COVID-19 Transmission in Hotels and Managed Quarantine Facilities (MQFs)

Purpose of the paper

The purpose of the paper is to provide a consensus view of the level of current COVID-19 transmission risk associated with hotels and those used as managed quarantine facilities (MQFs) in the United Kingdom (UK). This work is to help inform relevant Government Departments (including Department for Health and Social Care (DHSC), Department for Transport (DfT), Home Office (HO) and Foreign, Health and Safety Executive, Commonwealth & Development Office (FCDO)) and the Devolved Administrations on future policy on the risk of COVID-19 transmission in these environments and similar communal accommodations such as ships, hostels and student accommodation.

The aim is to set out current evidence and understanding of the COVID-19 transmission risks associated with hotels and MQFs to understand whether there are risk factors specific to hotels (e.g. ventilation systems, staff interaction, communal spaces, travel to and from the hotel, etc.) that should be considered in light of evaluating the risk of COVID-19 transmission, and set out whether/where further guidance should be put in place to mitigate against the risk of COVID-19 transmission in these spaces.

In this context, hotels are defined as an establishment providing accommodation, meals, and other services for travellers and tourists. MQFs are government-approved hotels specifically used to quarantine individuals directly after arrival into the country.

Executive summary

- Transmission is a continuous risk in settings where people interact, and can occur in any of the environments encountered during an individual's day.
- There are three main routes through which the SARS-CoV-2 virus is thought to be transmitted: air, through inhalation of aerosols; person-to-person, through inhalation of aerosols and direct exposure to larger droplets; surfaces, through contamination by droplet deposition or hands which are transferred to mucous membranes by touch. The relative importance of each of these pathways remains unclear, and will depend on the behaviour and activities undertaken by individuals as well as their physical environment.
- In the context of hotels, there are a breadth of activities where there is evidence for risk. The risk of activity varies depending on how likely it is that individuals, whether guests or staff, interact closely with one another, if they are largely independent, if communal spaces are used, or if individuals pass in the corridor or dining room for example. The range of activities include (*inter alia*):
    - Transport to the hotel for guests and staff;
    - Common areas for guests and staff;
    - Kitchens, staff changing rooms, staff toilets and facilities;
    - Hotel bedrooms, staff accommodation;
    - Spa/swimming, gym, bar/restaurant, retail, toilets
    - Use as a venue for parties or weddings;
    - Business guest use, conference or function rooms.

- In the context of MQFs, there is a smaller proportion of risk associated with guest-related social activities or with building/room use as a venue for events, as these activities are limited due to isolation of guests. But where transmission in MQFs does happen, it can be between different community groups who have connection to different countries, with associated risk of transmission of variants of concern.
- In case-control studies conducted in late June/early July 2021, there was strong evidence that staying in overnight holiday accommodations generally, and hotels/bed and breakfast accommodations (B&Bs) specifically, was associated with increased likelihood of being a COVID-19 case. This is not the same as evidence of increased risk of transmission, but does highlight the reason for a particular focus on these settings as part of risk management.
- Suitable and sufficient risk assessments should be completed for these specific settings, within the context of an overall risk management strategy. It is critical that the risk assessment covers all activities undertaken by all staff (including night workers, security staff etc) and guests, and that mitigations are considered for each activity and each of the three routes of exposure outlined above. The selection of appropriate control measures should follow the hierarchy of risk control, and the objective should be to reduce the risk of transmission to as low as reasonably practicable, taking into account both the expected behaviours of staff and guests.
- The first level of control is where possible to minimise the chance of the virus entering an environment, in this context, the community. Mitigations in MQFs need to be particularly strict owing to the potential risk of importation of Variants of Concern. This is also a risk with guests from overseas arriving and staying in mainstream hotels. The evidence so far is that most outbreaks within MQFs have been small and generally amongst staff, however, the consequences of a new variant reaching the community from a MQF are potentially severe.
- The second level (which is less effective) is minimising transmission risk within an environment, in this context, within MQFs and hotels. Mitigations in mainstream hotels need to be proportionate to the risk.
- Other communal accommodation settings, which are beyond the scope of this paper, such as cruise ships, backpacker and similar hostels, student halls of residence, prisons and homeless shelters can pose specific risks especially within facilities which are shared and where vaccine uptake is low (e.g. in homeless shelters). Communal accommodation often involves an increased number of close contacts, sharing bedrooms, and sharing communal areas, all of which are associated with increased risk of transmission.
- Regular checking of compliance with risk mitigations can help ensure adherence to the agreed hierarchy of controls in all settings.

Minimising virus ingress

- Evidence suggests the majority of outbreaks associated with hotels and MQFs are among staff. International and wider evidence suggests that staff working in these facilities are at a higher-than-average risk of infection as compared to the general population. This is likely owing to multiple factors which may include: social and economic deprivation, being exposed to a large number of close contacts at work over long working hours, workplace culture, working in multiple jobs, and living in overcrowded housing. Many of these factors are deep rooted and will require **social policy considerations** if they are to be overcome [High Confidence].
- **Full vaccination of workers** is likely to prevent a significant number of quarantine system failures, where COVID-19 spreads within the quarantine facility [High Confidence].

- **Minimising the number of people who enter the country whilst carrying the virus**, through testing and/or vaccination prior to travel, is important for minimising the risk of transmission within a hotel or an MQF [High Confidence].

Minimising transmission: isolation of cases

- **Regular testing** of guests and staff with isolation of positive cases can help reduce the risks of onward transmission in both mainstream hotels and MQFs, but only where there is appropriate support for those having to isolate [High Confidence].

Minimising transmission: identifying transmission routes

- Staff and guest **communal areas** are likely to pose the highest risk for transmission within mainstream hotels as they are the spaces where interaction with others occurs most frequently and for longer durations. This risk may vary with the type of hotel, facilities and types of guest, with higher risks likely in settings where there are events which promote prolonged and close interaction (conferences, weddings etc) [medium confidence].
- Guest communal areas in MQFs are likely to pose a lower risk than in mainstream hotels given the likelihood that these will only be used by guests briefly and infrequently [Medium Confidence].
- Transmission via **interactions** between staff-staff and guest-staff in both mainstream hotels and MQFs need to be assessed and minimised in each situation [High Confidence].
- Although rare, transmission between hotel or MQF bedrooms **via shared air** has occurred under certain conditions. Some hotel and MQF bedrooms can have air leakage from one room to another; this may result from ventilation pressure differences especially in naturally ventilated spaces, inadequately sealed doors or opening of doorways especially if prolonged. Potential air leakage through internal doors between linked rooms could be a challenge. The consequences of this airborne transmission could be high in the case of a Variant of Concern [High Confidence].
- Transmission between hotel or MQF bedrooms **via drains** may be possible under certain conditions. There is evidence of contamination in floor drains and also evidence that floor drains dry out if not used or maintained on a daily basis. In the event that floor drains dry out, this may create a passage for contaminated air to move between rooms via the building sanitation system [High Confidence].
- Effective management of exposure and transmission in hotels and MQFs requires the cooperation and understanding of all stakeholders, including guests and staff. Effective management requires effective information exchange, effective training, and continuous feedback to all stakeholders.

In summary, there is a paucity of evidence for the risks that hotels, as a specific setting, pose for COVID-19 transmission. There are however, some features specific to hotels - physical, behavioural, and site-specific - that need important consideration when assessing risks and writing guidance. Further, it is clear that hotels can be run as MQFs with the proper application and enforcement of risk assessment.

Appendices: Summaries of current evidence

A. International evidence and wider context

We undertook a literature review using the Living Evidence on COVID-19, a database collecting COVID-19 related published articles from Pubmed and EMBASE and preprints from medRxiv and bioRxiv. Articles containing the words ((hotel*) OR (quarantine) AND ((transmission) OR (outbreak)) in the Title/Abstract published before 23 June 2021 examined for relevance. From 149 potentially relevant articles screened 48 were carried forward for full text review. In total, we included 12 papers that included outbreak investigation or risk of infection in hotels or MQFs.

Majority of international evidence is based on either MQFs or hotels used to relocate individuals during lockdowns. While these settings might differ from other hotel settings, these investigations can inform the risks associated with transmission in these environments.

Main considerations gathered from international evidence in regard to risk of infection in hotel facilities could be divided into 4 main themes:

1. Factors associated with risk in hotels/quarantine facilities

During the COVID-19 lockdown period, French authorities in Paris and its suburbs relocated people experiencing recurrent homelessness to emergency shelters, hotels, and large venues. Overall, 829 people living in 14 facilities were surveyed between 23 June and 2 July 2020, at two food distribution sites, two workers' residences, and ten emergency shelters (Roederer, et al., 2021).

