

# Displaying Adequate Ventilation Provision in Crowded Gathering Places

W.K. Chow

Department of Building Environment and Energy Engineering

The Hong Kong Polytechnic University, Hong Kong, China

Email: wan-ki.chow@polyu.edu.hk

## Abstract

Upon relaxing COVID-19 control, ventilation provision is no more controlled at 6 ACH. However, infectious variant XBB.1.16 gave another wave of infection, 10,000 a day, in Hong Kong. Problems encountered in crowded gathering places without adequate ventilation are discussed. Owners can take two actions proposed earlier voluntarily and advertise that their ventilation provision is adequate. These are on display the instantaneous energy use on ventilation operation and carbon dioxide levels at indoor stagnant positions. Consumers can then have a choice.

## 1. Introduction

With the COVID-19 calming down, many gathering regulations are removed in Hong Kong [1-3]. The important issue of providing 6 ACH in gathering places [4] is no more required. There is no more control on wearing masks, or isolating infected persons. Many gathering places are obviously having inadequate ventilation provisions [5,6], but overcrowded. A very infectious omicron subvariant XBB.1.16 or “Arcturus” was found to have landed in Hong Kong in May 2023 with many people, including a government expert [7-9] on COVID-19 control infected. The Emergency Section of Hospital Authority is 24 hours operated, with number of infections over 10,000 a day. This might be labelled as the 6<sup>th</sup> wave of infection [10]. The subvariant is not so toxic, only 7% of infected persons had serious symptoms.

Leaders must be responsible to their staff and family members, only allowing necessary gathering with appropriate safety precautions. If more toxic and infectious variants than XBB.1.16 are found, the public healthcare systems might be overloaded as observed before. Lockdown might then be needed, though economic impact is a big issue. The tourist industry, catering services and airlines business might be seriously affected again.

## 2. Key Points on Relaxing Ventilation Requirement

The 6 ACH ventilation requirement appears to be relaxed in many gathering places including restaurants [4]. Relaxing 6 ACH requirement in catering areas should be watched because customers are eating with masks taken off. It is too expensive to keep and monitor whether 6 ACH is provided as reported [5].

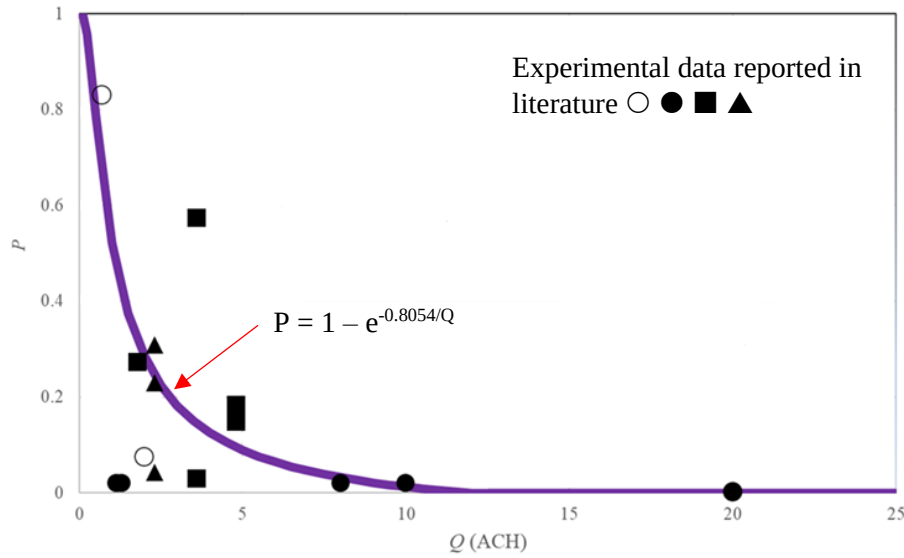
The ventilation rate requirement of 6 ACH for COVID-19 spread control in gathering places including restaurants [4,11] is now removed. As demonstrated before, many restaurants had inadequate ventilation provision of 2 ACH as observed, with some even 0 ACH. Virus can be transmitted within a short time under this ventilation rate.

