National Collaborating Centre for Methods and Tools

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Rapid Review: What is known about the risk of COVID-19 transmission across different indoor settings in the community such as restaurants and gyms?

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The authors declare they have no conflicts of interest to report.

Executive Summary

Background

To prevent and reduce coronavirus 2019 (COVID-19) transmission, lockdown measures were implemented restricting individual, community, and social activities and exposures. As jurisdictions have begun to relax these restrictions, it is important to understand the transmission risk associated with common community settings frequented by the public. Such knowledge can inform planning around appropriate mitigation measures for specific types of source settings.

This rapid review was produced to support public health decision makers' response to the COVID-19 pandemic. This review seeks to identify, appraise, and summarize emerging research evidence to support evidence-informed decision making.

This rapid review includes evidence available up to October 20, 2020 to answer the questions: **What is known about the risk of COVID-19 transmission across different indoor settings in the community? What is known about the risk of COVID-19 transmission in indoor dining settings, such as restaurants and bars/nightclubs? What is known about the risk of COVID-19 transmission in indoor physical activity settings, such as gyms and fitness centres?**

Key Points

What is known about the risk of COVID-19 transmission across different indoor settings in the community?

- Based on the limited available evidence, it is not possible to compare an individual's risk of infection across community settings or compare the risk of outbreaks or infection clusters across settings. Certainty of evidence is very low, and findings are very likely to change as more evidence becomes available.
- Since the beginning of the pandemic, household and shared accommodation settings appear to be the most prevalent settings for clusters of infections or outbreaks to occur. Certainty of evidence is low, and findings are likely to change as more evidence becomes available.

What is known about the risk of COVID-19 transmission in indoor dining settings, such as restaurants and bars/nightclubs?

- Reported attack rates in indoor restaurants, bars and nightclub settings are highly variable, ranging from 1.74%-45%. Certainty of evidence is very low, and findings are very likely to change as more evidence becomes available.
- Reduced/poor ventilation and lack of physical distancing have been suggested as critical drivers of transmission risk in restaurant settings, however further evidence is needed to understand how infection prevention and control (IPAC) measures (e.g., mask wearing by patrons and staff) impact risk in these settings. Certainty of evidence is very low, and findings are very likely to change as more evidence becomes available.

What is known about the risk of COVID-19 transmission in indoor physical activity settings, such as gyms and fitness centres?

- Attack rates, reported only in few instances of outbreaks involving indoor fitness classes, are highly variable and range from 7.3%-26.3%. Transmission appears to occur more commonly from fitness instructors to participants. Certainty of evidence is very low, and findings are very likely to change as more evidence becomes available.
- Factors that have been suggested to influence transmission risk in gym exposures include number of individuals within the facility, room size, length of exposure time, ventilation type, type of fitness activity, and viral load of infected source. Certainty of evidence is very low, and findings are very likely to change as more evidence becomes available.

Overview of Evidence and Knowledge Gaps

- Across syntheses and single studies, households and shared accommodations (e.g., cruise ships) thus far appear to be the most prevalent locations for infection clusters.
- The majority of studies have only reported the proportion of outbreaks or cases that were attributed to specific settings but do not account for the number of individuals who visit these locations. For example, a large number of outbreaks are linked to healthcare settings, however these settings are visited by a large number of individuals and were not closed during lockdown, compared to gyms or recreation facilities which serve a smaller population and may have more recently reopened. A direct comparison in terms of number of outbreaks do not account for these important differences.
- Modelling studies estimated risk level for different indoor scenarios by exploring the influence of ventilation, emission rate from infected individuals, crowding, exposure time, or mitigation strategies (e.g., masks, physical distancing, crowd control). Ventilation, reducing crowd size, masking, and physical distancing may decrease transmission risk.
- Available data includes both prior to lockdown and during/after lockdown with limited discussion about IPAC measures such as physical distancing and/or mask wearing across settings which likely influences study findings and differences across settings.
- Across indoor settings (including indoor dining and physical activity settings), further evidence is needed to understand different factors that may mitigate transmission risk to inform safe opening practices.
- One case control study found that a group of adults who tested positive for COVID-19 were 2.4 times more likely to have visited a restaurant in the previous two weeks before illness onset compared to a group with no confirmed COVID-19, and were also less likely to have worn a mask in these settings.
- In one two-week long randomized controlled trial which compared a control group (no access to gym facility) with an intervention group who had access to a training facility, no differences were found between groups however only one case was identified.

