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Effect of Ultraviolet - C Light Irradiation on the Bioburden of Hospital Contact Surfaces

Sixtus, A., Okafor*[1] Innocent, C., Ekuma,[3], Innocent, O., Eze[2], Uchenna, L., Ezeamaku[2], Felicia, E. Uwakwe[4], Augusta, C. Okafor[1], Chiagoziem, O., Emerole[5], Chidera, O., Obasi[5]

[1]Department of Biomedical Engineering, Federal University of Technology, Owerri, Nigeria

[2]Department of Polymer and Texile Engineering Federal University of Technology, Owerri, Nigeria

[3]Department of Biomedical Engineering, Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Nigeria

[4]Department of Environmental Health Science, Federal University of Technology, Owerri, Nigeriia

[5]Department of Public Health, Federal University of Technology, Owerri, Nigeria

* 0000-0002-6560-9277

ABSTRACT: Microbial species replicate and propagate on every surface. Contact surfaces have become inevitable in hospitals as they are for convenience of staff and visitors. These hospital contact surfaces are microbial reservoirs, which play a leading role in the spread of nosocomial infections. Cleaning and disinfection of these surfaces deplete its bioburden, however, paucity of fund occasioned by lean healthcare budget has impacted on the continuous Cleaning and disinfection of these surfaces. We used a sterile swab moistened in normal saline to collect 600 samples in duplicate from various contact surfaces of 20 randomly selected hospitals before and after ultraviolet – c light irradiation. Standard microbiological assay were used to identify and characterize the isolated microbes. The mean of the pre-exposure bioburden in cfu/square swabbed surface was significantly higher than that of the post-exposure bioburden in cfu/square swabbed contact surface with ($p < 0.005$). This result shows that ultraviolet – c light irradiation if effective in depleting the bioburden of hospital contact surfaces, we therefore, suggest the deployment of ultraviolet – c light irradiation in the integrated and continuous hospital contact surfaces disinfection regime.

KEY WORDS: Cleaning, contact, infections, microbiota, surfaces, irradiation and ultraviolet light

INTRODUCTION

Hospital contact surfaces are found in every hospital where they are in continuous contact with those around the hospital environment. These surfaces are known to pose a health challenge in the hospitals due to inoculated microbes [1, 2]. Microbes inhabit every surface they are in contact with, and in most cases continue to persist on the surfaces even after cleaning and disinfectant schedule. Their spread is aided by air circulation, human and other environmental factors [3, 4]. Microbial contaminants of hospital environments and surfaces are known to continue to exist for a long period of time [5, 6]. Their role in the spread of healthcare acquired infections (HAIs) [7], its associated economic burden [8], loss of man hour and strain on hospital bed spaces have led to increase in research relating to microbial contamination of these hospital contact surfaces.

Although, Studies have continued to elucidate the role of contact surfaces in the spread of microbes and pathogens in the hospitals, including the intensive care unit (ICU) [9 – 12]. Routine cleaning and disinfection of these surfaces, however, deplete its bioburden and aid the management of nosocomial infections [13, 14], but they are unsuccessful to making the surfaces sterile, hence, microbes are continually isolated from the surfaces [15], due to re- inoculation of microorganisms onto the surfaces by hospital staff, patients and their visitors, occasioned by poor hygiene, ineffective disinfection and cleaning [16]. These, therefore, make the surfaces microbial reservoir [17, 18].

The lethality of ultraviolet (UV) light on microorganisms has been reported [12, 2]. Its mode of action involves DNA damage, as UV irradiation induces mutagenesis, causing DNA lesions and decay of the purines and pyrimidines, thus resulting to cell cycle arrest of the microbes [18]. Studies on UV irradiation for microbial disinfection have focused on water irradiation for drinking water treatment, due to its lethality on *Cryptosporidium* and *Giardia* [19, 20]. No studies, however, have evaluated UV irradiation of hospital contact surfaces and thus, there is paucity of information on the potency of UV irradiation of these contact surfaces. This study however was carried out to elucidate the effect of UV-c light irradiation on the bioburden of hospital contact surfaces, so as to appraise its usage as an alternative for continuous hospital contact surface disinfections, since it

requires no chemical usage and produces no disinfection byproduct.

