PURO™
UV Disinfection Lighting

DISINFECTION IN A FLASH

Healthy Facilities, Healthy Athletes

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Introduction

While athletes may typically be in better physical health, the nature of competitive sports can lead to increased risk for injuries, and associated infections. Most athletes are in constant proximity to other athletes, coaches, fans, support staff, etc., and often in relatively enclosed spaces like locker rooms, film rooms, gyms, and even planes. This level of contact leads to increased exposure to infectious diseases that cause both individual illnesses and can lead to broader outbreaks.

While exposure to infectious diseases often occurs through person-to-person contact, there is extensive evidence that environmental exposure to pathogens can also transmit illnesses. Many bacteria and viruses can remain viable on surfaces, such as sports equipment, gym or weight room equipment, floors, benches, toilets, mats, and locker rooms for hours up to weeks at a time.

This white paper, written by PURO Lighting's technology partner Violet Defense, lays out the challenges that we face in helping keep athletic facilities safe from harmful germs and how advancements in UV disinfection technology will change the way we think about protecting these environments.

Role of the Environment in the Spread of Infections

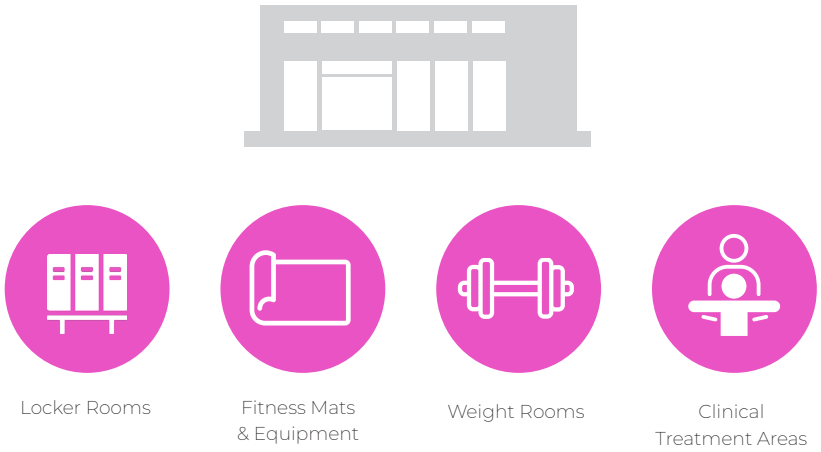
Historically, concerns over pathogens such as Methicillin-resistant Staphylococcus aureus (MRSA) were largely contained within hospitals. However, while there are a specific set of infections that are still more likely to occur in hospital settings, there has been a growing awareness and concern over the risks from community-acquired infections, which arise from pathogens in everyday community settings.[1]

The fact that pathogens can survive on surfaces, and in the air, for extended periods of time presents one of the biggest challenges. While influenced by temperature, humidity, and other factors, research has shown that harmful pathogens can remain viable and create a continuous source of transmission if proper disinfection does not occur.

Bacteria such as Staphylococcus aureus, including MRSA, have been shown to survive 7 days on the low end, and 7 months on the high end. Viruses, including influenza and rhinovirus can also last for several days, and *E. coli* has persisted on dry inanimate surfaces for up to 16 months.[2]

In fact, viruses that remain viable on surfaces may only need to be present in small numbers to infect a person. For example, the Norwalk virus (Norovirus) can cause illness with as few as 18 viral particles.[3]

Areas to target for enhanced disinfection



Moreover, it only takes limited contact with surfaces for microorganisms to be transferred to a host. In a study by Gwaltney, it was found that after only a 10-second exposure, 70% of rhinovirus was transferred from donor to recipient hands. Another study showed that 50% of the study subjects developed infections after handling a coffee cup contaminated with rhinovirus.

> "It is now recognized that the environment can facilitate transmission of several important healthcare-associated pathogens."
>
> Stephanie Dancer
> Department of Microbiology
> Hairmyres Hospital

Infections can also be transferred from infected people who rub their eyes, nose, etc.[4] to surrounding spaces on doors, switches, seating, arm rests, and more.

