Combined Multi-Cellular Phone Charger and Sterilizing Unit to Reduce Hospital Acquired Infections

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Abstract

Cellular phones have an important role in hospitals in order to facilitate health care through communication and information access that can, however be a source of cross-infection. We designed, built and evaluated a unit that will sterilize several cellular phones while being charged in a hospital environment, using clear ultraviolet light. Thirty healthcare workers' cellular phones were tested for bacteria pre-, immediately and six hours after being exposed to the unit. All cellular phones were contaminated with potentially pathogenic bacteria before exposure to the unit. The unit decreased the bacterial burden by over 98% and this decrease persisted six hours after exposure to the unit. All healthcare workers' surveyed were prepared and able to use the unit. The unit proved to be an effective and acceptable infection control intervention and if placed in the hospital environment could reduce the risk of cross infections and contamination, potentially decreasing hospital acquired infections.

Introduction

Infection control is a priority in healthcare facilities where there are often strict regulations to prevent cross-infections. On a daily basis healthcare workers come into physical contact with patients who are susceptible to hospital acquired infections. Cellular phones are frequently used in hospitals by healthcare workers for verifying and communicating medical information and cellular phones have become an integral part of modern healthcare. However, cellular phones may harbour pathogenic or opportunistic micro-organisms (1-4) and serve as a potential source for transmitting hospital acquired infections (5, 6). Infection control regulations regarding the cleaning of cellular phones in healthcare facilities are frequently lacking (7, 8). By finding an affordable, effective way to significantly decrease the number of bacteria on healthcare workers' cellular phones, they can continue to use their cellular phones in the hospital environment with less of a potential threat to patients. Regular cleaning of cellular phones has been shown to decrease the bacterial load but this requires additional input from healthcare workers (9).

Other studies have shown that healthcare workers often do not comply with cleaning protocols (10-12). Furthermore, in order to eliminate the risk of cross-infection caused by cellular phones they should be sterilized. Clear ultraviolet (UVC) light is germicidal, killing micro-organisms by damaging their cell membranes and breaking the organisms' DNA (13, 14). The use of UVC light is well established in hospital environments to sterilize equipment and is used for other infection control purposes such as surface and air cleaning (14). Exposing health care workers' cellular phones to UVC light when connected to a charger will allow the cellular phones to be routinely sterilized while being charged. A single unit that can charge and sterilize several cellular phones simultaneously, placed centrally in a ward, will increase security and convenience and hence compliance. The purpose of this investigation was to design, build and evaluate a unit that will sterilize several cellular phones while they are being charged. The unit should be affordable, suitable for the use in a hospital ward, and user friendly. This will ensure regular exposure of health care workers' cellular phones to sterilizing UVC light and should decrease the risk of cross-infections caused by the use of cellular phones in hospitals.

Construction

A unit was constructed which can house different models of cellular phone chargers and contains UVC light bulbs (Figure 1). Cellular phone chargers that were used in the unit were based on cellular phones that healthcare workers were using at the time of constructing the unit. When a cellular phone is placed on one of the chargers, a push switch closes a circuit which allows the UVC light to be switched on (Figure 2). Three pairs of two opposite UVC lights are connected in parallel and a switch is placed in such a way that only when a phone is placed on a charger will the pair of lights used to sterilize that particular cellular phone turn on. This makes the device more energy efficient. As UVC light is harmful to humans, the mechanism is housed in a protective case which is impermeable to UCV light (Figure 3).

