GREENRE SUSTAINABILITY WEBINAR SERIES

EPISODE6: ENHANCING INDOOR AIR QUALITY POST COVID-19

# IMPORTANCE OF INDOOR AIR QUALITY & HEALTH

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# Outline

- IAQ and health impact
- Public health and social measures
- IAQ and Risk Reduction of Spread of COVID-19
- How to use the roadmap

a) Health care settings including quarantine facilities

b) Non-residential settings

c) Residential settings including homes and self-quarantine at home

- Ventilation

# Poor Indoor Air Quality

People spend 90% of time indoors

The concentrations of some pollutants are often 2 to 5 times higher than typical outdoor concentrations ( US EPA )

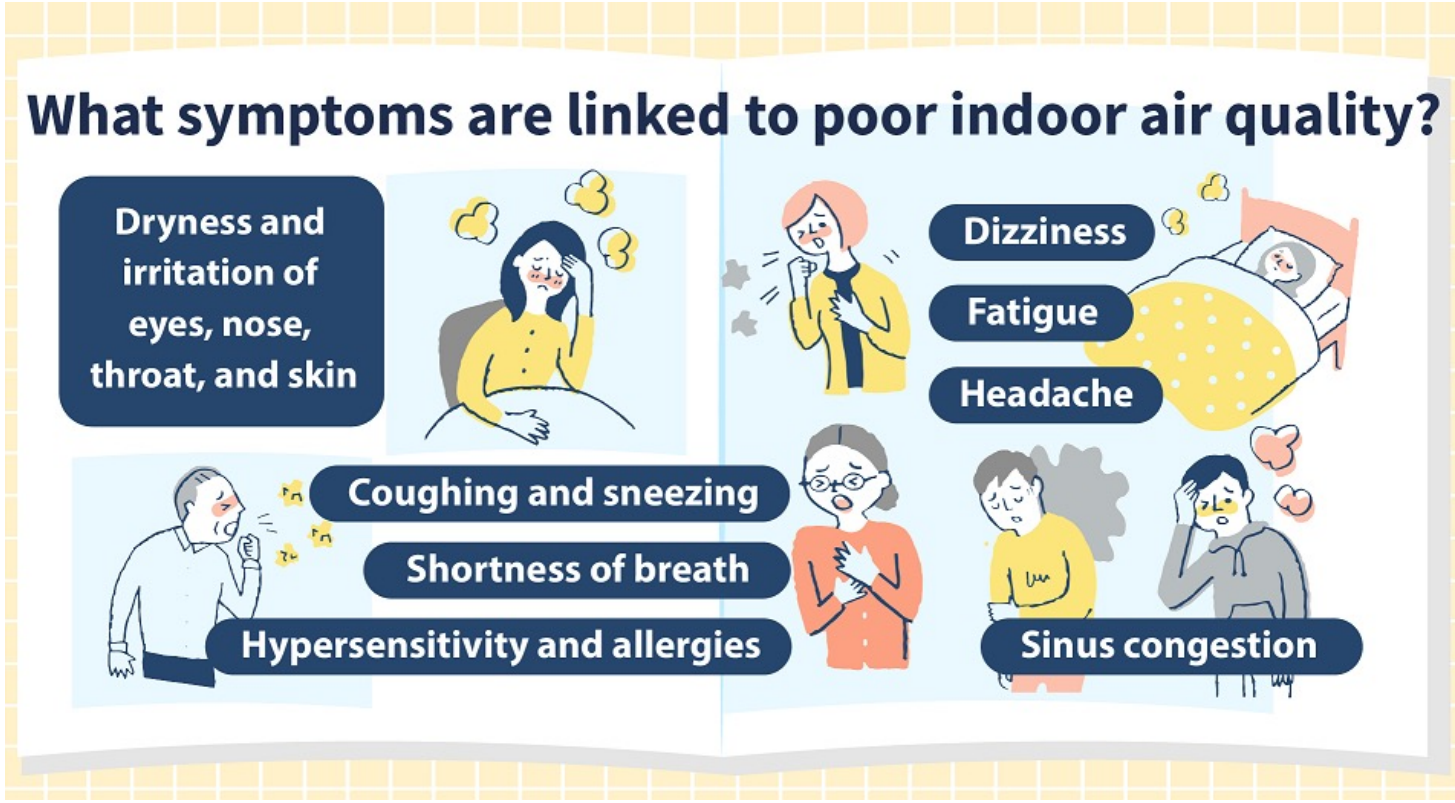
- Combustion byproducts such as carbon monoxide, particulate matter, and environmental tobacco smoke.

- Pest, House dust mites, cockroaches
- VOCs -in cleaning products, paints, formaldehyde
- Substances of natural origin such as radon, pet dander, and mold
- ozone emitted from photocopiers and laser printers or from some air cleaners
- Overcrowding
- Pesticides, lead, and asbestos.

https://www.epa.gov/report-environment/indoor-air-quality

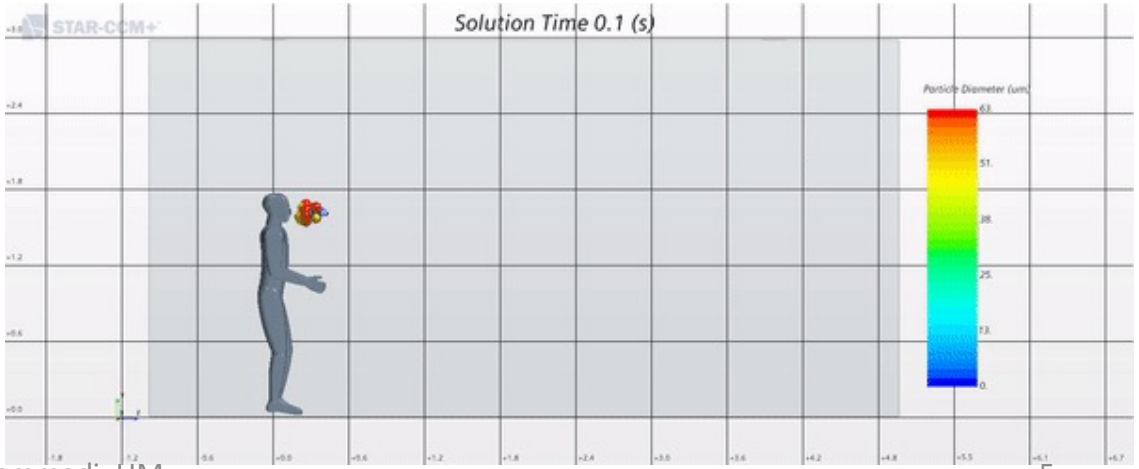
# Indoor air quality (IAQ) and Health Impact

- IAQ problems occur in buildings that are served by a mechanical ventilating and air conditioning (MVAC) system including air-cooled split unit.
- IAQ problems can be due to indoor **air pollutants or to inadequate ventilation.**
- Poor indoor air quality can cause a **variety of short-term and long-term health problems.**



