Ventilation guide for indoor environments

Shops, hotels & hospitality facilities, cinemas, theatres, museums and other densely occupied places

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INDAIRPOLLNET Improving indoor air quality | cost European Cooperation in Science and Technology

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This guide is a tool to reduce the risk of infection with COVID-19 and improve the indoor air quality.

It is based on the INDAIRPOLLNET COST-ACTION guide for ventilation in schools

https://indairpollnet.eu/wp-content/uploads/2021/01/Guide-for-ventilation_Indairpollnet.pdf

It is applicable to different types of indoor environments such as offices or other buildings for public use.

The use of face masks, social distancing and appropriate hygiene measures are recommended to be applied, along with the strategies described within.

Zero risk of infection does not exist. The measures described here reduce the risk but do not eliminate it completely.

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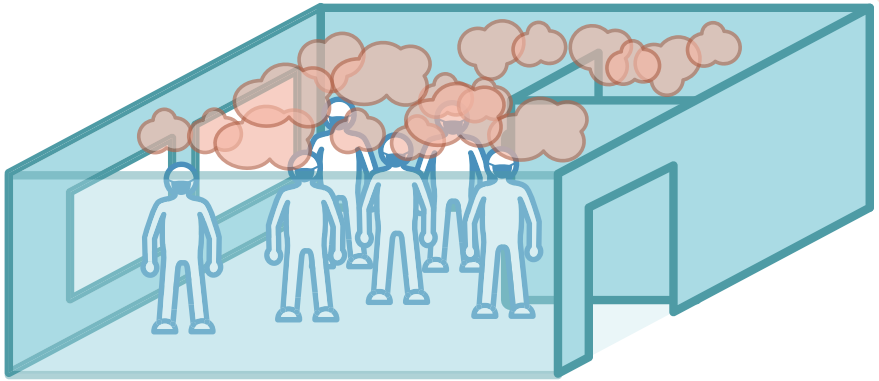
1. Why ventilate?

1. WHY VENTILATE?

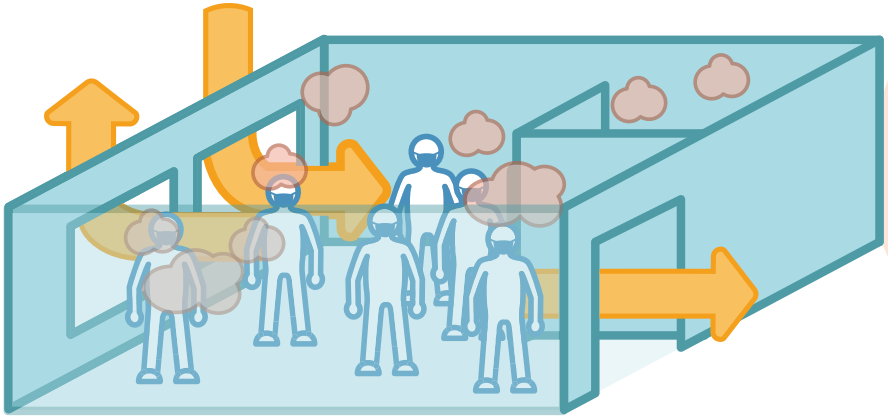
People emit aerosols when they breathe, speak or cough. Aerosols are small particles of saliva or respiratory secretions that remain airborne for minutes to hours. For infected people, these aerosols can contain viruses.

In poorly ventilated indoor environments, aerosols from an infectious person are distributed throughout the space with the risk of infecting others who inhale them.

Therefore, it is necessary to ventilate: **continuously renew the indoor air with outdoor air.**



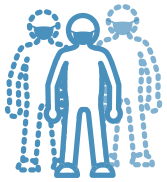
Without ventilation: higher risk of infection with airborne pathogens



With increased natural or mechanical ventilation: decreased risk of infection with airborne pathogens

Reducing the risk of infection is achieved by reducing emission and exposure.

How can the emission be reduced?



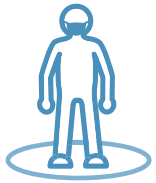
Limiting the number of occupants present – lower occupant density

Minimizing talking and singing

Using a suitable and well fitted face mask for protection

How can exposure be reduced?

