Guidance on non-healthcare building ventilation during COVID-19

V3.0 18/11/2021

This guidance does not apply in healthcare settings

Version	Date	Changes from previous version
3.0	18/11/2021	Update key points Update modes of transmission to include airborne of respiratory liquid particles Update ventilation & COVID-19 Update conclusion and references
2.2	16/09/2021	Inclusion of Air Change Rate guidance Update guidance for ECDC. Links to sector specific advice for schools, businesses
2.1	23/7/2021	Updated conclusion
2.0	22/01/2021	New guidance outlay applied; updated information on fans; updated Public Health
1.1	14/10/2020	Added European Standards for air filters
1.0	22/09/2020	Original Version

Key Points

- All HPSC guidance should be read and interpreted in conjunction with all sector specific government departmental advice[1]
- The virus that causes COVID-19 is spread through exposure to very small respiratory liquid particles released in the exhaled breath of an infectious individual.
- There are a number of factors that can reduce the transmission of COVID-19. These include, social distancing, vaccination, good cough and respiratory etiquette, meticulous hand hygiene, wearing a face mask/covering and ensuring adequate ventilation.
- Exposure to infection occurs in three principal ways:
    - inhalation of respiratory liquid particles
    - deposition of respiratory liquid particles on exposed mucous membranes in the mouth, nose, or eye by direct splashes and sprays
    - touching mucous membranes with hands that have been soiled either directly by virus-containing respiratory fluids or indirectly by touching surfaces with virus on them.
- Current evidence indicates that respiratory liquid particles travel through the air over variable distances and can cause infection if they are inhaled. This risk increases if individuals are in close proximity and/or over a prolonged period of time.
- These respiratory particles can travel over longer distances i.e. more than 2 metres and the evidence would suggest that this is most likely to happen in crowded indoor environments with prolonged exposure and when the ventilation in a room is poor.

[1] www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/guidance/infectionpreventionandcontrolguidance/
www.hpsc.ie/az/respiratory/coronavirus/novelcoronavirus/guidance/infectionpreventionandcontrolguidance/hseinfectionpreventionandcontrolguidanceandframework/Interim%20HSE%20Guidance%20on%20IPC.pdf
www.gov.ie/en/publication/ad236-guidance-on-ventilation-in-schools/
www.hsa.ie/eng/topics/covid-19_coronavirus_information_and_resources/
https://www.gov.ie/en/publication/22829a-return-to-work-safely-protocol/ https://www.hpsc.ie/a-z/respiratory/coronavirus/novelcoronavirus/guidance/employersemployeesguidance/Hospitality%20guidance.pdf
https://www.sportireland.ie/sites/default/files/media/document/2021-11/return-to-sport-guidance-november-2021-revised.pdf
https://covid19.failteireland.ie/
https://www.artscouncil.ie/COVID-19/

Ventilation is the process of air exchange by bringing in fresh air from outside and removing indoor air, which may contain pollutants including virus particles, through mechanical or natural methods.

- Improving indoor ventilation and air quality will help reduce the risk from COVID-19 in particular for long range (> 2m) transmission. It is important to ensure adequate ventilation of any indoor spaces, either through natural ventilation (i.e. opening windows and external doors) or by mechanical means (e.g. central air-conditioning unit).
- Air changes per hour (ACH) is one measure of ventilation which estimates how many times the air in a room/space is replaced with fresh air per hour. Increasing the number of air changes alongside other measures can reduce the risk of COVID-19 transmission.
- Carbon dioxide (CO2) monitoring is also likely to be beneficial in raising a person's awareness of ventilation requirements and has been used to inform individual behaviour in improving ventilation
- **Natural ventilation** includes continuous use of trickle vents[2]; partial or complete window opening; and opening external doors. Natural ventilation relies on individual behaviour to open windows and vents which can present issues with winter thermal comfort, uncontrolled energy use, noise, pollution intrusion and security.

- **Mechanical ventilation** employs fans to transfer air into and out of an area. In smaller indoor spaces these may be in the room, but larger buildings may employ a network of ducts and fans to blow clean air into rooms and/or extract the stale air.

