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Communication

Public acceptance of the use of Far-UVC for virus inactivation: Challenges and opportunities

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ABSTRACT

Objectives: There is an urgent need for technologies which can reduce the impact of airborne disease transmission. Far-UVC (200–230 nm) is a range of wavelengths growing in relevance for airborne virus disinfection in occupied public spaces. These wavelengths quickly and efficiently inactivate airborne pathogens, while to current knowledge remaining low risk to room occupants. If there is ever to be an effective widespread implementation of these technologies in public spaces, it is important to assess public opinion to ensure appropriate use and understanding of the technology.

Methods: A self-administered survey was distributed through social media channels with several questions to gather opinions on using Far-UVC. The survey was distributed between September 2021 and January 2022. Outcome measures included how safe respondents would feel with or without Far-UVC in indoor spaces and how acceptable the technology would be in certain indoor spaces.

Results: There were 111 respondents to the survey. The median age range of the respondents was 36–45, most respondents had never studied biology or related science subjects beyond school level (68%, $n = 76$), and 87% ($n = 97$) were indoor workers or attended formal education. Less than one-third of respondents had heard of the term 'Far-UVC'. Though, on learning about the core principles of Far-UVC, respondents became more supportive of its use in public spaces. Acceptance of Far-UVC was strongest in areas where a higher benefit-risk ratio was perceived, such as in hospitals.

Conclusion: We have shown that when the basic concepts of Far-UVC are clearly communicated, public opinion on its adoption improves. Without such a general understanding amongst members of the public, Far-UVC may then face challenges in gaining widespread adoption. The assessment of public opinion presented here will help to determine where primary concerns lie, and the actions needed to address these.

Introduction

Since the start of the COVID-19 pandemic, strategies to help mitigate the spread of viruses have been the subject of research and public debate. One such approach is the use of ultraviolet-C (UVC) wavelengths to inactivate viruses in the air and on surfaces. UVC technology, often referred to as ultraviolet germicidal irradiation (UVGI) or germicidal ultraviolet (GUV), has historically been used in water treatment facilities and heating, ventilation and air conditioning (HVAC) units to reduce disease transmission between rooms. Whilst both techniques are effective in their respective purposes, neither of these applications of UVC is specifically designed to prevent or reduce the risk of in-room transmission of disease. A proven effective measure for in-room transmission mitigation is irradiation of the upper air volume of a room, above head height, with UVC to inactivate airborne pathogens[1]. In such systems, irradiation of people is prevented by engineering controls because the source of UVC, mercury vapour lamps (with an emission peak at 254 nanometres (nm)), are known to have adverse effects on human health such as erythema (skin redness) and keratitis (inflammation of the eye's cornea)[2]. Before the COVID-19 pandemic, implementation of upper-room GUV was limited to mainly control the spread of tuberculosis in specialist hospitals and whilst the use of upper-room GUV has increased, it has not been as widespread as one might expect given the good evidence base on effectiveness and minimal reports of accidental overexposure to the UVC[3]. Reasons for a lack of uptake could be a lack of competent installers, maintenance of such systems, lack of public awareness and fear of the harmful effects of the UVC.

A potential solution is Far-UVC, which encompasses a sub-range of UVC (200–230 nm) usually from filtered Krypton Chloride excimer lamps, which primarily emit at 222 nm. These wavelengths are significantly less harmful to the skin and eyes than longer wavelengths of UVC due to minimal penetration in tissue. Therefore, it is proposed that

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whole room irradiation of occupied spaces can be performed to disinfect the air [4,5]. While there is good evidence for the use of Far-UVC to inactivate viruses and other pathogens[6,7] it is important that the general public is well informed about the benefits, limitations, and safety implications of UVC technologies if they are to be deployed in public or private spaces.

Methods

The authors developed a survey in-house and distributed via social media (Facebook, Twitter, Instagram, Reddit, SurveyCircle and SurveyWorld), asking respondents several questions about Far-UVC (Supplement #1). The survey asked what respondents knew about Far-UVC, then outlined some information on Far-UVC and asked for the respondents' opinions. The information given to respondents was:

UVC is a type of UV that is currently used in some places (such as hospitals and water treatment plants) as a disinfectant. It can kill viruses and bacteria in the air and on surfaces, but is only used in unoccupied rooms or above people's heads, as it can cause damage to the skin and eyes. Use of UVC has been proven to reduce airborne transmission of diseases. UVC is not found in sunlight as it is absorbed by the Earth's atmosphere.