Overcrowded housing conditions, whether long term or as temporary emergency measures, carry risks to the residents. In this analysis, increased number of close contacts, sharing bedrooms, and sharing communal areas were associated with increased risk of infection. Those who had been housed in shared sleeping space, and emergency shelters had particularly high risk of infection. Individuals' frequency of leaving their residence during lockdown was the most important determinant of protection, possibly due to time spent outdoors and away from indoor exposure to infected people.

2. Environmental sampling in quarantine room environment

From 39 COVID-19 cases, 271 swab samples from environmental surfaces related to observational patients were collected. Eighteen swab samples from seven patients were positive. The highest contamination rates occurred on cups, followed by hand sink, toilet seat and flush, telephone, bedside table and floor drain. The results showed that environmental surface contamination was associated with the clinical cycle threshold values for patients (P = 0.01) and the sampling interval time after the cases left their rooms (P = 0.03). Moist surfaces were more vulnerable to remaining SARS-CoV-2 RNA-positive [having detectable virus] (Liu, et al., 2021).

3. Identified quarantine system failures in Australia and New Zealand (up to 31 March 2021)

This analysis identified 32 quarantine system failures [spread within the quarantine facility] in Australia and New Zealand combined (Grout, et al., 2021). In Australia, 16 failures were identified, one causing over 800 deaths (Victoria's second wave). Ten of these 16 failures resulted in transmission to the community, with eight resulting in lockdowns. In New Zealand, there were ten failures, with one causing an outbreak into the community which resulted in three deaths, and also a lockdown.

Main findings:

- Majority of these outbreaks were associated with infections among staff (some staying on site) and mostly not resulting in further onward transmission outside this group.
- Overall risks for both countries combined were one failure per 15,972 travellers, and one failure per 173 SARS-CoV-2 positive cases in quarantine.
- Genomes of the first 649 viral isolates collected in New Zealand show that only 19% of virus introductions resulted in ongoing transmission of more than one additional case
- Approximately 55.4% of quarantine system failures were potentially preventable with the full vaccination of frontline border workers (combined effects of vaccination lowering the risk of getting infected and the lesser duration of infectivity and lower peak infectivity for those infected.)
- Ventilation or aerosol transmission between rooms is directly cited in 4/32 cases detailed, with another case suggested as resulting from a nebuliser use, and a 6th case linked to shared air in successive use of an elevator

Key infection control processes at quarantine facilities in Australia and New Zealand:

- Shared space restrictions - In some facilities required to book allocated times to access shared spaces
- Mask requirements for staff and customers (outside of rooms)
- Regular staff and guest testing
- Certain hotel workers, including security guards, cleaners, and catering staff, have been given a 40% wage increase and are no longer allowed to hold a second job.
- Ventilation assessments, with one hotel that had continual problems no longer used as an MQF

4. Experience from other countries

Singapore experience:

From about January to May 2021, more than 10,000 people stayed in hotel quarantine each day. Most of the major hotels in Singapore are involved in hotel quarantine. Hotel room capacity is reduced and special staff (usually in Personal Protective Equipment (PPE), including facemasks and face shields) man the entrances to the quarantine sections. Corridors are monitored by CCTV and the penalty for leaving a hotel room during quarantine is jail. Despite the widespread use of hotel quarantine, and the fact that testing in Singapore is high, transmission in hotel quarantine settings is only known to have happened twice. In one incident 3 members of staff were involved, in the 2nd incident 13 cases of infection amongst people in quarantine were shown by genomic testing to be all connected. In both cases the most likely explanation for the infections was human error breaking COVID-19 protocols, though in both cases the exact source was not found. A possible source of infection was when those in quarantine left their room and had to line up for testing in the hotel, but this was not certain. It was concluded that ventilation could also have been improved in the hotel, but not concluded that ventilation or air conditioning systems were the cause.

New Zealand experience:

The total number of people through MQFs in New Zealand since 26 March 2020 is almost 150,000. Only a few incidences were reported and the majority of incidences include <5 people, mostly staff. First incident (Auckland August 2020) included a total of 179 cases, with 3 deaths. The cause of this outbreak remains unknown. Second one included 2 incidents; 1st one included two genomically linked

cases among travellers who were identified through routine day 12 testing. The Source investigation did not identify any opportunities for person-to-person contact. Given the index case was accommodated in a room directly above the secondary case and given the ventilation in these rooms are connected via vertical risers in the fresh air ducts, exhaust ducts and drainage systems, the most plausible transmission mechanism was thought to be via aerosol transmission or contaminated air or condensation on exhaust ducts walls. Second incident included 1 person taking a bus while symptomatic, 2nd case returned to hotel offsite on the bus with 14 other returnees. However, no transmission occurred. The overall risk of transmission to those that were accommodated at the hotel was low.

Conclusions

International evidence suggests that staff working in these facilities are at higher risk of infection, which is likely due to multiple factors including deprivation, long working hours, being exposed to large number of contacts at work, working in multiple jobs, and overcrowded housing. This is in line with evidence in regards to occupational risk previously presented by Environmental Modelling Group (EMG) Transmission Group (see **EMG - Transmission Group: COVID-19 risk by occupation and workplace** paper). Occupations which involve a higher degree of physical proximity to others such as security guards, chefs, drivers, cleaners and domestics tend to have higher COVID-19 infection risk and mortality rates. This is due to combination of risk factors including high risk of exposure and disease burden due to living and working conditions. Therefore, to reduce the risk of infection for staff in these settings, addressing the social and structural factors that have led to the clustering of health and safety risks among hospitality workers is necessary to alleviate health and safety disparities. Workplace policy recommendations to protect workers are needed such as self-isolation support to ensure symptomatic/PCR+ staff members can afford to stay home. In addition, avoiding overcrowding in the facilities, especially in shared areas and management of shared spaces such as smoking, exercise and dining areas will be important to reduce the risk of infection for customers and staff. Aerosol transmission between guest rooms or from guest rooms to staff in corridors has been cited in a small number of cases

B. Outbreak in a Managed Quarantine Facility – Case Study for EMG-SAGE

Context and Background

Five cases of a P.3 (Theta-VUI-21MAR-02) variant of COVID-19 were identified (01.03.21 to 11.03.21) at a MQF.

The MQFs were set-up on 15 February 2021 and this outbreak was one of the first outbreaks managed by the local Health Protection Teams in an MQF setting. This MQF is situated across four floors. Each bedroom has a stand-alone air-conditioning unit with no vents leading to neighbouring rooms or corridors. The MQF is operated by a combination of hotel staff, security staff, transportation staff and contractors.

Eight multi-agency incident management team meetings were held in total and the outbreak was declared over on 13 April 2021.

Investigations Results

Types of investigation undertaken:

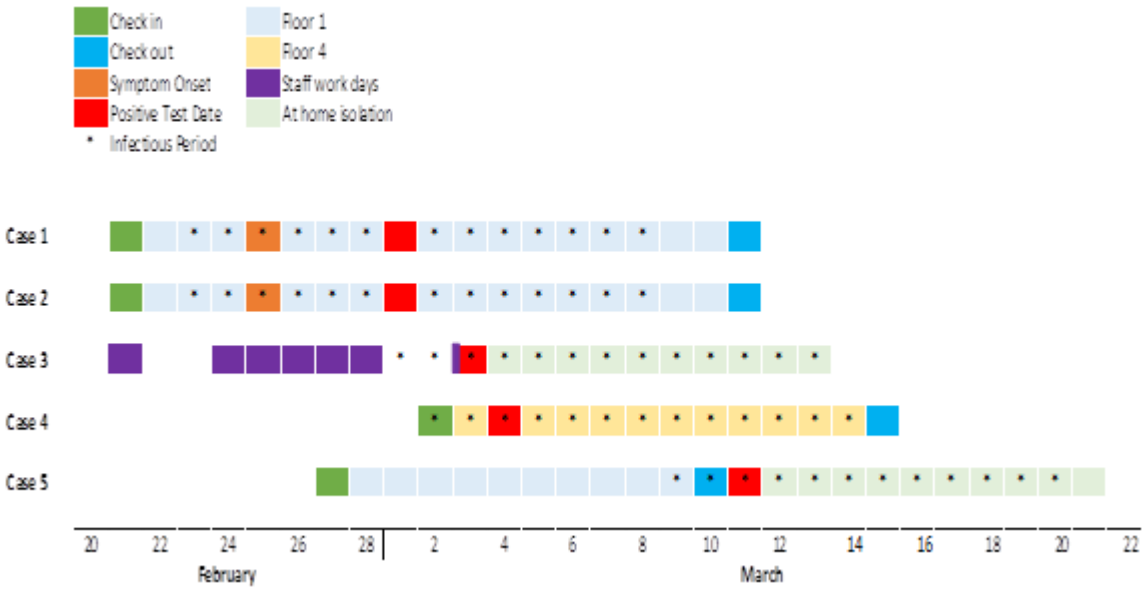
1. Individual Case Interviews (case movements and floor allocations)
2. Genomic Sequencing of All Positive Cases at the MQF
3. Mass Staff Testing
4. Environmental Studies (Ventilation and Air Flow studies and Wastewater Studies)

1&2: Case Interviews, Genomic Sequencing and Epidemiology

Between 19 February 2021 and 6 April 2021, 24 COVID-19 positive cases were identified from staying at this MQF, with five of these cases being of the P.3 (Theta) variant. Five other cases were of different lineage and the remaining 14 cases had no sequencing results.

