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Evaluating a 'no-touch' UVC Radiation Device on High Touch Surfaces

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Abstract
The computers at nurse's stations, patient rooms and mobile carts are used 24 hours a day. They are rarely manually wiped down or disinfected and there is seldom training or documented procedures around cleaning of computer workstations. Housekeeping, nursing and IT dispute over who is responsible for the computer workstation cleaning, making computer workstations one of the dirtiest places in healthcare contributing to the prevalence of healthcare associated infections (HAIs) that lead to morbidity, mortality and excess healthcare expenditure.

Continuing advancements in automation in all industries have led to increased productivity, efficiency, reliability and confidence in effectiveness. Automation in infection control, specifically in using UVC automated disinfection devices, is an enhancement to traditional infection control practices that require human intervention, accuracy and reliability. Ultimately this automation has the ability to significantly reduce HAIs.

Main Article
Nosocomial pathogens, commonly referred to as health care associated infections (HAIs), cause life-threatening complications for patients and costly consequences for health care facilities. One in 31 patients hospitalized in the United States in 2017 had at least one HAI on any given day[1]. In a public health report, an estimated 1.7 million people a year acquire a HAI during a hospital stay, costing the health care industry $35.7 billion to $45 billion annually[2,3].

High touch surfaces are a source of HAIs that cause secondary transmissions of bacteria directly through patient contact or indirectly through the hands of health care workers who touched a contaminated surface[4]. Infectious pathogens, including *Clostridium difficile* (C. diff), vancomycin-resistant *Enterococci* (VRE), methicillin-resistant *Staphylococcus aureus* (MRSA), *Acinetobacter baumannii, Pseudomonas aeruginosa* and norovirus, can contaminate high touch surfaces, survive disinfection attempts, transfer to the hands of healthcare workers and infect patients upon contact[5].

Multiple studies have demonstrated how frequently touched surfaces can contain pathogens. A study in a medical ICU found colonization rates were higher for keyboards in rooms with patients positive for MRSA and another study found keyboards tested positive for the growth of two or more microorganisms, including coagulase-negative *Staphylococci* (100% of keyboards), diphtheroids (80%), *Micrococcus* species (72%), *Bacillus* species (64%) and oxacillin-resistant *Staphylococcus aureus* (4%)[6,7].

In addition to keyboards in patient rooms, portable medical equipment (PME) and computers on carts, also known as workstations on wheels (WOWs), can be used hundreds of times a day, acting as a mobile reservoir for multidrug-resistant microorganisms. The top three most common interactions involving PME and patients were WOW to patient (22.6% of total sequences), patient to WOW (20.4%) and patient to IV pump (16.1%), demonstrating that frequently touched PME and WOWs are potential sources of contamination from patients or the environment[8].

Pathogens can spread from WOW to patient and patient to WOW as established in a study that revealed daily cleaning of WOWs was nonexistent over a baseline evaluation period[9].

If a health system's cleaning and disinfection protocols are insufficient, harmful microorganisms can be transmitted, underscoring the need for an extensive review aimed at improving cleaning and disinfection techniques[10].

UVC

A way to expand cleaning protocols is with the advent of ultraviolet (UV) disinfection devices. Used as early as 1878 by Arthur Downes and Thomas P. Blunt, the short wavelength light was investigated as a means to sterilize bacteria[11]. Since then, UV light has been used in air and water treatment and as a surface disinfectant of fruit and vegetables[12]. The short wavelength of UV, UVC (between 250 and 280 nm), is considered germicidal and can inactivate bacteria, viruses and other microorganisms by damaging their deoxyribonucleic acid (DNA) to prevent the spread of HAIs[13,14].

New no-touch decontamination technologies can offer benefits for disinfecting high touch surfaces in a health care environment such as in-room computer workstations, WOWs and PME. A recent article reported that ultraviolet light disinfection is "successful in reducing the bio burden of a room and [has] been shown to stop outbreaks associated with environmental contamination"[15]. Multiple studies have also demonstrated the effectiveness of UV light to reduce HAIs, and specifically no touch methods, including UV devices, have confirmed their ability to reduce HAIs on high touch surfaces[16].

Point-of-care UV units like UV-CLEAN (Proximity Systems, Tomball, TX), are attached to or positioned above high touch surfaces (Fig 1). The unit provides automated cleaning cycles of UVC light to inactivate microorganisms at the genetic level by damaging their DNA. A built-in motion sensor enables the unit to safely emit UVC light to disinfect when in-room workstations, stationary equipment, WOWs or PME are not in use and no motion is detected. The following clinical study evaluated the effectiveness of UV-CLEAN in a hospital setting.

