SARS-CoV-2 Superspread in Fitness Center, Hong Kong, China, March 2021

Daniel K.W. Chu,1 Haogao Gu,1 Lydia D.J. Chang, Sammi S.Y. Cheuk, Shreya Gurung, Pavithra Krishnan, Daisy Y.M. Ng, Gigi Y.Z. Liu, Carrie K.C. Wan, Dominic N.C. Tsang, Malik Peiris, Leo L.M. Poon

Author affiliations: The University of Hong Kong, Hong Kong, China (D.K.W. Chu, H. Gu, L.D.J. Chang, S.S.Y. Cheuk, S. Gurung, P. Krishnan, D.Y.M. Ng, G.Y.Z. Liu, C.K.C. Wan, M. Peiris, L.L.M. Poon); The Government of Hong Kong Special Administrative Region, Hong Kong (D.N.C. Tsang)

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Hong Kong, China, is at the end of a fourth wave of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. The virus causing this wave was introduced in September 2020 (GISAID clade GH) (1) and has continued to evolve in Hong Kong. As of April 30, 2021, a total of 11,771 SARS-CoV-2 cases had been laboratory confirmed; more than half (56%) were detected during the fourth wave. We describe a superspreading event that occurred in a 3,000-ft² fitness center in March 2021 (Appendix Figure 1, https://wwwnc.cdc.gov/EID/article/27/8-210833-App1.pdf).

On March 10, 2021, an asymptomatic 27-year-old male fitness trainer (patient FC1) received a positive reverse transcription PCR (RT-PCR) test result as part of a voluntary coronavirus disease (COVID-19) screening program. This program provided services to persons for community or private purposes (e.g., for work or travel). The fitness trainer had previously received a negative COVID-19 test result on February 17, 2021. He taught small group classes in the fitness center every day from February 28 through March 8, except March 4, 2021.

His positive test result triggered a local health authority to conduct epidemiologic investigation and contact tracing. The fitness center was immediately closed to the public. The local government also issued a compulsory testing notice to those who had visited this center from February 25 through March 10. About 300 visitors were tested and 101 cases were confirmed (7 staff members and 94 customers; case-patients FC2–FC102) (Appendix Table 1). All case-patients had recently visited this center; >80% of cases were detected within 3 days of the first case (Appendix Figure 2). Another 53 SARS-CoV-2–positive persons were subsequently identified; they had had close contact with the 102 case-patients but no epidemiologic link to the fitness center.

Of the 102 case-patients, all were hospitalized according to local standard practice, recovered uneventfully, and were discharged. None had received COVID-19 vaccination before this outbreak. A total of 46 case-patients were asymptomatic at the time of testing. The percentage of asymptomatic case-patients in this cluster (45%) is higher than that of all persons with confirmed cases in Hong Kong (30%; p<0.005). It is not known whether the general physical well-being of case-patients in this cluster affected their clinical status. Their ages, on average, were lower than that of all persons with confirmed cases in Hong Kong (38 vs. 44 years; p<0.005).

Among the 56 symptomatic case-patients, signs and symptoms started to develop for 36 of them during March 9–11; the earliest onset date was March 6 (case-patient FC46). Assuming the average incubation period of COVID-19 to be ≤5 days (2), the superspreading event might have occurred around March 5. Because SARS-CoV-2 can be transmitted by asymptomatic and presymptomatic persons (3), our data did not enable us to identify the index case-patient of this cluster.

To exclude unrelated transmission chains in this fitness center, we used next-generation sequencing to study respiratory samples from 59 of the case-patients (1,4). We used 5 epidemiologically unrelated local case-patients, including 4 detected in the same period, as controls. All virus sequences from the fitness center outbreak genetically clustered together and were genetically distinct from the controls (Figure), demonstrating that this superspreading event was caused by a single virus introduction.

Many case-patients, including FC1 and FC46, were located at the root of this phylogenetic branch. There are a few minor clades in this phylogenetic branch, suggesting that the initial introduction triggered multiple independent transmission chains thereafter in this setting.