Of the five P.3 (Theta) cases, four were travellers and one was staff. Cases arrived on different flights at different times and there was no direct or indirect contact between any of the P.3 cases (Figure 1)

Figure 1 P.3 (Theta) Cases Timelines



Case 1, 2, and 5 were on the same floor and all symptomatic late in their quarantine.
- Case 1 and 2 both on D8.
- Case 5 symptomatic/positive on D11 (Figure 2)

Case 3 was an asymptomatic staff member identified on routine testing.
Case 4 was positive on D2 staying on 4th floor.

There was no direct or indirect contact between any cases.

Action Taken:
Ventilation studies were undertaken to investigate the link between case 1,2 and 5

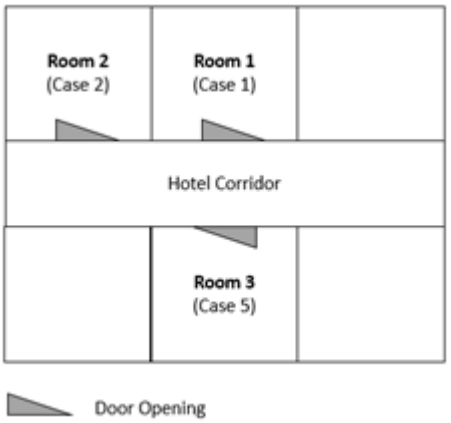


Figure 2 Room Allocations (Case 1,2,5)

3: Staff Testing and Positive Case Finding

Only six cases of the P.3 (Theta) variant have been observed in the UK as of 3 June 2021. Five of these cases are linked to this MQF and all five are genomically clustered.

To ensure no continuing transmission, all 350 staff associated with the hotel, security and transport were tested by PCR for COVID-19 and all tests were negative. (two weeks after last known P.3 case)

4: Ventilation Studies

Studies were undertaken out to assess the ventilation in each room and to assess the potential for movement of air from room to room. Under normal conditions, it was found that rooms had air change rate of around 1 air change per hour with air extracted through the bathroom. As information was provided that Case 1 regularly opened the windows of their room the impact of the opening of these windows on airflows was studied. The results are summarised in Table 1.

Table 1 Summary of results from ventilation case study

Tests / Areas	***Key Findings***
General	Air flow between room and corridor was transient. The direction of air flow was affected by staff movement, opening of corridor doors and wind effects from open windows and doors
Room 1 Windows open Room 2 and 3 Door shut	Smoke originating in room 1 (Case 1) moved rapidly into the corridor and was detected in room 3 (Case 5). No ingress of smoke was detected in room 2 (Case 2).
Room 1 Windows open Room 2 and 3 Door shut	Smoke originating in corridor, was detected in room 2 and 3. (Levels detected in room 2 order of magnitude less than room 3)
Room 1 and Room 3 Windows both open	Aerosol tracer moved from room 1 to corridor, and was found at a higher concentration in room 3
Room 2 and 3 Both doors opened at same time	Clear and significant ingress of smoke into the rooms from the corridor
Threshold Bars	Significant 2cm gap under room 1 and 3 due to faulty threshold bar causing increased air flow under both doors compared to room 2 which had a correctly operating threshold bar.

4: Wastewater Studies

Four auto-samplers were placed at the hotel and no positive wastewater samples were identified during this investigation.

Conclusions

There were no transmission pathways linking all five cases, despite all cases being genomically linked.

There may have been a missing epidemiological link with an unidentified P.3 (Theta) case(s) in the 14 positive cases with no sequencing results, however national data still suggests only six P.3 cases seen in the UK. All positive cases at the MQF should have been sequenced where possible.

Ventilation studies may help explain transmission between three cases on the ground floor. Public health actions taken were around closing windows for positive cases, and reviewing operational threshold bars, on the back of these findings. Further modelling and understanding of how to interpret these environmental findings are required before control measures are applicable across other MQFs.

C. Ventilation in hotels and MQFs

Key points:

- Airborne room to room transmission is rare, but may be exacerbated by inadequate ventilation systems and poorly managed airflows. Room to room transmission may have a high consequence in an MQF in the case of a new variant.
- Ventilation needs to be considered throughout a hotel whether it is used for mainstream purposes or as an MQF. This includes communal areas, exercise spaces and staff areas as well as guest rooms.
- The quality of the ventilation in MQF bedrooms should be considered from a comfort and wellbeing perspective. Many hotels operate with very low ventilation rates which may cause discomfort due to the long duration spent in the same room.
- Ventilation and shared facilities should be an important consideration if other settings (e.g. student halls of residence) are used for quarantine. Many of these settings have minimal designed-in ventilation with reliance solely on opening windows, and hence may pose a greater risk for transmission than hotels.

The ventilation strategy in a hotel varies significantly depending on the design, location, occupancy, facilities and age of a hotel building. Ventilation approaches will vary within the building too, with different approaches for communal areas such as restaurants and conference facilities compared to bedrooms. The Chartered Institution of Building Services Engineers (CIBSE) guidance indicates flow rates for most areas should be 10 l/s/person, although this is adjusted for design occupancy for bedrooms (business hotels 1.1-1.3 people per room (ppr), holiday resort at least 2 ppr. Budget hotel near airports maybe up to 2.4 ppr).

Thermal comfort is usually a primary factor in design for hotel bedrooms and this can take priority over air quality. It is common to have an air conditioning unit above the entrance lobby of a bedroom which may just recirculate the air, or can also supply fresh air. Fresh air is also sometimes supplied in the corridor and enters rooms under the doors. Ventilation air is normally extracted via the en-suite bathroom. Budget hotels often have opening windows to provide fresh air, however this varies by location – high rise or highly polluted locations are more likely to have mechanical ventilation.

There is very little data on ventilation rates and air quality in hotel bedrooms. Studies in other countries have found insufficient ventilation and poor indoor air quality (Asadi, et al., 2011) (Kuo, et al., 2008) (Chan, et al., 2009), while one UK estimate from an influenza challenge study suggested a ventilation rate of 0.57 Air Changes per Hour with windows closed and intermittent bathroom extract only. While this low ventilation rate within a hotel bedroom is unlikely to pose a substantially raised risk for COVID-19 transmission (as guests are already closely interacting), poor indoor air quality is a concern for the wider health and wellbeing, particularly in MQFs where people are spending much more time within the bedrooms than under normal circumstances. There are unlikely to be any long-term health impacts of quarantine in a poorly ventilated room, but it is likely to impact short-term on comfort and mental health of guests.

There is evidence of potential for room to room transmission within MQFs in Australia and New Zealand and the case highlighted above in the UK. However there is limited detailed evaluation of most of these cases, with the majority of reports through incident reports and media reporting rather than published outbreak investigations (Grout, et al., 2021). While one outbreak investigation suggested that this transmission may happen during the brief periods when doors are opened (Eichler, et al., 2021) , initial modelling based on the UK P.3 case suggests that continuous exposure

to aerosol via flow under doors due to pressure differences between rooms is likely to result in a higher exposure to virus in the air compared to a short duration exposure due to opening doors. This pathway has also been suggested a hospital scenario in Australia where rooms were positively pressurised resulting in flow from the rooms to an extract in the corridor/circulation zone (Buising, et al., 2021). Transmission via shared air ducts is also possible in some buildings and has been highlighted in apartment blocks (Hwang, et al., 2021).

As highlighted above evidence from MQFs in Singapore suggests that transmission between guests in hotels is rare, however there are a number of cases cited for Australia and New Zealand. The airborne pathway indicated here is likely to pose a low risk in most settings as it relies on a setting creating a particular combination of airflow conditions combined with an infectious guest who is producing sufficient aerosol to cause infection at long range. However, the consequences of this risk could be very high in the case of new variants; there are only 6 recorded cases of P3 within the UK and at least one of these may have resulted from room-to-room airborne transmission. As a result ensuring good ventilation maintenance and protocols is important for MQFs where there is a need to prevent new variants of the virus from transmitting to the wider population.

