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Letter to the Editor

Do far ultraviolet-C light technologies increase ozone concentrations in healthcare facility patient rooms?

Samir Memic BS[1,2], Claire E. Kaple BS[3], Jennifer L. Cadnum BS[2] and Curtis J. Donskey MD[4,5]

[1]Department of Systems Biology, Case Western Reserve University School of Medicine, Cleveland, OH, USA, [2]Research Service, Louis Stokes Cleveland VA Medical Center, Cleveland, OH, USA., [3]Department of Molecular Biology and Microbiology, Case Western Reserve University School of Medicine, Cleveland, OH, USA, [4]Department of Medicine, Case Western Reserve University School of Medicine, Cleveland, OH, USA and [5]Geriatric Research, Education, and Clinical Center, Louis Stokes Cleveland VA Medical Center, Cleveland, OH, USA

To the Editor - Ultraviolet-C (UV-C) light is effective for inactivation of pathogens in air and on surfaces.[1] In recent years, far-UV-C light (200 to 230 nm) has been proposed as an alternative to 254 nm UV-C light that may provide similar efficacy while being safe in occupied areas.[2,3] However, there is concern that far-UV-C light could have adverse health effects due to production of undesirable air byproducts, particularly ozone.[2,4] Far UV-C light can generate ozone that may accumulate in indoor areas with suboptimal ventilation.[4–8] However, previous studies have not reported ozone concentrations in well-ventilated healthcare settings. Therefore, we examined the impact of a far UV-C technology on ozone concentrations in unoccupied hospital rooms.

The evaluation was approved by the Cleveland VA Medical Center's Biosafety Committee. Testing was performed in June 2024. Three far UV-C technologies were tested in a non-ventilated room (32.4 m^3). The devices were turned on at 8 A.M. and off at 3 P.M. or 4 P.M.. The devices included the Pathogen Suppression System (Mynatek, Inc., Oakland, California),[2] Visium 1 with diffused optics (Lit Thinking, Orlando, Florida), and a 250-Watt GermBuster Channel (Sterilray, Inc.).[9] Each Pathogen Suppression System contains 3 Care222 Filtered Far UV-C Excimer Lamp Modules (Ushio America, Cypress, California); Visium 1 devices contain 1 Care222 module. Per the manufacturer, a single Visium 1 with diffused optics is certified as producing zero ozone emissions by Underwriters Laboratory 2998. As a positive control, we tested an electronic air cleaning device that produces hydroxyl radicals but also generates ozone.

Based on the results in the non-ventilated room, the electronic air cleaner and Pathogen Suppression System were used for testing in a double-occupancy positive-pressure patient room (124.8 m^3) with 8 total air changes per hour and a minimum of 2 changes of outdoor air per hour; 2 of the devices (6 total Care222 modules) were operated because the manufacturer recommends use of 2 devices in patient rooms.[3] The devices were turned on at 8 A.M. and off at 4 P.M.. Testing of the Pathogen Suppression System was also completed in a single-patient room (74.8 m^3) with the same air changes per hour.

A 2B Tech Personal Ozone Monitor (Broomfield, CO) was used to measure ozone levels every 10 seconds (limit of detection, 3 parts per billion [ppb]). Baseline ozone measurements were recorded for 30 minutes before the technologies were turned on and measurements were recorded for 7–8 hours from 8 A.M. to 3 or 4 P.M.. Tests were repeated 3 times. For each patient room trial, the local outdoor ozone levels in Cleveland were retrieved from iqair.com (https://www.iqair.com/us/usa/ohio/cleveland). Ozone measurements were grouped for each hour and averaged to determine the time-weighted average ozone concentration. For the double-occupancy patient room, a linear mixed effects model was used to compare ozone concentrations with the technologies versus control levels with no device. The data were analyzed using R version 3.5.0 software (The R Foundation for Statistical Computing, Vienna, Austria).

Ozone concentrations in the non-ventilated room remained below 5 ppb with no devices operating but increased to above 50 ppb when the electronic air cleaner was running (Figure 1.A). No increase in ozone occurred with the Visium 1 device, whereas 4 to 12 ppb increases occurred during operation of the other far UV-C technologies.

