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Identifying SARS-CoV2 transmission cluster category: An analysis of country government database

Basem Fouda[a,b,1], Ha P.B. Tram[b,c,1], Omar M. Makram[b,d,e,1], Abdelrahman S. Abdalla[b,f,1], Tushar Singh[a,b,1], I-Chun Hung[b,1], Akshay Raut[b,g], Lina Hemmeda[b,h], Majd Alahmar[b,i], Ahmed S. ElHawary[b,j], Dina M. Awad[b,k], Nguyen T. Huy[l,m,*]

[a] School of Medicine, Trinity College Dublin, Dublin, Ireland
[b] Online Research Club, Nagasaki, Japan[2]
[c] VN-UK Institute for Research and Executive Education, The University of Danang, Danang, Vietnam
[d] Department of Cardiology, Faculty of Medicine, October 6 University, Giza, Egypt
[e] Faculty of Public Health and Policy, London School of Hygiene and Tropical Medicine, London, United Kingdom
[f] Faculty of Medicine, Minia University, El-Minya, Egypt
[g] Rajarshee Chhatrapati Shahu Maharaj Government Medical College, Kolhapur 41002, Maharashtra, India
[h] Faculty of Medicine, University of Khartoum, Khartoum, Sudan
[i] Faculty of Medicine, Mansoura University, Mansoura, Egypt
[j] Faculty of Medicine, South Valley University, Qena City, Egypt
[k] Alexandria Faculty of Medicine, Alexandria University, Alexandria, Egypt
[l] Institute of Research and Development, Duy Tan University, Da Nang 550000, Viet Nam
[m] School of Tropical Medicine and Global Health, Nagasaki University, 1-12-4 Sakamoto, Nagasaki 852-8523, Japan

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ABSTRACT

Background: As a result of the high contagiousness and transmissibility of SARS-CoV-2, studying the location of the case clusters that will follow, will help understand the risk factors related to the disease transmission. In this study, we aim to identify the transmission cluster category and settings that can guide decision-makers which areas to be opened again.
Methods: A thorough review of the literature and the media articles were performed. After data verification, we included cluster data from eight countries as of 16th May 2020. Clusters were further categorized into 10 categories and analysis was performed. The data was organized and presented in an easily accessible online sheet.
Results: Among the eight included countries, we have found 3905 clusters and a total number of 1,907,944 patients. Indoor settings (mass accommodation and residential facilities) comprised the highest number of both number of clusters (3315/3905) and infected patients (1,837,019/1,907,944), while the outdoor ones comprised 590 clusters and 70,925 patients. Mass accommodation was associated with the highest number of cases in 5 of the 7 countries with data available. Social events and residential settings were responsible for the highest number of cases in the two remaining countries. In the USA, workplace facilities have reported 165 clusters of infection including 122 food production facilities.
Conclusions: Lockdown could truly be a huge burden on a country's economy. However, with the proper knowledge concerning the transmissibility and the behaviour of the disease, better decisions could be made to guide the appropriate removal of lockdown across the different fields and regions.

* Corresponding author at: School of Tropical Medicine and Global Health, Nagasaki University, 1-12-4 Sakamoto, Nagasaki 852-8523, Japan.
E-mail addresses: bfouda@tcd.ie (B. Fouda), tram.ha180313@vnuk.edu.vn (H.P.B. Tram), omarmakram95@gmail.com (O.M. Makram), Abdelrahman.sherif@protonmail.ch (A.S. Abdalla), tsingh@tcd.ie (T. Singh), researchmd31415@gmail.com (I.-C. Hung), akshayraut2610@gmail.com (A. Raut), lina.hemmeda@gmail.com (L. Hemmeda), majd7777775@gmail.com (M. Alahmar), ahmed.salam@med.svu.edu.eg (A.S. ElHawary), Dina.awad1798@alexmed.edu.eg (D.M. Awad), tienhuy@nagasaki-u.ac.jp (N.T. Huy).
[1] Authors equally contributed to the work.
[2] https://www.onlineresearchclub.org/.

