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ASHRAE Position Document on Airborne Infectious Diseases

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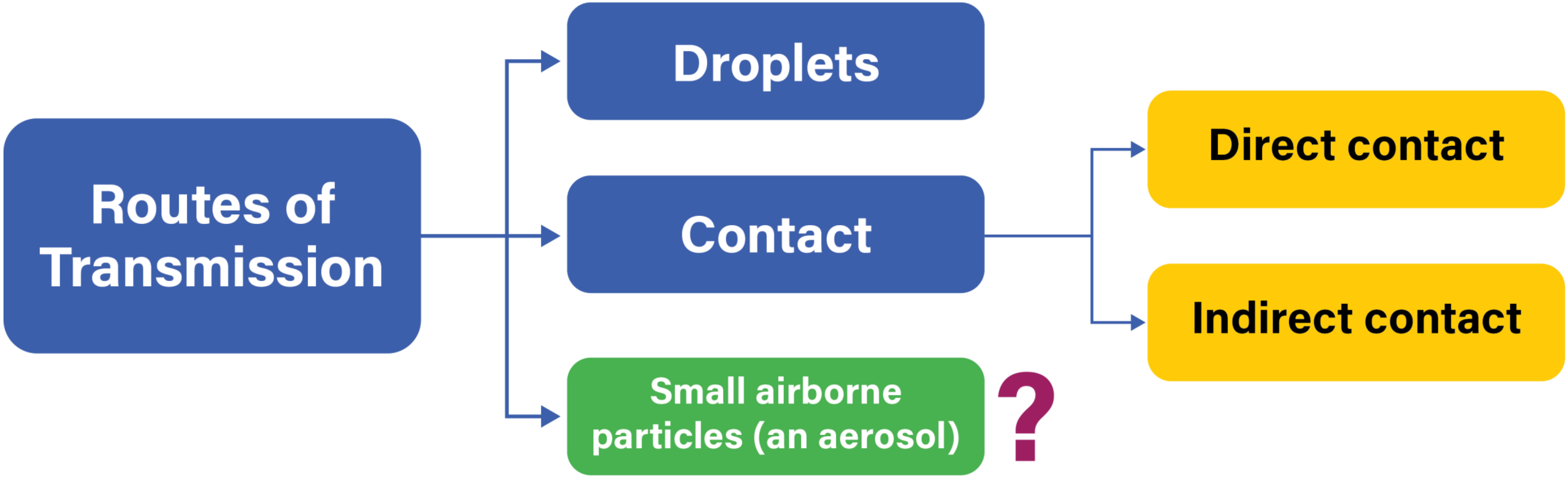
How Infectious Diseases Transmit



