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The Effect of UV Disinfection On Public Restroom Surfaces

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Part 2

Introduction

In the previous part of this article, we acknowledged that, according to the studies, UV disinfection is an effective method of self-cleaning in eSOS toilets [1]. Toilet flushing generates airborne particles that contain bacteria and viruses [2]. Larger droplets can travel short distances and settle on surfaces and may also rapidly form smaller droplet nuclei that follow air currents potentially for long distances [3, 4]. The fate of the toilet plume will depend on the distribution of droplets within it, the environmental conditions (temperature and relative humidity), and room air currents dictated by local ventilation. Despite this variable distribution of microorganisms, both aerosol and surface contamination may increase disease transmission risk. One cost effective decontamination tool used in hospitals as an adjunct to traditional cleaning and disinfection is ultraviolet C (UVC) irradiation [5-7]. In this part of the article, we are going to evaluate the effectiveness of UV disinfection, based on several studies.

Efficacy of an automated ultraviolet C device in a shared hospital bathroom Reference 8: [8]

This study was conducted in November 2015 in a 268-bed community hospital with common hallway bathrooms shared by up to 8 patients. All samples were collected without a UVC device and in a shared bathroom and with a permanently installed, wall-mounted automated UVC (254-nm) device. The decontamination cycle initiates only after there has been 30 seconds of no motion detected by infrared sensors, after which a UVC cycle will run for 5 minutes. The device is located directly above the door and has an automatic shutoff safety feature that terminates the cycle if the bathroom door is opened during each run. Both the UVC-treated bathroom and control bathroom contain a 6.0 L per flush, wash down toilet and have similar room volumes (12.7 and11.7 m3, respectively). Air and surface samples were collected in each bathroom 5 minutes and 30 seconds after each patient use—a time that accounts for the decontamination cycle and permits comparison of the samples between each bathroom. A dual headed SAS 360 bio aerosol sampler (Fig 1) set to collect 150 L of air over 50 seconds was used to permit simultaneous collection of aerobic and anaerobic bacterial cultures. The anaerobic Brucella plates were immediately placed in a candle jar post sampling and subsequently incubated anaerobically at 37°C for 48 hours prior to counting bacterial colonies. The aerobic 5% sheep blood agar plates were incubated at 37°C for 24-48 hours prior to counting.

Surface bacteria on the toilet seat and handwashing sink counter were sampled using 65-mm Replicate Organism Detection and Counting (RODAC) Contact Plates containing Trypticase soy agar, with a contact time of 10-12 seconds, and were incubated aerobically at 37°C overnight. Surface sample locations were matched between the 2 bathrooms, with samples taken at random locations on the counter, approximately 1.5 m away from the toilet, and on the top of the toilet seat. They collected a total of 66 air samples (32 aerobic and 34 anaerobic) and 64 surface samples (32 counter and 32 toilet seat). Mean bacterial concentrations were compared between the 2 bathrooms for each of the different sample types using Welch t tests.

Fig 1. SAS Duo 360 high volume air sampler [9].

As a result, the UVC-treated bathroom had a 35.2% reduction in aerobic bacterial bio aerosol concentration compared with the control bathroom. This difference was even more pronounced for anaerobic bacterial bio aerosols, where the UVC-treated bathroom had a 47.7% reduction compared with the control bathroom.

UV disinfection was even more effective for the surface of the counters and toilet seats. The mean bacterial concentration on the UVC-treated bathroom counter was reduced by approximately 95% compared with the control bathroom. The greatest effect was seen for surface seat bacteria, with a 97% reduction in the UVC-treated bathroom compared with the control bathroom. Two outliers collected from the toilet seat of the control bathroom had concentrations >2,000 CFU/(10 cm)^2. These outlier samples may represent highly contaminated droplets deposited onto the seat after flushing.

Fig 2. Ultraviolet disinfection robots in Hong Kong airport’s restrooms [10].

Virus-killing robots to disinfect public areas in Hong Kong Airport [10]

Robots, emitting ultraviolet lighting have reportedly been used in hospitals to kill microbes and viruses [11]. The light destroys bacteria, viruses and other harmful microbes by damaging their DNA and RNA, so they can’t multiply [11].

While robots have been reportedly used to disinfect public places by the spread of Covid-19, in a number of hospitals around the world, Hong Kong’s airport is the first airport in the world to use the sterilization robots, which were developed in the city.