D. Plumbing in hotels and MQFs

Of most concern in relation to sanitary plumbing systems within hotels and MQF's is the possibility of floor traps drying out in bathrooms thus creating a pathway for contaminated air to travel between rooms. Transmission can be either vertical through the building (Kang, et al., 2020) or horizontal from rooms where bathrooms are arranged 'back to back'. Pipework arrangements often interconnect a number of rooms to a single vertical stack (between 5 and 10 is usual), which are usually on one side of a corridor only.

The phenomenon of floor traps drying out is not unusual but it is not well documented. Most existing evidence is either observational or anecdotal and is often observed as a foul smell in the hotel bathroom. Designers and suppliers of plumbing products are well aware of the issue. Gormley et al. (2017) showed how the mechanism worked using bacteria which aerosolised naturally within the plumbing system and showed that pathogens generated in one room could travel to another room, connected only by sanitary plumbing system (SPS) pipework and aided by ventilation fans. The contamination of these areas, particularly floor drains, was also observed by (Liu, et al., 2021) in their study of quarantine rooms in Guangzhou, China between March and June 2020.

Floor drains will dry out over time if not filled with water (usually from floor cleaning) or by overuse of the system (at peak morning usage times for example). Under normal operating conditions bathrooms would be cleaned every day and so these floor drains would be topped up. The same is true of trap seals on sinks and baths/showers however these will refill when appliances are used. There is no provision for dealing with this issue in the Standard Operating Procedures for hotels or in the additional guidance for cleaning in non-healthcare settings outside the home (COVID-19: cleaning of non-healthcare settings outside the home - GOV.UK (www.gov.uk))

A simple mitigation against this potential issue is to issue advice on filling floor drains daily to prevent potential cross-contamination between rooms. This could easily be added to the standard operating procedure (SOP) for the facility, and the advice for cleaning in non-healthcare settings outside the home.

Key Findings: Transmission between hotel or MQF rooms is possible under certain conditions. There is evidence of contamination in floor drains and also evidence that floor drains may dry out if not maintained on a daily basis. Evidence of cross-transmission relates more to tall buildings and large hotel complexes but is not inconceivable in smaller low-rise buildings. There is no direct evidence from hotels and MQFs but the risk may be elevated by certain cleaning regimes. Mitigation against risk is straight-forward (fill floor drains every day) and could be included in the SOP and/or advice to occupants on arrival. Wider inclusion in guidance also recommended.

E. Hotels as temporary accommodation for the homeless

The EveryOne In response to COVID-19 in the homeless involved closing communal shared sleeping space night-shelters early in the pandemic and opening single room, own bathroom hotels providing accommodation over several months for people experiencing homelessness. Infection control was intensified for those remaining in hostels. These hostels had single rooms but shared bathrooms. The communal dining and leisure spaces were either closed or used with intensive social distancing measures and masks both in the hotels and hostels, with meals delivered to rooms in some hostels and hotels. In London, during the first and second waves of the pandemic a system of active surveillance was established with managers of facilities being contacted daily to ask about anyone with symptoms of COVID-19. Outreach testing was arranged and positive cases were transferred to a specialist hotel for isolation and clinical observation. In addition to testing of suspected cases, contacts were tested and if more than one case was seen in a hotel/hostel testing was offered to all those in the hotel/hostel (outbreak testing). Finally as a means to monitor the level of COVID-19 in homeless venues, sentinel testing (whereby residents were invited to be tested regardless of whether there were any symptomatic residents) was undertaken periodically. In London 14 Greater London Authority funded hotels were opened (approx. 1400 residents) and a similar number were opened by Local authorities.

Key findings were:

No large outbreaks were observed in hotels (maximum 3 cases). In the first wave the only outbreaks seen in hotels in London were at the very start of the pandemic and were thought to represent infections acquired before moving into hotels. In the second wave, 30 cases were identified across all the hotels (housing over 3000 people). Testing during outbreaks found a 6% prevalence of infection in hotels and a 7% prevalence in hostels. Sentinel testing showed a prevalence of 1% in hotels (similar to general population prevalence at the time) and 5% in hostels (substantially higher than the general population). This is in contrast to international experience where homeless people often continued to be housed in dormitory style shared sleeping space night-shelters leading to large outbreaks with 30-50% of staff and residents infected.

Implications – Experience from the Everyone In approach to housing homeless people found the risk of COVID-19 transmission in communal accommodation settings is highly dependent on the amount of shared airspace. Infection rates in single room own bathroom facilities are much lower than in those with shared bathrooms, which in turn are very much lower than in shared sleeping space night-shelters.

F. Staff and guest behaviours in hotels and MQFs

Hotels have traditionally been spaces involving numerous social contacts of long duration and close proximity, variables known to increase the risk of contracting and spreading COVID-19. COVID-19 restrictions and adaptations have reduced the number of staff and guests in many hotels, and reduced the number of contacts occurring in these settings. Alterations to delivery standards have been made, including becoming more contactless and implementing increased hygiene control measures (Goh & Baum, 2021). In spite of these efforts, hotels are not and cannot be contact-free environments. Greater understanding of the nature of social interaction and behaviour in hotels will generate insights into the challenges, barriers, enablers, and opportunities for managing the risk of infection in hotels during COVID-19.

Social Interaction and Behaviour in Hotels

Hotels are an under-studied environment. This may be in part due to the diversity of the sector. There is a great difference between the scale and scope of a large hotel providing conference facilities within a larger complex, a hotel catering for regular business guests in a city centre and a smaller, rural hotel that provides facilities for the local community. Nevertheless, there are some important aspects of hotels that present challenges for managing the flow and nature of social interactions. Studies of activities in other workplaces and semi-public settings suggest some common areas of concern in light of the many features that hotels have in common with other workplaces and semi-public settings, such as those in the hospitality sector and in retail.

What is of critical importance in the hotel sector is that hotels are not only places for temporary accommodation. They can provide a range of other services and functions (e.g. meetings, dining, spa, gym, performances, retail) as well as accommodating permanent residents. These activities take place in a range of internal spaces, these spaces may have multiple use and can be open to non-residents. Hotels, therefore are distinctive in that they combine a variety of areas for very different kinds of social interaction (Chang, 2017). Also, of importance to the sector is that interactions with guests are not merely transactional: in common with other businesses quality of service is seen as critical for developing long-term relationships with customers (Yilmaz, et al., 2018) and for attracting new customers via social media reviews (Leung, et al., 2013). Good service quality is accomplished through social interaction and underpins the accomplishment of key activities such as understanding and attending to guest needs in the check-in and check-out process (Yilmaz, et al., 2018) as well as other 'informal' interactions between staff and other staff such as waiting staff, cleaners and managers (Wilkins, et al., 2009).

Over-the-counter interactions

The most explicit form of social interaction occurs in reception, principally the service encounters related to check-in and check-out. These encounters between staff and guests require the integration of structured processes (e.g. form filling and payment), with informal interaction, addressing ad hoc concerns of guests. Previous research in the context of reducing face-to-face interaction indicated that customer need for human interaction plays a significant role in the experience of the service process (Ko, 2017). In common with other domains, one way of achieving better quality of service is to emphasise the informal nature of the interaction and interleave other services into the formal process (e.g. providing and responding to requests for information about other services (Moore, et al., 2010). These practices are likely to extend the length of over-the-counter interactions. They also may require the involvement of more than one member of staff to handle one encounter. Hotel service encounters, particularly at non-business focussed hotels are also likely to be with more than one guest. Service interactions also involve aspects of queue management. To provide a high quality of service, receptionists will interleave attending to those

who are first in the queue with others in the queue and the local environment (Brown, 2004). Responses to COVID-19 that move these interactions towards contactless systems or that create distance through implementing physical barriers and other additional hygiene measures must balance their effectiveness in infection control with the recognition that:

- Minimising human interaction will have an impact on perceived service quality for guests and staff in some, more up-scale hotels where time is not the critical concern.
- Over-the-counter service encounters are not 1-1 transactions and interventions (technical and organisational) tend to focus only on this aspect.
- One would expect that, as in similar organisations that depend on social interaction, staff are explicitly instructed to follow 'best practice' in terms of ways of greeting and responding to queries. These may, in practice, conflict with guidance to restrict face-to-face interaction and close contact.

Passing encounters

Apart from explicit occasions of interactions, there are numerous passing encounters in public and semi-public settings, including lobbies, restaurants and leisure facilities. Passing encounters between staff and guests may be transient, but the requirement to provide a high quality of service can place demands on these interactions being more than minimal. Passing and transitory encounters also take place in private spaces of hotels, such as bedrooms, between guests and staff and guests with other guests. Furthermore, critical co-ordination activities take place when people pass each other in semi-public locations such as corridors. González-Martínez et al. (2015) analysed passing encounters between hospital staff whilst moving through corridors. These encounters were typically brief ('stops' lasting 7 – 14 seconds) with corridor conversations most often subordinated to mobility with mobility being occasionally suspended to accommodate talk between two or more individuals. They found that the most common professional activities were: 'informing someone of something; making enquiries about cases, colleagues or other matters; clinical conferring on a case; giving orders or instructions; making requests; checking how something is going; and offering help' (González-Martínez et al., 2015, p 525). In hotel work one would expect similar forms of social interaction between staff, particularly surrounding the co-ordination of cleaning activities and the delivery of restaurant and banquet service to guests. In light of this:

- Placing constraints on staff interaction with guests and between staff is likely to have negative implications for service quality and for the co-ordination of work.
- Engaging with hoteliers and hotel organisation could lead to a set of revised practices for quality service interactions that minimise contact and face-to-face interaction.