Direct air transmission of common virus was suspected to be possible under inadequate rate [12-20], though not yet been confirmed. As reported in the literature [21-23], the virus is carried by respiratory droplets and then transmitted by air. Such droplets are not distributed uniformly in most of the gathering places.

In minimizing airborne transmission, ventilation provision with adequate ventilation requirement, the Wells-Riley (WR) infection model [24,25] was used to work out the required number of air changes per hour ACH on virus control indoors. The probability  $P$  of infection risk for a susceptible is expressed in terms of the air change rate  $Q$  through a parameter  $A$  by:

$$P = 1 - e^{-A/Q} \quad (1)$$

There are very few experimental data for the novel coronavirus SARS-CoV-2 [26-29].  $P$  is plotted against  $Q$  as reported before [5,6] and shown in Fig. 1. The data are fitted with Eq. (1) to yield  $A = 0.8054 \text{ hr}^{-1}$ , with a very low correlation coefficient of 0.4621. Values of  $P$  fluctuate for  $Q$  less than 5 ACH, but at low values over 5 ACH. Therefore, using 6 ACH is reasonable to give low  $P$ .



**Fig. 1:  $P$  Vs  $Q$  (Chow et al. 2021)**

### 3. Action to Consider

Keeping indoor ventilation rate at 6 ACH has led to challenges, particularly from the catering industry. Ventilation requirements for buildings had been reviewed [30] by including indoor air flow pattern for developing ventilation codes. Local air speeds and turbulence are the key factors affecting virus transmission and can be predicted by Computational Fluid Dynamics (CFD) [31-42].

The ventilation rate cannot be measured quickly. Running the ventilation system to keep 6 ACH is very expensive. Two actions were proposed [5] to be considered:

- Installing an energy use meter [43,44] to the mechanical ventilation system will show whether the system is operating properly.
- Carbon dioxide concentration will be very high for inadequate ventilation rate. Measuring transient concentration of carbon dioxide at appropriate indoor stagnant positions by CFD supported by field measurement can estimate the instantaneous ventilation rate based on the well-mixed model in a suitable region [31].

It is difficult to implement those two actions by regulations as before. However, the owner can do it voluntarily as advertisement. They can display the instantaneous ventilation energy uses and carbon dioxide level to indicate their gathering places are properly ventilated. The consumers then can have a choice to have appropriate service at their affordable price.

## **4. Discussion**

Relaxation of requirements appears to be based on observed trends of infection number and the consequences [45]. However, the consequences at the moment are not so serious, The public healthcare systems are heavily loaded [46], but not so serious as in March, 2022. Markets like catering and tourists which are seriously disturbed due to blocking have to be resumed normal.

Further, insurance coverage is another concern [47]. Infecting more people with COVID-19 everyday would lead to direct or indirect effects on normal operation of the work force. Interaction of staff directly would infect colleagues. Families infected would affect staff too. Those infection citizens with or without symptoms might take place in series, not in parallel.

Low punishment on general safety incidents as in the Crane Tower incident 2007 [48] would lead to reluctance to invest properly on safety management. Increasing the fine to HK\$10 million might be better [49-52]. People responsible for safety should have more to do.

On the other hand, business has to keep moving, for credits and might be for survival. But with such infectious variants coming in through traveling, even limited, still over having thousands of citizens confirmed infection everyday in Hong Kong until December 2022. Such a high infection number stands for several months.

After studying relevant data and discussing with affected or infected persons, wearing masks and/or adequate ventilation is the key. For crowded gathering places in HKSAR to watch are:

- Pre-educational systems for children below 6 and crowded tutorial classes in small rooms.
- Elderly caring halls.
- Restaurants without cleaning thoroughly after serving a table, inadequate ventilation below 6 ACH. Some might even shut down the ventilation to give 0 ACH.
- Private parties with many friends in small rooms.
- Public transport.

## **5. Conclusion**

Two actions are proposed to demonstrate ventilation rate in a gathering place is adequate. Firstly, energy use meters reading to demonstrate that ventilation system is turned on, and using energy required. Secondly, showing the carbon dioxide level at critical positions determined by CFD are low, indicating adequate ventilation provisions. The gathering places owners to advertise themselves that adequate ventilation rates of 6 ACH is provided by displacing 2 key

parameters. It is difficult to implement stringent monitoring now, in order not to affect normal operation of business. The proposal can be a voluntary action for consumers to select.