Methods

Research Question

1. What is known about the risk of COVID-19 transmission across different indoor settings in the community?

2. What is known about the risk of COVID-19 transmission in indoor dining settings, such as restaurants and bars/nightclubs?

3. What is known about the risk of COVID-19 transmission in indoor physical activity settings such as gyms and fitness centres?

Search

On October 15, 16, and 20, 2020, the following databases were searched using key terms “super spreader”, "transmission", "outbreak", “restaurant”, “gym”, “bar”, “pub”, “recreation”, “dining”, “fitness”, “aerobic”, “zumba”, “treadmill”, “fitness”, “club”, “nightclub”, “lounge”, “dancehall”.

- Pubmed’s curated COVID-19 literature hub: LitCovid
- Trip Medical Database
- World Health Organization’s Global literature on coronavirus disease
- COVID-19 Evidence Alerts from McMaster PLUS™
- Public Health +
- COVID-19 Living Overview of the Evidence (L·OVE)
- Prospero Registry of Systematic Reviews
- NCCMT COVID-19 Rapid Evidence Reviews
- MedRxiv preprint server
- NCCDH Equity-informed Responses to COVID-19
- NCCEH Environmental Health Resources for the COVID-19 Pandemic
- NCCHPP Public Health Ethics and COVID-19
- NCCID Public Health Quick Links
- NCCID Disease Debrief
- NCCIH Updates on COVID-19
- NLCAHR
- Institute national d’excellence en santé et en services sociaux (INESSS)
- Uncover (USHER Network for COVID-19 Evidence Reviews)
- Public Health Ontario
- Oxford COVID-19 Evidence Service
- Centers for Disease Control and Prevention’s Morbidity and Mortality Weekly Report (MMWR)
- BC Centre for Disease Control
- Institut national de santé publique du Québec Ajouts récents et mises à jour

A copy of the full search strategy is available at this link.

Study Selection Criteria

The search results were first screened for recent guidelines and syntheses. Single studies were included if no syntheses were available, or if single studies were published after the search was conducted in the included syntheses. English-language, peer-reviewed sources and sources published ahead-of-print before peer review were included. When available, findings from syntheses and clinical practice guidelines are presented first, as these take into account the available body of evidence and, therefore, can be applied broadly to populations and settings.

	Inclusion Criteria	Exclusion Criteria
Population	All	
Intervention	Exposure to or diagnosis of COVID-19	
Comparisons		
Outcomes	Transmission of COVID-19	
Setting	All community settings; dining/nightlife; gyms/fitness centres	Hospital/healthcare settings only; household settings only

Data Extraction and Synthesis

Data relevant to the research question, such as study design, setting, location, population characteristics, interventions or exposure and outcomes were extracted when reported. We synthesized the results narratively due to the variation in methodology and outcomes for the included studies.

Appraisal of Evidence Quality

We evaluated the quality of included evidence using critical appraisal tools as indicated by the study design below. Quality assessment was completed by one reviewer and verified by a second reviewer. Conflicts were resolved through discussion. For some of the included evidence a suitable quality appraisal tool was not found, or the review team did not have the expertise to assess methodological quality. Studies for which quality appraisal has not been conducted are noted within the data tables.

Study Design	**Critical Appraisal Tool**
Synthesis	Assessing the Methodological Quality of Systematic Reviews (AMSTAR) AMSTAR 1 Tool
Case Control	Joanna Briggs Institute (JBI) Checklist for Case Control Studies
Prevalence	Joanna Briggs Institute (JBI) Checklist for Prevalence Studies
Case Report	Joanna Briggs Institute (JBI) Checklist for Case Reports
Cross Sectional	Joanna Briggs Institute (JBI) Checklist for Analytical Cross Sectional Studies

Completed quality assessments for each included study are available on request.

The Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach was used to assess the certainty in the findings based on eight key domains.

In the GRADE approach to quality of evidence, **observational studies,** as included in this review, provide **low quality** evidence, and this assessment can be further reduced based on other domains:

- High risk of bias
- Inconsistency in effects
- Indirectness of interventions/outcomes
- Imprecision in effect estimate
- Publication bias

and can be upgraded based on:

- Large effect
- Dose-response relationship
- Accounting for confounding.