Using a suitable and well fitted face mask for protection



Increasing social distancing

Reducing the exposure time

Ventilating or cleaning the indoor air

Risk of contagion in different situations

Occupancy and group activity	Low occupancy				*High occupancy		
	Outdoor environment	Properly ventilated indoor environment	Poorly ventilated indoor environment		Outdoor environment	Properly ventilated indoor environment	Poorly ventilated indoor environment
With mask, short contact time							
In silence							
Speaking							
Shouting, singing							
With mask, long contact time							
In silence							
Speaking							
Shouting, singing							
Without mask, short contact time							
In silence							
Speaking							
Shouting, singing							
Without mask, long contact time							
In silence							
Speaking							
Shouting, singing							

low risk

medium risk

high risk

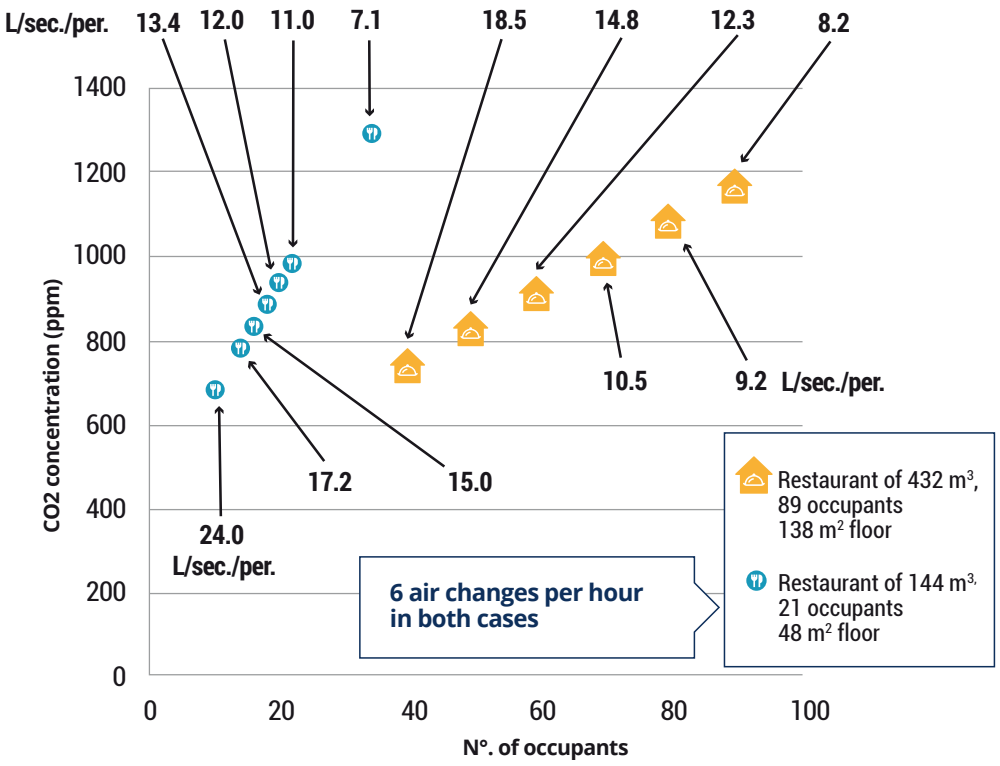
Source:
https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov/documentos/COVID19_Aerosoles.pdf