Back-stage interactions

Hotels also have numerous spaces where interaction is primarily between hotel staff (e.g., offices and kitchens). Although locations for sustained collaboration, these spaces are ones where the co-ordination depends on transient interaction. Kitchen work relies on highly time-dependent interactions between staff in close presence to each other, co-ordinated by out loud announcements, the close monitoring of another's activities and the joint manipulation of tools and artefacts (Fine, 1996). There is also a highly gendered work culture in kitchens that is frequently characterised by high adrenaline, 'laddish' cultures that are not conducive to managed behaviours (Robinson, 2008) (Cooper, et al., 2017) (Meiser & Pantumsinchai, 2021). Office interaction relies on informal social interaction whether this with participants principally located in the space or transient interactions with people passing by (e.g. back-to-back interaction, when people pass through offices, from the doorway) (Goodwin, et al., 1996) (Salvadori, 2016) (Tuncer & Licoppe, 2018). These activities are often interleaved with other tasks. Goh and Baum (2021) identified several of these

factors in their study of job perceptions of Australian Generation Z hotel employees working in COVID-19 quarantine hotels. Their respondents reported emotional and physical exhaustion as a result of working longer hours, working flexibly in multiple roles across multiple departments, navigating the dangerous work environment, and redeployment when other departments are short-staffed. Key points:

- Placing constraints on staff interaction within constrained spaces is likely to undermine task co-ordination and increase the time to undertake tasks.
- There are potential health and safety implications for the welfare and safety of staff standing up in multiple roles in riskier environments whilst being emotionally and physically exhausted.

Interactions in public spaces

Hotels also include many spaces that are open to interaction between guests and between guests and members of the public. These areas have been referred to as 'liminal' (Pritchard & Morgan, 2006). They are spaces where guests meet other guests, locations for pre-arranged meetings with external parties and places where guests wait for external visitors or services. They are also places where informal meetings take place, some of extended durations and requiring the use of tools and technologies. Hotels also make available services (e.g. spas, gyms and dining) for the local community. Most hotels do not impose constraints on access to public spaces to visitors who have not registered or reserved a service, and this freedom of access makes control of interaction difficult. Key points:

- Hotels include boundary spaces that make possible interactions between staff, guests and visitors from the local community.
- Limiting the forms of interaction in semi-public spaces within will constrain the activities that take place in hotels, and may mean these move elsewhere and into areas that are less easy to monitor.
- In rural areas, it would be necessary to engage with local communities to gauge the impact and what possible mitigation measures could be for the loss or amenities or new ways of providing services (e.g. taxi services).

Potential for support from new technologies beyond over-the-counter interactions

The issues regarding quality of service and the particular nature of service encounters in domains such as hotels place distinct requirements on technological solutions. A key step in hotels since the onset of the pandemic has been the introduction of technologies to reduce contact between customers, facilities and staff. There has been an acceleration in the introduction of self-service technology in hotels as a direct consequence of the pandemic as a means by which to reduce potential transmission (Shin & Kang, 2021) and increase the confidence of both guests and employees. Whereas, single or limited function systems, like those for payment and distributing keycards can be useful for particular kinds of users (e.g. frequent travellers), the use of multi-function systems can be frustrating and may undermine the quality of service provided (Engeström & Escalante, 1996). For example, with regard to automated self-service technologies, it is hard to support the range of services and information provided by staff. This may not be because those services cannot be provided through technology, or that information may not be available, but it is hard to design a system that makes it clear what scope of the service are available. Similar challenges face robot assistants (Collins, 2020). Even when technology performs a single function research indicates that the quality of human interaction is a key factor customers report for remaining loyal to a particular hotel (Ko, 2017).

Conceptualising the risk of staff and guest behaviours in hotels and MQFs during COVID-19

Hotels are, in social, behavioural and business/organisational terms, complex places, in effect amalgamating a multiplicity of transactional activities under the one roof. In terms of place and space and their usage, hotels are also, generally, open access, semi-public spaces with few restrictions to visiting public areas as well as frequent access to non-guests to those parts of the operation that are notionally deemed private or restricted (cf. (Pritchard & Morgan, 2006). Hotels in the UK are also widely diverse against a range of considerations – age, size, service standards/ grades, market focus, ownership/ management and location – hotels, to all intents and purposes, represent 'an industry of every parish'. Definitions of hotels (such as they exist) are inadequate in a contemporary context (see Hotel Proprietors Act, 1956) to describe the complexity and the behavioural risks associated with each of the areas. Table 2 highlights the facilities (and the suggested associated behavioural risk levels) which a hotel may include.

Hotels share operating, cultural and staffing characteristics with other sub-sectors of frontline services such as hospitality (restaurants, bars, nightclubs), retail, leisure (wellness, fitness) and, indeed, social care (catering, cleaning). Indeed, there are frequently blurred lines between services and hotels do offer facilities and services in common with all these other areas. Therefore, much of the analysis addressed in the document "Insights on transmission of COVID-19 with a focus on the hospitality, retail and leisure sector" applies to those areas of hotels providing food and beverage and retail services and could be substantially adopted. Specifically in hotels, operating and service standards were adapted rapidly in response to the evolving demands of public authorities and guests as consequences of the pandemic unfolded (Chan, et al., 2021) and this remains an on-going process of adaptation.

The particular demands and requirements of the hotel industry are generally recognised. For example, in the context of the current pandemic, the boundaries of guest and operational/ employee behaviour in hotels is framed in line with current pandemic restrictions, which are covered and updated here. Employers are encouraged to factor this guidance into risk assessments that they are already required to make under pre-pandemic health and safety rules. The 19 July lifting of restrictions is likely to result in greater diversity of practice and service as hotels make about the management of risk in their facilities (Working Safely during Covid-19, 2021).

Notwithstanding clear guidance to customers with respect to behaviour in hotels and the wider hospitality industry, customer resistance to COVID-19 rules/ protocols appears to have increased, and there is also emerging empirical evidence of management failure to support staff in the face of abuse (Hadjisolomou, et al., 2021). However, the issue of ensuring respect for staff working in hotels is recognised by some key industry operators.

Table 2 Facilities common to hotels

Transactional area	**Guest – employee risk**	**Employee – employee risk**	**Guest – Guest risk**	**Comments**	**Possible Mitigation**
Front desk, lobby	High	Medium	High	The main thoroughfare of most hotels – entrance and exit route	Use of self-service facilities, contactless payments, physical barriers, clearly marked human traffic systems, reduced public seating, entry security to reduce casual visitation, good ventilation
Restaurants	High	High	High	High volume contact area, depending on service model adopted (table service, buffet etc.)	As widely implemented: Table layout, clear traffic systems for guests and staff, service style to reduce crowding (no buffets) , good ventilation
Kitchens	Low	High	Low	Nature of work, physical facilities and workplace culture not	Implement Government advice (https://assets.publishing.service.gov.uk/media/5eb96e8e86650c278b077616/working-safely-during-covid-19-restaurants-pubs-takeaway-services-091120.pdf) Address physical and wider environmental considerations in hotel kitchens Encourage cultural change in hotel kitchens

				conducive to separation	
Bars	High	Medium	Very high	'Alcohol factor' most obvious, behaviour management can be challenging	Key behavioural area and most challenging to address Without restrictions in place on spacing, service and hours, unlikely to see change
Night venues	High	Medium	Very high	'Alcohol factor', lighting, noise	As above. Ventilation may be important to mitigate superspreading as crowded locations with dancing may be higher risk for aerosol transmission
Conference/ meeting facilities	Medium	Medium	High	Main purpose is guest interaction, contact with employees is limited to service points	Physical layout Facilitate hybrid/ remote conferencing (international delegates) to reduce new variant transmission Good ventilation
Spa/ pool (indoors)	Very high	Medium	Medium	Depending on services offered, involves high levels of	Key consideration – service is dependent on intimate interaction (massage) – focus on testing, training of staff, educating both registered guests and external users

				intimate service	
Sports/ fitness (indoors)	Medium	Low	Medium		As above A number of outbreaks in gyms where aerobic exercise takes place have been associated with poor ventilation
Transit routes to bedrooms (corridors)	Medium	Medium	Medium		Clear traffic systems, implications for design of new/ refurbished facilities Minimise time spent in corridors
Bedrooms	Low	Low	Medium	Depending on guest choice and use of room (hosting of meetings/ liaisons/ sex work)	Enable partial guest self-servicing of rooms, restrict access to bedroom floors for non-residents (already widely implemented but largely ineffective) Ensure good maintenance of plumbing and ventilation systems to mitigate potential for room to room transmission
Retail	Medium	Low	Medium	Generally, small, specialist facilities	
Back of house, offices, systems	Low	Medium/ high	Low	Variety of contexts in this category	

In spite of the challenging working conditions and potential impacts of these conditions on hotel staff, an interesting trend was noted in the evidence being generated during COVID-19. Specifically, younger employees reported that they are finding hospitality work more motivating and meaningful than the experience of younger staff working in these roles prior to COVID-19. Younger workers are perceiving their roles as meaningful and for the greater good ((Goh & Baum, 2021), p. 14).

