rzero

R-Zero Efficacy Compendium

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UV-C Proven to Reduce Exposure to Harmful Microorganisms

Germicidal ultraviolet-C (UV-C) refers to a region of the electromagnetic spectrum that can inactivate a wide range of microorganisms within line of sight by damaging their deoxyribonucleic acid (DNA) or ribonucleic acid (RNA). Germicidal UV-C (GUV) has been widely adopted in hospital environments because of robust evidence (table below) demonstrating its efficacy at reducing Healthcare Acquired Infections (HAIs).

UV-C is not only effective against HAIs, but is also proven effective against respiratory infections, including measles, one of the most contagious diseases, and tuberculosis, one of the world's deadliest infectious diseases. This is possible through engineering design and different applications, such as upper-room and Far UV-C.

R-Zero has engineered this validated their solution to be practical and affordable not just in healthcare, but also in education, office, hospitality, entertainment, and other settings as well.

Clinical trials evaluating the effectiveness of UV-C interventions on HAI reduction

STUDY	DESIGN	OUTCOME
Anderson et al. (Lancet)	Randomized controlled trial, CDC-funded	30% decrease in the clinical incidence of MRSA, VRE, C difficile
Levin et al. (Am J Infect Control)	Before-after	53% decrease in CDI incidence
Pegues et al. (Infect Control Hosp Epidemiol)	Before-after	25% decrease in CDI incidence
Sampathkumar et al. (Am J Infect Control)	Before-after	47% reduction in CDI and 52% reduction in VRE rates
Nagaraja et al. (Am J Infect Control)	Before-after	22% reduction in CDI incidence
Miller et al. (Am J Infect Control)	Before-after	57% decrease in CDI transmission
Haas et al. (Am J Infect Control)	Before-after	22% decrease in multidrug-resistant organisms plus CDI rates
Ethington et al. (Am J Infect Control)	Before-after	57% decrease in HAI rates

Efficacy Validation: Laboratory Testing

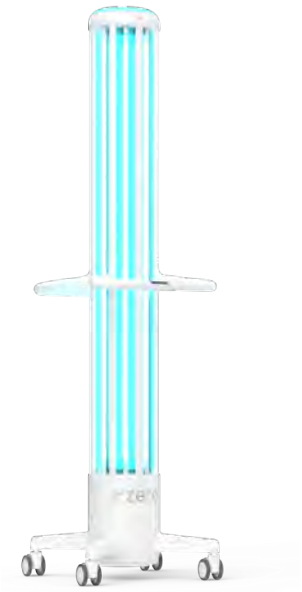
Rigorous laboratory efficacy studies are critical to ensure that technologies achieve what they were designed to do, and that their claimed benefits are sound. Efficacy research cited on the following pages was conducted at independent, certified laboratories following internationally accepted protocols and practices.

LABORATORY TESTING

UV-C devices are tested in controlled conditions at EPA and FDA compliant laboratories to ensure that uncontrollable environmental variables (e.g., cross-contamination between UV-C treated and non-treated areas, equipment calibration, timing of sampling, disinfection protocols, etc.) do not lead to flawed results.

Surface disinfection tests typically follow ASTM E3135 - Standard Practice for Determining Antimicrobial Efficacy of Ultraviolet Germicidal Irradiation Against Microorganisms on Carriers with Simulated Soil.

For airborne microorganisms, UV-C manufacturers are expected to provide a description of the aerosol generator, the aerosol generation process, description of medium used for generation, description of aerosol sampler including air volume sampled, volume of the chamber, particle size, aerosol dispersion of test material, sterility of the chamber, the procedure for introducing microorganisms into the air of the chamber, sampling and recovery procedures employed, the environmental conditions in the room or chamber, the irradiance of the UV-C device, and contact time needed to demonstrate effectiveness.



