Evidence check

18 November 2020

Rapid evidence checks are based on a simplified review method and may not be entirely exhaustive, but aim to provide a balanced assessment of what is already known about a specific problem or issue. This brief has not been peer-reviewed and should not be a substitute for individual clinical judgement, nor is it an endorsed position of NSW Health.

High-risk settings for transmission of COVID-19

Evidence check question

What is the evidence for transmission of COVID-19 in different settings, and which settings are high-risk?

In brief

- A statement from the Australian Health Protection Principal Committee (AHPPC) describes several very high-risk environments including nightclubs, dance venues, and large unstructured outdoor events such as music festivals, food festivals, school guardians' festivals, carnivals, community sporting events and other non-ticketed spectator events. These events are high risk due to factors such as but not limited to large numbers, close proximity and mixing between groups of people.(1)
- Healthcare and residential aged care settings are known to be high risk but are excluded from this review.
- A systematic review identified 22 types of settings, predominantly indoor settings that result in SARS-CoV-2 transmission clusters. Risk was classified based on the number of infections per cluster or the proportion of people in that setting who became infected. Most clusters involved fewer than 100 cases, with the exceptions being in large religious gatherings, food processing plants, schools, shopping, and large co-habiting settings (worker dormitories, prisons and ships). Other settings with examples of clusters between 50–100 cases in size were weddings, sporting events, bars, shops and workplaces.(2)
- A rapid review, prepared by The National Collaboration Centre for Methods and Tools looking at risk of COVID-19 transmission across different indoor settings in the community, reported that households and shared accommodations (e.g. cruise ships) thus far appear to be the most prevalent locations for infection clusters. In settings involving indoor physical activity (gyms and fitness classes), attack rates are highly variable and range from 7.3-26.3%. Transmission appeared to occur more commonly from fitness instructors to participants. Furthermore, modelling studies estimated risk level for different indoor scenarios found ventilation, reducing crowd size, wearing a mask and physical distancing may decrease transmission risk.(3)
- Most evidence were from single case reports. For many settings, there were insufficient data to determine whether the settings are categorically high risk. Studies were mostly descriptive, with

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some concluding that transmission was likely facilitated by close proximity. Settings featured in the literature include:

- **Indoor establishments providing accommodation**

  - **Homeless shelters.** Homeless shelters are often crowded, making social distancing difficult. Many people experiencing homelessness are older or have underlying medical conditions, placing them at higher risk for severe COVID-19-associated illness.(4-10) A multicentre observational study at 19 homeless shelters in the United States reported a range of incidence of SARS-CoV-2 transmission ranging between 1-66% of residents and 2-16% of staff working at these shelters.(7)

  - **Prisons.** In five prisons in China, over 500 new COVID-19 cases were diagnosed.(11) In the US, many of confirmed cases and deaths are tied to prisons, including up to 38,000 COVID-19 cases among prison residents according to one data source.(12)

  - **Worker dormitories.** Worker dormitories have been recognised as key places linked to transmission in Singapore. On 18 April 2020, 893 out of 942 new cases recorded were dormitory residents.(2)

  - **Household.** Many case studies describe household transmission of COVID-19.(13-20) A cohort study of 105 index patients and 392 household contacts showed secondary transmission of SARS-CoV-2 developed in 64 of 392 household contacts (16.3%)(21) with another in 155 close contacts of 85 infected patients saw a secondary transmission rate of 30%.(22) A study of infection in 23 families with children in Greece revealed that an adult member with COVID-19 was the first case in 91.3% of clusters, with no evidence of child-to-adult or child-to-child transmission.(23)

  - **Cruise ships.** Ships are often settings for outbreaks of infectious diseases because of their closed environment, contact between travellers from many countries, and crew transfers between ships. In January 2020, the Diamond Princess was the setting of the largest outbreak outside mainland China.(24) The CDC reported more than 800 confirmed COVID-19 cases which occurred during outbreaks on three cruise ship voyages in March 2020. Transmission occurred across multiple voyages from ship-to-ship by crew members; both crew members and passengers were affected. Secondary community-acquired cases linked to return passengers on cruises have also been reported.(24)

- **Indoor occupational settings**

  - **Military.** A case in a military school in Switzerland resulted in 55 of 140 recruits in quarantine, of which seven became symptomatic and one other tested COVID-19 positive.(25) In March 2020, it was expected that 1000 US service members

on board of the aircraft carrier USS Theodore Roosevelt, which arrived at port in Guam, were infected with SARS-CoV-2 virus.(26)

- **Factories and offices.** Large numbers of occupational transmissions have been reported by the European Centre for Disease Prevention and Control mainly from the food packaging and processing sectors, factories and manufacturing and in office settings, indicating a link with work in an indoor environment and an inability to maintain physical distance.(27)

- **Call centre.** An outbreak that occurred in a call centre in South Korea shows, alarmingly, that transmission can be exceptionally contagious in crowded office settings as 97 staff were confirmed cases in one building with an attack rate of 8.5%. If restricting the infection to the floor where the outbreak started the attack rate was 43.5%.(28)

- **Schools.** Multiple studies have described outbreaks of COVID-19 in schools.(29-32) One described cases in school children (as a result of household transmission) where an outbreak did not occur.(33) COVID-19 incidence among adolescents aged 12–17 years was approximately twice that in children aged 5–11 years.(32) In England, outbreaks were uncommon across all educational settings. Staff members had an increased risk of SARS-CoV-2 infections compared to students in any educational setting, and the majority of cases linked to outbreaks were in staff.(31) A prospective cohort study in Australia found no secondary transmission in nine of 10 schools.(34) In NSW, the National Centre of Immunisation Research and Surveillance investigated all schools and early childhood education and care centre COVID-19 cases between April and July. Only four students and two staff members were confirmed as primary COVID-19 cases and no secondary cases were reported in any of the educational settings.(35)

