衞生防護中心
Centre for Health Protection

Scientific Committee on Infection Control
Transmission of SARS-CoV-2: implications for infection control measures

Introduction

Coronavirus disease 2019 (COVID-19) has great impact to Hong Kong and the world. It is caused by a new coronavirus related to SARS-CoV and is termed SARS-CoV-2. During the outbreak, many clusters of infections occurred in different confined environments. The mode of transmission in these environmental conditions has significant implication on the advice on infection control practice including personal protective equipment (PPE) required and environmental control for this novel infection. This paper sets out the scientific evidence to critically appraise on the issue of short-range airborne transmission of COVID-19 in poorly ventilated enclosed environment, and provides recommendation on the infection control measures to be adopted.

Global & Local Situation of COVID-19

2. COVID-19 was first reported to the World Health Organization (WHO) on 31 December 2019, followed by rapid and wide scale international spread. WHO declared COVID-19 as a pandemic on 11 March 2020. As of 13 May 2021, there have been 160,074,267 confirmed cases of COVID-19, including 3,325,260 deaths worldwide. There is currently about 745,256 new cases reported daily, with a majority from the Indian subcontinent [1] Locally, as of 13 May 2021, there have been 11,818 confirmed/probable cases with 210 deaths related to COVID-19 according to the Centre for Health Protection of the Department of Health. [2] As a result, a huge demand on isolation rooms in public hospitals, community treatment facilities, and quarantine centres, quarantine hotels, home quarantine are needed. Demand for PPE especially for surgical masks and respirators remains a challenge.

Settings in which COVID-19 Transmission occurs

3. Most of the cases of human-to-human transmission of COVID-19 were associated with prolonged and close contact. About 78-85% of clusters occurred within household settings in an analysis of 75,465 COVID-19 cases in China. [3] Outside household setting, infection tends to occur in those who had close physical contact, shared meals or in enclosed space for over one hour with symptomatic cases, in places of worship, gymnasium, or workplaces. The proportion of confirmed cases without symptoms is estimated to be 16% (12-20%). Asymptomatic or pre-symptomatic individuals can contribute to the transmission of COVID-19. Infectivity starts at about 2 days prior to and peak at time of symptom onset. [4]

Predominant Modes of Transmission of COVID-19

4. **Respiratory droplet** is the major route of transmission, similar to other coronaviruses. Droplets with diameter ≥5 μm typically projects to nearby surrounding 1-2 meters from the respiratory tract with deposition by gravitational force. [5] The larger the size of the droplet, the faster and nearer to the source it gets deposited. These droplets may directly deposit on another person in the vicinity to cause infection, or contaminate the surrounding environment. Surgical mask can greatly reduce the distance travelled by droplets when a person coughs and thereby prevent droplet transmission. [6]

5. **Contact** is another important route of transmission. Direct contact transmission occurs with direct physical contact between two persons, with viral particles passed by touching contaminated skin or mucosal surfaces. Indirect contact transmission occurs when the person touches contaminated environmental surface or object and then touch his or her eyes or nose. Indirect contact transmission is also termed 'fomite' transmission. Viable SARS-CoV-2 virus or RNA has been noted to persist on environmental surfaces for periods ranging from hours to days, depending on the ambient environmental conditions such as temperature and humidity and the type of surface. [7][8] High viral concentration has been found in health care facilities where COVID-19 patients received treatment. [9] Although there is no specific report which have directly demonstrated fomite transmission, this route is considered likely given the consistent environmental findings and the fact that other coronaviruses are known to be transmitted through this mechanism.

Short-Range Airborne Transmission in Poorly Ventilated Enclosed Environment

6. Airborne transmission is defined as spread of an infectious agent caused by dissemination of small droplets (also termed droplet nuclei or aerosols) that are generally <5 μm in diameter and remain suspended in air over long distances and time. These droplet nuclei travel further than typical respiratory droplets and may cause transmission to people staying out of the immediate surrounding. SARS-CoV-2 viral particles in aerosols produced by jet nebulizers under experimental conditions have been found to remain infectious for up to 3 hours. [7]

7. Within healthcare settings, most studies conducted with symptomatic COVID-19 patients not undergoing aerosol-generating procedures (AGPs) have reported absence [10] of viral RNA detected using reverse transcription polymerase chain reaction (RT-PCR) based assays in the large volume of air sampled. Among studies where viral RNA was detected, the amount was extremely small. [11] The detection of RNA per se is not necessarily indicative of replication- and infection-competent (viable) virus that could be transmissible and capable of causing infection. [12] Viable viruses have not been detected in the majority of the studies with positive RNA detection. [4]

8. AGPs are known to produce SARS-CoV-2-laden infective aerosols associated with airborne transmission, thus airborne precautions should be adopted when these procedures are carried out in healthcare settings as far as possible. [13][14] The types of medical procedures considered as AGPs have been described in the literature [15]. Although internationally there is no general consensus on which procedures are aerosol-generating, locally, both CCIDER of HA and CHP have their own list of activities that are classified as AGPs. [16][17][18]

9. In the community, airborne transmission can occur in special settings as reported in the literature for the following three clusters:

(a) <u>The Bus Ride Cluster</u>

In Zhejiang province, individuals riding a 100-minute round trip on the same bus as index had a much higher attack rate of COVID-19 compared to the other bus (35% vs 0%). Zoning within the same bus was not significantly associated with difference in risk, suggesting airborne transmission at least partially contributed to transmission within the bus compartment. None of the event participants wore masks during the bus ride. The air conditioning system was on heating and recirculating mode with little fresh air supply. [19] Similar transmission in poorly ventilated setting is known to be

compatible with reported outbreak of influenza aboard a commercial airliner with inoperative ventilation system, which resulted in a high infection rate among passengers involved in a jet delay. [20]

