1st July 2020

Rapid synthesis of evidence on settings which have been associated with SARS-CoV-2 transmission clusters

Contributors: Fatim Lakha, James W. Rudge, Hannah Holt
Affiliation: Communicable Diseases Policy Research Group, London School of Hygiene and Tropical Medicine

Key messages

- Evidence on settings associated with SARS-CoV-2 transmission clusters can help inform targeted surveillance and control strategies.
- A rapid review of documented SARS-CoV-2 clusters reveals a wide range of settings that have been linked to these events, but highlights several key factors which can increase transmission risk:
    - **Indoor environments** pose a greater risk than open-air spaces;
    - **Crowded** environments, and spaces in which people have more **prolonged** and/or **intense contacts** in **close proximity** with each other.
- Large clusters have occurred in settings where large numbers of people congregate or reside, such as **large group accommodation**, **confined working environments** with large numbers of employees, and **mass gatherings**.
- The majority of documented clusters have been associated with **household transmission,** highlighting the importance of isolation of cases from their household members, wherever possible, and rapid quarantine of their household members and other close contacts.
- There is a lack of data on settings associated with SARS-CoV-2 clusters in low and lower-middle income countries indicating a need for more studies which include these countries and a more representative evaluation of settings globally.

Background

There is increasing evidence of high individual-level variation in SARS-CoV-2 transmission, with one study estimating that 80% of transmission is caused by 10% infected individuals [1]. As countries begin to relax more stringent measures, transmission clusters and superspreader events (SSEs) could play an important role in the resurgence of Covid-19 cases [2]. It is therefore important to identify settings which are high risk of clusters and SSEs so that these can be targeted for active monitoring, preventative measures, or remain restricted/closed for longer [1,3,4]. Following a previous review of events up to 10th April 2020 by Leclerc et al. [5], we conducted an updated search on documented settings associated with SARS-CoV-2 clusters.

Summary of evidence

- As of June 17th, 2020, we found evidence on 616 SARS-CoV-2 transmission clusters from 28 countries (13% of countries with reported cases globally); these were classified into 11 broad categories and 28 sub-categories of settings (Table 1).
- 74% of clusters from the scientific literature and government dashboard came from China. Of the 87 transmission clusters identified in media reports, 21% came from Germany, 20% from Japan and 15% from the USA. Few data were from lower-middle income countries (1% of data from scientific literature and 2% of media articles) and only one cluster was reported from a low income country [6] (Appendix Table A1).

Settings associated with clusters

- Over 96% of the identified clusters (and of all cases associated with clusters) were associated with indoor environments. An analysis of 110 COVID-19 cases in Japan found that the odds of transmission in a closed environment was more than 18 times (95% CI: 6-58 times) higher than in open-air spaces [7].

- Households were associated with 50% of all clusters, with 2-8 cases per cluster. Over 90% of documented household clusters were in China.
- Entertainment and leisure activities were linked to 15% of all events, notably dining (9% of all clusters), sports and fitness (mostly indoors), parties, bar and nightclubs.
- Indoor shopping malls and supermarkets were linked to 32 documented clusters (5% of all events), representing another frequently documented public space setting. Only three events were associated with outdoor markets, although these clusters were relatively large (25-163 cases per cluster).
- 19 clusters (3%) were associated with religious gatherings, including one very large cluster of 4482 cases in South Korea.
- Workplace clusters were mostly associated with office settings, followed by food processing plants, with the latter involving relatively larger numbers of cases. A few clusters were associated with outdoor work environments.
- Ten clusters were linked to schools (2% of all documented events) including one large cluster involving 133 cases.
- Eight events were linked to transport, including buses (5), flights (2) and trains (1), with 2-30 cases per cluster.
- Numerous clusters were associated with environments requiring people to converse/interact at close range (e.g., elderly care homes), and settings with high noise levels such as food processing plants, and factories) and events involving singing or shouting (choir practice, weddings, sports events, concerts) [8,9,10].

Size of clusters

- 5% of clusters involved more than 100 cases, with these large clusters accounting for over two-thirds of the total number of cases across clusters (Table 1). Clusters involving >100 cases all occurred in settings where a large number of people were confined together indoors for prolonged periods of time, including:
    - Shared accommodation in dormitories, shelters, prisons, cruise ships, elderly care facilities, hospitals;
    - food processing plants and a call centre;
    - religious services, a choir and a school.
- The majority (64%) of clusters involved fewer than 10 cases. Three quarters of these smaller clusters were among households. Other settings associated with numerous, but relatively small clusters included offices, and dining outside the home.
- Clusters of moderate size (~10 to 50 cases) were predominantly associated with entertainment and leisure settings.

