Institute for Progress
1140 Third Street NE
Suite 401
Washington, DC 20002

December 5, 2022
To: Jonathan D. Edwards, Director
Office of Radiation and Indoor Air
Docket ID No. EPA–HQ– OAR–2022–0794

Re: Request for Information: Better Indoor Air Quality Management To Help Reduce COVID–19 and Other Disease Transmission in Buildings: Technical Assistance Needs and Priorities To Improve Public Health

Submitted directly to *Regulations.gov*

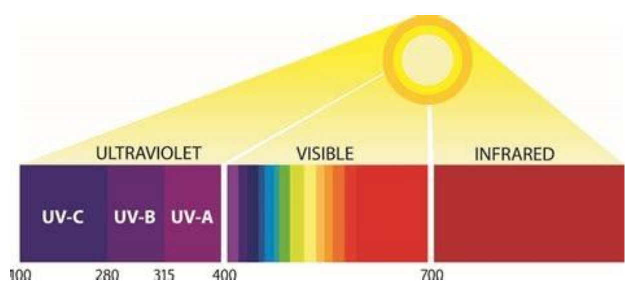
Dear Johnathan D. Edwards,

The Institute for Progress (IFP) is a non-partisan think tank dedicated to accelerating scientific, technological, and industrial progress while safeguarding humanity's future. We appreciate the opportunity to comment on Question 3.1 of EPA–HQ– OAR–2022–0794: *In your opinion, what approach(es) could the Federal government consider deploying to move decision makers/owners/managers toward making and sustaining improved ventilation, filtration, and air cleaning practices to reduce the risk of disease transmission?*

At IFP, we believe that the federal government should, while upgrading ventilation and filtration systems to meet today's challenges, also invest in next generation technologies that could substantially improve the efficiency, effectiveness, and reliability of air cleaning systems. In particular, we believe the federal government can help the U.S. become the world leader in reducing disease transmission by pursuing research, development, and regulation of far-UVC.

Far-UVC is an emerging technology that could dramatically improve indoor air quality (IAQ) and reduce disease transmission. Far-UVC can achieve impressive pathogen suppression – far greater than ventilation and filtration systems (Eadie et al., 2022). Far-UVC may also sidestep the health concerns of conventional UVC systems, which we will describe first.

Conventional UVC Systems



UVC light – a form of radiation with wavelengths between 100 to 280 nanometers (nm) on the electromagnetic spectrum – has been used for over 100 years to disinfect air, surfaces, and water (Reed, 2010). UVC has strong germicidal effects, especially at the 254 nm wavelength, and exposing air in the upper portion of a room to this wavelength has been shown to be highly effective at preventing the spread of SARS-CoV-2, influenza, tuberculosis, and other airborne pathogens. These findings have led the CDC to recommend UVC disinfection in the unoccupied upper portion of spaces with insufficient HVAC systems

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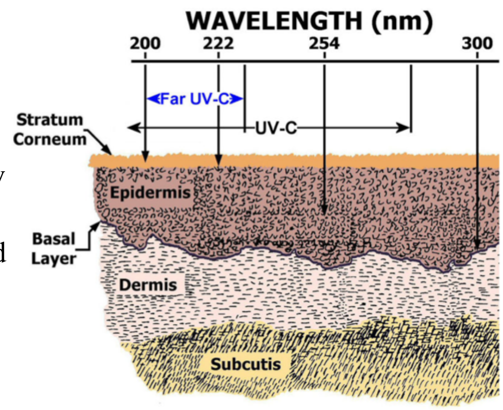
(CDC, 2021). As direct exposure to conventional 254nm UVC can have carcinogenic and cataractogenic effects on humans, such systems must be carefully installed to avoid the risk of accidental exposure.

Far-UVC Systems

Early studies in far-UVC systems have suggested that a narrow band of UVC – from 200-230 nm – may share conventional UVC's germicidal properties, while avoiding health risks from direct exposure and allowing installation in a greater variety of building situations.

Safety



In 2013, scientists discovered that light in the band between 200-230 nm effectively inactivates pathogens while *not* causing harm to humans (Buonanno et al., 2013). This "far-UVC" easily penetrates through microscopic viruses and bacteria, yet cannot penetrate through the outer, non-living layers of human skin and eyes (see image from Blatchley et al., 2022). Far-UVC causes no known significant damage to human skin and cell models even at doses significantly higher than required germicidal doses – as long as optical filters are used to block emissions outside the far-UVC range (Hessling et al., 2021; Hickerson et al., 2021; Welch et al., 2022; Zwicker et al., 2022). While some older studies found unfiltered far-UVC to cause harm (Woods et al., 2014), the adverse effects have been determined to be due to the wavelengths outside the 200-230 nm band, which are blocked by wavelength filtration. Filters should always be used with far-UVC devices. Far-UVC systems should also not exceed the Threshold Limit Values set by The American Conference of Governmental Industrial Hygienists (ACGIH), which are currently 161 mJ/cm² (eyes) and 479 mJ/cm² (skin) over 8 hours.

Efficacy

Research has also demonstrated far-UVCs potential to rapidly mitigate disease transmission. Far-UVC can inactivate all tested bacteria (≥23 species/spores), viruses (≥23), and fungi (≥5; Hessling et al., 2021). Far-UVC is also effective against typically UV-resistant pathogens, which is likely due to how far-UVC's primary antimicrobial effect is through damage to proteins, whereas conventional UVC's is through damage to DNA/RNA (Clauss et al., 2009).