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Introduction

The coronavirus SARS-CoV-2, responsible for the coronavirus pandemic of 2019 (COVID-19), was first discovered in Wuhan, China by the end of 2019 and has since spread worldwide [1]. COVID-19 is characterized as a febrile infection with respiratory symptoms and belongs to the same family of SARS-CoV that caused the outbreak of 2003 which had a case fatality rate of 11% [2]. Due to the high human-to-human transmissibility and lack of immunity in the population (as COVID-19 is quite novel), strict movement restrictions have been implemented in an effort to contain the spread and impact of the disease. While these measures, widely termed 'lockdowns', have had varying levels of success, the toll these measures have taken on people's health, wellbeing, and finances has had countries looking to lift these restrictions and restart their economies. However, countries that were hit early on and have begun easing lockdown restrictions have experienced surges in cases. Consider South Korea as a cautionary tale: The country eased restrictions as the number of cases reached single digits; following this, on May 6th, a 29-year-old man tested positive for the disease after visiting 5 dance clubs in one night in the Itaewon district of Seoul. As a consequence, as of June 8th, 96 other clubgoers, with an additional 178 people with whom these clubgoers came in contact with, have been linked to this sick man by the South Korean Centres for Disease Control [3].

The WHO recommended that countries detect cases and clusters like the one above as early as possible, isolate patients, trace contacts, and halt community transmission [1,4]. As such, there have been reports of a small number of clusters by several countries; however, the number of comprehensive reports that supply an overview on the types of settings that expedite the transmission of COVID-19 are few in the current literature [5,6]. Studying the patterns of infections such as these clusters of infection will help understand the behaviour of the disease transmission as well as the risk factors. Consequently, this data could help public health officers take better decisions concerning the lockdown whether restricting it or staged easing of these restrictions, and finally which facilities need to be closely monitored for any re-emergence of the disease.

Hence, we analysed clusters in eight countries, with the aim of our work being to provide further insight on clusters of COVID-19 cases that can assist in the current global efforts to suppress the disease.

Methods

Search strategy

Literature review and media articles concerning the infection clusters were searched. We used hand searching through each country website and google to find databases of cluster types for each country. A list of 99 countries that have more than 1000 cases as of 16/5/ 2020 was created (COVID-19 Coronavirus data – COVID-19 cases worldwide – European Union Open Data Portal, 2020) [7,1,3,8]. The data of every 12 countries were searched for by one of the reviewers. Then, the final data for each country were reviewed and double-checked by two members. We finally included clusters from eight countries: USA, Germany, Ireland, Singapore, South Korea, Malaysia, Japan and New Zealand. Each database was checked to be a reliable and only the trustworthy ones were included — most databases included in this study were taken from government sources or trusted newspapers. A Google spreadsheet was created that contains the more data description and their sources for further checking (accessible through https://bit.ly/320ZgRb).

Data synthesis and definition

We divided cluster types into 10 main categories and some of them were further divided into subcategories (Table 1). Databases were examined and the following data was extracted: (1) total number of clusters for each cluster type, (2) total number of cases for each cluster type, (3) number of cases in the country at the time of data collection, (4) date of data collection, and (5) source of the data.

Mass accommodation and residential facilities were defined as indoor settings. Workplace, healthcare, education, social events, travel, catering, leisure, and shopping were considered outdoor settings. Nursing homes were considered among the mass accommodation facilities.

Results

In our study, we have included clusters from eight different countries: USA, Germany, Ireland, Singapore, South Korea, Malaysia, Japan and New Zealand. We found 3905 clusters in these countries, excluding Germany, with total number of 1,907,944 patients. Details concerning German clusters of infections were lacking in the official reports. Out of the eight included countries, USA had the largest number of clusters across all the included countries (2824/3905). On the other hand, New Zealand has reported the lowest number of clusters (16/3905).

