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Throwing open the windows: The need for ventilation improvements as part of Covid-19 outbreak control in Aotearoa

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Leah Grout, Nick Wilson, Julie Bennett, Jennifer Summers, Amanda Kvalsvig, Michael Baker

The importance of indoor aerosol transmission of the virus that causes COVID-19 is increasingly recognised. In addition to public health measures such as masking and physical distancing, further protections are needed to prevent the spread of the virus. Interventions to improve ventilation and filtration are needed for indoor settings in Aotearoa NZ. In this blog we address the particular need to improve ventilation in three settings: (i) homes with contacts who are self-

isolating; (ii) indoor workplaces that have essential workers; and (iii) MIQ facilities.

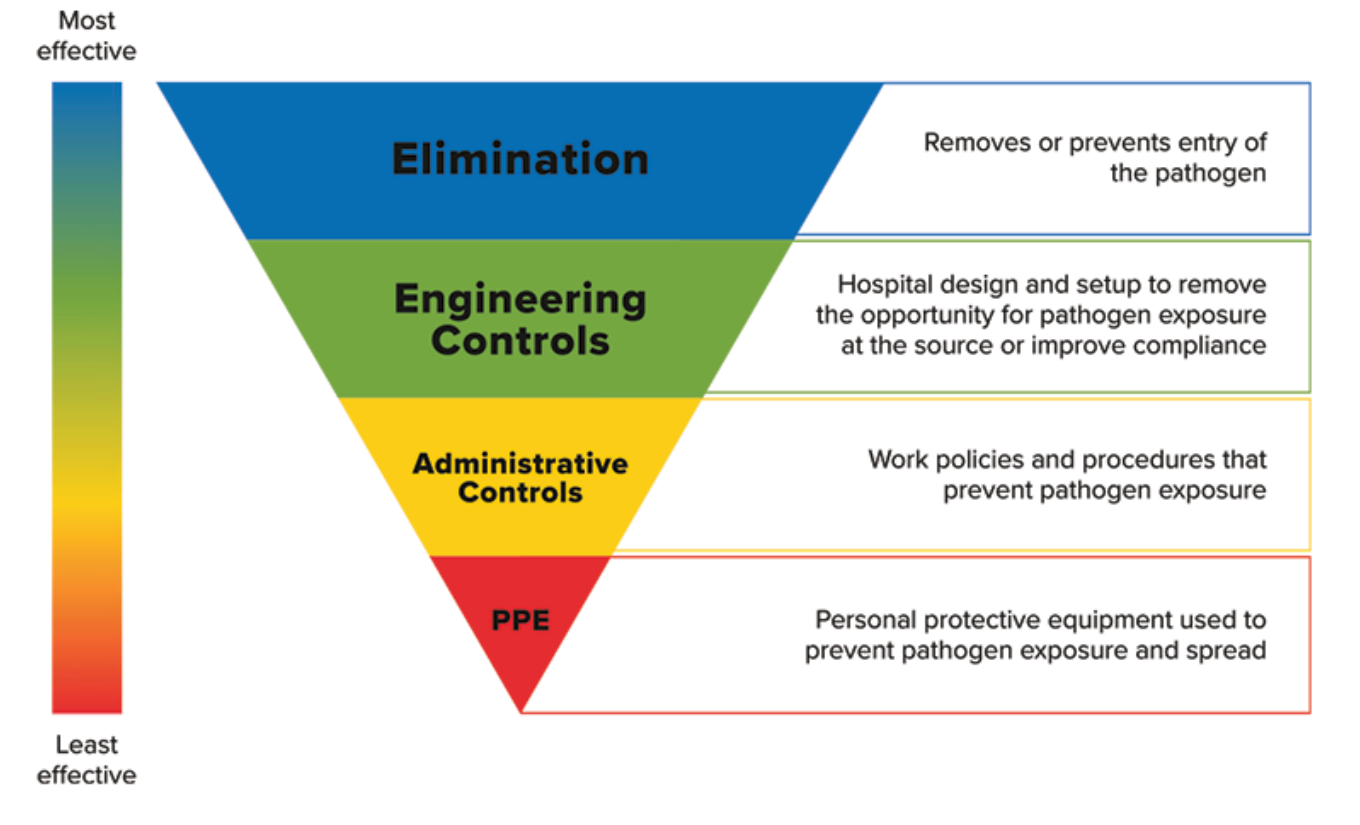
Introduction

Airborne transmission of the pandemic virus causing COVID-19 has been recognised by the World Health Organization, which states that it can spread in “poorly ventilated and/or crowded indoor settings” [1]. This is also the view of the US Centers for Disease Control and Prevention (CDC), which recommends: “adequate ventilation, and avoidance of crowded indoor spaces” [2]. Moreover, there is confirmation that long-range aerosol transmission (defined as within the same room but more than two metres away) has occurred [3, 4].

Indoor spaces with low levels of ventilation are high-risk settings for transmission, as virus-laden aerosols can remain airborne for hours [3, 5]. A recent review has noted the importance of infectious aerosols as a main way in which Covid-19 has been spread [6]. It notes that droplet transmission alone could not account for the numerous super-spreading events and the differences in transmission between indoor and outdoor environments [6]. To date, ventilation has not been a focus of efforts to reduce transmission in the NZ setting. This is despite the identification of ventilation inadequacies within MIQ facilities (see examples in the appendicised table below).

Approaches to preventing exposure to pathogens can be considered in the Hierarchy of Controls for preventing exposure to harmful agents (see Figure 1). While the figure was designed with hospitals in mind, it is relevant for all indoor workplaces during COVID-19 outbreaks. Ensuring adequate ventilation can involve both engineering and administrative controls to reduce exposure to pathogens. These interventions are considered more effective than the use of personal protective equipment (PPE).

Figure 1. Hierarchy of infection control and prevention measures [7].



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