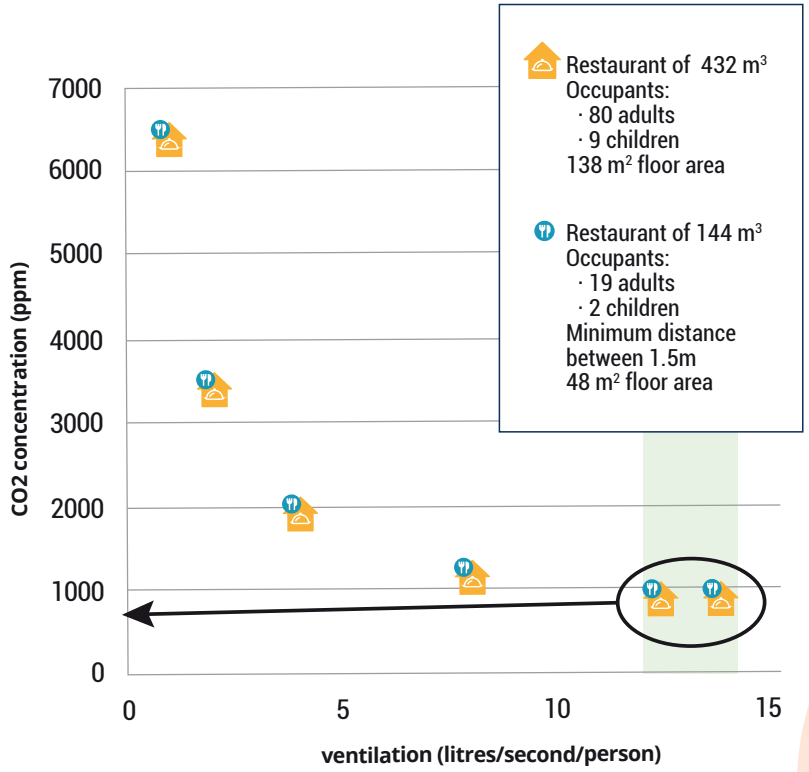
Adapted from:
Jones N.R., et al., 2020. Two meters or one: what is the evidence for physical distancing in covid-19? BMJ.
http://dx.doi.org/10.1136/bmj.m3223

* For example a crowded pub

Ventilation criteria

Relationship between CO2 concentration and number of occupants for different ventilation rates (litres/second/person)





For the same dining room volume, if the number of occupants (persons) increases, the air change rate per hour should be increased to reach the recommended per person ventilation rate and avoid increase of the CO2 level.

EN 16798-1 ventilation criteria for Category I indoor spaces = 10 litres/second/person)

Ventilation criteria

Ventilation refers to air renewal, that is, replacement of potentially contaminated indoor air with virus-free outdoor air.

Air renewal can be abbreviated as **ACH**, Air Changes per Hour. If a space has 1 ACH (1 air renewal per hour), it means that a volume of outside air equal to that of the room enters the room in one hour.

The ventilation necessary to reduce the risk of infection depends on the volume of the room, the number and age of the occupants, the activity carried out, the incidence of cases in the region and the risk to be assumed. The Harvard guide recommends an air change rate at least **5-6 air changes per hour**.

ACH (Air changes per hour)

