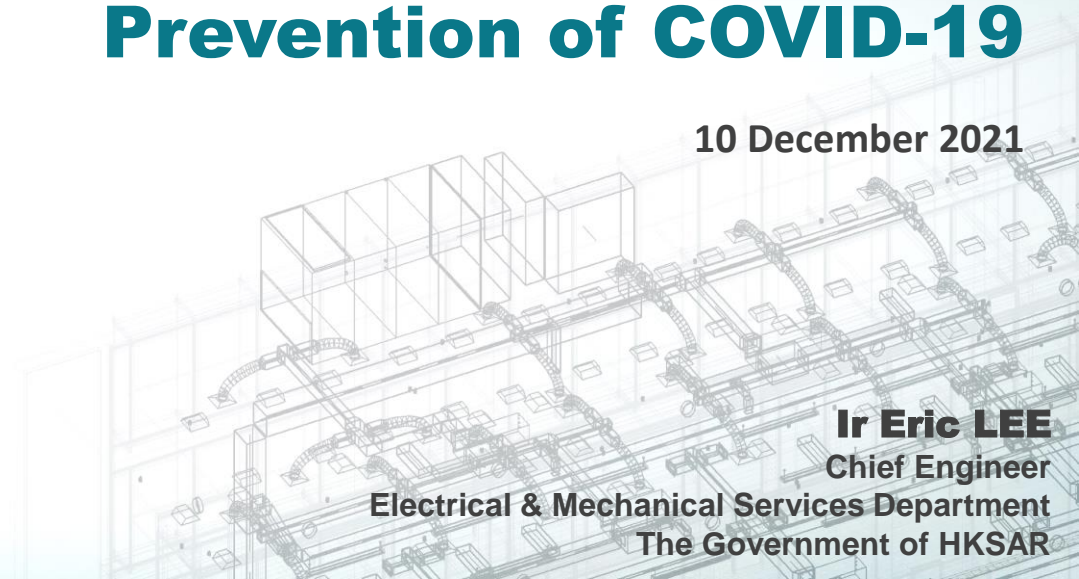


# Role of Ventilation and Prevention of COVID-19

10 December 2021



**Ir Eric LEE**  
Chief Engineer  
Electrical & Mechanical Services Department  
The Government of HKSAR



# Introduction



## 2 main roles of Electrical and Mechanical Services Department (EMSD):

### Regulatory Services Branch

- enforcement of 15 E&M related ordinances (e.g. electrical, gas, lift & escalator safety, etc.) to protect public safety.

### Trading services branch

- provision of E&M related engineering and advisory services to the Government and other statutory organizations.





# Role of EMSD in Tackling COVID-19

To be well prepared for the COVID-19 Pandemic...

1



EMSD Together with the HA  
Developed the MMHU



Conversion of General Wards to  
2<sup>nd</sup> tier Isolation Wards



Community Treatment Facility  
in Asia World-expo

4



North Lantau Hospital Hong Kong Infection  
Control Centre (HKICC)



Setup of Community Testing  
and Vaccination Centres

6



Assessment of Ventilation Systems for  
quarantine facilities and premises with  
infectious cases



# **Role of Ventilation in Infection Control**



# Role of Ventilation in Infection Control

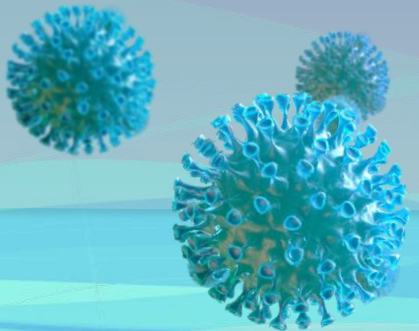
## Two Objectives:

### 1. **MAKE** the “Zone” clean

- Remove contaminants in the air from the “Zone”

### 2. **KEEP** the “Zone” clean

- Prevent contaminants from entering the “Zone”

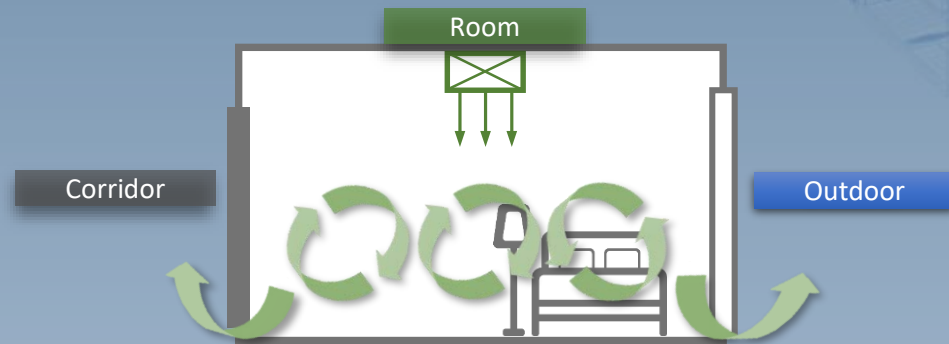


# “Make the Area Clean”

## Dilution Ventilation & Displacement Ventilation

### 1. Dilution Ventilation

Dilute concentration of the **contaminant** with incoming clean air.