SARS-CoV-2 transmission in fitness centers/gyms has been reported (5–8). SARS-CoV-2 can be
**Figure.** Phylogenetic tree of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) viruses detected in a fitness club in Hong Kong, China, in March 2021. Viruses from clades L, S, V, G, GH, GR, and O (others) are also included in the analysis. Near full-length genomes of studied samples were deduced by a previously described Illumina (https://www.illumina.com) sequencing protocol (sequence coverage >100) (1,4). Human SARS-CoV-2 WIV04 is selected to be the root of this phylogenetic tree. The tree was constructed by using the neighbor-joining method. Only bootstrap values >80 are shown. EPI ISL accession nos. for sequences retrieved in GISAID (https://www.gisaid.org) are provided. Scale bar indicates estimated genetic distance.
transmitted by close contact, droplets, or fomites (9). Uncontrolled physical activities in a fitness center might produce any or all of these transmission modes (e.g., increased physical contact, increased levels of exhaled respiratory droplets in a confined space because of vigorous breathing, and shared communal space and equipment). Although in this study we were unable to identify the predominant transmission mode accounting for this superspreading event, a recent report indicates that physical activities in a fitness center can create a pronounced level of saliva aerosol (10). An air change rate of 2.2/ hour in a fitness center is insufficient to dilute the amount of saliva aerosol generated from physical activities (10). Of note, mask wearing during exercise was not compulsory by law at the time of this outbreak. Many case-patients in our study reported not wearing a mask while training at that time (e.g., weight training, high-intensity circuit training, and boxing). A follow-up investigation revealed that this center has air conditioning units but lacks a fresh air and exhaust duct system. This finding suggests that poor ventilation might have played a major role in this outbreak.

After this outbreak, new recommendations were issued to prevent superspreading events at fitness centers in Hong Kong. For staff in these settings, RT-PCR testing for SARS-CoV-2 every 2 weeks is compulsory, and staff are prioritized to receive COVID-19 vaccination. For all persons in fitness settings, mask wearing at all times is now mandatory, except when showering or eating. Recommendations for air ventilation in all fitness centers are under investigation.

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Virus sequences reported in this study are available in GISAID (http://platform.gisaid.org; accession nos. EPI_ISL_1824501 to EPI_ISL_1824564). The epidemiologic data for the 102 case-patients can be accessed in a public database (https://data.gov.hk/en-data/dataset/hk-dh-chpsebcddr-novel-infectious-agent).

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About the Author
Dr. Chu is a research assistant professor at The University of Hong Kong, China. His research interests focus on diagnostic virology, molecular diagnostics, and virus evolution.

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Address for correspondence: Leo Poon, School of Public Health, The University of Hong Kong, Rm 528, Lab Block 21, Sassoon Rd, Pokfulam, Hong Kong, China; email: llmpoon@hku.hk
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Appendix

