Safe Air

Preventing the Spread of Viruses

Using UV-C Light

Introduction

Airborne viruses are nothing new in our environment. The rhinovirus (cause of the common cold) and influenza (seasonal flu) were previously the most well-known and commonly contracted of these viruses, until the novel coronavirus, SARS-CoV-2, entered the scene in late 2019, kicking off a global pandemic that is still presenting global health challenges over a year later. When the novel coronavirus first began spreading, the world watched as it lit across the globe like wildfire and the scientific community scrambled to understand its transmission vector. It has since reached scientific consensus that the virus is airborne and spreads readily via respiratory droplets. These droplets are first exhaled from the infected person through normal breathing, coughing, or even just talking. Respiratory droplets can be microscopic and hang in the air for a long time before settling on physical surfaces. The infection then spreads when those airborne droplets are inhaled or an infected surface is touched and the virus is carried into the body through contact with the membranes of the eyes, nose, or mouth.

Once infected, the SARS-CoV-2 coronavirus causes the COVID-19 illness, which can range from asymptomatic to deadly. The challenge with the most mild and asymptomatic cases is that the infected individuals often do not even know they are carrying and spreading the virus. Normal activity brings the average 20-60 year old in contact with more than 20 other people per day, meaning transmission can reach exponential levels quickly, as we have seen in the current pandemic. This does not account for individuals with higher contact rates through the workplace or event attendance, which present even greater avenues for spread.

For those that are symptomatic, the impact can (and often is) severe. As of spring of 2021, COVID-19 has claimed the lives of more than 3 million people globally. This sits in contrast to the 2019 death toll from influenza, which claimed 34,200 lives. At the most severe, COVID-19 can cause extreme respiratory distress, reduced blood oxygen saturation, and an extreme immune response called a cytokine storm. Affected individuals require intensive medical attention, which puts extreme strains on hospitals worldwide as demand for specialized equipment and care began to far outstrip the need. Meanwhile, the essential workers who are caring for and treating the sick are placed at severe risks for contracting the virus.

Impacts and challenges of airborne coronavirus transmission

While originally thought to spread through larger respiratory droplets (produced when we cough or sneeze) which fall quickly to the floor (or other surfaces), further research has determined that the virus can spread through the much smaller droplets that we inevitably produce when talking, laughing, or singing. These smaller droplets can hang in the air, easily being moved around enclosed spaces on air drafts or from air recirculation systems. With the ability to remain airborne and ride indoor air currents, this presents a challenge far beyond just close contact. All individuals in an enclosed space are at risk should any single individual present be a carrier of the virus, and the risk can remain even after they have left the room.

And it isn't just small spaces that pose a threat for transmission. With normal levels of indoor air movement, droplets can traverse distances greater than 30 feet, posing challenges for larger interior spaces, especially those with closed recirculatory ventilation systems. Openly ventilated spaces can replace the air within the space at a rate that can greatly reduce the risks, but recirculating air systems will move the particles around the room, bringing everyone into potential contact. A perfect example of such an environment is the pressurized cabin of an airplane. Increase the density of people in the space and the risk of infection continues to increase exponentially. Knowing this, the virus and its mechanism and potential for spread poses significant risks and challenges for a variety of enclosed environments.

To truly understand the environments with extraordinary risk, we must also understand who the most vulnerable are when it comes to infection and it's adverse impacts. There are a number of comorbidities that can increase the chance of extreme illness or death when sickened with COVID-19, including pre-existing respiratory illness, heart disease, and disorders that compromise the immune system. COVID-19 can be deadly to persons of all ages, but poses an increased risk to the elderly, who often have decreased lung and/or heart function. And children, while infected in lower numbers, will be at increased risk as early stage vaccines are not approved for persons under the age of 16.

When we combine these factors together - environments that pose stronger physical risks and an increased density of the significantly vulnerable - we find ourselves faced with a particularly dicey challenge. Examples of these environments include churches and schools, communal homes for the elderly (nursing homes and assisted living facilities), and medical and dental facilities. In the case of churches and schools, air recirculation is a primary area of concern, as these buildings frequently have few or no windows that open and large HVAC systems that may lack the necessary capacity to prevent the spread of airborne disease. Long-term care or assisted living facilities caring for the elderly, are already suffering conditions that put staff and residents at far greater risk of death from diseases like influenza or COVID-19. An additional complication lies in the fact that these are places where people live, not simply congregate on occasion, meaning that should an outbreak occur, containment can pose even larger challenges. Similarly affected are medical facilities such as hospitals and clinics, where patients are already compromised and at greater risk, and staff must work in close contact. Even outpatient facilities have their challenges - with dental care, staff must work closely with patients who must be unmasked and open-mouthed and come directly into contact with saliva and respiratory droplets.

