Living without Infection (Part 5)

Group Infection Control for Ending Pandemics

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Cluster Outbreaks Cause the Spread of Infection

The spread of infections in SARS-CoV-2 and other respiratory infectious diseases (influenza, cold, chickenpox, pneumonia, etc.) and the increase in the number of infected individuals are both due to frequent occurrences of cluster (group infection) outbreaks.

Examples of cluster outbreaks

First, let us present some examples of cluster outbreaks. On 17 March 2020, a 2.5-hour choir practice took place at a church in Skagit County, Washington. There was one asymptomatic person among the 61 participants. From this one infected person, 32 people were infected, and there were 20 secondary infections. Three people were hospitalised, and one person died. The fact that many people were gathered together in a closed space, as well as the fact that they were singing, contributed to the extensive spread of the virus.[1]

Similar examples of cluster outbreaks include records of 800 infected people linked to migrant workers' dormitories in Singapore, 80 infected people linked to a live music venue in Osaka, and 60 infected people linked to a Zumba class in South Korea. All of these examples are recorded in the database of the London School of Hygiene & Tropical Medicine.[1]

Group infections have occurred in various places where people gather together, such as in homes, workplaces, businesses, schools, day care centres, hospitals, nursing homes, movie theatres, theatres, restaurants, karaoke bars, train coaches, on cruise ships, in care facilities, meat packaging plants, at ski resorts, ice rinks, and in prisons.[2-5] It has been reported that one person can infect dozens of others. Cluster outbreaks that spread successively across multiple locations have also been reported.[3]
Data presented at the Tokyo Metropolitan Government Monitoring Meeting has shown that group infections can lead to infection spreading into households, with household infections accounting for about 70% of infection routes. Children who become infected in household infections contribute to the cycle of spreading the infection by going to day-care centres or schools and causing cluster outbreaks there.

In the context of the spread of the Omicron variant of SARS-CoV-2 in Japan, there have been numerous instances of cluster infections. The outbreak of the Omicron variant (BA.2) in 2022 (the sixth wave) began around 10 January, and by 25 January, the number of infected individuals had exceeded 100,000 nationwide (Figure 3.1). In the week leading up to that infection peak, there were 813 reported instances of cluster infections throughout the country (according to the Ministry of Health, Labour, and Welfare, Japan).

Broken down by location, educational institutions and schools had the highest number of cluster infections with 317 cases, which was 2.7 times higher than the previous week. Next was child welfare facilities with 516 cases (3.5 times higher than the previous week) and companies with 114 cases (1.9 times higher than the previous week). The number of cases in elderly care facilities, which have a higher risk of severe illness, also increased to 117 cases (2.1 times higher than the previous week). The number of cases in restaurants and bars remained relatively stable at 69 cases more per week.[5]

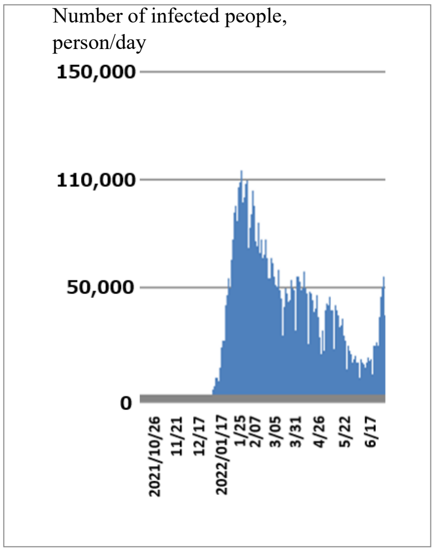

Figure1 Outbreak of the Omicron BA.2 Subvariant in Japan

The rapid spread of infection (sixth wave) due to the Omicron subvariant BA.2 in Japan, began around January 10, 2022, and peaked at over 100,000 infectious people on the 25th, for 16 days. In the week previous to the peak, there were 813 group infection events. This was a major cause of the rapid expansion of infection. Data from NHK (Japan Broadcasting Corporation, 23 August 2022)

From this analysis of the case of the Omicron strain, it is clear that the main cause of the spread of infection is through cluster infections. We have to ask the question why cluster infections occur so frequently?