How Infectious Diseases Transmit

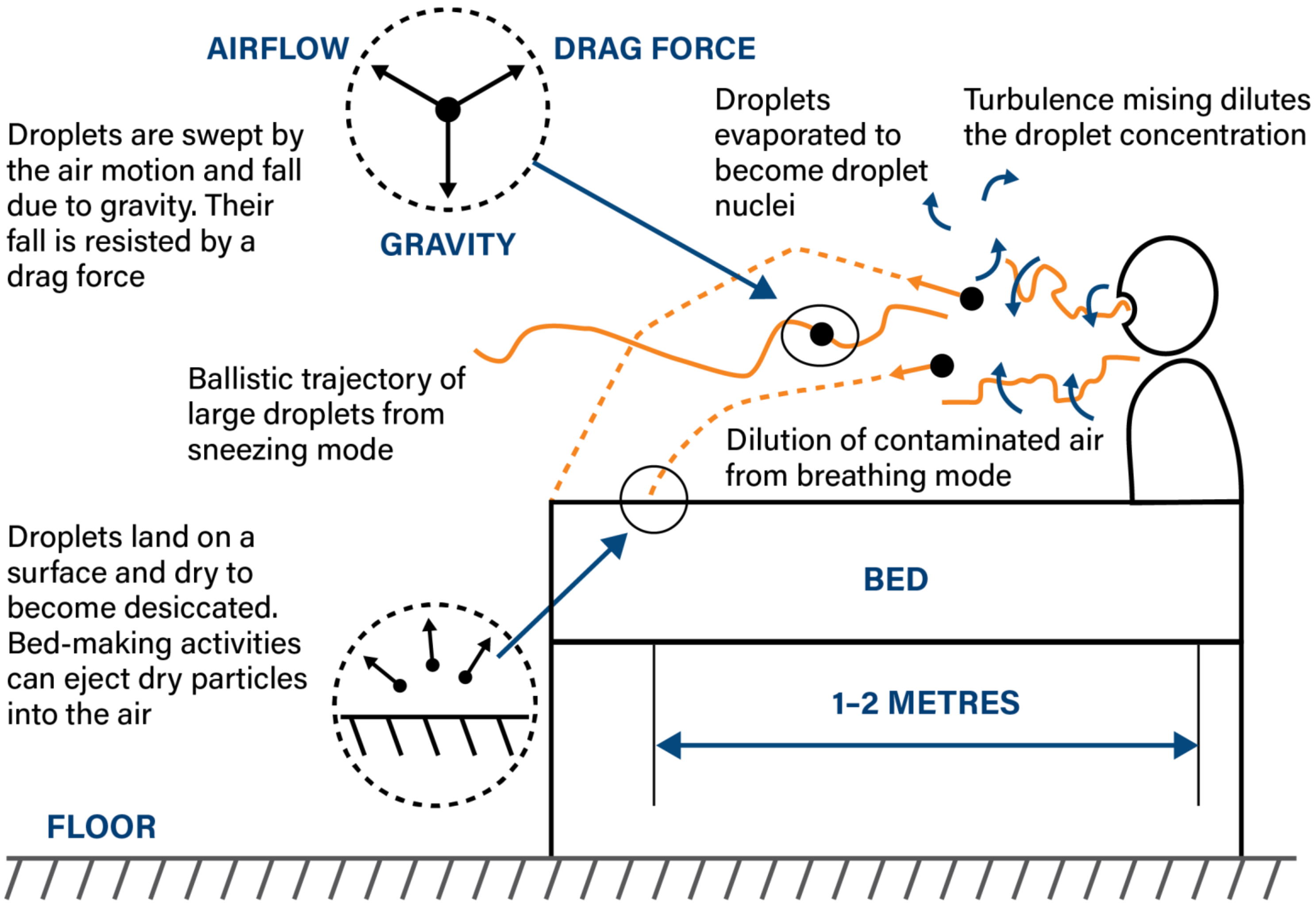
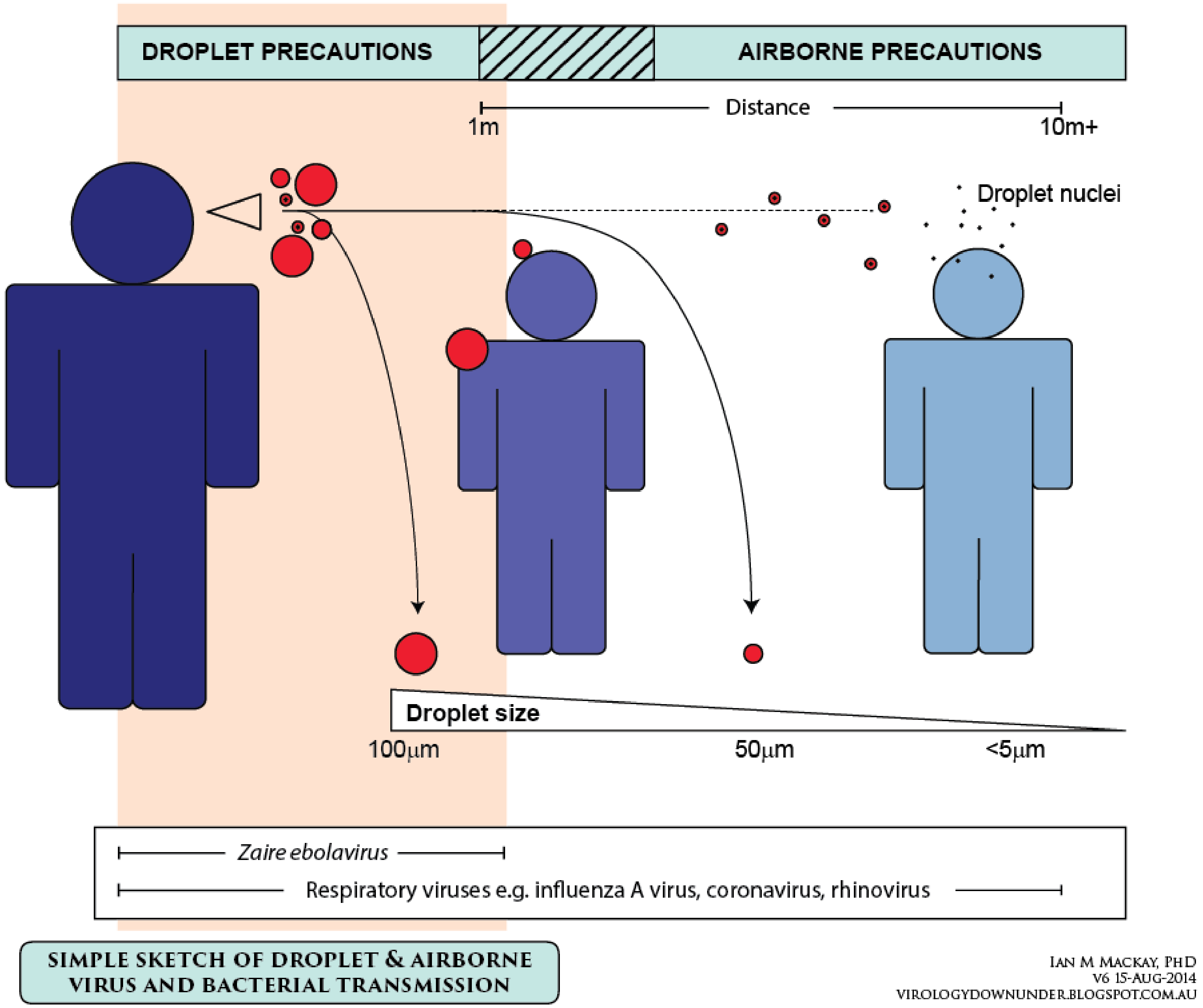


