Managing ventilation in small facilities

Covid risk reduction

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Isaac Matheson

Context

- Globally moving from epidemic to endemic
- Delta variant in NZ, spreading
- Consensus now that aerosol transmission is a significant transmission path

Virus particles remaining suspended in tiny exhaled droplets, referred to as "aerosols" are likely responsible for several kinds of transmission events, including super-spreading events and transmission in managed isolation and quarantine facilities (MIQF). This mode of transmission is of particular interest as we accept that contacts may not always be in the same room at the same time, as was initially thought for COVID-19. Reducing the risk of airborne transmission can be achieved by reducing the spread of virus from an infected person, decreasing the viral load in the air, and reducing the risk of someone inhaling infectious particles.

Source:
https://www.health.govt.nz/system/files/documents/pages/csu_23_july_2021_delta_-_viral_load_and_incubation_period_masks_and_hepa_filters_impact_on_aerosols.pdf

What's the problem?

Need to reduce transmission risk within buildings and protect vulnerable populations – ventilation/IAQ (indoor air quality) is critical for this

- Ventilation to NZBC / AS/NZS1680 are the *bare minimum* for a legally occupiable building
- Best-practice: use international ventilation standards/guidance for healthcare facilities : e.g. ASHRAE 170-2021, HTM 03-01 2021
- Many buildings have minimal ventilation systems, if any
- Status of ventilation / HVAC in many facilities may not be well understood by the facility operator

Goal for facilities

Modify / operate facilities to reduce transmission risk as much as possible / practicable

- No greater than general risk in the community, ideally much less
- Some patient groups may be at much greater risk of poor outcomes than the general population – we should be trying everything we can to protect these groups
- Long-term solutions - consider maintenance and operation safety / risk / costs when designing and evaluating solutions

First Steps

What healthcare services / functions will be delivered from your facilities?

Understand the current state of your facilities

Define performance goals and understand the likely risk reduction of any proposed intervention

- Aerosol generating procedures?
- Areas with specialist ventilation requirements?
- Known covid +ve patients?

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Define performance goals and understand the likely risk reduction of any proposed intervention

- Audit / measurement of ventilation systems – engage test and balance contractor to test and document ventilation rates, etc.
- Are toilet / shower exhaust systems working? – often find faulty / disabled
- Are grilles clean? – often neglected, blocked with lint, greatly reducing air flow
- Check operation of any outside air / recirculation dampers / air economisers
- Check air handling equipment – Filters intact and well fitted?
- Check separation between building air intakes / exhausts

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https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-healthcare-c19-guidance.pdf

https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-covid19-infographic-.pdf

- Plenty of good guidance available internationally, e.g. ASHRAE, CIBSE etc. ASHRAE has some excellent resources freely available.
- Discount marketing hype, rely on independent, peer reviewed research
- Simple solutions are good – e.g. easy for occupants to tell if the system is working as intended, no complex maintenance or management requirements, don't rely on occupant behaviour
- Resources are limited – use them wisely

Risk reduction measures

Contain

- Air flow from clean to less clean areas

Reduce aerosol concentration

- Increase effective air change rate (air changes per hour / ACH).
- Increase outside air ACH – limited by thermal comfort / energy
- Increase filtration efficiency in existing equipment
- Add supplemental air filtration equipment
- Source capture / point capture
- Air stream sanitisation / disinfection
- Upper air UVGI

- Particularly ensure air flow moving from non-covid areas, towards any areas with known / suspected covid cases
- Toilet exhaust systems critical as these may be the only active ventilation system in a small building

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HEPA Filters – Filtration Efficiency

- HEPA (High Efficiency Particulate Arrestance) filters
- Filtration efficiency specified at worst-case particle size – *'Most Penetrating Particle Size'* (MPPS) - typically ~0.15um
- H13 - ≥99.95% capture efficiency @ MPPS
- H14 - ≥99.995% capture efficiency @ MPPS
- Standards: EN1822:2019 and ISO29463
- E11 - ≥95% capture efficiency @ MPPS

Figure 3 Source:
https://ntrs.nasa.gov/api/citations/20170005166/downloads/20170005166.pdf