Group Infections Occur Through Airborne Transmission

The Japanese Research Centre carried out a survey in 14 countries in April 2022 on the subject of mask-wearing.[6] It reported that the percentage of people who said that they always wore masks in public places was highest in Japan. There, the percentage rate was 87%. This was the highest in the world at that time.

Masks are highly effective in blocking droplets, so their use is most effective in preventing droplet transmission. Additionally, many Japanese people already observe social distancing. Also, acrylic partitions have been installed in many stores and workplaces. These measures go a long way in the prevention of transmission. However, despite these measures, there has been a surge in cluster infections during the Omicron outbreak. This indicates that it is not droplets that lead to cluster infections. In droplet transmission, which occurs when droplets fall, within 1 second, in a face-to-face situation, the infection is spread to only one or a few people at most, by one infected person. The route of infection has therefore not significantly contributed to cluster infections.

Cluster infections occur through airborne transmission
If there is even one SARS-CoV-2 infected person in an indoor space with poor ventilation, aerosols containing the virus released with the infected person's breath will continue to spread and remain lingering in the enclosed space. Everyone present in the space will share the aerosols containing the virus and have a risk to inhale them through respiration.

Airborne transmission via aerosols can result in one infected person spreading the virus to several hundred people at once. If there is even one person infected with the SARS-CoV-2 in a poorly ventilated indoor space, the virus-laden aerosols will continue to spread and remain suspended in the air. Everyone present in the same space will share the virus-laden aerosols, resulting in a high probability of a group infection. (Figure 2).

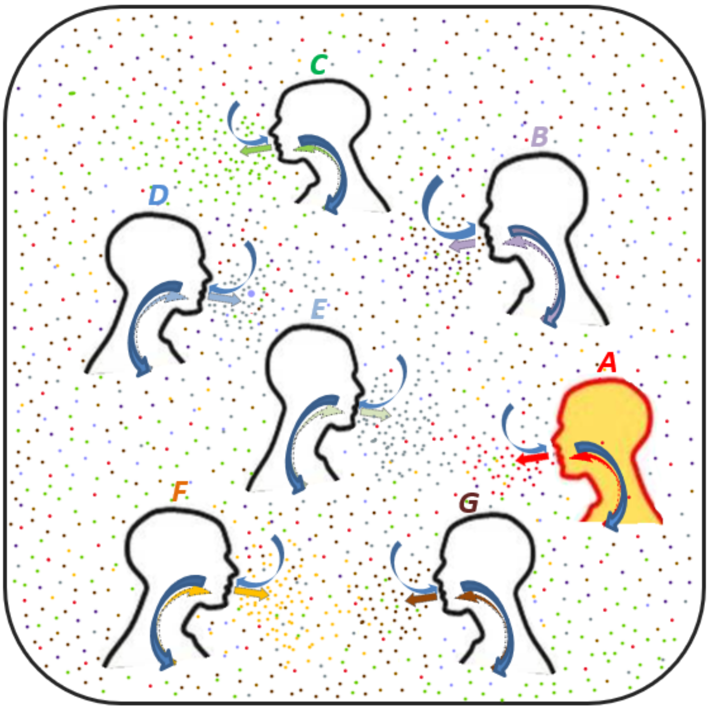

Figure 2 Aerosols exhaled by persons in an enclosed room are mixed and inhaled by every person through rebreathing

(1) Seven people A~G are in a closed room. Each person breathes with a different rhythm and volume and exhales aerosols through breathing out. Aerosols are produced primarily from each person's airway lining fluid (RTLF) and each person's airway lining fluid has different characteristics. The aerosols from each person are colour coded. A: red, B: light purple, C: green, D: blue, E: pale blue, F: orange, and G: purple. Since A is an infected person, he exhales an aerosol (red) containing the virus.
(2) The aerosols emitted from each person float and circulated in the air, and all the aerosols are mixed.

(3) Each person rebreathes and inhales the mixed aerosols through the mouth and nose into the lungs. In this way, everyone has a risk to inhale aerosols (red) containing the virus.
(4) Each person exhales new aerosols generated from each RTLF.