Hong Kong International Airport has deployed several self-driving robots, called “Whiz”, and “Intelligent Sterilization Robot (ISR)”, to clean and disinfect public areas such as toilets (Fig 2 and Fig 3), to protect against the spread of the coronavirus.

These robots are being used “round-the-clock” in public toilets and “key operating areas” in the terminal building and they are tall, self-moving robots that are equipped with both a UV light sterilizer and an air sterilizer to kill germs.

Each ISR has a head that can spin 360 degrees to spray disinfectant and a body that is lined with bulbs that emit ultra-violet lights.

The airport said that, these robots are able to “sterilize up to 99.99% of bacteria and virus in the air and on object surfaces” in just 10 minutes.

The airport authority said that, during the UV light sterilization process, the cleaning areas are cordoned-off to prevent travelers at the airport from coming in contact with the robots and its light. During the air spray sterilization process, the robots can sterilize designated areas with people on site.

The airport is also using five Whiz robots, which are self-driving vacuum sweepers that clean floors at the airport’s terminals, and apart from enhancing cleaning performance, robot “Whiz” also helps boosting the operational productivity as cleaners can be reallocated to other cleaning tasks, particularly those critical cleaning and disinfection tasks [10].

Fig.3. An Intelligent Sterilization Robot (ISR), produced by TMiRob of China, uses UV light to sanitize, at a toilet, following the coronavirus disease (COVID-19) outbreak, at the Hong Kong International Airport, in Hong Kong, China May 7, 2020. Picture taken May 7, 2020, Tyrone Siu/REUTERS.

Boeing's self-cleaning lavatory zaps germs with UV light [12]

Boeing engineers and designers have built a prototype lavatory (fig 4) that uses UV light to kill 99.99 percent of pathogens, thus sanitizing all the lavatory surfaces. Combined with touchless faucets, soap dispensers and more, the lavatory of the future could make for a more hygienic, less worrisome experience.

Engineers in Commercial Airplanes Product Development and Boeing Research & Technology (BR&T) are working on the lavatory and other concepts that would make the overall cabin cleaner. These innovations can minimize the growth and potential transmission of disease-causing microorganisms. Boeing has filed for a patent on this concept.

Fig.4. Boeing's self-cleaning lavatory using UV light to kill germs [12].

The lavatory uses far UV light. Ultraviolet (UV) light in the 222nm wavelength has the same germicidal capabilities of 254nm light to kill or inactivate pathogens (bacteria and viruses) without the same damaging effects of 254 nm exposure on the skin or eyes. This is due to the shorter UV wavelengths (known as Far-UV, wavelength 200 to 235nm), that have reduced penetration depths in live tissue when compared with standard UVC (240to 280nm) light. While the effects on live tissue, such as skin and eyes, are diminished, Far-UV (222nm light being the most prevalent) has increased efficacy for killing bacteria and viruses. Like standard UVC, Far-UV light breaks pathogen DNA bonds. In addition, Far-UV is highly effective at breaking protein bonds in the membrane shells of pathogens, including SARS CoV-2. This same protein interaction makes Far-UV222nm much safer for human exposure, including: reduced UV damage to skin and eyes, faster on/off times, more rapid disinfection, and the elimination of mercury from the lamp [13].

Conclusion

The toilet plume can be a vector for disease transmission. The severe acute respiratory syndrome outbreak at the Amoy Gardens apartment complex in Hong Kong was caused by contamination of the sewage drainage system by the index patient [4]. The dry U-tube drains allowed virus containing–droplet nuclei to be pulled by air currents from the bathroom fan to neighboring apartments, with subsequent secondary severe acute respiratory syndrome cases [2]. Portable UVC devices have been used as effective decontamination tools and have been shown to be more effective than manual cleaning alone [6]. Recently, UVC significantly outperformed manual cleaning using accelerated hydrogen peroxide in the removal of methicillin-resistant Staphylococcus aureus, vancomycin-resistant enterococci, and Clostridium difficile [6]. Similar results have been seen with the use of short exposure time UVC devices (5-10 minutes), significantly reducing C difficile and methicillin-resistant S- aureus levels [7]. The results of a study demonstrate the potential utility of permanently installed UVC lights to supplement decontamination efforts. Specifically, the short run time and automatic shutoff safety feature, in addition to its antimicrobial efficacy, make this device an ideal decontamination adjunct in shared bathrooms, where high microbial burden and frequent occupant use pose significant challenges to current manual cleaning and disinfection efforts. The potential to use this technology both in health care (bathrooms and procedure rooms) and in commercial applications (aircraft, train, and cruise ship bathrooms) is intriguing.

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