#### Legend



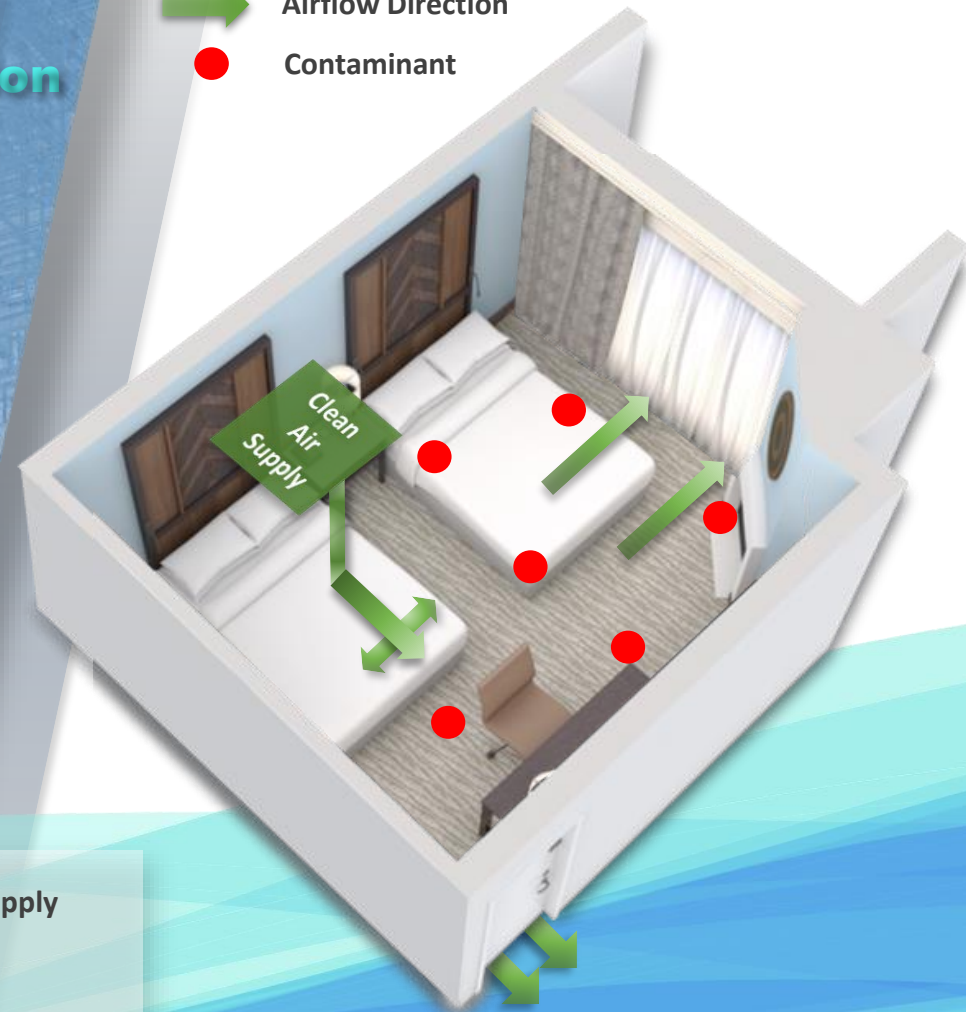
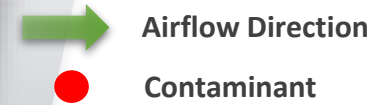
Airflow Direction

Door



Clean Air Supply

Window



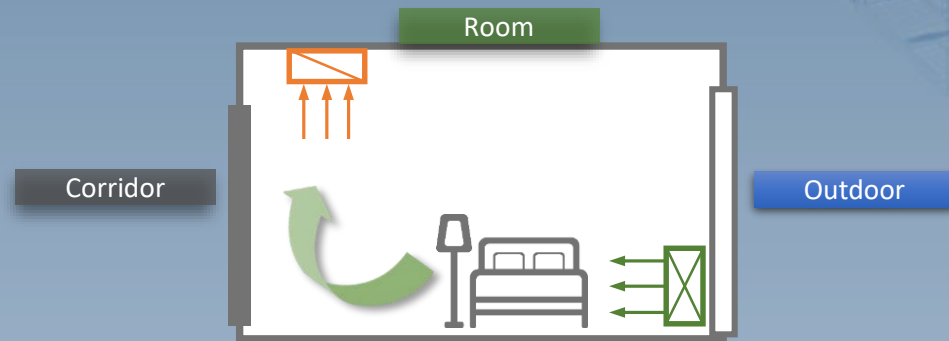


# “Make the Area Clean”

## Dilution Ventilation & Displacement Ventilation

### 2. Displacement Ventilation

Contaminants are removed by the air exhaust at high level of the space



#### Legend



Airflow Direction

Door



Clean Air Supply

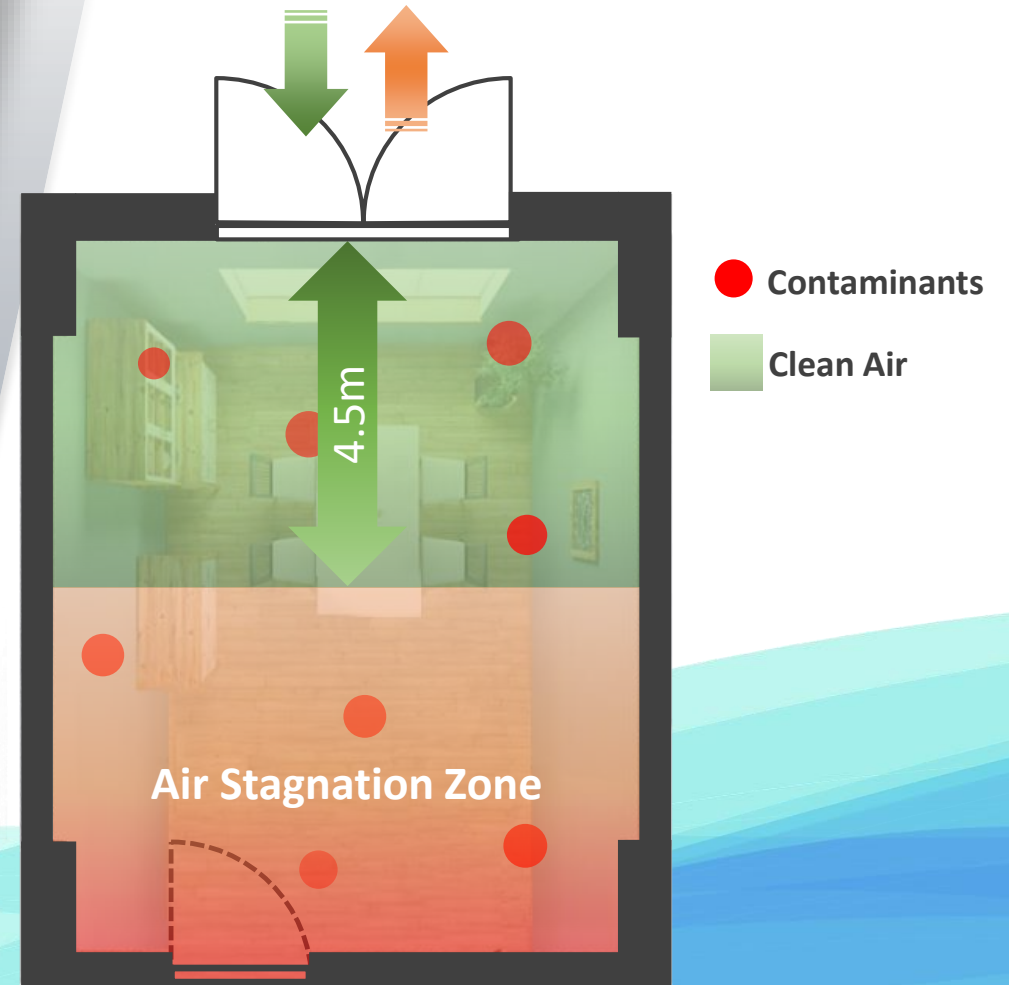
Window



# Ventilation Plays an Important Role in Infection Control

## 3 Principles for Good Ventilation:

- Volume Flow Rate (Amount of Fresh Air)  
↑ Amount ➡ ↓ Virus Concentration
- Even Distribution of Ventilation  
Ensure Air in the Whole Room is “Changed”
- An Airflow Pathway (From Clean to Dirty Zone)