During patient room testing, outdoor ozone levels varied considerably from day-to-day with increasing concentrations after 8 A.M.; measured outdoor ozone concentrations were like those reported by iqair.com (Supplementary material). Figure 1.B shows ozone concentrations in the double-occupancy room. With no devices operating, ozone levels were ~25% to 50% of outdoor concentrations with increasing concentrations after 8 A.M.. Operation of the electronic air cleaner resulted in a significant increase in ozone concentrations in comparison to control testing ($P < .05$), whereas operation of 2 Pathogen Reduction Systems (6 Care222 modules) did not ($P \geq .41$). With the Pathogen Reduction Systems operating, the average ozone concentrations were 20 and 21.7 ppb at 8 A.M. and 4 P.M., respectively. The far UV-C technology also did not substantially increase ozone concentrations in the single-patient room (Supplementary material).

Exposure to ozone has substantial acute and chronic adverse health effects.[2,10] Therefore, public health agencies recommend that exposure to ozone should not exceed 50–100 ppb.[2] Our findings are consistent with reports from non-healthcare settings that outdoor air is the major source of indoor ozone.[10] In patient rooms, ~10 to 20 ppb of ozone was detected during multiple days

Corresponding author: Curtis J. Donskey; Email: Curtis.Donskey@va.gov
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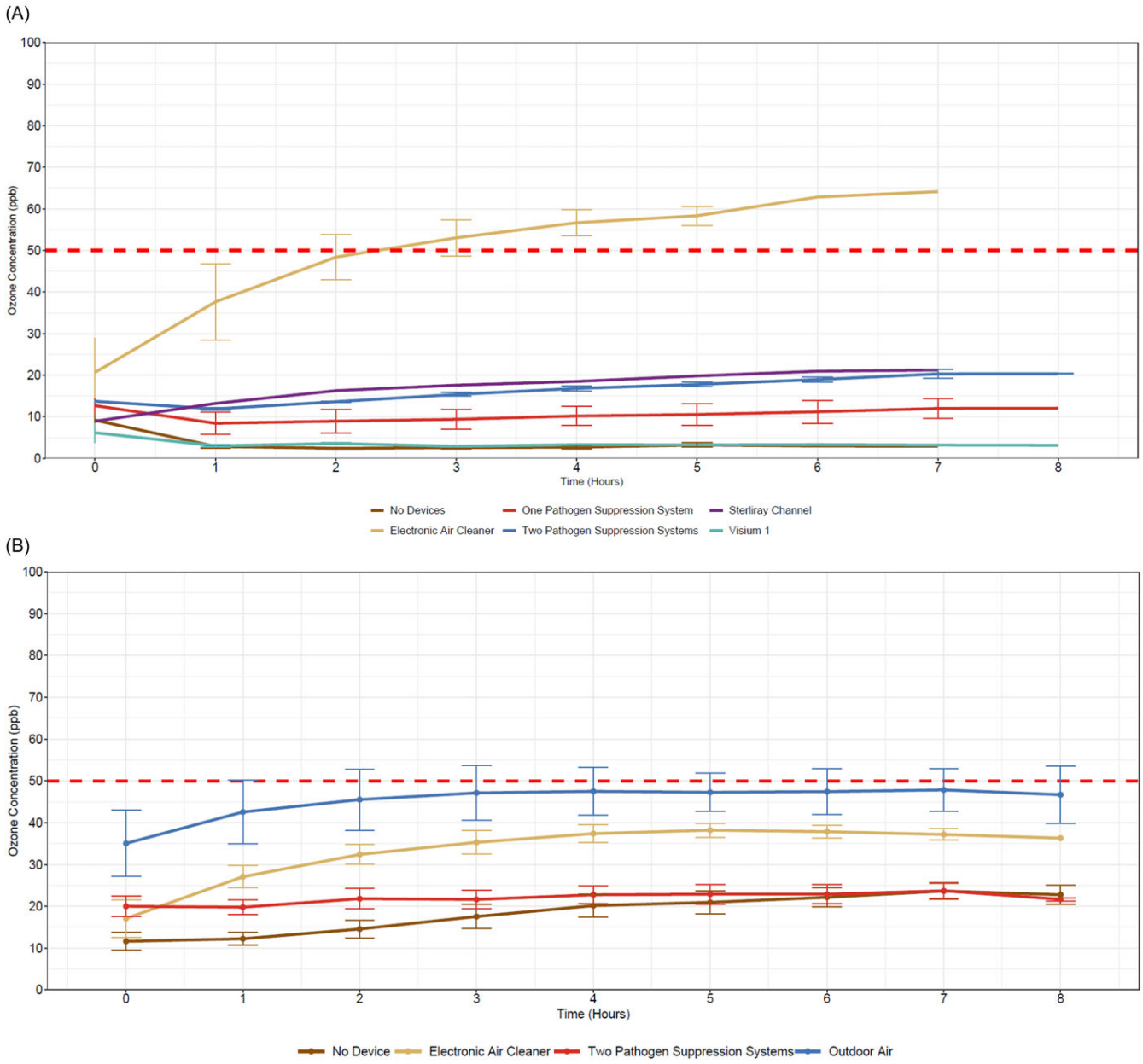

