The Truth About Germ-Killing Lights

Facts vs. Myths in a Growing Market

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Existing Antibiotics and Cleaning Solutions Are Not Sufficient

Globally, infection control is an $18 billion industry with projected growth of another $10 billion in the next 5 years.[1] This is in large part due to growing concerns over foodborne and other illnesses caused by bacteria and viruses, such as Norovirus, E. coli, and Salmonella that sicken over half a billion people each year worldwide.[2]

“Superbugs,” which are bacteria that have grown resistant to a majority of current antibiotics, have raised further alarm. Antimicrobial resistance is leading to approximately 700,000 deaths per year, and could increase to 10 million deaths per year worldwide by 2050 according to the World Health Organization.[3]

Cross-resistance where microbes resistant to certain antibiotics may then also experience increased resistance to certain biocidal agents has now emerged as an additional threat.[4] All of this culminates in the need for better disinfection solutions to help prevent the spread of illnesses.

Without effective interventions, antimicrobial resistance may result in:

10m deaths per year **by 2050** and an **economic loss** of **$100 trillion**

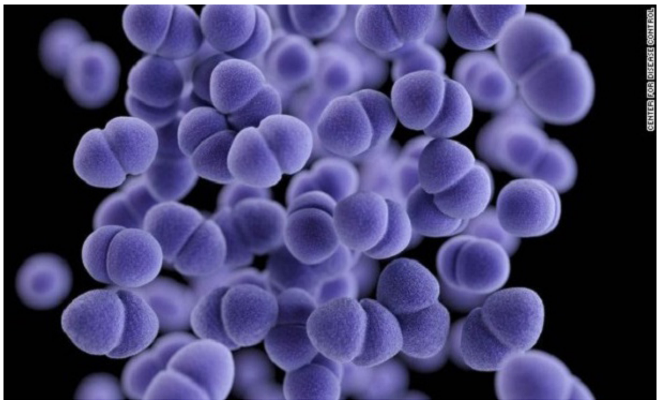
Studies have shown that traditional cleaning is often insufficient with reports of more than 50% of surfaces not being disinfected properly after terminal cleaning.[5] This fact has forced the healthcare industry to take this issue seriously, researching and implementing new solutions as part of their infection prevention protocols. As a result, there has been a resurgence of UV light solutions, as well as other enhanced disinfection products, over the past several years.

Germ-killing lighting products aimed at the broader consumer marketplace have also begun to emerge. For example, at the CES show in Las Vegas in January, Delta airlines announced it would be incorporating antibacterial lights into its airplane cabins. A rideshare company in 2019 planned to integrate a UV surface sanitizer into its “Wellness Pods.”[6] Kickstarter and other similar campaigns have funded the development of germ-killing robots and balls to clean everything from inside of your sneakers to the sheets on your next hotel stay.

While increased adoption of germ-killing lights will ultimately benefit people and spaces around the globe, it has also led to confusion and sometimes misleading information about the benefits, effectiveness, and other elements of UV and blue light for disinfection.

Bacteria Vs. Viruses – Not All Germs Are the Same

While much attention has been given to antibiotic-resistant bacteria, viruses are a threat that cannot be ignored. Worldwide, norovirus causes 685 million cases of gastrointestinal illnesses each year, which have caused over 50,000 deaths and cost the economy $60 billion. In the last flu season alone, the influenza virus caused over 35 million illnesses in the United States, resulting in 34,200 deaths.[7]



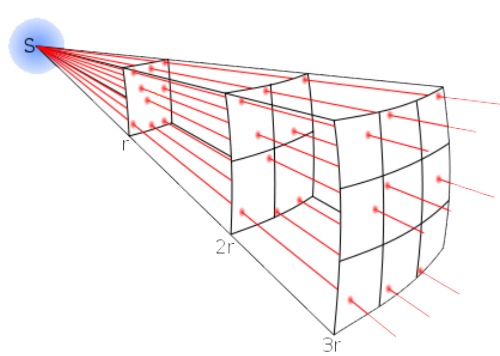
The CDC consistently must educate people about the difference between bacteria and viruses, particularly when it comes to the use of antibiotics. Antibiotics can only treat infections caused by bacteria, not those caused by viruses.[8]

Similarly, bacteria and viruses are susceptible to germ-killing light in different ways. Studies have demonstrated that near-UV blue light (405 nm) can kill certain bacteria if exposed long enough, but it is ineffective against viruses.