Typical Room with Single-side Window for Natural Ventilation



# Ventilation Plays an Important Role in Infection Control

## 3 Principles for Good Ventilation:

- Volume Flow Rate (Amount of Clean/ACH)  
↑ Amount ➡ ↓ Virus Concentration
- Even Distribution of Ventilation  
Ensure Air in the Whole Room is “Changed”
- An Airflow Pathway (From Clean to Dirty Zone)  
↓ Chance of Contact with the Virus

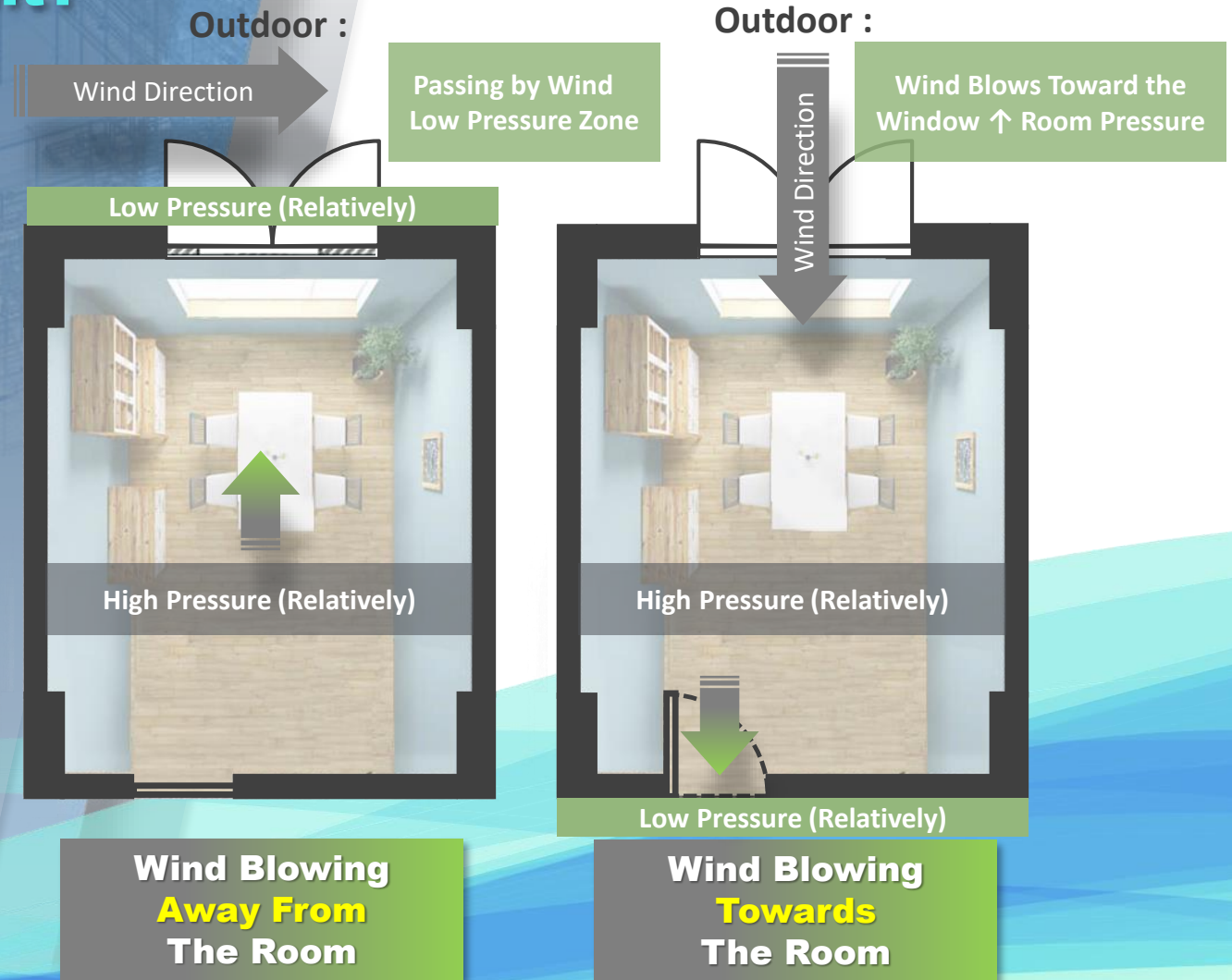


# What drives the air movement?

## What drives the air movement?

- Wind
- Differential air pressure

High P → Low P



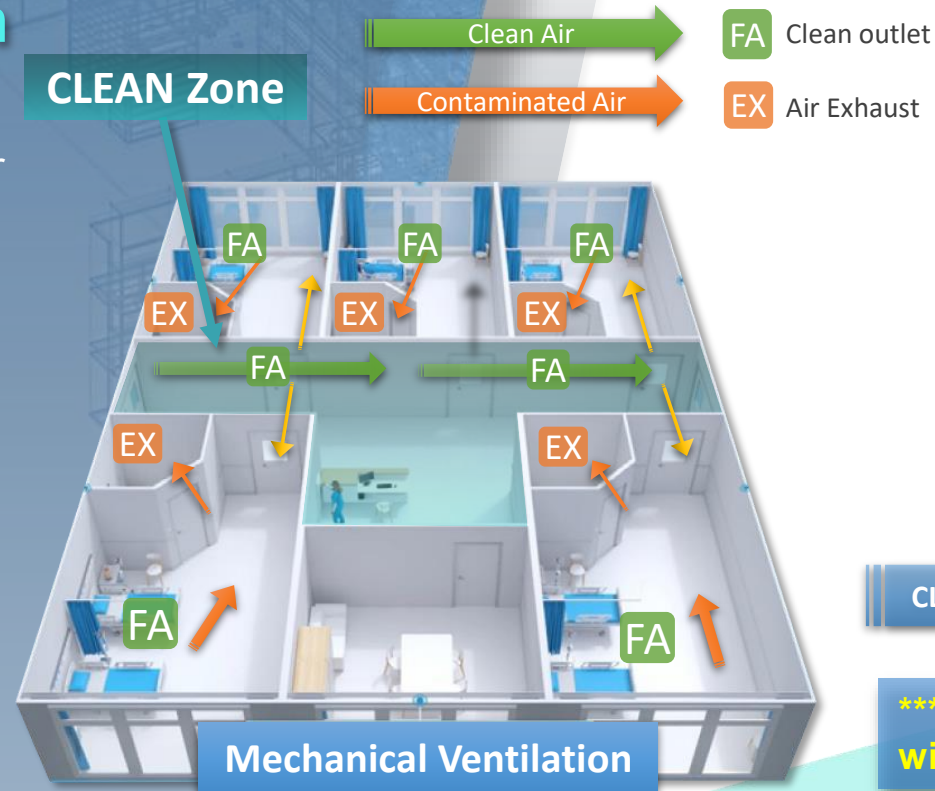


# Mechanical Ventilation

Recall: Pressure (P) difference creates air movement

- High P → Low P

Mechanical Equipment (Fans) → Create Pressure Difference → Control Air Movement



\*\*\*↑ Airflow direction controllability  
windows should be **CLOSED**

Mechanical Ventilation (**Fans**) Used to  
**Control Pressure** of Different Zone

Airflow Path Design:  
Low Risk Zone → High Risk Zone → Air Exhaust

**Minimized the Risk of  
Spreading Virus**

# Natural Ventilation VS Mechanical Ventilation

Pros		Cons
Natural Ventilation	<ul style="list-style-type: none"><li>• High ventilation rate may sometimes be achieved (climate dependent)</li><li>• Lower energy consumption</li></ul>	<ul style="list-style-type: none"><li>• Depends on Weather Condition (e.g. Wind speed and direction)</li><li>• Difficult to control</li></ul>
Mechanical Ventilation	<ul style="list-style-type: none"><li>• Volume Flow Rate can be controlled</li><li>• Filtration / purification systems can be installed</li><li>• Airflow path can be controlled</li><li>• Even air distribution can be achieved</li></ul>	<ul style="list-style-type: none"><li>• High cost</li><li>• Consume energy</li><li>• Require space for equipment and duct work</li><li>• Requires proper operation and maintenance</li></ul>



# Ventilation Terminology

Statutory Regulations & Engineering Standards

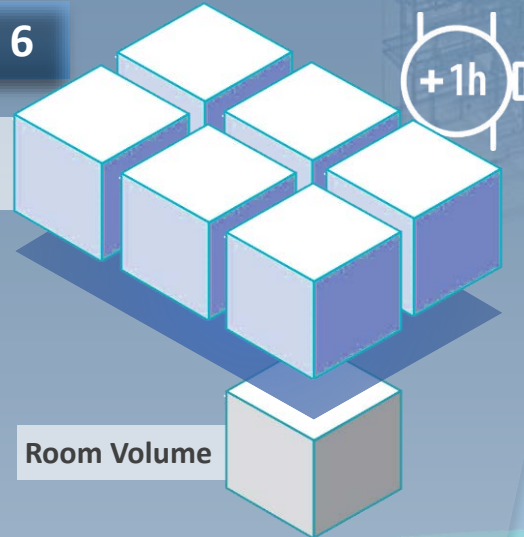
**Air Changes Per Hour - ACH**

**Ventilation Flow Rate (L/s)**

Vary with the occupancy status and types of work activity

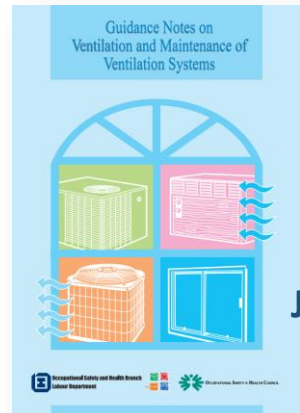
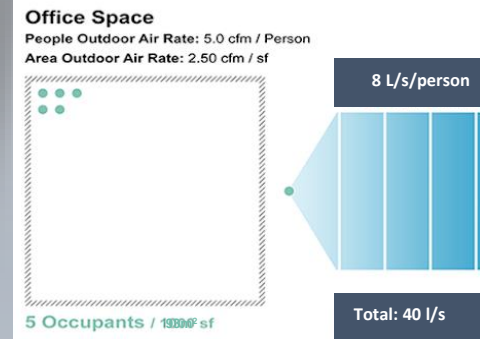
e.g. ACH = 6

Volume of Air Flowing into the Room within an Hour



ACH is the Ratio of Volumetric Flow Rate to Room Volume