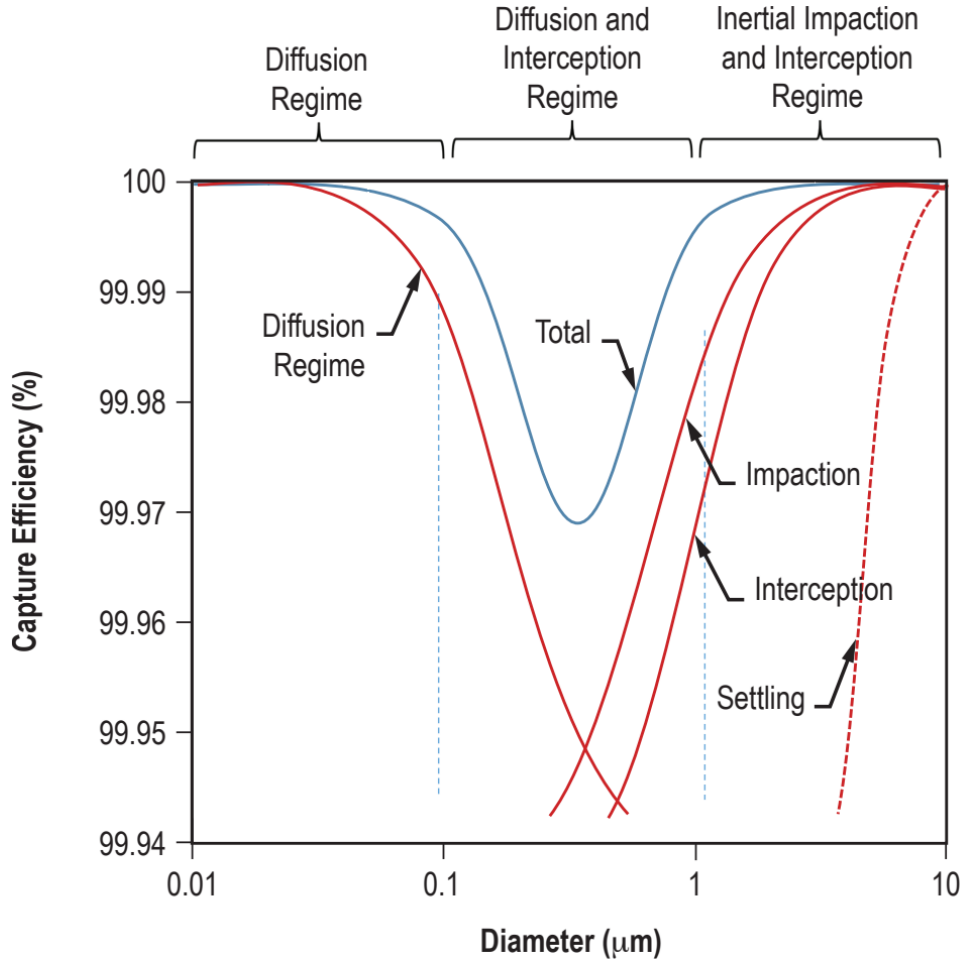


Figure 3. Filter efficiency as a function of particle diameter.

Portable HEPA air cleaners

Portable air scrubbers / Air cleaners / HEPA fan units / HEPA fan filter units

- Recirculate air within a room via a HEPA-grade (H13 – H14) air filter using a fan – effectively captures and removes particulates, including potentially infectious aerosols.
- Portable, so can be redeployed in other locations are space usage / requirements change
- Increases effective air change rate, reduces airborne viral load
- Reduces transmission risk
- Recommend units that discharge clean air vertically

Portable HEPA air cleaners

Portable air scrubbers / Air cleaners / HEPA fan units / HEPA fan filter units

- H13 – H14 filter grade to EN1822:2019 / ISO29463 recommended
- May include UV – not essential, but nice. Wide differences in UV spectrum and intensity.
- May include carbon or catalytic (VOC / odour) filtration – not essential for this application
- All units are not created equal – due diligence required, know what you are buying!
- Costs are wildly variable – does not necessarily equate to performance

Portable HEPA air cleaners – Source capture

Portable air scrubbers / Air cleaners / HEPA fan units / HEPA fan filter units

- Source capture possible for aerosol generating procedures (AGP) – e.g. dental
- Captures aerosols before they can circulate in the general room air
- Noise may be an issue

Lift Car HEPA Installation

H14 HEPA filtered fan unit on a bed lift in Wellington Hospital:

- Wired to existing lift car exhaust fan power supply
- Reused existing exhaust fan roof penetration – no new holes in lift car
- Supports clamped to lift roof beams – no holes / modifications to lift structure
- Up to >50 ACH – rapid dilution
- All air exhausted from cabin, *net airflow into the cabin* – some measure of aerosol containment, a bit like a fume hood

UVGI – Ultraviolet Germicidal Irradiation

- Long history of use of certain UVGI technologies in certain applications – e.g. UV-C water treatment, upper-air UVGI
- Different products emit UV at different wavelengths – specific organism susceptibility varies widely with wavelength.
- Solutions need to be engineered for the specific application to provide adequate dose to achieve the intended kill or inactivation rate of the target organism.
- Solutions need to account for effects that may diminish UV output: e.g. aging of light sources, temperature, dust on lamps etc. to guarantee UV output meets minimum requirements. Ideally, UV output is continuously monitored.
- Some filtration products marketed with UV appear to have been designed to work with a photocatalyst to help break down VOCs – this does not necessarily provide a significant airstream sanitisation effect.

https://www.ashrae.org/file%20library/technical%20resources/covid-19/i-p_s16_ch17.pdf

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

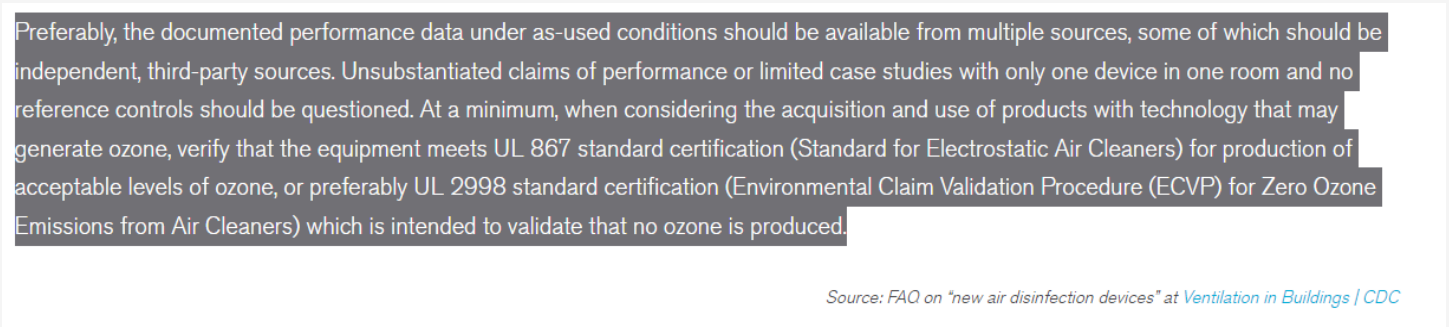
https://youtube.com/c/ScottishPhotobiologyUnit

Other Strategies / Emerging Technologies

CDC emerging technologies position statement

May work, but limited independent, peer reviewed research, particularly long-term in real-world situations

- Ionisation
- Chemical air stream sanitisation
- Photocatalytic systems



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

Relative risk reduction

- Use mask brace / fitting devices – greatly increases filtration effectiveness, even with standard surgical masks

- Relative risk reduction magnitude is similar or greater than going from poor ventilation to good ventilation

- Compared to no masking and no air cleaning, HEPA filtration alone decreased the exposure to simulated airborne particles by 50-65% (depending on their location in the room) and masking alone reduced exposure by 72%.
- The combination of HEPA filtration and masking reduced the concentration of aerosols by 90%.

Source:
https://www.health.govt.nz/system/files/documents/pages/csu_23_july_2021_delta_-_viral_load_and_incubation_period_masks_and_hepa_filters_impact_on_aerosols.pdf

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Types of Masks and Braces Tested

They include a commercial four-ply knit cotton mask (KCM); a three-ply spunbond polypropylene mask designed by the University of Wisconsin–Madison Emergency Operations Committee (EOCM), a single-use three-ply disposable mask with a meltblown polypropylene center ply medical procedure mask (PM); and an ASTM F2100 Level 2 rated surgical mask (SM).

In addition, external braces tested include the UW fitter (U) and a commercial brace (C).

FIGURE 1 Conditional probability of infection for each of the three case scenarios as a function of effective mask filtration efficiency. KCM–knit cotton mask, PM–procedure mask, SM–surgical mask, EOCM–emergency operations committee mask, –C = commercial brace, -U = UW fitter.

