The Cost of Sick Days: The Direct Organizational Fiscal Benefits of UV-C Protection

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1 Overview

Sick leave is an important and necessary component of employee management. While illness is an unfortunate reality of life, the costs of sick leave are multifold, ranging from sick paid leave to the opportunity costs of lost productivity. It is infeasible to prevent the need for sick leave; illnesses can be complex and are not always acute in nature. However, reducing the probability of employees catching a communicable illness while at work will help boost employee health and wellness while also cutting down on sick day costs. Here, we discuss the utility of UV-C protection in reducing pathogenic particle load to help combat one causative element of illness.

2 Risks of Poor Indoor Air Quality

Indoor Air Quality (IAQ) refers generally to the content comprising the air in and around buildings and structures, accounting for particulate concentration, partial pressures of gasses, temperature, ventilation, and humidity. Sources of indoor air pollution, which diminish IAQ, can stem from urbanization, deterioration of building materials, external sources, fuel-burning machinery, and inefficient central ventilation and airflow systems (Tham, 2016). Quantifying IAQ involves factoring in the relative contributions of numerous different variables and is made difficult by a high degree of variation between individual buildings. IAQ has been recognized as a public health issue for decades, as urban residents spend more than 90% of their time indoors (Spengler and Sexton, 1983).

The effect of air pollution on human health is a complex topic and involves multiple confounding variables, making it difficult to isolate the effect of IAQ. For example, the elderly, immunocompromised, and those with respiratory illnesses are disproportionately affected by low air quality, though these groups do not comprise a major component of the labour force. Therefore, in the context of sick leave and economic impact, it is reasonable to focus on the percentage of those comprising the majority of the labour force.

Designing buildings with proper airflow and ventilation has an immense benefit on human health and productivity (MacNaughton et al., 2015). In the simplest sense, inadequate ventilation will result in the buildup of pollutants and other particulates in any given space. Despite this, few buildings go beyond the minimum ventilation standards. Part of this trend is the perception that enhancing IAQ through better ventilation is an unnecessary cost to the building owner, leading to the cost of energy being often prioritized (Hamilton et al., 2015). Oftentimes, quantifying the effects of poor IAQ using sick leave as an endpoint can be difficult due to numerous confounding factors (Aguirre and Forest, 1994). Demographic factors, as well as the type of work, can cause artifacts in any epidemiological study. A 2000 study analyzed the association

between ventilation rates and the frequency of sick leave in a large US manufacturing company via a Poisson distribution (Milton et al., 2000). Even after controlling for age, gender, seniority, ethnicity, and type of job, increased sick leaves were seen in areas deemed as having lower levels of air supply. In another instance, researchers in Norway examined the impact of various contributors to poor IAQ on the prevalence of sick leave. An increase in small particulate matter of just $1ug/m^3$ was seen to result in a 0.6% increase in sick leaves (Hansen and Selte, 1997).

Interestingly, enhancing ventilation from 20 ft^3/min to 40 ft^3/min resulted in an 8% increase in workers ability to perform on a cognitive test (MacNaughton et al., 2015). This suggests both a physical and a cognitive benefit to improved airflow and IAQ.

3 Cost of Sick Days

While events such as the COVID-19 pandemic have brought forth an unprecedented amount of disruption, seasonal influenza and other communicable diseases have always impacted businesses. In a survey of 490 Norwegian employees in 2019, 74% of them reported having taken an average of 3.5 days off due to a communicable illness, such as influenza (Edwards et al., 2019). Those with lower job security took less sick leave, while a greater proportion of employees with higher job security took sick leave. The researchers modelled the impact that a seasonal pandemic would have on Norway's mean total costs and found that US$94 million to US$479 million was lost in a combination of healthcare resource usage and lost productivity (Edwards et al., 2019). In a meta-analysis of 22 articles examining influenza transmission and sick leave recommendations in Europe, an average of 16% of influenza transmissions were estimated to occur in the workplace (Edwards et al., 2016).