Far-UVC is a short wavelength of UVC that, according to ongoing research, can kill viruses and bacteria in the air without causing damage to the human skin or eyes. This could be a more effective alternative to UVC and be used to sanitize the air of public places and reduce the spread of diseases such as COVID-19.

These statements were written to provide as clear and succinct information as possible whilst being accurate. A note is made in this statement that research on Far-UVC especially is ongoing, however, current evidence supports the statements made. 111 responses to the survey were collected (Supplement #2), and the data were analysed for trends and common concerns or themes. Data were collected from 4th Nov 2021 to 28th Jan 2022.

Results

The age range of respondents was from 18 to 75 years old ($n = 111$). The most populous age range was 18–25 years (37%, $n = 41$), followed by 36–45 years (23%, $n = 26$) then 46–55 years (13%, $n = 14$), 26–35 and 56–65 years (11%, $n = 12$), and 66–75 years (5%, $n = 6$). Most respondents had never studied biology or related science subjects beyond school level (68%, $n = 76$), and 87% ($n = 97$) were indoor workers or attended formal education.

Of the respondents, 32% ($n = 36$) had heard of the term 'Far-UVC'. In comparison, 65% ($n = 72$) had heard of 'UVC'. On a scale of 1 (very unsafe) to 5 (very safe), 40% ($n = 44$) scored 2 or less and 35% ($n = 39$) scored 4 or more based on their assumptions of safety regarding current conditions in public spaces during the pandemic. However, after some introduction to Far-UVC, respondents said they would feel safer in indoor spaces if Far-UVC was used: 19% ($n = 21$) scored 2 or less while 56% ($n = 62$) scored 4 or more (Fig. 1).

Overall, there was good support for the use of Far-UVC in public spaces. There was greatest support for Far-UVC use in hospitals (77%, $n = 85$), followed by public transport (61%, $n = 68$), public leisure spaces (61%, $n = 68$) and the workplace (57%, $n = 63$). In a corresponding free-text box, the common theme in responses was that it was considered that the benefits would outweigh the risks in settings such as hospitals, but that Far-UVC might be less necessary in subjectively lower-risk environments, such as the workplace. However, respondents noted that due to an increase in working from home, many workplaces are indeed their own homes. This perhaps also indicated the relative lack of interest in home use of Far-UVC.

Discussion

Considering the more reserved views on Far-UVC, respondents were

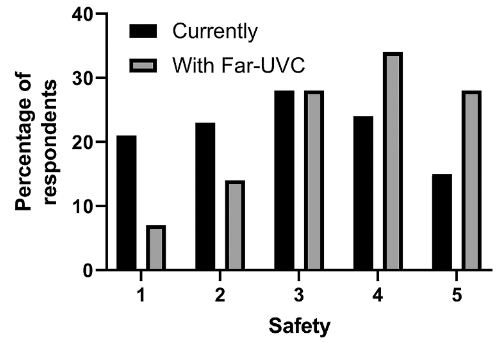

Fig. 1. Responses to the questions 'On a scale of 1–5, how safe do you currently feel in public spaces/how safe would you feel if Far-UVC lighting was installed?', where 1 is 'very unsafe' and 5 is 'very safe'.

primarily concerned about safety, effectiveness and cost. It would be fair to assume that some safety information surrounding solar UVR blends into opinions on Far-UVC. Sun safety messaging has been very effective – in our survey, 100% ($n = 111$) of respondents were aware of the hazards associated with solar UVR. Encouragingly, 87% ($n = 97$) were also aware of the beneficial effects of solar UVR, which demonstrates the capability to appreciate the nuances of solar UVR exposure. With effective messaging, there is no reason to suspect that a similar level of understanding could not be achieved for Far-UVC.

There are some limitations to our study, primarily that respondents were likely somewhat biased as a result of some of the networks of the investigators that the survey was shared via (professional Twitter, LinkedIn accounts), exemplified in the authors' opinion by the number of respondents who had previously heard of Far-UVC (32% $n = 36$). We are reassured however as even excluding such respondents in the analysis, the overall trend in Fig. 1 is preserved (data not shown). Additionally, the survey was only available during the transition into the winter months, whereby there may be a change in opinion on measures to combat indoor disease transmission compared to the summer months for example. In a future study design, gathering public opinion at different times of the year would be beneficial.

