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Airborne infection control in the indoor environment

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Outline

- Physical distancing threshold in indoor environment
- Engineering control for airborne infection in hospitals

Background: Transmission modes of SARS-CoV-2

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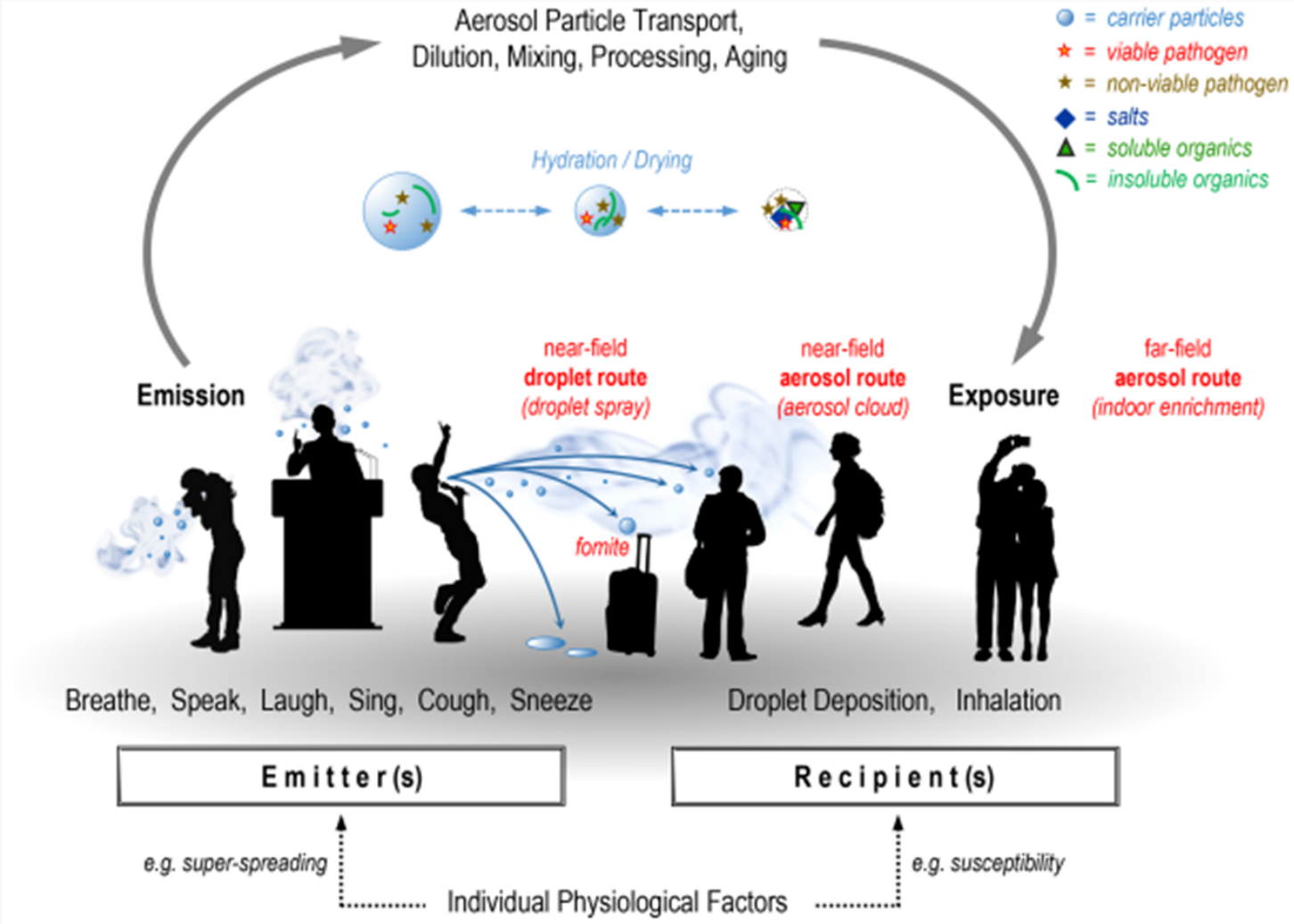

https://arxiv.org/pdf/2103.01188v2.pdf

What are physical distance thresholds? Where do they come from?

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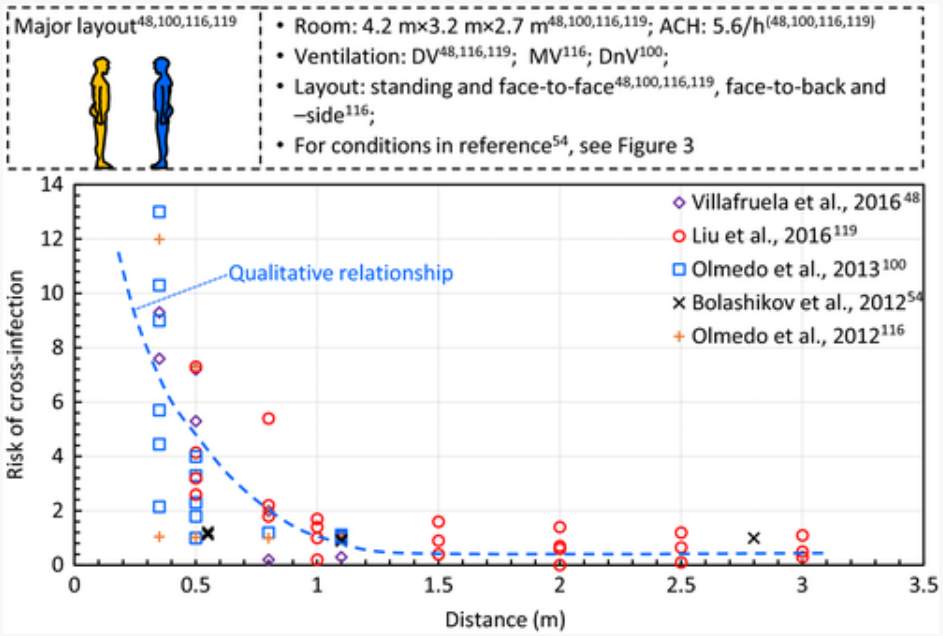
Two metres or one: what is the evidence for physical distancing in covid-19?