Illustration of the aerobiology of droplets and aerosols produced by an infected patient:

- The patient generates droplets by coughing or sneezing
- Droplets evaporated to become droplet nuclei
- Droplets fall due to gravity
- Droplets land on a surface and become desiccated. It can be ejected back into the air by bed-making activities.

How Infectious Diseases Transmit



U.S. health officials say Americans shouldn’t wear face masks to prevent coronavirus — here are 3 other reasons not to wear them

Published: March 2, 2020 at 12:47 p.m. ET

How Infectious Diseases Transmit

Why we care about viruses transmitting through aerosols?

- Air ventilation won't have a significant impact on the concentration, velocity, and direction of the respiratory droplets **with bigger sizes** [1]
- Aerosols travel a relatively long distance and can be significantly impacted by the building heating, ventilating, and air-conditioning (HVAC) system [2]

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[1] Siegel J.D., E. Rhinehart, M. Jackson, and L. Chiarello. 2007. *2007 Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings*. Atlanta: Centers for Disease Control and Prevention, The Healthcare Infection Control Practices Advisory Committee.

[2] ASHARE Position Document on Airborne Infectious Disease

Mathematical Model of Airborne Infection

$$C = S\left(1 - e^{-Iqpt/Q}\right)$$

C = number of new infections;

I = number of infectors;

S = number of susceptibles;

q = number of doses of airborne infection added to the air;

Tuberculosis: 1.25~249 qph

Measles: 5,480 qph

p = pulmonary ventilation per susceptible; typically 0.6 m^3/h;

t = exposure time, typically 8 hours;

Q = volume flow rate of fresh or disinfected air (m^3/h)

Characteristics of Transmission Through Aerosols

Transmission Types	Characteristics	Disease
Obligate	Only transmit through aerosols, aerodynamic diameters of the particles between 1~ 5 μm	Mycobacterium tuberculosis
Preferential	Transmit through multiple routes, predominantly by aerosols	Measles
		Chicken pox
Opportunistic	Transmit through multiple routes, can by aerosols when in favorable conditions	To be determined

Roy, C.J., and D.K. Milton. 2004. Airborne transmission of communicable infection—The elusive pathway. *New England Journal of Medicine* 350:17.