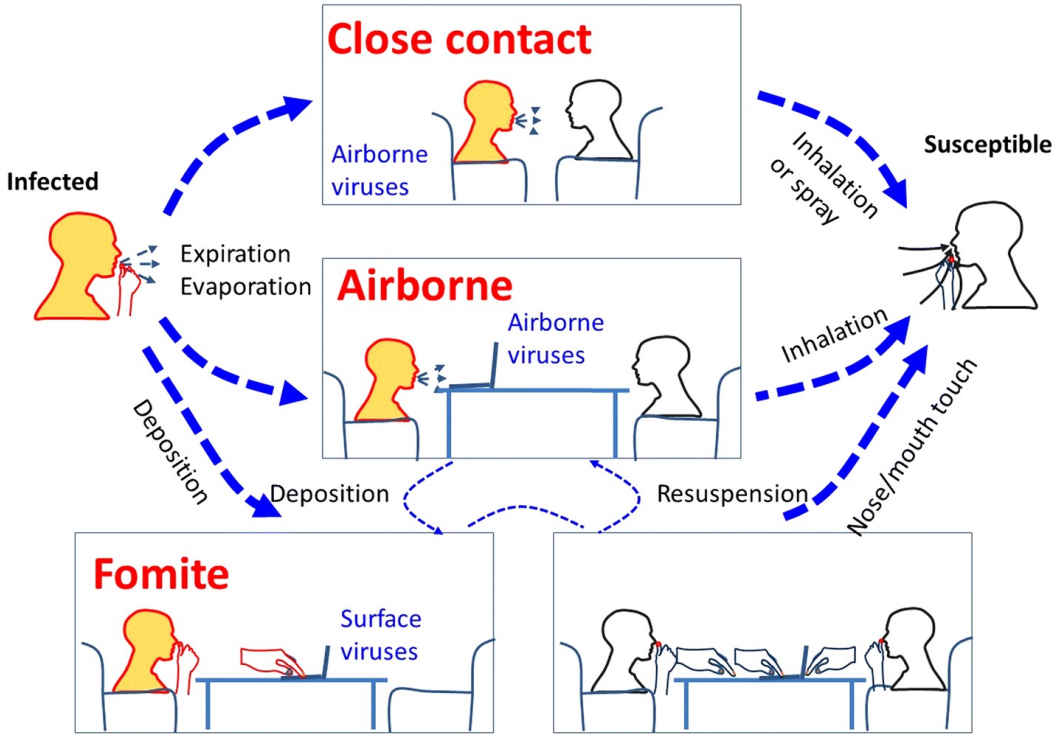
# The airborne transmission of  COVID-19

- Enclosed spaces with Inadequate ventilation or air handling within which the concentration of exhaled respiratory fluids, especially very fine droplets and aerosol particles, can build-up in the air space.
- Increased exhalation of respiratory fluids if the infectious person is engaged in physical exertion or raises their voice (coughing , sneezing,  exercising, shouting).
- Prolonged exposure to these conditions, typically more than 15 minutes.

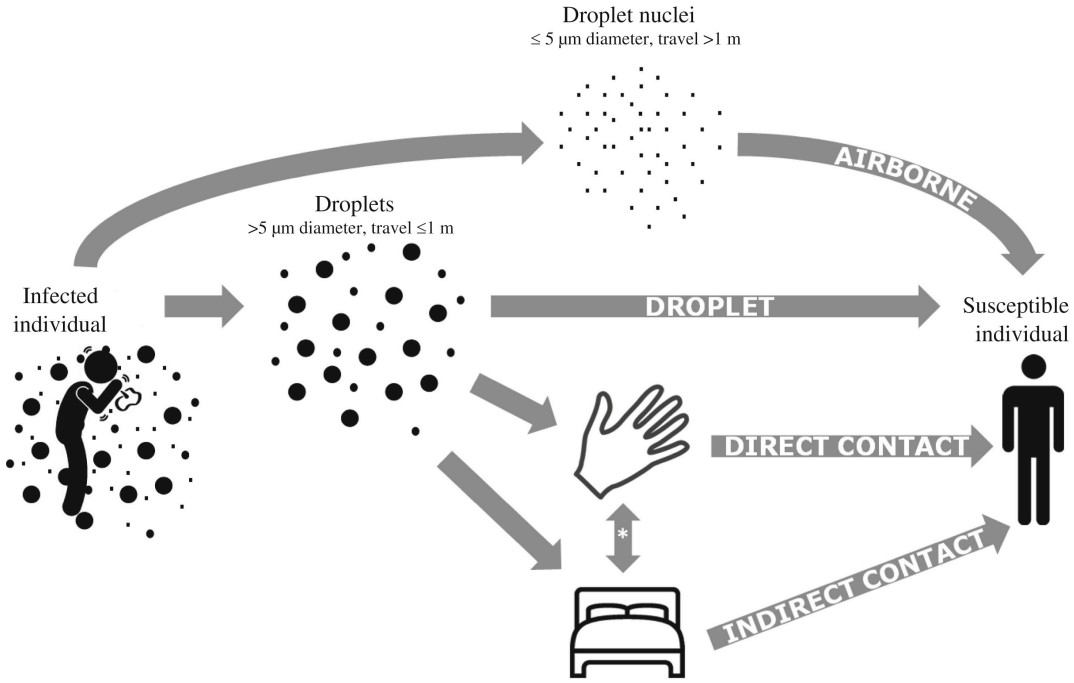



Jayaveera Muthusamy et al 2021

# Transmission Route of COVID-19




Raymond Tellier et al 2019

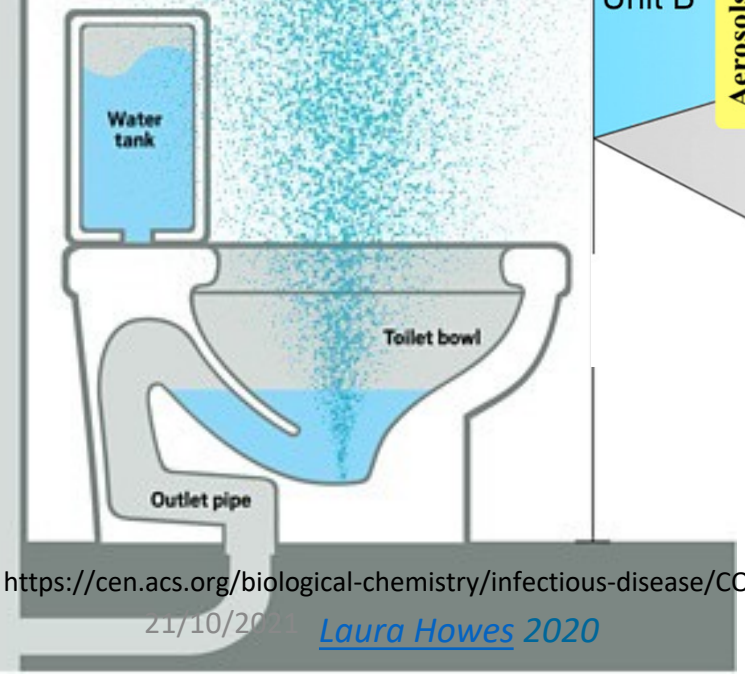



* Transmission routes involving a combination of hand & surface = indirect contact.