- **Indoor settings - social and recreational**

  - **Family gatherings.** COVID-19 was identified in 56% of wedding attendees who engaged in close physical contact, shared drinks and shisha during a family gathering in Bali. The attack rates ranged from 64% to 87% for different exposures.(36) A modelling study, which estimated the probable outbreak size of COVID-19 clusters mathematically from different countries between February and April 2020, demonstrated that the highest attack rates are found in wedding party events.(37) A funeral and a birthday party likely facilitated transmission of COVID-19 in Chicago. An investigation identified a cluster of 16 confirmed or probably cases including three deaths, likely resulting from one introduction.(38) Following a two day wedding and family party, 539 contacts were screened and the secondary attack rate among close contacts was reported to be 29% (2 of 7) and for the casual contacts to be 0.6% (3 of 473).(39)

  - **Religious gatherings.** An outbreak following a church event in the US and one large religious gathering in Malaysia (a Moslem missionary movement where people shared communal spaces such as prayer hall, collectively eating from

one plate and sharing of sleeping area) were identified. Both had an age specific attack rate of up to 59.4% (for those aged 19-64 years). The mass gathering accounted for more than 35% of the COVID-19 cases in Malaysia.(40, 41)

- **Shopping centres.** A cluster of COVID-19 cases was associated with a shopping mall in Wenzhou, China. After tracing and testing of contacts, seven people from the same office tested positive for COVID-19.(42)

- **Choir practice.** Following a choir practice attended by 61 people, including a symptomatic index patient, 32 confirmed and 20 probable secondary COVID-19 cases occurred. Transmission was likely facilitated by close proximity (within six feet) during practice and augmented by the act of singing.(43) Many COVID-19 clusters in Japan were associated with heavy breathing in close proximity, such as singing at karaoke parties and cheering at clubs.(44)

- **Restaurants.** An outbreak of COVID-19 in an air-conditioned restaurant in Guangzhou, China, involved three family clusters.(45)

- **Fitness centres.** 112 persons were infected with COVID-19 associated with fitness dance classes at 12 sports facilities in South Korea. Most (50.9%) cases were the result of transmission from instructors to fitness class participants.(46)

- **Indoor settings - travel**

  - **Aircrafts.** Transmission of COVID-19 on aircraft has been reported in a separate review. Since the date of that publication, four additional publications were found. One had an attack rate of 4.8% with 16 infected passengers including 10 who were symptomatic. Following a flight from Singapore to China, one passenger screened positive and eventually, 12 of the 325 patients tested positive to COVID-19. There were two transmissions likely occurred before or after a flight within a tourist group, with the likely on-board transmission cases sitting within two rows of an index case.(47-50)

Limitations

As most evidence is derived from single case reports, it is not possible to compare the risk of outbreaks or infection clusters across various settings. The evidence is very likely to change over time and is determined by a number of factors including prevalence, specific activity performed and emission rate by infected individuals, crowding, exposure time, numbers of individual interactions and ventilation. Studies describing transmission often use the specific setting name, and so terms not used in our search string may lead to articles in some settings not being captured. Low-quality evidence, such as letters, are included in this review and no attempt at assessing the quality of these studies was made. Large clusters, such as those linked to churches and ships, were infrequently reported in peer reviewed manuscripts and only reported in low-quality evidence through media articles. These have not been included in the review, however they are referred to where there was a lack of peer-reviewed evidence. Aged care facilities and healthcare settings are also identified as high-risk settings; however, these settings are subject to a separate evidence check.

Background

Current evidence suggests that transmission of SARS-CoV-2 occurs primarily between people through direct, indirect, or close contact with infected people through infected secretions such as saliva and respiratory secretions, or through their respiratory droplets, which are expelled when an infected person coughs, sneezes, talks or sings.(51) Airborne transmission of SARS-CoV-2 can occur during medical procedures known as aerosol generating procedures. Whether SARS-CoV-2 may also spread through aerosols in the absence of aerosol generating procedures is actively being discussed. Some outbreak reports related to indoor crowded spaces have suggested the possibility of aerosol transmission, combined with droplet transmission, for example, during choir practice, in restaurants or in fitness classes.(51)

A statement from the Australian Health Protection Principal Committee (AHPPC) describes several very high-risk environments including nightclubs, dance venues, and large unstructured outdoor events such as music festivals, food festivals, school guardians' festivals, carnivals, community sporting events and other non-ticketed spectator's events. These events are high risk due to factors such as, but not limited to, large numbers, close proximity and mixing between groups of people.(1)

Methods (Appendix 1)

PubMed and Google were searched on 20 October 2020.

Studies were included if they described the transmission of COVID-19 in a particular setting, published in English language, the transmission described was in humans and they were published from 2019 onwards. Studies with modelling or projecting COVID-19 cases and those that were pre-peer review were excluded.

The Critical Intelligence Unit has previously published a review on COVID-19 transmission risk on aircraft, therefore studies on aircraft were only included if they were published after the date of this search (16 June 2020). Studies in healthcare settings were published previously in a review on Nosocomial COVID-19 infections dated 5 June. This review is due to be updated and these studies have been excluded from this review. Studies in aged care settings have been subject to a separate review and were excluded from this review.

Results

Table 1

Source	Summary
Peer reviewed sources	
Systematic review	
What settings have been linked to SARS-CoV-2 transmission clusters? Leclerc, et al. 2020 (2)	• A systematic review of available literature and media reports published until 26 May 2020 to identify the types of potential indoor and outdoor settings that result in transmission clusters. • The review found evidence of SARS-CoV-2 transmission clusters from 201 events, which were then classified into 22 types of settings (Table 1 and Table 2). It was found that clusters of cases were reported in many, predominantly indoor settings. Most clusters involved fewer than 100