The most common setting for COVID-19 clusters infection was found to be the indoor facilities including both mass accommodation and residential settings. This was true for four of the examined countries. However, healthcare facilities have been tied with mass accommodation for first place in South Korea. The Japanese Prime Minister office and the ministry of health have mentioned the significant impact of the "Three Cs" that increase the risk of cluster infection "Closed spaces with poor ventilation, crowded places, and close-contact settings", which greatly applies to the healthcare settings as well [9]. Moreover, an article published by The Japan Times in May has reported that about 44.9% of the deaths due to COVID-19 infection in the city of Osaka were linked to in-hospital infection. These patients included health care workers as well [10].

Among all the included countries, we have found that mass accommodation facilities constituted the highest number of infected patients in five (USA, Germany, Singapore, Japan, and New Zealand) out of the seven countries with data available. Moreover, mass accommodation was the most common cluster type in four countries (USA, Ireland, Singapore, and New Zealand). Additionally, it was evident that most of the clusters are reported to be in indoor facilities or activities: mass accommodation and residential (3315 clusters and 1,837,019 patients), other than the outdoor ones (590 clusters and 70,925 patients).

Healthcare settings was followed by both mass accommodation and catering facilities being the most common in Japan. In South Korea, the highest number of clusters was in social events followed by both healthcare and mass accommodation facilities. Residential settings were most common in Malaysia. Similar results were found for the setting linked to the highest number of cases. Mass accommodation was associated with the highest number of cases in 5 of the 7 countries with data available. Social events and residential settings were responsible for the highest number of cases in South Korea and Malaysia, respectively. In the USA, workplace facilities have reported 165 clusters of infection including 122 food production facilities.

Discussion

SARS-CoV has recently re-emerged in China and was considered a global pandemic by the WHO on the 11th of March 2020. As

Table 1
Summary of the collected data.

Countries		USA[d]		Germany		Ireland		Singapore		South Korea[e]		Malaysia		Japan[g]		New Zealand	
Number of cases		11,603,800		119,424		23,089		16,169		11,468		7819		1953		1147	
Date of collection		18/11/2020		16/5/2020		10/5/2020		30/4/2020		31/5/2020		31/5/2020		31/3/2020		13/5/2020	
Cluster type	Subgroup	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases
Mass accommodation		2587	1,798,395		23,123	423		58	11,327	15	524	10	1073	5	161	5	152
	Nursing homes[a]/long term care facilities/ detention centre/shelter	1690	1,531,194		23,123	273				14	521	5	447	5	161	5	152
	Prison	897	267,201							1	3						
	Undefined							58	11,327			5	626				
Workplace		165	30,816			35		64	2325	10	359	11	369	1	5		
	Food production facilities	122	25,107														
	Undefined workplace	41	5581			35		54	1894	10	359	8	262	1	5		
	Construction site	2	128					10	431			3	107				
Healthcare[a]		8	568		14,473	89		1	9	15	566	5	164	6	64		
Travel		14	1714			22				1	49			1	19	3	56
	Cruise ship	14	1714											1	19	1	24
	Travelers group					22				1	49					2	32
Residential		2	708			174		6	90	7	104	19	1274	1	5	3	83
	Community	1	154			13		2	26	4	79	17	1254	1	5	2	44
	Private cluster					159		2	50	3	25	2	20			1	39
	Hotel	1	554			2		2	14								
Education	School/institute/ conference/research centre/ day care facilities/ kindergartens/ after school care/ holiday camps	21	2950		4227			3	41	4	28	7	388	2	20	2	134

Table 1 (*Continued*)