Ventilation in homes with contacts who are “self-isolating”

The Ministry of Health website gives advice for those contacts who are “self-isolating” (technically “home quarantine” if they are contacts who have not been diagnosed as cases) [8]. However, in terms of ventilation, this advice is extremely limited with only the words: “keep shared spaces well ventilated”. This advice should be updated to something like the following:

- If possible use a bedroom with at least one window and keep the window(s) open for as much time as possible (outdoor temperature and safety permitting).
- Block any air gaps under the door of the bedroom (eg, with a towel).
- It is particularly important to have the windows open for at least 5 minutes before leaving the bedroom, but then to close the windows just before opening the door to leave the bedroom. The latter is to avoid turbulent air from the bedroom moving into a corridor, as per suggestions made for quarantine facilities [9].
- The person in self-isolation should also open windows when using any shared areas in the house (eg, bathrooms). Generally, the US CDC also recommends using exhaust fans in kitchens or bathrooms, or ceiling fans, to improve airflow and prevent the spread of COVID-19 within homes [10]. However, if a fan is used in the home, then the airflow of the fan should not be directed so that it blows directly from one person towards another person [11].

Such information should also be reiterated when identified contacts call Healthline for advice. Furthermore, the Ministry advice urgently needs upgrading to include the use of masks by people who are self-isolating.

Ventilation in indoor workplaces that have essential workers

Under Alert Level 4 settings there are workers and customers in supermarkets, pharmacies, and healthcare facilities. There are also factories and other workplaces that are in use by essential workers. Generally, experts have advised that to maintain proper ventilation in schools, homes, and businesses to prevent or minimise COVID-19 transmission, building managers should bring in as much outdoor air as possible, with a room air exchange rate of four to six times per hour, which is more than double the rate in a typical office or school building [3, 5]. New Zealand’s pre-pandemic guidelines for schools advised four or more air changes per hour [12], but this advice is not mandated. It has also been recommended that in buildings that recirculate interior air, filters should be upgraded to hospital-grade MERV 13 filters, which can remove up to 70% more small particles (<2.5 microns) than the MERV 8 filters that are typically used [3, 5]. Failing the use of such filters, then window opening is again a very simple approach to improving workplace ventilation.