Source	Summary
Peer reviewed sources	
	cases, with the exceptions being in healthcare, large religious gatherings, food processing plants, schools, shopping, and large co-habiting settings (worker dormitories, prisons and ships). Other settings with examples of clusters between 50–100 cases in size were weddings, sporting events, bars, shops and workplaces.
Schools	
COVID-19 Trends Among School-Aged Children - United States, March 1-September 19, 2020 Leeb, et al. 2020 (32)	• An analysis of demographic characteristics, underlying conditions, clinical outcomes, and trends in weekly COVID-19 incidence between 1 March and 19 September 2020 among 277,285 laboratory-confirmed cases in school-aged children in the United States. • COVID-19 incidence among adolescents aged 12–17 years (63%) was approximately twice that in children aged 5–11 years (37%). Underlying conditions were more common among school-aged children with severe outcomes related to COVID-19.
SARS-CoV-2 infection and transmission in educational settings: cross-sectional analysis of clusters and outbreaks in England Ismail, et al. 2020 (31)	• Public Health England conducted enhanced surveillance, including daily monitoring of schools following the reopening of educational settings between 1 June and 31 July 2020. Overall, there were 67 single confirmed cases, four co-primary cases and 30 outbreaks. • Infections and outbreaks were uncommon across all educational settings. Staff members had an increased risk of SARS-CoV-2 infections compared to students in any educational setting, and the majority of cases linked to outbreaks were in staff. • The probable transmission direction for the 30 confirmed outbreaks was: staff-to-staff (n=15), staff-to-student (n=7), student-to-staff (n=6) and student-to-student (n=2).
SARS-CoV-2 antibody prevalence in blood in a large school community subject to a Covid-19 outbreak: a cross-sectional study Torres, et al. 2020 (29)	• A SARS-CoV-2 outbreak affecting 52 people from a large school community in Santiago, Chile was identified on 12 March. • A cross sectional study was implemented in a home-delivery, self-administered, IgG/IgM antibody test and survey to a classroom stratified sample of students and all staff from 4-19 May. Antibody positivity rates were 9.9% (95% CI: 8.2-11.8) for 1,009 students and 16.6% (95% CI: 12.1-21.9) for 235 staff. • Among students, positivity was associated with younger age (P=0.01), lower grade level (P=0.05), prior RT-PCR positivity (P=0.03), and history of contact with a confirmed case (P<0.001). • Among staff, positivity was higher in teachers (P=0.01) and in those previously RT-PCR positive (P<0.001). Within antibody positive individuals, 40% of students and 18% of staff reported no symptoms (P=0.01).
A large COVID-19 outbreak in a high school 10 days after	• Case series. • Settings: school. • On 17 March 2020 all schools in Israel were reopened after the government declared closure of the school. Ten days later, a major outbreak of COVID-19 occurred in a high school.

Source	Summary
Peer reviewed sources	
schools' reopening, Israel, May 2020 Stein-Zamir, et al. 2020 (30)	• The first case was registered on 26 May, the second on 27 May. Testing of the complete school community revealed 153 students (attack rate of 13.2%) and 25 staff members (attack rate of 16.6%) who were COVID-19 positive. • COVID-19 rates were higher in junior grades (7–9) than in high grades (10–12). The peak rates were observed in the 9th grade (20 cases in one class and 13 cases in two other classes) and the 7th grade (14 cases in one class).
Transmission of SARS-CoV-2 in Australian educational settings: a prospective cohort study Macartney, et al. 2020 (34)	• Settings: school and early childhood education and care. • Laboratory-confirmed paediatric (aged ≤18 years) and adult COVID-19 cases who attended a school or early childhood education and care setting while considered infectious (defined as 24h before symptom onset, based on national guidelines during the study period) in NSW from 25 January to 10 April 2020, were investigated for onward transmission. • All close contacts identified in school and early childhood education and care settings were required to home quarantine for 14 days and were monitored and offered SARS-CoV-2 nucleic acid testing if symptomatic. • 15 schools and 10 early childhood education and care settings had children (n=12) or adults (n=15) attend while infectious, with 1,448 contacts monitored. Of these, 633 (43.7%) of 1,448 had nucleic acid testing, or antibody testing, or both, with 18 secondary cases identified (attack rate of 1.2%). • Five secondary cases (three children; two adults) were identified (attack rate 0.5%; 5/914) in three schools. No secondary transmission occurred in nine of ten early childhood education and care settings among 497 contacts. • However, one outbreak in an early childhood education and care setting involved transmission to six adults and seven children (attack rate 35.1%; 13/37). • Across all settings, five (28.0%) of 18 secondary infections were asymptomatic (three infants - all aged 1 year, one adolescent - 15 years, and one adult).
Novel Coronavirus 2019 Transmission Risk in Educational settings Yung, et al. 2020 (33)	• In February and March 2020, comprehensive nationwide surveillance and contact tracing as part of Singapore's public health strategy identified three potential SARS-CoV-2 seeding incidents in three separate educational settings • All students and parents of the school were advised to monitor for symptoms and were admitted for COVID-19 evaluation if they were unwell within the 14-day incubation period. • Two students were found to be SARS-CoV-2 positive from contact tracing following their exposures to adult family household members who were part of a community cluster. Both students attended their respective educational settings on the first day of their symptoms before subsequently being diagnosed with COVID-19 and isolated in the hospital.

Source	Summary
Peer reviewed sources	
	• In the secondary school setting, a total of eight students from the school developed symptoms and were screened for SARS-CoV-2 during the incubation period. • All eight symptomatic student contacts tested negative from that school. • In the preschool setting, a total of 34 preschool student contacts developed symptoms during the incubation period post-exposure and hence were swabbed for SARS-CoV-2. All 34 symptomatic contacts at the preschool were found to be negative for SARS-CoV-2.
Household transmission	
Reconstruction of Transmission Pairs for novel Coronavirus Disease 2019 (COVID-19) in mainland China: Estimation of Super-spreading Events, Serial Interval, and Hazard of Infection Xu, et al. 2020 (19)	• Database analysis. • A unique database with detailed demographic characteristics, travel history, social relationships, and epidemiological timelines for 1,407 transmission pairs that formed 643 transmission clusters was reconstructed from 9,120 COVID-19 confirmed cases. • Age and gender-stratified risk of infection were estimated for household versus non-household transmissions. • There were 34 primary cases identified as super-spreaders, with five super-spreading events occurring within households. • Risk of being infected outside of households is higher for those aged between 18 and 64 years, whereas risk of being infected within households is higher for young and old people.
Adolescent with COVID-19 as the Source of an Outbreak at a 3-Week Family Gathering - Four States, June-July 2020 Schwartz, et al. 2020 (20)	• A case study during July–August 2020. Four US state health departments and the CDC investigated a COVID-19 outbreak that occurred during a three-week family gathering of five households, in which an adolescent aged 13 years was the index and suspected primary patient; 11 subsequent cases occurred. • The report concluded that children and adolescents can serve as the source for COVID-19 outbreaks within families, even when their symptoms are mild.