Rigid safe distancing rules are an oversimplification based on outdated science and experiences of past viruses, argue Nicholas R Jones and colleagues

Nicholas R Jones, Zeshan U Qureshi, [2] Robert J Temple, [3] Jessica P J Larwood, [4] Trisha Greenhalgh, [1] Lydia Bourouiba[5]

Liquid droplets from the 1942 Jennison experiment



Ai et al. Indoor Air. 2018

- 1897, Flugge experiment
- 1940, Jennison experiment

Jones et al. BMJ. doi: 10.1136/bmj.m3223

Research gap1: Droplet-physics based versus infection-risk based?

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Xie et al. 2007

Liu et al. 2017

Wei et al. 2015

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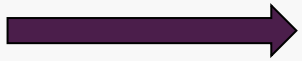
Droplet- Physics based



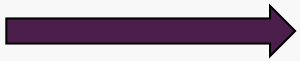
CDC: 6 feet

WHO: 1-2m

UK/Germany: 1-2m

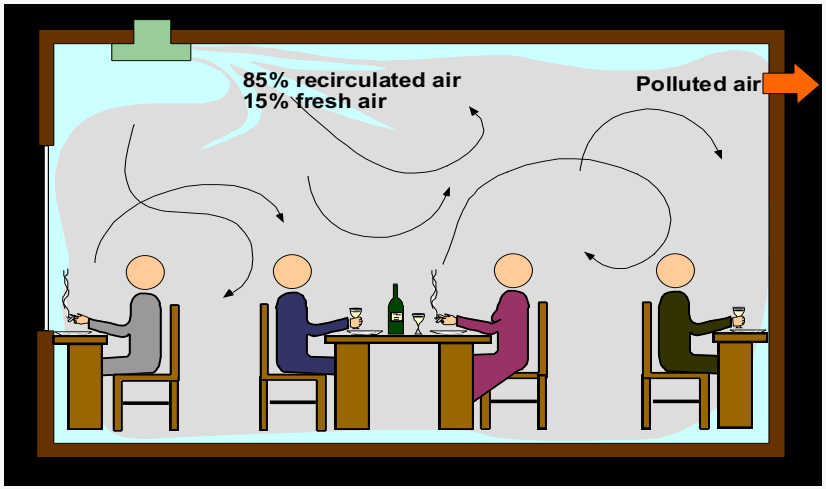
Infection-risk

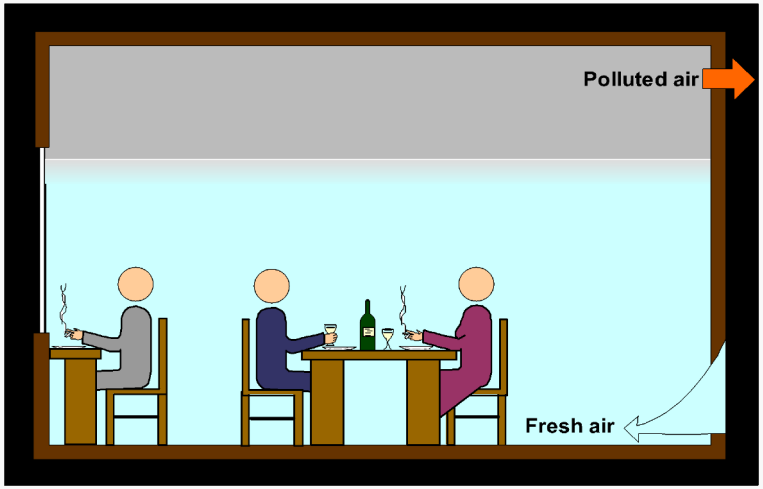
Infection-risk based

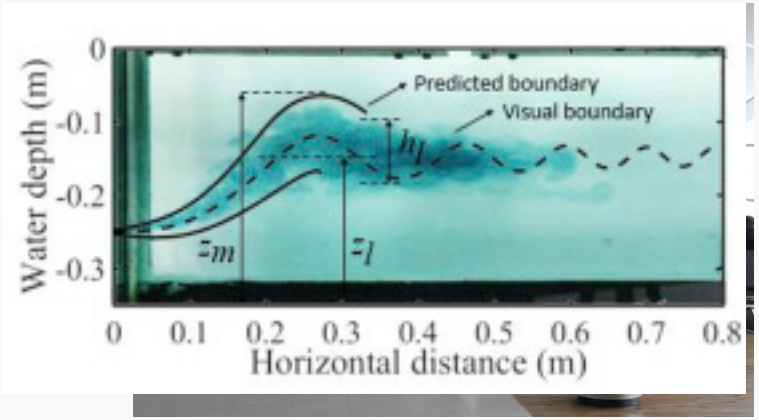


Physical distancing safety threshold?

Research gap2: Well-mixed versus thermally stratified environment?







Liu et al. Build Environ. 2020

Research gap 3: Relative posture matters?