My Research on Mycobacterium Tuberculosis Transmission

Flu virus can transmit through aerosols, but it is not the main route

Common flu virus and rhinovirus (common cold), can transmit through aerosols

Cases that viruses transmit through aerosols

- In an Alaska Airline airplane, 72% of the 54 passengers were infected with flu, due to the airplane's recirculated air ventilation system.[1]
- In the 1986 H1N1 period, researchers arranged the susceptibles to be over 6.5 feet (2 meters) from the infected patient; the susceptibles were still infected.[2]
- A SARS Coronavirus outbreak in a high-rise building in Hong Kong (Amoy Gardens) was due to the exhaust fans in restrooms [3]

[1] Moser, M.R., T.R. Bender, H.S. Margolis, G.R. Noble, A.P. Kendal and D.G. Ritter. 1979. An outbreak of influenza aboard a commercial airliner. *American Journal of Epidemiology* 110(1):1–6.

[2] Klontz, K.C., N.A. Hynes, R.A. Gunn, M.H. Wilder, M.W. Harmon, and A.P. Kendal. 1989. An outbreak of influenza A/Taiwan/1/86 (H1N1) infections at a naval base and its association with airplane travel. *American Journal of Epidemiology* 129:341–48.

[3] Li, Y., H. Qian, I.T.S. Yu, and T.W. Wong. 2005a. Probable roles of bio-aerosol dispersion in the SARS outbreak in Amoy Gardens, Hong Kong. Chapter 16. *Population Dynamics and Infectious Disease in the Asia-Pacific*. Singapore: World Scientific Publishing.

Ventilation & Air Cleaning

Humidity Control

Emergency Planning

HVAC system design, operation, and maintenance strategies

1. Increase outdoor air
2. Control airflow direction
3. Control room air differential pressure
4. Personalized ventilation
5. Use high-efficiency filter
6. Utilize UVGI

Ventilation & Air Cleaning

Humidity Control

Emergency Planning

Research show that controlling air relative humidity may reduce transmission of certain airborne infectious organisms

