UV LAMPS

RECOMMENDATION

We recommend against the use of UV lamps or other UV devices in any place outside of a controlled clinic or hospital setting to prevent and control COVID-19 transmission. *(Low quality of evidence; Strong recommendation)*

Consensus Issues

A strong recommendation was made based on the potential adverse reactions and the risks associated with UV lamps. Although the panel recognizes the germicidal effect of UV light in clinical settings, emphasis was made to limiting its use only in controlled environments (i.e., without the presence of human beings) with trained staff to minimize its potential health hazards. Since the use of personal UV lamps and devices in households has also become widespread following advertisements, the public must be appropriately informed that misuse of these devices may cause harmful, long-term effects on health.

EVIDENCE SUMMARY

Are ultraviolet lamps effective in infection prevention and control of COVID-19 infections in public spaces in locations with sustained community transmission?

Gina Antonina S. Eubanas, MD, FPDS, GDip (ClinEpi), Namnama P. Villarta-De Dios, MD, MSc, Howell Henrian G. Bayona, MSc, CSP-PASP

Key Findings

No direct evidence was found evaluating the effectiveness of ultraviolet lamps in the prevention and control of COVID-19 infections in public spaces in locations with sustained community transmission. Indirect evidence of low quality showed some benefit in reducing the incidence of viral infection in a hospital ward. However, the evidence for its potential harm such as skin erythema, ocular itching, blurring and conjunctival injections, was more significant.

Introduction

Ultraviolet light C (UVC), as a germicidal, is widely used in health care facilities for sterilization of instruments and rooms. Its wavelength of 250-280 nm can inactivate microorganisms by breaking the DNA or RNA causing defects in cell replication and eventually cell death [1]. There are various

UVC devices used in hospital units, namely: UV-C surface-disinfecting devices, UV-C germicidal irradiation technologies, UV-C irradiation lamps and mercury-based, light emitting diodes (LED), and pulsed xenon (PX) lamps [2].

The generally acceptable dose of UVC to kill at least 99.9% of any pathogenic microorganism is 40mJ/cm2 of 254 nm light. But the current guidelines for exposure to UVC radiation for eyes and skin should not exceed 3 mJ/cm^2 at 270 nm. At 254 nm, the maximum exposure limit is set at 6mJ/cm^2 [6]. The more common health risks associated with UV-C exposure are skin and eye irritation [3]. In addition, the UVC photons are only effective if they make direct contact with the surface, limiting its effectiveness on creases or on areas that cannot be reached by light [8].

Review Methods

We searched for relevant studies on 12 February 2021 in various electronic databases (PubMed, Google Scholar, Cochrane CENTRAL, pre-print databases such as Chinaxiv.org, Medrxiv and biorxiv.org, trial registries of EU, Canada, IISRCTN, China, ANZ, Brazil, Germany, Japan, Korea, India, the Netherlands and Pan Africa) and recommendations from health agencies (USPSTF, NICE, WHO, EU, Canadian Preventive Task Force, Australia and Covid-19 Open Living Evidence Synthesis). Search terms include both free text and MeSH terms for “ultraviolet light,” “UVC,” “ultraviolet rays,” “black light,” or “far UVC,” and “disinfection,” or “sterilization.”

Results

We did not find any direct evidence that studied the effects of UV germicidal irradiation in preventing or reducing infection rates in community settings. Indirect evidence from 2 systematic reviews [7,12] of non-clinical studies on SARS-CoV-2 virus and 2 in-vitro studies [5,9] assessed the efficacy of various types of UV lamps in deactivating or reducing viral load in laboratory and hospital settings [7].

The rapid review summarized existing literature on the viability (7 studies; Table 1) of the SARS-CoV-2 virus, and the efficacy of UVGI in reducing viral load under laboratory conditions (20 studies). UVGI showed partial to complete viral elimination ($\geq$ 4.0 $\log_{10}$ reduction) on N95 masks and filtering facepiece respirators (Appendix 1, Table 2). Results varied depending on factors such as viral titers, inoculum size, viral medium and the shape, contour and type of material or surface, and thus also explains the relatively inconsistent findings in literature [7].

Another systematic review was done on the efficacy and safety of UV-C in sterilizing hospital units such as operating rooms, hallways, wards and patient rooms [6]. Twelve (12) eligible studies including 1 cluster RCT, 7 quasi-experimental and 4 uncontrolled before and after) used various UV-C lamps and Pulsed Xenon UVC (PX-UV) lamps (Table 3). The overall certainty of evidence from these 12 studies was rated low because study design limitations, imprecision, and high risk of bias. Only one study reported a 44% reduction in incidence of viral infections (influenza, rhinovirus, enterovirus, pneumovirus) among pediatric patients in that facility (Incidence risk ratio = 0.56, 95%CI: 0.37, 0.84, p=0.003)) [12]. Ten of the 12 studies concluded that UV-C is an efficacious complement to existing cleaning protocols, adding that the latter remained far more superior in removing microorganisms [6].