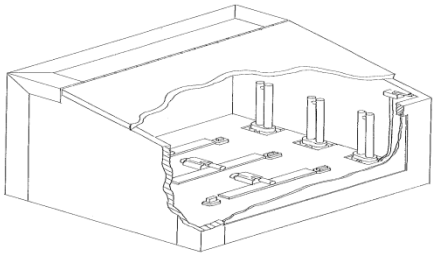

Figure 1: The inside of the combined multi-cellular phone charger and sterilizing unit which can house different models of cellular phone chargers and contains UVC light source

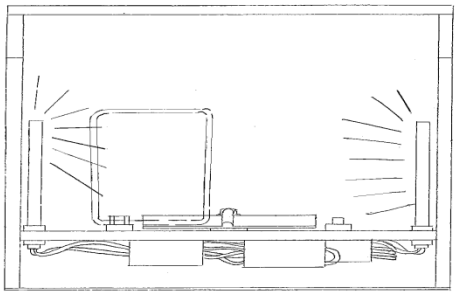

Figure 2: The inside of the combined multi-cellular phone charger and sterilizing unit showing a cellular phone on one of the chargers which has closed the circuit, with a push switch, allowing the UVC light to be switched on to sterilize the phone

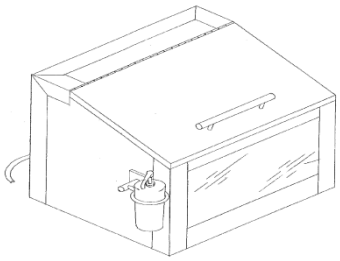

Figure 3: The outside of the combined multi-cellular phone charger and sterilizing unit which is impermeable to UVC slight and has a hand sanitizer attached. The glass window in the case is tinted to prevent damage to eyes; the glass is thick and shatterproof. The lid of the protective case is connected to a trip switch so that if the case is open the circuit is broken and the UVC lights will not switch on. The lid of the unit was designed with a slope to prevent health care workers storing things on top of the unit. A hand sanitizer is attached to the outside of the unit and health care workers would be instructed to clean their hands before retrieving the sterilized phone (Figure 3).

Testing the efficacy of the UV light charging unit

Thirty healthcare workers working in an intensive care unit were invited to participate in the study. After giving informed consent, their cellular phones were swabbed.

Participants were asked to place their cellular phone on a charger in the charging unit for ten minutes and then remove the cellular phone which was re-swabbed immediately and six hours later. Immediately after the swabs were taken they were placed in transport media and were taken to the laboratory where swabs were spread onto agar plates, streaked for individual colonies and cultured at 37^{o}C for 48 hours. Agar plates were examined, bacterial colonies were counted and organisms identified using colony morphology, Gram's stain and basic enzyme tests. *Staphylococcus aureus* was tested for antibiotic susceptibility to methicillin. All healthcare workers who participated in the study were asked to complete a questionnaire regarding the use of the UVC light charging unit and their cellular phones.

We considered the unit to be effective if its use resulted in a greater than 95% decrease in the bacterial load immediately after use and if the decrease persisted six hours after the use of the unit. The results were recorded and analysed in Microsoft Excel. The number and type of bacteria on healthcare workers cellular phones pre, immediately post-exposure and six-hours after exposure to the unit were compared using Student's *t* and chi-square tests of significance. All hospital acquired infections in the ICU was recorded for the month preceding the intervention. The bacteria found on the healthcare workers' cellular phones were compared to the bacteria that were known causes of the hospital acquired infections in the ICU. The study was approved by the Human Research Ethics Committee University of Witwatersrand (Protocol M1311106).

Results

Before exposure to the unit all 30 health care worker's cellular phones grew bacteria with 269 bacterial colonies being counted in total, a mean and median of 8.97 and 4 respectively, (IQR 1-9.5) colonies/phone. Immediately after the use of the unit only one colony was cultured from one healthcare worker's cellular phone (p = 0.0001), with a mean of 0.03 colonies/phone (p = 0.005). Six hours after the unit was used, of 25 cellular phones tested, two grew a total of three colonies, a mean of 0.12 colonies/phone (p = 0.0050) Organisms that were isolated included *S. aureus*, all sensitive to methicillin, coagulase negative staphylococcus, micrococcus, streptococci, Gram-positive bacilli, nocardia, Gram-negative bacilli and *Aspergillus sp.* Aspergillus was cultured off a cellular phone pre-exposure to the unit and the unit destroyed the fungus. Organisms isolated from patients with hospital acquired infections from the intensive care where the study was conducted included methicillin sensitive *S. aureus*, coagulase negative staphylococci, Gram-negative bacilli and enterococcus. Of the surveyed healthcare workers only 6.2% stated that they washed their hands after using their cellular phones, 80% allowed other people to use their cellular phones, and only 8.4% said that they cleaned their cellular phones regularly. All healthcare workers surveyed used their cellular phones while working with patients and were prepared to use the unit.