Resolution of insufficient ventilation with CO_2 monitor

Good ventilation can be evaluated by looking at the CO_2 monitor. Why can that help? Breath contains CO_2. Its concentration is about 3% if you are doing light work. If a person is in a poorly ventilated room, the concentration of CO_2 will rise steadily. If the room is ventilated, CO_2 will be released, and the CO_2 concentration will decrease. Therefore, if we know the amount of CO_2 concentration, it is possible to determine whether the ventilation is good or bad.

How much CO_2 concentration can be considered sufficient or insufficient ventilation? The CO_2 concentration threshold is 1,000 ppm (0.1%). CO_2 concentration is measured in ppm units in the monitor shown in Figure 3, you can see the number 0689 on the CO_2 monitor, which means the CO_2 concentration is 689 ppm. The CO_2 concentration in the air is around 420 ppm. If the CO_2 concentration is lower than 1,000 ppm and close to 420 ppm, the ventilation is good. Meanwhile, if the number is higher e.g., between 1,000 ppm and 1,500 ppm or 2,000 ppm, the ventilation has deteriorated and has become more unsatisfactory. If the CO_2 monitor display exceeds 1,000 ppm, it indicates that ventilation is inadequate, and some ventilation action needs to be taken.

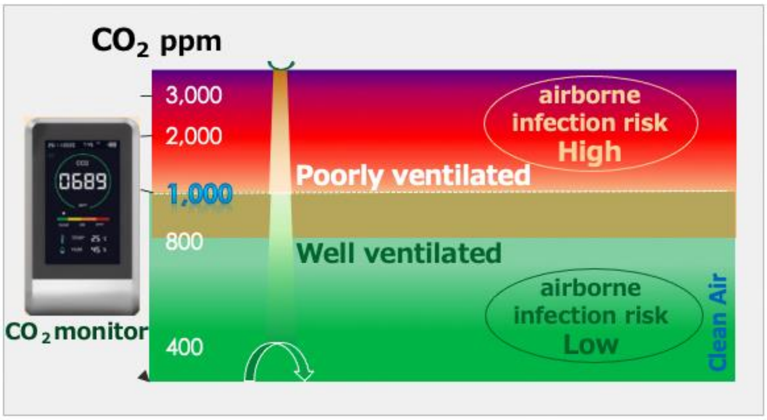

Figure 3 CO_2 Monitor and Ventilation

CO_2 below 1,000 ppm: Ventilation is sufficient. The air in the room is clean. The risk of airborne infection is low. CO_2 exceeds 1,000 ppm: Ventilation is insufficient. The risk of airborne transmission is high.

Group infection occurs based on this mechanism. The aerosols containing pathogens such as virus and bacteria caused airborne transmission can be removed by ventilation. Whether they have been effectively removed or not, can be determined by using a CO_2 monitor. By maintaining ventilation to keep the CO_2 concentration consistently below 1,000 ppm, the risk of infection can be greatly reduced. When the risk of infection is significantly reduced, the spread of infection is also likely to diminish (Figure 4). This has been demonstrated by the Mikawa-Kase model (MK model)[8] and it has been estimated that by managing and maintaining ventilation to keep the CO_2 concentration below 1,000 ppm, the infection risk is less than 1%

(Refer to What' CAP, PointPath-CAP http://pointpath.loopsnet.jp/cap/)