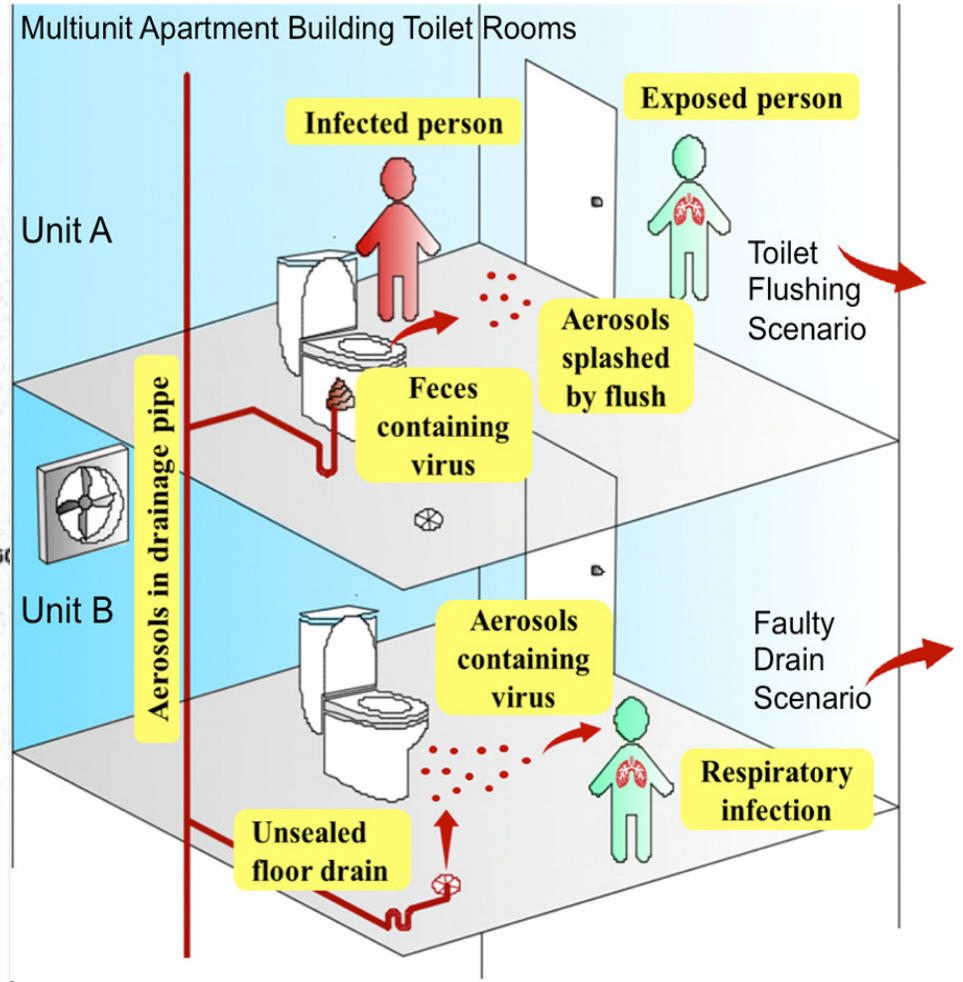
*Otter et al 2016*

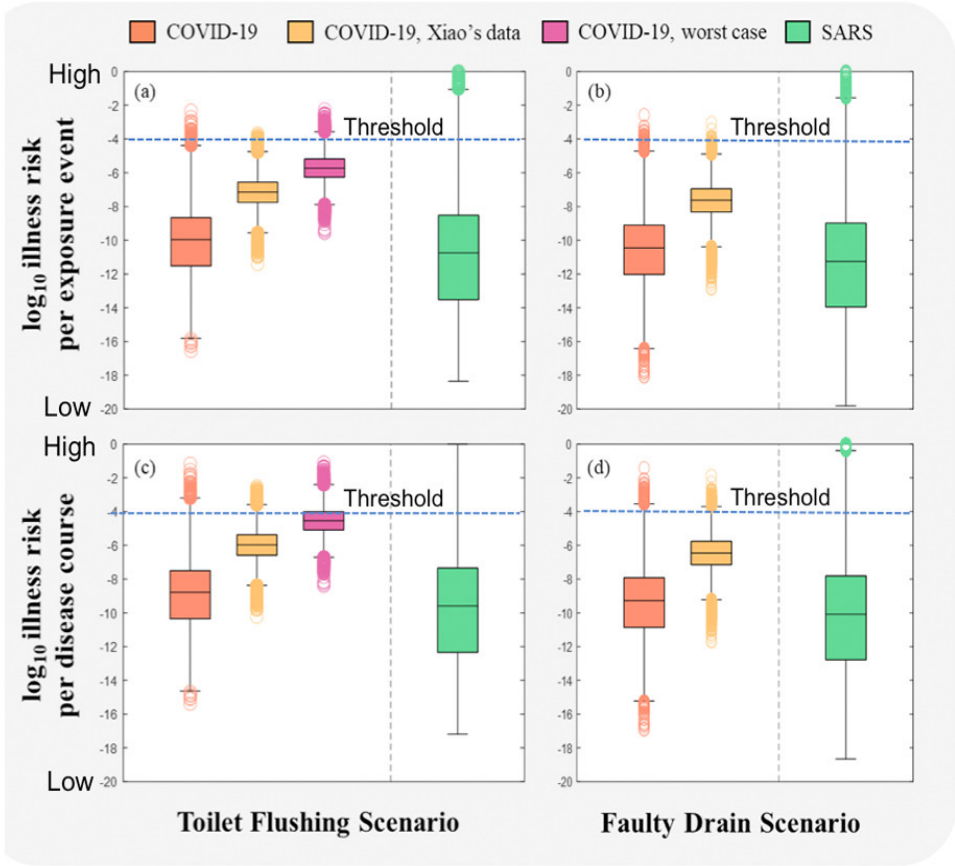
# Aerosols source of transmissions in Buildings

A vortex caused by flushing can force aerosols to rise out of the toilet




https://cen.acs.org/biological-chemistry/infectious-disease/COVID-19-bathroom/98/i38




Kuang-WeiShi et al 2021

https://www.sciencedirect.com/science/article/pii/S0048969720365864#!