The overall certainty in the evidence for each outcome was determined taking into account the characteristics of the available evidence (observational studies, some not peer-reviewed, unaccounted-for potential confounding factors, different tests and testing protocols, lack of valid comparison groups). A judgement of 'overall certainty is very low' means that the findings are very likely to change as more evidence accumulates.

Findings

Summary of Evidence Quality

This document includes three completed syntheses and 18 single studies for a total of 21 publications included in this review. The quality of the evidence included in this review is as follows:

Research Question	Evidence included		Overall certainty in evidence
What is known about the risk of COVID-19 transmission across different indoor settings in the community?	Completed syntheses Single studies	3 8	Very low
What is known about the risk of COVID-19 transmission in indoor dining settings, such as restaurants and bars?	Single studies	9	Very low
What is known about the risk of COVID-19 transmission in indoor physical activity settings, such as gyms and fitness centres?	Single studies	6	Very low

Warning

Given the need to make emerging COVID-19 evidence quickly available, many emerging studies have not been peer reviewed. As such, we advise caution when using and interpreting the evidence included in this rapid review. We have provided a summary of overall certainty of the evidence to support the process of decision making. Where possible, make decisions using the highest quality evidence available.

A number of mathematical modelling studies are emerging related to COVID-19. While these studies may provide important estimates, their ultimate usefulness depends on the quality of the data that is entered into the model. Given the constantly evolving nature and changing understanding of COVID-19 around the world, a high degree of caution is warranted when interpreting these studies, and when presented, include the range of confidence intervals rather than single effect estimates.

Question 1: What is known about the risk of COVID-19 transmission across different indoor settings in the community?

Note: Data relating to indoor dining and indoor physical activity may also be presented in Table 1 and 2 in addition to their respective sections (Tables 3 and 4).

Table 1: Syntheses

Reference	Date Released	Description of Included Studies	Summary of Findings	Quality Rating: Synthesis	Quality Rating: Included Studies
Liu, T., Gong, D., Xiao, J., Hu, J., He, G., Rong, Z., & Ma, W. (2020). Cluster infections play important roles in the rapid evolution of COVID-19 transmission: a systematic review. *International Journal of Infectious Diseases 99*, 374-380.	Aug 5, 2020 (Search completed June 15)	This systematic review included 65 studies describing 108 cluster infections from: China, Vietnam, Germany, USA, Singapore, France, Spain, Korea, Japan, India, Bolivia, and Thailand.	Major types of cluster infections were associated with: • families (n=62) • gatherings (n=15) • tourists (n=6) • transportation (n=6) • religious organizations (n=5) • community transmission (n=4) • conferences (n=4) • nosocomial infection (n=3) • shopping malls (n=3) In this review, authors identified studies released prior to June 15, 2020 that described outbreaks of COVID-19. No comparisons were made with respect to the risk of infection or size of outbreak across settings. The authors' classification of source of outbreak or setting was unclear. Outbreak date and any IPAC measures in place within community settings were not reported.	Low	Not reported

Leclerc, Q.J., Fuller, N.M., Knight, L.E., CMMID COVID-19 Working Group, Funk, S., & Knight, G.M. (2020). What settings have been linked to SARS-CoV-2 transmission clusters? [version 2; peer review: 2 approved]. *Wellcome Open Research 5*: 83. ***Not peer reviewed.***	Jun 5, 2020 (Searched completed May 26)	This systematic review included peer reviewed articles and media reports of 201 transmission events. Half the reported events were from China (n=47) or Singapore (n=51).	Indoor sites were the most common sites of cluster infections with households producing the greatest number of events (n=36). The greatest number of cases were attributed to ships (n = 3597), worker dormitories (n = 1702), and food processing plants (n = 1207). With respect to community settings, religious institutions (15 clusters, 570 cases), shopping (9 clusters, 361 settings), schools (8 clusters, 349 cases) and bars (12 clusters, 319 cases) had the highest number of cases. Limitations may exist within the categorization of settings in which overlap may occur (e.g., schools that are faith based and hold religious services). No formal comparisons were made across settings, and no indication of the number exposed was provided to calculate risk. Most clusters produced fewer than 100 cases, although sites with large numbers of cases included hospitals, long-term care homes, worker dormitories, food processing plants, prisons, schools, shopping, ship settings and religious venues.	Low	Not reported