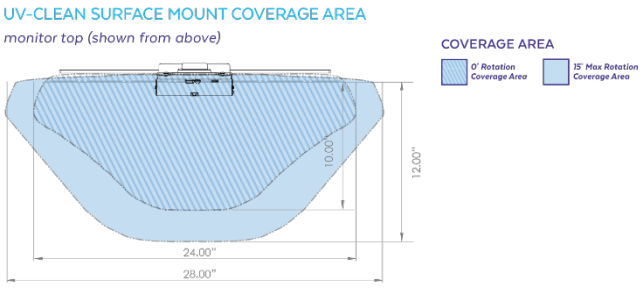

Fig. 1. UV-CLEAN Surface Mount configuration attaches to the top of any monitor bezel.

Materials and Methods

Location

In an effort to reduce cross-contamination of HAIs in their facility, HCA Houston Healthcare Southeast partnered with Proximity Systems to complete a study of the use of an automated UVC disinfection unit in the neurology unit and Intermediate Medical Care Unit (IMCU) at HCA Houston Healthcare Southeast, a fully accredited, 345-bed, medical facility located in Pasadena, Texas from March 2019-April 2019.

The study involved 52 computer workstations. Of these workstations, 16 were Ergotron StyleView mobile computing carts (two different models) that were primarily used and stored in the hallways. There were also 36 wall mounted Proximity Systems workstations (two different models) in 36 individual patient rooms. Of the 36 rooms, 32 were occupied and the other four rooms has been occupied within the past 24 hours of initial swabbing.

Collection of baseline data

Baseline keyboard cultures were taken prior to UV exposure of all 52 workstations using the COPAN

ESwab 480c Collection Kit. Using sterile saline, sterile gauze was moistened and the swab was wetted using an aseptic technique to prevent cross-contamination. Keys A-Z were swabbed by rolling the swab over the surface of each key. The entire surface of the spacebar and enter key were also sampled. A single swab was used for each workstation.

Negative controls were processed at the beginning, during and end of the sampling process using a wet sterile gauze with the saline solution to ensure aseptic conditions were maintained throughout the sampling process. Samples were sent to Lodestar Diagnostic Laboratory in Houston, Texas. Samples were plated on Blood Agar and Rose A66 aerobically and Chocolate Agar anaerobically. Catalase and Staphtex testing were performed on all suspected *Staphylococcus aureus* and all positives were tested for Cefoxitin sensitivity. VRE screening was using PYR and vancomycin sensitivity.

Installation of UV disinfection units

After samples were obtained, the UV-CLEAN disinfection unit was installed. Both cart models had sliding keyboard trays that stored under the worksurface when not in use and pulled out to the front of the worksurface when in use. Because of the difference in cart models, two different locations were chosen to mount the unit. Additionally, 10 carts were older models that offered minimal space between the keyboard and bottom of its worksurface, resulting in the development of a custom bracket designed to mount the unit to the back of the keyboard storage area. Six of the second cart type had sufficient space to use the standard keyboard mount stand supplied with the unit, allowing the unit to be positioned three inches above the back of the keyboard directly over the function keys.

There were two different models of Proximity wall mounted workstations, consisting of a flip down worksurface, which holds a keyboard and mouse. When the worksurface is down, a monitor is revealed and the keyboard and mouse are 20 inches from the UVC light disinfection unit. When the worksurface is closed, the keyboard and mouse are still exposed to UVC light. 14 of the workstations allowed for the use of the standard retrofit configuration that features a bracket to mount the UV-CLEAN unit to a shelf directly above the monitor. 22 units used the standard surface mount configuration that attached the unit to the top of a monitor. Both solutions were approximately 20 inches from the worksurface where the keyboard was placed, allowing for a large area of exposure to UVC light.

Device settings

At the time of the testing, the units were set up in the following pre-set time configuration:

- Clean Time *(the period of time the device is producing UV-C light)*: 300 seconds (five minutes).
- No Motion Time *(the length of time the device will allow to pass before producing UV-C after the motion sensor has communicated an absence of movement)*: 60 seconds (one minute).
- Wait Time *(downtime scheduled between cleaning cycles that are unrelated to motion sensor activity)*: 60 minutes (one hour).