## References

1. Hong Kong Free Press, “Hong Kong to reopen 4 border checkpoints on Sunday, as mainland China scraps most Covid travel rules”, 5 January 2023. <https://hongkongfp.com/2023/01/05/breaking-hong-kong-to-reopen-4-border-checkpoints-on-sunday-as-mainland-china-scraps-covid-travel-rules/>
2. The Standard, “Lo Wu border to fully reopen on February 6: sources”, 1 February 2023. <https://www.thestandard.com.hk/breaking-news/section/4/199831/>
3. The Standard, “John Lee announces scrapping of Hong Kong mask mandate from tomorrow”, 28 February 2023. <https://www.thestandard.com.hk/breaking-news/section/4/200841/>
4. A Guide on Compliance with the Requirement on Air Change / Air Purifiers in Seating Areas of Dine-in Catering Premises under Cap. 599F. Food and Environmental Hygiene Department, Government of the Hong Kong Special Administrative Region, April 2021.
5. W.K. Chow, “Ventilation requirements and recommendations for controlling SARS-CoV-2 and variants outbreaks in indoor gathering places with close contact”, MedRxiv, Posted on 21 June 2021. <https://www.medrxiv.org/content/10.1101/2022.06.15.22276447v1>
6. W.K. Chow, C.L. Chow and C.H. Cheng, “Virus transmission modes and mitigation strategies”, ASHRAE Journal, Letters, pp. 8-10, July 2021.
7. The Standard, “HK detects first XBB sub-variant infection, adds 4874 Covid cases”, 10 October 2022. <https://www.thestandard.com.hk/breaking-news/section/4/195691/>
8. TVB News, “Prof. David S.C. Hui pointed out that the number of flu cases has peaked and dropped, and the coronavirus variants has greatly reduced the efficacy of the vaccines”, 13 May 2023. (In Chinese) <https://news.tvb.com/tc/local/645f19a39fe48fbeb6842aa9/>
9. The Standard, “Arcturus, the Covid strain sparking alarm in India, is in HK, says health expert”, 17 April 2023. <https://www.thestandard.com.hk/breaking-news/section/4/202652/>
10. The Standard, “Hong Kong passed the peak of ‘small Covid wave’, says health expert”, 22 May 2023. <https://www.thestandard.com.hk/breaking-news/section/4/203996/>
11. Press Release, “Appointments to Working Group on Implementing the Requirement on Air Change or Air Purifiers in Dine-in Restaurants under Cap. 599F”, Government of the Hong Kong Special Administrative Region, 16 March 2021.