Discussion

All the participants used their cellular phones while in wards and clinics and only 6.2% of the healthcare workers surveyed said that they washed their hands in between using their cellular phones and interacting with patients. All the sampled cellular phones were contaminated with bacteria before being sterilized. Studies have shown that bacteria on inanimate objects such as cellular phones can be transferred to the users hand in a single touch (15) and are a likely cause of cross-infection in the hospital environment. The groups of bacteria identified from the cellular phones were the same groups of bacteria that led to hospital acquired infections in the ward for the month of sampling suggesting that cellular phones may play a role in of hospital acquired infections. However in order to directly link cellular phones as a cause of hospital acquired infections, further phenotyping and genotyping comparing the organisms would need to be done and a temporal relationship would need to be established. This should be the subject of further investigations. Using the multi-charging and sterilizing unit for 10 minutes resulted in an immediate decrease of 99.6% in the number of bacterial colonies cultured from the cellular phones. Six hours later this decrease persisted at 98.9% of the total original bacterial colonies cultured. Both these results were highly significant.

The fungus *Aspergillus sp*. was present on one cellular phone and the unit killed the fungus even though fungal spores have a thicker protective structure than bacteria making them harder to kill. Because UVC kills organisms by damaging the organisms DNA this method is likely to kill a wide range of organisms (16). It is likely that the use of the unit will destroy bacteria, including those that are antibiotic resistant, as well as other potential pathogens providing an important addition to other methods of infection control (16). Most hospital wards and intensive care wards in particular, are clean environments with strict infection control policies, including regular hand washing by healthcare workers, to limit the amount of bacteria in the wards.

Bringing into the wards and using contaminated devices, such as cellular phones, undermines infection control and may re-contaminate the clean environment. However, the use of cellular phones in the hospital environment can assist in patient care so that prohibiting the use of cellular phones would not be ideal. Sterilizing cellular phones regularly will reduce the risk of recontamination while still allowing the use of cellular phones in hospital wards.

It is possible that healthcare workers could be spreading hospital bacteria including antibiotic resistant bacteria into the community via their cellular phones. Because most healthcare workers are willing to share their phones with people in the community this poses a risk of introducing antibiotic resistant organisms into the community. The use of the sterilizing unit would greatly reduce this risk. All of the healthcare workers surveyed were able to use the unit, found it user-friendly and were prepared to use the prototype combined cellular phone sterilizer and charger. As the combined cellular phone sterilizer and charger proved to be germicidal and healthcare workers were prepared and easily able to use the device, the device could greatly reduce cellular phones as a source of contamination in the hospital environment. The multi-charging and sterilizing unit is an automatic system that requires no added input besides connecting the cellular phone to the correct charger.

The unit would ideally be placed in high-care units where hospital acquired infections are common, especially among immune compromised patients. In most high-care units nurses caring for patients have twelve hour shifts. It is feasible for the healthcare workers to charge their cellular phones at the start of and six hours into their shift. In the intensive care unit where the study took place, the nurses had a charging station. The multi-charging and sterilizing unit could replace the usual charging station. While the unit can be used to charge the healthcare workers' cellular phones its primary function is to sterilize the cellular phones, which only took ten minutes. This study was not able to establish a long term reduction in the incidence of hospital acquired infections in the ICU but this should be the subject of future research. The total cost of building the prototype of the multi-charging and sterilizing unit was $300 two thirds of which was for the cellular phone chargers. If these were sourced directly from the manufactures the cost would be considerably lower. Given that six cellular phones can be charged and sterilized simultaneously, and the potential reduction in hospital acquired infections and associated costs, the multi-charging and sterilizing unit would be affordable, considering hospital acquired infections are estimated to cost the United States of America US$10 billion a year.