(b) The Restaurant Cluster

In another cluster reported in a Guangzhou restaurant, diners seated around tables placed >1m apart from one another. It was found that a pre-symptomatic diner infected 9 other diners (4 at own table, 5 at other tables). All infected diners were in one area of the restaurant underneath an air conditioner (attack rate 9/20, 45%), while none of the 68 diners in other areas were infected (attack rate 0/68). None of the 8 waiters were infected. Some of the infected diners were up to 4 meters (12 feet) away from the index case. Air conditioner was recirculating "old" air rather than fresh (exhaust vents were closed). Tracer gas studies confirmed very poor ventilation in the affected area of the restaurant at only about 0.7 air changes per hour (ACH) or 0.75–1.04 L/s per person of outdoor air supply. It is postulated that strong airflow from air conditioners could have propagated droplets along the direction of airflow with poor ventilation being key contributing factors. [21] [22]

(c) The Choir Cluster

In Skagit County, Washington, 61 persons attended a choir practice at which one person was symptomatic at the time of rehearsal. 53 cases were identified including 33 confirmed and 20 probable cases (53.3% among confirmed case and 86.7% attack rate among all case). The attendees were seated close to each other (6-10 inches apart) and cases broadly spread throughout the room, with no clustering by seating location. Infection was not limited to those who stayed in the immediate surrounding of the index case. Although throughout the 2.5-hour practice there were ample opportunities for droplet and fomite transmission, such as sharing of snacks and stacking of chairs, the act of singing might have contributed to transmission through emission of aerosol, which was known to be affected by loudness of vocalization. [23] The ventilation was noted to be poor in this cluster with ACH estimated to be only about 0.7 or 2.5L/s/person. The heating system was reported to be turned on at the start of rehearsal but the amount of outdoor air supply was not known. [24]

10. Locally, two clusters have occurred recently – a restaurant in a shopping mall with 57 cases in February, and a fitness centre with 155 cases in March. Both places were found to have inadequate fresh air supply upon on-site assessment and airborne transmission of SARS-CoV-2 within the confined environment has been implicated. [25][26]

11. In summary, circumstances under which airborne transmission tends to occur include poor ventilation in enclosed space, extended period of time (over an hour) and without consistent wearing of mask. The transmission was considered **short-range** as the infected cases tend to occur mostly within the range of several meters in the direction of strong air current. There is hitherto no definite evidence of efficient airborne transmission over long ranges (>10m) analogous to other highly transmissible infectious diseases such as measles and varicella. There were some suggestions of using carbon dioxide concentration as a surrogate for indoor air quality, however local experience found that various factors can affect the carbon dioxide concentration in the confined indoor environment.

Implications to Infection Control Measures

12. The evidence has illustrated the critical importance of proper ventilation to prevent short-range airborne transmission of COVID-19. In general, outdoor environment with natural ventilation is considered well ventilated given the rapid dilution effect by winds. For good air quality in indoor spaces e.g. restaurants, internationally, different fresh air ventilation rates have been recommended by different authorities: 5.15 L/s per person is recommended by ASHRAE [27] while 10 L/s per person is recommended by others. [28][29][30] The standard for public place is 8.3 L/s per person as recommended by the State Administration for Market Regulation and the Standardization Administration of the People's Republic of China. [31]

13. Locally, Cap. 132 Public Health and Municipal Services Ordinance requires scheduled premises e.g. restaurants to have adequate natural ventilation or be provided with a ventilation system which will provide for each person who may be accommodated in such premises an amount of outside air (fresh air) of not less than 17m^3 /h per person (which is equivalent to 4.72 L/s per person) [32] Conversion between ventilation rate in L/s and air-change rate (ACH) can be calculated based on the following formula: [33]

Ventilation rate (L/s) = ACH × room volume (m^3) × 1000 (L/m^3)/3600 (s/h)

14. According to the WHO Q&A on Ventilation and Air Conditioning, if COVID-19 is circulating in the community and the use of a table or pedestal fan is unavoidable, it is important to regularly bring in air from outside by opening windows or doors if the windows and doors are away from sources of contamination, while minimizing how much air blows from one person (or group of people) to another person (or group of people). The use of ceiling fans can improve the circulation of air from

outside and avoid pockets of stagnant air forming indoors. However, it is critical to bring in air from outside when using ceiling fans, such as by opening windows. [34]

15. In all cases, fresh air supply should be maximized if the window opening and fresh air intake are away from sources of contamination (e.g. exhaust air outlet, drainage vent pipe outlet and toilet window). If natural ventilation is used, windows should be opened as much as possible if feasible and safe to do so. Factors like rate of flow, airflow pathway from clean to dirty area and distribution of fresh air need to be taken into consideration. For mechanical system, set the air vent of air conditioners to increase fresh air supply. Ensure proper maintenance of the ventilation system by periodic inspection and regular replacement of air filters according to manufacturer's recommendations.

16. In view of the possibility of short-range airborne transmission for COVID-19, members of the public are reminded to avoid the 3'C's – Crowded places, Close-contact settings (close-range conversations), Confined and enclosed spaces (with poor ventilation). [35]

December 2020 (First draft)
May 2021 (Last updated)

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