$$ACH = \frac{\text{Volume of Outdoor Air Flowing into the Room per Hour (m}^3\text{)}}{\text{Room Volume (m}^3\text{)}}$$



Types of Work Activity	Minimum Ventilation Rate
Private offices	0.6 m <sup>3</sup> /min/person or 10 L/s/person
Conference rooms	1 m <sup>3</sup> /min/person or 16.7 L/s/person
Hotel rooms	18 L/s (exhaust)

$$ACH = \frac{\text{Ventilation Rate } \left(\frac{L}{s}\right) \times 3600 \left(\frac{s}{hr}\right) \times 0.001 \left(\frac{m^3}{L}\right)}{\text{Room Volume (m}^3\text{)}}$$

Formula from WHO guideline

# International Guidelines on Ventilation – WHO Droplet Nuclei Concentration Decay & Infection Risk



WHO Publication/Guidelines

## Natural Ventilation for Infection Control in Health-Care Settings

Edited by:  
James Atkinson, Yves Chartier,  
Carmen Lúcia Pessoa-Silva,  
Paul Jensen, Yuguo Li  
and Wing-Hong Seto

Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed

Interim guidance  
29 June 2020



### Background

This is the third edition of WHO's interim guidance on infection prevention and control (IPC) strategies during health care when coronavirus disease (COVID-19) is suspected or confirmed. The first edition was adopted from WHO's interim guidance on infection prevention and control during health care for probable or confirmed cases of Middle East respiratory syndrome coronavirus (MERS-CoV) infection, and the second edition was updated to include evidence and practical advice for management of patients with suspected or confirmed COVID-19. The main differences and additions compared to the previous versions include the following:

- all sub-sections in the section "Principles of IPC strategies associated with health care for suspected or confirmed cases of COVID-19" were expanded to include clarifications and additional recommendations;
- new guidance and practical advice for management of visitors especially in areas with COVID-19 community transmission;
- inclusion of a sub-section on ventilation in the section "Transmission and engineering controls";
- new guidance on IPC considerations for surgical procedures for patients with suspected or confirmed COVID-19, as well as those patients whose COVID-19 status is unknown;
- considerations for dual body management in health-care facilities;
- practical advice and available tools to assess health-care facility IPC readiness and to monitor and evaluate IPC measures for COVID-19.

