COVID-19 Living Rapid Review
Transmission Risk & Activities/Settings
Expedited Draft Summary #5

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Question

What is the risk of COVID-19 transmission associated with different activities (e.g., dining, exercising etc.) or settings (e.g., educational, hospitality etc.) and what factors contribute to risk (e.g., type of contact, number of contacts, time within the risk environment)?

How does transmission risk of common activities alter with background population prevalence of SARS-CoV-2 and population vaccine coverage?

Methods

A detailed peer-reviewed search strategy was developed by an information specialist in consultation with the review team. Electronic databases searched include MEDLINE and Embase. The initial search was conducted September 29, 2021, and updated on October 26, 2021, December 20, 2021, January 20, 2022, and February 21, 2022. No search update was performed in November due to librarian absence. A targeted search of the grey literature was conducted on January 20, 2022.

All reviewers independently conducted a training exercise based on 50 articles for title and abstract screening and 10 articles for full-text review before beginning study selection to ensure agreement between reviewers. One reviewer independently screened titles and abstracts and then full-text studies for relevant articles. For data extraction, all reviewers completed a training exercise based on 5 articles before beginning data extraction. One reviewer independently extracted data from included studies with a second reviewer verifying study inclusion and extracted data. Critical appraisals and analyses of the included studies have not been completed and will be available in the final manuscript.

Findings

For transmission risk of settings and activities, we present a visual summary of evidence in Table 1 followed by detailed individual study information further below.

The initial search retrieved 10,341 references. The October update added an additional 398 references, the December update added 930 references, the January update added 357 references, and the final update in February added 468 references. We also conducted a targeted search of the grey literature which added an additional 1,587 references for a total of 14,081 references included identified. From the 14,081 titles and abstracts reviewed, we excluded 12,236 references and reviewed 1,845 full-text articles of which **139 have been included**. **46 new studies** have been added since the previous report (see Version 4, 31 January 2022) and have been used to complete this expedited draft summary. Newly added items are highlighted in green throughout the report.

Table 1: Visual summary of evidence for transmission risk of COVID-19 and different settings and activities

Setting & Activity	References	Risk Level as reported by study author(s)	Preventative Measures	Time Period Studied
Accommodations				
Chalet	Previous[1]	High	NR	February 2020
Shared housing (e.g., dormitories)	**New**[2,3] Previous[4,5]	Unclear[2,3] Low[4], High[5]	masking, disinfection, accessibility of alcohol pumps, social distancing	July 2020 – May 2021
Dani	Previous[6]	Unclear[6]	NR	May - August 2021
Business				
Conference	Previous[7]	High	social distancing	March - April 2020
Education				
Kindergarten	Previous[6,8–17]	Unclear[6] Low[8–17]	Hand hygiene, mask wearing (adults)	June 2020 – August 2021
Primary schools	**New**[18–20] Previous[6,8,9,11–17,21–31]	Unclear[6] Low[8,9,11–31]	face masks; distancing; screening, handwashing, hybrid education, improved ventilation, bubbles	January 2020 – August 2021
Secondary schools	**New**[20] Previous[7,9,11–14,16,17,21,23–25,27–30,32]	Low	face masks; distancing; screening, handwashing, hybrid education, improved ventilation, bubbles	January 2020 - February 2021
University	**New**[33,34]	**Unclear**[34] **High**[33]	**face masks, social distancing, quarantine**	**August 2020 – November 2020**
Events and entertainment				
Social events[a]	**New**[35–37] Previous[6,38–45,45,46]	High	social distancing, **face masks**	April – June 2020
Weddings	Previous[7,47]	High	social distancing, public	March - April 2020

Setting & Activity	References	Risk Level as reported by study author(s)	Preventative Measures	Time Period Studied
			awareness of epidemic prevention and control	
Hospitality venues	Previous[7]	High	social distancing	March - April 2020
Shopping	**New**[48] Previous[6,39,49]	Unclear[39,49] Low (except convenience stores)[6] **High**[48]	social distancing, public awareness of epidemic prevention and control	January 2020 – August 2021
Healthcare				
Community healthcare	Previous[50]	Low	face masks	June 2020
Hospitals	**New**[51–56] Previous[38,39,49,56–82]	Unclear[38,39,49,54,57,66,77,79,80,82], Low[57,62,69–71,73,75,76,78], High[51–53,55,58–61,63–65,67,68,72,74,81]	face masks, hand hygiene, staff training, PPE, restricting visitors, environmental cleansing and disinfection, quarantine, testing, shorter shifts	March 2020 – March 2021
Specialty care[b]	Previous[68,83,84]	Low[83], Unclear[68,84]	face masks, hand hygiene, PPE, environmental cleansing and disinfection, quarantine	February 2020 – June 2020
Primary care	Previous[85]	High	Social distancing, wearing PPE, testing and contact tracing	March 2020 – June 2020
Healthcare workers (transmission to household)	**New**[86–88] Previous[77,89]	High	hand hygiene, face masks, physical distancing	March 2020 – June 2020
Healthcare workers (transmission to patients)	**New**[90] Previous[78]	Low	face masks and other infection control policies	October 2020 – April 2021

Setting & Activity	References	Risk Level as reported by study author(s)	Preventative Measures	Time Period Studied
Healthcare workers (transmission from patients)	**New**[45,91–99] Previous[100]	**High**[45,91–99] Unclear[100]	PPE, infection prevention programs	March – May 2020
Residential and long-term care	**New**[101] Previous[7,42,46,77,78,85,102–105]	High	face masks, hand hygiene, restricting visitors, physical distancing, enhanced cleaning	January – September 2020; March – April 2020
Hospitality				
Cruise ships	Previous[106]	High	ship based quarantine, enhanced health measures and access to onshore quarantine and isolation facilities	March 2020 – April 2020
Tour guides	Previous[107]	High	NR	January – March 2020
Waiter or bartenders	Previous[107]	Low	NR	January – March 2020
Cooks	Previous[107]	Low	NR	January – March 2020
Restaurants	**New**[108] Previous[6,45,49]	Unclear[108] Low[6] High[4,37]	contact tracing and quarantine, and early introduction of social distancing measures	January 2020 – August 2021
Household				
Family home	**New**[94,95,98,108–113] Previous[40,49,82,114,115]	Unclear[108,109,111,113,114] High[40,49,82,94,95,98,110,112,115]	public awareness of infection and control, hand hygiene, self-isolation	January 2020 – October 2020
Specialized services				
Dental	Previous[116]	Low	PPE	May – October 2020

Setting & Activity	References	Risk Level as reported by study author(s)	Preventative Measures	Time Period Studied
Personal care services[c]	Previous[45]	Medium	contact tracing and quarantine, and early introduction of social distancing measures	January – June 2020
Sports and activities				
Outdoor sports and activities	**New**[117–119] Previous[6,117,120–122]	Low[6,117–120], High[121,122]	quarantine for infected individuals, face masks, physical distancing, hygiene measures, **temperature checks**	July 2020 – August 2021
Indoor sports and activities	**New**[123–125] Previous[25]	High	Masks, social distancing, hand hygiene	September 2020 - December 2020
Camp[d]	Previous[31,126]	Low	screening, daily temperature checks, masks, hand hygiene, physical distancing, small cohorts, scheduled site cleanings, and staff COVID-19 education and workplace training	March – August 2020
Transportation				
Bus or metro	**New**[127] Previous[49]	High	public awareness of epidemic prevention and control, masks	January 2020 – November 2020
Flight travel	Previous[6,49,82,128–132]	High[49,82,129–131], Low[132], Unclear[6]	post-flight quarantine, contact-tracing,	January 2020– August 2021

Setting & Activity	References	Risk Level as reported by study author(s)	Preventative Measures	Time Period Studied
			distancing, masks	
Car sharing	Previous[6,82,133]	High[82,133], Low[6]	masking	January 2020-August 2021
Modes of transportation	**New**[48,54,94,98,109,125] Previous[6,38,42,134]	Unclear[6,38,54,98,109,125], Low[42], High[48,94,134]	Physical distancing, masking, hand hygiene	January 2020 – August 2021
Workplaces				
Construction labour	Previous[39,107,135]	High	NR	January – March 2020
Domestic housekeepers	Previous[107]	High	NR	January – March 2020
Drivers (e.g., car, taxi, van)	Previous[107]	High	NR	January – March 2020
Drivers (e.g., bus, train)	Previous[107]	Low	NR	January – March 2020
Processing plants	**New**[136] Previous[137]	**High**[136] Unclear	masking, testing, ventilation, physical barriers, distancing, disinfection	March-October 2020
Personal care workers	Previous[107]	Low	NR	January – March 2020
Receptionists	Previous[107]	Low	NR	January – March 2020
Salesperson	**New**[54,138] Previous[107,139]	High	Social distancing, masking	January – May 2020
Religious professionals	Previous[107]	High	NR	January – March 2020

Descriptive summaries of newly added studies

Accommodations

Shared housing (e.g., dormitories)

Currie et al. 2021[3] conducted an observational study in the Fall of 2020 describing a COVID-19 outbreak at the University of Wisconsin-Madison, Madison, Wisconsin, USA. During August-October 2020, a total of 3,485 students, including 856/6,162 students living in dormitories, tested positive. Case counts began rising during move-in week, August 25-31, 2020, then rose rapidly during September 1-11, 2020. Across all dormitories, 81.6% of residents had a roommate. Percentage **positivity was higher overall among students with roommates** (15.4%) than those without roommates (7.3%) ($p<0.0001$). The university initiated multiple prevention efforts, including quarantining 2 dormitories; a subsequent decline in cases was observed. Genomic surveillance of cases from Dane County, in which the university is located, did not find evidence of transmission from a large cluster of cases in the 2 quarantined dorms during the outbreak. Coordinated implementation of prevention measures can reduce COVID-19 spread in university settings and may limit spillover to the surrounding community.

Vang et al. 2021[2] conducted a cohort study August 21, 2020 to September 5, 2020 to assess the relationship between participation in university fraternity or sorority activities and the spread of COVID-19 among residential communities at university. A total of 965 confirmed and probable COVID-19 cases associated with university A were identified, with symptom onset occurring during August 20-September 5, 2020; 31% of the patients with these cases reported involvement in any fraternity or sorority activity. Network analysis identified 54 gatherings among all linkages of cases to places of residence and cases to events, 49 (91%) were linked by participation in fraternity and sorority activities accounting for 42 (72%) links among gatherings. On September 4, university A banned gatherings of ≥10 persons, and fraternity bid day was held virtually. The rapid increase in COVID-19 cases was **likely facilitated by on- and off-campus congregate living settings and activities**, and health departments should work together with student organizations and university leadership to ensure compliance with mitigation measures.