Appendix Table 1. Epidemiology data of FC1-FC2

| Case no. | Report date (2021) | Sex  | Age | Onset date (2021)  |
|----------|--------------------|------|-----|-------------------|
| FC1      | Mar 10             | Male | 27  | Asymptomatic      |
| FC2      | Mar 11             | Male | 46  | Mar 9             |
| FC3      | Mar 11             | Male | 40  | Asymptomatic      |
| FC4      | Mar 11             | Male | 56  | Asymptomatic      |
| FC5      | Mar 11             | Male | 30  | Mar 8             |
| FC6      | Mar 11             | Male | 44  | Mar 8             |
| FC7      | Mar 11             | Male | 47  | Mar 9             |
| FC8      | Mar 11 Female      | 23   | Mar 8 |
| FC9      | Mar 11 Female      | 30   | Mar 9 |
| FC10     | Mar 11 Female      | 30   | Mar 9 |
| FC11     | Mar 11 Male        | 34   | Asymptomatic |
| FC12     | Mar 11 Male        | 41   | Asymptomatic |
| FC13     | Mar 11 Female      | 19   | Mar 9 |
| FC14     | Mar 11 Male        | 47   | Mar 9 |
| FC15     | Mar 11 Female      | 54   | Asymptomatic |
| FC16     | Mar 11 Female      | 31   | Asymptomatic |
| FC17     | Mar 11 Female      | 35   | Asymptomatic |
| FC18     | Mar 12 Female      | 42   | Mar 8 |
| FC19     | Mar 12 Male        | 34   | Mar 7 |
| FC20     | Mar 12 Female      | 42   | Asymptomatic |
| FC21     | Mar 12 Male        | 39   | Asymptomatic |
| FC22     | Mar 12 Male        | 33   | Mar 10 |
| FC23     | Mar 12 Female      | 26   | Mar 10 |
| FC24     | Mar 12 Male        | 36   | Mar 10 |
| FC25     | Mar 12 Male        | 34   | Mar 10 |
| FC26     | Mar 12 Male        | 39   | Mar 10 |
| FC27     | Mar 12 Male        | 53   | Mar 10 |
| FC28     | Mar 12 Female      | 33   | Asymptomatic |
| FC29     | Mar 12 Male        | 42   | Mar 11 |
| FC30     | Mar 12 Male        | 37   | Asymptomatic |
| FC31     | Mar 12 Male        | 46   | Mar 10 |
| FC32     | Mar 12 Female      | 38   | Mar 9 |
| FC33     | Mar 12 Male        | 41   | Asymptomatic |
| FC34     | Mar 12 Female      | 22   | Asymptomatic |
| FC35     | Mar 12 Male        | 36   | Asymptomatic |
| FC36     | Mar 12 Male        | 20   | Asymptomatic |
| FC37     | Mar 12 Female      | 35   | Mar 10 |
| FC38     | Mar 12 Female      | 33   | Mar 10 |
| FC39     | Mar 12 Female      | 24   | Mar 10 |
| FC40     | Mar 12 Female      | 37   | Mar 11 |
| FC41     | Mar 12 Male        | 36   | Mar 11 |
| FC42     | Mar 12 Female      | 38   | Asymptomatic |
| FC43     | Mar 12 Male        | 40   | Mar 9 |
| FC44     | Mar 12 Female      | 36   | Mar 9 |
| FC45     | Mar 12 Male        | 44   | Mar 8 |
| FC46     | Mar 12 Female      | 32   | Mar 6 |
| FC47     | Mar 12 Male        | 34   | Asymptomatic |
| FC48     | Mar 12 Female      | 37   | Mar 10 |
| FC49     | Mar 12 Male        | 41   | Mar 9 |
| FC50     | Mar 12 Male        | 27   | Asymptomatic |
| FC51     | Mar 12 Male        | 45   | Asymptomatic |
| FC52     | Mar 12 Male        | 31   | Mar 11 |
| FC53     | Mar 12 Female      | 44   | Asymptomatic |
| FC54     | Mar 12 Female      | 25   | Asymptomatic |
| Case no. | Report date (2021) | Sex   | Age | Onset date (2021) |
|----------|--------------------|-------|-----|-------------------|
| FC55     | Mar 12             | Female| 38  | Asymptomatic      |
| FC56     | Mar 12             | Male  | 41  | Mar 11            |
| FC57     | Mar 12             | Male  | 36  | Asymptomatic      |
| FC58     | Mar 13             | Female| 37  | Mar 11            |
| FC59     | Mar 13             | Female| 37  | Asymptomatic      |
| FC60     | Mar 13             | Male  | 61  | Asymptomatic      |
| FC61     | Mar 13             | Female| 28  | Mar 11            |
| FC62     | Mar 13             | Male  | 48  | Asymptomatic      |
| FC63     | Mar 13             | Female| 34  | Mar 11            |
| FC64     | Mar 13             | Male  | 36  | Mar 11            |
| FC65     | Mar 13             | Female| 31  | Mar 11            |
| FC66     | Mar 13             | Male  | 35  | Mar 10            |
| FC67     | Mar 13             | Female| 36  | Mar 11            |
| FC68     | Mar 13             | Male  | 40  | Asymptomatic      |
| FC69     | Mar 13             | Male  | 49  | Mar 12            |
| FC70     | Mar 13             | Male  | 33  | Asymptomatic      |
| FC71     | Mar 13             | Male  | 38  | Asymptomatic      |
| FC72     | Mar 13             | Male  | 37  | Asymptomatic      |
| FC73     | Mar 13             | Male  | 48  | Mar 11            |
| FC74     | Mar 13             | Male  | 62  | Asymptomatic      |