Requiring isolation in MQFs for arriving international travellers raises issues that impinge on notions of what hospitality is as well as questions about the ethics of such requirements and how these impact on behaviour (https://theconversation.com/is-it-ethical-to-quarantine-people-in-hotel-rooms-155080). Indeed, the notion of controlling guest behaviour and freedom of movement in a hotel (through the use of military security and guest tracking as has been the case in some countries (New Zealand and Singapore) runs counter to generally held notions of hospitality that lie at the heart of traditional hotel service. From a guest perspective, restricting movement in this way is likely to elicit some confusion as a consequence although such practice is not entirely new and was in place during the SARS outbreak in Hong Kong in 2003.

The pricing of MQF hotels appears to raise issues in the press and among users with guests having little choice in relation to the quality of the facilities they use (https://www.euronews.com/travel/2021/02/24/quarantine-hotels-which-countries-are-using-them-to-stop-arrivals-spreading-covid) This approach is probably unsustainable going forward as guests are generally aware of the value attached to different grades of hotels and the services provided. It is also unlikely that many commercial hotels will wish to retain their quarantine function once 'normal' hotel trading returns

Staff who work in MQFs do so within a conventional hotel ecosystem but the rules that apply to them and to guests are clearly different. In some countries that also operate MQFs, the role of staff (whether hospitality, security or medical) is clearly articulated (cf. https://www.miq.govt.nz/assets/miq-staff-guide.pdf) Sharing real-time information on MQF utilisation and trends relating to use is valuable from a planning and wider management perspective (cf. https://www.mbie.govt.nz/business-and-employment/economic-development/covid-19-data-resources/managed-isolation-and-quarantine-data/)

Use of hotels as a temporary solution to the housing needs of asylum seekers and the homeless (Nowicki, et al., 2019), although not new to the COVID-19 era, has expanded significantly (https://homeofficemedia.blog.gov.uk/2020/08/08/the-use-of-temporary-hotels-to-house-asylum-seekers-during-covid-19/). How this relates to regular hotel usage (also cf. https://www.bbc.co.uk/news/uk-scotland-glasgow-west-57448267) adds a further dimension of complexity to this area

Going forward, hotel architecture and interior design and related planning regulations pertaining to safety may need to incorporate mitigation considerations on the use of shared space, ventilation and security. Much attention by architects has been to make spaces more flexible and open to multiple uses. A case in point are hotel foyers, lobbies and meeting spaces. Indeed, lobbies and foyers are recognised as places where transient work activities occur. If longer term consideration of the implications of pandemics is to be considered then engaging with those in the architectural profession with extensive knowledge of hotel design would seem critical. Repurposing hotels and similar facilities through design will be particularly important with respect to specific user/ guest groups, including the elderly/ vulnerable and those required to quarantine. However, much of the UK's 'traditional' hotel stock comprises old buildings, perhaps a combination of buildings of different vintage and many of historic and conservation interest. Modifying the use of space to meet safety

requirements and guest expectations may be difficult for such properties. Changes to the use of space may also be important to the challenge of attracting back international visitors to the UK. There is also significant discussion of this theme within the design and architecture community (cf. https://architecturetoday.co.uk/what-is-the-future-for-hotel-design-after-covid/ and https://www.hvs.com/article/9102-hvs-monday-musings-hotels-of-the-future-hotel-design-trends-in-the-post-covid-era)-

Managing the risk of transmission via staff and guest behaviours in hotels and MQFs during COVID-19

1. This exploration of the evidence-base related to staff and guest behaviours in hotels and MQFs recognised hotels as spaces containing variables known to increase the risk of contracting and spreading COVID-19. As a result, multiple mitigations have been put in place to help hotels manage the spread of infection during the COVID-19 pandemic.

Potential management challenges included addressing the contrast between pre-pandemic hotel best practice in respect to customer service and the reduction in contact required by COVID-19 restrictions. COVID-19 mitigations have implications for service quality, the ability of staff to coordinate activities, and finding the right balance between technological and face-to-face approaches to service. Additionally, this work highlights potential health and welfare implications for staff working in dynamic, challenging environments made more so as a result of COVID-19.

Our conceptualising of the risk of staff and guest behaviours in these hotels and MQFs during COVID-19 provides additional detail on the transactional areas, related risk, and possible mitigations that hotels must consider and manage during COVID-19. Once again, the shared characteristics and blurred lines between hotels and other sub-sectors of frontline services are evident, though hotel-specific evidence has been evolving throughout the course of COVID-19. Significant trends in the management of social interactions in hotels during the pandemic include disruption to the traditional, highly valued boundaries of guest and operational/employee behaviour; deterioration in customer misbehaviour/increased resistance to guidance; and the rapid implementation of self-service technology as a direct consequence of COVID-19 mitigations. Precarious working conditions, and a workforce characterised by multiple factors of disadvantage have amplified existing inequalities and risk factors within the hotel industry in the face of COVID-19. However, unique trends in the satisfaction level of younger employees working in hotels during COVID-19 suggests that feelings of contributing to the greater good may mediate some of the more challenging social factors. Unique challenges have arisen in the shape of the role of hotel staff in controlling guest behaviour (e.g. isolation), disparity in the quality of MQFs, and the use of hotels as temporary housing for asylum seekers and the homeless during a pandemic. Finally, the challenges of repurposing and modifying the space within hotels to meet safety standards requires upstream engagement with architects and other stakeholder groups to ensure that these spaces have the greatest chance of mitigating risk and meeting guest expectations.

Finally, SPI-B [The Scientific Pandemic Insights Group on Behaviours provided evidence on the risks and steps that can be taken to reduce the risk of transmission in high-contact occupations (see Managing Infection Risk in High Contact Occupations) in June 2020. This report on the level of current risk associated with hotels and MQFs in the UK provides an excellent opportunity to revisit and review previous SPI-B advice in light of the challenges and opportunities faced by the hotel industry during COVID-19. The advice contained in the SPI-B Managing Infection Risk in High Contact Occupations holds true in the context of hotels, though the insights generated in this report highlight the challenges of implementing some of the advice in the hotel sector. For example, one of the key principles encourages people with different social networks to avoid meeting or sharing the same

spaces if they work in high-contact occupations. This is especially challenging in light of the highly-valued face-to-face interactions between staff and guest, as well as the need for hotel staff to move between different spaces and roles to plan and coordinate, and to make up for staff shortages. Additionally, a balance must be struck between 'redesigning shared activities and spaces to enable changes' and the risk of designing out of the personal interactions that form the core of a good customer experience in the hotel industry. The SPI-B principles and approaches to co-design are very useful and relevant in this context.

The findings around the precarious nature of employment, low skills profile, multiple indicators of disadvantage, and youth of a significant part of the hotel workforce resonate with the SPI-B/EMG: MHCLG Housing Impacts Paper (September, 2020) which identified higher transmission risk for people working in occupations with high levels of social connectivity, particularly when they also live in overcrowded housing with shared communal kitchens and bathrooms (e.g. young people, people in lower socio-economic groups).

The SPI-B/EMG: MHCLG Housing Impacts Paper noted that 'student housing, rented housing among migrant precarious workers and employee provided accommodation have different forms of social relations, domestic labour and responsibility' and highlighted the importance of understanding the unique dynamics of risks, mitigations, and communications each group. The hotel workforce would benefit from co-designed, targeted messaging to support them in managing the risks of COVID-19 in the workplace and at home. Additionally, socially deprived households at high risk of infection should be supported in implementing COVID-19 mitigations. The SPI-B: Increasing adherence to COVID-19 preventative behaviours among young people report argued that ability to adhere will be affected by employment, education, and housing status. Young people are more likely than adults to work in occupations with high numbers of social contacts, and with less recourse to sick pay, which may undermine their motivation to seek testing and ability to isolate in response to symptoms.