R-Zero Arc

Arc Surface Testing

All tests conducted at a distance of 8 feet and exposure time of 7 minutes

MICROORGANISM	MICROORGANISM TYPE	% REDUCTION (vs. CONTROL)	LOG REDUCTION (vs. CONTROL)	LABORATORY
Escherichia coli	Bacterium	99.99	4	Bioscience Laboratories
Methicillin Resistant *Staphylococcus aureus* (MRSA)	Bacterium	99.99	4	Bioscience Laboratories
Staphlococcus aureus	Bacterium	99.9999	6	Microchem
Pseudomonas aeruginosa	Bacterium	99.99	4	Microchem
Clostridioides difficile spores	Bacterium	99.99	3	Microchem
Influenza A (H1N1), strain A/PR/8/34	Virus	99.9996	5	Microchem
Monkeypox surrogate	Virus	99.996	5	Microchem
Human Coronavirus, strain 229E	Virus	99.9	3	Bioscience Laboratories
Feline Calicivirus	Virus	99.99	4	Bioscience Laboratories
Candida auris	Fungi	99.9	3	Microchem

R-Zero Beam

Beam Aerosol Testing

All tests conducted in chambers with a displacement volume range of 580 - 1,280 ft³, and exposure time of 30 minutes.

MICROORGANISM	MICROORGANISM TYPE	VOLUME (FT^3)	% REDUCTION (vs. CONTROL)	LOG REDUCTION (vs. CONTROL)	LABORATORY
Staphylococcus epidermidis	Bacterium	580	99.999	5	ARE Labs
Klebsiella aerogenes	Bacterium	580	99.99	4	ARE Labs
T1	Virus	580	99.999	5	ARE Labs
SARS-CoV-2	Virus	1,280	99.994	4	Innovative Bioanalysis

R-Zero Vive

Vive Aerosol Testing

All aerosol tests conducted in a 580 ft³ chamber.

Vive Surface Testing

All surface tests conducted at a distance of 3.28 ft (1 meter).

MICROORGANISM	EXPOSURE TIME (MIN)	MICROORGANISM TYPE	% REDUCTION (vs. CONTROL)	LOG REDUCTION (vs. CONTROL)	LABORATORY
Aerosol					
Staphylococcus epidermidis	90	Bacterium	99.9	3	ARE Labs
Klebsiella aerogenes	90	Bacterium	99.99	4	ARE Labs
T1	120	Virus	99.99	4	ARE Labs
Aspergillus brasiliensis (black mold spores)	120	Fungi	99	2	ARE Labs
Surface					
Human Coronavirus, strain 229E	30	Virus	99.78	2	Microchem

Efficacy Validation: In-situ Testing

Once a product has been validated in a laboratory setting, it is critical to demonstrate efficacy in real-world environments. Properly designed in-situ studies are the gold standard in evaluating the significance of UV-C disinfection in shared indoor spaces, where efficacy is measured not only against microorganisms, but also confounding environmental variables.

IN-SITU TESTING

In-situ research is typically conducted at facilities that may benefit from the technology. Examples include schools and senior care homes. The technology is installed in a manner that mimics the intended use and allows researchers to collect intervention and control data using a large sample size so that the effect of UV-C disinfection on pathogen reduction is isolated and measurable. There are several research designs possible depending on the study goals, and the results are analyzed for statistical significance. In-situ studies are often disseminated in scientific conferences and publications/peer-reviewed manuscripts.

DID YOU KNOW?

UV-C inactivates microorganisms via DNA photodamage. This means that structural complexity matters more than new DNA variations. As a rule of thumb, bacterial spores (e.g. *C. difficile* spores are harder to inactivate than vegetative bacteria (e.g. *E. coli*), which in turn are harder to inactivate than enveloped viruses (e.g. SARS-CoV-2 and influenza). In fact most enveloped viruses would require only a fraction of the UV-C dose required to inactivate spores. Viral variants are just as susceptible to UV-C as their wild-type counterparts.

Arc reduces C. diff in a Patient Room

RESEARCHER

ResInnova Labs - ResInnova's mission is to reduce the transmission of infections of all kinds in multiple and varied environments. ResInnova Laboratories tests products that reduce pathogens on surfaces.