Collection of post-disinfection data

After two weeks of usage, identical samples were taken from carts and wall mounted units using the identical sampling procedure (one wall mounted unit was removed from the study as no access was allowed by the collectors due to an airborne isolation protocol patient being in the room). As with the pre-disinfection samples, post-disinfection samples were sent to Lodestar Diagnostic Laboratory in Houston, Texas.

Results

Comparison of computer workstation bioburden at baseline versus post-UV light disinfection

Initial culturing of the computer workstation keyboards prior to the installation of UV-CLEAN units identified bacteria in 75% of the units. Of the 16 mobile computing carts, seven (44%) were found to have bacteria on the surface of the keyboard. Of the 35 wall mounted units, 31 (89%) were found to have bacteria on the surface of the keyboard. Wall mounted units in three patient rooms had multiple bacteria isolated. A variety of bacteria was isolated on the mobile computing carts and wall mounted computer workstations as shown in Figure 2.

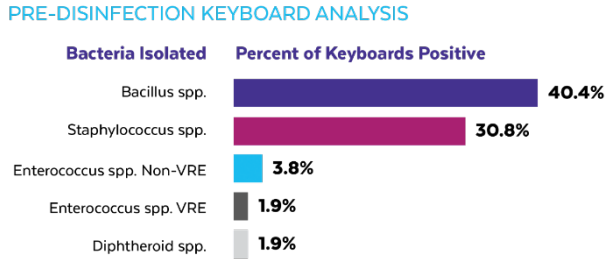

Figure 2: *Percent of keyboards after initial culturing positive for various bacteria isolates.*

The post-UV light disinfection cultures were sent for evaluation of the effectiveness of the units. All samples came back negative for growth on all surfaces swabbed indicating a 100% reduction in keyboard bio burden as shown in Figure 3. All negative controls taken during the study were negative for bacterial growth.

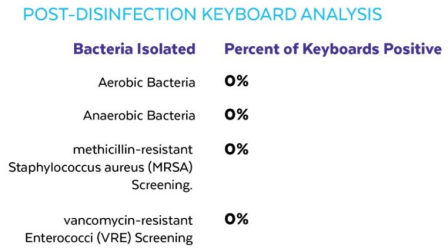

Figure 3: *Percent of keyboards after post-disinfection culturing positive for various bacteria isolates.*

Internal audit data

The UV-CLEAN unit has an internal audit feature that records when the unit disinfected and when the unit registered motion. During the 14-day study, the 51 computer workstations recorded 42,034 cycles with 15,672 being complete, uninterrupted 300 second cleaning cycles, as shown in Table 1.

BREAKDOWN OF RECORDED CLEANING CYCLES DURING CLINICAL STUDY

Disinfection Time *(UV light production)*	**Number of Recorded Cycles**
5 minutes *(complete cycle)*	15,672
4 minutes	1,328
3 minutes	1,960
2 minutes	3,058
1 minutes	5,605
< 1 minute	14,411

Table 1: *Breakdown of recorded cleaning cycles during clinical study.*

During the study, the mobile computing carts saw significantly more activity than did the in-room computer workstations (Fig 4A, 4B). It was observed during the study that the motion sensor on the carts was being triggered by activity other than the use of the keyboard.

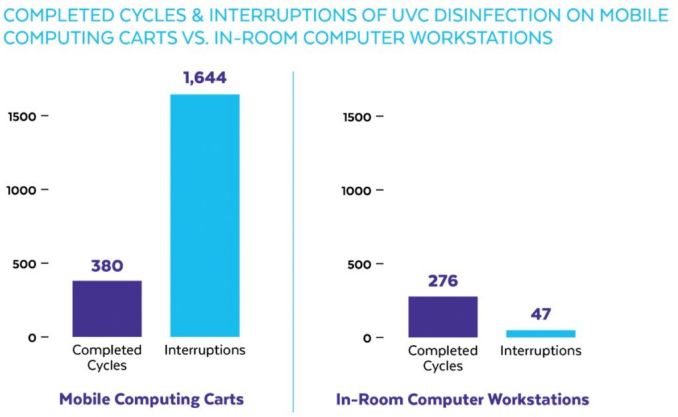

Figure 4: *(A) Average number of completed disinfection cycles versus average number of interrupted disinfection cycles for unit placement on mobile computing carts. (B) Average number of completed disinfection cycles versus average number of interrupted disinfection cycles for unit placement on in-room computer workstations.*

UVC Exposure

Using high speed photography, it was determined that the maximum UVC exposure obtained prior to the motion sensor triggering the bulb to turn off was 30 uW/cm^2. Total exposure time never exceeded one second. The National Institute for Occupational Safety and Health (NIOSH) recommends that the time of exposure to an intensity of 100 microwatts per square centimeter at wavelength 254 nanometers not exceed one minute; and based on the NIOSH recommendation, the maximum time to be exposed of 30 uW/cm^{2}should not exceed 200 seconds during an eight-hour period[17].