Laura Howes 2020

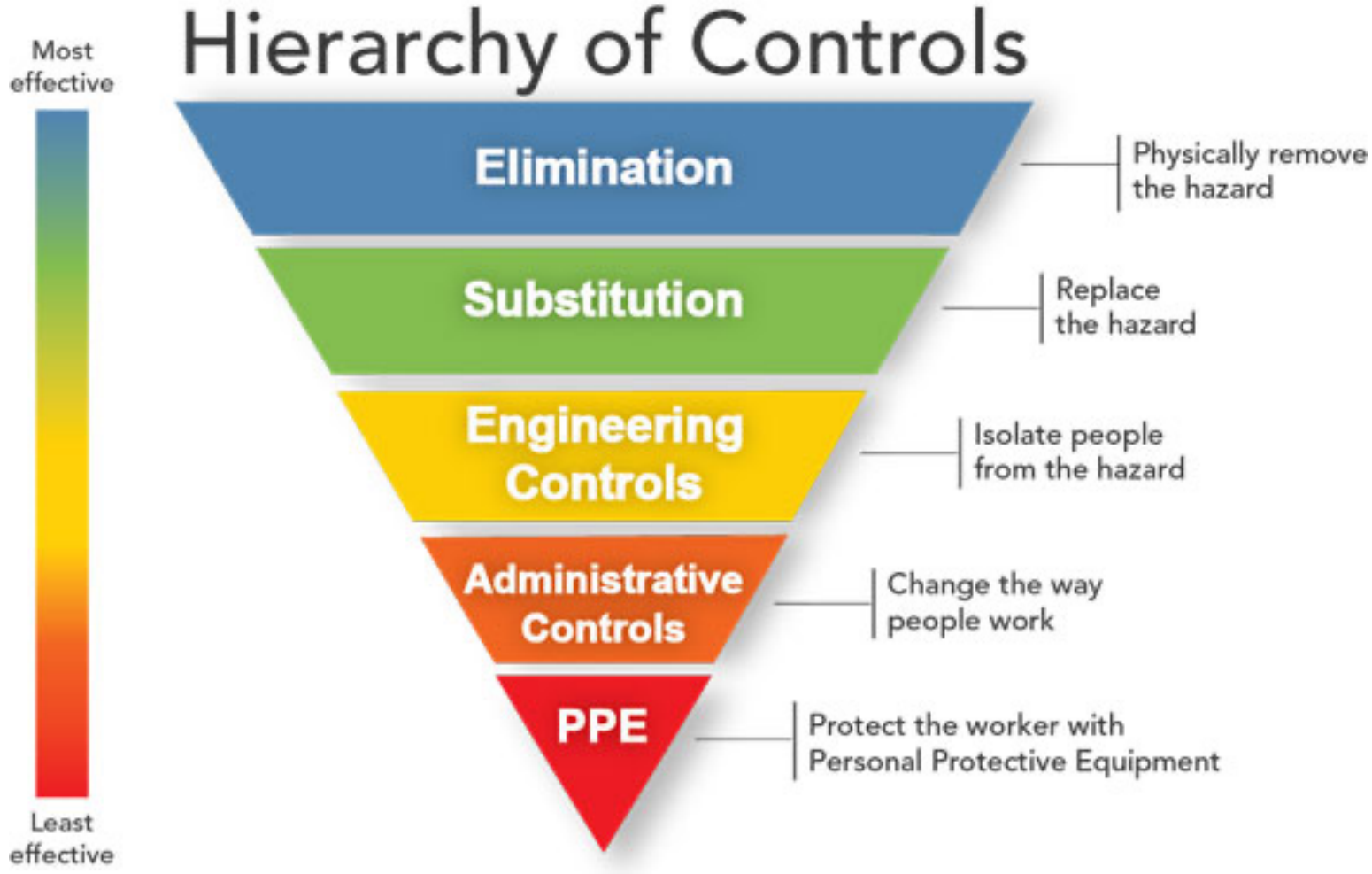
# Public health and social measures : Health Risk Management

Early recognition, Contact Tracing, quarantine, pathogen removal

**Aerosol Control , adequate Ventilation , Adequate Environmental cleaning and disinfection , Social Distancing At least 1 m**

**SOPs, Guidelines,( WHO roadmap, CDC, DOSH, etc.) Adequate training**

**Face makes and shields hand hygiene**




https://www.cdc.gov/niosh/topics/hierarchy/default.html

# IAQ and Risk Reduction of Spread of COVID-19

To assess indoor ventilation and the major steps needed to reach recommended ventilation levels or simply improve indoor air quality (IAQ) in order to reduce the risk of spread of COVID-19.

World Health Organization

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

How to assess and measure the different parameters, specifically in :

- Health care,
- Non-residential and
- Residential settings.

It is meant to be a technical document helping users to analyse building HVAC systems in order to implement, if required, the different strategies proposed to improve HVAC's ability to mitigate and reduce the risk of COVID-19 transmission.

# IAQ and Risk Reduction of Spread of COVID-19

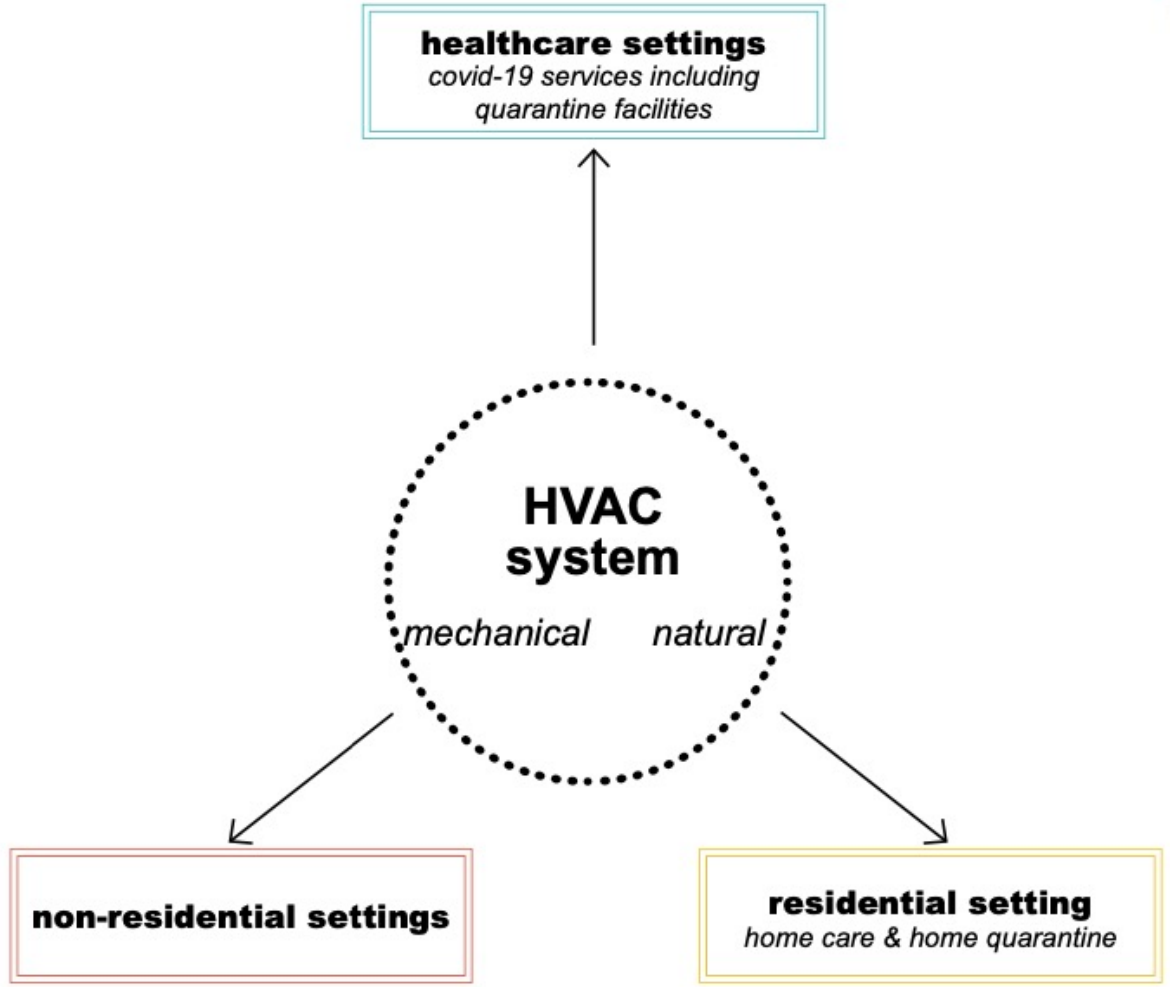
There are three methods that may be used to ventilate a building:

Natural,

Mechanical and

Hybrid (mixed mode) ventilation.

This roadmap only considers mechanical and natural ventilation as all key questions and strategies described can also be adopted for hybrid ventilation.



# Risk Reduction of Spread Of COVID-19

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

- Ventilation alone, even when correctly implemented, is insufficient to provide an adequate level of protection.

- Correct use of masks, hand hygiene, physical distancing, respiratory etiquette, testing, contact tracing, quarantine, isolation and other infection prevention control (IPC) measures are critical to prevent transmission of SARS-CoV-2.