Vulnerable Populations

Schools

Everyone involved in our schools are at risk of contracting or spreading viruses, teachers, students and staff. Surfaces are touched and retouched by hundreds or thousands of students per day, and sanitization between uses is difficult to achieve. And younger children may struggle with good hand washing hygiene and social distancing.

Medical & Dental Facilities

Medical and dental facilities face the challenge of staff needing to work closely with patients who may be ill. Patients coming into the facility may already be compromised due to injury and illness and may be more susceptible to infection. These facilities struggle to provide and promote a safe environment for all.

Elder Care Facilities

The eldery are one of our most at-risk populations, due to weakened immune systems and organ function, as well as often having multiple comorbidities. Live-in facilities also forced quarantining a sick patient from the rest of the population, which poses other unique challenges. And the staff in these facilities face the same increased risk as those working in hospitals.

Confronting air quality challenges to combat the spread

So what can organizations do? In order to operate safely and lower the risk of transmission, air quality challenges must be addressed. Now that we understand the transmission vectors of the coronavirus (as well as other airborne diseases) through the air we breathe, we can begin to seek out solutions for how to quickly eradicate viruses in the air.

Light-Based Disinfection

Science Overview: The Light Spectrum

The light spectrum is a subset of the electromagnetic spectrum, consisting of both non-visible and visible light ranges. Non-visible light includes infrared (like that used in remote controls for your television) and ultraviolet light (such as that emitted by the sun, which causes the skin to tan and/or burn), while visible light is the range perceptible to the human eye. What differentiates each type of radiation and/or light along the spectrum is the length of the electromagnetic wavelength. At the long, low-frequency end of the spectrum are radio waves. As we move up in frequency and shorten the wavelengths, we reach the infrared, visible light, then ultraviolet spectrums and beyond. As we get to higher frequencies, the electromagnetic radiation increases its potential to be harmful to living organisms. For example, the UV-light from the sun can be quite harmful to our skin with sufficient exposure.

UV-C Light

The ultraviolet spectrum is broken into three subtypes, designated UV-A, UV-B, and UV-C, with each band having different properties and effects. The UV-C band, ranging from 100-290nm, which is the most harmful to humans, however is almost completely filtered out by the earth's atmosphere. It has the ability to damage many types of cells and tissues, including those of microorganisms, by destroying nucleic acids and proteins, and/or disrupting DNA,RNA, and cellular function.

This particular property of UV-C light gives it the ability to be a powerful disinfectant, used for destroying harmful bacteria, viruses, molds, and other pathogens in food, air, and water. The use of germicidal lamps has been known for decades to be an effective way to sterilize air when implemented as part of air flow management, as well as non-porous surfaces in buildings. The FDA confirms that UV-C light can effectively destroy the outer proteins of the novel coronavirus, helping prevent transmission when used to treat air or surfaces.

The UV Spectrum

UV-A:

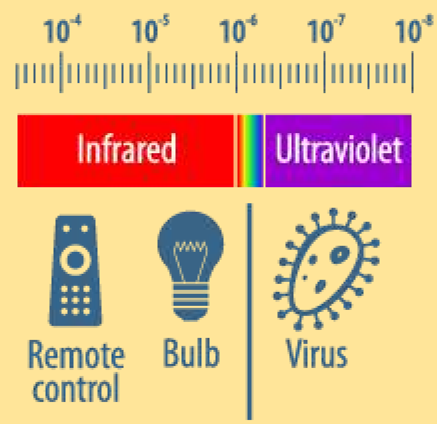
Occurs between 315-400nm and is the longest wavelength in the UV band. Commonly known as “blacklight” which causes fluorescence in certain objects and colors
This band has the fewest harmful effects on mammalian tissues and cells

UV-B

Occurs between 280-315nm and sits in the middle of the UV range
This is the light responsible for sunburns and skin damage
The Ozone layer blocks significant amounts of this wavelength from reaching Earth, but enough reaches the surface to pose significant risks for skin cancer.