In general, fitness equipment is known to have significant amounts of bacteria. Exercise bikes and treadmills have been tested to have over 1.3 million colony forming units (CFU) of bacteria, and free weights had as many as 1.2 million CFU, which is 362 times the CFU found on a public toilet. Of the bacteria found on exercise equipment, 70% was determined to be harmful to humans.[5]

Of special concern to athletes is the increased likelihood of contracting MRSA, an antibiotic-resistant strain of Staphylococcus aureus that causes skin infections. Due to the difficulty in treating MRSA, it can easily lead to serious complications, including pneumonia, sepsis, or even death.

According to the CDC, MRSA cases are more likely when the "5 Cs" occur: crowding; skin-to-skin contact; compromised skin (cuts or abrasions); contaminated items and surfaces; and lack of cleanliness.[6]

Athletic facilities have been well documented with MRSA colonization. University of Central Missouri took 108 samples from the football locker room and weight room and found that 26 (24%) contained methicillin-susceptible S aureus (MSSA) and 33 (31%) contained methicillin-resistant S aureus (MRSA).[7]

Athletic facilities have been well documented with MRSA colonization.

The Threat to Athletes

As mentioned, athletes are at higher risk for infections, ranging from respiratory and gastrointestinal to skin infections, like MRSA. Furthermore, athletes participating in contact sports are even more likely to carry MRSA than non-contact sport athletes. Vanderbilt University found that contact-sport athletes had a *S. aureus* colonization rate range of 32%-62%, as compared to the lower occurrence range in non-contact sport athletes (18% and 53%).

When exposure to MRSA results in an infection, it can have dire consequences for players. Since 1999, there have been hundreds of players across different sports that have contracted MRSA with numerous instances where teams faced widespread outbreaks among its players.

In 2003, the Bengals had a MRSA outbreak that affected at least 10 players. In fact, some teams have faced repeated battles with MRSA outbreaks. The Cleveland Browns have had at least 6 players acquire MRSA infections over an extended period, including two that eventually sued the team for inability to properly protect them from infections.

When exposure to MRSA results in an infection, it can have dire consequences for players.

The Washington Redskins also had an outbreak of MRSA that infected 5 players, including Brandon Noble whose infection ended his career. The Redskins ultimately renovated their facility, adding new technology such as ultraviolet light to help kill germs and combat future outbreaks.[9]

However, the threat of infection is not just contained to the NFL nor does it stop with MRSA. Researchers have found that the mere act of competing is a major risk factor for athletes to contract respiratory tract and gastrointestinal illnesses.

At the World Athletics Championship in London in 2017, at least 30 athletes and team mates fell ill during an alleged Norovirus outbreak.[10] Furthermore, athletes are 5 times more likely to acquire symptoms of these types of illnesses after air travel. [11]

Researchers at Auburn University conducted a study where they specifically tested airplane cabins for the presence and persistence of microbes and found numerous common areas to have bacteria and virus that survive for

days and even weeks, thereby extending the potential to cause illness. Researchers indicated that the airline industry may need to consider whether different sanitation strategies are needed to better protect passengers.[12]

Many people attribute illnesses after air travel solely to the proximity of travelers. However, case studies have demonstrated that the transmission of pathogens (i.e. Norovirus) were not from person-to-person contact, but rather, through exposure to the airplane cabin. Flight attendants over the course of 6 days contracted gastroenteritis even though there was no direct contact between the attendants. The source of the illness was traced back to a passenger that vomited in the cabin during a prior flight.[13]

Due to the ability for disease transmission on planes, the CDC has created specific guidance for cabin crews on preventing the spread of disease on commercial aircraft, included cleaning and disinfecting contaminated areas.

This could include ultraviolet light or other strategies, such as those used by hospitals to kill microbes.

Traditional Environmental Disinfection

Given the nature of their business, hospitals have extensive experience cleaning and/or disinfecting environmental surfaces. Their policies dictate the frequency and type of cleaning conducted based on clinical risk, patient turnover, contact surfaces, and other factors.

Often referred to as terminal cleaning, deep cleaning is performed following the discharge of a patient. Additional measures may be taken if the patient was known to be colonized or infected with a specific pathogen, such as *C. diff* or MRSA.

