LumiBio®
Infection | Prevention | Control

LIMITING FACTORS ON MOBILE ULTRA-VIOLET SYSTEMS FOR ROOM DISINFECTION

Introduction

Room disinfection by using mobile ultra-violet (UV) systems in addition to traditional cleaning for healthcare settings is an emergent application of technology. It has been evaluated by various health departments and found to be requiring more research/data (1)(2)(3). This article aims to identify specific areas where this would be appropriate.

Background

The germicidal effect of UV has been researched for nearly 150 years (4) and has been utilised successfully in water purification and air handling (5). In these applications the working environment is extremely controllable, systems being constructed to minimise aspects and variables causing reductions in effectiveness. Leveraging this technology in healthcare settings introduces dynamic and variable environmental considerations that need to be addressed.
UV Room disinfection is typically carried out using either a steady high intensity beam or a pulsed discharge of UVC light (5). Whilst there are technical differences between the two methods, for the purposes of this article they are treated as the same due to the similarities of the systems in technical nature, effects and in factors affecting resultant use.

Discussion

arious pathogens have different susceptibilities to UV radiation and therefore require exposure to different energy levels in order to bring about a reduction in numbers (5)(6)(7)(8). The points below are related to or have a bearing on the energy received and require consideration.
Effect of distance/room size: As the UV system is a point source of energy the intensity is inversely proportional to the square of the distance from the unit. This means that a surface at 4 metres from the unit will only receive 6.25% of the energy to that of a surface 1 metre from the unit. This can be overcome by using multiple units or repositioning the unit for multiple treatments in the same room. Either of these options would still result in some areas receiving greater exposure than others. Effect of orientation: A surface parallel to the unit will receive greater exposure than one perpendicular to the unit (6)(7)(9). Monitoring equipment in various locations would confirm energy levels on a given surface.
Line of sight/shadowing: Any surface not in direct line of sight of the unit is considered “shadowed” and would not directly receive any of the transmitted UV energy. In reality some of these areas would be exposed to a proportion of UV light by way of reflection from other

surfaces (7)(10). Multiple units/repositioning would reduce this but again only use of monitoring equipment could confirm energy levels on a shadowed surface.
Type of surface: Studies on the use of UV typically use hard flat surfaces as sample points. Studies on the use of UV for disinfection of PPE have shown smaller log reductions on mask straps than on the surface of the filter (11), thereby bringing into question the effectiveness of UV on soft and complex surfaces e.g. furnishings.
Humidity: In certain environments high levels of humidity may be experienced. UV systems have been shown to have a much-reduced effect dependant on humidity (5)(8).
Material degradation: The effects of UV on materials are widely documented (5). However, most UV stabilisers used in common materials typically only protect from UVA & UVB radiation. UVC is not normally a consideration as it is filtered out from sunlight by the earth's atmosphere (12). As UV room disinfection units utilise UVC material susceptibility must be assessed. Studies have shown changes to material properties when exposed to varying levels of UVC including a reduction in strength of PPE (13).
Safety: UV radiation is harmful to humans (5)(14) and there have been impacts on health due to exposure(15) therefore controlled access to the area being treated is required. Some systems utilise motion sensors to mitigate this risk. Germicidal UVC systems operate at 254nm with some also emitting 185nm radiation. These 185nm systems can produce ozone (5) which has its own associated health risks and material degradation properties which need to be assessed.

Conclusion

Use of UV room disinfection adjunct to traditional cleaning should be subject to careful consideration. Due to the variables involved, use of monitoring systems to confirm energy levels is to be recommended to ensure effective disinfection. Some of the factors above can be addressed by using multiple units/treatments. This however results in greater exposure to some surfaces with a potential increase in degradation of materials in these areas. The difficulty in exposing some shadowed surfaces means these are less likely to be disinfected than by other methods. Overall, long term study is required in all the above points to assess the clinical benefits and shortcomings of UV disinfection in healthcare settings over prolonged periods.

References

(1) Portable Ultraviolet Light Surface-Disinfecting Devices for Prevention of Hospital-Acquired Infections: Health Quality Ontario 2017
(2) Summary of disinfection technologies for microbial control: Environmental and Modelling group (EMG) for the Scientific Advisory Group for Emergencies (SAGE). 18 May 2020.
(3) Literature Review and Practice Recommendations: Existing and emerging technologies used for decontamination of the healthcare environment Ultraviolet Light. Health Protection Scotland. December 2016
(4) Downes, A.; Blunt, T: Researches on the Effect of Light upon Bacteria and other Organisms. Proceedings of the Royal Society of London (1854-1905). 1877-01-01. 26:488–500

(5) Wladyslaw Kowalski: Ultraviolet Germicidal Irradiation Handbook. Springer Heidelberg Dordrecht London New York ISBN 978-3-642-01998-2, DOI 10.1007/978-3-642-01999-9.
(6) Lindblad M, Tano E, Lindahl C, Huss F. Ultraviolet-C decontamination of a hospital room: Amount of UV light needed. Burns. 2020;46(4):842-849. doi:10.1016/j.burns.2019.10.004
(7) Boyce, J., & Donskey, C. (2019). Understanding ultraviolet light surface decontamination in hospital rooms: A primer. Infection Control & Hospital Epidemiology, 40(9), 1030-1035. doi:10.1017/ice.2019.161
(8) Chun-Chieh Tseng & Chih-Shan Li (2007) Inactivation of Viruses on Surfaces by Ultraviolet Germicidal Irradiation, Journal of Occupational and Environmental Hygiene, 4:6, 400-405, DOI:10.1080/15459620701329012
(9) Cadnum, J., Tomas, M., Sankar, T., Jencson, A., Mathew, J., Kundrapu, S., & Donskey, C. (2016). Effect of Variation in Test Methods on Performance of Ultraviolet-C Radiation Room Decontamination. Infection Control & Hospital Epidemiology, 37(5), 555-560.
doi:10.1017/ice.2015.349
(10) Lindsley WG, McClelland TL, Neu DT, et al. Ambulance disinfection using Ultraviolet Germicidal Irradiation (UVGI): Effects of fixture location and surface reflectivity. J Occup Environ Hyg. 2018;15(1):1-12. doi:10.1080/15459624.2017.1376067
(11) D.Mills, D.A.Harnish, C Lawrence, M.Sandoval-Powers, B.K.Heimbuch Ultraviolet germicidal irradiation of influenza-contaminated N95filtering facepiece respirators. American Journal of Infection Control 46 (2018) e49-e55
(12) G.Wypych, Handbook of UV degradation and stabilization. ChemTec Publishing, 2011,2015,2020, ISBN: 978-1-927885-57-4
(13)B.Heimbuch, D.Harnish, Research to Mitigate a Shortage of Respiratory Protection Devices During Public Health Emergencies, Applied Research Associates Inc. HHSF223201400158C Final Report September 30, 2019
(14) Ultraviolet radiation(Environmental health criteria: 160) World Health Organisation 1994 ISBN 92 4 157160 8
(15) D Sylvain, L Tapp: UV-C Exposure and Health Effects in Surgical Suite Personnel. Health Hazard Evaluation Report HETA 2007-0257-3082Brigham and Women's Hospital Boston, Massachusetts May 2009.DEPARTMENT OF HEALTH AND HUMAN SERVICES Centers for Disease Control and Prevention Workplace Safety and Health National Institute for Occupational Safety and Health

Disclaimer