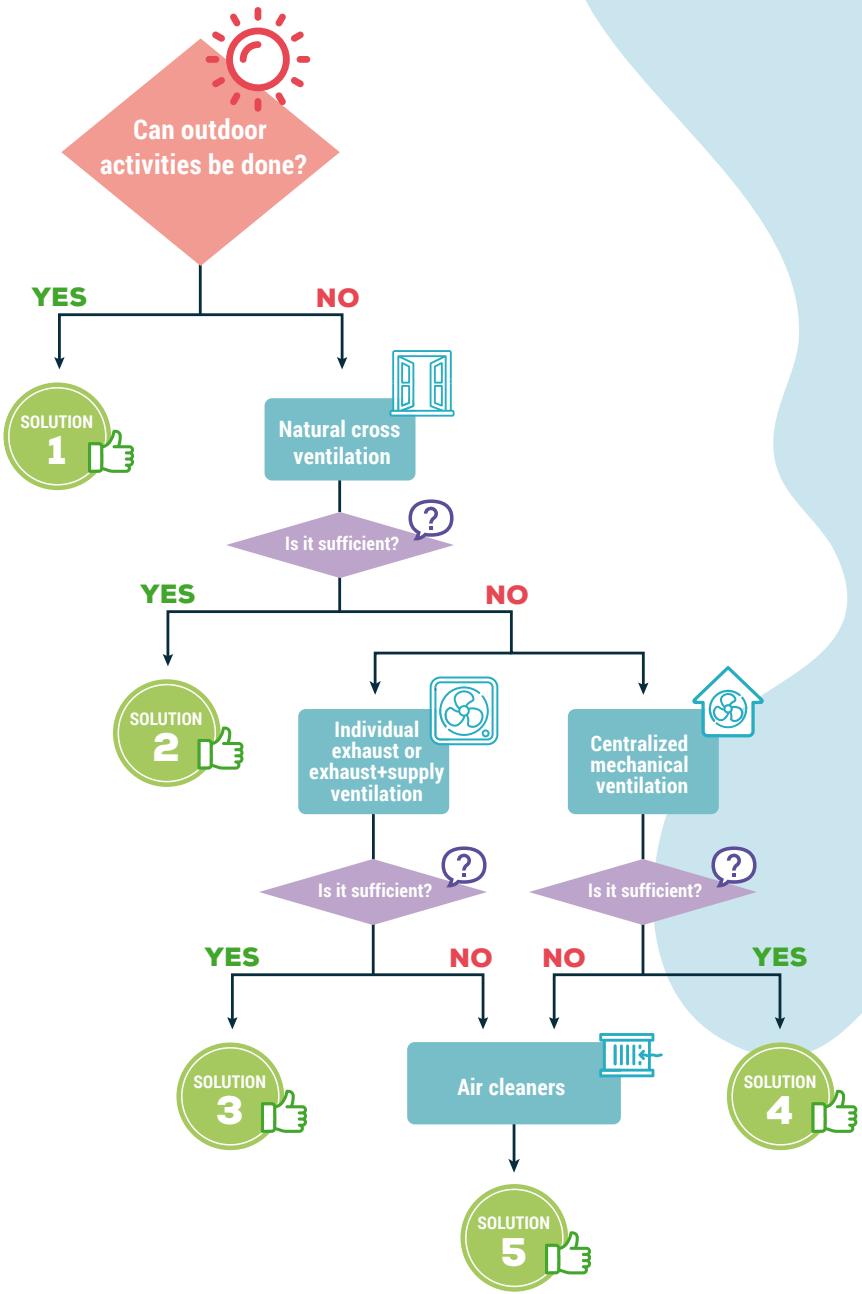
2. Search for solutions

2. SEARCH FOR SOLUTIONS

FLOW CHART FOR SOLUTIONS

- Activities should be preferably performed outdoors.
- If the activity is to be indoors, use natural ventilation, especially cross ventilation (windows and doors open on opposite sides).

  If natural ventilation is insufficient, extra ventilation can generally be achieved using individual exhaust fans or outdoor air supply+exhaust systems with sufficient airflows.
- If centralized mechanical ventilation systems are available, outside air supply should be prioritized, recirculation should be minimized, and filters in the air recirculation flow should be upgraded to be as efficient as possible.
- If none of the above is possible or sufficient, the indoor air must be cleaned with portable air cleaners equipped with high efficiency (HEPA) filters to eliminate pathogens in air.
- The final solution can be a combination of options, for example, natural ventilation with additional air cleaning.
- The use of face masks, social distancing and appropriate hygiene measures are recommended along with the technical solutions. During occupant conversations, the use of face masks (apart from during food consumption) should be encouraged.



3. Recommendations for natural ventilation

3. RECOMMENDATIONS FOR NATURAL VENTILATION

1. Apply cross ventilation (openings on opposite sides of the room). It provides more efficient natural ventilation than only opening windows or doors on one side. This ventilation should be continuous.

2. Open windows and doors only at the time people arrive (if heating or cooling is required).

3. If there are several different spaces connected to one another, open doors and windows in the common areas (corridors, hall, etc.).

4. Doors and windows should preferably be open continually. Opening them intermittently can be effective to achieve adequate ventilation and reduce thermal load, but it may be less practical.

5. Reduce occupant density if possible.

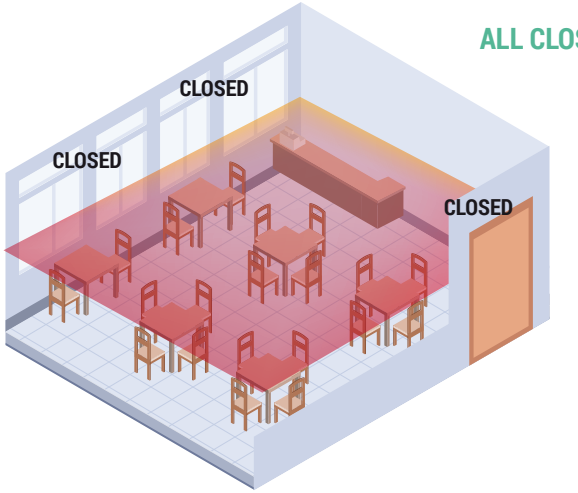
6. Strong outdoor winds and large indoor/outdoor temperature differences facilitate ventilation, and windows will not need to be opened as widely.