Despite the awareness of the importance of proper disinfection, hospitals (and other settings) often do not achieve the levels of cleanliness necessary to protect patients or staff. Carling conducted a study in acute-care hospitals and found that only 49% of evaluated surfaces had reached the desired compliance with the cleaning standards.[13]

There are several challenges with manual cleaning processes, regardless of what environment is being cleaned, including the challenge of complying with the saturation requirements of most chemical disinfectants. To achieve the effective kill rates claimed by chemicals or disinfectant wipes, many of them must be applied such that the surfaces are visibly wet for extended periods of time. In fact, most EPA-registered disinfectants for hospital use require a contact time of 10 minutes to be effective.[14]

Many household consumer products, such as disinfecting wipes require 3-4 minutes or more of remaining wet on the surface for effective kills, which few people know or follow.

Furthermore, chemical disinfectants pose health risks to those using them and can potentially contribute to microbial resistance. In 2016, the U.S. Food and Drug Administration issued its final ruling related to over-the-counter consumer antiseptic wash products containing certain active ingredients. The ruling stated that manufacturers were unable to demonstrate that their ingredients were safe for long-term daily use, nor that they were more effective than plain soap and water in preventing illness and the spread of certain infections.

The agency issued the ban after reviewing data that suggested that exposure to certain ingredients, including triclosan and triclocarban could pose health risks in humans, such as bacterial resistance and hormonal effects. The ban required these products to be pulled from the market.[15]

Benefits of UV Disinfection

Given the health risks of chemicals, as well as the inability to consistently achieve the necessary disinfection levels, many hospitals and other healthcare settings have begun incorporating additional automated decontamination devices.

While not a "new" disinfecting technology, UV light has rapidly been growing in use in hospital settings as it is a proven disinfectant for surfaces, instruments, and air. With over 140 years of research behind it, UV light has been proven effective at killing bacteria, viruses, mold, and fungi.

Ultraviolet light attacks microorganisms at the DNA and RNA level. Microbes are not able to develop resistance to ultraviolet light, compared to their ability to form resistance to certain types of chemical disinfectants.

Ultraviolet light has been repeatedly proven effective against pathogens, including *C. diff*, MRSA, *E. coli*, Salmonella, Norovirus, and many more. The ability of UV light to kill microorganisms is directly related to the energy

	Pathogen	UV Dosage (mJ/cm²)*
Bacteria	*E. coli*	6-11
	Staphylococcus aureus	10.4
	Clostridium tetani (*C. diff*)	22
	Salmonella typhimurium	7.1-15.2 (2-log)
	Vibrio cholerae	2.9-6.5 (2-log)
	Pseudomonas	6.6-10.5
	Legionella	6.4-7.7
	Shigella	3-8.2
	Campylobacter	4.6
Viruses	Adenovirus	165
	Rotavirus	200 (36 for SA-11)
	Norovirus	30 (based on Calicivirus feline)
	Hepatovirus	16.4-29.6
	Calicivirus	30
	Influenza	6.6 (2-log)
Protozoa	Cryptosporidium	22 (EPA Requirement); 9.5 (Parvum study)
	Giardia	22 (EPA Requirement)

Table 1 — Ultraviolet Exposure Dosages[17 18]
*4-log reduction unless otherwise noted

dosage produced by the UV source as a function of time and distance to the target. (See Table 1 for a summary of UV dose required to achieve a at least a 99% reduction in various types of microorganisms).

UV light has also been shown to have great benefits when combined with other cleaning methods for optimal results. Researchers at Duke University and the UNC Schools of Medicine found an additional 94% reduction in epidemiological-important pathogens when UV was added to the standard use of quaternary compound disinfectants.[16]

Another potential benefit is the ability to reduce the labor and/or cost of chemical cleaning. A study using pulsed UV for routine once-daily disinfection of hospital surfaces cut the number of housekeeping hours required in half, compared to using alcohol wipes in manual cleaning.[13]

However, the use of ultraviolet light has not been limited to the healthcare space. For example, in addition to incorporation of UV light technology into the Redskins facility, two NFL teams are also utilizing ultraviolet technology to disinfect artificial turf grass after concerns were raised about the possibility of MRSA on the playing field. Moreover, UV technology has been used in hotels, food production facilities, universities, and commercial office buildings and more to routinely disinfect surfaces as part of their cleaning protocols.

