



Assessment of air handling (HVAC) systems and worker arrangements at Western Australian Quarantine Hotels as they relate to the risk of worker exposure to SARS_CoV_2 virus

This assessment presumes that hotels will continue to be required to quarantine persons entering Western Australia. Therefore, the purpose of the investigation was to identify risk factors associated with ventilation in quarantine hotels that can be adequately managed so as to exclude central (plant room) air handling systems as transmission pathways inside State quarantine hotels. The consideration of alternate quarantine facilities is outside the scope of this investigation.

The review first considered the circumstances leading to infection of a security guard at Four Points by Sheraton Hotel that led to a five-day lockdown of Perth and parts of the south-west of WA in February 2021.

The DOH engaged PDF Engineering and Glossop Consultancy to investigate how the security guard, known as case 903, became infected. The consultants determined local air flow transmission a plausible mechanism of exposure and therefore infection. The consultants' scope was then extended to complete an investigation and site inspections of each State controlled quarantine hotel in use in February 2021 and one new (proposed) hotel to:

- provide information to SHICC on the suitability (with regard to ventilation and air-handling) of each premises to be used as State controlled quarantine hotels
- identify potential improvements or additions to building mechanical ventilation systems to prevent infection to security guards, hotel staff, guests and visitors
- where ventilation is not suitable or cannot be improved, identify other measures to reduce the risk of transmission within a hotel environment (e.g. restrictions on use of rooms, positioning of security guard stations)
- identify ventilation criteria important in the selection of any new hotels proposed to be used for quarantine.

This document summarises the findings of the PDF Engineering and Glossop Consultancy reports and must be read in conjunction with those reports.

RECOMMENDATIONS

As reported by Professor Weeramanthri following in the *Review of Western Australia's Hotel Quarantine Arrangements*, ventilation remains the single remaining modifiable risk factor in prevention of transmission. However, the extent to which hotel ventilation can be practically modified is an important consideration.

The feasibility of further reducing low level risks needs to be considered in the context of the effectiveness of hotel quarantine to date and the relative suitability and availability of other options. Care needs to be taken in ensuring that any alternative arrangements or introduced control measures do not create a greater transmission risk and potential for community spread than the risk that is being prevented.

PDF Engineering and Glossop Consultancy have not identified flaws or faults in the air handling systems of any of the hotels that necessitate the removal of hotels from quarantine use. Instead recommendations are designed to maximise what is considered internally to be good practice supported by the World Health Organisation to minimise risk of transmission.

The following measures are recommended for implementation across all state quarantine hotels, but are particularly important to mitigate risks for hotels in the amber and red category identified in the Glossop Consultancy report.

1. Administrative measures

- a. moving or eliminating guard stations and or
- b. replacement of security guard by CCTV
- c. connecting rooms to be used for family units or as single room occupancy (using one room of the two rooms)
- d. Ongoing iterative review of training/education in infection control for security guards, hotel staff including the use of PPE

2. Engineering measures

- a. use of HEPA unit in rooms with positive cases
- b. operable windows to be closed and secured so as to maintain a consistent pressure in the rooms.
- c. regular maintenance checks of supply and exhaust room ventilation systems.

Introduction

There is growing acceptance among the scientific community that inhalation of aerosols that move between interconnecting spaces represent a plausible mode of transmission of SARS-CoV-2 virus, especially for more contagious variants. While there are specific reported cases where this may have occurred, currently there is insufficient information to be able to reliably predict conditions under which such transmission may occur. However, protecting the inhalation pathway is an important measure to consider in addition to other controls in order to reduce the probability of transmission via small particle aerosols in any situation where this may be reasonably anticipated to occur.

The prevention of transmission of SARS-CoV-2 virus from returned travellers to security guards and hotel workers remains a critical control point for subsequent community spread. Protection of workers has two main objectives:

1. Prevention of transmission of the virus (and associated disease) to individual workers.
2. Prevention of community spread through an infected worker who might expose the wider community once they leave their workplace.

The consequences and severity of risk associated with community spread and State lockdowns means that protection of workers to prevent community spread within the community is a priority consideration. While every effort must be made to prevent *any* transmission, disease transmission between people within the quarantine system is likely to be detected and contained prior to the quarantine period ending, thereby reducing the potential for community spread.

When reviewing recommended mitigation measures, those that are aimed at the protection of workers and that prevent transmission to other persons within the quarantine system are preferred. The Department of Health (DOH) is also committed to meeting its worker safety and health obligations as an employer and contractor of services.