Mechanical ventilation advice includes:

  - set the ventilation system to bring 100% fresh air in and not recirculate air
  - Use of appropriate filters as per manufacturer's specifications
  - Disable air recirculation systems where possible
  - Extend operating hours of ventilation systems
  - Regular maintenance of central heating, ventilation and air conditioning (HVAC) systems. If well-maintained and adapted for use in the COVID-19 pandemic, heating, ventilation and air conditioning (HVAC) systems may have a complementary role in decreasing potential airborne transmission of SARS-CoV-2
  - Avoid the use of ceiling mounted, desk and portable fans where possible

[2] Small slot/opening in a window or building envelope component, that allows small amounts of ventilation (trickle ventilation) through a window and/or door when it is closed

Useful Links:

https://www.gov.ie/en/publication/aa43c-expert-group-on-the-role-of-ventilation-in-reducing-transmission-of-covid-19/#reports

https://www.gov.ie/en/publication/ad236-guidance-on-ventilation-in-schools/

https://enterprise.gov.ie/en/Publications/Publication-files/Work-Safely-Protocol.pdf

https://www.hsa.ie/eng/topics/covid-19_coronavirus_information_and_resources/

https://covid19.failteireland.ie/

https://www.gov.uk/government/publications/emg-simple-summary-of-ventilation-actions-to-mitigate-the-risk-of-covid-19-1-october-2020/emg-simple-summary-of-ventilation-actions-to-mitigate-the-risk-of-covid-19-1-october-2020

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/928720/S0789_EMG_Role_of_Ventilation_in_Controlling_SARS-CoV-2_Transmission.pdf

https://www.gov.ie/en/publication/22829a-return-to-work-safely-protocol/

Background

Ventilation refers to the movement of outdoor air into a building, and the circulation of that air within the building or room. This can be achieved through natural means (e.g. opening a window) or mechanical means (e.g. a central heating, ventilation and air conditioning (HVAC) unit). Lack of appropriate ventilation within healthcare settings has been associated with increased rates of infection with airborne diseases[1]. Similarly, inadequate ventilation in non-healthcare settings has been shown as a contributing factor in outbreaks of highly infectious airborne diseases like measles and TB[2].

The understanding of the role of ventilation in the transmissibility of SARS-CoV-2 (the virus that causes COVID-19) continues to evolve. Epidemiological evidence indicates that transmission occurs predominantly among people who have had relatively prolonged close contact with an infected individual. While incidents of infection can occur in settings where close contact does not appear to be a factor, these incidents account for a relatively low number of cases. It is broadly recognised that long-range transmission of SARS-CoV-2 can occur in certain circumstances, although the relative importance of this has yet to be comprehensively established. This document provides an overview of the literature examining the association between ventilation and COVID-19, and provides recommendations based on the literature, specifically for non-healthcare settings.

Modes of transmission

SARS-CoV-2 is transmitted through the air by respiratory liquid particles carrying the SARS-CoV-2 virus leaving the mouth and nose (respiratory tract) of an infected person when they breathe, talk, sing, shout, laugh, cough or sneeze.

Previously, scientists in the medical community have emphasised the importance of large respiratory droplets[3] for respiratory virus transmission. However, in relation to SARS-CoV-2, particularly from the beginning of 2021 and as stated in SARS-CoV-2 related updates in the USA, Centers for Disease Control and Prevention (May 7, 2021) Scientific Brief: SARS-CoV-2

[3] mucus and saliva sprayed from coughs and sneezes

Transmission; and the WHO (April 30, 2021) there has been an increasing importance attached to the role of "aerosol"[4] transmission

In recent work[3] undertaken via the Joint Research Centre (JRC) for the European Commission scientists have called into question the demarcation between droplet and airborne transmission. In fact, in previous work, dated back as early as 2008 and more recently in April 2020 and May 2021, the JRC have been calling for a revision of the guidelines on the modes of transmission of respiratory viruses.

Evidence from research studies conducted in 2020 and more recently in 2021, suggests that there is an important and significant likelihood that the mode of transmission of SARS CoV-2 is airborne[3,4,5,6] including transmission arising from respiratory liquid particles that usually only travel a short distance (<2m) due to their size and smaller particles which may travel longer distances and remain suspended in the air. These infective respiratory liquid particles may directly reach the respiratory tract of susceptible individuals and result in infection. The risk is higher if people are in close proximity, as more particles can travel a shorter distance. These respiratory liquid particles can also land on surfaces conducive to the SARS-CoV-2 survival. Uninfected individuals who touch these surfaces and then touch their face may inadvertently transmit the virus to themselves indirectly[7].

For these reasons current Public Health recommendations of using cloth face coverings or masks in public settings, social distancing, respiratory etiquette, regular hand washing and improving ventilation remain important in limiting transmission of the virus.

Ventilation and COVID-19

Crowded indoor spaces have been shown to be associated with increased SARS-CoV-2 transmission. Factors that are likely to play a role in increased transmission of SARS-CoV-2 in indoor settings include the infectiousness of the person, the activities of the infectious person, and the size and ventilation of the indoor space[8]. A large study conducted in China in November 2020, identified that out of 318 outbreaks (classified as 3 or more cases in a single setting), all occurred in indoor environments[9]. In addition, a study in Japan by Nishiura et al[10] examined 110

[4] smaller than droplets and contain fewer infectious particles; remain suspended in the air for longer than large droplets

cases and found that a primary case is 20 times more likely to transmit SARS-CoV-2 in a closed environment than in an open-air environment.