Requiring mask use by all essential workers who are working indoors under Alert Level 3 and 4 settings would also help to prevent airborne transmission of the virus. Furthermore, there is growing evidence that improved ventilation can result in a range of other benefits in the workplace environment, including improved functioning of workers on cognitive tests, reports of improved sleep, and fewer “sick building” symptoms [13].

There is an urgent need for the Ministry of Health to communicate these ventilation issues to employers, unions, and workers. There is also a need for improved ventilation of schools that are open under Alert Level 3 for children of essential workers, along with mandatory

mask wearing by all school children, staff, and school visitors, in line with CDC advice [14].

Ventilation in MIQ facilities

Available evidence indicates that inadequate ventilation has led to multiple quarantine system failures in Australia and NZ [15, 16]. For example, after three transmission events at the Pullman Hotel MIQ facility in Auckland (see appendicised table), it was revealed that corridor ventilation was only operating for two hours per day at the time of the incidents [17]. As a result of the transmission events, a number of changes in the ventilation system and practices were introduced [18]. Short-term changes at the Pullman Hotel included operating at reduced capacity (50%) to reduce congestion in shared spaces, the placement of air purifiers (eg, HEPA units) in the lifts and corridors, expanded use of N95/P2 particulate respirators for MIQ workers (undertaken at all MIQ facilities) [18], and it was also announced that corridor ventilation would operate for 24 hours a day to reduce the risk of airborne transmission [17]. These measures were put into place while longer-term remedial ventilation work was undertaken at the Pullman Hotel [18].

However, the ventilation systems of most hotels used as MIQ facilities are not generally built for quarantine purposes, and a study that examined the ventilation systems in hotels used for quarantine in Hong Kong reported that:

"… it may not be possible to increase the fresh air supply to the hotel premises or install higher-grade filter in the hotel ventilation system. Alternatively, portable air purifiers with HEPA filters should be considered, at least in the corridor of each floor, and ideally in each room. Thirdly, alternate rooms instead of adjacent and opposite rooms should be utilized to reduce the risk of door-to-door transmission. Fourthly, residents are advised to close the windows before opening the doors to avoid unpredicted direction of airflow, and to wear surgical mask for mutual protection while the doors are opened. [9]"

While upgrading ventilation systems and PPE used in hotel-based MIQ facilities may help to prevent/reduce airborne transmission, ideally NZ should move away from the use of hotels to purpose-built quarantine facilities (as being built in Victoria and Queensland), or discrete accommodation units that allow for natural ventilation and reduce or eliminate shared indoor spaces (eg, the cabins used at the Howard Springs facility outside of Darwin, Australia).

In summary, while the country is at Alert Level 3 or 4, efforts should be undertaken to improve ventilation in several different settings in NZ, including: (i) homes with contacts who are "self-isolating"; (ii) indoor workplaces where there are essential workers; and (iii) MIQ facilities. Further work is also needed on ventilation in schools and other settings, and even with improved indoor air ventilation and filtration, other measures including mask wearing and physical distancing will remain important for preventing the spread of COVID-19. Improved indoor air quality will also have health and productivity benefits that extend well beyond the COVID-19 pandemic.

* **Author details:** Department of Public Health, University of Otago, Wellington

Appendix

Table 1. Examples of confirmed and probable MIQ system failures for COVID-19 control in NZ that may have been related to inadequate ventilation in the facility