G. EXACT case-control study

Most recent case-control studies – late June/early July 2021

In the most recent case-control studies conducted in late June/early July 2021, there was strong evidence that staying in overnight holiday accommodations generally, and hotels/bed and breakfast accommodations (B&Bs) specifically, was associated with increased odds of being a COVID-19 case (aORs for hotels/B&Bs 3.00 & 3.20, for studies 6a and 6b, respectively). The population attributable fractions (PAF) for staying in hotels/B&Bs were 4.57% and 4.37% for studies 6a (test-negative controls) and 6b (market research panel controls), respectively. See Table 3 and Table 4 for full results. During this period the Government had eased restrictions in England as outlined in step 3 of the Government roadmap, and accommodation sites were open. Some hotels functioned as MQFs.

Note that adjusted odds ratios (ORs) indicate associations between exposure settings and being a COVID-19 case, but are not necessarily indicative of transmission having occurred in these settings. Although results of multivariable analyses presented here are adjusted for demographics and work/education, as well as leisure exposures (and vaccination status for studies 6a and 6b), all of these data are self-reported. Residual confounding is likely to still be present and results should be interpreted with this in mind. Recruitment of controls via commercial market research panel companies and test-negative cohorts are subject to selection bias, which can cause over- or underestimation of effect measures. It is important to note that population attributable fractions are crude measures and do not indicate the overall proportion of cases that would be prevented by closing these venues as they do not account for the effect of other exposures elsewhere in the community.

Previous case-control studies – September 2020 to February 2021

Case-control studies 1 and 2 were conducted in early and late September 2020 during the pre-tiers period when accommodation sites were open. Study 1 shows strong evidence that staying overnight in hotels/B&Bs was associated with being a COVID-19 case (aOR 3.38), but no statistical evidence for that association was obtained in study 2 (aOR 1.49, p = 0.20).

Case-control study 3 was conducted during late October 2020, during the 1st tiered system of restrictions in England and showed no statistical evidence of an association between staying in hotels/B&Bs and being a COVID-19 case (aOR 1.26). The same was true for study 4b, which took place in late November 2020, during the second national lockdown (aOR 0.16).

Case-control study 5 was conducted in late February 2021, during the third national lockdown, and showed some evidence of an association between staying overnight in a hotel/B&B and being a COVID-19 case (aOR 4.47). Please note approximately 30% of the of the population in England had received at least one dose of a COVID-19 vaccination at that time, but results for this study have not been adjusted for vaccination status.

See Figure 3 for an overview of case-control study results over time.

A further caveat is that while staying in hotels for leisure purposes was restricted during national lockdowns, some hotels continued to function as accommodations for homeless individuals and as MQFs. Individuals having stayed in a hotel under those conditions could have possibly still reported their stay as a holiday stay on NHS Test & Trace (NHSTT). Some hotels functioned as accommodations for health care workers and adjusted ORs reported are adjusted for working in the health/social care sector using self-reported occupation data.

Overnight stays, as well as all other exposures, are self-reported, giving rise to possible misclassification. In previous case-control studies specifically (up to and including study 5), participants periodically reported an overnight stay away from home, but then gave the address of their main residence. Therefore, beginning in study 6, answer options to those questions were further refined and supplemented with examples.

Methods

For each study in England[1] approximately 2,000 cases are randomly sampled from the NHSTT database. Approximately 2,000 controls are recruited from volunteers registered with commercial market research panel companies (studies 1 – 5, 6b) or recruited from individuals tested negative for COVID-19 (study 6a). Cases complete enhanced contact tracing via NHSTT, collecting information about activities and settings visited prior to symptom onset or testing positive for COVID-19. Controls complete a survey structured according to the NHSTT questionnaire. Resulting data are deduplicated and exclusions performed. Cases are excluded from the study if they have an incomplete NHSTT profile, an undefined onset or sample date, or are a household contact of a previous case. Controls are excluded if they have had a positive COVID-19 test in the past 7 days and (in studies 1 – 5, 6b) if they have COVID-19 symptoms or are a household contact of a COVID-19 case. Excessive responders are excluded in cases and controls according to pre-defined thresholds, i.e., individuals who report having visited an unrealistically high number of work/education or leisure settings within a week, as these are likely to have rushed through the surveys selecting random exposures to complete the survey as quickly as possible.

Table 3 Single variable analyses of case-control data on overnight stays, overnights holiday stays, and overnight stays in hotels/B&Bs and being a COVID-19 case

Study	Exposure	Cases exposed		Controls exposed		Odds ratio	95% CI	p-value	PAF (%)	Restrictions in place
		n	%	n	%					
1	Overnight stay	579	28.95	268	13.02	2.72	2.31 - 3.21	<0.001	18.31	Early September 2020: Pre-tiers; accommodation sites open
	Overnight holiday stay	316	15.80	106	5.15	3.46	2.74 - 4.39	<0.001	11.23	
	Overnight hotel /B&B stay	173	8.65	48	2.33	3.97	2.84 - 5.61	<0.001	6.47	
2	Overnight stay	417	20.86	193	9.46	2.52	2.09 - 3.04	<0.001	12.60	Late September 2020: Pre-tiers; accommodation sites open
	Overnight holiday stay	139	6.95	93	4.56	1.57	1.19 - 2.07	0.001	2.51	
	Overnight hotel /B&B stay	78	3.90	47	2.30	1.72	1.18 - 2.54	0.003	1.64	
3	Overnight stay	264	13.20	133	6.41	2.22	1.78 - 2.78	<0.001	7.23	Late October 2020: 1st tiered system; localized restriction
	Overnight holiday stay	82	4.10	69	3.33	1.24	0.89 - 1.75	0.192	0.80	
	Overnight hotel /B&B stay	55	2.75	32	1.54	1.80	1.14 - 2.90	0.008	1.23	
4b	Overnight stay	73	3.66	67	3.36	1.09	0.77-1.56	0.61	0.31	

[1] https://www.medrxiv.org/content/10.1101/2020.12.21.20248161v1

	Overnight holiday stay	18	0.90	3	0.15	6.05	1.76-32.08	0.001	0.75	Late November 2020: 2nd national lockdown; stay at home order
	Overnight hotel /B&B stay	14	0.70	3	0.15	4.69	1.31-25.49	0.008	0.55	
5	Overnight stay	149	7.06	79	3.74	1.95	1.47 - 2.62	<0.001	3.45	Late February 2021: 3rd national lockdown; stay at home order
	Overnight holiday stay	30	1.42	3	0.14	10.13	3.14 - 51.95	<0.001	1.28	
	Overnight hotel /B&B stay	19	0.90	2	0.09	9.58	2.31 - 84.89	<0.001	0.81	
6a	Overnight stay	465	19.80	310	13.19	1.63	1.39 - 1.91	<0.001	7.62	Late June/early July 2021: 3rd step of Government roadmap; accommodation sites open
	Overnight holiday stay	205	8.73	97	4.13	2.22	1.72 - 2.88	<0.001	4.80	
	Overnight hotel /B&B stay	153	6.52	48	2.04	3.34	2.39 - 4.75	<0.001	4.57	
6b	Overnight stay	315	15.75	206	11.31	1.47	1.21 - 1.78	<0.001	5.01	
	Overnight holiday stay	181	9.05	61	3.35	2.87	2.12 - 3.93	<0.001	5.90	
	Overnight hotel /B&B stay	121	6.05	32	1.76	3.60	2.41 - 5.53	<0.001	4.37	

Note: Binary exposure "overnight stay" includes any overnight stay away from the main residence, i.e., stays in a second home or relative's home, in shared living spaces (e.g., student halls), supported living facilities, holiday places, and other settings (e.g., prison, shelter). Exposure "overnight holiday stay" includes overnight stays in hotels/bed and breakfast accommodations, campsites, youth hostels, and private holiday houses/flats.