Source	Summary
Peer reviewed sources	
Absence of Evidence of Transmission of Coronavirus Disease 2019 from a Young Child to Mother Despite Prolonged Contact Nassih, et al. 2020 (13)	• A case report presented in a letter to the editor. • Asymptomatic two-year-old girl presented to the hospital for SARS-CoV-2 testing. Her father tested positive for COVID-19 a day before. Nasal swab for SARS-CoV-2 RT-PCR was positive for the child and negative for the mother. • The girl's RT-PCR became negative by the tenth day of diagnosis, while SARS-CoV-2 RT-PCR and serology controls of the mother stayed negative up to twenty-eight days of follow-up.
Household Transmission of Severe Acute Respiratory Syndrome Coronavirus 2 from Adults to Children Yung, et al. 2020 (33)	• This report describes age-specific attack rates in children in households with confirmed COVID-19 in Singapore. • Among 137 households with a total of 223 adults with laboratory-confirmed COVID-19, 213 children age ≤16 years were tested for SARS-CoV-2; 13 cases were detected in seven households, for an attack rate of 6.1% among children. Transmission from adults to children was documented and found to have occurred in 5.2% of households. • In age-stratified analysis, the attack rate was 1.3% among children age <5 years, 8.1% among those age 5-9 years, and 9.8% among those age 10-16 years. The attack rate among children was highest when the household index case was the mother (11.1%), and lower and similar if the index case was the father (6.7%) or a grandparent (6.3%).
COVID-19 Transmission Within a Family Cluster in Yancheng, China Zhang, et al. 2020 (14)	• This case series reports the clinical characteristics of COVID-19 in a family setting with person-to-person transmission in China. • A total of 13 patients from a family cluster were tested SARS-CoV-2 positive. • On 20 January 2020, seven family members without any symptoms went back to Yancheng from Wuhan after participating in activities celebrating the Chinese Spring Festival. In Yancheng, two people from this family were infected. • Another four family members were subsequently infected following a family wedding. Afterwards, all 13 family members were tested positive for SARS-CoV-2 infection. • All 13 patients in the family recovered well and became symptom-free. The uniqueness of this cluster is that only four people were infected during the wedding despite so many people attending the wedding. Therefore, the authors assume that infection of this virus is correlated with the strength of individual immunity. They report that to prevent and control disease as early as possible, people with family members with COVID-19 diagnosis should be closely monitored and tested to rule out the virus infection, even if they do not show any symptoms.

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Peer reviewed sources	
Clinical and epidemiological features of COVID-19 family clusters in Beijing, China Song, et al. 2020 (18)	• The study revealed that SARS-CoV-2 is transmitted quickly through contact with index case, and a total of 22/24 infections were observed. • Among those infected, 20/22 had mild symptoms and only two had moderate to severe clinical manifestations. • The incubation period varied from 2 to 13 days, and the shedding of virus from the upper respiratory tract lasted from 5 to over 30 days. • A prolonged period of virus shedding (>30 days) in upper respiratory tract was observed in 6/24 cases.
Characteristics of Household Transmission of COVID 19 Li, et al. 2020 (21)	• Household transmission. • A total of 105 index patients and 392 household contacts were tested. • Secondary transmission of SARS-CoV-2 developed in 64 of 392 household contacts (16.3%). • The secondary attack rate to children was 4% compared with 17.1% for adults. • The secondary attack rate to the contacts within the households with index patients quarantined by themselves since onset of symptoms was 0% compared with 16.9% for contacts without quarantined index patients. • The secondary attack rate to contacts who were spouses of index cases was 27.8% compared with 17.3% for other adult members in the households.
Household transmission of SARS-Cov-2 Wang, et al. 2020 (22)	• Household setting. • Retrospective study. • Authors enrolled 85 patients infected with SARS-CoV-2 and their household members in Wuhan. Patients were confirmed infected with SARS-CoV-2. • There were 155 close contacts in total. • The rate of secondary transmission among household contacts of patients with SARS-CoV-2 infection was 30%. • The infection rate of close contacts was 38% for households with one contact, 50% for households with two contacts, and 31% for households with three contacts.

Source	Summary
Peer reviewed sources	
COVID-19 Transmission Within a Family Cluster by Presymptomatic Carriers in China Qian, et al. 2020 (15)	• Household setting. • The study reports a family cluster of nine family members, including eight laboratory-confirmed with COVID-19, and a six-year-old child who had no evidence of infection. • Among the eight patients, one adult and a 13-month-old infant were asymptomatic, and one adult was diagnosed as having severe pneumonia. • There are variations across individuals in the clinical manifestations of COVID-19.
Asymptomatic and Human-to-Human Transmission of SARS-CoV-2 in a 2-Family Cluster, Xuzhou, China Li, et al. 2020 (16)	• Household setting. • The study reported epidemiologic, laboratory, and clinical findings for seven patients with COVID-19 in a two-family cluster. • On 14 January, 2020, a 56-year-old man (index patient) departed from Guangzhou, China, transferred at Hankou Station in Wuhan, China, for six hours, and arrived at Xuzhou, China, showing no symptoms on the same day in the evening. • During 14-22 January, a 56-year-old man, who came from Guangzhou, China had close contact with his four family members. • On 15 January, he began caring for his 42-year-old son-in-law who had been hospitalised. • Meanwhile, a 62-year-old man who stayed in the same shared ward with the patient and was cared for by his son. • On 19 January, the 62-year-old man was discharged to home and had close contact with his wife. • On 25 January, the index patient was confirmed to have COVID-19. • Subsequently, during 26-31 January, another six members of the two families all tested positive for SARS-CoV-2.
Transmission of COVID-19 in the terminal stages of the incubation period: A familial cluster Li, et al. 2020 (17)	• Household setting. • Five family members had close contact with a patient during his incubation period, with four of them confirmed positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in the subsequent sampling tests.

