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COVID-19 fight: what's next for facilities engineers, managers and researchers?

While different parts of the world have been reopening their economies after experiencing lockdowns and shelter-in-place for several months due to the COVID-19 pandemic, the recent third wave of infections in Hong Kong have sparked fears of resurgence of the virus. This article reviews the characteristics of COVID-19, compares the prevention measures promulgated in guidelines, and suggests what further efforts may be needed from facilities engineers, managers and researchers to combat this pandemic.

What do we know about COVID-19?

With its reproduction number (R0 up to 3.0) higher than that of influenza and other similar types of human coronavirus, COVID-19 has strong transmissibility[1, 2]. "Contact transmission", "droplet transmission" and "airborne transmission" are three plausible paths of transmission (see Figure 1). Other than physical contact with pathogen carriers, viruses may spread via droplets or aerosols. Droplets (large particles; Ø ≥ 5μm) generated by expiratory events may eventually deposit onto susceptible mucous membranes. Aerosols, which are tiny droplets (Ø < 5μm), may reach a susceptible lower respiratory tract without being trapped by mucus or cilia[3].

Expiratory events (coughing, sneezing, talking, etc) of a human may generate both droplets and aerosols[4]. Droplets settle gravitationally within a short duration (typically within seconds)[5, 6], while aerosols have long suspension times (for example, 8 to 10 mins for aerosols of 4 μm) by lingering in stagnant air environments[7].

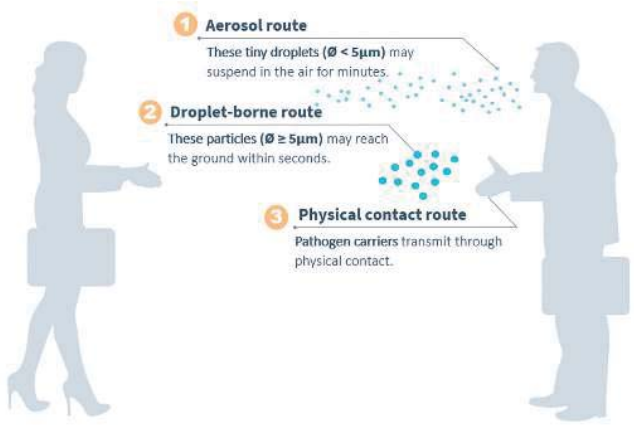

Figure 1: Transmission routes of respiratory diseases

Aerosols which can contain traces of COVID-19 (Ø ~ 0.1 μm) are considered a factor of severe epidemics[8, 9]. Evidence has also revealed that SARS-CoV-2 can survive longer than other respiratory viruses and remain viable and infectious in aerosols for three hours[10]. Not long ago, the National Health Commission and the State Administration of Traditional Chinese Medicine and the World Health Organisation (WHO) acknowledged the possibility of aerosol transmission in some indoor environments (for example, with high concentrations of aerosols and inadequate ventilation)[11, 12].

Multi-pronged strategy of controls

"Breaking the chains of infection" is the signature tune of WHO's advice in epidemiology. Early detection and isolation of suspected/confirmed cases, quarantining close contacts, social distancing, wearing masks in public places and improving personal hygiene are WHO's major recommendations on infection prevention.

As proven vaccines or drugs for treating COVID-19 are not yet available, a multi-pronged approach should be taken to contain the risk of community outbreaks. With reference to the hierarchy of controls of the Centres for Disease Control and Prevention (CDC)[13], an integrated strategy, as Figure 2 depicts, may be taken:

1. Elimination - removing the hazard is an effective control
2. Substitution - replacing the hazard could be an alternative control measure if elimination is infeasible
3. Engineering control - it can be highly effective in health protection if properly implemented (for example, adoption of disinfection technology)
4. Management control - it can mitigate the risk to building/facility users at building/facility level (for example, more stringent inspections)
5. Administrative control - such as a directive from the government (for example, social distancing), which can control how people behave, reducing the risk of infection
6. Personal protective equipment - such as masking, which is simple and yet often an effective line of defence

Figure 2: Multi-pronged strategy of controls

International, national and local guidelines

Professional institutions, including the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Chartered Institution of Building Services Engineers (CIBSE), the International Facility Management Association (IFMA) and the China Property Management Institute (CPMI), have published guidelines on guarding against COVID-19. The measures recommended for strengthening indoor air quality are summarised in Table 1.