Two in vitro studies utilized 222nm UVC (far UVC) to deactivate cells incubated with coronaviruses and concluded that far UVC can be used in public places because it has very limited penetration in biological materials such as the stratum corneum [5,9]. However, they found that the applied dose was not the same as the actual dose received by the target virus, citing the influence of surface irregularities, shadowing, and type of surrounding medium and structures [7]. Although only 5% of UVC penetrates the stratum corneum, UVC from artificial light sources are readily absorbed by the eyes and skin and with increased exposure time, intensity and distance from the source. Thus, it can potentially cause adverse reactions such as skin erythema, ocular itching, blurring and conjunctival injections, among others. The magnitude of adverse reactions is dependent on the exposure duration, intensity, and number of cycles. One laboratory study showed the effective protection provided by clear face shields, UV goggles and sunscreen to protect against side effects of UVC exposure [8].

Recommendations from Other Groups

WHO recommends not to use UV lamps to disinfect hands or other skin surfaces It can cause irritation and damage to the eyes [10]. Similarly, the Philippine DOH warns against the use of devices emitting ultraviolet (UV) light to disinfect objects or surfaces [11] because of adverse effects such as damage to one's sight, skin irritation, burns, and increased the risk of skin cancer. Their use should only be limited to hospitals, clinics, and other health-care centers [11].

The Philippine Society for Microbiology and Infectious Diseases (PSMID) did not mention the use of UV lamps in its Unified COVID-19 Algorithms. Other international groups (NICE, USPSTF and the Australian National Covid-19 Clinical Evidence Task Force) did not have any recommendation on UV-C use.

References

[1] Hadi J, Dunowska M, Wu S, Brightwell G. Control Measures for SARS-CoV-2: A Review on Light-Based Inactivation of Single-Stranded RNA Viruses. Pathogens.2020 Sep 8;9(9):737. doi: 10.3390/pathogens9090737. PMID: 32911671; PMCID: PMC7558314.

[2] Yin R, Dai T, Avci P, Jorge AE, de Melo WC, Vecchio D, *et al*. Light based anti-infectives: Ultraviolet C irradiation, photodynamic therapy, blue light, and beyond. Curr Opin Pharmacol 2013;13:731-62.

[3] International Commission on Non-Ionizing Radiation Protection. Guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400 nm (incoherent optical radiation). Health Phys 2004;87:171-86.

[4] Kaidzu S, Sugihara K, Sasaki M, Nishiaki A, Igarashi T, Tanito M. Evaluation of acute corneal damage induced by 222-nm and 254-nm ultraviolet light in Sprague-Dawley rats. Free Radic Res 2019;53:611-7.

[5] Hickerson RP, Conneely MJ, Tsutsumi SKH, Wood K, Jackson DN, Ibbotson SH,Eadie E. Minimal, superficial DNA damage in human skin from filtered far-ultraviolet-C (UV-C). Br J Dermatol. 2021 Jan 16. doi: 10.1111/bjd.19816. Epub ahead of print. PMID: 33452809.

[6] Ramos CCR, Roque JA, Sarmiento DB, Suarez LEG, Sunio JTP, Hilario AL. Use of ultraviolet-C in environmental sterilization in hospitals: A systematic review on efficacy and safety. International Journal of Health sciences. 2020Nov;14(6):52–65.

[7] Derraik JGB, Anderson WA, Connelly EA, Anderson YC. Rapid Review of SARS-CoV-1 and SARS-CoV-2 Viability, Susceptibility to Treatment, and the Disinfection and Reuse of PPE, Particularly Filtering Facepiece Respirators. Int J Environ Res Public Health. 2020 Aug 22;17(17):6117. doi: 10.3390/ijerph17176117. PMID: 32842655; PMCID: PMC7504573.

[8] Lyons, A.B., Narla, S., Torres, A.E., Parks-Miller, A., Kohli, I., Ozog, D.M., Lim, H.W. and Hamzavi, I.H. (2021), Skin and eye protection against ultraviolet C from ultraviolet germicidal irradiation devices during the COVID-19 pandemic. Int J Dermatol. https://doi.org/10.1111/ijd.15255

[9] Buonanno M, Ponnaiya B, Welch D, Stanislauskas M, Randers- Pehrson G, Smilenov L, *et al*. Germicidal efficacy and mammalian skin safety of 222-nm UV light. Radiat Res 2017;187:483-91.

[10] COVID-19 Mythbusters [Internet]. World Health Organization. World Health Organization; [cited 2021Jan26]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/myth-busters#uv

[11] Santos,TG (2020). 'DOH cautions against "tuob," UV light devices' [online]. *Philippine Daily Inquirer. Manila*. 26 June 2020.[accessed 26 February 2021].