Source	Summary
Peer reviewed sources	
Transmission dynamics of SARS-CoV-2 within families with children in Greece: a study of 23 clusters Maltezou, et al. 2020 (23)	• A study of the transmission dynamics of SARS-CoV-2 within 23 family clusters in Greece. • Overall, there were 109 household members (66 adults and 43 children). • The median attack rate per cluster was 60% (range: 33.4%-100%). • An adult member with COVID-19 was the first case in 21 (91.3%) clusters. • Transmission of infection occurred from an adult to a child in 19 clusters and/or from an adult to another adult in 12 clusters. • There was no evidence of child-to-adult or child-to-child transmission. • Concludes that while children become infected by SARS-CoV-2, they do not appear to transmit the infection to others.
Homeless shelters	
Characteristics of COVID-19 in Homeless Shelters : A Community-Based Surveillance Study Rogers, et al. 2020 (8)	• Setting: 14 homeless shelters in King County, Washington. • A total of 1,434 study encounters were done in shelter residents and staff, regardless of symptoms. • Among 1,434 encounters, 29 (2%) cases of SARS-CoV-2 infection were detected across five shelters. Most (n=21, 72.4%) were detected during surge testing events rather than routine surveillance, and most (n=21, 72.4%) were asymptomatic at the time of sample collection. • 86% of persons with positive test results slept in a communal space rather than in a private or shared room.
Prevalence of SARS-CoV-2 Infection in Residents of a Large Homeless Shelter in Boston Baggett, et al. 2020 (4)	• All individuals residing in a shelter (n=408) underwent symptom assessment and SARS-CoV-2 PCR testing in one large homeless shelter in Boston. • A total of 147 participants (36.0%) had PCR test results positive for SARS-CoV-2. Men constituted 84.4% of individuals with PCR-positive results.
Assessment of SARS-CoV-2 Infection Prevalence in Homeless Shelters — Four U.S. Cities, March 27–April 15, 2020 Mosites, et al. 2020 (7)	• At 19 homeless shelters from four US cities, 1,192 residents and 313 staff members were tested for SARS-CoV-2. • When testing followed the identification of a cluster, high proportions of residents and staff members had positive test results for SARS-CoV-2 in Seattle (17% of residents; 17% of staff members), Boston (36%; 30%), and San Francisco (66%; 16%). • Testing in Seattle shelters, where only one previous case had been identified in each shelter, found a low prevalence of infection (5% of residents; 1% of staff members). • Among shelters in Atlanta, where no cases had been reported, a low prevalence of infection was also identified (4% of residents; 2% of staff members).

Source	Summary
Peer reviewed sources	
Pandemic Planning in Homeless Shelters: A pilot study of a COVID-19 testing and support program to mitigate the risk of COVID-19 outbreaks in congregate settings Bodkin, et al. 2020 (5)	• 104 residents and 141 staff for COVID-19 who failed daily symptom screening in homeless shelters in Hamilton, Canada were tested. One resident (1%), seven staff (5%) and one case of secondary spread were detected COVID-19 positive.
COVID-19 Prevalence among People Experiencing Homelessness and Homelessness Service Staff during Early Community Transmission in Atlanta, Georgia, April-May 2020 Yoon, et al. 2020 (10)	• In Georgia, USA, 2,875 individuals at 24 shelters and nine unsheltered outreach events underwent SARS-CoV-2 testing and 2,860 (99.5%) had conclusive test results. SARS-CoV-2 prevalence was 2.1% (36/1,684) among people experiencing homelessness (PEH) living sheltered, 0.5% (3/628) among PEH living unsheltered, and 1.3% (7/548) among staff. • Prevalence by shelter ranged 0-27.6%. Repeat testing 3-4 weeks later at four shelters documented decreased SARS-CoV-2 prevalence (0-3.9%).
Homeless people hospitalized with COVID-19 in Brussels Schrooyen, et al. 2020 (9)	• A single centre study in Brussels between 3 March and 26 May 2020 identified a high incidence of hospitalisation for COVID-19 among homeless patients in Brussels. • Homeless patients had a high but similar proportion of comorbidities as compared to non-homeless patients. Their outcomes were not worse however, the study revealed that the incidence of hospitalisation for COVID-19 was three times higher in homeless people than in the general population.
COVID-19 among people experiencing homelessness in England: a modelling study Lewer, et al. 2020 (6)	• An epidemic model to explore the potential incidence of COVID-19 among people experiencing homelessness in England concluded that outbreaks of SARS-CoV-2 in homeless settings can lead to a high attack rate among people experiencing homelessness, even if incidence remains low in the general population. Avoidance of deaths depends on prevention of transmission within settings such as hostels and night shelters.
Aircraft	