More recently, an editorial for the British Medical Journal[5] published in April 2021, Tang and colleagues commented upon the need to improve indoor ventilation and air quality in order to help people stay safe. In particular, they emphasised the need for additional focus upon ventilation as they highlight that the tiniest suspended particles can remain airborne for hours, and these constitute an important route of transmission.

The nature of indoor activities also appears to be associated with increased risk of transmission in closed environments. Activities involving forceful expulsion of air, such as singing[11], loud, excessive talking[12], and high-exertion fitness routines[13] have been associated with COVID-19 outbreaks. This is likely due to the increased number of respiratory liquid particles that are produced during activities such as singing, loud talking and exercise[15]. Determining what proportion of this transmission is due to proximity and poor hygiene practices, and what is due to poor ventilation though, is difficult, as detailed investigations of these outbreaks suggest that respiratory liquid particles and fomite transmission alone could explain the spread[7].

There are limited studies that have examined the direct effect of mechanical ventilation on COVID-19 transmission. A rapid review carried out in August 2020, sought to determine whether indoor HVAC systems contribute to the spread of COVID-19 and found only 6 studies specific to SARS-CoV-2: 4 supported the hypothesis by using computer simulations, while 2 excluded the hypothesis based on epidemiological considerations[16]. One of these studies examined an outbreak in a Chinese restaurant[17]. The authors concluded that the strong airflow created by the individual air-conditioning unit, combined with low ventilation rates due to lack of outdoor air supply, and overcrowding, led to the outbreak of COVID-19 in 3 non-associated families.

A study published in September 2020 in Eastern China found that poor ventilation was also associated with an outbreak on a 100-minute bus ride, during which 23 out of 67 passengers were infected from a single index case[18]. The bus used a recirculating air-conditioning system. In this instance, passengers sitting closer to the infected individual did not have a statistically higher chance of contracting COVID-19 when compared to those sitting further away, as cases were located throughout the bus (some more than 5m from index case). Apart from the passenger sitting next to the index case, none of the passengers sitting next to windows with air-vents on the same side as the index case contracted COVID-19, nor did the driver or passengers sitting close to the door. While only one person sitting next to a window that could be opened (there

were 4 such windows on the bus) developed COVID-19. The authors concluded that closed environments using recirculated air increases the transmissibility of SARS-CoV-2.

A study examining a large COVID-19 outbreak in a meat-processing plant in Germany in July 2020 came to a similar conclusion[19]. The authors considered the social and working conditions of the affected cases, and concluded that transmission of SARS-CoV-2 occurred over a distance of at least 8m due to the confined working space, proximity of workers, low outside air infiltration rate, and high rate of recirculated unfiltered air.

Conclusion

There is evidence that COVID-19 outbreaks are more commonly associated with crowded indoor spaces where it is harder to implement Non-Pharmaceutical Interventions (NPI), and that poor ventilation can increase the risk of transmission in such settings by facilitating the spread of respiratory liquid particles over longer distances through the air.

In addition to vaccination, precautionary measures for mitigating transmission indoors at both short and long ranges should be considered. These include increasing and optimising ventilation, good cough and respiratory etiquette, meticulous hand hygiene, social distancing, and wearing a face mask /covering[20]. The application of these critical measures are important strategies to help reduce risk of transmission of SARS-CoV-2 as well as other viruses spread through respiratory liquid particles such as flu.

General recommendations

Several organisations have produced documentation relating to building ventilation since the beginning of the COVID-19 pandemic. Below are set out general public health advice for all non-healthcare settings. This is followed by suggestions specifically for commercial and public buildings[21,22,23,24]. It is recommended to take advice from the building engineer or system manufacturer before implementing any of the suggestions relating to mechanical ventilation.

General Public Health measures:

- Get vaccinated if vaccine is recommended for you. One of the most effective ways to protect yourself and others is to get fully vaccinated. Vaccinations are proven to be effective at preventing severe illness, reducing hospitalisations and preventing death.

- Stay at home and do not meet other people if you have symptoms of an infectious illness. Self-isolate and book a COVID-19 test.
- Optimise social distancing where feasible
- Avoid crowded indoor spaces where it is harder to implement Non-Pharmaceutical Interventions (NPI)
- Appropriate use of cloth face coverings or masks as per government guidelines (https://www.gov.ie/en/publication/3361b-public-health-updates/)
- Clean your hands thoroughly and regularly
- Ensure indoor spaces are kept well ventilated, particularly where a case has been identified, by:
    - opening windows and doors (if possible). Natural ventilation relies on user behaviour to open windows and vents, which can present significant issues with winter thermal comfort, uncontrolled energy use, noise, pollution intrusion and security
    - mechanical means (e.g. central air-conditioning unit) - larger buildings may employ a network of ducts and fans to blow clean air into rooms and/or extract the stale air. These components should always be used in accordance with manufacturer's instructions

Ventilation

The following are recommendations for natural and mechanical ventilation from the Ventilation Expert Group.