Guidance and considerations included in this document are based on published WHO scientific, technical, guidelines and guidance documents, including the WHO Guidelines on infection prevention and control of epidemic and pandemic-prone acute respiratory infections in health care, scientific levels on modes of COVID-19 transmission and

disinfection of isolation, and other WHO COVID-19 interim guidance documents on clinical management, dual body management, and laboratory biosecurity available at the WHO Country and Technical Guidance Centres for Disease (COVID-19). In addition, this IPC guidance has been developed by consulting the WHO's COVID-19 IPC Guidance Development Group (COVID-19 IPC GDG) that meets at least once a week, and as an ad hoc expert group that provided input for the section on ventilation.

WHO will continue to update this guidance as new information becomes available.

This guidance is intended for health workers, including health care managers and IPC teams at the facility level, but it is also relevant for the national and district/provincial levels.

Principles of IPC strategies associated with health care for suspected or confirmed cases of COVID-19

To mount an optimal response to the COVID-19 outbreak using the strategies and practices recommended in this document, a facility-level IPC programme with a dedicated and trained team or at least an IPC focal point should be in place and supported by the national and facility senior management. In countries where IPC is limited or non-existent, it is critical to start by ensuring that at least basic IPC standards are in place at the national and health-care facility level to provide minimum protection to patients, health workers and visitors. These are known as the minimum requirements for IPC that have been developed by WHO in 2019<sup>1</sup> based on a broad consensus among international experts and institutions to facilitate the implementation of the WHO recommendations on the core components for IPC programmes.<sup>2</sup> Achieving the IPC minimum requirements as well as more robust and comprehensive IPC programmes according to the WHO core components across the whole health system in all countries is essential to sustain efforts to control the COVID-19 pandemic, other emerging infectious diseases, health-care-associated infections and antimicrobial resistance.

<sup>1</sup> Previous versions of this interim guidance were published on 23 January and on 19 March 2020 at <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/publications>

<sup>2</sup> WHO Country and Technical Guidance COVID-19 <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/publications>

Table E.1 Decay of droplet nuclei concentration in an isolation room for different ventilation rates and duration of time

What happen when ACH = 12 ?

	Ventilation rate (ACH) (%)			
Time (minutes)	6	12	18	24

Table E.2 Infection risk with 15 minutes exposure with different ventilation rates and quanta generation for an infector entering an enclosed space with a dimension 6 m × 6.7 m × 2.7 m

Quanta generation (quanta/min)	Ventilation rate (air changes per hour) (%)							
	1	3	6	12	15	18	24	30
0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
0.10	0.03	0.02	0.01	0.01	0.01	0.01	0.00	0.00
0.14	0.05	0.03	0.01	0.01	0.01	0.01	0.01	0.01
0.19	0.07	0.03	0.01	0.01	0.01	0.01	0.01	0.01
0.23	0.08	0.04	0.02	0.02	0.01	0.01	0.01	0.01
0.27	0.10	0.05	0.03	0.02	0.02	0.01	0.01	0.01
0.30	0.11	0.06	0.03	0.02	0.02	0.01	0.01	0.01
0.34	0.13	0.07	0.03	0.03	0.02	0.02	0.02	0.01
0.37	0.14	0.07	0.04	0.03	0.03	0.02	0.02	0.02
0.40	0.16	0.08	0.04	0.03	0.03	0.02	0.02	0.02

No. of Quanta increases ↓

Risk decreases →

ACH ↑ → Infection Risk ↓

% of Pollutant Remaining in a Space

100.00  
1.83  
0.03  
0.00  
0.00

Decay of Droplet Nuclei Against the Ventilation Rates in a Period of Time

ACH ↑  
→ Pollutant Removal % ↑

The room is initially full of pollutants and pollutants being extracted from the room

When:

1. However... =

• ACH ↑ fr 1 to 12 (+11) → ↓ Risk = 0.4 → 0.04 (↑ 10 Times (0.36))

2. • ACH ↑ fr 15 to 24 (+9) → ↓ Risk = 0.03 → 0.02 (↑ 1.5 Times (0.01 ONLY))

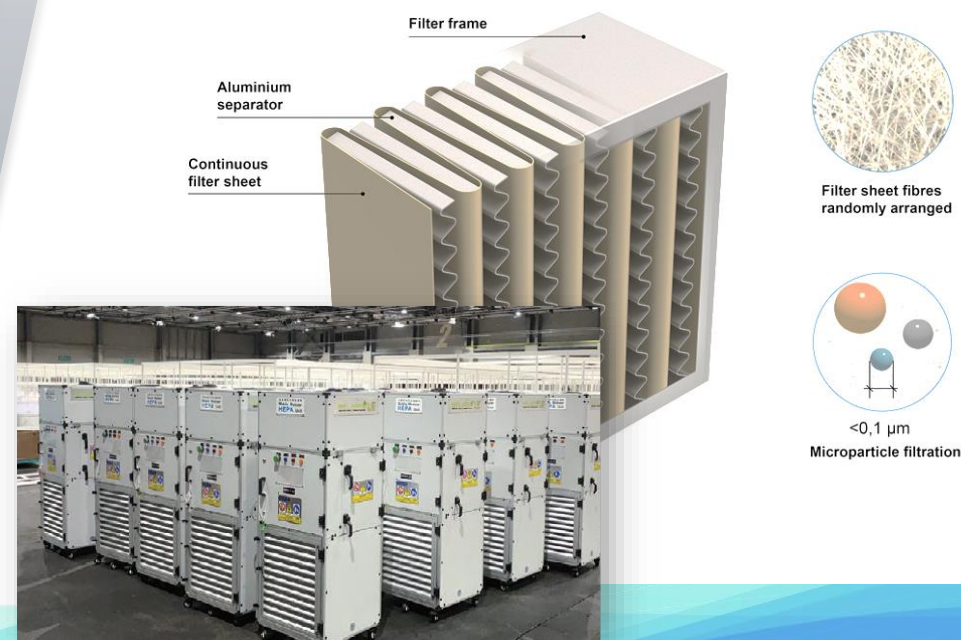


# Ventilation Terminology

Standard	EN 1822	Efficiency
EPA	E10	$\geq 85\%$
	E11	$\geq 95\%$
	E12	$\geq 99.5\%$
HEPA	H13	$\geq 99.95\%$
	H14	$\geq 99.995\%$
ULPA	U15	$\geq 99.9995\%$
	U16	$\geq 99.99995\%$
	U17	$\geq 99.999995\%$