It is important to note that ventilation is a single factor impacting one mode of transmission (inhalation). There are other significant factors that may influence disease transmission including, either independently or in combination with ventilation factors:

- close contact (all modes of transmission possible)
- infectivity of COVID-19 variants (e.g. UK B.1.1.7) which may be more infectious at lower viral numbers
- time spent in vicinity of an infected persons
- distance from the infected persons
- ventilation factors (air flow, room air changes per hour, pressure differentials between rooms and corridors where workers are located)
- the number of aerosols being produced, e.g. AGP (Aerosol Generating Procedure such as use of nebulisers), coughing, sneezing, exercising, shouting and talking
- indirect exposure (touching of fomites)
- virus survivability in air and on surfaces.

Initial Investigation

A preliminary assessment of the air-handling system, ventilation and room configurations at the Four Points by Sheraton Hotel Ventilation System found that a plausible transmission pathway existed for a security worker stationed in close proximity to a room with a confirmed COVID-19 case (UK variant confirmed by whole genome sequencing). The infected guest's room was under significant positive pressure (approx. 33% of air supplied to the room was escaping around the door). The corridor did not have its own air supply and the direction of air travel was past the security guard's location, with minimal dilution from other rooms (only occupied room located in the corner in proximity to the worker, with the room with the infected guest). The room door was frequently opened on the day of the security guard's shift; possibly up to 10 times (see Sheraton Four Points Report, Glossop Consultancy).

The preliminary findings supported the need for further investigation of ventilation and worker arrangements at other hotels to better understand and reduce risks to workers.

Further Investigation of quarantine hotels

PDF Engineering and Glossop Consultancy undertook investigations and site inspections of each State controlled quarantine hotel and proposed hotel to:

- determine the suitability (with regard to ventilation and air-handling) of each of the 9 existing premises and 1 possible new premise to be used as State controlled quarantine hotels
- identify potential improvements or additions to building mechanical ventilation systems to minimise infection to security guards, hotel staff, guests and visitors
- identify system improvements to reduce the risk of transmission within a hotel environment (e.g. factors to consider in hotel selection, room allocation and positioning of security guard stations).

The PDF Engineering report considers ventilation design and effectiveness mostly in isolation of other factors contributing to risk of transmission to workers and others. The Glossop Consultancy report provides a qualitative assessment of the inhalation risk of transmission to security guards and other persons that incorporates the findings of the PDF Engineering report. The reports have endeavoured to categorise quarantine zones in hotels based on the relative risk associated with local ventilation and other related factors as identified in the Glossop Consultancy individual hotel reports.

The review of the main HVAC system at each hotel was completed through examining documentation (e.g. engineering drawings and records), visual inspection of air handling units and discussion with each facility manager. One or more empty representative rooms were selected for assessment at each hotel. Where room pressurisation was likely to vary (e.g. hotels with windows that open) additional rooms were qualitatively tested for room pressurisation, including, when necessary, on occupied floors (doors with occupants were kept closed with smoke or tissue paper test undertaken beneath doors). The plant rooms at each hotel were inspected. Professional judgement was used to assure the rooms tested were representative, with additional rooms and floors tested where inconsistencies in room pressurisation was found or where non-standard rooms were accessible (vacant) for testing, noting that the investigation team was not permitted to visit occupied rooms to comply with SHICC and infection prevention and control protocols. It is not necessary to test every room to gain an overall understanding of the ventilation arrangements and its effectiveness at each hotel as the ventilation design within hotel rooms is generally consistent (e.g. position and size of supply and return/exhaust vents and standard room sizes) and the main supply and exhaust air velocity is managed and primarily influenced by one or more central air handling units (rather than room controls)

Findings

After completing the assessments of hotels, the Glossop Consultancy report concluded that the security guard position at the Four Points represented the highest risk of inhalation exposure of all the security guards, including at other hotels with similar ventilation conditions (positive pressure rooms with no dedicated corridor air supply).

It is important to note that the highest risk of transmission remains close contact, such as for health care workers who are entering guest rooms for testing or treatment.

The risk to security guards is most relevant when the security guard position in the accommodation floor corridor has little dilution of air and there is a significant positive pressure differential between the room and the corridor. This could allow the passage of air containing small droplets and aerosols from rooms with COVID19 positive guests to be

carried towards relief air/extraction grilles in corridors and past a possible security guard location which is impacted when doors are opened and/or from air leakage around the door.

The length of time an infected person spends in one location (e.g. infected person stationary in occupied room vs moving through an area) and the exposure duration of the security guard (e.g. remaining in a stationary security location for 12 hours per shift) is likely to be influential. In addition, symptoms that increase respiratory aerosol production (e.g. coughing) may be an influencing factor.