Prakash, M.K. (2020). Eat, Pray, Work: A meta-analysis of COVID-19 Transmission Risk in Common Activities of Work and Leisure. ***Preprint***.	May 24, 2020 Date of search not reported	This meta-analysis included 418 case studies.	Greater proximity and close interaction were linked to higher average attack rates. Of note, average attack rates for most of the settings were calculated across a small number of case report studies (e.g., AR=100% for sharing a ride based on 1 case). Average attack rates across settings included: <u>Workspace interactions</u> • Brief small group meetings (< 1 hr), direct contact (8/11; 72.7%) • Open workspace with no separation (89/113; 78.7%) • Open workspace with talking, partial separation, less interaction (94/216; 43.5%) • Large conference (7/111; 6.3%) <u>Social activities</u> • Night club (94/1500; 6.27%) • Singing in a group with interaction (53/61; 86.9%) • Shopping with direct interaction (5/17; 29.4%) <u>Family events</u> • Family dinners (20/30; 66.7%) • Sit-down dinners with less interaction (50/318; 15.7%) • Birthday party (52/99; 52.5%) <u>Mobility</u> • Sharing a ride with family member (1/1; 100%) • Elevator/lobby with possible masks (0/1143; 0%) • Metro trains with possible mask (number susceptible not available; 0%) Limited data provided from case reports on date of cluster event and what, if any, IPAC measures were in place. Difficult to make comparisons across settings given the limited data.	Low	Not reported

Table 2: Single Studies

Reference	Date Released	Study Design	Setting	Summary of findings	Quality Rating:
Epidemiologic Studies					
Adam, D.C., Wu, P., Wong, J.Y., Lau, E.H.Y., Tsang, T., Cauchemez, S., Leung, G.M., & Cowling, B.J. (2020). Clustering and superspreading potential of SARS-CoV-2 infections in Hong Kong. *Nature Medicine*. Epub ahead of print.	Sep 17, 2020	Prevalence	Hong Kong	Between January 23 and April 28, 2020, 51 cluster infections were identified among 1,038 COVID-19 cases. The source settings linked to the three largest clusters included: • bars (n=106 cases) • wedding and preceding social event (n=22 cases) • attendance at local temple (n=19) Transmission in social settings was associated with more secondary cases compared to households when controlling for age (p = 0.002). IPAC measures in place to reduce transmission not reported.	High
Fisher, K.A., Tenforde, M.W., Feldstein, L.R., Lindsell, C.J., Shapiro, N.I., Files, D.C., … Self, W.H. (2020). Community and Close Contact Exposures Associated with COVID-19 Among Symptomatic Adults > 18 Years in 11 Outpatient Health Care Facilities – United States, July 2020. *Morbidity and Mortality Weekly Report 69*(36): 1258-1264.	Sep 11, 2020	Case-control	USA	This study compared community and close-contact exposures among adults who tested positive (cases) and negative (non-cases) for COVID-19 infection. Cases were more likely to report having dined at a restaurant (aOR=2.4; CI=1.5-3.8) in the 2 weeks prior to illness. There was no significant difference between cases and non-cases in relation other to community exposure settings (gatherings with ≤10 persons in a home; office space, salon visit, gatherings with ≥10 persons in a home; gym; public transportation, bar/coffee shop; attending church/religious gathering).	High