## HEPA Filter

High-Efficiency Particulate Air Filter



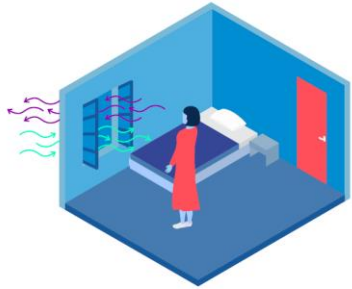
Special Requirement on Fan →  
Enough power to move air through the filter

# International Guidelines on Ventilation – WHO

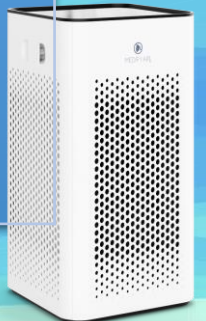
## Roadmap to improve and ensure good indoor ventilation in the context of COVID-19



Roadmap to improve and ensure good indoor ventilation in the context of COVID-19



	Minimum Requirements	Healthcare Settings (where AGP are performed)	Healthcare Settings (General application)	Non residential / Residential Settings
WHO recommendation	Ventilation Rate (L/s/person)	160	60	10
	ACH	12	6	Not specified
WHO top up provision if the ACH cannot be met	Filter grade <b>air purifier</b> if cannot meeting the requirement above	HEPA	HEPA	MERV 14

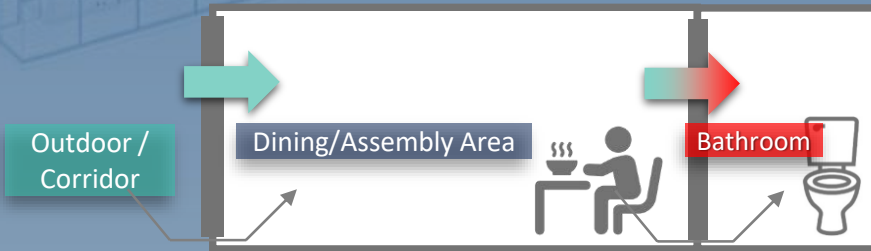


Air Purifier



# Comparison of Ventilation System in Different Settings

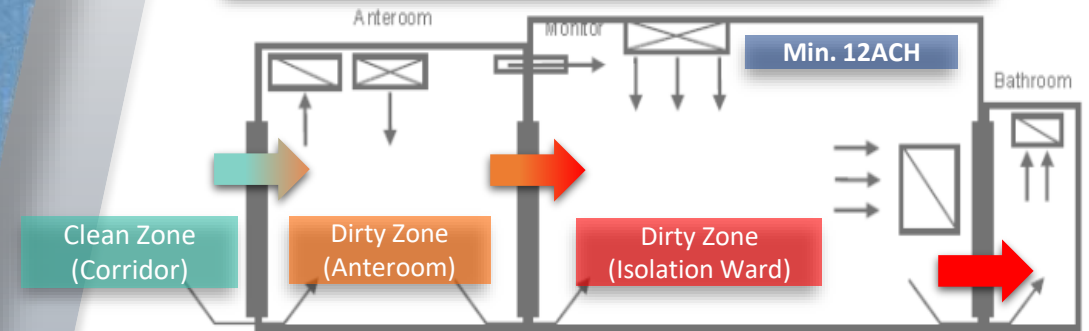
## Example: Elderly Home



High Pa → Negative Pressure Differential → Low Pa

CLEAN ZONE → LESS CLEAN ZONE → DIRTY ZONE → EXHAUST

## Typical Negative Pressure Isolation Room



0 Pa      2.5Pa      5 Pa

High Pa → Negative Pressure Differential → Low Pa

CLEAN ZONE → LESS CLEAN ZONE → DIRTY ZONE → EXHAUST

### Legend



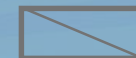
Airflow Direction



Clean Supply

Min X Pa

Differential Pressure



Air Exhaust

# Fresh Air Source & Air Exhaust

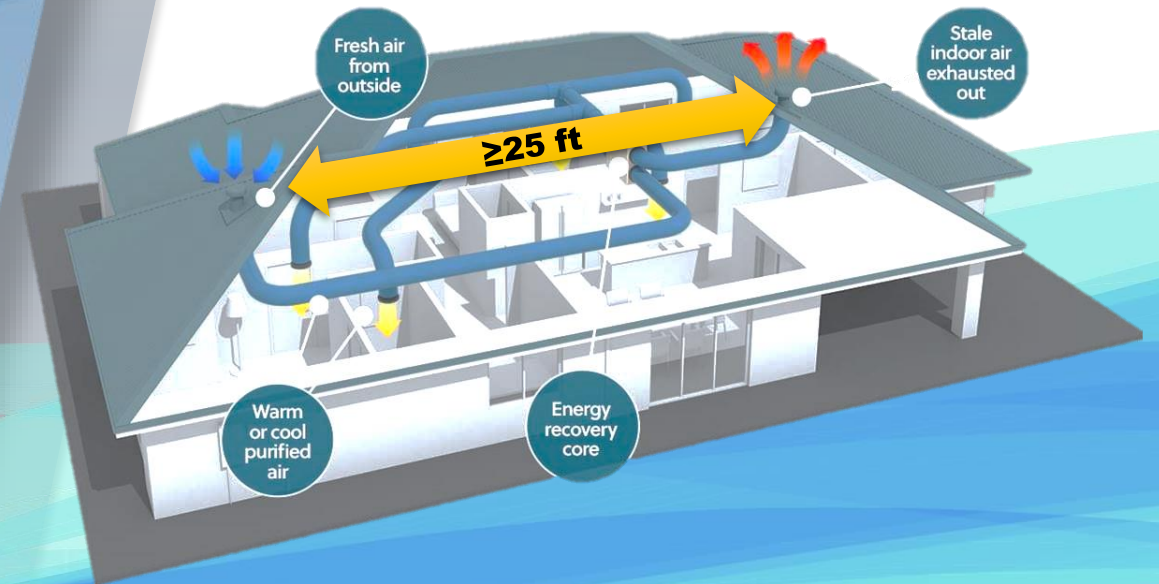
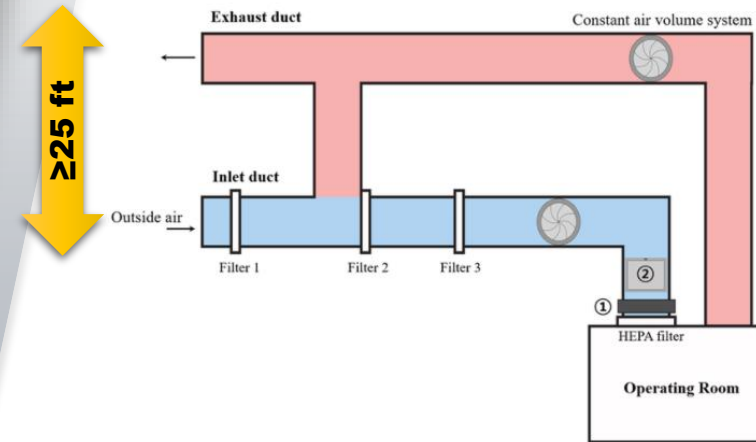
Distance between fresh air inlet and any sources of air contamination should be  $\geq 25$  ft