- Make sure that any mechanical ventilation systems are adequately maintained as per manufacturer's instructions[22,23]. There is no need for additional maintenance cycles beyond the routine maintenance[23,25]
- Where filters are used in the central HVAC system, ensure that these are replaced regularly as per manufacturer's instructions. Ensure that filters are well sealed[8]. There is no need for additional cleaning or changing beyond routine maintenance[25]
- If filters are used as part of a central ventilation system, consideration should be given to installing the most efficient filter for the system (MERV 13 to 16; ISO 16890 ePM1 rating 60-90%). HEPA filtration should be considered where air is re-circulated[22]. It is accepted that HEPA filters can reduce the transmission of SARS-CoV-2 and therefore will be

effective at removing a substantial proportion of the airborne virus. Increase air filtration to as high as possible without significantly diminishing design airflow/fresh air amount[25].

- Increase the outdoor air fraction of air inside buildings as much as possible[21],[25]. This can be done by fully opening outside air dampers in mechanical systems, or opening windows where available, taking into account weather and comfort level of room occupants.
- Increase total airflow supply to occupied spaces by increasing number of air exchanges per hour[21,23,25.]
- Fans should only be used where there is a single occupant in a room[22]. Ceiling mounted, desk and portable fans do not provide fresh air and can mask poor ventilation issues. They are difficult to keep clean, and could increase the duration of suspended particles by creating air currents in confined spaces. Such fans merely recirculate air in a room if there is no source of fresh air. Therefore, a fresh air supply, as required by building regulations, or 10L per second per person (whichever is greater), should be provided when using a fan[26]. When used, fans should be directed to exhaust directly to the exterior environment (e.g. open window), to minimise potential spread of pathogens.
- Disable demand controlled mechanical ventilation if possible[23,24,25,27]. These types of HVAC systems are set to only circulate air when a certain threshold is passed, usually the amount of CO2 build-up in the room, or the ambient room temperature. If it is not possible to bypass this system, then set the threshold to the lowest possible setting (e.g. 400ppm or less of CO2) so that the system remains ventilating at a nominal speed.
- Extend the hours of nominal HVAC operations to begin two hours before the building is occupied, and to only reduce to lowest setting 2 hours after the building has emptied[23,24,27]. This ensures that rooms are well ventilated before occupancy each day.
- Keep ventilation running at all times regardless of building occupancy[24]. When unoccupied, ventilation can be reduced to the lowest setting.
- Ensure extractor fans in bathrooms/kitchens are functional and running optimally[24]. taking into consideration cost and climate. When the building is occupied, they should operate at full capacity[27]. As with the central HVAC system (above), they can be set to the lowest speed 2 hours after the building is emptied, and increased again 2 hours before occupancy if the system allows[24].
- Avoid directing air flow directly onto individuals or across groups of individuals, as this may facilitate transmission of pathogens between individuals[23].
- Avoid the use of air-recirculation systems in HVACs as much as possible[23,24,25]. Use 100% outdoor air if supported by the HVAC system and compatible with outdoor/indoor air

quality considerations[27]. If it is not possible to disable the air recirculation system, then HEPA filtration or the highest efficiency filter possible according to the HVAC manufacturer's specifications should be considered (MERV 13 to 16; ISO 16890 ePM1 rating 60-90%)[22]. Increase air filtration to as high as possible without significantly diminishing design airflow/fresh air amount[24].

- The Irish Expert Group on the Role of Ventilation in Reducing Transmission of COVID-19 are aligned with the recommendations of The Federation of European Heating, Ventilation and Air Conditioning Associations (REHVA) which indicate "at least two air changes per hour (ACH) and will have a positive effect up to five ACH". Increasing the number of air changes alongside other measures per hour can reduce the risk of COVID-19 transmission.
- While there is evidence in experimental settings that coronaviruses like the SARS-CoV-2 virus deteriorate faster in high temperatures and humidity[28], the levels that need to be achieved are not attainable or acceptable in buildings[24]. In addition, indoor humidification is not a common feature in most HVAC systems, and would incur additional maintenance and equipment costs[29]. However, low relative humidity (<20%) is known to increase an individual's susceptibility to infection[21,24]. Where such systems do exist, the advice is to maintain a relative air humidity of 30-50% if feasible[8].
- Create "clean" ventilation zones for staff that do not include high-risk areas (e.g. visitor reception). This can be done by re-evaluating the positioning of the supply and exhaust air diffusers and adjusting flow rates to establish measurable pressure differentials[27].

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