# Importance of Building Ventilation

It has three basic elements:

1. Ventilation rate ($m^3$/hr, l/s or ACH) – the volume of outdoor air that is provided into the space;
2. Airflow direction – the overall airflow direction in a building and spaces, which should be from **clean zones to dirty zones**; and
3. Air distribution or airflow pattern – the **external air** should be **delivered** to each part of the space in an effective and efficient manner and the **airborne pollutants** generated in each part of the space should also be **removed** in an effective and efficient manner.

# Health Care Settings

Adequate ventilation in all patient care areas plays a key role to help prevent and reduce infections.

COVID-19 treatment centres and wards including :

- Quarantine,
- Community facilities and
- Long-term care facilities.

These settings require strict ventilation requirements to enable a safe working environment and reduce the risk of health care associated infections amongst HCWs, patients and visitors.

# Non-residential setting

For this document “non-residential setting’’ refers to public and private indoor spaces characterized by a heterogeneous occupancy rate with people not belonging to the same household, such as

- Workplaces
- Schools and universities,
- Accommodation sector buildings , and
- Religious and commercial spaces.


The load of air pollution or infectious aerosol potentially released in a building depends on:

1- The activities performed inside,

2- The number of occupants and

3- Whether or not the occupants are wearing masks.

*in order to strengthen proposed IPC measures, simplify the COVID-19 risk assessment and facilitate the implementation of corresponding countermeasures, **a minimum ventilation rate per person is proposed.**

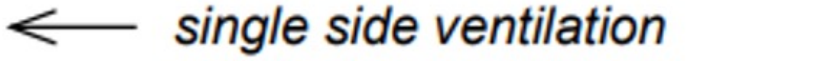
## Residential settings

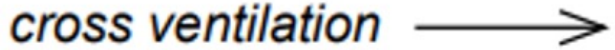
This roadmap aims to strengthen the use of ventilation as an environment and engineering control measure to reduce the risk of COVID-19 transmission amongst household members whenever a person is **under home care or home quarantine** and should be considered as a complementary part for the already existing IPC guidance.

# Natural Ventilation

Ventilation rate minimum requirements

- 160 L/s/patient or 12 ACH where AGP are performed ( min 80 L/s/patient)
- 60 L/s/patient or 6 ACH other ( general wards)
- 2.5 L/s/$m^3$ for corridors and other transient spaces without a fixed number of patients
- Temperature and RH  should be monitored to ensure acceptable IAQ as per standards.


**Short-term strategy :**
**consider using a stand-alone air cleaner with HEPA filters.**
Consider stand-alone air cleaners do not replace ventilation in any circumstance.

Note: Cross ventilation should not be implemented in these specific cases: • within a room or ward for COVID-19 suspected cases where AGP may take place and when the exhaust air is not properly managed;
• when the airflow is moving from **a less clean to a clean area.**


*Aerosol-Generating Procedures

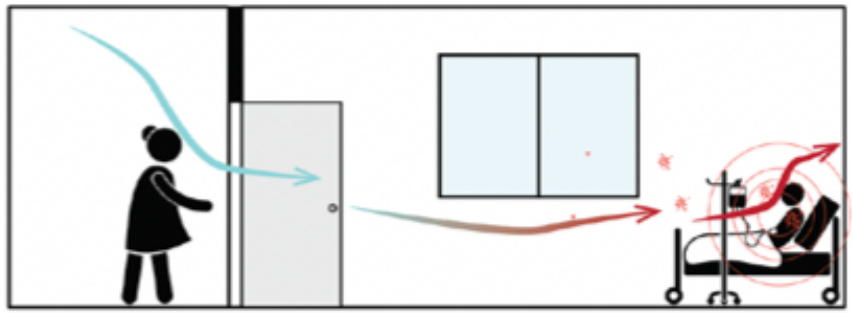
# Mechanical Ventilation

HVAC professional team must consult on air circulation and the method of evaluation
Increasing the outdoor supply
Installation of HEPA filter on air return ducts
Stand alone HEPA Filter ( Orientations and Positioning, must operate continuously ,
Filtration recirculated air do not replace the normal ventilated air)
HVAC System operation shall remain continuously when people are around,
The Inspections shall carry on time to time to check for efficient cleaning.
Non-ducted convectors ( indoor air recirculation) :split or Fan Coil Units are discouraged to be used due to poor filtrations, maintenance and turbulences that increase the risk of transmissions. AVOID using in areas where AGP is performed

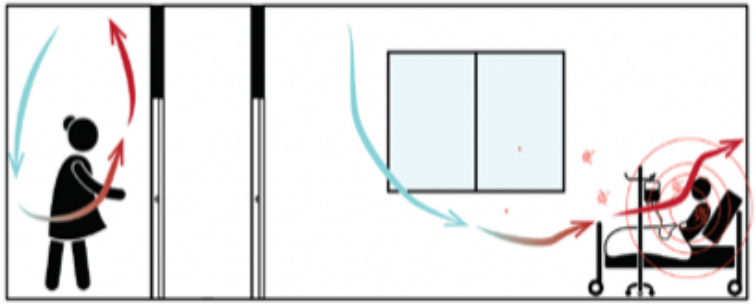
# Air Conditioning and Split System

- Avoid use of split system and fan coil units for COVID-19 patients
- Whenever in-room recirculating units with poor filtration are used, consider creating a negative pressure relative to the corridor to reduce the potential for aerosols to escape from the room.
- Negative pressure can be created by increasing the airflow of extracted air from the room by **installing extractor fans or devices.** Units should be cleaned carefully in between patients