Education

Primary schools

For Falk et al. 2021, see Secondary Schools.

Edwards et al. 2021[18] conducted a prospective cohort study to assess rates of asymptomatic severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) positivity in K-8 schools and to evaluate SARS-CoV-2 transmission in school and household contacts of these positive individuals in the US. SARS-CoV-2 testing was performed on students and staff at K-8 private schools between January to March 2021. Among 11 K-8 private schools, 468 participants (346 students, 122 staff members) underwent screening testing. At the first school, 17 participants (36%) tested positive, but epidemiologic investigation suggested **against in-school transmission**. Only 5 participants in the subsequent 10 schools tested positive for an overall 4.7% positivity rate (1.2% excluding school 1). All but 1 positive test among in-person students had high PCR cycle threshold values, suggesting very low SARS-CoV-2 viral loads. In all schools, no additional students, staff, or household contacts reported new diagnoses or symptoms of COVID-19 during the 2 weeks following screening testing. As a result, infrequent asymptomatic COVID-19 in schools in high-risk Chicago communities **did**

not identify transmission among school staff, students, or their household contacts suggesting that COVID-19 mitigation procedures, including masking and physical distancing, are effective in preventing transmission of COVID-19 in schools.

Schoeps et al. 2021[19]conducted a surveillance study in Germany from August to December 2020 to provide estimates on the transmission risk of SARS-CoV-2 in schools and day-care centres by calculating secondary attack rates (SARs). Monitoring of 14 594 institutional high-risk contacts (89% PCR-tested) of 441 index cases during quarantine revealed 196 secondary cases (SAR 1.34%, 0.99-1.78). SARS-CoV-2 infection among **high-risk contacts** was more likely around **teacher-indexes** compared to student-/child-indexes (incidence rate ratio (IRR) 3.17, 1.79-5.59), and in day-care centres compared to secondary schools (IRR 3.23, 1.76-5.91), mainly due to clusters around teacher-indexes in day-care containing a higher mean number of secondary cases per index case (142/113 = 1.26) than clusters around student-indexes in schools (82/474 = 0.17). In 2020, SARS-CoV-2 transmission risk in educational settings was low overall but **varied strongly** between settings. Surveillance of SARS-CoV-2 transmission in educational institutions can powerfully inform public health policy and improve educational justice during the pandemic.

Secondary schools

Falk et al. 2021[20] conducted a surveillance study August 31, 2020 to November 29, 2020 to evaluate COVID-19 cases, spread, and compliance with mask use among 4,876 students and 654 staff members who participated in in-person learning in 17 K-12 schools in rural Wisconsin. School-attributable COVID-19 case rates were compared with rates in the surrounding community. School administration and public health officials provided information on COVID-19 cases within schools. During the study period, **widespread community transmission was observed**, with 7%-40% of COVID-19 tests having positive results. Masking was required for all students and staff members at all schools, and rate of reported student mask-wearing was high (>92%). COVID-19 case rates among students and staff members were lower (191 cases among 5,530 persons, or 3,453 cases per 100,000) than were those in the county overall (5,466 per 100,000). Among the 191 cases identified in students and staff members, one in 20 cases among students was linked to in-school transmission; no infections among staff members were found to have been acquired at school. These findings suggest that, with proper mitigation strategies, K-12 schools might be capable of opening for in-person learning with minimal in-school transmission of SARS-CoV-2.

University

Valesano et al. 2021[34] conducted a prospective surveillance study from 16 August, 2020 to 24 November, 2020 to evaluate the extent of transmission between students at the University of Michigan and the community. The authors sequenced complete severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) genomes from 1659 individuals, including 468 students, representing 20% of cases in students and 25% of total cases in Washtenaw County over the study interval. Phylogenetic analysis identified >200 introductions into the student population, most of which were not related to other student cases. There were 2 prolonged student transmission clusters, of 115 and 73 individuals, that spanned multiple on-campus residences. Remarkably, <5% of nonstudent genomes were descended from student clusters, and viral descendants of student cases were rare during a subsequent wave of infections in the community. In conclusion, the largest outbreaks among **students at the University of Michigan did not significantly contribute to the rise in community cases** in Fall 2020. These results provide valuable insights into SARS-CoV-2 transmission dynamics at the regional level.

Denny et al. 2021[33] conducted a surveillance study August 2, 2020 to October 11, 2020 at Duke University, a in Durham, North Carolina. The university implemented a five-to-one pooled testing program for SARS-CoV-2 using a quantitative, in-house, laboratory-developed, real-time reverse transcription-polymerase chain reaction (RT-PCR) test. By September 20, 2020, asymptomatic testing was scaled up to testing targets, which include testing for residential undergraduates twice weekly, off-campus undergraduates one to two times per week, and graduate students approximately once weekly. During August 2-October 11, 68,913 specimens from 10,265 graduate and undergraduate students were tested. Eighty-four specimens were positive for SARS-CoV-2, and 51% were among persons with no symptoms. Testing because of contact tracing identified 27.4% of infections. A combination of risk-reduction strategies and frequent surveillance testing likely contributed to a prolonged period of **low transmission on campus**. These findings highlight the importance of combined testing and contact tracing strategies beyond symptomatic testing, in association with other preventive measures.

Events and entertainment

Social events

Kang et al. 2020[35] conducted a contact tracing study from April 30, 2020 to May 6, 2020 to evaluate individuals who had visited any of the 5 major nightclubs in Seoul, South Korea. 5,517 individuals were identified for screening; of which, 1,257 were actively monitored. Overall, 246 cases of coronavirus disease (COVID-19) have been linked to nightclubs in Seoul, South Korea. During the April 30-May 5 holiday, young adults from across the country who **visited nightclubs in Seoul contracted COVID-19 and spread it nationally**. Nightclubs were temporarily closed to limit COVID-19 spread.

Delaugerre et al. 2021[36] conducted a randomized-controlled trial from May 11, 2020 to May 25, 2020 to assess whether infection rates among attendees at a large, indoor gathering event would be similar to those in non-attendees, given implementation of a comprehensive prevention strategy. The non-inferiority, prospective, open-label, randomised, controlled SPRING trial was done on attendees at a live indoor concert held in the Accor Arena on May 29, 2021 in Paris, France. Participants were randomly allocated in a 2:1 ratio to the experimental group (attendees) or to the control group (non-attendees). The primary outcome measure was the number of patients who were SARS-CoV-2-positive by RT-PCR test on self-collected saliva 7 days post-gathering in the per-protocol population (non-inferiority margin <0.35%). 18 845 individuals registered on the dedicated website, and 10 953 were randomly selected for a pre-enrolment on-site visit. Among 6968 who kept the appointment and were screened, 6678 participants were randomly assigned (4451 were assigned to be attendees and 2227 to be non-attendees; median age 28 years; 59% women); 88% (3917) of attendees and 87% (1947) of non-attendees complied with follow-up requirements. The day 7 RT-PCR was positive for eight of the 3917 attendees (observed incidence, 0.20%; 95% CI 0.09-0.40) and three of the 1947 non-attendees (0.15%; 0.03-0.45; absolute difference, 95% CI -0.26% to 0.28%), findings that met the non-inferiority criterion for the primary endpoint. Participation in a large, indoor, **live gathering without physical distancing was not associated with increased SARS-CoV-2-transmission risk,** provided a comprehensive preventive intervention was implemented. FUNDING: French Ministry of Health.

Whaley et al. 2021[37] conducted a cross-sectional study between January 1, 2020 and November 8, 2020 to assess the association between social gatherings and SARS-CoV-2 transmission by studying whether COVID-19 rates increase after birthdays in a household. The study used nationwide data from 2.9 million US households with private insurance to compare COVID-19 infections between

households with and without a birthday in the preceding 2 weeks, stratified according to county-level COVID-19 prevalence in that week and adjusting for household size and both week- and county-specific differences. Among the 2.9 million households in the study, in the top decile of counties in COVID-19 prevalence, households with a birthday in the 2 weeks prior had 8.6 more diagnoses per 10 000 individuals (95% CI, 6.6-10.7 per 10 000 individuals) compared with households without a birthday in the 2 weeks prior, a relative increase of 31% above the county-level prevalence of 27.8 cases per 10 000 individuals, vs 0.9 more diagnoses per 10 000 individuals (95% CI, 0.6-1.3 per 10 000 individuals) in the fifth decile (P < .001 for interaction). No differences were found by milestone birthdays, county political leaning, precipitation, or shelter-in-place policies. The study suggests that **birthdays were associated with increased rates of diagnosed COVID-19 infection within households** in counties with high COVID-19 prevalence.

Shopping

Susan et al. 2021[48] conducted a cohort study to identify which non-household activities increased risk of acquisition of COVID-19 infection and which accounted for the greatest proportion of non-household acquired COVID-19 infections during the second wave of the pandemic. Based on analysis of 10475 adult participants including 874 infections acquired outside the household, infection was independently associated with: leaving home for work (AOR 1.20 (1.02 - 1.42) p=0.0307, APAF 6.9%); public transport use (AOR for use more than once per week 1.82 (1.49 - 2.23) p<0.0001, APAF for public transport 12.42%); and shopping (AOR for shopping more than once per week 1.69 (1.29 - 2.21) P=0.0003, APAF for shopping 34.56%). Other non-household activities such as use of hospitality and leisure venues were rare due to restrictions and there were no significant associations with infection risk. Going to work was an important risk factor for infection but **public transport use likely accounted for a lot of this risk**. Only a minority of the cohort left home for work or used public or shared transport. By contrast, most participants visited shops and this activity accounted for about one-third of non-household transmission.

Healthcare

Hospitals

Dimcheff et al. 2021[51] conducted a serologic survey between June 8, 2020 to July 8, 2020 to assess potential risk factors for transmission and infection. Of the 2,900 employees, 51% participated in the study, revealing a positive SARS-CoV-2 seroprevalence of 4.9% (72 of 1,476; 95% CI, 3.8%-6.1%). There were no statistically significant differences in the presence of antibody based on gender, age, frontline worker status, job title, performance of aerosol-generating procedures, or exposure to known patients with COVID-19 within the hospital. Employees who reported exposure to a known COVID-19 case outside work had a significantly higher seroprevalence at 14.8% (23 of 155) compared to those who did not 3.7% (48 of 1,296; OR, 4.53; 95% CI, 2.67-7.68; P < .0001). Notably, 29% of seropositive employees reported no history of symptoms for SARS-CoV-2 infection. Employees who reported direct personal contact with COVID-19-positive persons outside work were more likely to have SARS-CoV-2 antibodies. **Employee exposure to SARS-CoV-2 outside work may introduce infection into hospitals.**

Oliveira et al. 2021[52] conducted a prospective cross-sectional study to evaluate the seroprevalence of SARS-CoV-2 and risk factors among 1,996 oligo/asymptomatic health care workers. The seroprevalence was 5.5% and risk factors associated with being infected with SARS-CoV-2 was professional category of cleaning (adj odds ratio 2.22, 95% confidence interval: 1.12-4.44, P: .023) and male gender (adj odds ratio: 1.54, 95% confidence interval: 1.03-2.32, P: .035). **Working at**

dedicated COVID-19 units (high-risk group) was not an independent risk factor for seropositivity.