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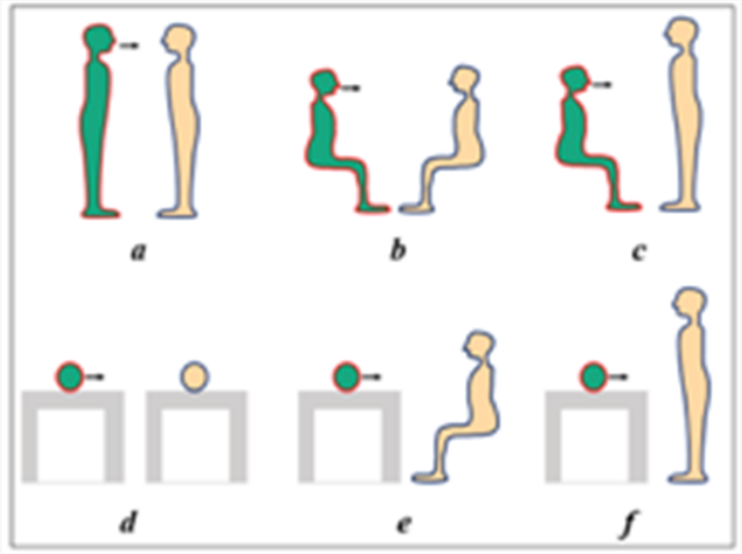

Methods: Infection-risk based physical distancing

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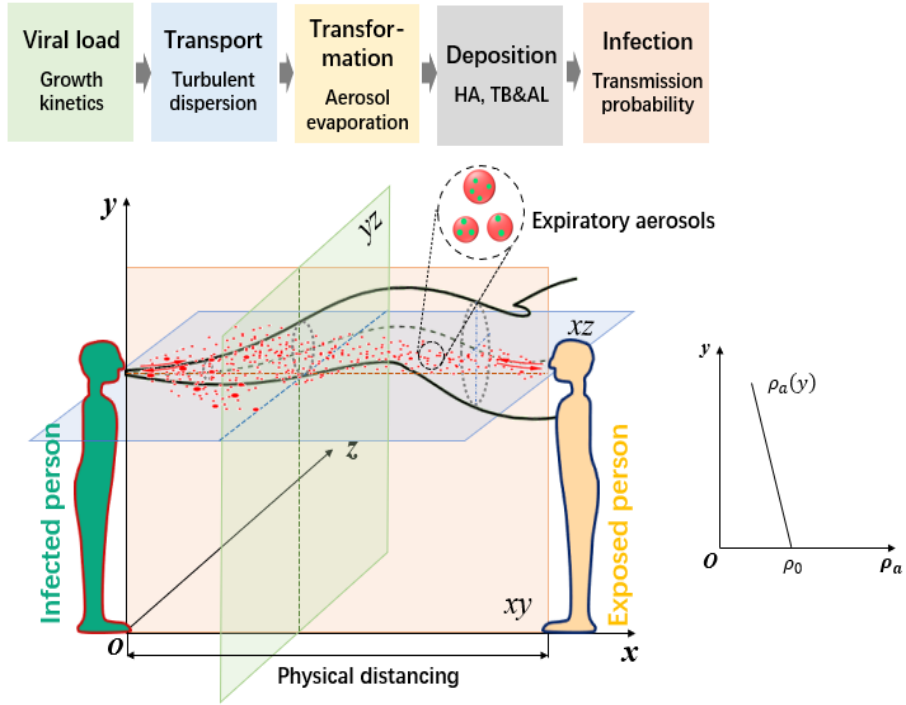