Role of UV Light in Reducing Infection

The use of ultraviolet light has been proven to help reduce actual infection rates for pathogens.

As a function of its effectiveness in environmental disinfection, the use of ultraviolet light has been proven to help reduce actual infection rates for pathogens, including MRSA, *C. diff*, and VRE.

The study at Duke University and the UNC Schools of Medicine found that not only did the combination of UV with quaternary compounds reduce the environmental microbial load, but it also subsequently reduced the infection rate by 35%.[16]

South Seminole Hospital implemented a pulsed Xenon UV disinfection system for all room discharges and transfers from ICU, and for *C. diff* discharges from non-ICU patients. The use of the system resulted in an overall 29% reduction of VRE+MRSA+*C. diff* infection rates facility wide. Specifically, in the ICU, there was a 56% reduction in MRSA infection rates, 45% reduction in *C. diff*, and 87% reduction in VRE rates.[19]

In a retrospective study of the implementation of an ultraviolet environmental disinfectant, Westchester Medical Center found a significant 20% reduction in hospital-acquired multiple-drug-resistant organisms (MDRO) during the 22-month study period.[20]

Furthermore, an acute care hospital system in Greensboro, NC incorporated pulsed UV for terminal cleaning of rooms, along with hand hygiene education. The results were significant, with rates of hospital associated MRSA decreasing by 57% for a large facility and 56% for the entire healthcare system.[21]

With the new advances in ultraviolet technology, it has become easier and more cost-effective to apply this technology to reduce the spread of disease in schools, athletic facilities, crowded airplanes, food processing plants, restaurants, assisted living facilities, hotels, and more.

Conclusion

Ultraviolet light has an extensive history of effectively killing microbes in the air and on surfaces, which has been proven to reduce the infection rates of MRSA, *C. diff*, VRE and other harmful pathogens.

As a result of the miniaturization of this technology, it is now possible to deploy UV disinfectant technology in dramatically more settings than ever before, thereby creating cost-effective deployments to fight off harmful germs, particularly when used in combination with existing cleaning protocols.

Given the increased risk that athletes face with regard to illnesses, including respiratory infections, gastrointestinal infections, and particularly skin infections and MRSA, ultraviolet light should be seriously considered as an addition to the cleaning protocols for weight rooms, locker rooms, equipment, showers, bathrooms, and other team facilities (including modes of transportation) to mitigate the risks and protect the athletes.

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ABOUT PURO UV DISINFECTION LIGHTING

Launched in 2019 in Lakewood, Colorado, PURO™ Lighting products, powered by Violet Defense™ technology, have set out to take proven UV light disinfection technology to the next level by making it more powerful, more affordable and most importantly, smaller and easier to utilize. PURO Lighting products can rapidly disinfect any room of any size and at any time using the proprietary miniaturized, pulsed Xenon Light Engine System. Our high intensity broad-spectrum UV disinfection units rapidly kill up to 99.9% of viruses and bacteria and can significantly reduce the growth of fungi such as yeasts and molds. All in remarkably small, yet powerful fixed or mobile units designed for any sized space. For more information, visit www.purolighting.com.

ABOUT VIOLET DEFENSE

Founded in 2012, Violet Defense is on a journey to find new ways to protect people from harmful germs that have grown resistant to traditional forms of cleaning and disinfecting. Its patented technology is the only known Pulsed Xenon UV solution that can be installed into a room full-time, creating continuous way to address disinfection needs of all types of settings, including healthcare and non-healthcare alike. Designed to bring hospital-grade disinfection to everyday spaces, Violet Defense has cost-effective solutions to kill up to 99.9% of bacteria and viruses, including *E. coli*, Salmonella, MRSA, Norovirus and *C. diff.* For more information, visit www.violetdefense.com.

PURO™
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