Kim, E.A. (2020). Social Distancing and Public Health Guidelines at Workplaces in Korea: Responses to Coronavirus Disease-19. *Safety and Health at Work 11*(3): 295-283.	Aug 25, 2020	Prevalence	South Korea	From January 20 to May 15, 2020, 11,018 cases were reported in Korea. The majority of cases were linked to religious groups (49.7%) and workplaces (15.7%). Prevalence of workplace related cases: • health care facilities (10.3%) • call centres (1.7%) • nightlife (1.4%) • sports clubs (1%) • public service (0.9%) • education (0.2%) • restaurants (0.2%) No information was given on IPAC measures in place, or the number of individuals at risk of exposure in each location to compare risk across settings.	High
Furuse, Y., Sando, E., Tsuchiya, N., Miyahara, R., Yasuda, I., Ko, E.K., … Oshitani, H. (2020). Clusters of Coronavirus Disease in Communities, Japan, January – April 2020. *Emerging Infectious Diseases 9*(26): 2176-2179.	Aug 19, 2020	Prevalence	Japan	From January 15 to April 4, 2020, 61 COVID-19 clusters (≥ 5 cases with primary exposures from common venue/event) were reported: • healthcare facilities (18; 30%) • nursing homes/day cares (10; 16%) • restaurants/bars (10; 16%) • workplaces (8; 13%) • musical related events (7; 11%) • gyms (5; 8%) • ceremonies (2; 3%) • airplane (1; 2%) Number of cases per cluster and number of exposed individuals were not reported. Any IPAC measures in place to reduce transmission were not reported.	High
Nishiura, H., Oshitani, H., Kobayashi, T., Saito, T., Sunagawa, T., Matsui, T. Wakita, T., … Suzuki, M. (2020). Closed environments facilitate secondary transmission of coronavirus disease 2019 (COVID-19). ***Preprint***.	Apr 16, 2020	Cross-sectional	Japan	This study examined source of infection among 110 cases of COVID-19 reported as of February 28, 2020 The odds of a transmission in an indoor environment was 18.7 times higher compared to an open-air environment (95% CI: 6.0, 57.9). These included fitness gyms, restaurants, hospitals, festivals. 7 of 110 cases involved super spreader events (defined as transmission to 3 or more persons). 85.7% took place indoors (OR: 32.6 (95% CI: 3.7, 289.5).	Low

Qian, H., Miao, T., Liu, L., Zheng, X., Luo, D. & Li, Y. (2020). Indoor transmission of SARS-CoV-2. ***Preprint***.	April 7, 2020	Prevalence	China	From January 4 to February 11, 2020, 318 outbreaks with 3 or more cases, involving 1245 total cases across 120 municipalities were reported. Outbreaks within households were most common (79.9%), followed by public or shared transport (34.0%), restaurant (4.4%), entertainment venue (2.2%) and shopping (2.2%). Mean cases per outbreak were highest for shopping (8.7), followed by food venues (4.9), transport (3.8), household (3.7) and entertainment (3.6). Number of individuals at risk and any specific IPAC measures in place were not reported.	Moderate
Simulation and Modelling Studies					
Somsen, G.A., van Rijn, C., K, S., Bem, R.A., & Bonn, D. (2020). Measurement of small droplet aerosol concentrations in public spaces using handheld particle counters. ***Preprint***.	Oct 14, 2020	Simulation	Various public spaces	Aerosol persistence time and risk of COVID-19 infection was assessed across a gym, train, meeting room, night club, elevator, car, airport, restroom, office space, unventilated living room, and restaurant, taking into consideration number of people and ventilation type. Aerosol concentrations were substantially lower in well ventilated public spaces compared to poorly ventilated settings. A 50% decrease in aerosol concentration takes approximately 1 minute in well-ventilated spaces, compared to 4-5 minutes in poorly ventilated spaces. Rate of air renewal and size of the given space also impact aerosol concentration. Authors conclude that public restrooms, unventilated living rooms and elevators were of 'intermediate' risk, while other tested spaces were low risk. These estimates were based on a specific size and number of individuals, for example, a 2000 cubic meter gym with 25 visitors, a 120 cubic meter restaurant with 25 visitors, etc. Real world applicability is unclear. This study did not explore the potential impact of mask wearing or physical distancing on likelihood of transmission in these settings.	Not appraised

Buonanno, G., Morawksa, L., & Stabile, L. (2020). Quantitative assessment of the risk of airborne transmission of SARS-CoV-2 infection: Prospective and retrospective applications. *Environment International*. Epub ahead of print.	Sep 14, 2020	Simulation	Guangzhou, China and Washington state, USA	The authors modelled risk of transmission across 4 settings (hospital room, gym, public indoors (e.g., restaurant), and conference room) and calculated maximum exposure time for different risk levels under different levels of ventilation. Specific expiratory activities (singing, talking loudly) or physical activity may result in high viral emission and risk given closed environments. Crowding in indoor environments may also influence risk level. Exposure times that guarantee an acceptable level of risk are limited, especially in naturally ventilated settings. In high forced ventilation settings, exposure times may be longer although <1 hour. The authors used data from two known outbreaks (a restaurant and a choir rehearsal) to validate their findings.	Not appraised

Question 2: What is known about the risk of COVID-19 transmission in dining settings, such as restaurants and bars/nightclubs?