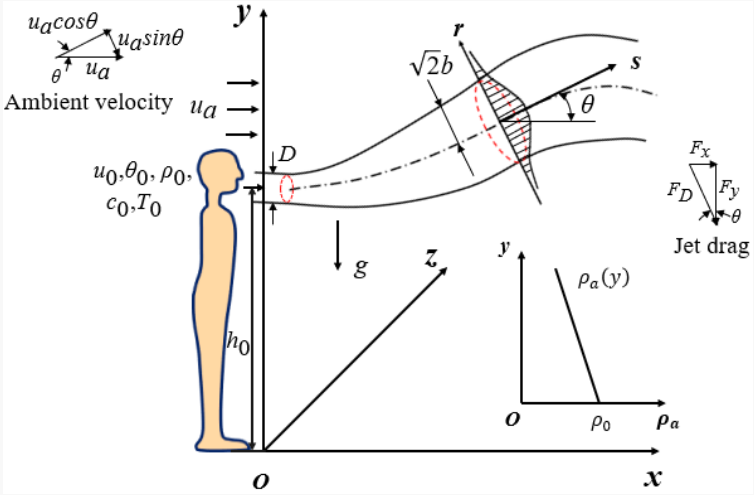

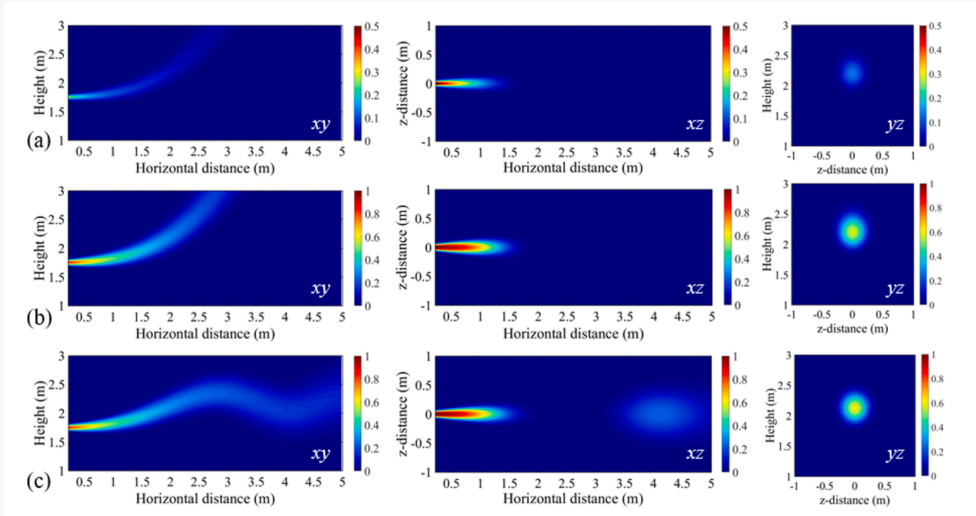

Liu et al. Environment International. 2021

a) 5min, uniform; b) 30min uniform; c) 30min, stratified

Results: mixing indoors vs stratified indoors

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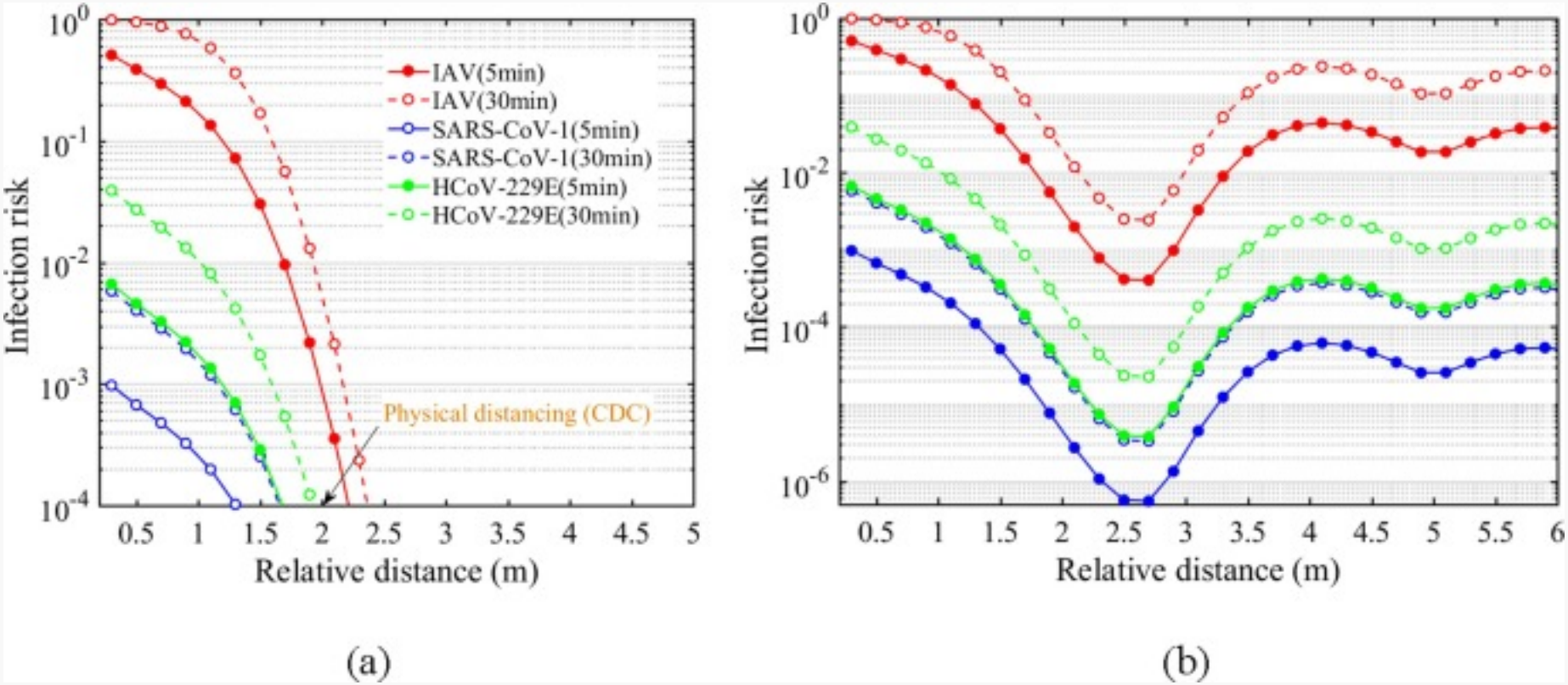