**Safe Distance:  $\geq 25$  ft**

Exhaust Outlet

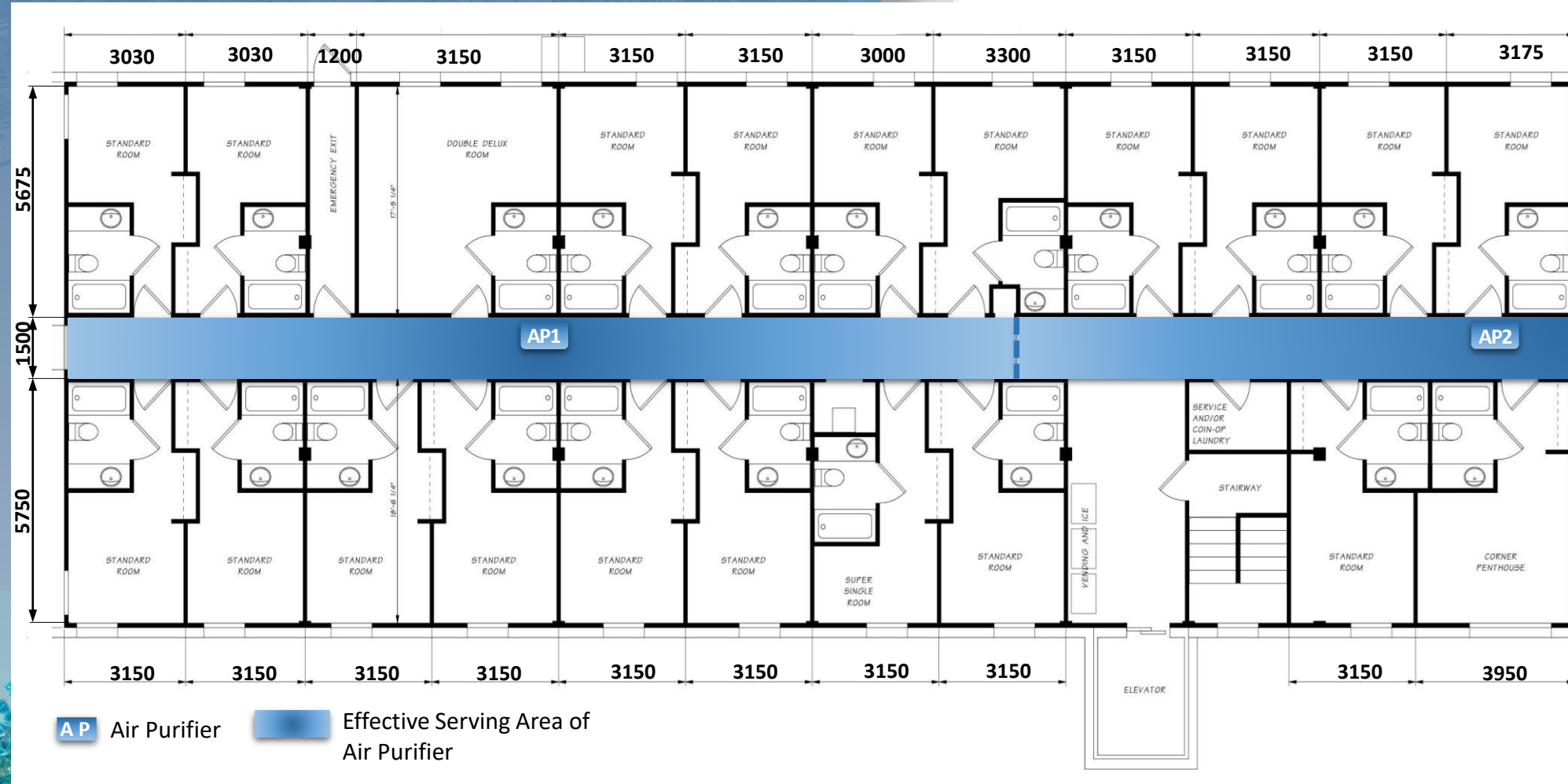


Drainage Vent Pipe Outlet





# Using Air Purifier as an Alternative of Clean Air Supply



# Air Exchange Through Doorways

Scenario 1



Room 19.8°C | Corridor 23.6°C  
Room ~ 4 °C Colder

Scenario 2



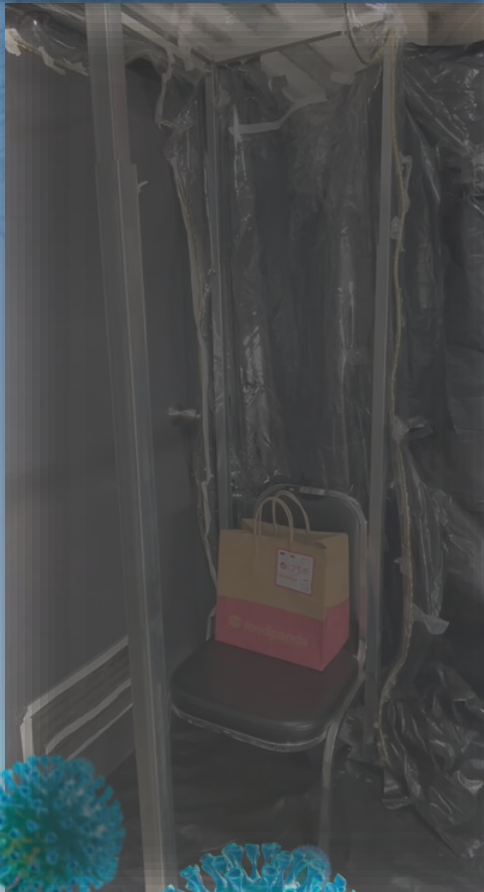
Room 23.6°C | Corridor 23.6°C  
Room = Corridor