UV-C

Occurs between 100-280nm and is the UV range that disinfects air and surfaces by disrupting RNA and DNA in virus molecules. 265nm is the peak of this germicidal range of UV-C light.



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UV-C and RNA Deactivation

What is RNA?

RNA (and DNA) is what cells read to build proteins. Proteins are what cells and tissues are made of. RNA is therefore like a blueprint that must be read in order for cells to divide and continue to replicate.

UV-C Effects on RNA

When bombarded with UV-C radiation, the chemical bonds that create the strand of RNA become disrupted, which causes errors in the RNA's blueprint. These errors quickly accumulate and render the RNA unreadable, unable to produce a functional protein. The RNA is considered "deactivated" and cellular replication is disabled.

When a bacteria or virus cannot replicate, it cannot spread.

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Air Changes Are Key

With any airborne pathogen, the length of time it can hang in the air significantly impacts its ability to spread throughout an indoor space. Air movement can affect this in both positive and negative ways, depending on where and how the air is moving. Open windows can create positive movement of air that brings fresh, uncontaminated air in while sweeping infected air around the room and then out. HVAC systems can be very effective at moving air about a space, but placement of intake and output vents can determine whether this is favorable or not, as well as whether the system is pulling in outside air or recirculating existing indoor air. Recirculated air must be filtered or cleansed, else airborne contaminants such as viruses will simply be redistributed. The HVAC settings and sophistication will also play a role, as a system that is set with a temperature of 72 degrees, for example, may spend significant amounts of time not running (moving air), depending on prevailing conditions.

The complete replacement of air in a room or building is called "air change" and is an important factor in considering the effectiveness of HVAC or any other method to ventilate a space. This is calculated volumetrically over the course of an hour. For example, if a room contains 1000 cubic feet of air and your HVAC can move that same volume of air in the space of an hour, you have an ACH (air change per hour) of one. The higher the ACH you have, the faster you are clearing the air and replacing it in any given room. HVAC systems have struggled to provide appropriate filtration or treatment systems, needed to significantly reduce or eliminate airborne pathogens in the interior air supply.

A perfect example of how this affects viral transmission is air change in an elevator - if one infected person enters the elevator, even if they exit, if the air has not been exchanged before the next rider enters, respiratory droplets may still be present in the air, waiting to be inhaled. If the elevator is equipped with a ventilation system that can replace the volume of air in the elevator at a sufficient rate, by the time the next rider enters, that contaminated air has already been removed and replaced - thus the need for continuous air treatment as every situation changes when people enter and exit any indoor space.

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Human Air Exchange

By the Minute

Humans breathe 12-15 times per minute. This translates to more than 17,000 breaths per day!

By the Gallon

The average adult breathes just over 1.5 gallons of air per minute. A 20X20 room contains 425 gallons of air. 10 people in this room for 30 mins will potentially breathe all of the air in this room.

Our Breathe and Indoor Air Exchange

Understanding how much we breathe can help us understand the need for proper room air changes - an empty room is very different from a room filled with each person exchanging more than a gallon of air per minute.

Air Treatment at the "Point of Infection"

The most vulnerable air space in a room is the air directly around a person's head, the air they breathe. This is the air that must be vacated and treated immediately to remove pathogens.

Practical Spacial Applications

As we identified previously, UV-C is extremely effective at destroying pathogens, including the novel coronavirus. To work effectively, pathogens must move into the “line of sight” of the UV-C rays, which can pose a challenge for treating complex spaces. There are multiple practical applications and approaches that can be implemented that can combine effective treatment with safe air change principles.

Simply recirculating the same air will contribute to viral spread as opposed to inhibiting it. It is important to consider where air is flowing to and from within an enclosed space. Outside can be considered “clean” in certain contexts, however continually heating or cooling outside air can be extremely energy inefficient. Systems designed to reduce this energy consumption alternatively can be quite expensive. Recirculation can be the most efficient way to move air, however it must be paired with strong air treatment systems in order to effectively and quickly replace contaminated air.