Source	Summary
Peer reviewed sources	
Potential transmission of SARS-CoV-2 on a flight from Singapore to Hanghzou, China: An epidemiological investigation Chen, et al. 2020 (47)	• Between 24 January 2020 and 15 February 2020, an outbreak of COVID-19 occurred among 335 passengers on flight from Singapore to China. • A total of 16 infected passengers, including 10 symptomatic passengers and six asymptomatic passengers, were diagnosed between 24 January and 15 February 2020. The overall attack rate among the passengers was 4.8% (16/335).
In-flight transmission cluster of COVID-19: a retrospective case series Yang, et al. 2020 (48)	• After a flight, from Singapore to China, a passenger was confirmed positive for SARS-CoV-2 after conducting screen for fever and respiratory symptoms. • Eventually, laboratory-confirmed COVID-19 was reported in 12 patients out of 325 passengers. Ten patients were admitted to hospital.
Asymptomatic Transmission of SARS-CoV-2 on Evacuation Flight Bae, et al. 2020 (50)	• A cohort study of 310 passengers was conducted to measure asymptomatic transmission of SARS-CoV-2 on a flight from Italy to South Korea on 31 March 2020. • On quarantine day 14, a 28-year-old woman who had no underlying disease had a confirmed positive test result for COVID-19. On the flight from Italy to South Korea, she shared toilet with passengers sitting nearby, including an asymptomatic patient. She was seated three rows away from the asymptomatic patient. • Given that she did not go outside and had self-quarantined for three weeks alone at her home in Italy before the flight and did not use public transportation to get to the airport, it is highly likely that her infection was transmitted in the flight via indirect contact with an asymptomatic patient.
Assessment of SARS-CoV-2 Transmission on an International Flight and Among a Tourist Group Hoehl, et al. 2020 (49)	• Among the 102 passengers in an airline flight from Israel to Germany, 24 members of a tourist group had contact with a hotel manager who was later diagnosed with COVID-19. No member of the group had diagnosed COVID-19 before the flight, and no measures to prevent transmission (e.g. wearing of masks) had been applied. • Two likely SARS-CoV-2 transmissions on this flight, with seven index cases, were discovered. These transmissions may have occurred before or after the flight. In this study, both passengers with likely on-board transmission were seated within two rows of an index case.
Family gathering	
Community Transmission of SARS-CoV-2 at Two Family Gatherings — Chicago, Illinois,	• Weekly report. • Settings: family gatherings (a funeral and a birthday party) • The report described the cluster of 16 cases of confirmed or probable COVID-19, including three deaths.

Source	Summary
Peer reviewed sources	
February–March 2020 Ghiani, et al. 2020 (38)	• In February 2020, a funeral was held for a decedent with a non-COVID-19, non-respiratory cause of death. A close friend of the bereaved family (patient A), who had recently travelled out of state and was experiencing mild respiratory symptoms, attended the funeral. • Three days after the funeral, the patient who was still experiencing mild respiratory symptoms, attended a birthday party with nine other family members. Meanwhile, patient A was diagnosed with COVID-19. • Seven party attendees subsequently developed COVID-19 3-7 days after the event. • Two people who provided personal care for the patient without using PPE, including one family member and a home care professional, both developed probable COVID-19.
High COVID-19 attack rate among attendees of wedding events in Bali, Indonesia, March 2020 Ravindran, et al. 2020 (36)	• A study of a cluster of COVID-19 cases in returning Australian residents who attended wedding events in Bali, Indonesia, during 15- 21 March 2020. Attendees participated in various social events, engaged in close physical contact, shared drinks and shisha and were in close proximity during wedding events. COVID-19 was identified in 56% of attendees (23/41) and the attack rates ranged from 64% to 87% for different exposures.
Estimation of the probable outbreak size of novel coronavirus (COVID-19) in social gathering events and industrial activities Saidan, et al. 2020 (37)	• The study estimated the probable outbreak size of COVID-19 clusters mathematically, using a simple model that can predict the number of COVID-19 cases as a function of time. • The model selected different types of clusters (religious, wedding, and industrial activity) from different countries between February and April 2020. • The highest attack rates were found in wedding party events, followed by religious gathering events.
A Cluster of Novel Coronavirus Disease 2019 Infections Indicating Person-to-Person Transmission Among Casual Contacts From Social Gatherings: An Outbreak Case-Contact Investigation	• Outbreak case-contact investigation. • Settings: wedding and a family party. • A total of 539 social and family contacts of the index patient, including members of a two-day wedding and a family party, were contacted and screened through epidemiologic surveys. • The secondary attack rate among close contacts to be 29% (2 of 7) and for the casual contacts to be 0.6% (3 of 473). The incubation period of case cluster was 4–12 days, with a median incubation period of 7 days.

Source	Summary
Peer reviewed sources	
Shen, et al. 2020 (39)	
Religious gathering	
High COVID-19 Attack Rate Among Attendees at Events at a Church — Arkansas, March 2020 James, et al. 2020 (40)	• Among 92 attendees at a rural Arkansas church during 6-11 March, 35 (38%) developed laboratory-confirmed COVID-19, and three persons died. • The age-specific attack rates among people aged ≤18 years, 19–64 years, and ≥65 years were 6.3%, 59.4%, and 50.0%, respectively. • During contact tracing, at least 26 additional people with confirmed COVID-19 were identified among community members who reported contact with church attendees and likely were infected by them; one of the additional persons was hospitalised and subsequently died.
A single mass gathering resulted in massive transmission of COVID-19 infections in Malaysia with further international spread Che, et al. 2020 (41)	• Rapid communication. • Settings: public gathering (religious gathering). • In Kuala Lumpur, more than 19,000 people of different nationalities attended the Sri Petaling gathering, a Moslem missionary movement that took place between 27 February 2020 to 1 March 2020. • As of 13 April 2020, 19,032 tests were conducted from a total of 21,920 samples taken. From these samples, 1,701 samples were positive. • The Sri Petaling event became the catalyst for the subsequent spread of COVID-19 in Malaysia.
Prison	
Fighting covid-19 outbreaks in prisons Yang, et al. 2020 (11)	• Letter. • On 20 February 2020, there were over 500 new COVID-19 cases in five prisons. • Prisoners are at much higher risk of infectious diseases than communities outside.

<table>
<tr><th>Source</th><th>Summary</th></tr>
<tr><td colspan="2">Peer reviewed sources</td></tr>
<tr><td>COVID-19 in jails and prisons: A neglected infection in a marginalized population

Carlos Franco-Paredes, et al. 2020 (12)</td><td>

Viewpoint.
In the US, there are already thousands of confirmed cases of COVID-19 tied to prisons and jails, with many deaths among prisoners and staff.