12. The Standard, “Yuen Long hotpot cluster infection rises to 12 as HK adds 233 new cases”, 9 May 2022. <https://www.thestandard.com.hk/breaking-news/section/4/189975/Yuen-Long-hotpot-cluster-infection-rises-to-12-as-HK-adds-233-new-cases>
13. on.cc. “Six more people were confirmed, Sheung Wan eatery cluster increased to 70 confirmed cases”, 18 May 2022. [https://hk.on.cc/hk/bkn/cnt/news/20220518/bkn-20220518163107203-0518\\_00822\\_001.html](https://hk.on.cc/hk/bkn/cnt/news/20220518/bkn-20220518163107203-0518_00822_001.html) (In Chinese)
14. W. Wang, “HK at fifth-wave tipping point”, The Standard, Top News, 3 January 2022. <https://www.thestandard.com.hk/section-news/section/11/237599/HK-at-fifth-wave-tipping-point>
15. Z. Low, R. Yeo and J. Tsang, “Omicron: second infection tied to family member of diner in restaurant cluster sparks fears of growing outbreak, as health chief warns Hong Kong at ‘tipping point’”, South China Morning Post, 2 January 2022. <https://www.scmp.com/news/hong-kong/health-environment/article/3161840/omicron-hong-kong-tipping-point-third-suspected>
16. The Standard, “Tin Hau eatery identified as source of infection for Tuen Mun surveyor”, 5 January 2022. <https://www.thestandard.com.hk/breaking-news/section/4/185540/Tin-Hau-eatery-identified-as-source-of-infection-for-Tuen-Mun-surveyor>
17. W. Wang, “Relief as Omicron infection puzzle figured out”, The Standard, 6 January 2022. <https://www.thestandard.com.hk/section-news/fc/11/237744/Relief-as-Omicron-infection-puzzle-figured-out>
18. TVB News, “Yuen Kwok-yung: First confirmed crew member sat near the door at Moon Palace, Virus might spread through the gap between screens”, 4 January 2022. (In Chinese) <https://news.tvb.com/local/61d40f34e774ff050b54c29c>
19. TVB News, “Yuen Kwok-yung inspected Six Garden Restaurant and believed that the lack of fresh wind caused the surveyor to be infected by diners”, 5 January 2022. (In Chinese) <https://news.tvb.com/local/61d59499e774ffb50a54c2be>
20. N. Lam, “Hong Kong tightens checks at quarantine hotels to ensure travellers stay in their rooms, prevent spread of Covid-19” South China Morning Post, 14 November 2021. <https://www.scmp.com/news/hong-kong/health-environment/article/3155973/hong-kong-tightens-checks-quarantine-hotels>
21. Y. Liu, Z. Ning, Y. Chen, et al., “Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals”, Nature 582, 557–560 (2020). <https://doi.org/10.1038/s41586-020-2271-3>
22. Nancy H.L. Leung, “Transmissibility and transmission of respiratory viruses”, Nat Rev Microbiol (2021). <https://doi.org/10.1038/s41579-021-00535-6>
23. Renyi Zhang, et al. “Identifying airborne transmission as the dominant route for the spread of COVID-19”, PNAS June 30, 2020 117 (26) 14857-14863; first published June 11, 2020; <https://doi.org/10.1073/pnas.2009637117>

24. J. Burkett, "Defining viruses and droplet release", ASHRAE Journal, Technical Feature, pp. 24-29, March 2021.
25. J. Burkett, "Airborne transmission and distribution", ASHRAE Journal, Technical Feature, pp. 10-16, April 2021.
26. M. Loomans, A. Boerstra, F. Franchimon, C. Wisse. "Calculating the risk of infection", The REHVA European HVAC Journal, Vol. 57, No. 5, pp. 19-24 (2020).
27. H. Dai, B. Zhao. "Association of the infection probability of COVID-19 with ventilation rates in confined spaces", Building Simulation, Vol. 13, pp. 1321-1327 (2020).
28. J. Kurnitski, M. Kiil, A. Boerstra, O. Seppanen, "A new ventilation criterion based on respiratory infection risk of COVID-19", Preprint submitted to Indoor Air (2021). doi:10.13140/RG.2.2.35510.83524
29. Pereira, M., R. Vilain, A. Tribess, L. Morawska. "Risk assessment for airborne infectious diseases between natural ventilation and a split-system air conditioner in a university classroom", Proceedings of the 23rd ABCM International Congress of Mechanical Engineering, December 6-11, 2015, Rio de Janeiro, RJ, Brazil.
30. W.K. Chow, "A comment on studying the ventilation requirements for buildings in the Hong Kong Special Administrative Region", International Journal on Architectural Science, Vol. 1, No. 1, pp. 1-13 (2000).
31. W.K. Chow, W.Y. Fung and L.T. Wong. "Preliminary studies on a new method for assessing ventilation in large spaces", Building and Environment, Vol. 37, No. 2, pp. 145-152 (2002).
32. W.K. Chow, S.S. Li, Y. Gao and C.L. Chow, "Numerical studies on atrium smoke movement and control with validation by field tests", Building and Environment, Vol. 44, pp. 1150-1155 (2009).
33. C.L. Chow and W.K. Chow, "Fire safety aspects of refuge floors in supertall building with Computational Fluid Dynamics", Journal of Civil Engineering and Management, Vol. 15, No. 3, pp. 225-236 (2009).
34. C.L. Chow and W.K. Chow, "A brief review on applying computational fluid dynamics in building fire hazard assessment", Fire Safety, Editors: Ingmar Søgaaard and Hans Krogh (2009).
35. C.L. Chow and S.S. Han, "Simulation of atrium smoke filling by computational fluid dynamics", The International Journal of Ventilation, Vol. 8, No. 4, Paper 7 (2010).
36. C.L. Chow, "Numerical studies on smoke spread in the cavity of a double-skin façade", Journal of Civil Engineering and Management, Vol. 17, No. 3, pp. 371-392 (2011).
37. C.L. Chow, "Studying macroscopic indoor aerodynamics flow parameters using Computational Fluid Dynamics", International Journal on Architectural Science, Vol. 8, No. 3, pp. 67-75 (2011).