As noted previously, the settings for the unit during this study was five minutes of cleaning time per hour or after a one-minute period of inactivity after motion is detected. The data from the over 42,034 records was analyzed and 63% of cleanings were interrupted. This resulted in 13.3 interruptions on average per eight-hour shift. Based on the exposure testing done, this would give 13.3 seconds of 30 uW/cm^2, resulting in just under seven percent of the maximum dosage recommendation set by the NIOSH for an eight-hour shift (Table 2).

UVC EXPOSURE CALCULATION	
Total Number of Complete Cycles	42,034
Total Number of Interrupted Cycles	15,672
Total Number of Completed Cycles	26,362
Average Daily Number of Cycles Initiated	63.4
Average Daily Interruptions	39.8
Rate of Interruptions	63%
Average Interruptions per 8-Hour Period	13.3
Average Completed Cycles per 8-Hour Period	23.6
Average UVC Exposure per 8-Hour Period	13.3 seconds
Percent of NIOSH Limit	6.7%

Table 2. *UVC exposure calculation*

Discussion

The need for hand washing protocols and chemical disinfection on high touch surfaces in health care environments has been long recognized; however, studies have shown cleaning regimens are not always followed.

Health care workers touch many surfaces daily, resulting in the need for consistent hand hygiene, including use of hand sanitizer before and after interaction with patients, workstations or PME. Although considered a standard practice, hand hygiene compliance throughout the United States is only 40%, which is why daily disinfection of frequently touched surfaces is also a standard procedure critical for reducing HAIs[18,19].

When hand hygiene is followed consistently, as was the case in this study with health care workers using mobile computing carts, high touch surfaces like keyboards have less chance of contamination. During the initial culturing, there was a lesser percentage of mobile computing carts that tested positive for bacteria than the wall mounted workstations in patient rooms. Hospital protocol was to sanitize hands prior to entering and after leaving a patient's room. Since mobile computing carts were seldom brought into a patient room and nurses sanitized their hands after leaving a patient's room and prior to touching the keyboard, the keyboard had less chance of contamination than the wall mounted workstations in a patient's room.

Also vital to reduce microbial contamination is environmental cleaning, as described as the physical act of cleaning a surface followed by an application of a disinfectant. Yet data from a recent study proves not all disinfecting agents are implemented correctly in relation to dwell time and type of surface — both impacting their effectiveness[20].

Infectious pathogens can spread if disinfection measures are inconsistent, which is why an automated cleaning modality is an effective complement to existing cleaning protocols. When used as a supplemental strategy, UV light can enhance disinfection and decrease bio burden to decrease HAI rates[21]. This study found that UV-CLEAN, an automated, low-intensity UVC radiation point-of-care unit, was effective at eliminating harmful pathogens on keyboards attached to WOWs and wall mounted workstations. When used in conjunction with existing cleaning protocols, the unit's timed

disinfection cycles also mitigated human error, a contributing factor to the spread of infection within a hospital. Because the unit is small (6" x 1" diameter) and available in multiple configurations, it can also be installed on other PME, including pumps and imaging machines, that may or may not be cleaned prior to or after patient use.

This study also found that the UVC light motion sensor was being triggered by activity other than use of the keyboard. To mitigate this, the No Motion Time default setting on the UV-CLEAN unit was changed from one minute to four minutes post-study. The data suggests this change would significantly decrease the amount of cycling and extend the bulb life but not impact the effectiveness of the UV disinfection. Based on that change and using the UVC exposure data collected, the exposure limit would decrease to three percent of the maximum dosage recommendation set by the NIOSH for an eight-hour shift.

Conclusions

While increased access to information at the bedside has proved to deliver better patient outcomes, it has also introduced greater risk for patients to acquire a HAI. This study demonstrates the efficacy of UV-CLEAN as an automated, UV disinfection unit reducing bacterial burden on high touch surfaces in and out of a patient's room. When used as a complement to existing cleaning protocols, UV-CLEAN can safely target high touch surfaces with no disruption to patient care or staff workflow and audit to ensure disinfection is taking place.

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