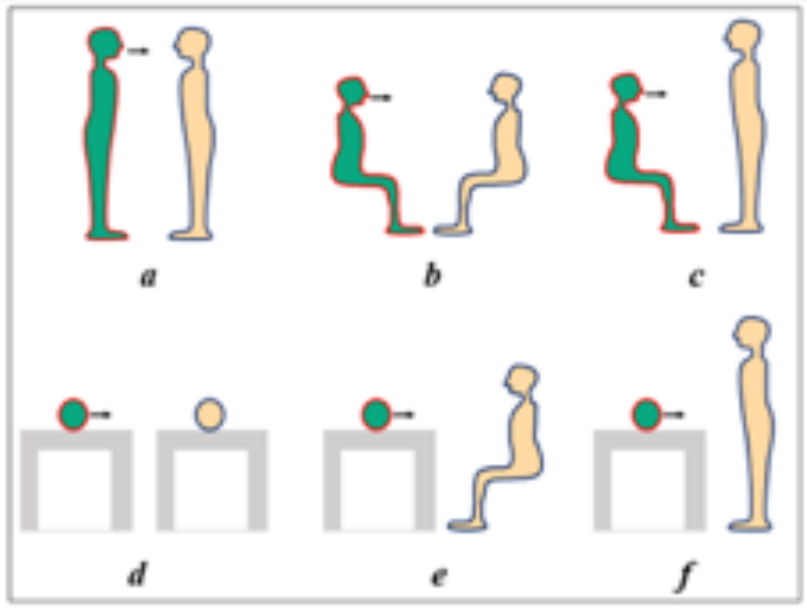
Uniform indoor temperature

$dT/dy = 0$

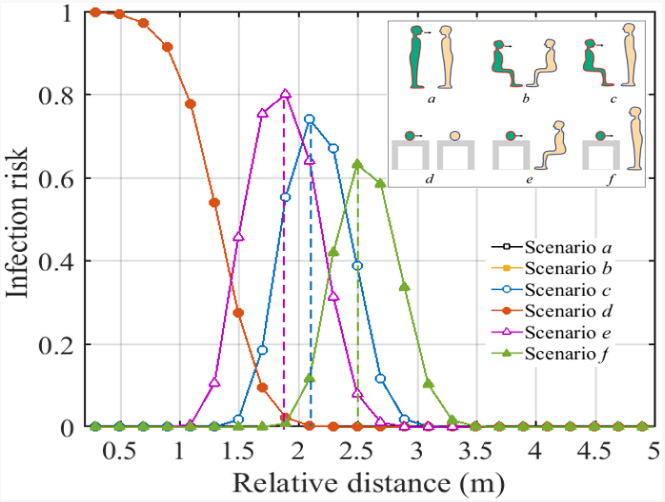
Stratified indoor temperature

$dT/dy = 2$ K/m

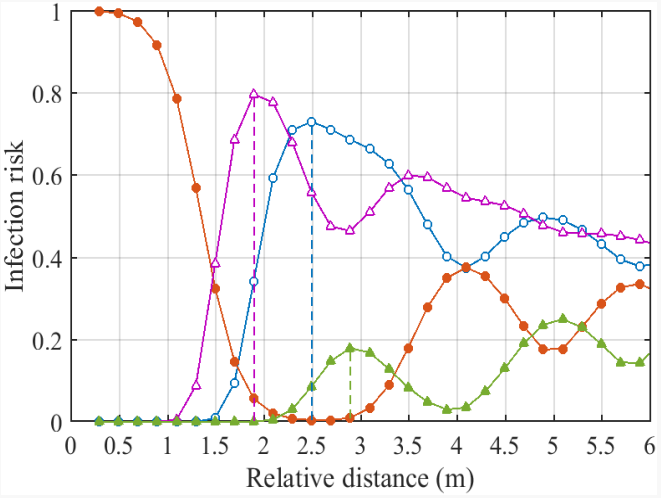
Results: Impact of relative posture



Uniform indoor temperature



Stratified indoor temperature



Summary 1

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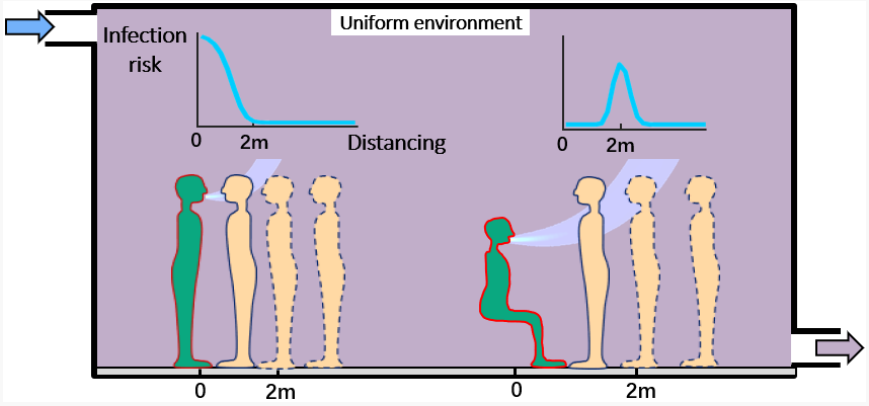
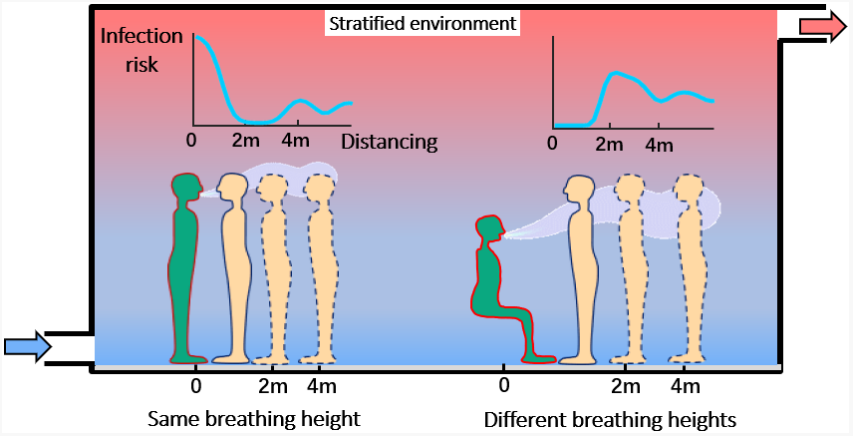
- There is no one-size-fit-in-all 2m physical distancing threshold- exposure time, indoor ventilation system matter and it also should be virus-dependent.
- The 2m physical distancing rule may increase transmission risk in when there is a breathing height difference.
- Multiple peaks in stratified environment much beyond 2m
- Avoid susceptible people with relatively high breathing heights in enclosed environment standing next to lying/seated patients/passengers.
- Use proper ventilation systems in critical environment.