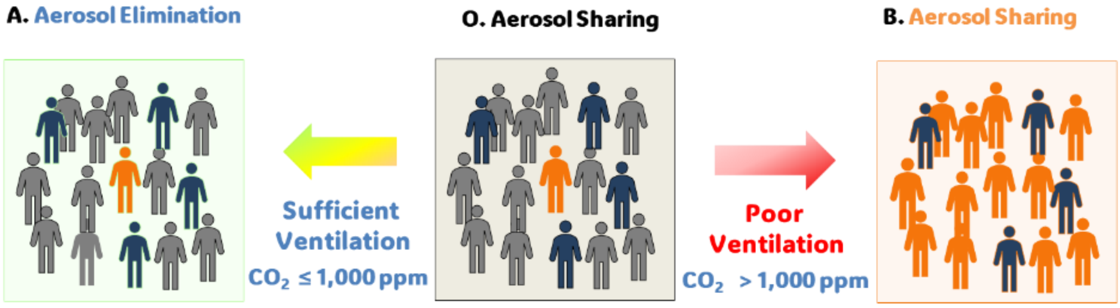

Figure 4. Group infection

Those infected and non-infected coexist in the same room. Aerosols containing the virus from the infector(s) are shared with everyone in the room (O). With sufficient ventilation, CO_2 level is less than or equal to 1,000 ppm, aerosols are transmitted outside, keeping the risk of outbreaks low in the room (A). When ventilation is poor, CO_2 level is more than 1,000 ppm, aerosols including viruses keep on being shared among people, and there is a high risk of outbreaks in room (B). Orange figures are infected, grey and blue figures are uninfected. Blue figures are those who are immune against the virus.

Group Infection Control for Ending Pandemics

Stopping the occurrence of group infections

Unperceived, poor ventilation can lead to outbreaks of COVID-19 group infections. This can occur in many places and can rapidly increase the number of infected individuals. This is the reality of an explosive outbreak.

In May 2023, three years after the start of the pandemic, the classification of COVID-19 in Japan was changed from Class 2 to the same class as influenza (Class 5). However, unlike influenza, COVID-19 does not show signs of settling into a seasonal spreading pattern.[7] Whether we call it a surge, a spike, a wave, or just a small wavelet, signs of increasing COVID-19 infections are still present. Scientists say that it is unlikely that there will be another wave of explosive, hospital-filling infections. Instead, countries including Japan are experiencing frequent waves caused by the constant massive outbreak of the relatively mild XBB.1.16 strain of the Omicron variant. While not fatal, the number of deaths from COVID-19 in the year and a half since the emergence of Omicron has reached about 10 times that of normal influenza deaths.[7] Unless group infections are stopped, COVID-19 will not end.

To eliminate unnoticed poor ventilation, monitoring CO_2 concentration in real-time using a CO_2 monitor is the most effective way to stop group infections. (Figure 4.)

If ventilation is maintained so that the CO_2 concentration is always below 1,000 ppm, the likelihood of inadequate ventilation and the occurrence of COVID-19 group infections will be less than 1%. This relationship among CO_2 concentration, ventilation volume, and infection probability has been confirmed by MK simulation model

(Mikawa-Kase AQIP model[8]). Furthermore, MK-model demonstrates that controlling the CO_2 concentration enables the control of almost all respiratory viral infections via airborne infection mechanism, i.e. respiratory infections can be effectively controlled by maintaining indoor ventilation with CO_2 concentrations below 1,000 ppm. Therefore, the same basic ventilation strategy for mitigating the infection risk can be applied to respiratory infectious diseases.

By ventilating and maintaining fresh air in the indoor space, it is possible to stop the occurrence of group infections, and as the number of group infections decreases, the number of infected individuals will decrease exponentially. This will lead to a reduction in cluster infections.

Reduce the concentration of CO_2 in all indoor areas to 1,000 ppm or less at all times.

As described above, by always having good ventilation indoors, group infection will not occur. However, if there is poor ventilation anywhere indoors in our social life, there is always a risk of infection there. This means that there exists a limit to individual infection prevention practices alone.

If all indoor areas where people move and stay are well ventilated and always filled with fresh air (CO_2 concentration 1,000 ppm or less), outbreak of infection will be eliminated. In such an indoor environment, even if droplet or contact infection occurs, it will be contained to a limited number of people and will not result in group infection.

The movement towards measuring CO_2 concentration as an indicator of how much fresh outdoor air replaces indoor air, and how to manage ventilation, has gained worldwide momentum.[9]
Originally, procedures to maintain fresh air ventilation were carried out in each country as measures solely against indoor air pollution and its negative health effects. However, with the arrival of the New Coronavirus pandemic, many countries such as Belgium, the UK, the United States, and Japan started to implement them also as measures to prevent infection.
Remember though that these global efforts were not aimed specifically at ending the New Coronavirus.
In the “Multilateral Consensus toward Ending COVID” attended by representatives from 112 countries, the agreed measures for all countries were “Vaccine Plus” measures.[9] Vaccine Plus combines multiple infection prevention measures. These measures included vaccination, actions to prevent airborne transmission, as well as the provision of certain financial support. It is to be noted that these are basically strategies to fight the virus after the pandemic has already occurred and are not aimed at ending the pandemic. Plans to end the pandemic have not so far been proposed by any country.