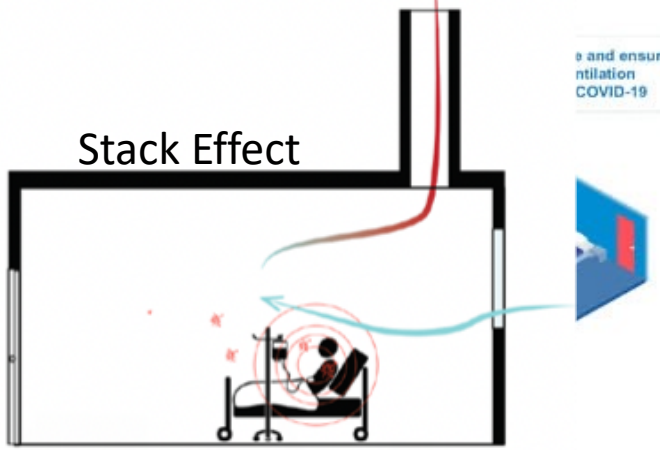
from clean to less clean area



Ante Room



Stack Effect

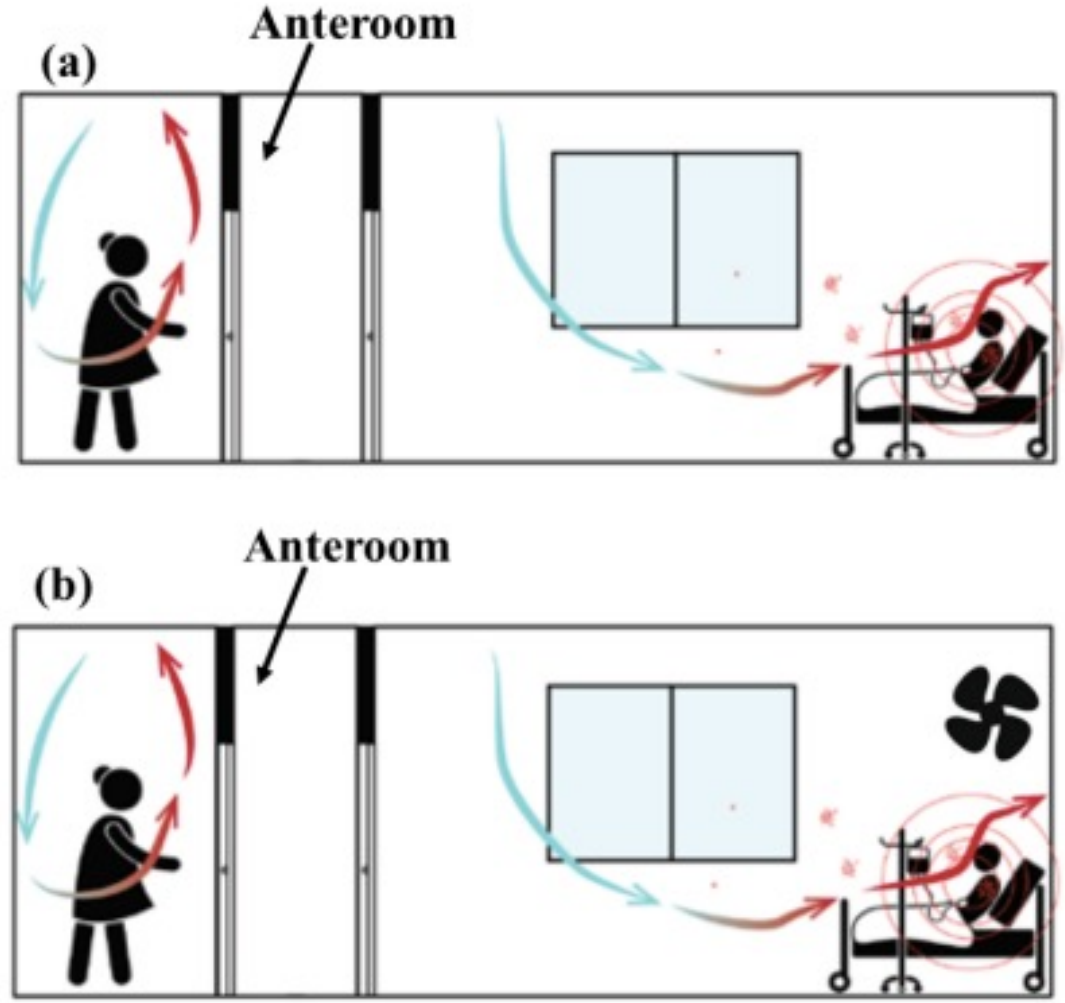


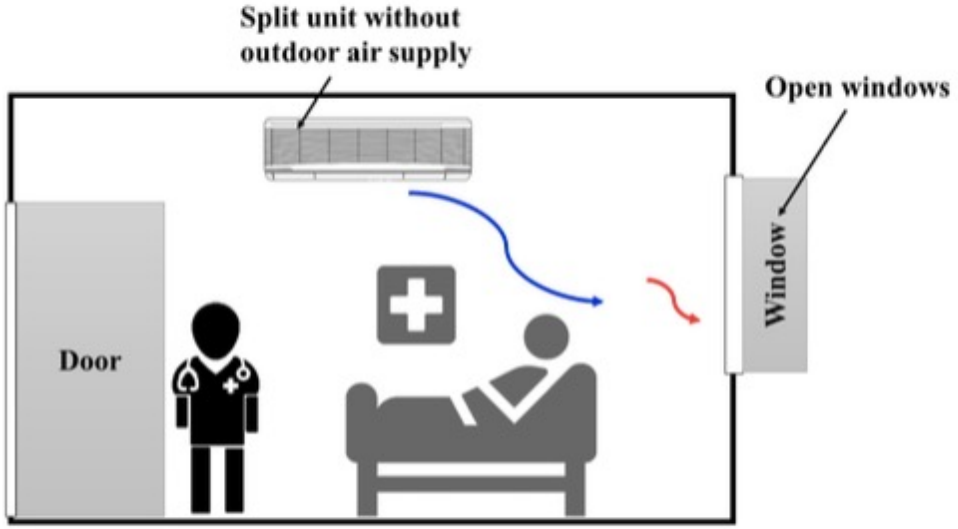
Double doors in ante-rooms should not be open at the same time in order to clearly separate the air between patient room and corridor (clean area).

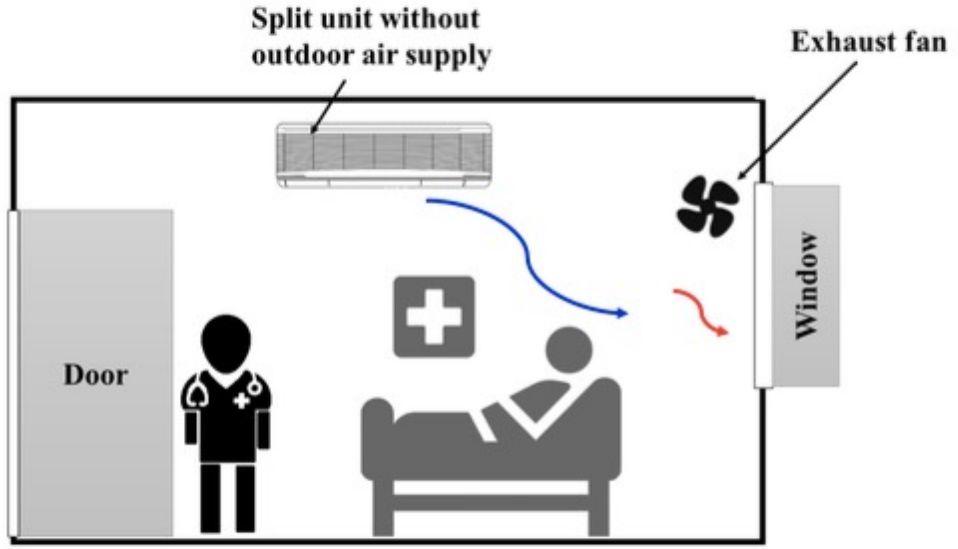
Note: In most cases, this strategy cannot be combined with cross ventilation, therefore the minimum ventilation rate should be attained with other strategies.