Lai et al. 2021[53] conducted a case-series study between January 1, 2020 to February 9, 2020 to explore infection risk and clinical characteristics of HCWs with COVID-19 and to discuss possible prevention measures. Data from 9684 HCWs in Tongji Hospital, Wuhan, China were reviewed. Overall, 110 of 9,684 HCWs in Tongji Hospital tested positive for COVID-19, with an infection rate of 1.1%. Seventeen (15.5%) worked in fever clinics or wards, indicating an infection rate of 0.5% (17 of 3110) among first-line HCWs. A total of 93 of 6,574 non-first-line HCWs (1.4%) were infected. The prevalence of subclinical infection was 0.74% (1 of 135) among asymptomatic first-line HCWs and 1.0% (2 of 200) among non-first-line HCWs. Overall, 93 of 110 HCWs (84.5%) with COVID-19 had non-severe disease, while 1 (0.9%) died. Contact with indexed patients (65 [59.1%]) and colleagues with infection (12 [10.9%]) as well as community-acquired infection (14 [12.7%]) were the main routes of exposure for HCWs. In this study, most infections among HCWs occurred during the early stage of disease outbreak. **That non-first-line HCWs had a higher infection rate than first-line HCWs differed from observation of previous viral disease epidemics.** Rapid identification of staff with potential infection and routine screening among asymptomatic staff could help protect HCWs.

Sierpinski et al. 2021[54] conducted cross-sectional study in Poland from April 17-18, 2020 to survey patients with mild COVID-19 who remained in home isolation, and analyze the sources and occupational risk factors for SARS-CoV-2 infection. Of the 4,878 patients in home isolation, the authors were able to contact 3313. Of them, 1,191 patients declined their invitation, and 2122 agreed to take part. Most patients (92%) had not been abroad before the infection. More than half (55%) knew how they became infected; of them, 75% became infected at work. Of all patients, 70% were occupationally active. Nearly half of the occupationally active patients (48%) worked in healthcare, 3% worked in public administration or defense, 3% worked in transportation, and 2% worked in education. Sixty-five percent of the occupationally active patients worked in companies with >100 employees.Most of the patients with COVID-19 in home isolation were occupationally active, wherein the majority of people who were aware of the source of SARS-CoV-2 infection worked in healthcare. As most of the infected patients worked in companies with >100 employees, which is not a Polish employment pattern, the authors expect that **smaller companies may have a lower risk of SARS-CoV-2 infections**..

Pandrowala et al. 2021[55] conducted cohort study from March 2020 to August 2020 to evaluate whether HCWs at the frontline of COVID-19 response in a pediatric hospital are at an increased risk of acquiring SARS-CoV-2. COVID-19 cases in our HCWs cohort rose and declined parallel to community cases. Forty two out of 534 HCWs (8%) were SARS-CoV-2 positive with no fatalities. No clinical staff in the special COVID ward or ICU was positive. Significant proportion of non-clinical staff (30%) were SARS-CoV-2 positive. About 70% of SARS-CoV-2 positive staff had likely community acquisition, with a significant proportion having travelled by public transport or having a contact history with a positive case in the community. Twenty four percent of positive staff were asymptomatic and detected positive on re-joining test. Sustained transmission of SARS-CoV-2 did not occur in our cohort beyond community transmission. Appropriate PPE use, strict and constantly improving infection control measures and testing of both clinical and non-clinical staff were essential methods for restricting transmission amongst HCWs.

Jung et al. 2021[56] conducted a contact tracing study to evaluate the risk of transmission at hospital staff cafeterias. From January 2020 through September 2021, authors analyzed the risk of SARS-CoV-2 transmission through closed-circuit television and radio-frequency identification tracking and

follow-up testing when 33 HCWs, who were eventually diagnosed as coronavirus disease 2019 (COVID-19), ate in staff cafeterias during the infectious period. Three of the 119 individuals who ate at seats next (about 30 cm) to index during the period of transmission and underwent follow-up SARS-CoV-2 polymerase chain reaction tests were diagnosed with COVID-19 (2.5%; 95% confidence interval, 0.5-7.4%). Among the 98 HCWs who were investigated about talking during meals, there was a higher attack rate among those who spoke with each other than among those who did not (12.5% [3/24] vs. 0% [0/74], P = 0.013). Overall, **the risk of transmission in a hospital's employee cafeterias is not high with side-by-side seating, especially in the absence of conversation**.

Healthcare workers (transmission to household)

Barry et al. 2021[87] conducted a retrospective cohort study in a tertiary care cardiac center in the Kingdom of Saudi Arabia (KSA) from 2 March to 31 December 2020, to determine the frequency, mode of transmission, and outcome of Coronavirus Disease 2019 (COVID-19) among healthcare workers (HCWs). 4462 patients tested for COVID-19 by real-time reverse transcriptase-polymerase chain reaction (RT-PCR), 203 (4.5%) HCWs were positive; of these, 125 (61.6%) were males, and the most common age group was < 40 years. The majority (184, 90.6%) of the HCWs contracted COVID-19 in the **community**, and only 19 (9.4%) were healthcare-associated infections. In the largest tertiary cardiac center in KSA, most HCWs who contracted COVID-19 developed mild symptoms; nurses and those aged <40 years were most infections were acquired in the community.

Mansoor et al. 2021[88] conducted a contact tracing study of infected HCWs from March 1, 2020, to July 31, 2020, at a tertiary care center in New Delhi, India, to provide a descriptive audit of healthcare workers (HCWs) exposed to COVID-19, and their contacts, to understand the dynamics of transmission among HCWs. Qualitative RT-PCR testing was performed on 106 HCWs (from a total of 257) owing to exposure or development of symptoms. Positive results were found in 16 HCWs (6.2%) who were exposed to 120 other HCWs, generating 197 exposure incidents. Of these, 30 (15.2%) exposure incidents were **high risk** with **multiple exposures** in 48 (40.0%) HCWs. **Exposure to infected HCWs** was noted in 3 (18.8%) of 16 positive cases. Of the 197 exposure incidents, 54 (27.4%) were deemed avoidable exposures. Infection prevention and control policies were periodically reviewed, and the department implemented mitigating steps to minimize the risk to healthcare providers. Instituting appropriate infection prevention and control policies and the use of adequate precautions by HCWs is vital to minimize high-risk exposure to COVID-19.

Healthcare workers (transmission to patients)

Baker et al. 2021[90]conducted a cohort study between March to June 2020 in an academic medical center in Boston, US to characterize the risk of COVID-19 transmission among patients exposed to HCWs with confirmed COVID-19. There were 226 patients exposed to healthcare workers with confirmed COVID-19. One patient may have been infected, suggesting that the risk of COVID-19 transmission from healthcare workers to patients is generally **low**.

Healthcare workers (transmission from patients)

Aydin et al. 2021[99] conducted a retrospective cohort study among healthcare workers (HCW) employed by the Umraniye Research and Training Hospital, Turkey and who were diagnosed with COVID-19 between 20 March 2020 to 20 May 2020. The aim of this study was to research the COVID-19 risks due to occupational exposure to HCW and the clinical characteristics of the affected. A total of 128 (3.8%) HCWs were diagnosed with COVID-19 including medical staff

(34%), nurses (24%), physicians (22%) and staff with no patient contact (20%). 56% of the infected HCWs were working in COVID-19 wards and out-patient clinics. 29% percent acquired the infection in hospital from an index patient and 32% of them from an infected HCW. The highest transmission was during the s**haring of the same environment** (53%). 13% of the HCW took the virus during examination or treatment, and 31% of the individuals were unaware of the transmission. The symptomatic cases were more (88%) than the asymptomatic cases (12%). A total of 28 (22%) HCWs were hospitalized and only 4% of the cases were severe. The a**symptomatic COVID-19** carrying HCW are to be considered as the **source of the spread** of the disease among their colleagues. Stricter measures should be implemented to prevent in-hospital transmission.

Bahrs et al. 2021[92] conducted a prospective cohort study between 19th May and 19th June 2020, at the Jena University Hospital (JUH), Germany, to assess SARS-CoV-2 IgG seroprevalence, individual exposure risk factors and compliance of HCWs to wear personal protective equipment (PPE). Researchers evaluated point seroprevalence using two IgG detecting immunoassays and issued a questionnaire to assess COVID-19 exposure, clinical symptoms and compliance to wearing PPE. Among 660 participants [out of 3,228; 20.4%], 212 participants (32.1%) had received a previous COVID-19 test. Four of them (1.9%) reported a positive test result. Overall, 21 participants (3.2%) had any evidence of a past or current SARS-CoV-2 infection. Among them, 13 (61.9%) were not aware of direct COVID-19 exposure and 9 (42.9%) did not report any clinical symptoms. COVID-19 **exposure at home** (adjusted OR (aOR) with 95% CI: 47.82 (5.49, 416.62)) was **associated with SARS-CoV-2 seroprevalence**. No evidence for an association between seroprevalence and exposure at work (aOR 0.48 (0.13, 1.70)) or with COVID-19 risk area according to the working place (aOR for intermediate-risk vs. high-risk: 1.97 (0.42, 9.22), aOR for low risk versus high-risk: 2.10 (0.40, 11.06); $p = .655$). Reported compliance of HCWs to wear PPE differed ($p < .001$) between working in high-risk (98.3%) and in intermediate-risk areas (69.8%). In conclusion, compared to administration staff, no additional risk to acquire SARS-CoV-2 infections by patient care was seen, probably due to high compliance to wearing PPE.