DESCRIPTION

Clostridioides difficile infections (CDI) pose a significant threat to patient safety in healthcare facilities. In this study, we investigated the effectiveness of an ultraviolet-C (UV-C) disinfection system in reducing *C. difficile* surface contamination in a simulated patient room. There were 39 tested carriers, including controls spread across the simulated patient room and bathroom.

RESULTS

The results showed an overall 98.17% reduction in *C. difficile* spores after UV-C treatment of directly exposed and shadowed areas, an efficiency that translated to a 4.91% reduction per minute of room vacancy. This study demonstrates that UV-C disinfection is an effective method for reducing *C. difficile* spores in healthcare settings.

Read the Study Report

Top 5 US School District

RESEARCHERS

Dr. Edward Nardell | Harvard Medical School

Dr. Edwin Oh | Univ. of Nevada, Las Vegas

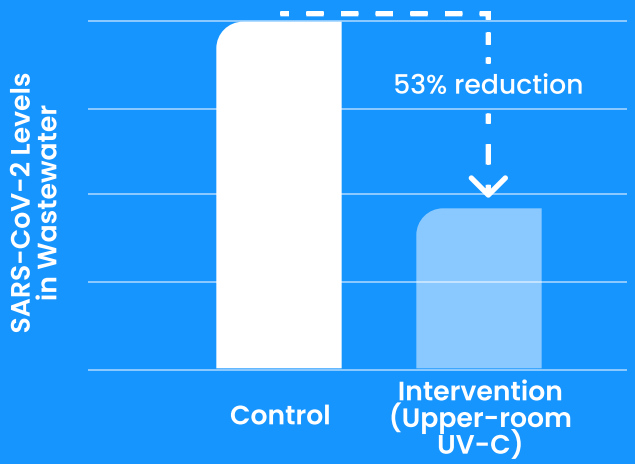
Dr. Carolina Koutras | R-Zero

DESCRIPTION

Seven schools with more than 4,500 students and staff were chosen to participate in the randomized experiment. In each intervention school, R-Zero Beams were installed in classrooms, cafeterias, and other large shared spaces. Beams were continuously active during school hours during Spring Semester 2022 (January - May), which coincided with the Omicron wave in Clark County.

RESULTS

Schools with R-Zero Beams had **53% fewer positive SARS-CoV-2 wastewater samples** than non-treated schools. Devices were safely deployed with **0 incidents or complaints reported**. The reduced detection in test schools suggests that the likelihood of contracting COVID is lower in schools with Beams.



Read the Study Report

Upper-room GUV & Far UV-C reduce *B. subtilis* spores in large, American academic hospital

DESCRIPTION

In this study, we sought to validate the two GUV disinfection systems (R-Zero Beam and Vive) using novel bioindicators to demonstrate efficacy. GUV devices were installed in waiting rooms, bathrooms, and a cafeteria. Real-time occupancy data and COVID-19 transmission risk modeling were also used to characterize and evaluate the tested environment.

RESULTS

The results suggest that bioindicators are a fast and reliable tool for GUV monitoring in outpatient facilities where patient and staff safety is critical.

The results show Beam and Vive achieved 95-99% reduction in hard-to-inactivate spores.

Manuscript currently being prepared for publication.

Reducing Microbial Contamination in a Corporate Environment

DESCRIPTION

R-Zero's UV-C disinfection ecosystem enables terminal and continuous disinfection of air and surfaces. This suite of solutions can lead to a dramatic reduction in microbial counts while enabling safer indoor environments where employees can thrive and enjoy peace of mind.

RESULTS

The data collected demonstrated that R-Zero devices exceeded performance expectations and were highly effective in decreasing microbial load at the office site. The devices tested met safety guidelines (TLV limits) while exceeding the UV dose required to inactivate microorganisms, resulting in a 177% increase in eACH and an overall risk reduction of 54%.