Table 3: Single Studies

Reference	Date Released	Study Design	Setting	Summary of findings	Quality Rating:
Epidemiologic Studies					
Kang, C., Lee, J., Park, Y., Huh, I., Ham, H., Han, J., ... Na, B. (2020). Coronavirus Disease Exposure and Spread from Nightclubs, South Korea. *Emerging Infectious Diseases, 26*(10), 2499-2501.	Sep 17, 2020	Prevalence	Nightclubs, Seoul, South Korea	From April 30 to May 25, 2020, 246 COVID-19 infections were linked to nightclubs in Seoul, South Korea. 96 (39%) of the cases were primary cases and 150 (61%) were secondary cases. Cell phone and credit card data were used to identify high and low risk contacts. The estimated attack rate among nightclub visitors was 1.74%. Cases originating from these nightclubs were also linked to a number of outbreaks in other settings.	Moderate
Fisher, K.A., Tenforde, M.W., Feldstein, L.R., Lindsell, C.J., Shapiro, N.I., Files, D.C., ... Self, W.H. (2020). Community and Close Contact Exposures Associated with COVID-19 Among Symptomatic Adults > 18 Years in 11 Outpatient Health Care Facilities – United States, July 2020. *Morbidity and Mortality Weekly Report 69*(36): 1258-1264.	Sep 11, 2020	Case control	Restaurants, bars and coffee shops, multiple locations, USA	This study compared community and close-contact exposures among adults who tested positive (cases) and negative (non-cases) for COVID-19. Case patients were more likely to have reported dining at a restaurant (indoor or outdoor patio) in 2 weeks before illness onset compared to non-cases (aOR=2.4; CI=1.5-3.8). When analyzing only cases with no recent close contact with confirmed COVID-19, case patients were more likely than non-cases to report dining at a restaurant (aOR=2.8; CI=1.9-4.3) or visiting a bar/coffee shop (aOR=3.9; CI=1.5-10.1). Among those who reported dining at a restaurant and visiting a bar/coffee shop, case patients were less likely to report having observed patrons adhering to COVID-19 prevention measures.	High
Sugano, N., Ando, W., Fukushima, W. (2020). Cluster of Severe Acute Respiratory Syndrome Coronavirus 2 Infections Linked to Music Clubs in Osaka, Japan. *The Journal of Infectious Diseases, 222* (10): 1635-1640.	Aug 25, 2020	Case report	Music clubs, Osaka, Japan	Among a cluster of 108 cases linked to various music clubs in February 2020, substantial exposure came from 51 cases with only a single visit to one club lasting a few hours. An estimated 53% of cases were likely infected through exposure to an asymptomatic case. Any IPAC measures in place were not described.	High

Maechler, F., Gertler, M., Hermes, J., van Loon, W., Schwab, F., Piening, B., … Seybold, J. (2020). Epidemiological and clinical characteristics of SARS-CoV-2 infections at a testing site in Berlin, Germany, March and April 2020—a cross-sectional study. *Clinical Microbiology and Infection*. Epub ahead of print.	Aug 19, 2020	Cross-sectional	Nightclub, Berlin, Germany	Among a group of 94 individuals who attended the same night club on February 29, 2020, 26 (27.7%) later tested positive for COVID-19. Any IPAC measure in place were not described.	High
Kim, N.J., Choe, P.G., Park, S., Lim, J., Lee, W.J., Kang, C.K., … Oh, M. (2020). A cluster of tertiary transmissions of 2019 novel coronavirus (SARS-CoV-2) in the community from infectors with common cold symptoms. *The Korean Journal of Internal Medicine, 35*(4): 758-764.	Jun 11, 2020	Case report	Restaurant, South Korea	This report describes a case report of an individual with COVID-19 who dined at a restaurant with a friend who was symptomatic and later tested positive for the infection. The meal lasted 90 minutes and individuals were <1m apart. Subsequent tertiary transmission resulted in two household cases and one colleague case.	High
Choi, H., Cho, W., Kim, M/. & Hur, J. (2020). Public Health Emergency and Crisis Management: Case Study of SARS-CoV-2 Outbreak. *International Journal of Environmental Research and Public Health, 17*(11), 3894.	Jun 4, 2020	Case report	Nightclubs, Seoul, South Korea	Data from large COVID-19 outbreaks were analyzed. A case of a single person visiting multiple nightclubs resulted in more than 160 additional COVID-19 infections. Modified social distancing restrictions were in place at this time, specific IPAC measures in place were not described. The number of individuals exposed was not reported.	Moderate
Lu, J., Gu, J., Li, K., Xu, C., Su, W., Lai, Z., … Yang, Z. (2020). COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020. *Emerging Infectious Diseases, 26*(7): 1628-1631.	Apr 2, 2020	Case report	Restaurant, Guangzhou, China	This case study describes a restaurant outbreak involving three families. On January 24, 2020, three unrelated families (Family A, B, C) dined in the same restaurant at neighbouring tables that were approximately 1m apart. Among the three families, 10 individuals tested positive for COVID-19, associated with one index case in Family A. Exposure times with the index case of those infected ranged from 53-73 minutes. The remaining 72 customers and 8 staff did not test positive.	Moderate