The plan outlined here, based on the fundamental principle of how to avoid getting infected in the first place, has the potential to bring about an end to the pandemic and remove the worry of infection.

Specific procedures to bring an end to the pandemic

1) In today's globalised world where travel is extensive and rapid, there will always be the risk of setbacks if only a limited number of countries are committed to implementing the advocated measures. It is an important challenge to achieve a worldwide existence without infection. The key to achieving this world without infection is to always keep indoor air quality clean by means of ventilation. We need this concept to be implemented without delay. Wherever the support is needed to carry this out, support should be provided.
2) We must sustain the ending of the infection. Therefore, even after infection has ended, we must be prepared for new strains of the Coronavirus as well as for emerging or resurging infectious diseases. To achieve these aims, it is necessary to continue to control indoor air quality by constantly ventilating indoor spaces with fresh air. This practice, initially begun under the name CAP "Clean Air Practice" (Figure 5), needs to be expanded globally.

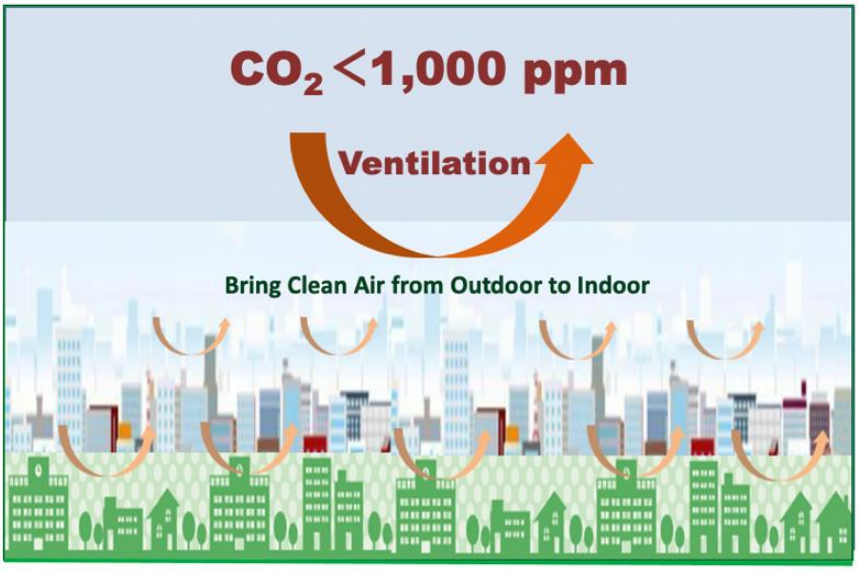

Figure 5. CAP (Clean Air Practice):

(What' CAP, PointPath-CAP, http://pointpath.loopsnet.jp/cap/)

CAP is an action that brings about the possibility of living in an environment with constant fresh air everywhere by allowing outdoor air to enter indoor spaces throughout an entire area. By maintaining indoor CO_2 levels below 1,000 ppm through ventilation, the indoor air contaminated with aerosols and CO_2 is replaced with fresh outdoor air. If CAP is practised everywhere, the COVID-19 pandemic will come to an end, and a healthy life without infections will be realised.

The practical process of carrying out CAP will involve a system of *ventilation* for introducing fresh air indoors and emitting the pollutants outside. How to achieve this involves installing CO_2 systems or constructing buildings with adequately equipped operational CO2 *monitors* which can detect insufficient ventilation and regulate it.

In carrying out the CAP procedures, the necessary equipment, devices, and operating systems will be backed up and supported by advanced science and technology. Such

back-up has already been developed. Given that the procedures have previously been put in place and are in operation on many building sites, *adding a CO_2 concentration monitoring and ventilation control system to existing systems makes CAP extremely feasible* (Figure 5). Newly developed APP CAP-AI, that estimate infection risk and optimize indoor air quality, will greatly help to proceed the procedures.
(Refer to CAP-AI : PointPath-Land, CAP-AI APP, http://pointpath.loopsnet.jp/cap-ai/).