In the absence of mandates or regulatory guidelines, an employee's likelihood of taking sick leave stems partially from its economic incentives. On average, a 1% increase in sick leave rate could result in a 1.2% reduction in an individual's earnings 2 years later (Markussen, 2011). Moreover, sick leave was also shown to negatively affect an employee's ability to secure future employment, with women being disproportionately affected (Ahlstrom et al., 2010). Therefore, sick leave presents as not only a cause to the employer, but also to the employee. While paid sick leave is an essential part of worker benefits, it is in everyone's best interest to minimize its necessity. Investing in improved ventilation in the goal of improving IAQ is one way to cut down on sick leave costs.

4 Advanced Air Sanitization with UV-C

Air sanitization via ultraviolet (UV) radiation has been an established tool since the 1900s (Biasin et al., 2021). In brief, UV rays

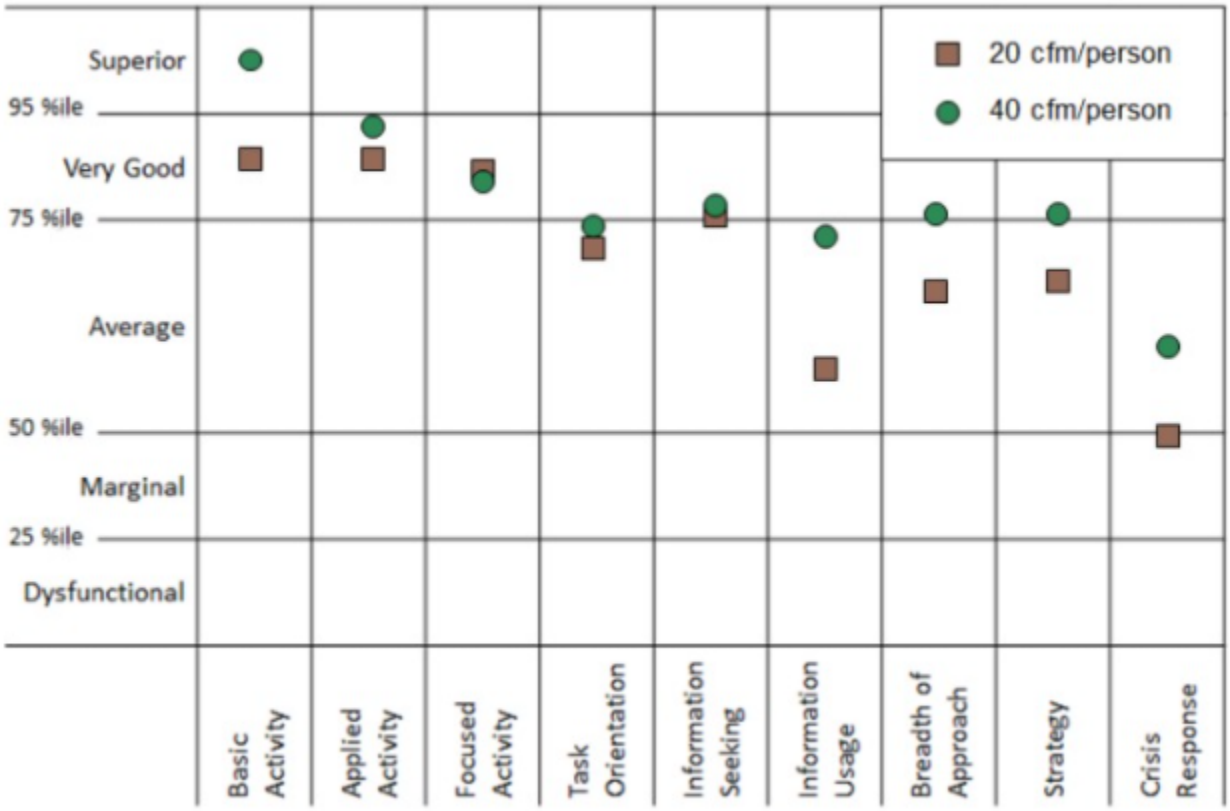

Figure 1: Average cognitive performance on the SMS tool of 24 participants in a green building at 20 and 40 $cfm/person$ of outdoor air relative to normative data from approximately 70,000 people. Figure adapted from MacNaughton et al., 2015.

