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Return To Office: Coronavirus, Risk, And Control Of The Indoor Environment

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INTRODUCTION

Coronavirus control measures remain a central concern for workplaces, especially with more employers encouraging a return to office (or some form of hybrid working). This article looks at the indoor climatic conditions most conducive to coronavirus survival and, based on these risk factors, considers the optimal mitigation measures that can be considered for lowering viral transmission. Not every mitigation measure will be practicable, and the balance is towards the use of portable HEPA filtered units.

This article considers these factors from the perspective of a standard room (such as an office). For an assessment of the risk factors relating to GMP facilities, see: "Consideration of COVID-19 Prevention Measures For Those Working In GMP Pharmaceuticals And Healthcare Facilities" as published in the*Journal of Validation Technology*.

UNDERSTANDING THE RISKS: AIRFLOW PATTERNS

Models of coronavirus distribution in the indoor environment, looking at the distribution of respiratory droplets and aerosols by techniques like Lagrangian turbulent air-flow scenarios, show how the coronavirus can be dispersed by the breathing of an infected person. This reveals that the concentration of viruses in the exhaled cloud can increase to infectious levels over time. The variables are the size of the space (with the chance of infection rising in a confined space) (1). Furthermore, slower airflow and air changes within a room increase the concentration of viral particles and hence the possibility of infection (2).

The studies also reveal that as time advances, airborne droplets and aerosols carrying the SARS-CoV-2 coronavirus cannot have been prevented by standard air-conditioning. This is because the presence of viral RNA detected in air handlers raises the possibility that viral particles can enter and travel within the air handling system from room return air and into supply air ducts. The findings suggest the potential for HVAC systems to facilitate transmission by environmental contamination via shared air volumes with locations remote from areas where infected persons reside (3). A greater risk is posed by ventilation systems that recirculate unfiltered inside air. Therefore, facilities that are not equipped with high-efficiency air filtration (HEPA) filters appear at a greater risk (4). While the virus is smaller than the efficiency provided by HEPA filters, most viruses are present in the air as viral particles in association with other matter and these are generally of a size that is filterable through HEPA filters of an EN 1822 H14 class filtration efficiency (5).

In terms of the risk to a room, given that the spray particle size from nasal or oral routes will be 1–5 mm, and the spread within a space of about 1–2 metres, there is a risk of person-to-person contact and of a recirculating air conditioning system representing viral particles to an indoor area (6). The particles in a bio-aerosol are generally 0.3–100 ?m in diameter (7). Within the air, SARS-CoV-2 remains viable in the air for at least one hour although this varies according to the air temperature and humidity. When deposited onto surfaces, the virus can remain viable for several days, depending upon the type of material (8).

INFLUENCE OF INDOOR ROOM CLIMATE

In terms of room climatic conditions, above a relative humidity of lower than 20% most coronaviruses are still active after 2 days at a constant temperature of 20 °C. The virus is inactivated more rapidly at a higher temperature (experimentally more so at 40°C than at 20 °C). The virus survives better in cold conditions (such as 4oC) and under conditions of low humidity ('dry conditions'). In general, higher temperatures and higher humidity create less favourable conditions for the coronavirus (9). For example, one study comparing different climate found that a 1°C temperature increase caused a 3.08% decrease in daily infected cases (10). However, the problem presented is that for rooms to be comfortable, temperatures of 20°C and a relative humidity of 40 to 60% are typically used and these conditions do not affect coronavirus transmission (11). Moreover, conditions of high humidity and high temperature are uncomfortable for humans and cause the growth of bacteria (making such conditions particularly uncomfortable for cleanrooms).