Simulation and Modelling Studies					
Buonanno, G., Morawksa, L., & Stabile, L. (2020). Quantitative assessment of the risk of airborne transmission of SARS-CoV-2 infection: Prospective and retrospective applications. *Environment International*. Epub ahead of print.	Sep 14, 2020	Modelling	Restaurant, Guangzhou, China	This modelling study assessed the risk for an exposed healthy subject in a restaurant setting, using data from a confirmed restaurant outbreak. Retrospective analysis demonstrated that an attack rate of 45% via airborne transmission may be likely attributed to an exposure time of 1-hour, reduced ventilation, and small area size.	Not appraised
Birnir, B. (2020). Ventilation and the SARS-CoV-2 Coronavirus: Analysis of outbreaks in a restaurant and on a bus in China, and at a Call Center in South Korea. ***Preprint***.	Sep 13, 2020	Modelling	Restaurant, Guangzhou, China	The restaurant outbreak was likely due to build-up of viral droplets/aerosols in a confined space over time despite physical distancing. Ventilation may play a key role in decreasing droplet/aerosol concentrations in indoor settings and in preventing infection of individuals physically distanced from an infected person. Further investigation is needed to determine the impact of mask wearing on droplet/aerosol concentrations in a restaurant setting.	Not appraised

Question 3: What is known about the risk of COVID-19 transmission in indoor physical activity settings, such as gyms and fitness centres?

Table 4: Single Studies

Reference	Date Released	Study Design	Setting	Summary of findings	Quality Rating:
Intervention Studies					
Helsinger, L.M., Loberg, M., Refsum, E., Gjostein, D.K., Wieszczy, P., Olsvik, O., … Kalager, M. (2020). Randomized re-opening of training facilities during the COVID-19 pandemic. ***Preprint.***	Jun 25, 2020	Randomized controlled trial	Oslo, Norway	In this study, 3,764 individuals were randomized to no access (n=1868 controls) or access to one of five training facilities (n=1896). Across the accessible training facilities infection control measures included: • avoidance of handshake or body contact • 1m of physical distancing • 2m distance for high intensity activities (spinning, workout classes) • disinfectants at all workstations • enforcement of equipment cleaning after each use • enhanced facility cleaning • change rooms open but showers and saunas were closed Of note, mask wearing was not enforced. Among individuals randomized to the training group, a majority trained at least once at a facility (81.8%) and 38.5% trained ≥6 times over a two-week period. After the two-week trial, among 3,016 individuals tested, the difference is SARS-CoV-2 test positivity between the training and no-training group was 0.05% (one versus zero cases); confirmed case in intervention group was determined to be unrelated to training facility exposure. There were no hospital admissions or outpatient visits among participants in either group related to COVID-19.	Moderate