Arc

	Before	After	Change
Microwave Handle	95	0	-100%
Refridgerator Handle	18	0	-100%

Beam and Vive

	Before	After	Change
Equivalent ACH (eACH)	3	8.3	177%
Risk*	37%	17%	-54%

*Defined as the probability of one occupant, infected with the Covid-19 Omicron variant, exposing at least one other occupant in the space

Read the Study Report

Reducing Microbial Contamination at Memphis-Shelby County Schools

DESCRIPTION

R-Zero's mobile UV-C tower, Arc, offers a non-chemical option for effective disinfection. To measure the efficacy and efficiency of Arc, testing took place in a large school district in Tennessee. The elementary school principal selected the classroom location for testing. Surfaces tested include two tabletops and a doorknob at distances of 3, 7, and 15 feet.

RESULTS

Arc effectively disinfected school spaces by an average of 99% and enabled time-saving efficiencies for incident management and disinfection in school environments.

Read the Study Report

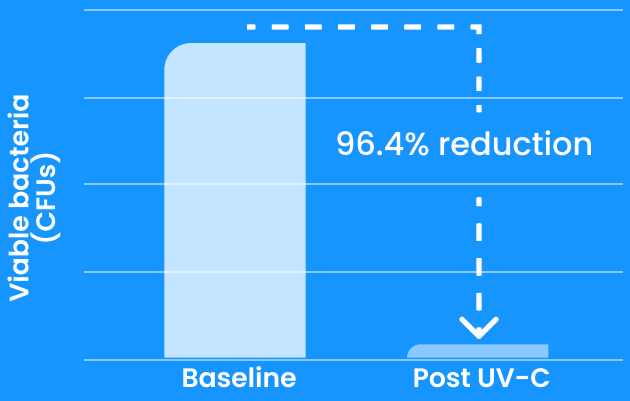
Reducing Microbial Contamination in a Texas School District

DESCRIPTION

In September 2021, Terracon Consultants, Inc., an independent industrial hygiene company, was hired by a large school district in Texas to conduct microbial sampling at a high school in order to test the effectiveness of R-Zero's flagship UV-C disinfection device, Arc. Five locations were tested, including: three locker rooms, the nursing station, and the cafeteria. Arc was used at distances ranging between 6 and 10 ft.

RESULTS

On average, Arc reduced the concentration of microbial bacteria by 96.4% across the five test locations at the Texas high school.



Read the Study Report

Safety

UV-C inactivates microorganisms through DNA/RNA photodamage. UV-C overexposure has the potential can cause skin and eye irritation. R-Zero UV-C devices (regardless of their emitted wavelength or application) adhere to threshold Limit Values (TLVs) published by the American Conference of Governmental Industrial Hygienists (ACGIH). This means that all R-Zero devices are commissioned to comply with ACGIH and OSHA guidelines for safe levels of UV-C exposure.

R-Zero's Far UV-C fixture, Vive, uses a short pass safety filter emitting UV-C light only at 222 nm. All R-Zero UV-C devices are equipped with motion sensors for added safety to eliminate the risk of accidental exposure. In addition to TLV compliance, R-Zero's UV-C devices have been tested for safe ozone emission levels, luminaire, bulb, and electrical safety, and electromagnetic interference levels (UL 1598, UL 8750, UL61010, FCC Part 15B/C).

	 **Arc** Mobile Tower	 **Beam** Upper-room	 **Vive** Far UV-C
Third Party Safety and Electronic Standards	UL 867 UL 61010 FCC Part 15B	UL 1598 UL 8750 FCC Part 15C	UL 867 UL 1598 UL 8750 FCC Part 15C
EPA Establishment Number (refers to manufacturer of devices)	100936-CA-1	100936-CA-1	99950-AR-1

Regulatory Compliance

In the United States, UV-C lights that are sold or distributed with claims that the product can be used for preventing, destroying, repelling or mitigating any pest (plant, animal, virus, bacteria or other microorganism) are federally regulated by the US Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as a device, in particular FIFRA Sections 2(q) and Section 7. These federal regulations require devices to:

> Be produced in an EPA-registered pesticide producing establishment and and adhere to production reporting requirements, per 40 C.F.R Part 167

> Adhere to label requirements per 40 C.F.R Part 156. Generally, device labels must include warning and caution statements, directions for use and the EPA establishment number, amongst other label requirements

All claims in connection with the sale or distribution of a device must be true and not misleading and supported with efficacy data as described above.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