Other workers/guests at further distance or in other rooms are likely to be at negligible risk of infection, even when ventilation conditions are unfavourable. For other workers their time on each accommodation floor is transitory, they are wearing masks and their exposure time is low. Other guests will also have their own clean air supply and are likely to receive relatively more diluted air. An exception to this would be where there is a positive pressure room facing a negative pressure room, especially where both doors may be opened at the same time, creating a scenario similar to close contact. Risks may increase should a more infectious variant of the virus emerge.

It is possible to mitigate risk through adjustments to ventilation such as, where possible, to reduce pressure differentials between occupied spaces. Ideally accommodation rooms should be negative/neutral pressure to corridors to assist in containment of small droplets and aerosols within rooms.

It should be noted that there is no suggestion of design fault or installation issues relevant to current building standards with the HVAC systems at any of the hotels investigated.

Suitability of existing premises to be used as State controlled quarantine hotels

The available hotels all have something different in their design and operation. The current 9 hotels being used vary in age from the middle of the 1970's (Mercure and Pan Pacific) through to 2020 (Novotel Murray Street and Westin).

The investigation found that some differences were more important than others. Such as:

- Pressure differentials between rooms and corridors affected by:
 - System design
 - Balance of supply air to exhaust air
 - Supply air to corridor
- The availability of drop blades installed on hotel room entrance doors. In the newer hotels smoke drop blades are a legal requirement. The smoke drop blades will not change whether a room is positive or negative pressure, but it would certainly reduce a lot of the airflow escaping from around the door. The doors with the smoke drop blades are also well sealed around the 3 other edges of the door making them nearly airtight.

Where rooms are negative to neutral pressure, the risk of movement of aerosols from rooms to corridors or other rooms and areas of the hotel is substantially reduced, and likely insignificant.

Most of the hotels have the ability to change the pressurisation of rooms by varying the balance of air supply and relief/exhaust flow. However, the consultant reports concluded that this could only be varied by about 10% of the main (air handling unit) supply and exhaust airflow.

The supply of air to corridors is an important factor in increasing dilution of air. Combined with distance of workers and guard stations to any room doors, dilution of air in the corridors is an important protection factor.

Hotels included in the red category (See Glossop Consultancy report) have no direct supply air ventilation of the corridors and rely on air escaping from rooms with positive pressure for ventilation. This substantially increases the risk of air (and associated droplet/aerosol) movement to any workers in the corridors and less so to guests who open their room doors, especially where the pressure difference is high. Continued use of these hotels will therefore require consideration of other mitigation strategies, such as removal of certain rooms from service and/or a change of the security guard positions. Such strategies will need to be considered in the context of other risk considerations.

The investigation found that one of the most unpredictable factors that could increase risks was guest behaviour (including not following infection control protocols, opening doors out of curiosity to see what is happening in corridor, opening windows (where operable), attempts to leave quarantine hotels, risk of close contact by moving between rooms and floors to visit other guests). Where security guards cannot be moved, administrative changes and higher protection personal protective equipment should be considered.

There has been some discussion in the media of the importance of room air changes per hour within quarantine hotels as compared with requirements for health care settings. Current protocols are such that hotel workers do not enter guest rooms under any circumstances. As such, room air changes per hour are a less important factor than in a health care setting where workers may frequently enter and exit patient rooms.

Health care workers who enter rooms do so for as short a period as possible and are required to follow infection control protocols (including use of PPE) which mitigate the risk. Further mitigation is possible through using personal protective equipment with higher protection factors, especially if more infectious variants become evident. For example:

- Disposable, approved, face-fitting Class P2 / N95 respirators.
- Re-usable, powered air supply respirators (do not require a fitted face seal but do require decontamination which require appropriate infection control protocols for handling and cleaning)

Within a health care setting additional mitigating factors are available to protect healthcare personnel such as personal ventilation hoods for patients.

Overall, the conclusion that can be drawn from the Glossop and PDF Engineering Reports is that all 10 hotels could potentially continue to serve as quarantine, although caveats will need to be in place for the amber and red category hotels. Hotels and/or hotel rooms with negative or neutral pressure rooms are preferable because the rooms more closely mimic the negative pressure conditions in healthcare environments which means that when the door to the corridor is opened potentially contaminated air will not flow outside.

Hotels with positive pressure rooms need not be ruled out, but additional controls should be implemented as a condition of their further use. In such hotels the location of security guards becomes very important and control measures such as increased use of CCTV and limiting security guard only to locations where they are receiving fresh air or diluted air, to fire escapes or other spaces. It may be that travellers arriving from low risk areas are placed in these hotels.