Event	Extent of known spread beyond border	Details
Maintenance worker infected in the Rydges Hotel, Auckland MIQ facility (August 2020)	A single worker	A shared lift environment in a quarantine hotel was the source of infection suspected by officials [19], with the sharing occurring only minutes apart [20]. However, officials originally speculated that transmission occurred through touching the same lift button [21]. Genomic sequencing indicated that the case was linked to a recent traveller in the same facility [20].
Traveller-related outbreak linked to the Crowne Plaza, Christchurch MIQ facility (September 2020)	The 2 returnees and 4 others	Three returnees (Cases A, B, and C) tested positive for SARS-CoV-2 while in an MIQ facility (ie, these cases were caught at the border) [22]. Evidence suggests that two returnees (Cases D and E) were then infected through suspended aerosol particles while in the same hotel quarantine facility (Cases D and E were staying in the room next to Case C), before then moving into the community [22, 23]. Transmission from the surface of communal rubbish bins was considered less probable because contact with the bin lid occurred more than 20 hours apart for the involved cases [22]. Furthermore, shared air space is far more likely given what is now known about the likely rarity of transmission via surfaces [24, 25]. The infected returnees appear to have then infected another person (Case G), potentially on a charter flight after leaving the facility [22, 23]. A household contact of Cases D and E was also infected (Case F) [22, 26]. Two household contacts of Case G were also infected [22].

Returnee infectious after leaving the Pullman Hotel, Auckland MIQ facility “Northland case” (January 2021)	A single returnee	A returnee was identified as being infectious in the community after leaving a MIQ facility (Pullman, Auckland). The returnee reportedly had the Beta variant (lineage B.1.351) of the pandemic virus [27]. Genome sequencing linked the case to another returnee who was in the same MIQ facility [28]. This might have been part of one single failure at the Pullman facility (ie, a super-spreading event at the facility given the cases in the subsequent two rows of this table).
Returnees infectious after leaving the Pullman Hotel, Auckland MIQ facility (January 2021)	2 returnees and 1 contact	Two returnees (a parent and child) were identified as infectious in the community after being infected with the Beta variant of the pandemic virus with a link to a MIQ facility (Pullman, Auckland) [29]. A close contact (the mother of the child) also became infected [30].
Infection within the Pullman Hotel, Auckland MIQ facility (January 2021)	Contained at the border	A returnee from India via the United Arab Emirates (arrival date 16 January 2021) tested positive on Day 10 in the Pullman MIQ facility in Auckland [31]. Genome sequencing revealed that the case was infected with the Alpha variant (lineage B.1.1.7) of COVID-19 and suggested that this case was closely linked to another case in the facility [32]. The other case in the facility was genomically related to two cases in Australia: one air crew member who tested positive on 13 January 2021 and a subsequent case in a MIQ facility who was on the same flight as the crew member (G. Hall, Ministry of Health, personal communication to Prof David Skegg, 16 March 2021 in response to an OIA request). “Genomic and epidemiological evidence indicate possible transmission within the MIQ” (G. Hall 2021, ibid). Given this evidence and the time frame around first testing positive on Day 10, we would regard this as a “probable” infection within the MIQ facility.

Infection within the Grand Mercure Hotel, Auckland MIQ facility (March 2021)	Contained at the border	A returnee in MIQ at Auckland's Grand Mercure Hotel returned a positive day 12 test [33]. The case travelled from the UK via Singapore [33], but results from genome sequencing showed a link to another case at the Grand Mercure [34]. The two returnees arrived on separate flights within two days of each other, and they were staying in separate rooms on different floors [34].
Infection within the Jet Park Hotel, Auckland MIQ facility (July 2021)	Contained at the border	A bubble of 3 people in the Jet Park Hotel tested positive for Covid-19 in July and the cases were genomically linked to a COVID-19 case in the room opposite [35, 36]. The Auckland Regional Public Health Service investigation found that doors to rooms on opposite sides of the corridor were opened at the same time for about three to five seconds on four occasions between July 27 and July 29, while the case in the room opposite was infectious [35, 36].
Delta variant infection within the Crowne Plaza, Auckland MIQ facility (August 2021)	Related to Auckland Delta outbreak	A bubble of three people in the Crowne Plaza returned a positive day 12 test on 18 August. These returnees were in a room adjacent to the primary case from NSW in the current Auckland outbreak [37].

Lead image by bady abbas on Unsplash

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