Figure 1. Ozone concentrations (parts per billion) in a non-ventilated room (A) and in a double-occupancy patient room with 8 total air changes and 2 or more outdoor air changes per hour (B) over 8 hours when far ultraviolet-C devices or an electronic air cleaner were operated from 8 A.M. (time 0) to 3 P.M. (time 7) or 4 P.M. (time 8). The dashed red line indicates 50 parts per billion which is a recommended threshold limit value.[2]

in June 2024 when outdoor ozone levels occasionally exceeded 50 ppb. The finding that operation of far UV-C technologies in a non-ventilated room resulted in modest (ie, 4 to 12 ppb) increases in ozone concentrations is consistent with previous studies.[2,4–8] However, there was no significant increase in ozone with operation of far UV-C devices in a patient room with 8 air changes per hour. These findings suggest that operation of far UV-C technologies in well-ventilated healthcare settings is unlikely to substantially increase ozone concentrations over baseline levels.

Our study has some limitations. We did not test for undesirable air byproducts other than ozone.[4] We completed testing with 1 Visium-1 with diffused optics device; in real-world settings, more than 1 device may be installed in patient rooms. We cannot exclude the possibility that the differing results for the non-ventilated and ventilated rooms might have been related to differing room size or differing items in the room. Finally, we did not assess ozone concentrations in negative pressure rooms or after discontinuation of use of the technologies.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/ice.2025.10207

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References

1. Boyce JM, Donskey CJ. Understanding ultraviolet light surface decontamination in hospital rooms: A primer. *Infect Control Hosp Epidemiol* 2019;40:1030–1035.
2. Blatchley ER, III, Brenner DJ, Claus H, *et al.* Far UV-C radiation: an emerging tool for pandemic control. *Crit Rev Env Sci Technol* 2022;53:733–753. doi: 10.1080/10643389.2022.2084315.
3. Memic S, Cadnum JL, Osborne A, Rutala WA, Donskey CJ. A novel approach for safe and automated implementation of far ultraviolet-C light decontamination in clinical areas. *Antimicrob Steward Healthc Epidemiol* 2024;4:e123.
4. Link M, Shore A, Robertson R, Hamadani B, Poppendieck D. Spectral characteristics and indoor air quality effects of germicidal 254 nm and 222 nm ultraviolet light, NIST Interagency/Internal Report (NISTIR), National Institute of Standards and Technology, Gaithersburg, MD. Available at: https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=958820. Accessed January 19, 2025.
5. Peng Z, Day DA, Symonds GA, *et al.* Significant production of ozone from germicidal UV lights at 222 nm. *Environ Sci Technol Lett* 2023;10:668–674.
6. Link MF, Robertson RL, Shore A, Hamadani BH, Cecelski CE, Poppendieck DG. Ozone generation and chemistry from 222 nm germicidal ultraviolet light in a fragrant restroom. *Environ Sci Process Impacts* 2024;26:1090–1106.
7. Park S, Rim D. Human exposure to air contaminants under the far-UVC system operation in an office: effects of lamp position and ventilation condition. *Sci Rep* 2024;14:24465.
8. Link MF, Shore A, Hamadani BH, Poppendieck D. Ozone generation from a germicidal ultraviolet lamp with peak emission at 222 nm. *Environ Sci Technol Lett* 2024;26:1090–1106. doi: 10.1021/acs.estlett.3c00318.
9. Osborne AO, Memic S, Cadnum JL, Donskey CJ. Evaluation of a wall-mounted far ultraviolet-C light device used for continuous air and surface decontamination in a dental office during routine patient care. *Infect Control Hosp Epidemiol* 2024;45:1250–1252. doi: 10.1017/ice.2024.109.
10. Salonen H, Salthammer T, Morawska L. Human exposure to ozone in school and office indoor environments. *Environ Int* 2018;119:503–514. doi: 10.1016/j.envint.2018.07.012.

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