MATERIALS AND METHODS

Sample Collection

We collected from various hospital contact surfaces, by means of sterile swab sticks that were moistened in 500µl normal saline, 600 duplicate samples from 20 randomly selected hospitals within Owerri municipality. Each swab stick was swabbed on approximately two square inch area of a contact surface and was aseptically replaced in its container, this procedure was used to collect all the 600 duplicate samples which were labeled and moved to the laboratory for analysis.

Media Preparation

Media used for this study were MacConkey Agar [MA] and Nutrient Agar [NA]. They were sourced from Oxoid LTD UK and prepared according to the manufacturer's instruction. Nutrient Agar [NA] was used to isolate microbes and for the bioburden assay. Prepared media were aseptically dispensed into sterile Petri dishes, labeled and incubated over night to confirm sterility.

Working Stock Preparation

Nutrient broth was used to prepare the working stock. The broth was prepared according to the manufacturer's instruction, while 2ml aliquot was poured aseptically into 2 bijou borosilicate bottles. Each swab stick containing (both pre-irradiated and post-irradiated samples) was hosed out into each bottle and was labeled.

Bioburden Assay

Spread plate technique as described by [21] was used for the bioburden assay. 100µl aliquot of the working stock both (pre-irradiated and post-irradiated samples) was inoculated on to labeled duplicate plates of the growth media and were incubated at of 37^0C for 24 to 48 hour, after incubation, the plates were examined, morphological characteristics of the organisms were observed and recorded. Discrete viable microbial colonies of generated species were enumerated using Gallenkamp England colony counter. The total viable colony counts were expressed as colony forming units per µl [cfu/µl] and are equivalent to colony forming units per square inch swabbed hospital contact surfaces.

UV-C Light Irradiation

UV-C light irradiation of the surfaces was carried out using a mobile low pressure Trojan UV device that emitted light at 254 nm wavelength with the Ultraviolet intensity measured by five light intensity meters. The UV-C device was positioned at the middle of the room to be Irradiated and was switched on via a remote control. Depending on the size of the room and number of objects, approximately 22,000 µW/square inch dose of UV-C light was used to irradiate and disinfect each room for a period of about 50 minutes. Disinfection time was estimated automatically by use of the inverse-square law of UV-C effectiveness. Upon irradiation, the post-irradiation bioburden of the contact surfaces was determined.

Statistical Analysis

Duncan's Multiple Range [DMR] test using SPSS20.0 software for windows SPSS, 2011 were used for statistical analysis of the data.

RESULTS

The bioburden of the pre-irradiated and post-irradiated hospital contact surfaces are presented as mean and standard deviation in cfu/square inch of the swabbed surface as shown below.

Table 1: Mean and standard deviation of bioburden of pre-irradiated hospital contact surfaces in [cfu/square inch] of swabbed contact surfaces.

Hospital Contact Surfaces	Bioburden (cfu/square surfaces)
Door Handle	$7.4 \times 10^6 \pm 0.03$
Bed Rail	$7.3 \times 10^6 \pm 0.03$
Table Top	$5.9 \times 10^6 \pm 0.05$
Bedside Desk	$6.7 \times 10^6 \pm 0.02$
Ward Screen	$8.2 \times 10^6 \pm 0.04$