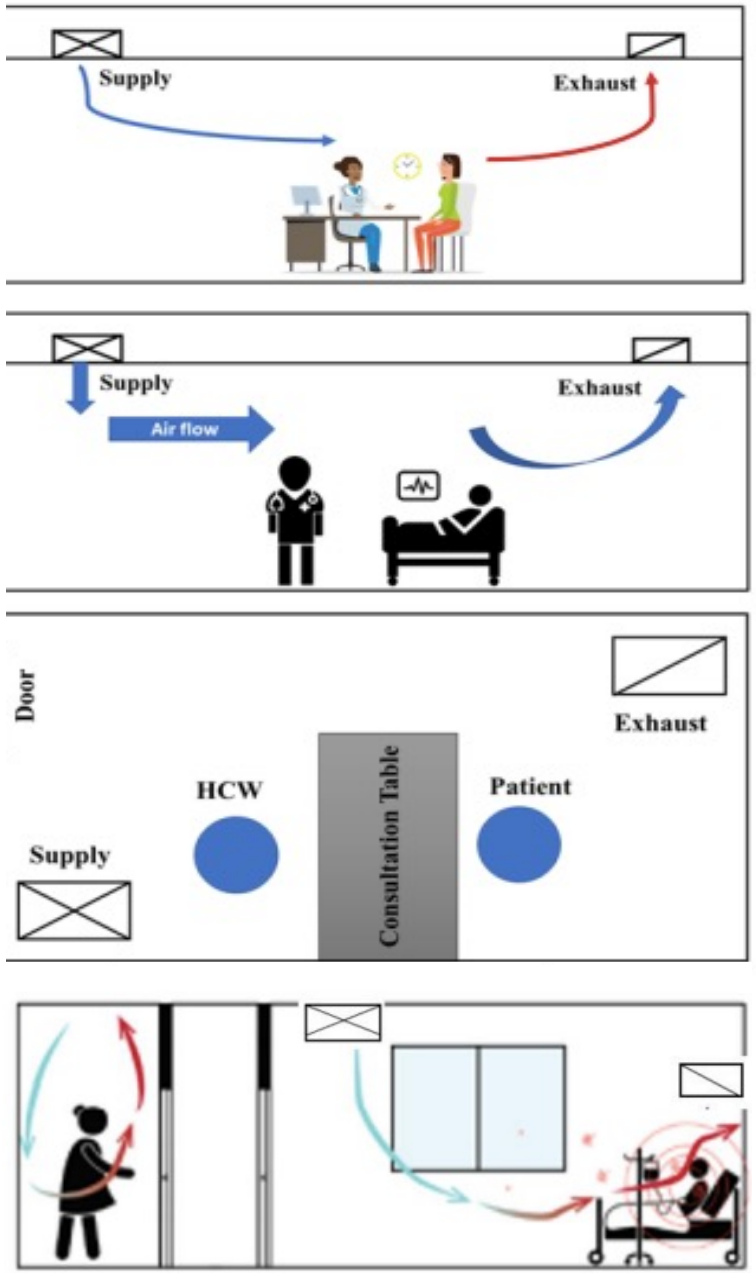
A cost-effective solution is the use of a plastic door zipper as a partition to create an ante-room.

GUIDELINES ON VENTILATION IN THE HEALTHCARE SETTING TO REDUCE THE TRANSMISSION OF RESPIRATORY PATHOGENS
ANNEX 52 , UMMC & MOH ( 2021)

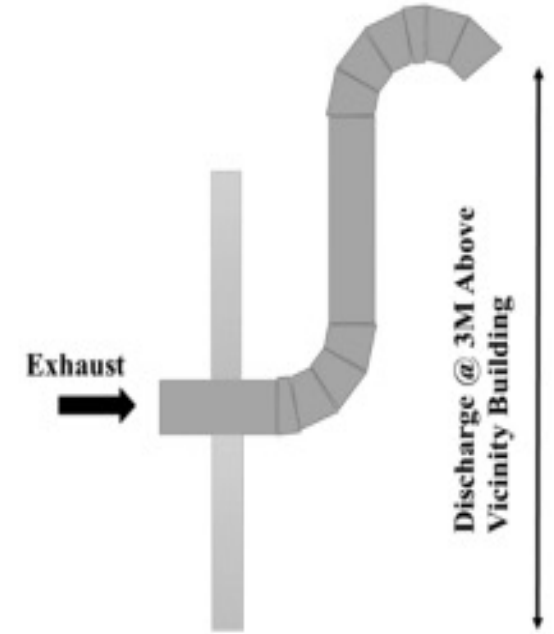


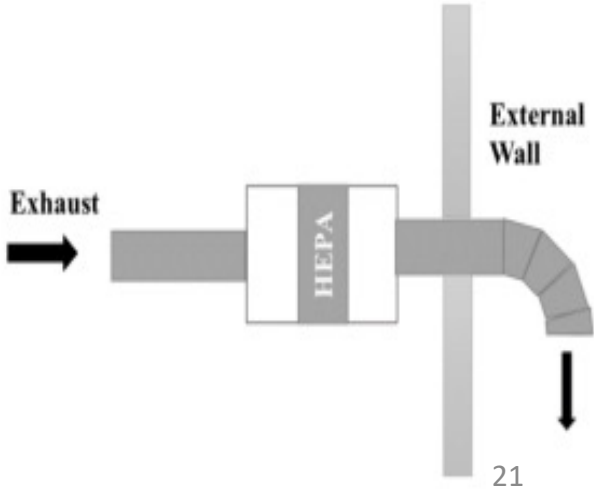

Split unit without
outdoor air supply
Open windows
Door
Window


Split unit without
outdoor air supply
Exhaust fan
Door
Window

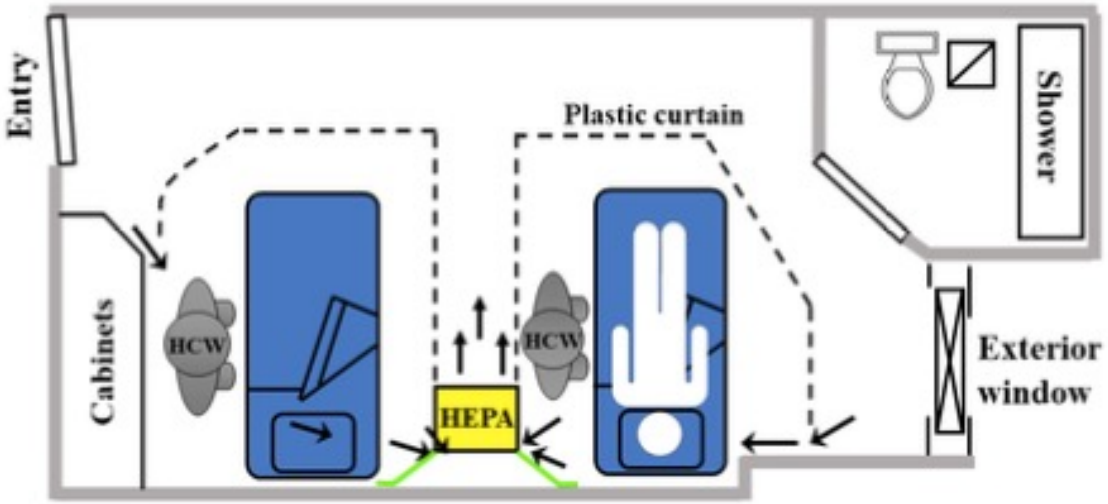

Supply
Exhaust
Supply
Air flow
Exhaust
Door
Exhaust
HCW
Consultation Table
Patient
Supply