Alternatively, ultraviolet light has been researched and proven to kill bacteria, mold, fungi, and viruses, helping protect people from all types of harmful pathogens.

Time, Distance, and Spectrum Matter

Light is subject to Newton's Inverse Square Law, which states that the intensity of light is inversely proportional to the square of the distance from the light source. This means that as you double the distance from a light source, the intensity of the light is reduced to ¼. Therefore, when reviewing efficacy of germ-killing lights (both UV and near-UV blue), review carefully both the time needed to disinfect according to the manufacturer, but also the distance at which the results were achieved. For example, hand-held germ-killing wands require



holding the device ½” to 1” from surface and hold it there for 10 seconds – covering approximately 12” wide area at a time. To disinfect surfaces in a 100 square foot room would take approximately 6.7 hours at that rate. They don’t tell you that in the instruction manual.

On the other end, the pulsed Xenon UV disinfection products powered by Violet Defense’s technology have been independently validated to kill up to 99+% of E. coli, Salmonella and MRSA at distances of 3 meters (~10 feet), which translates to disinfecting the air and surfaces in 100 square feet area in 30 minutes.

While visible light disinfection technologies can operate continuously even when a room is occupied, the time to achieve effective kills (bacteria only) is extremely lengthy. Manufacturers of these types of lights have cited that they can “continuously reduce harmful bacteria by 70%+” or that “statistically significant reductions can occur in a matter of weeks.” When rooms are occupied, these systems usually activate an antimicrobial “white” light version and offer an enhanced “blue light” version used when rooms are empty.

A study conducted by researchers at Duke University and UNC Schools of Medicine found that the “white light demonstrated no statistically improved reduction at any time point compared to control die-off for VRE, MDR-Acinetobacter and C. diff.”[9] The study did show effectiveness against MRSA and that the inactivate was more significant with blue light, though 90+% reduction still required 24-48 hours and was not achieved for C. diff.

Therefore, in evaluating germ-killing UV and near-UV blue lights, one must account for desired pathogen reduction, available time, and space for disinfection.

Broad Spectrum UV vs. UV-C

The ultraviolet spectrum has three primary bands: UV-C (100-280 nm), UV-B (280-320 nm) and UV-A (320-400 nm). Low pressure mercury vapor lamps have a peak at 253.7 nm within the UV-C band that is very close to DNA absorption peaks of various pathogens, making it highly effective. However, these peaks vary depending on species, such that E. coli’s peak absorption occurs at 265 nm versus Cryptosporidium parvum oocysts whose optimal wavelength is 271 nm. Medium pressure mercury bulbs produce a broad but flatter spectrum (200-400 nm) than low-pressure mercury bulbs and “have approximately 15 to 20 times the intensity of low-pressure lamps.”10

Certain manufacturers of single wavelength UV-C (254 nm) products have claimed that broad spectrum, pulsed Xenon UV devices (200-400 nm) produce UV energy that is not useful. However, studies have shown that UV-B[11] and UV-A wavelengths[12] also have antimicrobial benefits. UV-A and UV-B light causes oxidation of proteins and lipids causing cell death. Beyond the scientific studies, simply consider the fact that the ozone layer blocks nearly all UV-C light from reaching earth, yet there are clearly antimicrobial effects of the sunshine (i.e. mold typically grows where the antimicrobial benefits of sunlight don't reach).