Table 4 Multivariable analyses of case-control data on overnight stays, overnights holiday stays, and overnight stays in hotels/B&Bs and being a COVID-19 case

Study	Exposure	Odds ratio	95% CI	p-value	Restrictions in place
1	Overnight stay	1.11	0.56-22.5	0.90	Early September 2020: Pre-tiers; accommodation sites open
	Overnight holiday stay	4.25	0.26-67.2	0.30	
	Overnight hotel/ B&B stay	3.38	2.12-5.39	<0.005	
2	Overnight stay	2.98	2.16-4.13	<0.005	Late September 2020:Pre-tiers; accommodation sites open
	Overnight holiday stay	1.44	0.89-2.33	0.13	
	Overnight hotel/ B&B stay	1.49	1.12-5.39	0.20	
3	Overnight stay	2.12	1.51-2.99	<0.005	

	Overnight holiday stay	1.14	0.7-1.84	0.50	Late October 2020: 1st tiered system; localized restrictions
	Overnight hotel/ B&B stay	1.26	0.68-2.30	0.45	
4b	Overnight stay	0.20	0.007 - 5.58	0.347	Late November 2020: 2nd national lockdown; stay at home order
	Overnight holiday stay	0.18	0.003 - 11.09	0.416	
	Overnight hotel/ B&B stay	0.16	0.002 - 13.34	0.421	
5	Overnight stay	1.69	1.15 - 2.46	0.006	Late February 2021: 3rd national lockdown; stay at home order
	Overnight holiday stay	3.91	1.12 - 13.60	0.03	
	Overnight hotel/ B&B stay	4.47	1.09 - 18.29	0.04	
6a	Overnight stay	1.61	1.27 - 2.04	<0.001	Late June/early July 2021: 3rd step of Government roadmap; accommodation sites open
	Overnight holiday stay	2.12	1.50 - 3.00	<0.001	
	Overnight hotel/ B&B stay	3.00	1.94 - 4.65	<0.001	
6b	Overnight stay	1.32	1.04 - 1.67	0.02	
	Overnight holiday stay	2.76	1.93 - 3.94	<0.001	
	Overnight hotel/ B&B stay	3.20	2.00 - 5.11	<0.001	

Note: Separate MVA analysis for the 3 overnight exposures. Adjusted for demographic variables (age group, sex, ethnicity, IMD, location of residence), health/social care worker status (yes/no), and work/education and leisure exposures. Period 6a and 6b exclude individuals with overseas travel and are further adjusted for COVID-19 vaccination status, as self-reported on the NHSTT system/control questionnaire. Binary exposure "overnight stay" includes any overnight stay away from the main residence, i.e., stays in a second home or relative's home, in shared living spaces (e.g., student halls), supported living facilities, holiday places, and other settings (e.g., prison, shelter). Exposure "overnight holiday stay" includes overnight stays in hotels/bed and breakfast accommodations, campsites, youth hostels, and private holiday houses/flats.

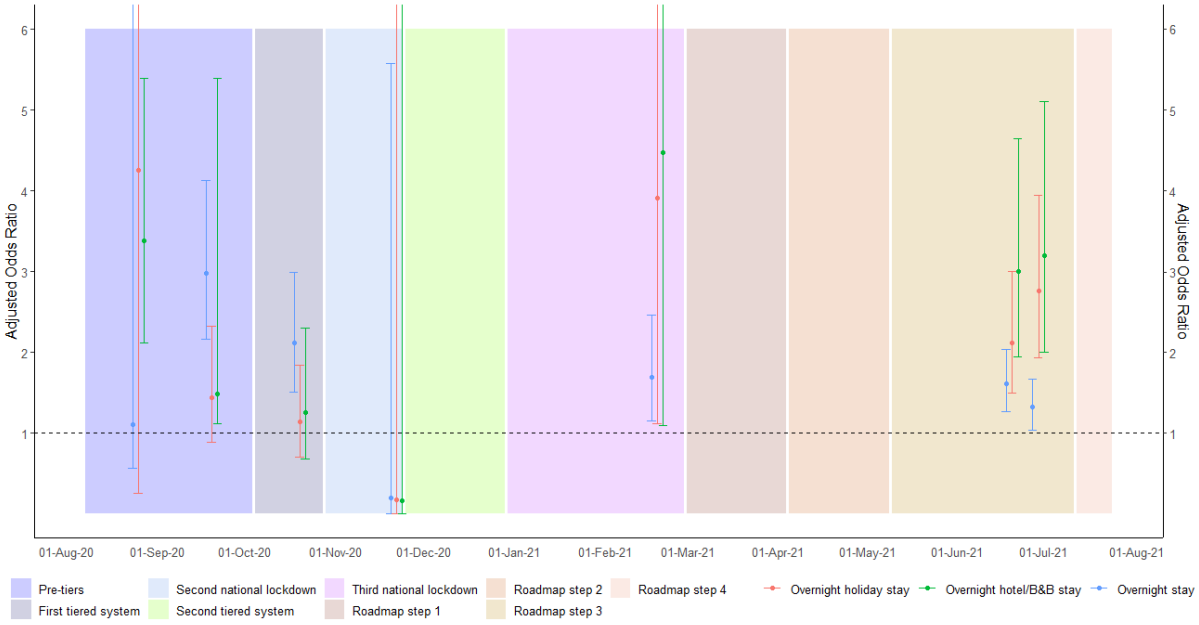


Figure 3 Case-control study results over time

Note: Binary exposure "overnight stay" includes any overnight stay away from the main residence, i.e., stays in a second home or relative's home, in shared living spaces (e.g., student halls), supported living facilities, holiday places, and other settings (e.g., prison, shelter). Exposure "overnight holiday stay" includes overnight stays in hotels/bed and breakfast accommodations, campsites, youth hostels, and private holiday houses/flats.

H. Concordance study

Groups of cases that reported attending the same place, on the same day, during the time when they may have acquired the infection, were compared using a genomic marker (S-Gene Target Failure; SGTF). This compares the level of concordance in events of a type we are studying to the level of concordance we would observe if the participants had been infected randomly with strains prevalent in their region, and compute an OR indicating how much higher the observed level of concordance is than the expected. The odds of the cases having the same marker, which means that transmission may have occurred, compared to discordant markers which shows the transmission from the same source could not have occurred were calculated for different settings. Higher ORs imply more likelihood of transmission from a common source, consistent with higher transmission rates in these settings.

When looking at people staying in holiday accommodation outside their primary residence, risks of transmission OR 11.7 (6.96 - 19.6) are higher than overall for hospitality OR 6.2 (5.25 - 7.32). All clusters in private holiday homes were concordant. Hotels with OR 10.1 (5.82 - 17.5) were the setting with most clusters. The risk observed among staff working in hotels and bed and breakfasts OR 10.1 (3.06 – 33.2).

Contact tracing information was used to identify clusters of cases which were in the same place on the same day up to 7 days prior to symptom onset. We assessed whether all cases in each cluster displayed positive or negative for SGTF (a specific genomic marker detectable via PCR). Baseline expected probabilities for concordance, positive or negative, are computed from the proportion of SGTF in cases developing symptoms on the date of the cluster. Assigning an OR compared to the baseline to the proportion of such clusters, weighted by the number of cases, in each setting gives us an estimate of the risk that transmission may have occurred in a particular setting or group of settings.

Caveats

Only time periods in English regions where SGTF in cases developing symptoms was between 20% and 80% could be analysed, and very few clusters could be identified in lockdown periods so some regions (London, the South East, East of England and Yorkshire and Humber) are under-represented. This analysis only shows the setting-associated risk of multiple case exposures, not the underlying incidence of such multiple exposures in people attending such settings, and also neglects the exchange of disease between staff and customers in hospitality and leisure settings. Different activities were possible during different periods, and 96% of data on leisure and hospitality data was captured during the 2 December – 4 January tiers period, which may not have been the case for the comparison group of visiting friends and family.

I. Secondary Attack Rates (SARs)

The SAR calculated among named close contacts of people with COVID-19 in NHSTT, from 23 October 2020 to 31 January 2021, was 10.2% (10.1% - 10.2%), with the majority of contacts named as household contacts.

Spending time in holiday accommodation was associated with a SAR of 11.2% (9.7% - 13.0%), comparable to that of household transmission 10.9% (10.9% - 10.9%), but there was insufficient data to report on holiday accommodation events after 1st Dec 2020. SARs for working in lodging was 4.4% (3.3% - 5.8%).

Contacts with exposure dates within 23 October 2020 to 31 January 2021 were included in SAR analyses. Analyses were restricted to these dates due to a change in setting categories on 23 October 2020. Contact Tracing Advisory Service (CTAS) data contains information collected from individuals with a positive test for SARS-CoV-2 referred to NHSTT ('cases') and individuals named by them as having been in contact with them between 2 days prior to symptom onset or test date and the date of tracing ('contacts'). Persons can arise multiple times as cases and/or contacts in the data and are matched with themselves via combination of name, NHS number, date of birth, address and contact information. Transmission is defined as a confirmed case (B) previously reported as a contact by a case (A), where the date for case (A) interacting with case (B) is between 2 and 14 days inclusive prior to the onset of symptoms (or test date) for case (B). Where there was more than one contact event within the transmission window leading to a case, one event is counted per case who was previously a contact, with priority given to household contacts and to later interactions. Hence leisure activities or visits to hospitality venues undertaken with members of one's household would not be considered as likely transmission events in this study.

Caveats

As links are only identified between named contacts, and rely on contacts accessing testing, SARs calculated here should be considered a minimum estimate. In leisure and hospitality venues, contacts between staff and customers may not be captured.

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