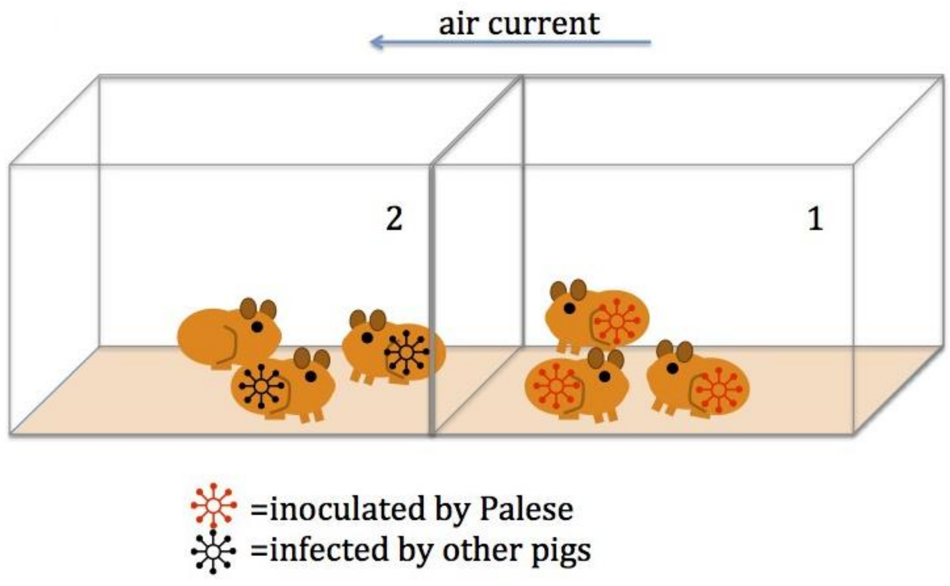
Possible Relative Humidity Impact

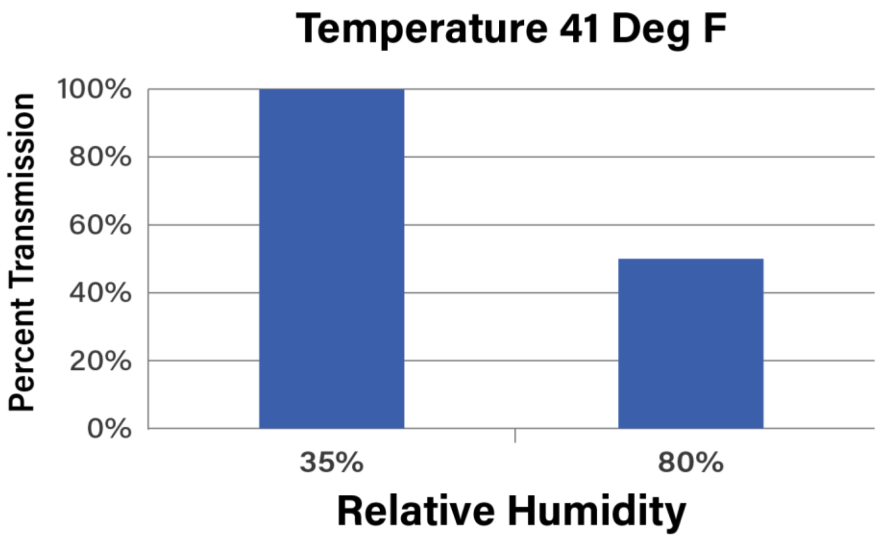
1. More humid air will slow the evaporation of large droplet into droplet nuclei
2. Breathing dry air could cause desiccation of the nasal mucosa, making the person more susceptible to respiratory virus infections
3. Humidity may affect the viruses' viability or toxicity

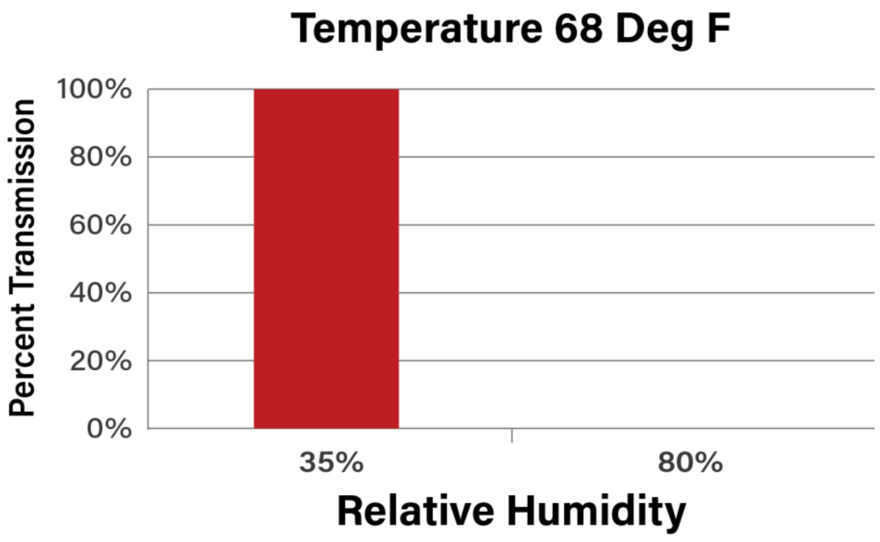
The ASHRAE document does not make a broad recommendation on indoor temperature and humidity. Industry practitioners should make their own decisions on a case-by-case basis.

Room Temperature and Humidity and Coronavirus Viability

- Coronavirus and flu virus can survive longer in cold and dry environments
- The transmission rates are also higher







Lowen, A.C., S. Mubareka, J. Steel, and P. Palese. 2007. Influenza Virus Transmission Is Dependent on Relative Humidity and Temperature. PLOS Pathogens. 3(10):e151.

Ventilation & Air Cleaning

Humidity Control

Emergency Planning

Issues

- Nobody knows what level of dilution ventilation is needed to decrease the droplets or droplet nuclei generated by patients to prevent their transmissions
- It is essential to control room differential pressure (DP) and the direction of airflow. Isolation rooms should be kept at negative DP, while rooms for people with low immunity should be kept at positive DP.
- Personalized ventilation systems may prevent virus transmission through aerosols, but this has not been validated.
- Adding highly efficient particle filtration to central ventilation systems may reduce the number of infectious particles in the air
- Two applications of Ultraviolet Germicidal Irradiation (UVGI):
  - Installation into air handlers and/or ventilating ducts
  - Irradiation of the upper air zones of occupied spaces with shielding of the lower occupied spaces

Ventilation & Air Cleaning

Humidity Control

Emergency Planning

How engineers can help?