Engineering design for infection disease control in hospital environment

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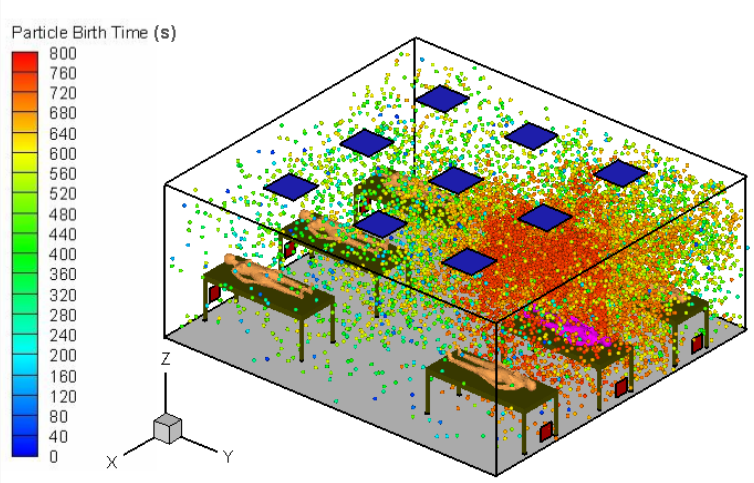
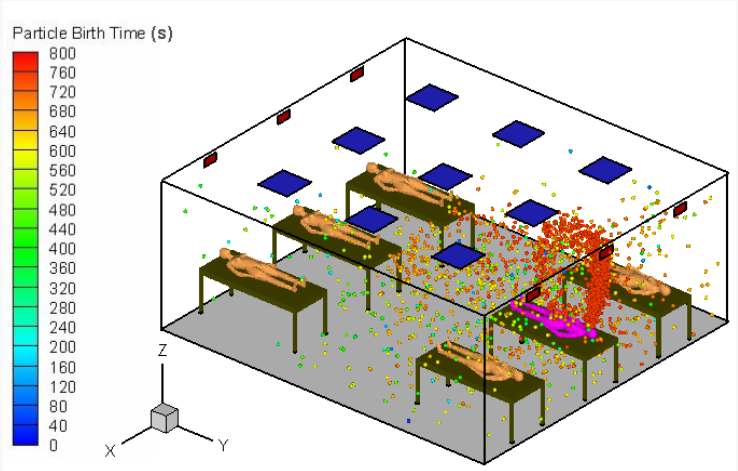
CDC

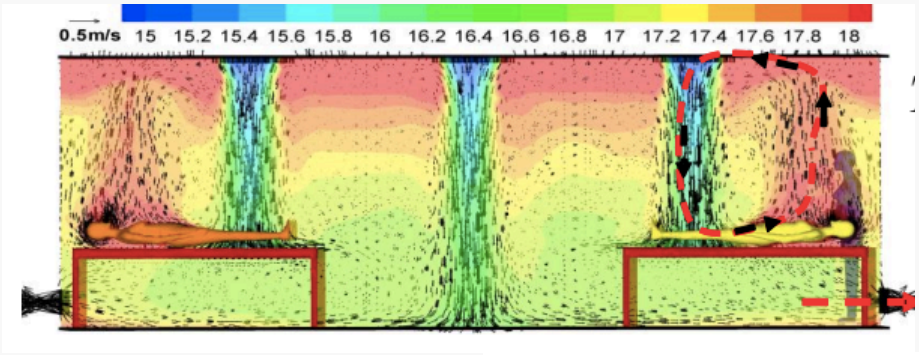
Floor return

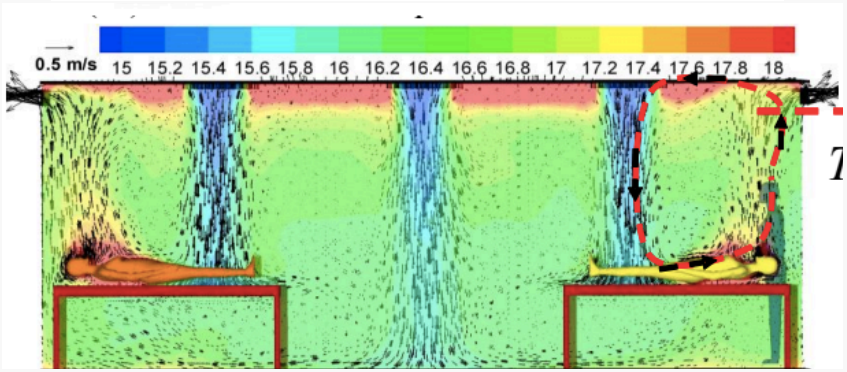


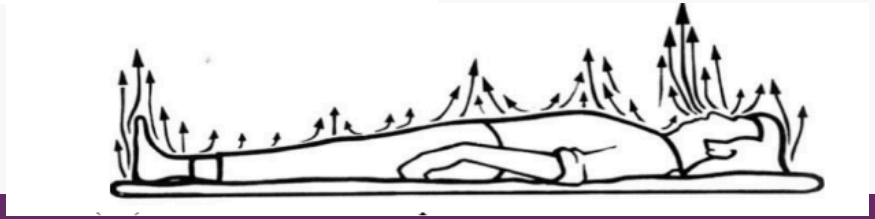
New

ceiling return









Qian et al. Indoor Air. 2010

Influenza outbreak in a general hospital ward

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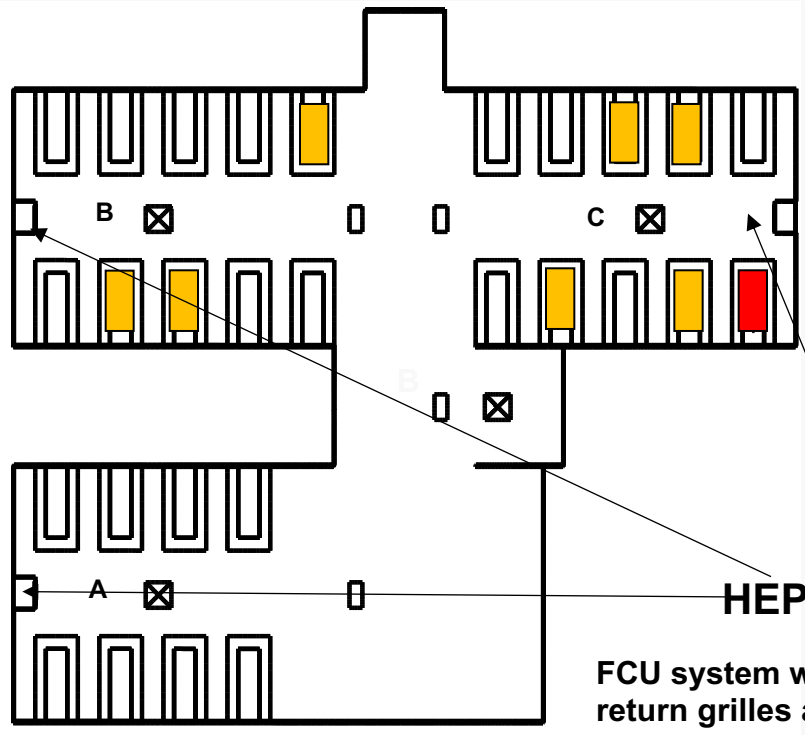