38. C.L. Chow, "Spread of smoke and heat along narrow air cavity in double-skin façade fires", *Thermal Science*, Vol. 18, No. 2, pp. S405-S416 (2014).
39. W.K. Chow, Y. Gao, J.H. Zhao, J.F. Dang, C.L. Chow and L. Miao, "Smoke movement in tilted tunnel fires with longitudinal ventilation", *Fire Safety Journal*, Vol. 75, pp. 14-22 (2015).
40. W.K. Chow, Y. Gao, J.H. Zhao, J.F. Dang and Nadia C.L. Chow, "A Study on Tilted Tunnel Fire under Natural Ventilation", *Fire Safety Journal*, Vol. 81, pp. 44-57 (2016).
41. W.K. Chow, Y. Gao, J.F. Zou, Q.K. Liu, C.L. Chow and L. Miao, "Numerical studies on thermally-induced air flow in sloping tunnels with experimental scale modelling justifications", *Fire Technology*, Vol. 54, No. 4, pp. 867-892 (2018).
42. K.C. Dahanayake, Y. Yang, Y. Wan, S.S. Han and C.L. Chow, "Study on the fire growth in underground green corridors", *Building Simulation*, Vol. 13, No. 3, pp. 627-635 (2020).
43. W.K. Chow and Philip C.H. Yu, "Simulation on energy use for mechanical ventilation and air-conditioning (MVAC) systems in train compartments", *Energy - The International Journal*, Vol. 25, No. 1, pp. 1-13 (2000).
44. M.Y. Chan, J. Burnett and W.K. Chow, "Energy use for ventilation systems in underground car parks", *Building and Environment*, Vol. 33, No. 5, pp. 303-314 (1998).
45. C.H. Cheng, C.L. Chow and W.K. Chow, "Trajectories of large respiratory droplets in indoor environment: A simplified approach", *Building and Environment*, Vol. 183, 107196 (2020).
46. W.K. Chow and C.L. Chow, "Modelling lockdown effects on controlling the spread of COVID-19", *medRxiv*. June (2022).  
<https://www.medrxiv.org/content/10.1101/2022.06.04.22275993v1>
47. TVB News, "The insurance industry urges the consumers to pay attention to the terms and conditions when purchasing travel insurance, they may not be compensated if they are not vaccinated against Covid-19", 10 October 2022.  
<https://news.tvb.com/tc/local/6343ea63b9cf14f1a95c6589/>
48. Oriental Daily, "Court News: Company fined HK\$36000 over two deaths in tower crane collapse", 3 December 2009. (In Chinese)  
[http://orientaldaily.on.cc/cnt/news/20091203/00176\\_072.html](http://orientaldaily.on.cc/cnt/news/20091203/00176_072.html)
49. Occupational Safety and Health Ordinance. Chapter 509, Laws of Hong Kong.  
[https://www.oshc.org.hk/eng/main/osh\\_info/osh\\_legislation\\_statist/](https://www.oshc.org.hk/eng/main/osh_info/osh_legislation_statist/)
50. The Standard. Bosses could be fined HK\$10m, jailed two years for safety breaches as latest bill passes. 19 April 2023. <https://www.thestandard.com.hk/breaking-news/section/4/202780/>
51. The Standard, "Docs charged with manslaughter in liver patient's tragic case", 11 January 2023. <https://www.thestandard.com.hk/breaking-news/section/4/199062>



52. The Standard, “Inquest into mom's death adjourned indefinitely”, 16 January 2023.  
<https://www.thestandard.com.hk/section-news/section/47295201/249034/>

engrxiv\_VR6ACH23-1a