It is important to note that a slight positive pressure would be acceptable provided these are subject to adjusting the HVAC system where possible, filtering the air with HEPA filters, within infected rooms, increasing the capacity of the bathroom exhaust fans and relocating security guard stations.

The consultant's reports are not intended to provide a statistically significant analysis. It was neither feasible nor necessary to investigate each room in each hotel nor even the majority of rooms in each hotel. Rather, it was reasonably inferred that the rooms chosen for analysis reflected the status of the hotel from an assessment of the HVAC systems.

Observed best practice infection prevention and control protocols

There was slight variation in procedures between hotels about how the hotel guests were notified of any deliveries, including food. Guests that are informed by a telephone call would further reduce risk to security guards and hotel workers making the deliveries as they may be able to move further away from opening doors.

There are different procedures for dropping off deliveries and in some cases hotel workers (eg. concierge) remain in the corridor until an item is picked up. While this may be the hotel's usual procedure during normal operation, confirmation of pickup at a secured quarantine facility can occur via the security guard, CCTV or phone call, rather than unnecessarily having additional workers present when doors are opened.

Room occupants can be more strictly restricted from opening doors without prior arrangement or warning (i.e. delivery pick up time, a set time to place waste, etc. outside door, knock from the inside prior to opening to give persons, who may incidentally be in the corridor, time to move away). This year Queensland Health instigated a new door-opening protocol in response to the Grand Chancellor incident in January (see below). Their door-opening protocol now alerts guests to turn on the bathroom exhaust before opening the door leading into the room. This does not apply in WA hotels where the bathroom exhaust is permanently on. Another point of difference with current practice at Perth quarantine hotels is the bright bold notice that is attached to the inside of the door at eye height (attached).

As quarantine is occurring within a hotel there appears to be an unrealistic expectation by guests that hotel services can be provided in the same way as for periods of holiday accommodation. For example, hotels aim to deliver items within pre-determined timeframes based on high quality guest service. However additional precautions that involve time delays are justified for a quarantine facility to reduce door opening events and interactions of hotel workers with quarantined guests. For example, non-urgent deliveries can be held and delivered at the same time as meals. Managing expectations of being in quarantine vs a "normal" hotel experience is an ongoing challenge.

Cases in other jurisdictions

A possible similar incident to Western Australia (WA) is the Security Guard in NSW who tested positive on 15 March 2021.

A simple engineering solution (installation of extraction fan within bathroom exhaust) suggested for the Perth Four Points by Sheraton Hotel to enable a small number of rooms to operate under negative pressure has been suggested for use in Victoria. However, PDF Engineering advises that although this may be applied to a small number of rooms, this is not possible as a blanket solution in Perth Quarantine hotels as it would disrupt the mechanical air handling system.

A hotel cleaner on 2 January 2021 at the Grand Chancellor hotel in Queensland was suspected to have acquired infection from indirect contact during room cleaning. An

important infection prevention and control criteria is that rooms are only cleaned or entered by hotel staff and other workers no earlier than 72 hours after guests have left. This timeframe must be strictly enforced and may possibly need review if new, and more infectious variants of COVID-19 emerge.

Summary of the [Queensland Health and Queensland Police Service joint agency continuous improvement review of the COVID-19 infection of a hotel worker \(Hotel Grand Chancellor\)](#) in January 2021

- Indirect contact, rather than ventilation, was suspected to be the mode of transmission.
- Air flow from positive pressure rooms to corridors was considered a possible mode of transmission (... *cannot be excluded*).
- Investigative environmental swabbing positively detected viral fragments only in rooms occupied by infected travellers. No positive detections were found in nearby rooms and common areas.
- Ventilation provisions were reviewed with similar recommendations being identified to the WA investigation:
 - Minimise room door openings (example given is for linen collection to occur at the same time as meal delivery)
 - Minimise traffic in corridors on accommodation floors
 - Guests to wear masks when opening doors
 - Ensure door seals are in good condition to minimise under door leakage.

A recent (March 2021) case of guest to guest transmission at the Grand Chancellor in Queensland is currently under investigation. Verbal reports from Queensland Health have suggested close personal contact between guests or transmission via health workers but it should be emphasised that how the guests became infected while in quarantine was not known at the time of writing.