Whereas the four institutions belong to two disciplines, namely engineering and management, they have the following recommendations in common: "increase outdoor air rate" and "provide full fresh air supply". Other measures that are recommended by both ASHRAE and CIBSE are: "bypass energy recovery ventilation system with potential air leakage"; and "consider portable room air cleaners with HEPA filters". On the management side, IFMA and CPMI both recommend: "upgrade central air filtration to MERV-13 or higher"; and "replace filters/clean and disinfect HVAC coils".

In Hong Kong, the Centre for Health Protection (CHP) has promulgated a series of Health Advice on Prevention of COVID-19. For properties management, for example, the

Table 1: Measures for strengthening indoor air quality

Measures	Engineering institutions		Management institutions	
	ASHRAE: Guidance for Building Operations During the COVID-19 Pandemic; Position Document on Infectious Aerosols	CIBSE COVID-19 Ventilation Guidance	IFMA Pandemic Manual	CPMI: Technical Guidelines for the Operation Management of Air-conditioning Ventilation System in Public Buildings during the COVID-19 Epidemic
1. Increase outdoor air rate	✅	✅	✅	✅
2. Bypass energy recovery ventilation system with potential air leakage	✅	✅	—	✅
3. Provide full fresh air supply (no use of recirculated air)	✅	✅	✅	✅
4. Upgrade central air filtration to MERV-13 or higher	✅	—	✅	✅
5. Extend operating hours of HVAC systems	✅ (24/7 if possible)	✅ (Full-speed operation for at least two hours before the building usage time and low-speed operation for two hours after the building usage time; maintain low-speed operation throughout the non-usage period)	✅	✅ (Start the AC system one or two hours before the building usage time)
6. Consider portable room air cleaners with HEPA filters	✅	✅	—	—
7. Consider ultraviolet germicidal irradiation (UVGI)	✅ (For high-density spaces such as waiting rooms, prisons and shelters)	✅ (Normally a suitable solution for healthcare facilities)	—	—
8. Adopt temperature and humidity control	✅ (As applicable to the infectious aerosols of concern)	✅ (Maintain relative humidity above 40% wherever possible)	—	Properly increase indoor temperature setpoint in summer, etc
9. Replace filters/clean and disinfect HVAC coils	—	As usual	✅	✅
10. Disable demand-controlled ventilation	✅	Change CO_2 setpoint to lower, 400 ppm value	—	—

Remark: For details of the above recommendations, please refer to the respective guidelines.

Health Advice covers: temperature checks for employees and visitors; more frequent cleaning and disinfection for toilets, etc. On its website, the CHP has also posted advices for various types of premises, for example, hotels and shopping malls.

To provide additional beds for COVID-19 patients, the Hospital Authority (HA) has retrofitted some general wards into standard negative pressure wards. The HA has also partnered with the Electrical and Mechanical Services Department (EMSD) and the trade to develop the "mobile modular high efficiency particulate arrestance unit" for reducing the risk of drawing contaminated air from ventilation exhausts. In this COVID-19 fight, the EMSD has introduced some innovative technology solutions, for example, AI-aided temperature sensing robot. The Hong Kong Institution of Engineers (HKIE), meanwhile, has updated its publication on public safety of building maintenance and repair, which provides references for tackling the common problems of drainage pipes.

What's next?

Over the past several months, facilities engineering and management (FEM) professionals have been making enduring efforts to minimise the threats posed by COVID-19. However, the recent spike of local confirmed cases has reactivated the epidemic alarm. Concomitantly, various questions arise, including: Have we done enough to combat COVID-19? Have the above guidelines or advices been fully adopted? Have there been any difficulties in their implementation?

Take the first recommendation in Table 1 as an example: Is it practicable to increase outdoor air rate of an existing air-conditioning system? Are the air intake opening and the associated fan and air duct big enough? Is the cooling capacity of the air-conditioning system large enough? What needs to be done with the respective automatic control system? Is any retro-commissioning work (for example, for air balancing) needed? What will be the eventual indoor air temperature and humidity? Along this line, many more technical questions arise from the butterfly effect, let alone the management, environmental and financial considerations in dealing with, for example, the increase in energy consumption.

Another area where due consideration should be given is, apart from healthcare facilities, what other facilities are at high-risk in terms of COVID-19 transmission. If the possibility of airborne transmission could not be excluded, aerosol-generating facilities such as steam rooms, spa-pools/ Jacuzzis, etc are likely to be the targets of concern. Where are all these facilities in our society and, other than banning their operation, are there alternative means for containing their risk of transmitting the virus?

The foregoing questions do not form the full picture of concerns. Before such questions could be answered, not only the professionals but also researchers in the FEM field should work together to investigate, for example, any barriers to implementing the recommended measures, and solutions for overcoming the barriers. How effective those measures are, expectedly, is another question to be explored.

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