Conclusion

The results showed that the healthcare workers' cellular phones were contaminated with potentially pathogenic bacteria and were a possible cause of cross infection in the ICU. The use of the multi-charging and sterilizing unit decreased the bacterial burden on the healthcare workers' cellular phones by over 98% and this decrease persisted for six hours after the healthcare worker had first used the unit. All the healthcare workers surveyed were prepared and able to use the unit. Thus the unit proved to be an effective and acceptable infection control intervention and if placed in the hospital environment could reduce the risk of cross infections and cross contamination, potentially decreasing hospital acquired infections.

Acknowledgements

I would like to acknowledge the hospital and laboratory management for allowing me to conduct the study, Dr R. Kuluratne and Ms N. Bulbulia for assisting with microbiological identification and support, Ms P. Moodley, Ms O. Peel Dr K. Ru, Dr G. Kay-Eddie for support and advise and Mr A. Emmerich for assistance with building the unit. I want to thank the healthcare workers who participated in the study.

Conflict of interest

This work was presented at the Intel International Science and Engineering Fair in Los Angeles, 2014 with the sponsorship of Eskom, South Africa. The authors declare no conflict of interest.

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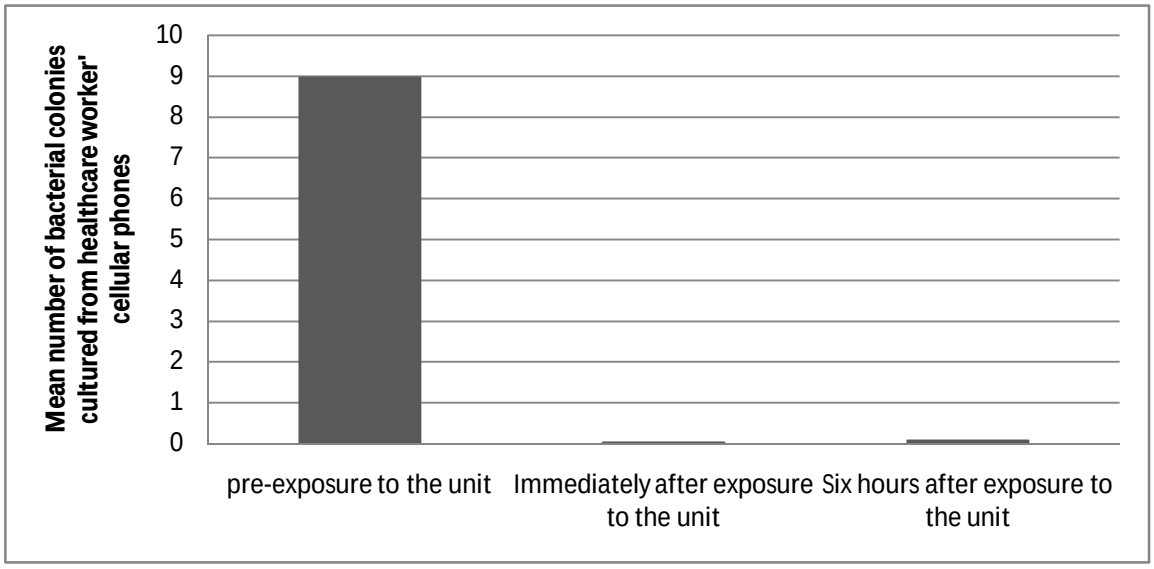

Figure 4: Graph showing the mean number of bacterial colonies/cellular phone pre-, immediately and six hours after being exposed to the combined cellular phone charger and sterilizing unit