<table>
<tr><td>Data source</td><td>COVID-19 cases among jail-prison residents</td><td>COVID-19 cases among staff</td><td>COVID-19 deaths among residents</td><td>COVID-19 deaths among staff in jails and prisons</td></tr>
<tr><td>UCLA Law COVID-19 Behind Bars</td><td>38,616</td><td>10,182</td><td>470</td><td>42</td></tr>
<tr><td>COVID Prison Data</td><td>29,519</td><td>7,402</td><td>392</td><td>20</td></tr>
<tr><td>CDC Data (6 May Updated Guidance Correctional Facilities)</td><td>4,893</td><td>2,778</td><td>88</td><td>15</td></tr>
<tr><td>The Marshall Project</td><td>29,251</td><td>7,435</td><td>415</td><td>33</td></tr>
</table>
</td></tr>
<tr><td colspan="2">Military</td></tr>
<tr><td>Case series of coronavirus (SARS-CoV-2) in a military recruit school: clinical, sanitary and logistical implications

Baettig, et al. 2020 (25)</td><td>

Setting: military recruit school.
The study conducted a retrospective review of COVID-19 cases among Swiss Armed Forces recruits.
A military recruit tested positive for SARS-CoV-2 and was put into isolation.
Quarantine was ordered for all recruits, a total of 55 people out of 140 in the company.
Seven out of nine recruits in one particular quarantine room became mildly symptomatic. One recruit was SARS-CoV-2 PCR positive.
Seven days after initial diagnosis, the index patient and the other one from quarantine retested positive for SARS-CoV-2, although they had been completely asymptomatic for over 96 hours.

</td></tr>
</table>

Source	Summary
Peer reviewed sources	
SARS-CoV-2 Infections and Serologic Responses from a Sample of U.S. Navy Service Members - USS Theodore Roosevelt, April 2020 (26)	• An investigation using a convenience sample of young, healthy US service members (n=385) experiencing close contact aboard an aircraft carrier which had a COVID-19 outbreak during deployment in January 2020. The outbreak expected to have caused 1,000 service members to be infected with SARS-CoV-2. • Among the participants, 60% had reactive antibodies, and 59% of those also had neutralising antibodies at the time of specimen collection, which was >40 days after symptom onset. One fifth of infected participants reported no symptoms. • Preventive measures, such as using face coverings and observing social distancing, reduced the risk of infection.
Choir practice	
High SARS-CoV-2 Attack Rate Following Exposure at a Choir Practice — Skagit County, Washington, March 2020 Hamner, et al. 2020 (43)	• Weekly report. • Settings: choir practice. • Following a choir practice attended by 61 people, including a symptomatic index patient, there were 32 confirmed and 20 probable secondary COVID-19 cases (attack rate = 53.3% to 86.7%); three patients were hospitalised and two died. • Transmission was likely facilitated by close proximity (within six feet) during practice and augmented by the act of singing.
Clusters of Coronavirus Disease in Communities, Japan, January–April 2020 Furuse, et al. 2020 (44)	• This was a study of COVID-19 cases in Japan reported during 15 January – 4 April 2020. • The primary source of the clusters were healthcare facilities and nursing homes, however it was noted that many COVID-19 clusters were associated with heavy breathing in close proximity, such as singing at karaoke parties, cheering at clubs, having conversations in bars, and exercising in gymnasiums.
Restaurant	
COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020 Lu, et al. 2020 (45)	• Letter • Setting: restaurant • During January 26–February 10, 2020, an outbreak of 2019 novel coronavirus disease in an air-conditioned restaurant in Guangzhou, China, involved 3 family clusters. • By February 5, a total of 9 others (4 members of the family, 5 members of two other families who sat at neighbouring tables at the restaurant become ill with COVID-19.
Fitness class	

Source	Summary
Peer reviewed sources	
Cluster of Coronavirus Disease Associated with Fitness Dance classes, South Korea Jang, et al. 2020 (46)	• Settings: Fitness dance classes. • During 24 days in Cheonan, South Korea, 112 people were infected with SARS-CoV-2 associated with fitness dance classes at 12 sports facilities. • Most (50.9%) cases were the result of transmission from instructors to fitness class participants; 38 cases (33.9%) were in-family transmission from instructors and students; and 17 cases (15.2%) were from transmission during meetings with co-workers or acquaintances.
Shopping mall	
Indirect Virus Transmission in Cluster of COVID-19 Cases, Wenzhou, China, 2020 Cai, et al. 2020 (42)	• On 20 January 2020, a 23-year-old man sought care at a hospital after 11 days of fever and headache. On 21 January, COVID-19 was confirmed for this patient and his co-worker. By 28 January, COVID-19 was confirmed for seven people from the same office. • During 19 January – 9 February, COVID-19 was diagnosed for seven mall staff from floors B1–3 and for 10 mall customers. Close contacts associated with the mall were traced, and COVID-19 was confirmed for 11 people. Sixteen patients had had direct contact with other patients or had gone shopping in the mall. The average incubation period was 7.3 (range 1–17) days.
Concerts	
Assessment of SARS-CoV-2 Transmission Among Attendees of Live Concert Events in Japan Using Contact Tracing Data Koizumi, et al. 2020 (52)	• Between 15-25 February 2020, a series of ‘Live House’ concert events were held in the Osaka, Japan. • 74 individuals who participated in one or more of the live house events were subsequently confirmed as SARS-CoV-2-positive by PCR. • Including secondary and tertiary cases, the live house events resulted in a total of 103 COVID-19 cases. Infected individuals ranged from being asymptomatic (21 total) to displaying one, or more symptoms (78 total). • Of the 74 primary cases identified, 48 (65%) were found in Osaka. The contact tracing data for these cases identified that 12 of the 48 primary cases (25%) transmitted the virus to 20 cases (secondary cases). Of those 20 secondary cases, six cases transmitted the virus to seven tertiary cases. • Of the 48 primary cases, the number of symptomatic and asymptomatic cases were 36 (75%) and 12 (25%) cases, respectively.
Call Centre	

Source	Summary
Peer reviewed sources	
Coronavirus Disease Outbreak in Call Center, South Korea Park, et al. 2020 (28)	• Epidemiologic characteristics of a COVID-19 outbreak in a call centre in South Korea. • 97 confirmed COVID-19 case-patients in one building, indicating an attack rate of 8.5%. • If restricting outbreak data to one side of the 11th floor, where most of the positive cases were detected, the attack rate is as high as 43.5%. • Despite considerable interaction between workers on different floors of the building in the elevators and lobby, spread of COVID-19 was limited almost exclusively to the 11th floor, which indicates that the duration of interaction (or contact) was likely the main facilitator for further spreading of SARS-CoV-2.