are able to induce double-stranded breaks in the DNA of viruses, ultimately leading to a failure of viral genomic replication and thus preventing its propagation (Portin, 2014). The efficacy of UV-C irradiation has been well studied. A 5-log reduction in multiple pathogens, including E. coli, S. aureus, and S. enterica was achieved at a power of $45mJ/cm^2$ (Kim and Kang, 2018). The MS2 bacteriophage is a widely used proxy of virucidal activity (Zhang et al., 2020). In our independent testing, we found that 30 minutes of exposure to UV-C at 254 nm resulted in undetectably low levels of MS2 viral load (ZiuZina, 2021). UV-C disinfection is an effective method of reducing airborne viral load and should be an important component of improving air quality.

The ongoing COVID-19 pandemic has brought the importance of proper sanitization and measures to reduce airborne viral load to the forefront of media attention. Isolation requirements due to the impacts of the COVID-19 pandemic have led to massive costs in lost productivity and economic damages (Chen et al., 2020). In a 2020 study, UV-C radiation at an industry-standard wavelength of 254 nm was found to be effective at inactivating human coronaviruses, including SARS-CoV-2, the causative agent of COVID-19 (Buonanno et al., 2020). Furthermore, UV light with smaller wavelengths (207-222 nm) were examined for their efficacy against coronaviruses. At an exposure of $3mJ/cm^2/hour$, 90% viral inactivation was achieved in 8 minutes, rising to 99.9% inactivation in about 25 minutes (Buonanno, et al., 2020).

Reducing viral load can have a drastic impact on IAQ, lowering the frequency of catching a communicable illness and reducing sick leave absences. Ongoing pandemic challenges have highlighted the critical importance of maintaining high IAQ in offices and workplaces.

5 Conclusion

Sick leave is a significant preventable expense that results in appreciable costs to a company as well as hazards to employee health and wellness. Here, we outline that an improvement in IAQ can have a meaningful impact on reducing the necessity of taking sick leave. Healthier employees allow for boosts to company productivity and also promote overall health and well-being. It is in everyone's best interest to ensure that an indoor working environment is able to operate at a high level of ventilation to be sure that IAQ remains well above industry-regulated minimums. In addition to ventilation, an indoor environment's relative humidity and temperature are also important factors that affect transmission rates of communicable diseases (Nichol et al., 1995). Therefore, a combination approach, one that accounts for these factors alongside UV sanitization and also employs preventative measures like hand hygiene, is likely to yield the greatest benefit.

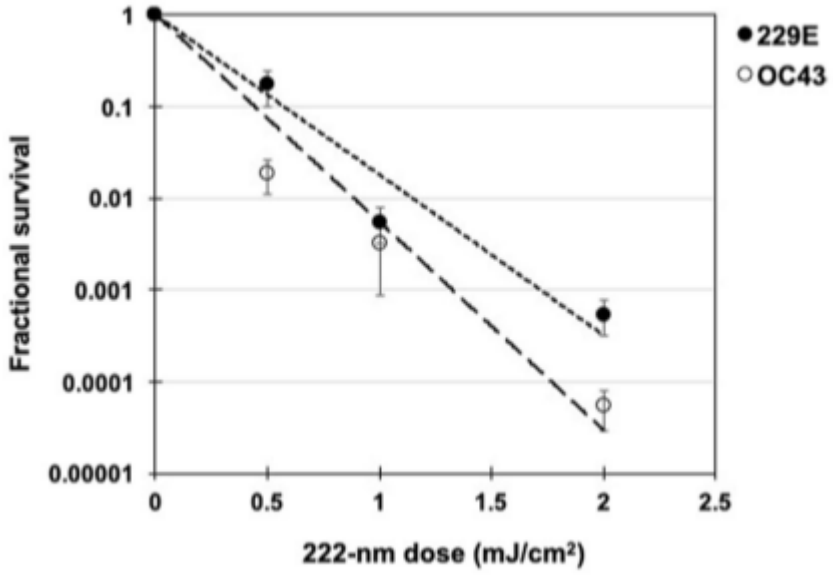

Figure 2: Coronavirus survival as a function of the dose of far-UVC light. Figure adapted from Buonanno, et al., 2020.

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