Heinzerling et al. 2020[93]conducted a cohort study to characterize and compare exposures among HCWs who did and did not develop COVID-19 on exposure to a hospitalized index patient on February 26, 2020, in Solano County, California. Among 121 health care personnel (HCP) who were exposed to the patient, 43 (35.5%) developed symptoms during the 14 days after exposure and were tested for SARS-CoV-2; three had positive test results and were among the first known cases of probable occupational transmission of SARS-CoV-2 to HCP in the United States. Standardized interviews were conducted with HCPs who were tested for SARS-CoV-2, including the three who had positive test results. Performing physical examinations and exposure to the patient during nebulizer treatments were more common among HCP with laboratory-confirmed COVID-19 than among those without COVID-19; HCP with COVID-19 also had exposures of longer duration to the patient. Because transmission-based precautions were not in use, no HCP wore personal protective equipment (PPE) recommended for COVID-19 patient care during contact with the index patient. Health care facilities should emphasize early recognition and isolation of patients with possible COVID-19 and the use of recommended PPE to minimize unprotected, high-risk HCP exposures and protect the health care workforce.

Squeri et al. 2020[94]conducted a surveillance study from March 9 to June 19, 2020, in a university hospital in Italy, to a) describe the importance of correct management of SARS-CoV-2 infections; b) report the number of positive healthcare workers after the epidemic phase and describe their socio-characteristics data, the main methods of transmission and the symptoms; c) to report the seroconversion rate of healthcare workers (HCWs).) In the first phase, we implemented the guidelines to be followed for patient care in our hospital; 2) In the second phase, we provided the

epidemiological investigation/contact tracing of HCWs; 3) we collected swabs on all healthcare workers, and we also performed serological investigation. The number of healthcare workers under surveillance is 2611 subjects and, of these, only 0.65% contracted COVID-19. 70.6% of these have been infected in the **healthcare setting**, 11, 8% in the **family** and 17.6% returning from **high-risk areas**. Ultimately, only 0.1% of HCWs dedicated to the treatment of COVID-19 patients contracted the infection (one was asymptomatic). Only 2% of HCWS were positive for serological investigation.

Wang et al. 2021[91] conducted a surveillance study between 5 January and 12 February 2020 to analyze data from healthcare workers with nosocomial infections in Wuhan Union Hospital (Wuhan, China) and their family members. The data on exposure history, illness timelines and epidemiological characteristics from 25 healthcare workers with laboratory-confirmed coronavirus disease 2019 (COVID-19) and two healthcare workers in whom COVID-19 was highly suspected, as well as 10 of their family members with COVID-19, were investigated and viral RNA of 12 cases were sequenced and analyzed. Nine clusters were found among the patients. The mean period of incubation was 4.5 days, the mean+/-sd clinical onset serial interval (COSI) was 5.2+/-3.2 days, and the median virus shedding time was 18.5 days. Complete genomic sequences of 12 different coronavirus strains demonstrated that the viral structure, with small irrelevant mutations, was stable in the transmission chains and showed remarkable traits of infectious traceability. SARS-CoV-2 can be **rapidly transmitted from person to person**, regardless of whether they have symptoms, in both **hospital settings and social activities**, based on the short period of incubation and COSI. The public health service should take practical measures to curb the spread, including isolation of cases, tracing close contacts, and containment of severe epidemic areas. Besides this, healthcare workers should be alert during the epidemic and self-quarantine if self-suspected of infection.

Pinarlik et al. 2021[95] conducted a cohort study between May 2020 and December 2020 to detect the risk factors for SARS-CoV-2 infection among healthcare workers (HCWs) in 2020 before the vaccination era. Occupational and non-occupational potential predictors of disease were surveyed for the HCWs included in this study. Among 1925 personnel in the hospital, 1732 were included to the study with a response rate of 90%. The overall infection rate of HCWs was 16.3% at the end of 2020, before vaccinations started. In the multivariate analysis, being janitorial staff (OR: 2.24, CI: 1.21-4.14, $p = 0.011$), being a medical secretary (OR: 4.17, CI: 2.12-8.18, $p < 0.001$), having at least one household member with a COVID-19 diagnosis (OR: 8.98, CI: 6.64-12.15, $p < 0.001$), and number of household members > 3 (OR: 1.67, CI: 1.26-2.22, $p < 0.001$) were found to be significantly associated with SARS-CoV-2 infection. The community-hospital gradient can explain the mode of transmission for infection among HCWs. In the setting of this study, community measures were less strict, whereas hospital infection control was adequate and provided necessary personal protective equipment. Increasing risk in larger households and households with diagnosed COVID-19 patient indicates the **community-acquired transmission** of the infection.

Su et al. 2021[96] conducted a cohort study from January 14 to March 7,2020 to estimate the hospital attack rate of coronavirus disease 2019 (COVID-19) and the stratified basic reproduction number of its causative agent severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in a hospital setting in Taiwan. A total of 138 healthcare workers (HCWs) in a hospital who were exposed to COVID-19 within a patient household were divided into two groups, based on their exposure level. The estimated attack rate and the reproduction number were calculated. Compared with the "low-risk" exposure group, the "high-risk" exposure group was less likely to have used partial PPE, and more likely to have had contact time >1 hour, performed "aerosol-production" tasks, and developed symptoms during quarantine. None of the HCWs in either group acquired COVID-19. All HCWs wore surgical masks and performed routine environmental disinfection. Estimated reproduction

number was 1.46 and 0 for household and HCW models, respectively, implying that **the index patient did not transmit** COVID-19.

Wong et al. 2021[86] conducted a cross-sectional study from 23 January and 17 April 2020 to describe the characteristics of healthcare workers (HCWs) infected with COVID-19 and to examine their sources of exposure. Occupation of HCWs was categorized into six categories. Their job nature was classified into "frontline", or "back-end" based on the frequency of direct patient contact, and source of exposure was classified as family/household, social interaction or workplace. A total of 88 (1.7%) HCWs were identified from 5,050 cases. About 81.8% acquired the infection locally, of which 40.3% did not have a clearly identifiable source of exposure. Exposure from the family/household was most common (27.8%), followed by workplace (16.7%) and social interaction (15.3%). All HCWs were discharged well with no mortality; three (3.4%) were ever admitted to intensive care unit and required increased care. Healthcare workers accounted for a small proportion of COVID-19 cases in Singapore with favourable outcomes. The possibility of **transmission resulting from family/household exposure and social interactions** highlights the need to always maintain strict vigilance and precautionary measures beyond the workplace.

Contejean et al. 2021[97] conducted a prospective cohort study from 24 February, 2020 until 10 April, 2020 to compare a 1500-bed adult and 600-bed pediatric setting of a tertiary-care university hospital located in central Paris. HCWs who screened positive were questioned on their profession, symptoms, and occupational and nonoccupational exposures to SARS-CoV-2. Among 1344 HCWs tested, 373 were positive (28%) and 336 (90%) corresponding questionnaires were completed. Three hospitalizations and no deaths were reported. Most HCWs (70%) had patient-facing occupational activities (22% in COVID-19 dedicated units). Attack rates were of 3.2% and 2.3% in the adult and pediatric settings, respectively (P=.0022). In the adult setting, HCWs more frequently reported exposure to COVID-19 patients without PPE (25% vs 15%, P=.046). Report of contacts with children attending out-of-home care facilities dramatically decreased over the study period. Universal masking, reinforcement of hand hygiene, and PPE with medical masks for patients' care allowed protection of HCWs and containment of the outbreak. Residual transmissions were related to **persistent exposures with undiagnosed patients** or colleagues and not to contacts with children attending out-of-home care facilities.

Nygren et al. 2021[98] conducted a cross-sectional study from 8 September, 2020 to 10 November, 2020 to investigate the association between questionnaire answers on potential exposure situations and SARS-CoV-2-positivity in HCWs. HCWs with and without COVID-19-patient contact at nine units at University Hospitals in Sweden and university employees from Lund University, Sweden were enrolled. SARS-CoV-2-positivity was detected in 11/51 (22%) health care workers in COVID-19-units, 10/220 (5%) in non-COVID-19-units and 11/192 (6%) University employees (p =.001, Fischer's exact). In health care workers, SARS-CoV-2-positivity was associated with work in a designated COVID-19-unit (OR 5.7 (95CI 2.1-16)) and caring for COVID-19-patients during most shifts (OR 5.4 (95CI 2.0-15)). In all participants, SARS-CoV-2-positivity was associated with a confirmed COVID-19 case (OR 10 (95CI 2.0-45)) in the household. The study confirmed previous findings of elevated risk of acquiring SARS-CoV-2 in health care workers in COVID-19-units, despite exclusion of units with known outbreaks. Interestingly, **HCWs in non-COVID-19-units had similar risk as university employees.**

Residential and long-term care

Kevin et al. 2021[101] conducted a retrospective cohort study from March 29 to May 20, 2020 to develop a reproducible index of nursing home crowding and determine whether crowding was

associated with incidence of COVID-19 in the first months of the COVID-19 epidemic. Over 78,000 residents of 618 distinct nursing homes in Ontario, Canada were identified. Of 623 homes in Ontario, complete information on 618 homes (99%) housing 78,607 residents was obtained. A total of 5,218 residents (6.6%) developed COVID-19 infection, and 1,452 (1.8%) died with COVID-19 infection as of May 20, 2020. The crowding index ranged across homes from 1.3 (mainly single-occupancy rooms) to 4.0 (exclusively quadruple occupancy rooms); 308 (50%) homes had high crowding index (>=2). Incidence in high crowding index homes was 9.7%, versus 4.5% in low crowding index homes (p<0.001), while COVID-19 mortality was 2.7%, versus 1.3%. The likelihood of COVID-19 introduction did not differ (31.3% vs 30.2%, p=0.79). After adjustment for regional, nursing home, and resident covariates, the crowding index remained associated with increased risk of infection (RR=1.72, 95% Confidence Interval [CI]: 1.11-2.65) and mortality (RR=1.72, 95%CI: 1.03-2.86). Propensity score analysis yielded similar conclusions for infection (RR=2.06, 95%CI: 1.34-3.17) and mortality (RR=2.09, 95%CI: 1.30-3.38). Simulations suggested that converting all 4-bed rooms to 2-bed rooms would have averted 988 (18.9%) infections of COVID-19 and 271 (18.7%) deaths. **Crowding was associated with higher incidence of COVID-19 infection and mortality.**

Hospitality

Restaurants

Ogata et al. 2021[108] conducted a cohort study to investigate the settings of coronavirus disease 2019 transmission in Tsuchiura in November 2020. The study assessed Tsuchiura City residents diagnosed with severe acute respiratory syndrome coronavirus 2 infection. To establish the setting of each transmission, study authors defined the first known setting of transmission in each epidemiological link of transmission as the "index setting of transmission." We were able to ascertain the transmission settings in 160 (85%) of the 188 cases with COVID-19, which were as follows: house (38%), restaurant (34%), workplace (12%), care facility for the elderly or disabled patients (7%), another prefecture (6%), and other contact settings (4%). Restaurant was the index setting of transmission in 54% of the cases. **Restaurant was found to be the setting of transmission in one third and the index setting of transmission in half the Tsuchiura residents** infected with COVID-19 in November 2020.