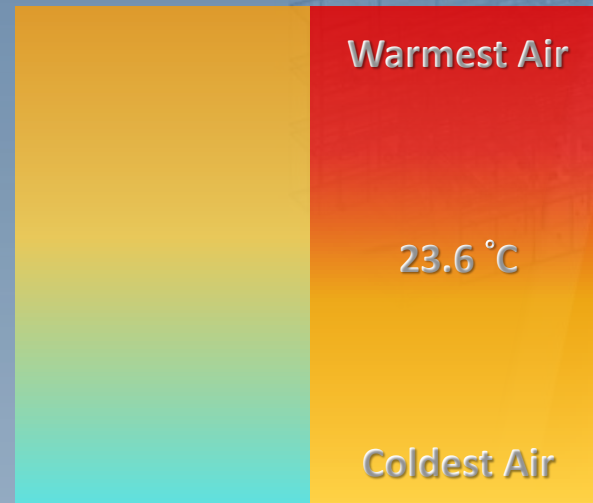
# Air Exchange Through Doorways

## Scenario 1

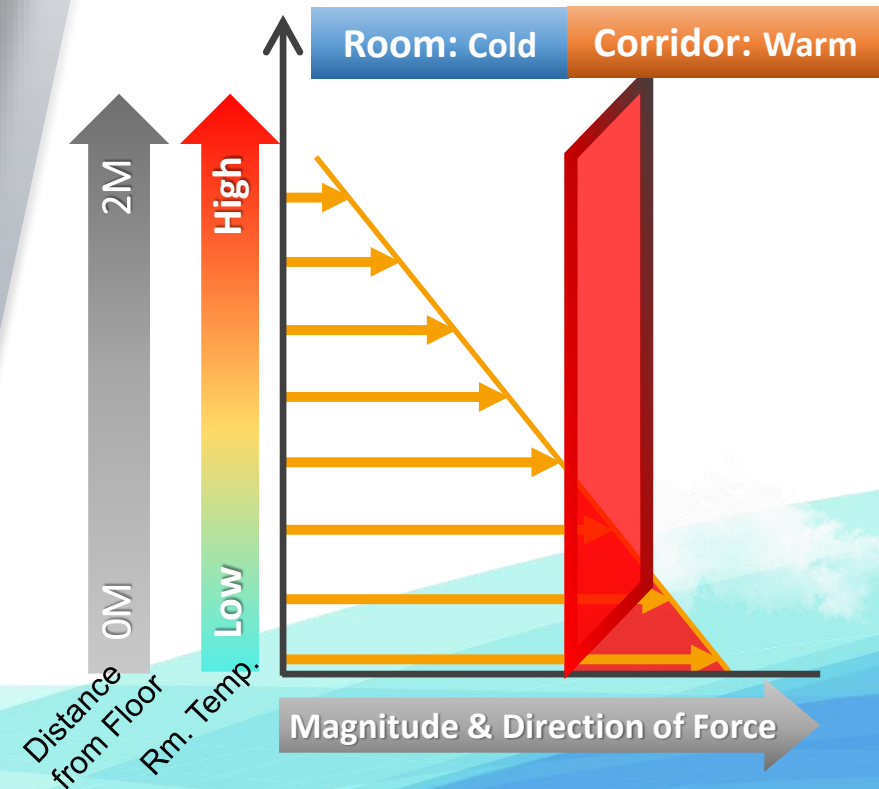


Room: Cold

Corridor: Warm



Room 19.8°C | Corridor 23.6°C  
Room ~ 4 °C Colder



# Why We Use Sliding Door For Isolation Ward?

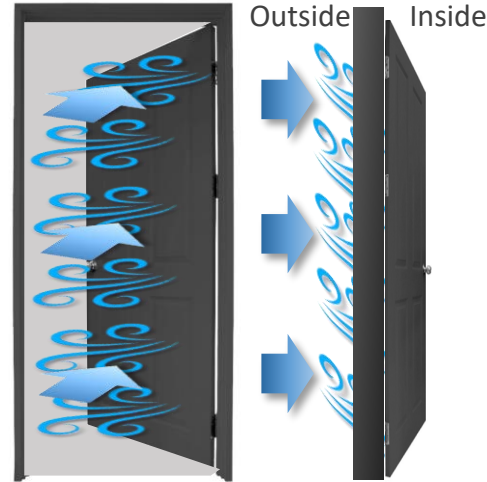
## Scenario Simulation



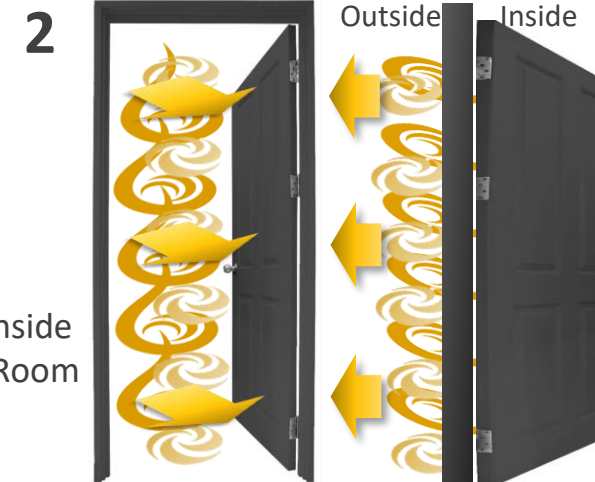
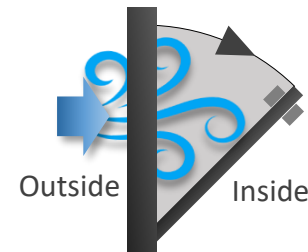
What happen if swing door is used? **1**

■ Air Outside the Room

■ Vacuum zoom

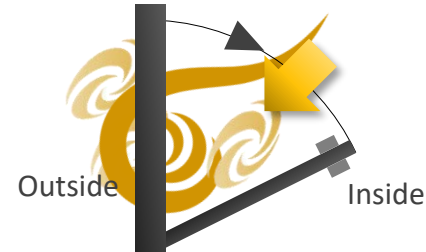


1. Small amount of air outside the room is dragged inward by the vacuum zone created by the door movement.



■ Air inside the Room

2. The air inside the room is forced to move outward to fill up the wake / vacuum zone behind the door (outward side of the door)







# What Role Do YOU Play?

Engineering Control is effective and reliable if it is **properly maintained and operated!**

Users of the Venue should always...

- Proper housekeep to ensure the ventilation system operates as designed and desired
- Identify opportunity for upgrading the ventilation system
- Upkeep proper maintenance of mechanical ventilation
- Appoint the right person to check the ventilation
- have a contingency plan for cases when ventilation system breaks down





**Thank You**