Exhaust Air

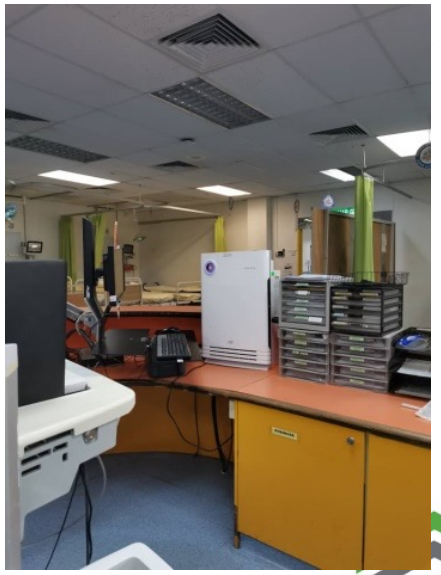

Exhaust
Discharge @ 3M Above
Vicinity Building

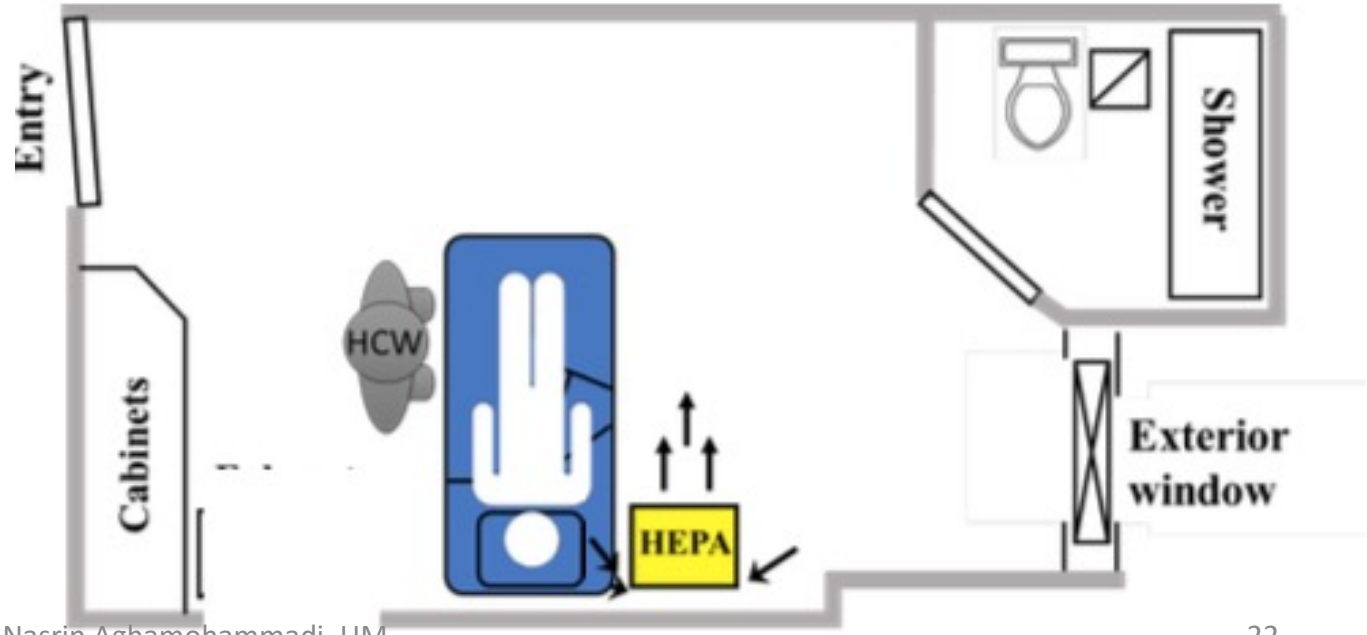

External
Wall
Exhaust
HEPA

**Two bedded patient room: Side to side airflow across head of bed**




99.97% efficient at capturing particles 0.3 μm in size.






ANNEX 52 , UMMC& MOH 2021

Acceptable range for specific physical parameters

| Parameter | |
|---|---|
| Temperature | 23-26 °C |
| Relative Humidity | 60% |
| Air Movement | 0.15 - 0.50 m/s |

**INDUSTRY CODE OF PRACTICE ON INDOOR AIR QUALITY 2010 ( DOSH)**

$CO_2$ is co- exhaled with aerosols containing SARS-CoV-2 by COVID-19-infected people and may be used as a proxy of SARS-CoV-2 concentrations indoors.

$CO_2$ concentrations cannot predict who has SARS-CoV-2 infection

Indoor AQ contaminants and the acceptable limits

| Indoor Air Contaminants | Acceptable limits | | |
|---|---|---|---|
| | PPM | $Mg/m^3$ | $cfu/m^3$ |
| Chemical Contaminants | | | |
| Corban monoxide | 10 | - | - |
| Formaldehyde | 0.1 | - | - |
| Ozone | 0.05 | - | - |
| Respirable Particulate | - | 0.15 | - |
| TVOC | 3 | - | |
| Biological Contaminants | | | |
| Total Bacterial Counts | - | - | 500* |
| Total Fungal Counts | - | - | 1000* |
| Ventilation Performance Indicator | | | |
| Carbon Dioxide | 800 | | - |

https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

# Recommended Minimum Number of Sampling Points for Indoor Air Quality Assessment

| Total floor area (equipped system MVAC) ($m^2$) | The Minimum number of samplings points |
|---|---|
| < 3,000 | 1 per 500 $m^2$ |
| 3,000 ≤ 5,000 | 8 |
| 5,000 ≤ 10,000 | 12 |
| 10,000 ≤ 15,000 | 15 |
| 15,000 ≤ 20,000 | 18 |
| 20,000 ≤ 30,000 | 21 |
| ≥ 30,000 | 1 per 1,200 $m^2$ |

# Summary

- Air flow should be from clean to less clean areas.
- Avoid using devices that generate a strong air flow in a common area, especially streams of air going from person to person.
- Airing shall carry out by opening windows and doors  wide against each other for 10 to 15 minutes after meeting in common areas (conference room, meeting rooms, etc.).This is not allowed if cause condensation in clinical settings.
- Toilet : Keeping **negative pressure in toilets** is recommended, as aerosol formation can occur; **Avoid open windows in toilets** to maintain the correct direction of ventilation. Keep toilet ventilation in operation **round the clock**. Flush toilets with **closed lid**.
- $CO_2$ Monitoring : keep the $CO_2$ levels to as low as practically possible below 800 ppm (CDC).
- Rh: 60% for **Airborne Infection Isolation Room (**AIIR) the rest 40-70% .
- Risk of condensations due to  growth fungus and bacteria from outdoor air
- Non-ducted (with indoor air recirculation) convectors such as split or fan coil units is discouraged (difficult to maintain, provide poor filtration and contribute to turbulence- potentially increasing the risk of infection). MUST be avoided where AGP is performed

# Recommendation

Improving the ventilation system to reduce the risk of transmission of airborne disease

Increasing the awareness and knowledge among different stakeholders regarding air ventilation and logic of changes

Prepare a suitable guideline with graphical illustrations for different levels of tropical ( HOT & HUMID) communities as well as building managers , workers and public.

A multidisciplinary team consisting of hospital engineers, maintenance facilities staff, Infection prevention and control (IPC) team and occupational health personnel OSHE should work together to evaluate building systems to ensure that they are operating in proper order

Regular monitoring of IAQ with calibrated equipment

Application of AI in building managements

The enforcement of suitable SOPs

# Thank You

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# References


- https://www.cdc.gov/coronavirus/2019-ncov/more/index.html
- https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-healthcare-c19-guidance.pdf \
- https://www.who.int/publications/i/item/9789240021280
- ANNEX 52, GUIDELINES ON VENTILATION IN THE HEALTHCARE SETTING TO REDUCE THE TRANSMISSION OF RESPIRATORY PATHOGENS , UMMC &MOH 2021
- J.A. Otter, C. Donskey, S. Yezli, S. Douthwaite, S.D. Goldenberg, D.J. Weber ( 2016) Transmission of SARS and MERS coronaviruses and influenza virus in healthcare settings: the possible role of dry surface contamination
- **INDUSTRY CODE OF PRACTICE ON INDOOR AIR QUALITY 2010 ( DOSH)**
- Raymond Tellier, Yuguo Li, Benjamin J. Cowling & Julian W. Tang (2019)**Recognition of aerosol transmission of infectious agents: a commentary**