Household

Family home

For Squeri et al.[94], Pinarlik et al.[95], and Nygren et al.[98], see Healthcare workers (transmission from patients).

For Ogata et al.[108] see Restaurants.

Meyer et al. 2021[109] conducted a retrospective cohort to explore the transmission of the coronavirus disease 2019 (COVID-19) in severely ill patients and analysed the relationship between co-morbidity and mortality or the need for intensive care unit (ICU) care. 101 consecutive patients with COVID-19 admitted to a regional Danish hospital were analyzed. In-hospital mortality was 30%, and 20% of the patients were offered ICU care. In ICU patients, we found a male preponderance (88% versus 44%, p = 0.006), but death (50% versus 25%, p = 0.053) and other pre-defined co-morbidities did not differ significantly from non-ICU patients. The source of infection

was unknown in 74% of patients, related to endemic travel in 10%, hospital acquired in 6% and related to close acquaintances in 11%. The frequency of co-morbidity in hospital-admitted COVID-19 patients and the correlation to death and ICU attendance were analysed. In all, 74% of the infection cases were of unknown source during the first weeks of the epidemic, which points to considerable **community transmission and possibly pre- or asymptomatic transmission**, also several weeks before 21 February 2020.

Le et al. 2021[113] conducted a surveillance study from January to February 2020 to analyzed 2 clusters of 12 patients in Vietnam with severe acute respiratory syndrome coronavirus 2 infection. Analysis indicated virus transmission from a traveler from China. One asymptomatic patient demonstrated virus shedding, indicating potential virus transmission in the absence of clinical signs and symptoms. The study found **limited community transmission** of SARSCoV-2 in Vietnam, and data indicated that viremic travelers may pose a risk for introduction of virus strains that could potentially lead to outbreak within a local community

Schepers et al. 2021[110] conducted a surveillance study from August to November 2020 to evaluate the details of SARS-CoV-2 household transmission by analyzing individual case and cluster data from statutory notifications in Rhineland. During the study period, 18,695 PCR-confirmed SARS-CoV-2 cases were notified, 3,642 of which occurred in 911 clusters (private households (67.3%), the workplace (7.8%), elderly homes (1.8%), others (23.2%). Demographically, clustered cases were representative of all notified cases. Two-thirds (77/113, 68%) of sample response clusters involved more than one private household. These caused on average more close contact persons (mean 13.5, +/-SD 15.8) and secondary cases (3.9, +/-SD 0.4) than clusters involving one household only (5.1 +/- 13.8 and 2.9 +/- 0.2). About one in six multi-household clusters in the private setting (13/77) followed a social gathering (e.g., birthday party). Breaches of one or more of the three major barrier concepts (mask, ventilation, and distance) were identified in most (10/13) of these social gatherings. SARS-CoV-2 clusters following social gatherings were overrepresented during the second half of the study period. In times of increasing infectious pressure in each population, **multi-household social gatherings appear** to be an important target for reducing SARS-CoV-2 transmission.

Xiaoke et al. 2021[111] conducted a cohort study from January 20 to February 19, 2020. The authors investigated infection events and transmission clusters of SARS-CoV-2 for estimating epidemiological characteristics at household and non-household settings. 9,120 confirmed cases of SARS-CoV-2 infections reported online by 264 Chinese urban Health Commissions in 27 provinces were examined. In total 34 primary cases were identified as super spreaders, and 5 **household super-spreading** events were observed. The risk of being infected outside of households is higher for age groups between 18 and 64 years, whereas the hazard of being infected within households is higher for age groups of young (<18) and elderly (>65) people. The identification of super-spreading events, short serial intervals, and a higher risk of being infected outside of households for male people of age between 18 and 64 indicate a significant barrier to the case identification and management, which calls for intensive non-pharmaceutical interventions (e.g. cancellation of public gathering, limited access of public services) as the potential mitigation strategies.

Choi et al. 2021[112] conducted a prospective cohort study from April 12 to June 30, 2021. They prospectively studied SARS-CoV-2 transmission at schools in an era of Variants of Concern (VoCs), offering all close contacts serial viral asymptomatic testing up to 14 days. Of 229 school close contacts, 3 tested positive (1.3%), of which 2 were detected through asymptomatic testing. Most secondary transmission (90%) occurred in **households**. Routine asymptomatic testing of close contacts should be examined in the context of local testing rates, preventive measures, programmatic costs, and health impacts of asymptomatic transmission.

Sports and activities

Outdoor sports and activities

Ben et al. 2021[119] conducted a contact tracing study in England from 1st July to 4th October, 2020. They evaluated the interactions between SARS-CoV-2 positive players and other players during Super League **rugby matches**, to determine the risk of in-game SARS-CoV-2 transmission. Eight SARS-CoV-2 positive players were involved in up to 14 tackles with other individual players. SARS-CoV-2 positive players were within a 2 m proximity of other players for up to 316 secs, from 60 interactions. One identified contact returned a positive SARS-CoV-2 result within 14 days of the match (subsequently linked to an outbreak within their club environment, rather than in-match transmission), whereas the other 27 identified contacts returned negative SARS-CoV-2 follow up tests and no one developed COVID-19 symptoms. Ninety-five players returned negative and five players returned positive SARS-CoV-2 RT-PCR routine tests within 14 days of the match. Sources of transmission in the five cases were linked to internal club COVID-19 outbreaks and wider-community transmission. Despite a high number of tackle involvements and close proximity interactions between SARS-CoV-2 positive players and players on the same and opposition teams during a rugby league match, these data suggest that in-game SARS-CoV-2 transmission is limited during these types of team sport activities played outdoors.

Yorck et al. 2021[118] completed a prospective cohort study between June 8th, 2020 and September 2nd, 2020 to determine the risk of viral transmission associated with **football (soccer)** during the COVID-19 pandemic. The infective and immune status of 1337 professional football players, team staff and league officials were described during a truncated football season (9 weeks) with a tailored infection control program. During the study period, 85 subjects returned positive (cycle threshold (cT)[≤]30) or reactive (30<cT<40) PCR tests, of which 36 were players. The infection rate was consistent with that of the general population during the same time period. More than half of infected subjects were asymptomatic, and the remaining had only mild symptoms with no one requiring hospitalization. Social contacts and family were the most common sources of infection, and no infection could be traced to training or matches. Of the 36 infected players, 15 presented positive serology during the study period. Football played outdoors involving close contact between athletes represents a limited risk for SARS-CoV-2 infection and severe illness when preventive measures are in place.

Indoor sports and activities

Paul et al. 2021[123] conducted a cross-sectional study with data collected between 1 Sep to 13 Sep 2020. The authors surveyed participants at the 2020 **USA Curling Club Nationals** to assess total positivity, potential days of transmission, and the burden of symptoms experienced among the participants. Preventative measures, such as increased cleaning and disinfection of surfaces, single use and disposable food containers, and canceling traditional event banquets were implemented. Despite these measures, 55.6% of all participants reported experiencing symptoms consistent with COVID-19, with nearly all experiencing more than one symptom. As a result of this study, we believe curling tournaments have the potential to be high-risk events for the transmission of COVID-19. Further infection prevention measures that were not yet publicly implemented at the time of this tournament may be an effective method of lowering transmission risk, although further research is required.

Pauser et al. 2021[124]

conducted a cohort study in Germany in 2020. They analyze the risk of SARS-CoV-2 transmission during a professional sports event (2nd division **professional basketball** in Germany). Whilst social distancing in this context is not always possible, the rate of infection was significantly reduced by wearing face masks that cover the mouth and nose. There was no infection amongst individuals who continuously wore medical particle filter masks (Category KN95/FFP2 or higher) during this sporting event.

Munch et al. 2021[125] conducted a national matched case-control study in Denmark from 4-6 December, 2020 to determine determinants of infection. Contact most often took place in the household or work place. Community determinants included: events with singing (OR=2.1, 95%CI:1.1-4.1), attending **fitness centre** (OR=1.8, 95%CI:1.1-2.8) and consumption of alcohol in a bar (OR=10, 95%CI:1.5-65). Other community exposures appeared not to be associated with infection, these included shopping at supermarkets, travel by public transport, dining at restaurants and private social events with few participants. Overall, the restrictions in place at the time of the study appeared to be sufficient to reduce transmission of disease in the public space, which instead largely took place following direct exposures to people with known SARS-CoV-2 infections.

Transportation

Bus or metro

Ramirez et al. 2021[127] conducted a surveillance study of school **transportation**-related transmission of COVID-19 among 1154 Virginian students in grade 1-12 from August 24, 2020 to March 19, 2021. Asymptomatic PCR testing was performed every 2 weeks during the highest community transmission. Fifteen buses served 462 students while operating at near capacity of 2 students in every seat, using a physical distancing minimum of 2.5 feet, universal masking, and simple ventilation techniques. A total of 39 individuals were present on buses during their COVID-19 infectious period, which resulted in the quarantine of 52 students. Universal testing and contact tracing revealed no transmission linked to bus transportation. This study demonstrates a model for the safe operation of school buses while near capacity. COVID-19 transmission can be low during student transport when employing mitigation including simple ventilation, and universal masking, at minimal physical distances and during the highest community transmission.

Modes of transportation

For Squeri et al.[94], and Nygren et al.[98], see Healthcare workers (transmission from patients).

For Meyer et al. 2021[109] see Family home

For Sierpinski et al. 2021[54] see Hospitals.

For Munch et al. 2021[125] see Indoor sports and activities.

For Susan et al. 2021[48] see Shopping.

Workplaces

Processing plants

Porter et al. 2021[136] carried out a surveillance study from March to October 2020 in Alaska. Large COVID-19 outbreaks have occurred in high-density **workplaces**, such as food processing facilities. Alaska's seafood processing industry attracts approximately 18,000 out-of-state workers annually. After 13 COVID-19 outbreaks in Alaska seafood processing facilities and on processing vessels during summer and early fall 2020, State of Alaska personnel and CDC field assignees reviewed the state's seafood processing-associated cases. Requirements were amended in November 2020 to address gaps in COVID-19 prevention. These revised requirements included restricting quarantine groups to <=10 persons, pretransfer testing, and serial testing. Vaccination of this essential workforce is important; until high vaccination coverage rates are achieved, other mitigation strategies are needed in this high-risk setting. Updating industry guidance will be important as more information becomes available.