7. Follow the concentration of CO_2 in the room. It is an indicator of ventilation in occupied spaces. Place the CO_2 monitor at a representative location where occupants are present, but avoid the effect of direct exhaled breath or direct fresh airflow (e.g., near windows) on the measurement.

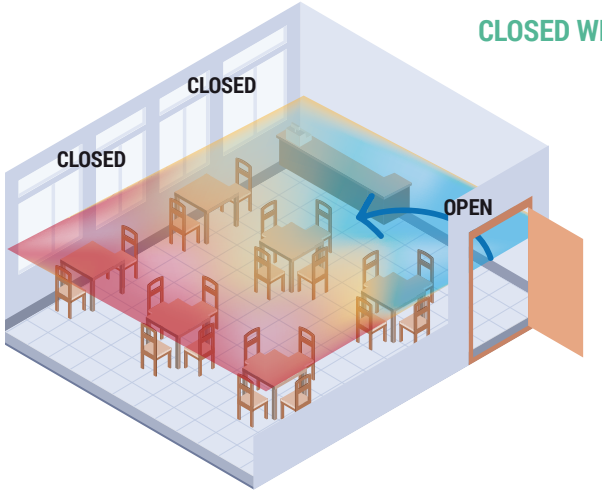
The annex contains an Excel file with a simplified calculation of the concentration of CO_2 corresponding to the number of occupants and different ventilation rates for a given room volume.

8 **Recovery of the premises**. At the end of occupation of any space, complete ventilation must be carried out, where ventilation rate is increased to the maximum possible to renew the air completely.