Public health implications and recommendations

- Indoor closed environments pose a higher risk of SARS-CoV-2 transmission than open air spaces, highlighting the importance of measures such as physical distancing, hand hygiene, respiratory etiquette and appropriate use of facemasks in these environments [11,12,13]. Directions of air flow generated by air-conditioning units may also need consideration given their potential role in facilitating droplet and aerosol transmission [14,15,16].
- Despite evidence showing that outdoor settings having an overall lower risk, some, typically those associated with crowds/mass gatherings (e.g. outdoor markets, rallies) have been linked to large SARS-CoV-2 clusters. Wherever feasible a risk assessment should be undertaken and appropriate measures such as physical distancing, size limitations, postponement or cancellation should be considered [17,18].
- Cases should, wherever feasible, isolate from their household members. Rapid quarantine of all household members and close contacts of cases is also important to prevent onward transmission during the incubation period [19,20].

- Active monitoring and other preventative measures are particularly important in large group/overcrowded accommodation (e.g. worker dormitories, prisons) for prevention and early detection of clusters associated with these settings.
- The large number of events associated with dining suggest that modified layouts, limiting seating capacity, discouraging crowded waiting areas and avoiding self-serve options should be considered in restaurants.
- Workplaces and schools should be supported to put in place hand hygiene, physical distancing and environmental cleaning. Where physical distancing is not possible, shift working and rotation in attendance should be considered to minimise risk. More evidence is needed on transmission potential among children and in educational institutions.
- Transmission may also be augmented by singing, shouting or conversing loudly at close range, following evidence of large of clusters linked to settings such as choir practice, karaoke parties, and workplaces with high noise levels. There is also evidence that the rate of bioaerosol particle emission increases with the loudness of vocalisation [21].
- Systematic surveillance and collation of reports on SARS-CoV-2 clusters in LMICs and LICs are needed to identify settings which pose a high risk of transmission clusters in these contexts.

Methods

A rapid review of available literature and media reports was carried out to identify settings linked to SARS-CoV-2 clusters. Data were collected on country, setting, numbers of clusters and numbers of cases following a previous review by Leclerc et al. [5]. Cases were defined as those who were identified as positive for SARS-CoV-2, regardless of symptoms. A cluster was defined as two or more cases linked to a specific setting at a specific time. Data were retrieved from the Leclerc database [5] (accessed 11th June 2020), which included information on clusters from 43 articles in the scientific literature, and 88 media articles. We also performed an updated, semi-systematic search in the Cochrane COVID-19 study register (11th June 2020) and Pubmed (14th June 2020), which identified a further 53 published articles, from which data were extracted and combined with the Leclerc dataset.

Limitations

This was a rapid review with the aim of providing a preliminary summary and synthesis of existing evidence. A full systematic review and critical appraisal of evidence was not possible within the time and resources available. The database is neither fully accurate nor complete and subject to limitations. Data were only captured from 28 (13%) of 213 countries and territories where COVID-19 cases have been reported. Seventy four percent of events documented in the scientific literature were in China, whilst media articles were more likely to capture events in high income countries (92%). Evidence from all sources are likely to be subject to reporting bias, both in terms of geographical coverage and types of settings/events which are more likely to be reported (Appendix Table A2).

1st July 2020

Table 1. Documented settings associated with SARS-CoV-2 transmission clusters (n=616)