Epidemiologic Studies					
Fisher, K.A., Tenforde, M.W., Feldstein, L.R., Lindsell, C.J., Shapiro, N.I., Files, D.C., … Self, W.H. (2020). Community and Close Contact Exposures Associated with COVID-19 Among Symptomatic Adults > 18 Years in 11 Outpatient Health Care Facilities – United States, July 2020. *Morbidity and Mortality Weekly Report 69*(36): 1258-1264.	Sep 11, 2020	Case control	Gyms, multiple locations, USA	This study assessed community and close contact exposures associated with COVID-19 among symptomatic adults who tested positive (cases; n=154) and negative (controls; n=160) for COVID-19 across 11 outpatient health care facilities in the United States. There was no significant difference between cases (n=12; 7.8%) and controls (10; 6.3%) for having reported using a gym in the preceding 14 days before symptom onset.	High
Furuse, Y., Sando, E., Tsuchiya, N., Miyahara, R., Yasuda, I., Ko, E.K., … Oshitani, H. (2020). Clusters of Coronavirus Disease in Communities, Japan, January – April 2020. *Emerging Infectious Diseases 9*(26): 2176-2179.	Aug 19, 2020	Prevalence	Gyms, multiple locations, Japan	Data from the Japanese Ministry of Health, Labour and Welfare from January 15 through April 4, 2020 were analyzed. Authors identified 61 clusters of COVID-19 infections where at least 5 cases had reported primary exposure at a common event or venue. Many COVID-19 clusters were associated with settings where heavy breathing in close proximity occurs, such as having conversations in bars and exercising in gyms.	High
Bae, S., Kim, H., Jung, T.Y., Lim, J.A., Jo, D.H., Kand, G.S., … Jeong S.H. (2020). Epidemiological Characteristics of COVID-19 Outbreak at Fitness Centers in Cheonan, Korea. *Journal of Korean Medical Science 35*(31): e288.	Aug 5, 2020	Case report	Fitness centres, Cheonan, South Korea	This study described a COVID-19 outbreak between February 24 and March 13, 2020 across 10 fitness centres in Korea that offered Zumba classes. 8 Zumba instructors had attended a national Zumba instructor workshop and were positive for COVID-19. Exposure to these instructors resulted in COVID-19 infections for 57 Zumba class participants, 37 family members and 14 other contacts, e.g., co-workers. The overall attack rate was 7.3%. Higher attack rates were found among the Zumba students (23.2%) and household family members (21.6%) compared to other contacts (1.7%). Infection control measures across the fitness centres were not described.	Moderate

Jang, S., Han, S.H., & R, J.Y. (2020). Cluster of Coronavirus Disease Associated with Fitness Dance Classes, South Korea. *Emerging Infectious Diseases 26*(8): 1917-1920.	Jul 19, 2020	Prevalence	Fitness centres Cheonan, South Korea	This study described a COVID-19 outbreak that occurred across 12 fitness facilities in Korea as of March 9, 2020. 8 Fitness dance instructors had attended a national instructor workshop and were positive for COVID-19. Exposure to these instructors resulted in 112 additional cases (as a result of primary, secondary, and tertiary transmission). Most cases (50.9%) were the result of transmission from instructors to class participants; 33.9% were the result of transmission from instructors and students to family members; and 15.2% were from transmission during meetings with coworkers or acquaintances. The overall attack rate was 26.3% (57/217) across the 12 fitness facilities. Secondary (4.10%) and tertiary (2.39%) attack rates were reported among close contacts. Characteristics that might have led to transmission included large class sizes, small spaces, and intensity level of workouts. Classes from which secondary COVID-19 cases were identified included between 5–22 students in a room ~60 m^2 during 50 minutes of intense exercise. No cases were identified among classes with <5 participants in the same space. Infection control measures across the fitness centres were not described. Of note, some reported cases may overlap with the above study by Bae et al. (2020).	High

Simulation and Modelling Studies					
Buonanno, G., Morawksa, L., & Stabile, L. (2020). Quantitative assessment of the risk of airborne transmission of SARS-CoV-2 infection: Prospective and retrospective applications. *Environment International*. Epub ahead of print.	Sep 14, 2020	Modelling	Gym, theoretical model	This modelling study assessed the probability of infection and individual risk for an exposed healthy subject in four distinct scenarios, including a gym setting. Ventilation was varied in the model to analyze the effect on different acceptable levels of risk in varied settings and activities. Authors applied the model to a gym setting, where infected and healthy individuals engaged in a sport activity with heavy oral breathing. For a gym measuring 300 m^3, the maximum exposure time resulting in an acceptable risk level of 1 infection per 1000 people was 12 minutes when natural ventilation was used and 17 minutes when mechanical ventilation was used. These maximum exposure times appear shorter than the typical workout duration in gyms. Transmission risk may depend on room occupancy, type of ventilation, and amount of viral load of infected individual.	Not appraised

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