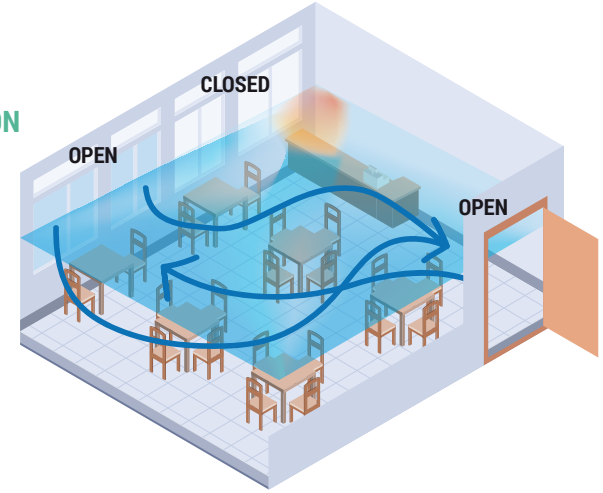
ALL CLOSED



CLOSED WINDOWS



ADEQUATE CROSS VENTILATION

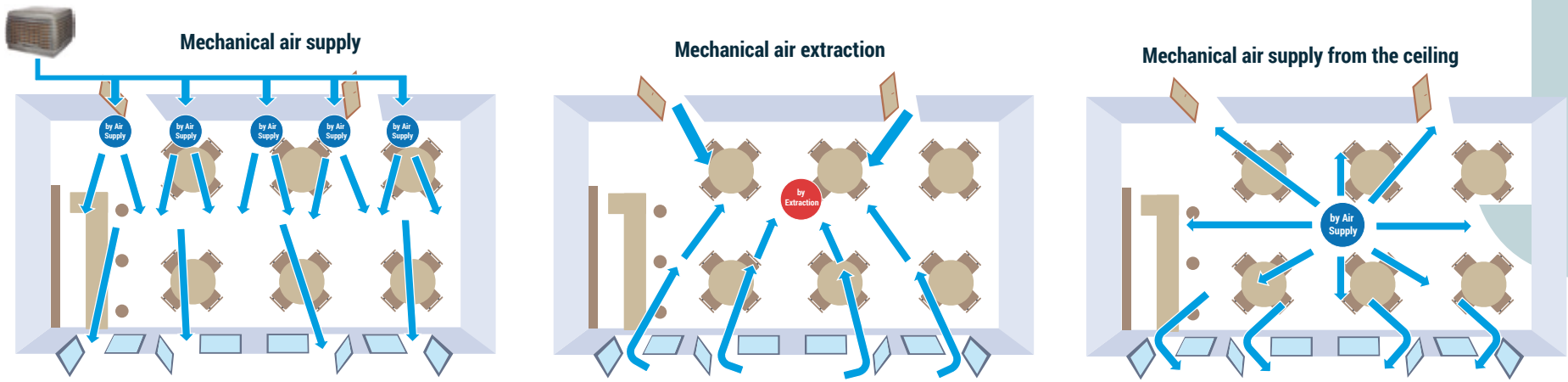


4. Recommendations for mechanical ventilation

4. RECOMMENDATIONS FOR MECHANICAL VENTILATION

1. Ventilate with increased external air flow, reduce the amount of recirculated air.
2. Upgrade and maintain, as far as possible, the existing filters in the ventilation system.
3. Ensure even distribution of the supply air across the space, if possible.
4. Reduce occupant density, if possible.
5. Follow the concentration of CO_2 in the room. It is an indicator of ventilation in occupied spaces. Place the CO_2 monitor at a representative location where occupants are present, but avoid the effect of direct exhaled breath or direct fresh airflow (e.g., near windows) on the measurement.

Examples of mechanical ventilation (available from professional suppliers)



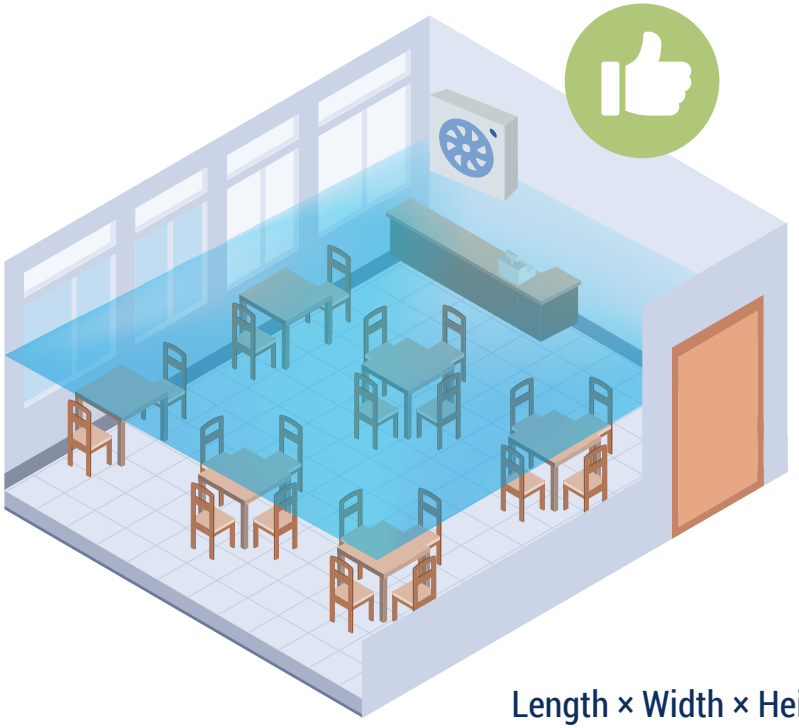
5. Air cleaners

5. AIR CLEANERS

Air cleaners should be used when additional natural and/or mechanical ventilation is insufficient or not feasible. Seek help of professional suppliers when selecting a product.

Air cleaners containing High Efficiency Particulate Air (HEPA) filters are recommended. Avoid air purifiers that use chemicals or plasma technology for air cleaning.