- Identify vulnerabilities with air intake, wind direction, shielding
- Identify building systems and safe zones in the general building environment
- Identify approaches to interrupting air supply to designated “shelter-in-place” locations
- Identify co-horting possibilities for pandemic situations so that whole areas of a hospital may be placed under isolation and negative pressure

Airborne Infectious Disease Engineering Control Strategies: Occupancy Interventions and Their Priority for Application and Research

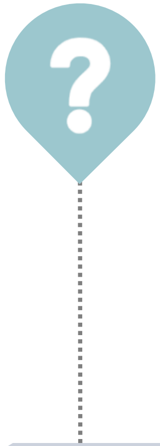
Strategy	Occupancy Categories Applicable for Consideration*	Application Priority	Research Priority
Dilution ventilation	All	High	Medium
Temperature and humidity	All except 7 and 11	Medium	High
Personalized ventilation	1, 4, 6, 9, 10, 14	Medium	High
Local exhaust	1, 2, 8, 14	Medium	Medium
Central system filtration	All	High	High
Local air filtration	1, 4, 6, 7, 8, 10	Medium	High
Upper-room UVGI	1, 2, 3, 5, 6, 8, 9, 14	High	**Highest**
Duct and air-handler UVGI	1, 2, 3, 4, 5, 6, 8, 9, 14	Medium	**Highest**
In-room flow regimes	1, 6, 8, 9, 10, 14	High	High
Differential pressurization	1, 2, 7, 8, 11, 14	High	High

***Occupancy Categories**

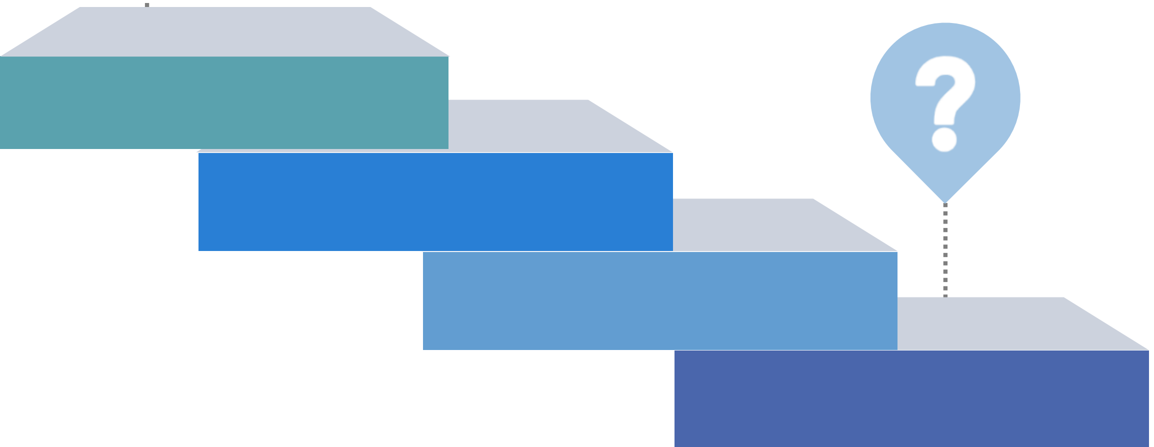
1. Health care (residential & outpatient)
2. Correctional facilities
3. Educational < age 8
4. Educational > age 8
5. Food & beverage
6. Internet café/game rooms
7. Hotel, motel, dormitory
8. Residential shelters
9. Public assembly & waiting
10. Transportation conveyances
11. Residential multifamily
12. Retail
13. Sports
14. Laboratories

Problems need to be resolved now: risk assessment of COVID-19 coronavirus transmission through aerosols in public spaces

Urgently needed: experiments on animals and mathematic model parameters determination



- Does it transmit through aerosols? (experiments on animals)
- The natural decay rate of the virus viability (various environments)
- Exposure threshold for virus infection (susceptibles)
- Rates of virus release by infected patients at different stages and by various activities



What is the indoor environment control parameter?

CO_2 level between 550–1000 PPM

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Thanks

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