Table 2

Source	Summary
Grey literature	
Australian Health Protection Principal Committee (AHPPC) coronavirus (COVID-19) statements on 24 April 2020 Australian Government, Department of Health (1)	• There is limited evidence of transmission between children in the school environment; population screening overseas has shown very low incidence of positive cases in school-aged children. In Australia, 2.4 per cent of confirmed cases have been in children aged between 5 and 18 years of age (as at 6:00am, 22 April 2020). The Australian Health Protection Principal Committee believes that adults in the school environment should practice room density measures (such as in staff rooms) given the greater risk of transmission between adults.
COVID-19 in schools and early childhood education and care services – the Term 2 experience in NSW National Centre for Immunisation Research and Surveillance (35)	• An investigation of COVID-19 cases in schools and early childhood education and care services took place in NSW in Term 2, between 10 April and 3 July. Schools remained open throughout the term following a graded return to face-to-face teaching, with full face-to-face learning resuming by week 5 (25 May) of Term 2. Schools and early childhood education and care services were not required to follow all adult physical distancing guidelines but to follow good hygiene practices and additional cleaning in line with guidance from the Australian Health Protection Principal Committee and NSW Health. There were three primary schools, two high schools and one early childhood education and care service with primary cases of COVID-19, of which two were staff members and four were students or children. There were a total of 521 close contacts (62 adults and 459 students/children) with no evidence of secondary transmission.

Source	Summary
Grey literature	
Public Health Responses to COVID-19 Outbreaks on Cruise Ships — Worldwide, February–March 2020 Centres for Disease Control and Prevention, 2020 (24)	• A report published on 23 March describing public health responses to COVID-19 outbreaks on three cruise ships: Diamond Princess, Grand Princess and Nile River Cruises. • Overall, more than 800 cases of confirmed COVID-19 cases occurred during outbreaks on three cruise ship voyages, and cases linked to several additional cruises have been reported across the United States. Transmission occurred across multiple voyages from ship-to-ship by crew members; both crew members and passengers were affected; 10 deaths associated with cruise ships have been reported. Secondary community-acquired cases linked to return passengers on cruises have also been reported.
COVID-19 clusters and outbreaks in occupational settings in the EU/EEA and the UK European Centre for Disease Prevention and Control, 2020 (27)	• A report describing clusters of COVID-19 in a variety of occupational settings in the European Union, the European Economic Area and the United Kingdom. Large numbers of clusters were reported from the food packaging and processing sectors, in factories and manufacturing, and in office settings. Fewer clusters were reported from the mining sector, however some of these clusters have been large. • In the food packaging setting, two main categories were identified: indoor food processing (e.g. meat and fish processing and packaging; dairy production; bread and pastry production) and agricultural food production (e.g. fruit picking and other mainly outdoor processes). • Thirteen countries reported a total of 153 clusters and 3,820 cases. In addition, one country reported 36 cases without specifying the number of outbreaks, bringing the total number of cases to 3,856. • The countries with the highest number of cases in this sector were Ireland (1,154), Spain (1,016), the UK (450), the Netherlands (406), France (306), and Romania (275). Of the 153 clusters, 114 were in the food processing category (2,529 cases), while 26 were linked to agriculture, where a total of 1,016 cases were reported. Thirteen outbreaks were not classified.
Rapid Review: What is known about the risk of COVID-19 transmission across different indoor settings in the community such as restaurants and gyms? (3)	• This rapid review was produced to support public health decision-makers' response to the COVID-19 pandemic. • This review seeks to identify, appraise, and summarise emerging research evidence to answer: What is known about the risk of COVID-19 transmission across different indoor settings in the community? The review concludes that household and shared accommodation settings appear to be the most prevalent settings for clusters of infections or outbreaks to occur. However, certainty of evidence is low and findings are likely to change as more evidence becomes available.

Appendix

PubMed search terms

(((2019-nCoV[title/abstract] or nCoV*[title/abstract] or covid-19[title/abstract] or covid19[title/abstract] OR "covid 19"[title/abstract] OR "coronavirus"[MeSH Terms] OR "coronavirus"[title/abstract] OR sars-cov-2[title/abstract] OR "severe acute respiratory syndrome coronavirus 2"[Supplementary Concept]))

AND (("gathering*"[title] OR event*[title] OR "high-risk setting*"[title] OR "high risk setting*"[title] OR "restaurant*"[title] OR "choir*"[title] OR "gym"[title] OR "gymnasium*"[title] OR "fitness*"[title] OR "church*"[title] OR "religio*"[title] OR "worship*"[title] OR "club*"[title] OR mall*[title] OR shop*[title] OR café*[title] OR school*[title] OR education*[title] OR "day care*"[ti] OR daycare*[ti] OR "aged care*"[title] OR "boarding house*" OR stadium*[title] OR cinema*[title] OR theatre*[ti] OR abattoir*[ti] OR prison*[title] OR "orphanage*"[ti])))

AND (transmission* OR transmitted* OR outbreak* OR "attack rate*" OR exposure* OR cluster* OR superspread* OR spread*)

AND (2019:2020[pdat])

Google search terms

Transmission COVID 19 and (gathering or event or choir or gymnasium or worship or club or mall or shop or café or education or day care or boarding house or stadium or cinema or theatre or abattoir or orphanage) *searched individually.*

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