Salesperson

Sierpinski et al. 2021[54] conducted a cross-sectional study from April 17-18, 2020 in Poland. Of 2122 patients with COVID-19 in home isolation in Poland who consented to take part in the study, 70% were occupationally active in **workplaces**. Nearly half of the occupationally active patients (48%) worked in healthcare, 3% worked in public administration or defense, 3% worked in transportation, and 2% worked in education. As most of the infected patients worked in companies with >100 employees, which is not a Polish employment pattern, the authors expect that smaller companies may have a lower risk of SARS-CoV-2 infections.

Fan-Yun et al. 2021[138] conducted a prospective cohort study between January 23 and March 14, 2020. The study examined high-risk **workplaces** for COVID-19 transmission. The five occupation groups with the most cases were healthcare workers (HCWs) (22%), drivers and transport workers (18%), services and sales workers (18%), cleaning and domestic workers (9%) and public safety workers (7%). Occupations at risk varied from early outbreak (predominantly services and sales workers, drivers, construction laborers, and religious professionals) to late outbreak (predominantly HCWs, drivers, cleaning and domestic workers, police officers, and religious professionals).

References of included studies

1. Danis, K. *et al.* Cluster of Coronavirus Disease 2019 (COVID-19) in the French Alps, February 2020. *Clin. Infect. Dis.* **71**, 825–832 (07 28).
2. Vang, K. E. *et al.* Participation in Fraternity and Sorority Activities and the Spread of COVID-19 Among Residential University Communities - Arkansas, August 21-September 5, 2020. *MMWR Morb Mortal Wkly Rep* **70**, 20–23.
3. Currie, D. W. *et al.* Interventions to Disrupt Coronavirus Disease Transmission at a University, Wisconsin, USA, August-October 2020. *Emerg. Infect. Dis.* **27**, 2776–2785.
4. Bjorkman, K. K. *et al.* Higher viral load drives infrequent SARS-CoV-2 transmission between asymptomatic residence hall roommates. *J. Infect. Dis.* **24**, 24.
5. Akaishi, T. *et al.* COVID-19 transmission in group living environments and households. *Sci. Rep.* **11**, 11616 (06 02).
6. Grant, R. *et al.* Impact of SARS-CoV-2 Delta variant on incubation, transmission settings and vaccine effectiveness: Results from a nationwide case-control study in France. *Lancet Reg. Health - Eur.* 100278 (2021) doi:10.1016/j.lanepe.2021.100278.
7. James, A. *et al.* Model-free estimation of COVID-19 transmission dynamics from a complete outbreak. *PLoS ONE Electron. Resour.* **16**, e0238800 (2021).
8. Meuris, C. *et al.* Transmission of SARS-CoV-2 After COVID-19 Screening and Mitigation Measures for Primary School Children Attending School in Liege, Belgium. *JAMA Netw. Open* **4**, e2128757 (10 01).
9. Bark, D. *et al.* SARS-CoV-2 transmission in kindergarten to grade 12 schools in the Vancouver Coastal Health region: a descriptive epidemiologic study. *CMAJ Open* **9**, E810–E817.
10. Loenenbach, A. *et al.* SARS-CoV-2 variant B.1.1.7 susceptibility and infectiousness of children and adults deduced from investigations of childcare centre outbreaks, Germany, 2021. *Euro Surveill. Bull. Eur. Sur Mal. Transm. Eur. Commun. Dis. Bull.* **26**, 05 (5).
11. Larosa, E. *et al.* Secondary transmission of COVID-19 in preschool and school settings in northern Italy after their reopening in September 2020: a population-based study. *Euro Surveill. Bull. Eur. Sur Mal. Transm. Eur. Commun. Dis. Bull.* **25**, 12 (12).
12. Calvani, M. *et al.* Reasons for SARS-CoV-2 infection in children and their role in the transmission of infection according to age: a case-control study. *Ital. J. Pediatr.* **47**, 193.
13. Ismail, S. A., Saliba, V., Lopez Bernal, J., Ramsay, M. E. & Ladhani, S. N. SARS-CoV-2 infection and transmission in educational settings: a prospective, cross-sectional analysis of infection clusters and outbreaks in England. *Lancet Infect. Dis.* **21**, 344–353 (3).
14. Gras-Le Guen, C. *et al.* Reopening schools in the context of increasing COVID-19 community transmission: The French experience. *Arch. Pediatr.* **28**, 178–185.
15. Ulyte, A. *et al.* Clustering and longitudinal change in SARS-CoV-2 seroprevalence in school children in the canton of Zurich, Switzerland: prospective cohort study of 55 schools. *BMJ* **372**, n616 (03 17).
16. Zimmerman, K. O. *et al.* Incidence and secondary transmission of SARS-CoV-2 infections in schools. *Pediatrics* **147(4) (no pagination)**,.
17. Zimmerman, K. O. *et al.* Community SARS-CoV-2 Surge and Within-School Transmission. *Pediatrics* **28**, 28.
18. Edward, P. R. *et al.* Screening Students and Staff for Asymptomatic Coronavirus Disease 2019 in Chicago Schools. *J. Pediatr.* **239**, 74-80.e1.
19. Schoeps, A. *et al.* Surveillance of SARS-CoV-2 transmission in educational institutions, August to December 2020, Germany. *Epidemiol. Infect.* **149 (no pagination)**,.
20. Falk, A. *et al.* COVID-19 Cases and Transmission in 17 K-12 Schools - Wood County, Wisconsin, August 31-November 29, 2020. *MMWR Morb Mortal Wkly Rep* **70**, 136–140.

21. Chua, G. T. *et al.* Clinical Characteristics and Transmission of COVID-19 in Children and Youths During 3 Waves of Outbreaks in Hong Kong. *JAMA Netw. Open* **4**, e218824 (05 03).
22. Wada, K., Okabe, N. & Shobugawa, Y. Infection and transmission of COVID-19 among students and teachers in schools in Japan after the reopening in June 2020. *BMJ Paediatr. Open* **4(1) (no pagination)**,.
23. Heavey, L., Casey, G., Kelly, C., Kelly, D. & McDarby, G. No evidence of secondary transmission of COVID-19 from children attending school in Ireland, 2020. *Eurosurveillance* **25**, (2020).
24. Alonso, S. *et al.* Age-dependency of the Propagation Rate of Coronavirus Disease 2019 Inside School Bubble Groups in Catalonia, Spain. *Pediatr. Infect. Dis. J.* **27**, 27.
25. Gettings, J. R. *et al.* SARS-CoV-2 transmission in a Georgia school district - United States, December 2020-January 2021. *Clin. Infect. Dis.* **17**, 17.
26. Ladhani, S. N. *et al.* SARS-CoV-2 infection and transmission in primary schools in England in June-December, 2020 (sKIDs): an active, prospective surveillance study. *Lancet Child Adolesc. Health* **5**, 417–427 (6).
27. Macartney, K. *et al.* Transmission of SARS-CoV-2 in Australian educational settings: a prospective cohort study. *Lancet Child Adolesc. Health* **4**, 807–816 (11).
28. Mossong, J. *et al.* SARS-CoV-2 transmission in educational settings during an early summer epidemic wave in Luxembourg, 2020. *BMC Infect. Dis.* **21**, 417.
29. Theuring, S. *et al.* SARS-CoV-2 infection and transmission in school settings during the second COVID-19 wave: a cross-sectional study, Berlin, Germany, November 2020. *Euro Surveill. Bull. Eur. Sur Mal. Transm. Eur. Commun. Dis. Bull.* **26**, 08 (8).
30. Thompson, D. A. *et al.* Staff-pupil SARS-CoV-2 infection pathways in schools in Wales: A population-level linked data approach. *BMJ Paediatr. Open* **5(1) (no pagination)**,.
31. Jordan, I. *et al.* Transmission of SARS-CoV-2 infection among children in summer schools applying stringent control measures in Barcelona, Spain. *Clin. Infect. Dis.* **12**, 12.
32. Kirsten, C. *et al.* SARS-CoV-2 seroprevalence in students and teachers: a longitudinal study from May to October 2020 in German secondary schools. *BMJ Open* **11**, e049876 (06 10).
33. Denny, T. N. *et al.* Implementation of a Pooled Surveillance Testing Program for Asymptomatic SARS-CoV-2 Infections on a College Campus - Duke University, Durham, North Carolina, August 2-October 11, 2020. *MMWR - Morb. Mortal. Wkly. Rep.* **69**, 1743–1747.
34. Valesano, A. L. *et al.* SARS-CoV-2 Genomic Surveillance Reveals Little Spread From a Large University Campus to the Surrounding Community. *Open Forum Infect. Dis.* **8**, ofab518.
35. Kang, C. R. *et al.* Coronavirus Disease Exposure and Spread from Nightclubs, South Korea. *Emerg. Infect. Dis.* **26**, 2499–2501 (2020).
36. Delaugerre, C. *et al.* Prevention of SARS-CoV-2 transmission during a large, live, indoor gathering (SPRING): a non-inferiority, randomised, controlled trial. *Lancet Infect. Dis.* **26**, 26.
37. Whaley, C. M., Cantor, J., Pera, M. & Jena, A. B. Assessing the association between social gatherings and covid-19 risk using birthdays. *JAMA Intern. Med.* **181(8)**, 1090–1099.
38. Lentz, R. J. *et al.* Assessing coronavirus disease 2019 (COVID-19) transmission to healthcare personnel: The global ACT-HCP case-control study. *Infect. Control Hosp. Epidemiol.* **42**, 381–387 (4).
39. Liu, Y., Gu, Z. & Liu, J. Uncovering transmission patterns of COVID-19 outbreaks: A region-wide comprehensive retrospective study in Hong Kong. *EClinicalMedicine* 100929 (2021).
40. Ai, J. *et al.* Epidemiologic characteristics and influencing factors of cluster infection of COVID-19 in Jiangsu Province. *Epidemiol. Infect.* **149**, e48 (02 10).
41. Nakajo, K. & Nishiura, H. Transmissibility of asymptomatic COVID-19: Data from Japanese clusters. *Int. J. Infect. Dis.* **105**, 236–238.
42. Martin-Sanchez, M. *et al.* COVID-19 transmission in Hong Kong despite universal masking. *J. Infect.* **83**, 92–95 (7).