HEPA purifier

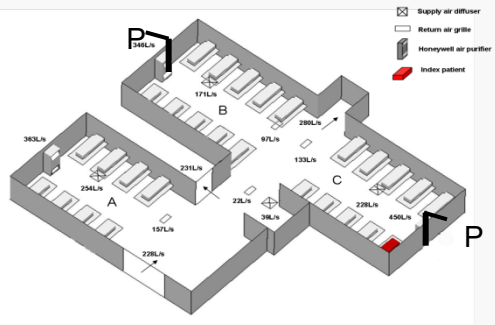
FCU system with supply diffusers and return grilles at ceiling level

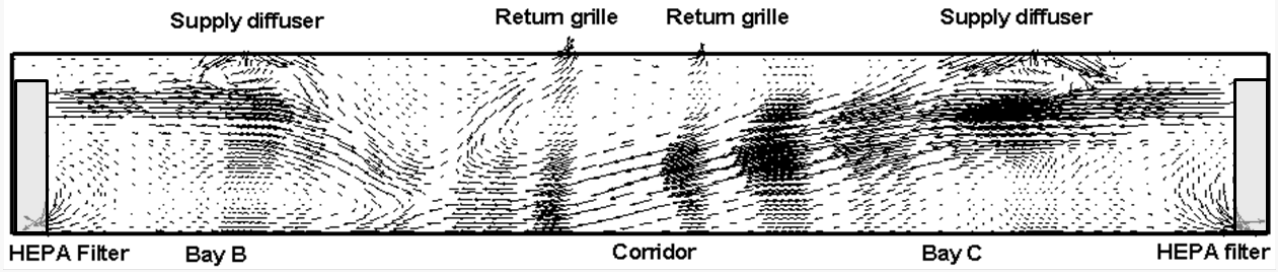
•All the infected patients were in Bay B and C, remote Bay C was not infected.

• No visitors and health-worker were infected

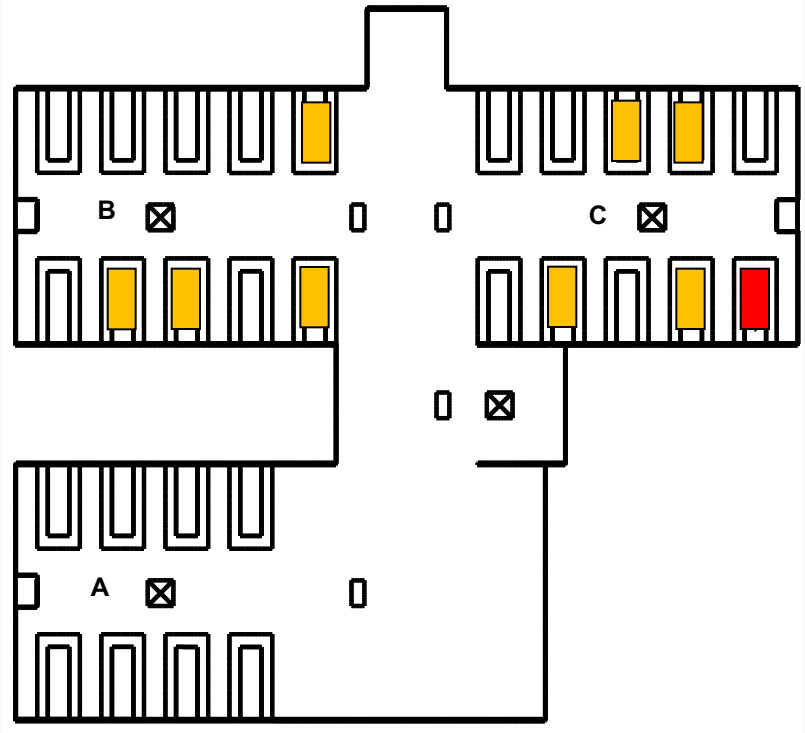
• All patients are immobile.

• Possible airborne transmission?