Far-UVC is particularly effective at the rapid inactivation of airborne viruses and bacteria. With ventilation and filtration systems, contaminated air is not disinfected immediately; air must flow to the system before it can be cleaned, even if it must cross the entire room and infect other occupants along the way. With far-UVC, such air flow is not required. Far-UVC begins to inactivate pathogens within seconds upon their release from an infected source. In one recent study (Eadie et al., 2022), researchers continually released the pathogen *S. aureus* into a room-sized chamber at a height of 5.5 feet. For one hour, the chamber was HEPA-filtered at a rate of 3 air-changes-per-hour (ACH), during which time the pathogen load in the air remained high (~24,000 cfu m^-3, measured every 5 minutes). When the

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researchers then turned on a far-UVC system that met ACGIH's Threshold Limit Value (TLV) for skin, the pathogen load in the air was reduced by >98% within five minutes. The pathogen remained reduced by >98%, and half the time could not even be detected, for the duration of the 50-minute experiment, *even as the pathogen was continually released into the air.* This reduction was equivalent to 184 air-changes-per-hour (eACH), or 61 times the ACH of the HEPA filtration alone. Although this experiment was conducted with a bacterium, the species was chosen for its similar far-UVC inactivation rate to coronaviruses and influenza viruses (Eadie et al., 2022; Welch et all., 2018; Buonanno et al., 2020). These findings indicate that far-UVC could be safely used to achieve major reductions in airborne pathogens in public, occupied locations (Buonanno et al., 2020).

Energy Efficiency

HVAC systems typically constitute half of a building's energy costs (Pérez-Lombard et al., 2008). Given the cost of energy, maintenance, and construction of ventilation and filtration systems, it is perhaps not surprising that schools rarely achieve the 4-6 ACH that is recommended by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), which likely contributes to pathogen transmission in schools (Fisk, 2017).

With recent advances in krypton chloride excimer (KrCl*) lamps, far-UVC has become substantially less expensive and more energy efficient than traditional ventilation and filtration solutions. Far-UVC could be installed, operated, and maintained for a fraction of an HVAC system's cost, and as indicated by prior studies, achieve >100 eACH – levels that can greatly reduce disease transmission yet that are typically not possible with ventilation and filtration systems due to cost of energy, maintenance, and construction (Brickner et al., 2003). The energy efficiency of far-UVC could not only enable schools and businesses to improve IAQ and sustain those improvements for less money, but could also help protect outdoor air quality, which has been deteriorating due to the burning of fossil fuels.

IFP Suggestions to the EPA

With assistance from the EPA, we believe the United States can become the world leader in safe, effective, and energy-efficient air cleaning and disease mitigation. In particular, we at IFP make the following suggestions:

Develop a Far-UVC Certification Program

While we do not think that new regulation of far-UVC would be useful at this time, we do think it would be helpful for the EPA to develop a voluntary certification program. This program could award certificates to far-UVC companies that can prove their products, when installed according to directions, produce a minimum of 12 eACH. This eACH level is above that currently recommended by ASHRAE for schools and commercial buildings, yet is the minimum eACH that research supports for areas with a high risk of airborne disease transmission (Zumla and Hui, 2014; Adhikari et al., 2019; with some research supporting even higher eACH; Beggs et al., 2010). The certification program should also require that far-UVC companies prove their products, when installed according to directions, meet the ACGIH-2022

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TLV. Such certification would help customers ensure that the far-UVC products they purchase are effective and safe.

Do Not Use CO2 as a Proxy for Air Quality in New Building Codes

Building codes that stipulate requirements for IAQ could help reduce disease transmission. However, these building codes should not use CO2 as a sole proxy for air quality. CO2 monitors measure exhaled breath, and CO2 levels will therefore decrease if ventilation is used to reduce pathogenic load. However, CO2 levels will not decrease if far-UVC is used to disinfect a room – even when far-UVC results in far greater disinfection. New building codes which use CO2 as a sole proxy for air quality will likely reduce adoption of biologically-based air-cleaning methods.

Promote Additional Research on Far-UVC

Preliminary research indicates that far-UVC is safe, but widespread adoption will require safety and efficacy studies conducted in real-world settings over longer periods of time. The federal government can accelerate this process by providing more funding to far-UVC researchers. Now is the time to invest in IAQ research, before memories of COVID-19 begin to fade among policymakers and the general public. The research that we see as especially necessary is as follows:

- *Additional safety studies, addressing all possible issues.* We believe that an open call for concerns about UVC may be useful, as it would ensure that all valid concerns are addressed. No evidence has raised concrete safety concerns about far-UVC thus far, but questions remain about the impact of far-UVC on materials and microbiomes.
- *Efficacy studies that measure disease spread in an isolated population*. Far-UVC studies have shown immense promise for pathogen inactivation, yet real-world transmission studies still must be done. It is particularly important to conduct studies that measure transmission in isolated populations. For example, studies on naval vessels could provide excellent indicators on the effectiveness of far-UVC at reducing disease transmission, as outside variables (e.g., exposure to people outside the study environment) are limited. Conversely, similar studies in restaurants and cafes would be less useful, as the effects would be too dispersed to reliably measure.

The threat of pandemics is ever-present, but because of the recency of COVID-19, we are currently seeing an unprecedented public and government willingness to think in far-reaching ways about preventing the next threat. While the memory of this pandemic is fresh, we must make sure that we invest adequately in preventing the next one.

We appreciate the opportunity to comment on this RFI.

On behalf of the Institute for Progress,

Alec Stapp

Institute for Progress
1140 Third Street NE
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Washington, DC 20002

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