43. Domenech-Montoliu, S. *et al.* Mass gathering events and COVID-19 transmission in Borriana (Spain): A retrospective cohort study. *PLoS ONE Electron. Resour.* **16**, e0256747 (2021).
44. Kwok, K. O. *et al.* Evolving Epidemiological Characteristics of COVID-19 in Hong Kong From January to August 2020: Retrospective Study. *J. Med. Internet Res.* **23**, e26645 (04 16).
45. Wong, N. S., Lee, S. S., Kwan, T. H. & Yeoh, E. K. Settings of virus exposure and their implications in the propagation of transmission networks in a COVID-19 outbreak. *Lancet Reg. Health West. Pac.* **4**, 100052.
46. Brandl, M. *et al.* Mass gathering events and undetected transmission of SARS-CoV-2 in vulnerable populations leading to an outbreak with high case fatality ratio in the district of Tirschenreuth, Germany. *Epidemiol. Infect.* **148**, e252 (2020).
47. Ravindran, A. V. *et al.* Canadian Network for Mood and Anxiety Treatments (CANMAT) 2016 Clinical Guidelines for the Management of Adults with Major Depressive Disorder: Section 5. Complementary and Alternative Medicine Treatments. *Can. J. Psychiatry - Rev. Can. Psychiatr.* **61**, 576–587 (9).
48. Susan, J. H. *et al.* Relative contribution of leaving home for work or education, transport, shopping and other activities on risk of acquiring COVID-19 infection outside the household in the second wave of the pandemic in England and Wales. (2021).
49. Zhao, P., Zhang, N. & Li, Y. A Comparison of Infection Venues of COVID-19 Case Clusters in Northeast China. *Int. J. Environ. Res. Public Health Electron. Resour.* **17**, 03 (06 03).
50. Lan, F. Y. *et al.* Sociodemographic risk factors for coronavirus disease 2019 (COVID-19) infection among Massachusetts healthcare workers: A retrospective cohort study. *Infect. Control Hosp. Epidemiol.* 1–6.
51. Dimcheff, D. E. *et al.* Seroprevalence of severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection among Veterans Affairs healthcare system employees suggests higher risk of infection when exposed to SARS-CoV-2 outside the work environment. *Infect. Control Hosp. Epidemiol.* **42**, 392–398 (4).
52. Oliveira, M. S. *et al.* SARS-Cov-2 seroprevalence and risk factors among health care workers: Estimating the risk of COVID-19 dedicated units. *Am. J. Infect. Control* **49**, 1197–1199 (9AD).
53. Lai, X. *et al.* Coronavirus Disease 2019 (COVID-2019) Infection among Health Care Workers and Implications for Prevention Measures in a Tertiary Hospital in Wuhan, China. *JAMA Netw. Open* **3(5) (no pagination)**,.
54. Sierpinski, R. *et al.* Occupational risks for SARS-CoV-2 infection: the Polish experience. *Int. J. Occup. Med. Environ. Health* **33**, 781–789.
55. Pandrowala, A., Shaikh, S., Balsekar, M., Kirolkar, S. & Udani, S. Characteristics and Transmission Dynamics of COVID-19 in Healthcare Workers in a Pediatric COVID-Care Hospital in Mumbai. *Indian Pediatr.* **58(6)**, 568–571.
56. Jung, J., Lim, Y. J., Kim, E. O. & Kim, S. H. Risk of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Transmission Among Healthcare Workers Dining in Hospital Staff Cafeterias. *J. Korean Med. Sci.* **37**, e14.
57. Jung, J. *et al.* Frequent Occurrence of SARS-CoV-2 Transmission among Non-close Contacts Exposed to COVID-19 Patients. *J. Korean Med. Sci.* **36**, (2021).
58. Costa, S. F. *et al.* Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Seroprevalence and Risk Factors Among Oligo/Asymptomatic Healthcare Workers: Estimating the Impact of Community Transmission. *Clin. Infect. Dis.* **73**, e1214–e1218 (09 07).
59. Ran, L. *et al.* Risk Factors of Healthcare Workers With Coronavirus Disease 2019: A Retrospective Cohort Study in a Designated Hospital of Wuhan in China. *Clin. Infect. Dis.* **71**, 2218–2221 (2020).
60. Zabarsky, T. F. *et al.* What are the sources of exposure in healthcare personnel with coronavirus disease 2019 infection? *Am. J. Infect. Control* **49**, 392–395 (2021).

61. Wang, Y. *et al.* Super-factors associated with transmission of occupational COVID-19 infection among healthcare staff in Wuhan, China. *J. Hosp. Infect.* **106**, 25–34 (2020).
62. Gagneux-Brunon, A. *et al.* SARS-CoV-2 infection: advocacy for training and social distancing in healthcare settings. *J. Hosp. Infect.* **106**, 610–612 (2020).
63. Chatterjee, P. *et al.* Healthcare workers & SARS-CoV-2 infection in India: A case-control investigation in the time of COVID-19. *Indian J. Med. Res.* **151**, 459–467.
64. Aranaz-Andrés, J. M., McGee-Laso, A., Galán, J. C., Cantón, R. & Mira, J. Activities and Perceived Risk of Transmission and Spread of SARS-CoV-2 among Specialists and Residents in a Third Level University Hospital in Spain. *Int. J. Environ. Res. Public. Health* **18**, 2838 (2021).
65. Wenlock, R. D. *et al.* The epidemiology of hospital inpatient exposure to SARS-CoV-2: A cohort study. *Infect. Prev. Pract.* **3**, 100173.
66. Sharma, S. *et al.* Assessment of Potential Risk Factors for 2019-Novel Coronavirus (2019-nCov) Infection among Health Care Workers in a Tertiary Care Hospital, North India. *J. Prim. Care Community Health* **12**, 21501327211002100.
67. Mostafa, A. *et al.* Universal COVID-19 screening of 4040 health care workers in a resource-limited setting: an Egyptian pilot model in a university with 12 public hospitals and medical centers. *Int. J. Epidemiol.* **50**, 50–61 (03 03).
68. Lidstrom, A. K., Sund, F., Albinsson, B., Lindback, J. & Westman, G. Work at inpatient care units is associated with an increased risk of SARS-CoV-2 infection; a cross-sectional study of 8679 healthcare workers in Sweden. *Ups. J. Med. Sci.* **125**, 305–310.
69. Ng, D. C. *et al.* Clinical and epidemiological characteristics of children with COVID-19 in Negeri Sembilan, Malaysia. *Int. J. Infect. Dis.* **108**, 347–352.
70. Landoas, A. *et al.* SARS-CoV-2 nosocomial infection acquired in a French university hospital during the 1st wave of the Covid-19 pandemic, a prospective study. *Antimicrob. Resist. Infect. Control* **10**, 114 (08 05).
71. Rasmussen, A. *et al.* Development and validation of a Haitian Creole screening instrument for depression. *Transcult. Psychiatry* **52**, 33–57 (2015).
72. Celebi, G. *et al.* Specific risk factors for SARS-CoV-2 transmission among health care workers in a university hospital. *Am. J. Infect. Control* **48**, 1225–1230 (10).
73. Cattelan, A. M. *et al.* An Integrated Strategy for the Prevention of SARS-CoV-2 Infection in Healthcare Workers: A Prospective Observational Study. *Int. J. Environ. Res. Public Health Electron. Resour.* **17**, 10.
74. Maltezou, H. C. *et al.* Hospital factors associated with SARS-CoV-2 infection among healthcare personnel in Greece. *J. Hosp. Infect.* **109**, 40–43.
75. Olmos, C. *et al.* SARS-CoV-2 infection in asymptomatic healthcare workers at a clinic in Chile. *PLoS ONE Electron. Resour.* **16**, e0245913 (2021).
76. Dutta, U. *et al.* Multidimensional dynamic healthcare personnel (HCP)-centric model from a low-income and middle-income country to support and protect COVID-19 warriors: a large prospective cohort study. *BMJ Open* **11**, e043837 (02 22).
77. Carazo, S. *et al.* Characterization and evolution of infection control practices among severe acute respiratory coronavirus virus 2 (SARS-CoV-2)–infected healthcare workers in acute-care hospitals and long-term care facilities in Québec, Canada, Spring 2020. *Infect. Control Hosp. Epidemiol.* 1–9.
78. Williams, V. R. *et al.* Risk of SARS-CoV-2 transmission from universally masked healthcare workers to patients or residents: A prospective cohort study. *Am. J. Infect. Control* **49**, 1429–1431 (2021).
79. Walker, A. *et al.* Characterization of SARS-CoV-2 infection clusters based on integrated genomic surveillance, outbreak analysis and contact tracing in an urban setting. *Clin. Infect. Dis. Off. Publ. Infect. Dis. Soc. Am.* (2021).

80. Huang, P.-Y. *et al.* A hospital cluster of COVID-19 associated with a SARS-CoV-2 superspreading event. *J. Microbiol. Immunol. Infect.* (2021).
81. Atsawawaranunt, K. *et al.* COVID-19 Transmission among Healthcare Workers at a Quarantine Facility in Thailand: Genomic and Outbreak Investigations. *Am. J. Trop. Med. Hyg.* **105**, 421 (2021).
82. Burke, R. M. *et al.* Enhanced contact investigations for nine early travel-related cases of SARS-CoV-2 in the United States. *PLoS ONE Electron. Resour.* **15**, e0238342 (2020).
83. Thadhani, R. *et al.* Transmission of SARS-CoV-2 considering shared chairs in outpatient dialysis: a real-world case-control study. *BMC Nephrol.* **22**, 313 (09 16).
84. Gianola, S. *et al.* The Spread of COVID-19 Among 15,000 Physical Therapists in Italy: A Cross-Sectional Study. *Phys. Ther.* **101**, 01 (08 01).
85. Froberg, M. *et al.* Risk for SARS-CoV-2 infection in healthcare workers outside hospitals: A real-life immuno-virological study during the first wave of the COVID-19 epidemic. *PLoS ONE Electron. Resour.* **16**, e0257854 (2021).
86. Wong, L. Y., Tan, A. L., Leo, Y. S., Lee, V. J. M. & Toh, M. P. H. S. Healthcare workers in Singapore infected with COVID-19: 23 January-17 April 2020. *Influenza Other Respir. Viruses* **15(2)**, 218–226.
87. Barry, M. *et al.* COVID-19 community transmission among healthcare workers at a tertiary care cardiac center. *Med. Sci.* **9**, 49 (2021).
88. Mansoor, S. *et al.* A descriptive audit of healthcare workers exposed to COVID-19 at a tertiary care center in India. *Int. J. Gynaecol. Obstet.* **153**, 393–397.
89. Mendez-Echevarria, A. *et al.* High Rates of SARS-CoV-2 Family Transmission in Children of Healthcare Workers During the First Pandemic Wave in Madrid, Spain: Serologic Study. *Pediatr. Infect. Dis. J.* **40**, e185–e188 (05 01).
90. Baker, M. A. *et al.* Low risk of COVID-19 among patients exposed to infected healthcare workers. *Clin. Infect. Dis. Off. Publ. Infect. Dis. Soc. Am.* **28**, (2020).
91. Wang, X. *et al.* Nosocomial outbreak of COVID-19 pneumonia in Wuhan, China. *Eur. Respir. J.* **55**, 06 (6AD).
92. Bahrs, C. *et al.* Prospective surveillance study in a 1,400-bed university hospital: COVID-19 exposure at home was the main risk factor for SARS-CoV-2 point seroprevalence among hospital staff. *Transbound. Emerg. Dis.* **69**, 720–730 (2022).
93. Heinzerling, A. *et al.* Transmission of COVID-19 to Health Care Personnel During Exposures to a Hospitalized Patient - Solano County, California, February 2020. *MMWR - Morb. Mortal. Wkly. Rep.* **69**, 472–476.
94. Squeri, R. *et al.* Correct management and low rate of contagiousness of healthcare workers in a University Hospital in Southern Italy: from contact tracing to serological investigation. *Acta Bio-Medica Ateneo Parm.* **91**, 79–86 (07 20).
95. Pinarlik, F., Genc, Z., Kapmaz, M., Tekin, S. & Ergonul, O. Risk groups for SARS-CoV-2 infection among healthcare workers: Community versus hospital transmission. *Infect. Dis. Rep.* **13(3)**, 724–729 (2021).
96. Su, W. L. *et al.* Masks prevent hospital-acquired COVID-19: A single hospital experience in Taiwan. *J. Intern. Med. Taiwan* **32(1)**, 32–39.
97. Contejean, A. *et al.* Comparing Dynamics and Determinants of Severe Acute Respiratory Syndrome Coronavirus 2 Transmissions among Healthcare Workers of Adult and Pediatric Settings in Central Paris. *Clin. Infect. Dis.* **72(2)**, 257–264.
98. Nygren, D. *et al.* Association between SARS-CoV-2 and exposure risks in health care workers and university employees-a cross-sectional study. *Infect. Dis.* **53(6)**, 460–468 (2021).
99. Aydin, M., Ozel, A. S. & Altunal, L. N. Transmission and clinical characteristic of covid-19 in healthcare workers: Cross-sectional study. [Turkish]. *Turk. Klin. J. Med. Sci.* **41(3)**, 219–224.