Thus, it is possible to initiate a process that starts at the individual level, which then gradually improves the current situation, in accordance with the regional conditions. This can then ultimately lead on to a much wider successful CAP program. Many challenges to improving ventilation systems and to improving buildings lie ahead. In many cases, existing buildings need to be updated. This can be a costly undertaking. However, the benefits obtained from such efforts greatly outweigh the costs.

To take this example, the UK spent an average of £2.3 billion (US$2.7 billion, 324 billion yen) per year in response to the outbreaks of the COVID-19 pandemic and seasonal influenza. It is estimated that improving building ventilation could save £17.4 billion (US$20.4 billion, 2.45 trillion yen) over 60 years[10].
This calculation does not take into account the financial outlay in the aftermath of the pandemic. Therefore, with hindsight, if the pandemic had been brought to an end through the implementation of CAP, the economic benefits would have been much greater, and the benefits to society, culture, as well as the health and safety of people would be immeasurably significant.

Gradually, as this process towards the implementation of CAP extends from individuals to groups, from buildings to regions, and from local governments to whole countries, corresponding measures will be required, according to the size or area of each unit. However, the operating system is basically the same, regardless of scale.
At each level a responsible manager is designated to carry out a CAP project, perhaps beginning with quite a simple structure. Projects at a municipal level will follow on a slightly larger scale. These will draw together other small projects in the same region. That will be followed by even larger projects at the prefectural level. Finally, national large-scale projects, bringing together all of these, will be developed.

In order to progress this work rapidly, it will be necessary to set up investment in facilities and equipment, as well as funding support. There will be a need to develop laws and regulations related to ventilation, CO_2 monitoring and buildings. It will also be important to standardise equipment such as CO_2 monitors and monitoring systems. However, since the basic unit system is the same across the board, these actions could be implemented and brought into force anywhere, and on any scale.

The sooner we reach our goals, the more we will be able to enjoy a safe and healthy life, free from infection

References

1. CDC (Centers for Disease Control and Prevention, USA), 2020. Morbidity and Mortality Weekly Report (MMWR), 15 May.
2. Effects of ventilation in railcar, Report on December 3, 2022, National Institute of Advanced Industrial Science and Technology, https://www.aist.go.jp/aist_j/new_research/2020/nr20201203/nr20201203.html, accessed 20 May 2023.
3. Kai Kupferschmidt, 2020. Why do some COVID-19 patients infect others, whereas most don’t spread the virus at all? Scientists say-Preventing big clusters of cases would help curb the pandemic. Science 19 May.
4. Takashi Kurabuchi. U. Yanagi, Masayuki Ogata, Masayuki Otsuka, Naoki Kagi, Yoshihide Yamamoto, Motoya Hayashi and Shinichi Tanabe, 2021. Operation of air-conditioning and sanitary equipment for SARS-CoV-2 infectious disease control. Japan Architectural Review 4, 608–620.
5. Cases of cluster infection: schools, public health centers, elderly care facilities, business facilities. Measures to prevent infection based on the characteristics of Omicron variant. Subcommittee on Countermeasures to Combat Infectious Diseases of New Coronaviruses (12th Meeting), Feb 4, 2022
6. Surveys around the world to establish what proportion of people say that they wear masks in public: Report surveyed by Japan Research Center in April 2022.
7. Ewen Callaway, COVID’s future: mini-waves rather than seasonal surge. Nature NEWS, 01 May 2023
8. Kase, H. and Mikawa, G. Y., “No More Pandemic-Toward a World Free from Infectious Diseases” , Appendices A1 and A2, Cambridge Scholars Publishing 2024
9. Jeffrey V. Lazarus, Diana Romero, Christopher J. Kopka and Salim Abdool Karim, 2022. A Multinational Delphi consensus to end the COVID-19 public health threat, The COVID-19 Consensus Statement Panel. Nature 611, 332–345.
10. Dyani Lewis, 2023. Indoor air is full of flu and COVID viruses. Will countries clean it up? Nature 615, 206–208.

CAP-AI

Estimate Infection Risk & Indoor Air Quality

http://pointpath.loopsnet.jp/cap-ai/