Countries		USA[d]		Germany		Ireland		Singapore		South Korea[e]		Malaysia		Japan[g]		New Zealand	
Number of cases		11,603,800		119,424		23,089		16,169		11,468		7819		1953		1147	
Date of collection		18/11/2020		16/5/2020		10/5/2020		30/4/2020		31/5/2020		31/5/2020		31/3/2020		13/5/2020	
Cluster type	Subgroup	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases	Clusters	Cases
Catering	Bar/entertainment/ cafe/karaoke/ restaurant/canteen/ catering service	13	1070		2023	4		4	27	7	336			5	120	1	77
Social Event		12	1076					4	41	23	5543	6	351			2	111
	Religious cluster	8	778					4	41	19	5504	5[f]	255[f]				
	Wedding											1	96			2	111
	Undefined	4	298							4	39						
Leisure	Gym/sporting clubs/etc.							2	12	3	125			3	55		
Shopping	Market/mall	2	139					3	132			5	333	1	10		
Total		2824	1,837,436		43,846	747		145	14,004	85	7634	63	3952	25	459	16	613
	Indoor[b]	2589	1,799,103		23,123	597		64	11,417	22	628	29	2347	6	166	8	235
	Outdoor[c]	235	38,333		20,723	150		81	2587	63	7006	34	1605	19	293	8	378

[a] Nursing homes were not classified as “healthcare facilities” but rather as mass accommodation facilities.
[b] Indoor data comprises mass accommodation and residential facilities.
[c] Outdoor data comprises all facilities excluding indoor ones.
[d] Data for USA is lacking information about school- and university-related educational clusters. The analysis also only includes major clusters (>50 cases).
[e] Seven clusters (associated with 82 cases) were excluded from our analysis due to lack of information allowing accurate classification.
[f] These numbers exclude the Sri Petaling Tabligh religious cluster. It was excluded to avoid double counting since a number clusters in our analysis are subclusters of this cluster. The cluster had 3373 cases as of 1/6/2020.
[g] Clusters which have less than 5 cases as per the live tracker were excluded from our analysis due to insufficient information about them.

more information became available, the association between clusters of cases and disease transmissibility has become increasingly significant. These data would affect health policies and empower the decision making by public health officers. Our study aims to present and analyse the various cluster types in the hopes of advising health authorities in making informed decisions to contain the disease.

A recent study by Leclerc et al. has reported similar results, yet we added data for other countries e.g. Malaysia and New Zealand, and updated the already published data from other countries [11]. They have found that most clusters were in indoor or mixed, indoor and outdoor settings. They also found great numbers of clusters reported in workers dormitories - mostly in Singapore. This finding agrees with our main result in that mass accommodation is most vulnerable to forming COVID-19 clusters. They also agreed with us in that they found a small number of school clusters and a substantial number of clusters in food processing plants. On the other hand, a major finding of the study by Leclerc et al. disagrees with our results. They reported that the greatest number of clusters reported was in households - and most of those were from China. This may be due to the different methodology they employed or simply due to the fact that their data came from a different set of countries than ours [11].

Mass accommodation may be considered similar to residential settings in that people inhabit them and are often in close contact. The difference in transmission, however, stems from the fact that they are often more crowded than normal accommodation and due to lower funding, they often do not meet the necessary hygiene requirements either due to the lack of tools, spaces or staff dedicated to cleanliness [11,12]. Moreover, a major subcategory of our mass accommodation cluster type is nursing homes and elderly care. Because inhabitants of such types of accommodation are generally older and less healthy than the general population, it is not surprising that various clusters were reported in such settings.

With nursing homes being established in most countries, there is no wonder why it became the most frequent cluster type in the analysed countries. This proves that more attention should be given to these establishments as they have become a great source of COVID-19 case clusters. Moreover, this population is more susceptible to infections due to their weakened immunity and the complex treatment adjustments based on age and weight [13,14].

Interestingly, food production facilities formed a majority of workplace infection clusters in the USA. Several reasons have been proposed to explain this surprising phenomenon. These reasons include cold temperatures allowing virus transmission, not enough distance between co-workers and the noisy environment making it necessary for co-workers to shout in order to communicate [15]. This phenomenon could be alternatively explained by the fact that while most workplaces were closed by governments to tackle the pandemic, food processing plants were considered essential business and thus were allowed to continue operating [11].