To determine the best way to treat air for viruses, it is important to understand the differences between different filtration and treatment types and their practical applications. Standard HVAC filters are designed to help clean larger particulates from the air, such as pollen, dust, and animal dander. HEPA filters are capable of filtering out far smaller particles, including some viruses, but can still allow the smallest particles to pass through and be pushed back into the room. Air filtration systems that rely on static electricity to remove particles and viruses from the air can struggle with SAR-CoV-2 due to its specific tiny particle size - too small to be trapped by the static charge and too small to be captured by fibers of even the best filtration media.

UV light treatment stands apart from filtration systems in that it can effectively inactivate and kill viruses of any size vs. capturing only the larger particles. As the virus must be directly exposed to UV-C light for a sufficient time to be rendered inactive, placement of UV-C fixtures at strategic locations nearest to the "point of infection" (example, above a table at a restaurant), coupled with effective HVAC-assisted air circulation can greatly lower indoor spread.

The struggle for many businesses and organizations is both in determining and implementing an effective solution and navigating the costs. Small businesses have less space to treat but may struggle with the costs of implementation. Schools may have the funds (though many school districts are already strapped financially) but are faced with complicated buildings and potentially aging air handling systems. A complete replacement of a building's HVAC system may not be plausible, but the addition of effective tools, such as UV-C, can retrofit an ineffective system into a highly effective one. Treating the problem in the air at a systemic (to the building) level also removes the individual element from the equation of combating the spread of the SAR-CoV-2 virus.

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UV-C Safety and Effectiveness

The two common types of UV-C lamps are Mercury Vapor and LED. The two technologies have some notable differences that can impact both safety and effectiveness. Mercury vapor is much older technology, dating back to the 1930's, and some distinct disadvantages. Mercury lamps take time to "warm up" to come to full intensity, are larger and require more power to operate, and of course use chemicals that can produce toxic by-products as well as are difficult to dispose of or recycle. Conversely, LED (light-emitting diode) lamps are much safer to operate, requiring no mercury or other toxic chemical gasses to function, can reach full-intensity immediately, are compact in size, and require significantly less power to operate.

Being larger and bulkier, mercury-based lamps are often housed in large fixtures that are difficult to move around and pair poorly with other applications. LEDs, being much smaller and therefore more flexible, allow these lights to be incorporated easily into a number of different style bulbs or lamps, and easily combine with other systems (like air handlers) to create a comprehensive treatment solution. LED lamps have been researched extensively and shown to be equally, if not more, effective than its older and more dangerous counterparts.

Air Purifier Device Comparison

	UV Health Group Assurance™ SafeAirUV	HEPA Filter with UV-C Air Sanitizers	Far UVC Light Systems	Upper Air UVC Fixtures	UVC Robots
Product Focus					
Surface Cleaning			✔		✔
Air cleansing	✔	✔	✔	✔	✔
Testing & Efficacy					
Tested with aerosolized COVID-19 virus	✔				
Efficacy Claim	99.9996%	99.99%	99%	99.4%	99.9%
Scientific Lab reports available	✔				
Virus particle size limitation	None	.3 microns	None	None	None
Inactivate or captures viruses	Inactivates	Captures	Inactivates	Inactivates	Inactivates
Impact on Humans					
Works in occupied rooms	✔	✔	✔	✔	
Potential for UV-C light exposure	None	None	✔	✔	✔
Safe for humans when operating	Yes	Yes	Undetermined	Questionable	NO
UV-C Technology					
UV-C wavelength	275nm	254-273nm	222nm	254nm	254nm
UV-C Light Source - LEDs	✔				
UV-C Light Source - Bulbs		✔	✔	✔	✔
Life expectancy of UV-C light before replacement	10 years	6 months	9 months	1 year	9 months
Environmental Impact	None	Contaminated HEPA filters & Mercury-vapor bulbs	Mercury-vapor /Krypton/ Chlorine bulbs	Mercury-vapor bulbs	Mercury-vapor bulbs
Operations					
Air Circulation - Fan speed(s)	20-60 CFM	600-1500 CFM	No fans	No fans	No fans
Operating noise (db)	28-48db	60+ db	N/A	N/A	N/A
Time to clear a room of all viruses (20X20 sf)	20-30 mins	Only partial	30-60 mins	Only partial	30-60 mins (per session)
Smart Phone App Controls	✔	✔			✔
FDA Approved	Pending	No	No	No	No
Cost of ownership	$	$$	$$	$$	$$$

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Common questions and myths

What does "clean air" really mean?