100. Leeman, D. S. *et al.* Severe acute respiratory coronavirus virus 2 (SARS-CoV-2) nosocomial transmission dynamics, a retrospective cohort study of two healthcare-associated coronavirus disease 2019 (COVID-19) clusters in a district hospital in England during March and April 2020. *Infect. Control Hosp. Epidemiol.* 1–7 (2021) doi:10.1017/ice.2021.483.
101. Kevin, A. B. *et al.* Association Between Nursing Home Crowding and COVID-19 Infection and Mortality in Ontario, Canada. *medRxiv* (2020) doi:10.1101/2020.06.23.20137729.
102. Kain, D. *et al.* A Longitudinal, Clinical, and Spatial Epidemiologic Analysis of a Large COVID-19 Long-Term Care Home Outbreak. *J. Am. Med. Dir. Assoc.* **22**, 2003-2008.e2 (2021).
103. Fisman, D. N., Bogoch, I., Lapointe-Shaw, L., McCready, J. & Tuite, A. R. Risk Factors Associated With Mortality Among Residents With Coronavirus Disease 2019 (COVID-19) in Long-term Care Facilities in Ontario, Canada. *JAMA Netw. Open* **3**, e2015957 (2020).
104. Tang, S. *et al.* Mass testing after a single suspected or confirmed case of COVID-19 in London care homes, April-May 2020: implications for policy and practice. *Age Ageing* **50**, 649–656 (05 05).
105. MacCannell, T. *et al.* Genomic epidemiology and transmission dynamics of SARS-CoV-2 in congregate healthcare facilities in Santa Clara County, California. *Clin. Infect. Dis.* **30**, 30.
106. Walker, L. J. *et al.* SARS-CoV-2 infections among Australian passengers on the Diamond Princess cruise ship: A retrospective cohort study. *PLoS ONE* **16(9 September) (no pagination)**,.
107. Lan, F. Y., Wei, C. F., Hsu, Y. T., Christiani, D. C. & Kales, S. N. Work-related COVID-19 transmission in six Asian countries/areas: A follow-up study. *PLoS ONE Electron. Resour.* **15**, e0233588 (2020).
108. Ogata, T. *et al.* Settings of coronavirus disease 2019 transmission during community outbreak in Tsuchiura, Japan, November 2020. *Nihon Koshu Eisei Zasshi Jpn. J. Public Health* **68(10)**, 677–681.
109. Meyer, C. N. Transmission, start of symptom and morbidity among Danish COVID-19 patients admitted to hospital. *Dan. Med. J.* **67**, 06.
110. Schepers, M. *et al.* Multi-household social gatherings contribute to the second SARS-CoV-2 wave in Rhineland-Palatinate, Germany, August to November 2020. *J. Infect.* **23**, 23.
111. xiaoke, X. *et al.* Close contacts and household transmission of SARS-CoV-2 in China: a content analysis based on local Heath Commissions' public disclosures. (2020).
112. Choi, A. *et al.* Symptomatic and asymptomatic transmission of SARS-CoV-2 in K-12 schools, British Columbia, April to June 2021. *medRxiv.* **20**, (2021).
113. Le, T. Q. M. *et al.* Severe Acute Respiratory Syndrome Coronavirus 2 Shedding by Travelers, Vietnam, 2020. *Emerg. Infect. Dis.* **26**, 1624–1626 (7AD).
114. Afonso, E. T. *et al.* Secondary household transmission of SARS- CoV- 2 among children and adolescents: Clinical and epidemiological aspects. *Pediatr. Pulmonol.* **57**, 162–175 (2022).
115. Zhang, H. *et al.* A multi-family cluster of COVID-19 associated with asymptomatic and pre-symptomatic transmission in Jixi City, Heilongjiang, China, 2020. *Emerg. Microbes Infect.* **9**, 2509–2514.
116. Natapov, L. *et al.* Risk of SARS-CoV-2 transmission following exposure during dental treatment - A national cohort study. *J. Dent.* **113**, 103791.
117. Schreiber, S., Faude, O., Gartner, B., Meyer, T. & Egger, F. Risk of SARS-CoV-2 transmission from on-field player contacts in amateur, youth and professional football (soccer). *Br. J. Sports Med.* **18**, 18.
118. Yorck Olaf, S. *et al.* Resuming professional football during the Covid-19 pandemic in a country with high infection ratesA prospective cohort study. (2020).
119. Ben, J. *et al.* SARS-CoV-2 transmission during team-sport: Do players develop COVID-19 after participating in rugby league matches with SARS-CoV-2 positive players? (2020).

120. Robinson, P. G., Murray, A., Close, G. & Kinane, D. F. Assessing the risk of SARS-CoV-2 transmission in international professional golf. *BMJ Open Sport Exerc. Med.* **7**, e001109 (2021).
121. Drogosz, M. *et al.* Implications of Sports on COVID-19 cases in Rhode Island School-aged Athletes. *R. I. Med.* **104**, 51–54 (06 01).
122. Drezner, J. A., Drezner, S. M., Magner, K. N. & Ayala, J. T. COVID-19 Surveillance in Youth Soccer During Small Group Training: A Safe Return to Sports Activity. *Sports Health* **13(1)**, 15–17.
123. Paul, M. L. Estimating the Burden of COVID-19 Symptoms Among Participants at the 2020 USA Curling Club Nationals Tournament. (2020).
124. Pauser, J., Schwarz, C., Morgan, J., Jantsch, J. & Brem, M. SARS-CoV-2 transmission during an indoor professional sporting event. *Sci. Rep.* **11(1)**, 20723.
125. Munch, P. K. *et al.* Societal activities associated with SARS-CoV-2 infection - A case-control study in Denmark, November 2020. *Epidemiol. Infect.* (2021) doi:10.1017/S0950268821002478.
126. D'Agostino, E. M. *et al.* Symptomatic SARS-CoV-2 Transmission in Youth and Staff Attending Day Camps. *Pediatrics* **147**, 04 (4).
127. Ramirez, D. W. E., Klinkhammer, M. D. & Rowland, L. C. COVID-19 Transmission during Transportation of 1st to 12th Grade Students: Experience of an Independent School in Virginia. *J Sch Health* **91**, 678–682.
128. Toyokawa, T. *et al.* Transmission of SARS- CoV- 2 during a 2- h domestic flight to Okinawa, Japan, March 2020. *Influenza Other Respir. Viruses* **16**, 63–71 (2022).
129. Lunney, M. *et al.* COVID-19 infection among international travellers: A prospective analysis. *BMJ Open* **11(6) (no pagination)**,.
130. Hu, M. *et al.* Risk of SARS-CoV-2 Transmission among Air Passengers in China. *Clin. Infect. Dis.* **21**, 21.
131. Guner, A. E. *et al.* First known COVID-19 case and contact tracing efforts in Istanbul, Turkey. *Turk. J. Med. Sci.* **51**, 1653–1658 (08 30).
132. Blomquist, P. B. *et al.* Risk of symptomatic COVID-19 due to aircraft transmission: a retrospective cohort study of contact-traced flights during England's containment phase. *Influenza Other Respir. Viruses* **15**, 336–344 (5).
133. Ng, O. T. *et al.* SARS-CoV-2 seroprevalence and transmission risk factors among high-risk close contacts: a retrospective cohort study. *Lancet Infect. Dis.* **21**, 333–343 (2021).
134. Zhong, P., Guo, S. & Chen, T. Correlation between travellers departing from Wuhan before the Spring Festival and subsequent spread of COVID-19 to all provinces in China. *J. Travel Med.* **27**, taaa036 (2020).
135. Sundar, V. & Bhaskar, E. Low secondary transmission rates of SARS-CoV-2 infection among contacts of construction laborers at open air environment. *Germs* **11**, 128–131.
136. Porter, K. A., Ramaswamy, M., Koloski, T., Castrodale, L. & McLaughlin, J. COVID-19 Among Workers in the Seafood Processing Industry: Implications for Prevention Measures - Alaska, March-October 2020. *MMWR - Morb. Mortal. Wkly. Rep.* **70**, 622–626.
137. Pokora, R. *et al.* Investigation of superspreading COVID-19 outbreak events in meat and poultry processing plants in Germany: A cross-sectional study. *PLoS ONE Electron. Resour.* **16**, e0242456 (2021).
138. Fan-Yun, L., Chih-Fu, W., Yu-Tien, H., David, C. C. & Stefanos, N. K. Work-related Covid-19 transmission. (2020).
139. Lan, F. Y., Suharlim, C., Kales, S. N. & Yang, J. Association between SARS-CoV-2 infection, exposure risk and mental health among a cohort of essential retail workers in the USA. *Occup. Environ. Med.* **78**, 237–243 (4).