Healthcare clusters ranked in the top 3 by number in Japan, South Korea, and Ireland. While this is expected due to close contact with COVID-19 positive cases, the fact that it did not rank higher is indeed surprising. It appears that good measures are being taken at such facilities to ensure the spread of the virus is limited.

Most settings are indoor, possibly due to easier reporting and tracking, higher probability of COVID-19 transmission as well as the fact that the COVID-19 pandemic started in the winter for many countries [11,16].

There were some unexpected results in our study. Social event clusters are highest in South Korea by number of cases (5543 vs 566 for healthcare) but not by number of clusters (23 vs 15 for healthcare and mass accommodation) due mainly to one religious cluster at the Shincheonji Church of Jesus. This cluster alone included 5212 cases of the 5543 total cases in the social event category [17]. Additionally, this one cluster alone formed about 45% of total cases in the country at the time of data collection. If this cluster were not present, healthcare would be number one both in number of clusters and number of cases.

It is possible that education, workplace, catering, shopping. leisure and travel had fewer COVID-19 clusters due to them being closed early in response to the pandemic. Therefore, they cannot be treated as being safe from COVID spread. Our results show that after closing such settings, we still need to focus on accommodation settings and particularly mass accommodation rather than residential settings.

The rationale behind school closures is based almost entirely on modelling studies on influenza outbreaks, which puts it at odds to recent COVID-19 modelling studies anticipate that only 2–4% of deaths could be averted by school closures alone, which is lacking in comparison to other social distancing measures. This review presents the difficulty in determining the value of school closures, and our results supplement this rationale as evidenced by the suggested lower susceptibility of educational settings to forming COVID-19 clusters [18]. While the causes may vary, a prime suspect would be due to the fact that school closures are one of the first measures taken by many countries. Health officials need to be made aware of this information when making policies concerning school closures in the context of broader social distancing measures.

Whereas, early on in the pandemic it was believed that children could not be infected with COVID-19, it is now accepted that they have the same risk of infection as adults. The main difference, however, lies in the fact that they display fewer and milder symptoms [19]. This could be another possible explanation for the relative scarcity of reports of COVID-19 clusters in educational/children settings since generally only serious cases tend to seek healthcare services and are therefore recorded and reported.

Our results show that redesigning of mass accommodation to resemble residential facilities in their separation and space is required. In particular, vulnerable accommodation should receive increased and better-quality monitoring (possibly through an app), testing, financial support, and hygiene standards; alternatively, a transfer to better quality accommodation if standards cannot be met. Furthermore, they can further illustrate the importance of contact tracing in deciding on the settings for COVID-19 clusters.

Our resources from which we extracted our data from consisted of verified databases, which is advantageous, especially in comparison to the method of creating a personal database, which another recent study utilized. Our method ensures that clusters are not missed, while the latter method is a tedious and error prone process, especially when considering the breadth of countries involved. Additionally, countries were chosen on the basis that they had greater than 1000 cases. This is because we suspected that smaller countries would present with different cluster types, either due to better control of COVID-19 or simply due to the small populations not being a representative sample for COVID-19 clusters in a country.

However, our study has some limitations. We were unable to collect the data required for most of the countries we searched for. This resulted in only eight countries being examined—a small number which can greatly limit the generalizability of our findings. In addition to the fact that some countries do not publicly publish databases of cluster settings, we may have also not found some databases simply due to language barriers and the fact that our search terms were mostly in English. Another limitation of our study which could limit the generalizability of our results is that we only examined countries that had >1000 cases and therefore mostly large populations. We cannot be sure, therefore, whether our results also apply to countries that achieved better control of the pandemic or those who have smaller populations than the countries we examined.

While most of our data could be considered high quality due to it coming from government sources, sometimes we were unable to find them and had to depend on databases published by newspapers and other trackers which could be considered of lesser quality.

