cfu).

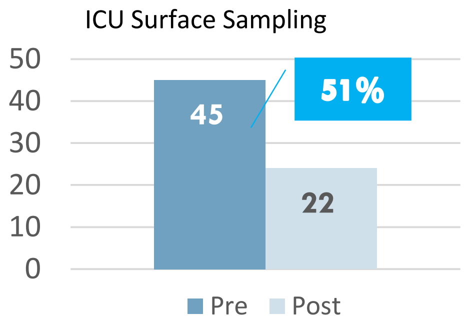
Reported short term study microbe reduction results may not be solely due to product and may not be representative of whole room product microbe reductions.

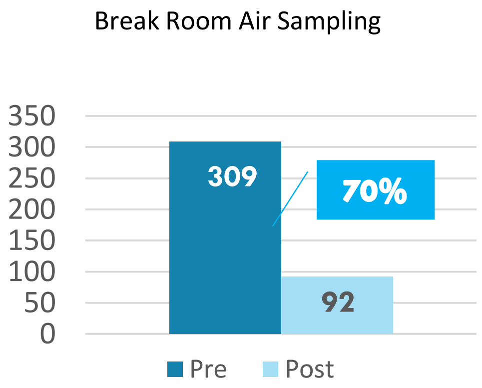
Surface and air: What impact does UV-C at the room level have on airborne and surface bacteria? CJIC, Summer 2017, Vol 32, Issue 2, p.108-111.

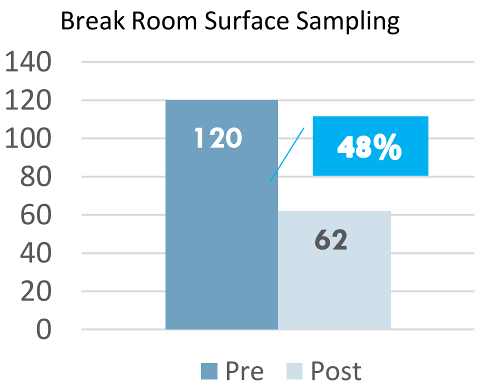
Acute Care Hospital, MA

ICU and OR break rooms



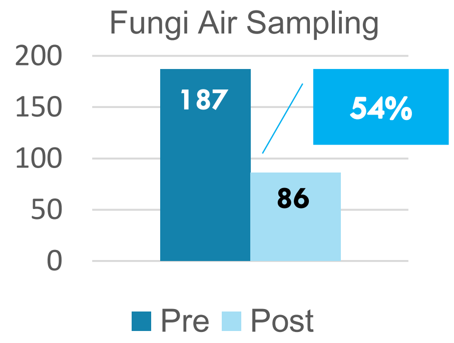


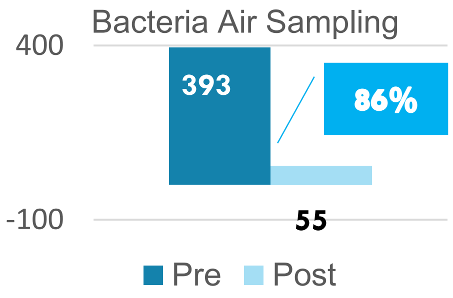




Surface and air: What impact does UV-C at the room level have on airborne and surface bacteria? CJIC, Summer 2017, Vol 32, Issue 2, p.108-111.

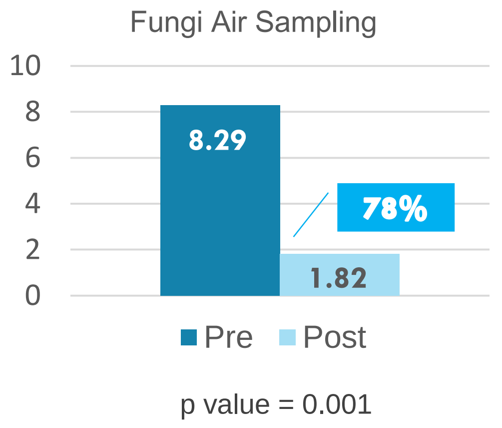
Children's Hospital Oncology Unit, Texas

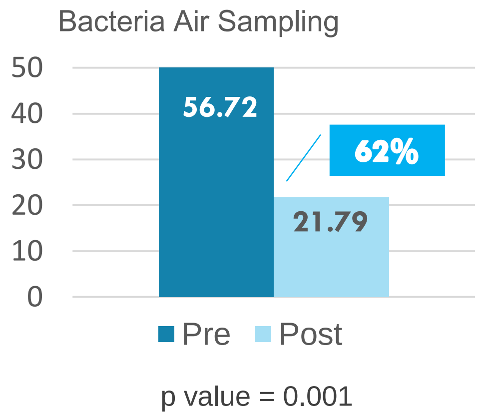




*Post-sampling period, no terminal cleaning took place.

Children's Hospital, Pharmacy, Memphis, TN





Compounding IV Room	Pre CFUs	Post CFUs	% Decrease
Fungi Air Sampling	3.25	0	100%
Bacteria Air Sampling	1.25	0.125	92%

Guimera, Don et al. Effectiveness of a shielded ultraviolet C air disinfection system in an inpatient pharmacy of a tertiary care children's hospital, American Journal of Infection Control, August 2017

AIR: PUBLISHED DATA

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

THANK YOU!

ANY QUESTIONS?

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