Setting type	Setting detail	No. reported events (n=616)	% total reported events	Total cluster size			Total no. of cases	Countries	Indoor/ Outdoor
				Min	Median	Max			
Household (n=306)		306	50%	2	3	8	1115	Bolivia, China, France, Germany, Hong Kong, Italy, S. Korea, Taiwan, USA, Vietnam	Indoor
Entertainment and leisure (n=94)	Dining	58	9%	2	18	47	1097	Australia, Austria, Brazil, China, Germany, Italy, Japan, Korea, Netherlands, New Zealand, Singapore, South Korea, USA, Vietnam	Indoor
	Sports – gym, fitness, table tennis, running	19	3%	2	4	92	179		Indoor/Outdoor
	Party	6	1%	7	18	60	179		Indoor/Outdoor
	Music venue, nightclub, indoor carnival	6	1%	3	20	20	100		Indoor
	Bar	5	1%	4	10	77	112		Indoor/Outdoor
Large group living (n=63)	Worker dorms, shelters, refugee housing,	26	4%	3	43	797	2286	Australia, Diamond Princess, Canada, Ethiopia, France, Germany, Grand Princess, Italy, Japan, Korea, Luxembourg, New Zealand, Scotland, Singapore, Spain, UK, USA	Indoor
	Elderly care home	23	4%	5	27	167	906		Indoor
	Cruiseliner, Navy Ship	5	1%	78	662	1156	3597		Indoor
	Hotel	4	1%	3	8	13	24		Indoor
	Prison	5	1%	66	225	353	989		Indoor
Workplace (n=54)	Office/meeting	29	5%	4	6	30	258	Australia, Canada, China, Germany, Ghana, Japan, S.Korea, Netherlands, New Zealand, Singapore, S.Korea, USA, Vietnam	Indoor
	Processing plant/slaughterhouse/ factory	12	2%	3	76	534	1843		Indoor
	Conference	5	1%	3	10	89	148		Indoor
	Shipyard/construction site	5	1%	5	22	49	117		Outdoor
	Call centre/Mail centre	3	0.5%	8	97	164	269		Indoor
Public spaces (n=40)	Shopping/supermarket	32	5%	7	13	87	588	China, Germany, Japan, Mexico, Peru, Singapore	Indoor
	Outdoor market	3	0.5%	25	27	163	215		Outdoor
	Community centre	3	0.5%	10	10	10	30		Indoor
	Playground	2	0.2%	20	23	26	46		Outdoor
Religious (n=22)	Religious services	19	3%	2	29	4482	5136	China, Germany, HK, India, Korea, Singapore, S.Korea, USA	Indoor
	Choir practice	3	0.5%	53	59	102	214		Indoor
Health care facility (n=14)		14	2%	2	10	118	325	China, Germany, India, Italy, Japan, Singapore, South Korea, Taiwan	Indoor
Educational setting (n=10)		10	2%	2	15	133	368	Australia, Canada, France, Germany, New Zealand, Singapore, Sweden, USA	Indoor
Travel related (n=8)		8	1%	2	8	30	89	China, India, Japan	Indoor
Other social gatherings (n=5)	Funeral	1	0.2%	4	4	4	4	Australia, China, New Zealand, USA	Indoor/Outdoor
	Wedding	3	0.5%	13	43	98	154		Indoor/Outdoor
	Rally	1	0.2%	83	83	83	83		Outdoor

References

[1] Endo A, CMMID_COVID-19_Working_Group, Abbott S, Kucharski A, Funk S. Estimating the overdisperion in COVID-19 transmission using outbreak sizes outside China [version 1]. Wellcome Open Res 2020.

[2] On_Kwok K, Hin_Chan HH, Huang Y, Hui DSC, Tambyah PA, Wei WI, et al. Inferring super-spreading from transmission clusters of COVID-19 inHong Kong, Japan and Singapore. J Hosp Infect 2020. https://doi.org/doi:10.1016/j.jhin.2020.05.027.

[3] Frieden TR, Lee CT. Identifying and Interrupting Superspreading Events - Implications for Control of Severe Acute Respiratory Syndrome Coronavirus 2. Emerg Infect Dis 2020;26.

[4] Lloyd-Smith JO, Schreiber SJ, Kopp PE, Getz WM. Superspreading and the effect of individual variation on disease emergence. Nature 2005;438. https://doi.org/10.1038.

[5] Leclerc QJ, Fuller NM, Knight LE, CMMID COVID Working Group, Funk S, Knight GM. What settings have been linked to SARS-CoV-2 transmission clusters? [version 2]. Wellcome Open Res 2020. https://doi.org/10.12688/wellcomeopenres.15889.2.

[6] Abera E. News: 66 COVID-19 cases in Addis Abeba connected to a police station as total number rises to 389. Addis Stand 2020.

[7] Nishiura H, Oshitani H, Kobayashi T, Saito T, Sunagawa T, Matsui T, et al. Closed environments facilitate secondary transmission of coronavirus diseases 2019 (COVID-19). MedRxiv 2020.

[8] Furuse Y, Sando E, Tsuchiya N, Miyahara R, Yasuda I, Ko Y, et al. Clusters of Coronavirus Disease in Communities, Japan, January–April 2020. Emerg Infect Dis J 2020;26. https://doi.org/10.3201/eid2609.202272.