Example: Recommended air flow rates through air cleaners (m^3/h) in a room with 360 m^3 volume



Length × Width × Height = 15 x 8 x 3 m

Volume = 360 m^3

Air cleaning flow rate

	N° OF PEOPLE			
	10	**20**	**30**	**40**
EN 16798-1 (Category I) (10 L/second/person)	360	720	1080	1440
HARVARD recommendation 6 ACH (air changes per hour)	6 x 360 = 2160 (never below 1080 m^3/h, for ACH to be greater than 3)			

6. How to ensure sufficient ventilation? - Summary

6. How to ensure sufficient ventilation - Summary

One way to assess the adequacy of ventilation is by measuring the CO_2 concentration, which can be used to estimate the ventilation rate. Ventilation rate can vary within a large range depending on the indoor space category and its requirement, from 4 to 15 litres per second per person present in the room, according to the EN and Harvard recommendations. The corresponding CO_2 concentration can be calculated in the attached Excel sheet. Further recommendations are:

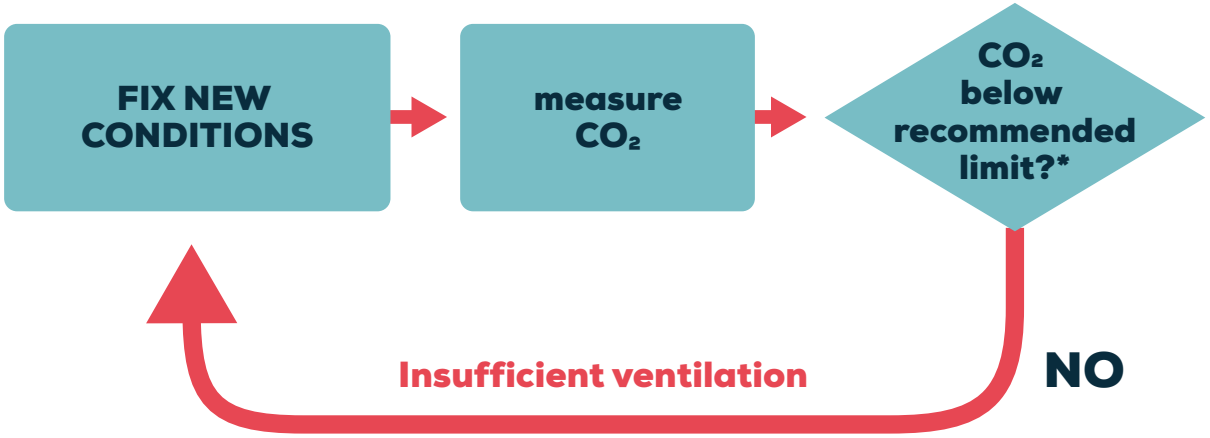
1. **Keep the doors open while the premises are in use** and flush with fresh air after the space is vacated. Doors should be closed to heat or cool the premises prior to the arrival of occupants.

2. **Ventilate with natural cross ventilation or mechanical ventilation,** depending on the possibilities.

3. **Record CO_2 concentrations.** Use continuous measurement with data recording. If recording is not possible, readings should be taken approximately every 5 minutes. It is recommended to measure during the course of one day.

4. **Maintain unchanged conditions** (windows, occupancy, ventilation settings, etc.) until reaching a steady-state concentration, which should be below 1000 ppm, according to WHO requeriments.