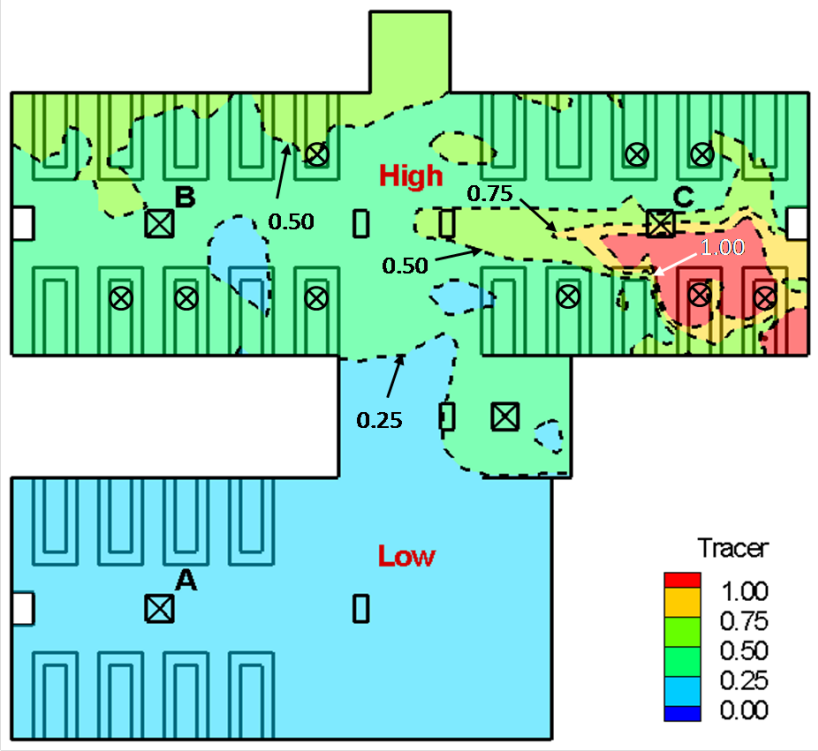




Velocity distribution at P-P plane



Spatial distribution of infected patients



Contour of normalized tracer concentration at z=1.1m

Wong et al. Clinical infectious disease. 2010

Outbreak in a restaurant in Guangzhou

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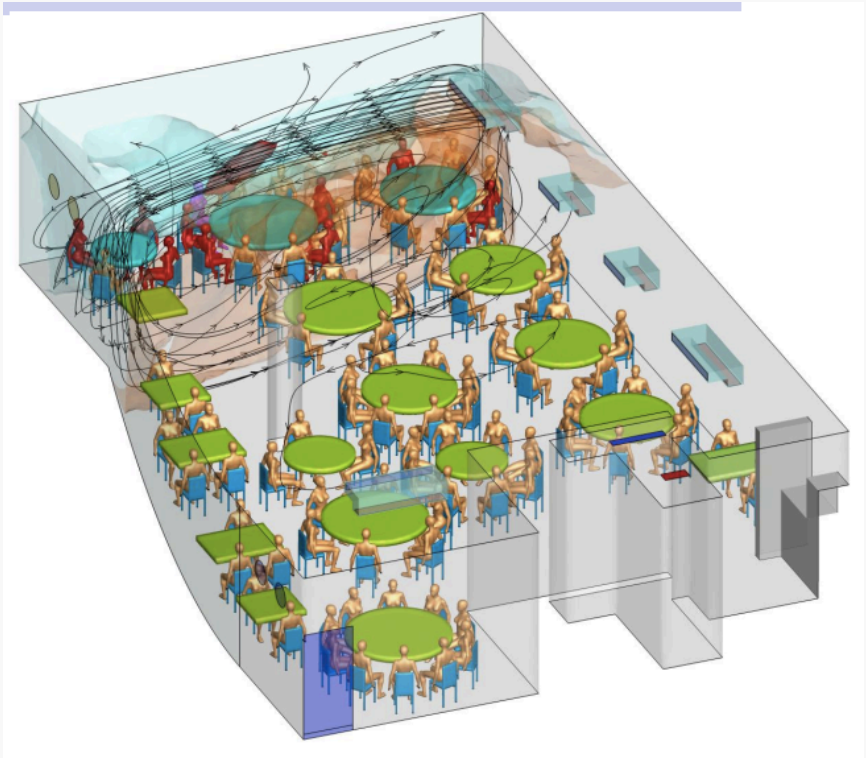
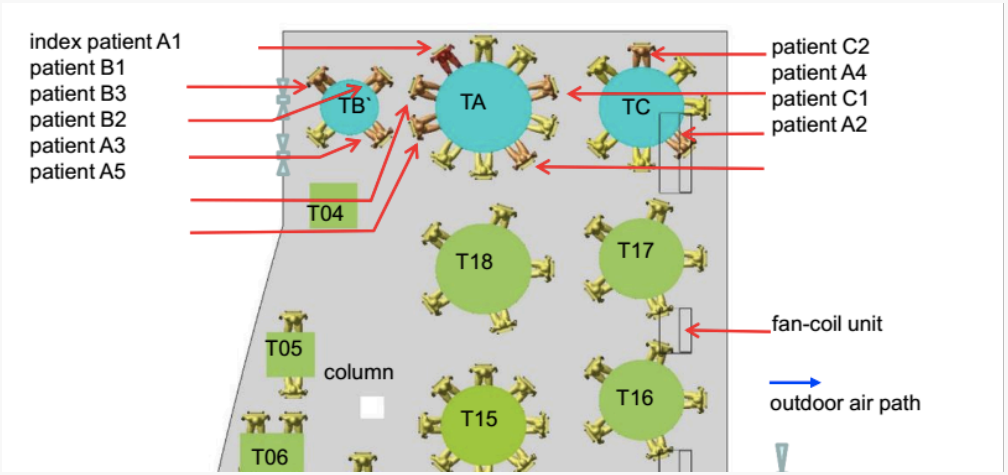
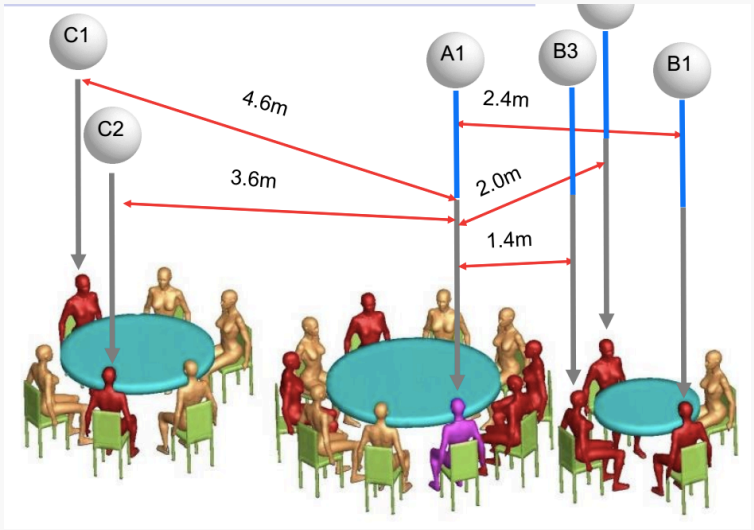
Poor ventilation:
0.75-1 L/s/p

Ventilation guideline:
10 L/s/p







Li et al. Building and Environment. 2021

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Thank you

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