The term "clean air" can mean a multitude of different things depending on the context. The EPA has a specific definition of clean air in regards to air pollution, for example, from factory and tailpipe emissions, wildfires, etc. But that does not translate to indoor air quality, which we have limited mechanisms to measure and quantify as to what that means. When it comes to tiny particles, such as airborne pathogens, there is no real-time way to test for or sense them, and such, no direct way to indicate what the air quality is within an indoor environment. From a regulatory standpoint, OSHA mandates a number of safety mechanisms for both workers and customers, however this type of indoor air quality is not among them.

Most businesses are required to follow specific guidelines to help slow and prevent the spread of COVID-19, however without an appropriate method in place to clean the air, simply reducing the number of individuals in a room is insufficient if the air is stagnant or simply recirculating contaminated air around the space. And while outdoor air may be considered "fresh" or "clean", again, how this air moves into and out of the space will have an impact on the infection vectors it creates.

Can't I just buy an air purifier from Amazon?

Alongside ineffective air filtration and/or management strategies lies a host of low-cost, ineffective consumer devices, easily found on sites like Amazon.com. UV-C is proven to be effective in killing viruses like SARS-CoV-2, however effective dosage must be achieved through appropriate exposure, power intensity and time, especially if trying to treat all the air in a room. Consumer devices are rarely designed to effectively treat the air, and UV wands and boxes emit extremely low level dosages that are often ineffective due to insufficient exposure times. And these devices provide no feedback on when enough dosage has been achieved. Sadly, the hype around these devices and their overall ineffectiveness has led to some public misunderstandings regarding the use of UV-C light for viral disinfection applications.

Isn't UV-C light dangerous?

The UV-C band of ultraviolet light contains dangerous radiation wavelengths that can pose significant risks to human health. Devices that operate in these ranges can be dangerous when improperly applied or used. Products should be scrutinized for any potential exposure to UV-C light to ensure its safe application.

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The benefits of proper air filtration or cleansing

Filtration and cleansing of indoor air is an effective method for removing viruses and other contaminants, however not all air filters or air cleaners are designed to capture all types and sizes of virus particles. The type of air filter or cleansing technology in use will determine the size of captured particles, and the size and air speed (CFM) will determine the size of the space the unit is designed to work in. One cannot simply place an air purifying device designed for a small room or bedroom in a house in a large commercial space and declare the air “clean”, as this will give people a false sense of security. The notion that “something is better than nothing” can be completely inaccurate, should the device in play simply be moving air around the room but ineffectively able to clean it at volume.

With the ability of UV-C to inactivate particles over a hundred times smaller than most HEPA filters can catch (.003 versus .3 microns), all types of virus and their variants can be effectively destroyed.

UV-C technology has been proven to be capable of mitigating many air quality challenges where room size, air movement, the right UV-C wavelength, and proper placement all can be united to create an extremely safe and effective air cleansing solution, as a pillar of your air management strategy.

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Future needs for virus-killing technology

UV-C isn't a new technology, even as we implement it in new devices. Discovered over 100 years ago, UV-C as a disinfection strategy has a major advantage over surface disinfectant and antimicrobial agents. Resistance to sanitizing agents is a risk, similar to the observed resistance in bacteria due to overuse of antibiotics. Surface agents suffer from multiple avenues of misuse, from ineffective concentrations to improper application. The viruses that survive eventually develop resistance as we "breed out" the strains and variants that are susceptible to being easily killed by the disinfecting power of UV-C. This light, however, does not exist naturally at the earth's surface, as this wavelength is naturally filtered out of sunlight by the earth's atmosphere. Therefore there is no natural immunity being selected for, and viruses remain susceptible to inactivation by exposure to UV-C radiation.

Even as viruses change and mutate, UV-C will remain an effective method of inactivation. So UV-C allows us to be proactive, instead of reactive against all manner of common viruses and airborne pathogens. As UV-C becomes a common part of our indoor air management systems, we will be able to head off future outbreaks of new, novel viruses and prevent pandemic-level spreading. Continued development of UV-C technology has the potential to place you ahead of the curve for cleaner, safer indoor environments, no matter what comes next.

If you're interested in learning more about how UV-C light can help you keep your space safe, reach out to UVHG to learn more about our

CALL: 503-597-8504 OR **VISIT:** https://uvhealthgroup.com