[9] Hamner L, Dubbel P, Capron I, Ross A, Jordan A, Lee J, et al. High SARS-CoV-2 attack rate following exposure at a choir practice - Skagit County, Washington, March 2020. Morb AndMortality Wkly Rep MMWR 2020;69:606–10.

[10] Jang S, Han SH, Rhee J-Y. Cluster of Coronavirus Disease Associated with Fitness Dance Classes, South Korea. Emerg Infect Dis J 2020;26. https://doi.org/10.3201/eid2608.200633.

[11] Greenhalgh T, Schmid MB, Czypionka T, Bassler D, Gruer L. Facemasks for the public during the covid-19 crisis. Br Med J 2020;369.

[12] Leffler C, Ing E, Lykins J, Hogan MC, McKeown C, Grzybowski A. Association of country-wide coronavirus mortality with demographics, testing, lockdowns and public wearing of masks. MedRxiv 2020.

[13] World_Health_Organisation. Overview of public health and social measures in the context of COVID-19. Geneva: WHO; 2020.

[14] Baka A, Ceniarelli O, Kinross P, Penttinen P, Plachouras D, Semenza J, et al. Heating, ventilation and air-conditioning systems in the context of COVID-19. Sweden: European Centre for Disease Control; 2020.

[15] Shen Y, Li C, Dong HJ, Wang Z, Martinez L, Sun Z, et al. Airborne transmission of COVID-19: epidemiologic evidence from two outbreak investigations. Preprint 2020.

[16] Li Y, Qian H, Hang J, Chen X, Hong L, Liang P, et al. Evidence for probable aerosol transmission of SARS-CoV-2 in a porrly ventilated restauarant. MedRxiv 2020.

[17] Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet 2020;395.

[18] World_Health_Organisation. Key planning recommendations for mass gatherings in the context of COVID-19 (Interimguidance). Geneva: World Health Organisation; 2020.

[19] Jing Q-L, Liu M-J, Zhang Z-B, Fang L-Q, Yuan J, Zhang A-R, et al. Household secondary attack rate of COVID-19 and associated determinants in Guangzhou, China: a retrospective cohort study. Lancet Infect Dis 2020. https://doi.org/doi:10.1016/s1473-3099(20)30471-0.

[20] Li P, Fu JB, Li KF, Liu JN, Wang HL, Liu LJ, et al. Transmission of COVID-19 in the terminal stages of the incubation period: A familial cluster. Int J Infect Dis 2020;96:452–3. https://doi.org/doi:10.1016/j.ijid.2020.03.027.

[21] Asadi S, Wexler AS, Cappa CD, Barreda S, Bouvier NM, Ristenpart WD. Aerosol emission and superemission during human speech increase with voice loudness. Sci Rep 2019;9:2348. https://doi.org/10.1038/s41598-019-38808-z.

1st July 2020

Appendix

Search strategy
Search strategy in Pubmed: ("COVID-19"[All fields] OR "COVID-2019"[All fields] OR "severe acute respiratory syndrome coronavirus 2"[Supplementary concept] OR "severe acute respiratory syndrome coronavirus 2"[All fields] OR "2019-nCoV"[All fields] OR "SARS-CoV-2[All fields] OR "2019nCoV"[All fields] OR (("Wuhan"[All fields] AND "coronavirus"[MeSH Terms] OR "coronavirus"[All fields]) AND (2019/12[PDAT] OR 2020[PDAT]))) AND (cluster[All fields] OR superspreader[All fields] OR super spreader[All fields])

Search strategy in Cochrane COVID-19 database: 1. Cluster 2. Superspreader

Table A1. The number (%) of documented clusters across sources and countries by income status.

Country income status	Scientific literature or National database n(%)	Media articles n(%)	Overall (%)
High Income country	128 (24%)	80 (92%)	208 (34%)
Upper-middle income country	393 (74%)	3 (3%)	396 (64%)
Lower middle income country	6 (1%)	2 (2%)	8 (1%)
Low income country	0	1 (1%)	1 (0.2%)

*2 cruiseliners and a flight were excluded (n=3)

Table A2. The proportion of documented clusters across settings and sources

Setting type	Scientific literature or National database	Media article
Entertainment	14%	23%
Healthcare facility	2%	6%
Home/Family	57%	2%
Large gathering	1%	1%
Large group accommodation (including elderly care home)	7%	31%
Public spaces	6%	7%
Religious	3%	7%
School	1%	5%
Travel	2%	0%
Work	7%	18%