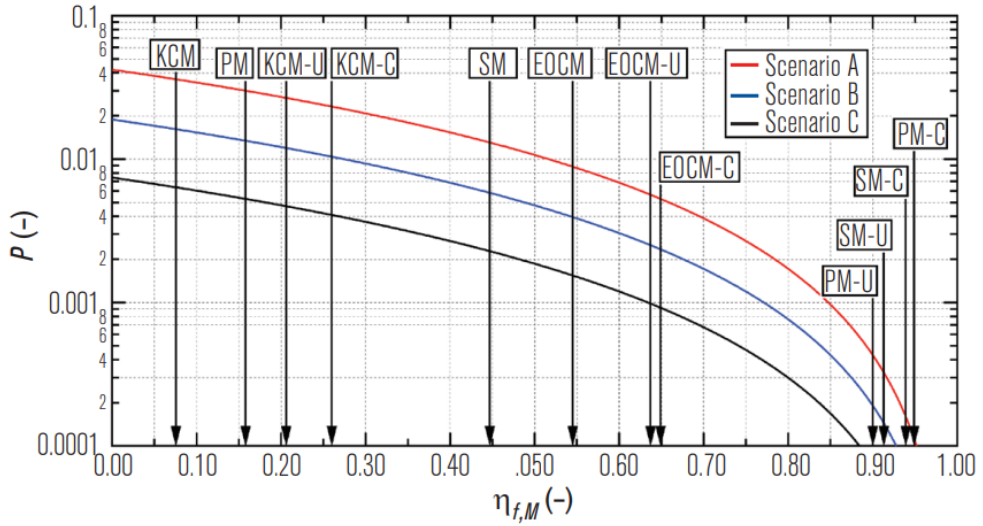
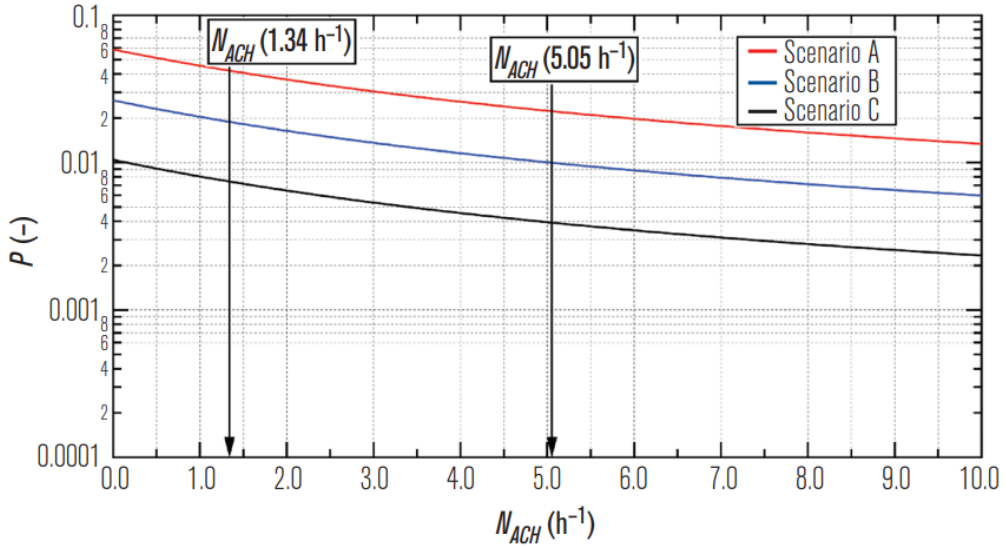


FIGURE 2 Conditional probability of infection for each of the three case scenarios as a function of ventilation rate in a well-mixed room.



Source: 'Minimising COVID-19 Transmission In High Occupant Density Settings' – modelling study: https://technologyportal.ashrae.org/Journal/ArticleDetail/2304

Final Thoughts

- Doing nothing is not an option – covid is not going away
- Even if covid disappeared, ventilation / IAQ features that reduce the risk of covid transmission will also reduce risk of other aerosol / small droplet transmission – e.g. influenza
- Much cheaper / easier to include additional central ventilation features during build rather than trying to retrofit into a occupied building – consider this when building / modifying facilities