Value as mean ± SD of duplicate counts

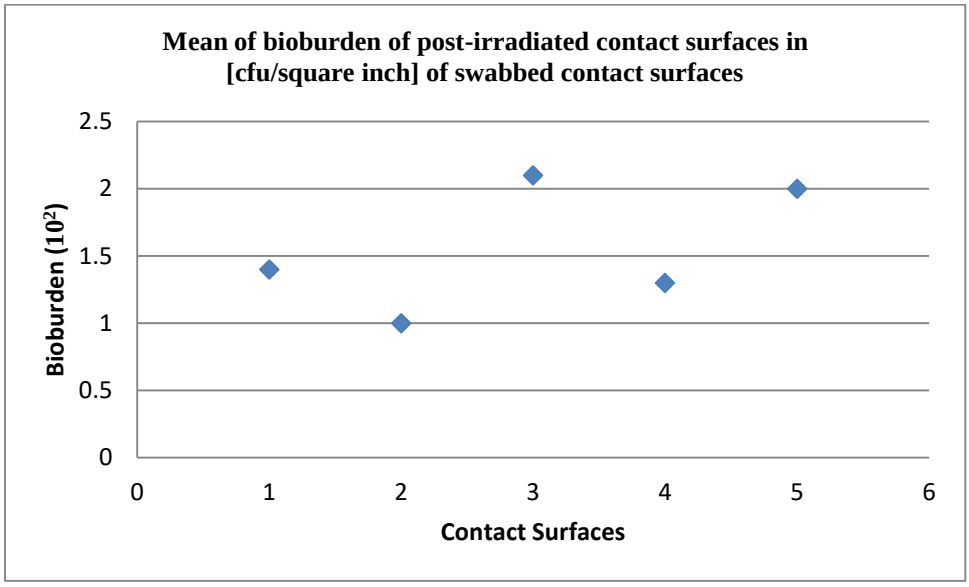

Figure 1: Graph of mean of the bioburden of post-irradiated hospital contact surfaces in [cfu/square inch] of swabbed contact surfaces. 1 = Door Handle, 2 = Bed Rail, 3 = Table Top, 4 = Bedside Desk and 5 = Ward Screen.

DISCUSSION

Contact surfaces found in hospitals are contaminated with an array of diversity of microorganisms depending on the microbiome of those that had contact with them[19, 22], as the frequency of contact and the health or hygienic status of those in contact with the surfaces play a role in the microbial populations that could be isolated on the surfaces. Routine cleaning and disinfection of the contact surfaces is recommended to effectively reduce their bioburden and the risks of acquiring nosocomial infections by workers, visitors and patiens in the hospitals and other healthcare facilities. Although, these cleaning regime have been shown to be grossly ineffective in achieving total disinfection [18, 12, 4], Integrated and target disinfection have also not achieved expected result, as microbes continue to persist on the surfaces [9, 12].

In this study, we explored UV irradiation of the hospital contact surfaces, to determine its efficacy in depleting the bioburden of the surfaces. The microbial yield from hospital contact surfaces is reported to be very high [15, 4] probably due to frequency of touch and negligence by hospital administrators and/or ineffective disinfection regime [20]. Some low contact surfaces are often neglected during routine disinfection, and have been reported to serve as reservoir for variety of microbes [4] and have also contributed to the persistency of healthcare acquired infections [4]. To ensure that no contact surface is neglected or omitted during disinfection, there is a need for UV irradiation of the surfaces in an integrated approach, as with UV, every surface will be irradiated and disinfected simultaneously. Hence, the mean and standard deviation from the mean of the bioburden in cfu/square inch of some of the contact surfaces in the hospitals sampled, before irradiation are: Door Handle 7.4 x 10^6 ± 0.03, Bed Rail 7.3 x 10^6 ± 0.03, Table Top 5.9 x 10^6 ± 0.05, Bedside Desk 6.7 x 10^6 ± 0.02 and Ward Screen 8.2 x 10^6 ± 0.04 (See Table 1). Ward Screen and Door Handle have a very high microbial yield, followed by bed rail; this is as a result of the frequency of touch and collaborate published data ([11, 23 – 25].

Following irradiation of the contact surfaces with UV – Light from a mobile low pressure Trojan UV device that emitted light at 254 nm wavelength, they were significant reduction in the microbial yield with ($p < 0.005$); hence the mean and standard deviation from the mean of the bioburden in cfu/square inch of some of the contact surfaces of the hospitals sampled were, for the Door Handle $1.4x10^2$± 0.04, Bed Rail $1.0x10^2$± 0.02, Table Top $2.2x10^2$± 0.03, Bedside Desk $1.3x10^2$± 0.03 and Ward Screen $2.0x10^2$± 0.04 (See Figure 1) indicating that UV irradiation is an effective disinfection option for the disinfection of hospital contact surfaces.

CONCLUSION

This study has shown that UV irradiation of hospital contact surfaces significantly depleted the bioburden of the surfaces as there is a significant variation in the bioburden of pre irradiated and post irradiated surfaces with $p < 0.005$. With this data, we conclude that UV irradiation, as part of an integrated disinfection regime, will play a role in the control of nosocomial infections.

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Conflict of interest

There is no conflict of interest

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