Summary of the [COVID-19 Transmission in the Peppers Waymouth Hotel Adelaide, November 2020](#). A cleaner and two security guards working at the Peppers Hotel tested positive and were linked by whole genome sequencing to a returned traveller from the UK. Two other guests at the hotel and a close contact of the cleaner also tested positive and shared the same sequence as the traveller from the UK.

The investigation found:

- CCTV did not show any direct contact between guests and workers.
- On several occasions the primary case opened the door without wearing a mask, including while one of the security guards was stationed outside the door and the cleaner was in the corridor.
- A *small amount* of airflow from the room of the primary case was leaking under the door of a positive pressure room (an issue was identified with the room exhaust, which was rectified at the time of the review).
- There were no door seals on the room door.
- The estimated room air changes (1.5 to 2 room air changes per hour) were similar to those found in WA hotels.
- Smoke testing indicated that room pressures were variable and directly linked to the room fan coil unit's speed setting.
- Recommendations that are relevant to the WA ventilation investigation included:
 - Use of eye protection and surgical masks by any workers entering corridors (orange zone)

- Enhance enforcement of guests wearing masks when opening doors
- Reduce interaction between guests and staff with greater usage of CCTV, door alarms and roving security on all guest floors and other critical areas, rather than have staff stationed on quarantine floors.
- Ensure all guest rooms in medi-hotels have adequate door seals and exhaust ventilation is increased (*set to high*)
- Ban the use of blow heaters and fans
- Continued regular maintenance of hotel HVAC systems
- Transfer of all COVID-19 cases to dedicated (medi-hotel) facility
- Commence COVID-19 testing of all medi-hotel staff

Application of recommendations

A precautionary approach has been taken in WA with regard to prevention of transmission of COVID-19.

It is important to note that close contact is associated with the highest risk of transmission and incidents of transmission between spaces is still relatively low risk. Over 38,000 people have been through the hotel quarantine system in Western Australia with over 500 positive cases and only one single infection of a hotel worker.

Since the incident involving Case 903 at the Four Points by Sheraton Hotel a number of additional precautions have been introduced:

- All persons entering the accommodation floors in the quarantine zones of hotels are to wear surgical masks and eye protection and use hand hygiene when leaving each accommodation floor.
- All workers are tested daily by saliva PCR testing as well as weekly nasal swabs.
- Updated infection prevention and control training was provided to all workers.
- HEPA filter extraction unit's became available for use in rooms with confirmed positive guests.

As reported by Professor Weeramanthri following in the *Review of Western Australia's Hotel Quarantine Arrangements*, ventilation remains the single remaining modifiable risk factor in prevention of transmission. However, the extent to which hotel ventilation can be practically modified is an important consideration. The feasibility of further reducing low level risks needs to be considered in the context of the effectiveness of hotel quarantine to date and the relative suitability and availability of other options. Care needs to be taken in ensuring that any alternative arrangements or introduced control measures do not create a greater transmission risk and potential for community spread than the risk that is being prevented. As such recommendations made by PDF Engineering and Glossop Consultancy are required to be reviewed and assessed by DOH prior to implementation.

It is important that the DOH, the State Health Incident Control Centre (SHICC) and the Public Health Emergency Operations Centre (PHEOC) remain responsive and adaptive to any new information and developments in this area, including emerging variants.

The following recommendations have been, or are in the process of being implemented:

- CCTV to be used with security guard locations being reduced or moved further away from accommodation room doors into better ventilated spaces (e.g. lift lobbies with supply air)

- All hotel rooms being used for quarantining to be inspected and tested between guests to ensure that the ventilation is performing as expected, particularly with regard to room pressurisation and any maintenance faults identified and remedied.

Room pressurisation can be assessed simply and quickly by the hotel Facility Manager or hotel ventilation maintenance support staff. The results of the testing should be supplied to SHICC as part of the audit requirements.

New hotels being introduced to State controlled quarantine will be assessed against the following criteria, as proposed by consultants:

- Accommodation rooms are negative to neutral pressure to corridors to restrict air movement between occupied spaces.
- Smoke drop blades and well-sealed doors are available on accommodation room doors.
- Corridors and lobbies receive direct outside supply air.
- Windows in accommodation rooms cannot be opened as this may cause changes in room pressure as a function of wind direction and speed.
- There are no rooms with connecting doors or these are in sufficiently small number that they can be used for families or where only one half of the connecting rooms are used there are sufficient other rooms available such that the number of rooms available for use is not severely restricted.
- Room pressurisation is checked on all hotel rooms used for quarantine each time a new guest arrives as people can change the room ventilation.
- Preferentially air exhausted from accommodation rooms is not recirculated (100% replacement "fresh" air supply to rooms).