[12] Pavia M, Simpser E, Becker M, Mainquist WK, Velez KA. The effect of ultraviolet-C technology on viral infection incidence in a pediatric long-term care facility. Am J Infect Control 2018;46:720-2.

Appendix 1. Summary of Findings

Table 1. Studies reporting the efficacy of UV germicidal irradiation (UVGI) against SARS-CoV-2 (Derriak, 2020)

Author, Year	Inoculum	UV Exposure	Key Findings
Fischer, 2020	Stainless steel and N95	UVC 260-285nm	Stainless steel - ≥4Log10 reduction N95 – LOD not reached with 1980 mJ/cm^2
Heilingloh 2020	Well plates	UVC 254	>6.7 log10 reduction at 1048 mJ/cm^2
Inagaki 2020	Petri dish	Deep UV-LED 280 nm	Below LOD (~3.2 log10 reduction at 75 mJ/cm^2
Smith 2002	N95 models with direct infiltration of high viral titers	UVC 254	UVC did not inactivate the virus from N95 at 630 mJ/cm^2
Ozog 2020	Viral droplets on N95 parts (nosepiece, apex, chin piece, strap)	UVC 254	Most facepiece samples (n=32) had viral loads <LOD but 4 samples from 2 models did not at 1500 mJ/cm^2

- LOD, Limit of detection

Table 2. Table of UVC devices and their known effects on viral load reduction and duration to effect.

Author, Year	UV device	Effectivity/ viral load reduction
Simmons 2020Aug	Pulsed Xenon UV	>4.54 log10 (99.992% reduction) at 2 min
Storm 2020Dec	UVC 254nm	>99.9 reduction at 9 sec wet virus >99.9% reduction at 5 sec for dry virus (droplets)
Fischer 2020	UVC 254nm	>4 log10 reduction with 330mJ/cm2 on stainless steel
Heilingloh 2020	UVC 254nm	>6.7 log10 reduction at 1048 mJ/cm2 on well plates
Inagaki 2020	DUV-LED 280 nm	~3.2 log10 reduction at 75 mJ/cm2
Bianco 2020	Low pressure Hg-lamp	ca5.7 log10 reduction at 15 mJ/cm2
Buonanno 2020	far UVC 217-222	99.9% reduction at 1.2 to 1.7 mJ/cm2 for 25 minutes

Table 3. Results of efficacy studies on UV-C (Ramos, 2020)

Author, Year	Study Design	Hospital type	UV device	Findings
Anderson, 2017	Cluster RCT	9 hospitals	UVC Tru-D	Incidence of target organisms (C difficile, MRSA, VRE) reduced RR 0.70 (95%CI 0.5 to 0.98, p=0.036
Cooper 2016	Quasi-experimental	Community hospital	UVC Sanuvox	Treated bathroom had 35.2% (aerobic) and 47.7% (anaerobic) reduction in bacterial bioaerosol concentration
Dippenaar 2018	Quasi-experimental	Acute care	PX-UV Xenex	90% reduction in total surface bioburden; risk trend/wk = 0.19 (95%CI (0.056 to 0.67) p=0.01
El Haddad 2017	Quasi-experimental	Cancer center	PX-UV Xenex	Significant reduction of 72.5% (p=0.0328) at 2 min and 73.1% (p=0.0075) at 8 min in high touch surfaces
Ethington 2018	Quasi-experimental	Acute care	UVC, Am Green tech	Reduced bacterial viable air particles by 42% (p=0.035)
Jinadatha 2014	Quasi-experimental	Acute care	PX-UV Xenex	IRR adjusted = 7 (95%CI 1-41)
Morikane 2020	Before & After	Tertiary Care	PX-UV Xenex	Incidence of MRSA reduced IRR 0.71 (p=0.002) from 13.8 to 9.9/10000 px days
Nerandzic 2012	Before & After	Acute care	Sterilray, Healthy Env Innov	Signif reduction in frequency of C difficile and MRSA cultures (p=0.007)
Pavia 2018	Quasi-experimental	Pediatric center	UVC Chlorox Healthcare	44% reduction in VIRAL infection incidence among pedia pxs (IRR 0.56; 95% CI (0.37-0.84)
Penno 2017	Before & After	Tertiary care	UVC Steritrak	Reduced risk of overall contamination by 0.48X with 1.04 log10 reduction ([p<0.001)
Sampathkumar 2016	Quasi-experimental	Tertiary Care	PX-UV Xenex	C difficile infection reduced from 28.7/10000 pxdays to 11.2 (p=0.03)
Villacis 2019	Before & After	Secondary Care	PX-UV Xenex	Signif reduction in CFU counts in ORs 87% (p<0.001) and patient rooms 76% (p<0.001)