5 Adjust the **ventilation** rate so as not to exceed the target CO_2 value



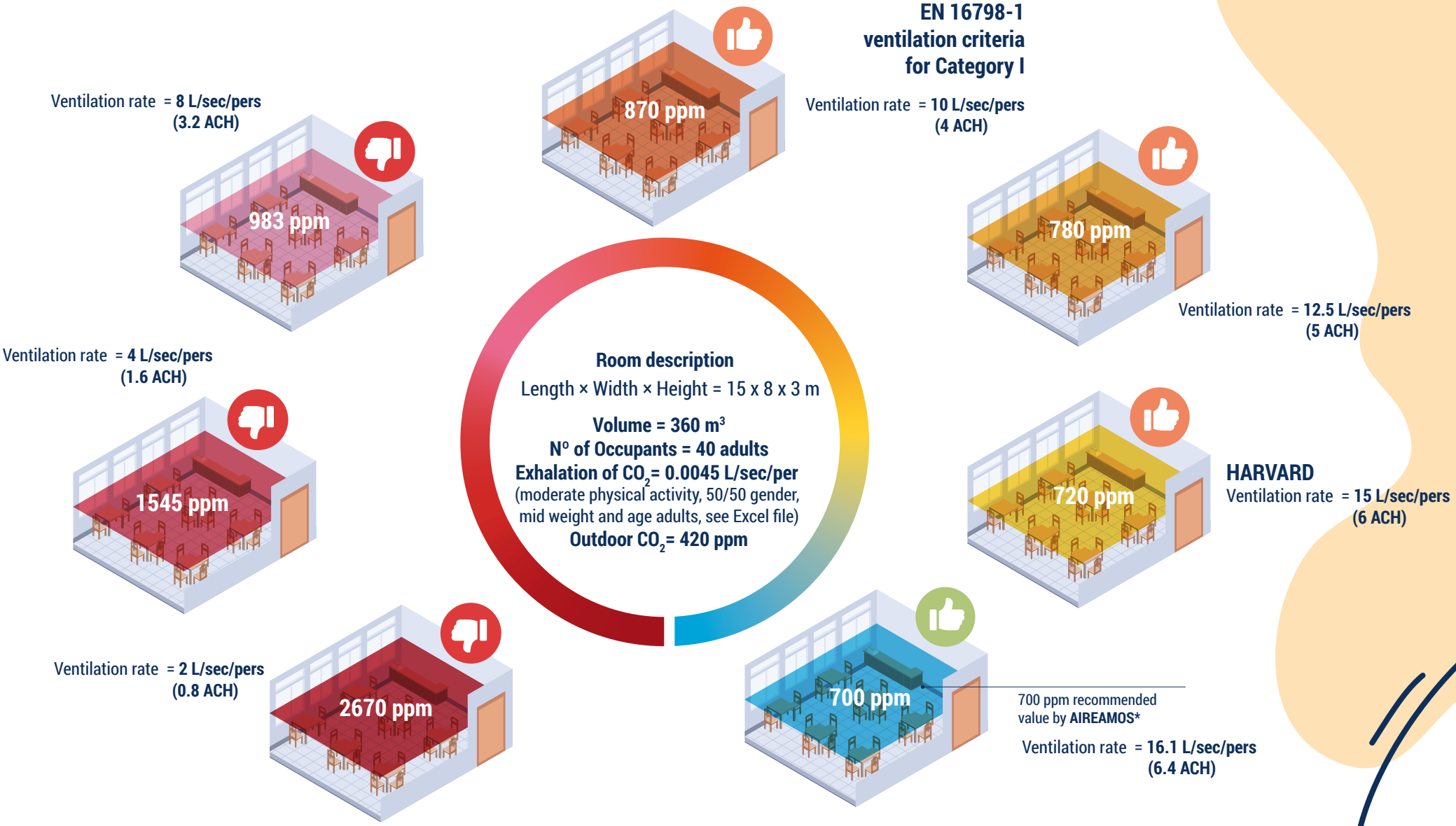
*The CO_2 concentration that the Excel spreadsheet indicates for a given number of occupants and ventilation rate.

NOTE: Not exceeding the 700 ppm limit proposed by the AIREAMOS group will comply with the EN 16798-1 and HARVARD recommendations for the vast majority of indoor conditions.

Important considerations:

- If significant sources of non-occupant generated CO_2 are present (e.g., from kitchen or other combustion sources), the proposed CO_2 approach to monitor ventilation is not applicable.

Example: CO_2 concentration as a function of the ventilation rate



Real case example of infection: *https://www.sciencedirect.com/science/article/pii/S0360132321001955*

*Aireamos, 2021. Guide about Affordable CO2 detectors for COVID-19 Prevention: *https://n9.cl/guia-limites-co2*

7. Disclaimer

7. DISCLAIMER

- This document is provided for informational and educational purposes only. Its objective is to offer guidance regarding questions about best practices for the evaluation of ventilation in public spaces in an effort to reduce the risk of disease transmission, specifically the new coronavirus SARS-CoV-2 and the disease it causes, COVID 19.

- Adherence to any information included in this document will not guarantee zero infection in every situation. Every situation and building is different, and the user must recognize that there is no "zero risk" scenario.

- The information in this document reflects the information available at the time the document was created. New information and / or results of future studies may require revisions of the document.

- We do not guarantee the accuracy or completeness of the guidance in this document and assume no responsibility for any injury or damage to persons or property arising from or related to any use of the report or for any errors or omissions.

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