Researchers have also concluded that certain viruses could be inactivated with doses of UV-B comparable to UV-C. Duizer et al. found canine calicivirus and feline calicivirus could be inactivated with about 113 J/m2 of UV-B, compared to UV-C doses of 67 J/m2 for canine calicivirus and 185 J/m2 for feline calicivirus.[11]

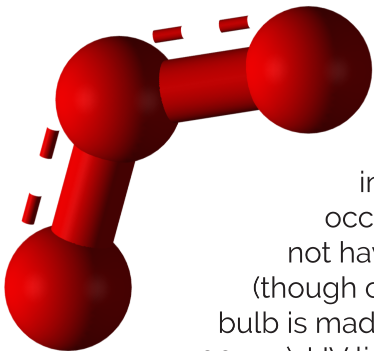
Furthermore, broadband UV lamps have been shown to inhibit photo-reactivation, the process that can result in self-repair of damaged microbes. Kalisvaart found that E. coli 0175:H7 was "able to repair the damage caused by low-pressure UV."[13]

Safety of UV Disinfection Systems

UV disinfection systems are designed to help protect people against dangerous pathogens that can cause unnecessary illnesses and even deaths. Therefore, safety is of utmost importance to any germ-killing lighting system, but they must still be effective.

Visible/blue light disinfection systems boast that they can continuously and safely disinfect, operating even when room is occupied, yet they take extended periods of time to partially reduce bacterial loads and cannot inactivate viruses.

UV disinfection systems can disinfect an environment much more quickly, including tackling any viruses in the air or on surfaces, but they are designed to only be used when a room is unoccupied due to concerns over negative impacts that UV light may have on skin and eyes. However, due to these concerns, the UV disinfection systems also typically incorporate motion detection systems that will suspend or discontinue disinfection until safe to do so.



Another safety concern frequently raised is the production of ozone by UV lights. Some companies claim that Xenon-based lamps, but not mercury-based lamps, emit ozone. However, the fact is that UV devices do not directly emit the ozone, regardless of bulb type. Rather the ozone is actually created when ultraviolet radiation, typically below 240 nm (produced by any source) interacts with oxygen in the air. The peak creation of ozone occurs at 185 nm. While low pressure mercury bulbs do not have a peak at 185 nm, they may still produce some ozone (though certain models may specifically block this wavelength if bulb is made of glass or fused quartz doped to block radiation below 200 nm). UV light itself (240-280 nm) can also destroy ozone, with peak absorption at 254 nm, thereby self-limiting the net ozone creation

While high levels of ozone have been linked to health concerns, "in general the levels (of ozone) produced are low, the concentrations dilute, and these byproducts of the UVGI process tend to break down or dissipate rapidly"11. The half-life of ozone is only about 15 minutes in the air.

Installation Locations Matter

Not only does the distance of a UV light source from the targeted area of disinfection matter, but the location of that light source will also impact effectiveness. There is much discussion over the relationship between shadowing and UV disinfection technology, which frequently leads to requiring multiple placements of a device within a room or extended run times to ensure enough UV dosage was delivered to areas not in direct line of sight. However, these discussions primarily center around mobile solutions where a single unit is stationary and vertical in orientation, positioned perpendicular to most high-touch areas in each space. This can lead to another effect, particularly for textured surfaces, referred to as the "Canyon Wall Effect."

To understand this effect, Jaffe describes a hiker in a canyon relative to the sun's position, where at certain times (i.e. the canyon at 9 a.m.), the canyon walls will not be exposed to direct sunlight. However, if the sun is directly overhead (i.e. at noon), the entire canyon will be flooded with light. This is comparable to a UV source being positioned directly overhead (i.e. the canyon at noon) versus a UV source being positioned perpendicular and to the side of the disinfection area (i.e. the canyon at 9 a.m.).[14]

Jaffe compared the kill rates of a UV disinfecting light positioned parallel to and above smooth and textured tiles with light versus one positioned in a vertical orientation, perpendicular to the tiles. It was found that for smooth surfaces, "the kill rate was >150 times greater with the lamps parallel and above than with the lamps vertical and to the side." The difference on textured surfaces was >500 times greater.[14]

Therefore, an installed solution positioned above and parallel to contaminated surfaces could provide significantly higher disinfection outcomes than the current mobile solutions.

Choose the UV Disinfection System Right for You

Sunlight has been killing germs since the beginning of time, but we are just now beginning to fully tap into the power of light to bring this proven technology indoors. As the UV disinfection and germ-killing light industry continues to expand, there will continue to be advancements to the deployment of this technology and the types of products available. It is critical that users do their homework to make sure they have the facts about the products they are considering so that they end up with solutions that are safe, proven and effective.

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