The cost of Far-UVC is unlikely to be borne directly by the individual, and in any case, is in flux due to market competition and manufacturing advancements. Products tend to be more expensive during the 'innovators' and 'early adopters' phase of the adoption curve[8], which is arguably where Far-UVC stands at the time of writing. Following successful early adoption of and confidence in the technology it is projected that the cost of Far-UVC installations would decrease. Information relating to engagement is then critical for Far-UVC to have a successful lifetime in the market and assessing public opinion will be a cornerstone of that.

Understanding the efficacy reported in studies requires an understanding of *how* efficacy is reported and how that may translate to 'real-world' scenarios. It is common for the results of trials to be misrepresented, either through spin or misinterpretation from published data to media reporting[9]. Truncated claims about the efficacy of any particular Far-UVC device may be harmful to the adoption of the technology if there is insufficient supporting information or doubt about the veracity of the claims. Researchers in this case must be mindful of how data are reported, engage with the wider communication of their results and liaise with the Far-UVC industry, such that inaccurate messaging is not propagated. Dialogue must be created with the wider public so that the translation of trial data to practical implementation is understood and, also so that study designs have translatability to relevant scenarios. The importance of patient and public interest (PPI) groups in early engagement with research design have been stressed in this regard[10].

This survey helps to outline the key hurdles facing widespread public adoption of Far-UVC. Though generally the outlook is positive, there is still clear justification to engage with the wider public and address concerns such that the endemic knowledge on Far-UVC is clear. Such channels utilised for current health protection measures could be leveraged to provide informative and reputable information on Far-UVC, as presently there is a lack of such information. A centralised, freely accessible resource would be key in appropriately conveying information on Far-UVC to the wider public.

Author declarations

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Ethical approval

Ethical approval was received by the University of Dundee Research Ethics Committee.

Declaration of Competing Interest

The authors have no conflicts of interest to declare

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ipemt.2023.100017.

References

[1] Miller S. Efficacy of ultraviolet irradiation in controlling the spread of tuberculosis [Internet]. Atlanta; 2002 [cited 2022 Mar 28]. Available from: https://stacks.cdc.gov/view/cdc/11285.

[2] ICNIRP, Guidelines on the limit of exposure to ultraviolet radiation of wavelengths between 180nm and 400nm (incoherent optical radiation), Health Phys 87 (2) (2004) 171–186.

[3] E. Nardell, R. Vincent, D.H. Sliney, Upper-room ultraviolet germicidal irradiation (UVGI) for air disinfection: a symposium in print, Photochem Photobiol 89 (4) (2013) 764–769. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/php.12098.

[4] E. Eadie, I.M.R. Barnard, S.H. Ibbotson, K Wood, Extreme exposure to filtered far-UVC: a Case Study, Photochem Photobiol (2021), https://doi.org/10.1111/php.13385.

[5] 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. https://doi.org/10.1667/RR0010CC1 [Internet]. 2017 Feb 22 [cited 2022 Jan 24];187(4):493–501. Available from: https://bioone.org/journals/radiation-research/volume-187/issue-4/RR0010CC.1/Germicidal-Efficacy-and-Mammalian-Skin-Safety-of-222-nm-UV/10.1667/RR0010CC.1.full.

[6] M. Buonanno, D. Welch, I. Shuryak, D.J. Brenner, Far-UVC light (222 nm) efficiently and safely inactivates airborne human coronaviruses, Sci Rep 10 (1) (2020) 1–8. Available from: https://www.nature.com/articles/s41598-020-67211-2.

[7] E. Eadie, W. Hiwar, L. Fletcher, E. Tidswell, P. O'Mahoney, M. Buonanno, et al., Far-UVC (222nm) efficiently inactivates an airborne pathogen in a room-sized chamber, Sci Rep 12 (1) (2022) 1–9. Available from: https://www.nature.com/articles/s41598-022-08462-z.

[8] E. Rogers, Diffusion of Innovations, 5th Ed., Free Press, 2003. Available from: www.enablingchange.com.au.

[9] A. Yavchitz, I. Boutron, A. Bafeta, I. Marroun, P. Charles, J. Mantz, et al., Misrepresentation of randomized controlled trials in press releases and news coverage: a cohort study, PLOS Med 9 (9) (2012), e1001308. Available from: https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001308.

[10] J. Brett, S. Staniszewska, C. Mockford, S. Herron-Marx, J. Hughes, C. Tysall, et al., Mapping the impact of patient and public involvement on health and social care research: a systematic review, Health Expect 17 (5) (2014) 637–650. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1369-7625.2012.00795.x.