MITIGATION STRATEGIES FOR THE OFFICE

So, *what can be done to mitigate the effects of the virus?*

- Insufficient ventilation can lead to a rise in the concentrations of particles carrying the coronavirus in closed places by not feeding enough outside air (fresh air) to further dilute viral particles. Therefore, air conditioning systems should be designed to ensure good supply of fresh air and a low supply of recirculated air (such as an 80% fresh to 20% recirculated air scenario).
- Ensuring a suitable number of air exchange rates for removing the indoor air pollutants outside the ventilated area (exhaust air). For example, targeting at least 12 air changes per hour (although 17 to 20 is optimal) (12). This will ensure that the air volume is replaced every 5 minutes, and this creates a time-based protection on the premise that the risk of contracting the virus increases with every 15 minutes of exposure in an enclosed space, rising as the concentration of viral particles increase and accumulates (which is based on U.S. CDC guidance) (13).
- Temperature and humidity are among the theoretical factors affecting the reduction or increase of the spread of the coronavirus, but these are not conducive for operator comfort. However, there is some evidence that operating rooms with a relative humidity of >50% can reduce the viability of the virus (14).
- Fitting pre-filters to air handling systems with minimum efficiency reporting value (MERV) of 13 (15).
- Equip building with HEPA filters or use portable HEPA filter units. Most of the viruses expelled from the body are found combined with water, proteins, salts, and other components as large droplets and aerosols. Aerosolized particles are found in a spectrum of sizes, typically 0.25 to 0.5 µm, and the majority of these can be filtered (16). Given that HEPA filters cannot be easily retrofitted to HVAC systems, the use of portable air systems appears to be the optimal solution. One study showed that the use of HEPA filtered air units prevented the migration of nearly 98% of the surrogate aerosols within an indoor space (17). HEPA filters must have at least 99.97% efficiency for removing all particles. The complexity with using such units is with the size of the room and the number of units required. In terms of the requirements for portable units:
  - HEPA filters have at least 99.97% efficiency for removing all particles, of a size 0.15 µm and greater. This means EN 1822 rated HEPA filters.
  - Tobacco smoke represents a particle size closest to coronavirus carrying particles (0.1-1 µm), therefore the ability of a portable unit to address tobacco smoke should be assessed where no viral rating is stated (18).
  - The clean air delivery rate (CADR), often stated in cubic feet per minute of air completely filtered of a particle by the air purifier, is an important measure. The CADR is calculated as flow of air through the filtration system multiplied by the efficiency of filtration of the particular particle. Here 0.1 µm should ideally be used.
  - A formula is available to assist with the number of units required. For example: a HEPA purifier that has a CADR score of 300 for 0.1 µm particles indicates that the device removes all 0.1 µm particles from 300 cubic feet of air every minute. This means, clearing 99% of all 0.1 µm particles in a 1000 cubic-foot room (10 × 10 × 10 ft) in 15 minutes (19). The U.S. FDA has put in place a standard for portable air purifiers and for their assessment against the coronavirus (20). Such approaches can be compared with the more traditional Wells–Riley equation of the infection risk of airborne transmissible diseases, which uses a basic reproduction number of the infection to estimate the disease spreading risk in a large community (21).

- The requirements are to meet:
  - 21 CFR 880.5045 Medical recirculation air cleaner
  - 21 CFR 880.6500 Medical UV air purifier
- In terms of the HEPA filter, this should carry ISO 29463 certification.
- Germicidal lamps, such as 254-nm UV C, can be fitted to air supplies or positioned in rooms. However, with air supply there will be issues of ensuring sufficient contact time and within rooms, as well as health and safety considerations, there will be concerns about air circulation in the vicinity of the lamps (22).

SUMMARY

This article has discussed the return to office concerns in relation to coronavirus transmission and along with the types of mitigations that can be considered along with the practicalities. The optimal mitigations relate to humidity control and the use of air purifiers fitted with suitable HEPA filters and with using the correct number of units for the room space. This may seem straightforward, but few units available of the market meet the desired specification. In the meantime, while such solutions are being sought, office managers should continue with ensuring personnel wear masks, keep socially distanced, and practice effective hand hygiene.

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