Another major limitation of our research is that different countries had different definitions of clusters. For example, New Zealand, unlike other countries, defines clusters as being "ten or more cases connected through transmission and who are not all part of the same household" [8]. This may explain the lack of residential clusters in the data for New Zealand. Analogously, Germany grouped all cluster subtypes pertaining to children and education together, which is a notable difference considering no other country followed this categorization.

Moreover, our study examines data which was collected often after lockdown measures have been implemented and our results cannot therefore inform decisions in the earlier phases of a pandemic. This is reflected in our results in how travel and educational settings often ranked lower. We believe the earlier closure of such settings was a large contributor to this seemingly surprising result.

Additionally, while the databases we use as data sources represent our best knowledge of cluster settings, they are clearly not perfect which further limits the deductive potential of our study. Reasons that these databases may be imperfect include difficult monitoring of COVID-19 transmission in outdoor settings (which explains the fact majority of settings recorded in our study are indoor) and the lack of monitoring in certain settings (it is understandable that nursing homes and prisons are better monitored than catering clusters for example). The USA data is the most up to date since it is continuously updated every day which makes it very difficult to reach some data at specified time points. This probably contributes to the high number of clusters and cases compared to other countries when it was last checked.

Further research can be done to further understand the transmission dynamics of each cluster type including R0, doubling time, etc. Future research could also further investigate why it is that some settings are more vulnerable for forming COVID-19 clusters than others. Our paper is only observational in nature and we can only make guesses as to why certain settings are more susceptible to forming COVID-19 clusters, we therefore need more research into the causes for these differences to focus on them when tackling a possible second wave of COVID-19 or potentially other similar respiratory viruses. Studies can also be done to understand the difference in transmission mechanism between different cluster settings and the measures which need to be undertaken to contain the infection in each type of cluster. Similarly, studies could be undertaken to compare the relative usefulness for closure of each of the above settings (if any) when it comes to limiting the spread of the virus. Such studies can help other countries in active surveillance of their communities to prevent development of such clusters and can also help in preparedness for future pandemics.

In our paper we only focused on countries with >1000 cases. It would therefore be interesting to investigate how cluster settings differ between our countries and ones that better controlled COVID-19 spread such as Taiwan. In a similar vein, most of our countries have relatively large populations so we also need to answer the question of how cluster types would differ between the countries we examined and those of smaller populations.

In carrying out our research something we were surprised with was the lack of databases for many countries concerning cluster settings. In fact, some countries had databases for clusters but did not mention the setting where this cluster developed. It is clear we need better monitoring, surveillance and data collection to identify settings where COVID-19 clusters formed since this can greatly inform future research and therefore help us deal with future COVID-19 virus spread or other similar pandemics.

The main application of our study is that it can assist governments in prioritizing control measures when tackling a possible second wave of the pandemic and future pandemics of a similar nature. Identifying settings more prone to the transmission of COVID-19 can inform opening and closure of such settings as well as monitoring and testing. To illustrate the importance of such knowledge, consider school closures: School closures have many drawbacks in that they affect children and parents alike. Children's educational progress is hindered, and the parents are tasked with finding childminders or else sacrificing their productivity. This brings into question whether the benefits of school closures outweigh the disadvantages? Similarly, the closure of the various kinds of settings mentioned above create major issues for large parts of the population. Therefore, these findings are beneficial in understanding the relative importance of a guided ease of lockdown restrictions and identifying whether close monitoring or closure of each cluster setting is warranted, potentially leading to the avoidance of a complete lockdown.

Conclusion

In conclusion, our results show that COVID-19 clusters take place in a variety of location types which vary across countries, although there are recurring themes. These results highlight the importance of countries to actively pursue close contact tracing of cases to prevent clusters from spreading. In addition, these results could lay the foundation to identifying links between locations and clusters; and by extension, determining the closure of locations and/or whether close monitoring would suffice.

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Competing interests

None declared.

Ethical approval

Not required.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.jiph.2021.01.006.

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