| FC75     | Mar 13             | Male  | 39  | Asymptomatic      |
| FC76     | Mar 13             | Male  | 36  | Asymptomatic      |
| FC77     | Mar 13             | Male  | 33  | Mar 12            |
| FC78     | Mar 13             | Female| 36  | Mar 11            |
| FC79     | Mar 13             | Female| 48  | Asymptomatic      |
| FC80     | Mar 13             | Male  | 26  | Mar 9             |
| FC81     | Mar 13             | Female| 36  | Asymptomatic      |
| FC82     | Mar 13             | Female| 39  | Mar 10            |
| FC83     | Mar 14             | Male  | 47  | Mar 13            |
| FC84     | Mar 14             | Female| 37  | Asymptomatic      |
| FC85     | Mar 14             | Male  | 31  | Asymptomatic      |
| FC86     | Mar 14             | Male  | 46  | Asymptomatic      |
| FC87     | Mar 14             | Female| 34  | Mar 13            |
| FC88     | Mar 14             | Female| 37  | Mar 13            |
| FC89     | Mar 15             | Female| 43  | Asymptomatic      |
| FC90     | Mar 15             | Male  | 47  | Mar 13            |
| FC91     | Mar 15             | Female| 45  | Mar 13            |
| FC92     | Mar 15             | Female| 36  | Mar 14            |
| FC93     | Mar 16             | Male  | 42  | Asymptomatic      |
| FC94     | Mar 17             | Female| 34  | Asymptomatic      |
| FC95     | Mar 18             | Male  | 42  | Mar 16            |
| FC96     | Mar 19             | Male  | 46  | Mar 17            |
| FC97     | Mar 20             | Male  | 44  | Asymptomatic      |
| FC98     | Mar 21             | Female| 37  | Asymptomatic      |
| FC99     | Mar 22             | Male  | 39  | Mar 20            |
| FC100    | Mar 22             | Female| 28  | Asymptomatic      |
| FC101    | Mar 22             | Female| 39  | Mar 20            |
| FC102    | Mar 23             | Male  | 33  | Asymptomatic      |
| Virus name                  | Accession No. | Collected   | Originating laboratory                                      | Submitting laboratory                                      | Submitted by                  |
|----------------------------|---------------|-------------|-------------------------------------------------------------|-------------------------------------------------------------|------------------------------|
| Australia/VIC1158/2020     | EPI_ISL_430602 | 2020 Apr 9  | Victorian Infectious Diseases Reference Laboratory (VIDRL) | Microbiological Diagnostic Unit Public Health Laboratory and Victorian Infectious Diseases Reference Laboratory, The Peter Doherty Institute for Infection and Immunity | Caly L. et al                |
| Australia/VIC1787/2020    | EPI_ISL_456649 | 2020 May 27 | Victorian Infectious Diseases Reference Laboratory (VIDRL) | Microbiological Diagnostic Unit Public Health Laboratory and Victorian Infectious Diseases Reference Laboratory, The Peter Doherty Institute for Infection and Immunity | Caly L. et al                |
| Australia/VIC98/2020      | EPI_ISL_419810 | 2020 Mar 16 | Victorian Infectious Diseases Reference Laboratory (VIDRL) | Microbiological Diagnostic Unit Public Health Laboratory and Victorian Infectious Diseases Reference Laboratory, The Peter Doherty Institute for Infection and Immunity | Caly L. et al                |
| England/20132080404/2020 | EPI_ISL_423805 | 2020 Mar 24 | Respiratory Virus Unit, Microbiology Services Colindale, Public Health England | Respiratory Virus Unit, Microbiology Services Colindale, Public Health England | Monica Galiano et al         |
| England/CAMB-77909/2020   | EPI_ISL_439431 | 2020 Mar 31 | Department of Pathology, University of Cambridge Quadram Institute Biocentre, Biocommunicable and Infectious Diseases Unit | Wellcome Sanger Institute for the COVID-19 Genomics UK (COG-UK) consortium | Luke W Meredith et al        |
| England/NORW-EC85D/2020   | EPI_ISL_457566 | 2020 May 13 | Virolab, Department of Infection, Immunity and Cardiovascular Disease, The Florey Institute, The Medical School, University of Sheffield | COVID-19 Genomics UK (COG-UK) Consortium | Dave J. Baker et al          |
| England/SHEF-C03E5/2020   | EPI_ISL_420221 | 2020 Mar 29 | Virology Department, Sheffield Teaching Hospitals NHS Foundation Trust | Health Protection Scotland, Public Health England | Thushan de Silva et al       |
| France/HDF-3668/2020      | EPI_ISL_443316 | 2020 Mar 25 | CH Complège Laboratoire de Biologie | National Reference Center for Viruses of Respiratory Infections, Institut Pasteur, Paris | Mélanie Albert et al         |
| HongKong/VB20175856/2020  | EPI_ISL_539823 | 2020 Aug 14 | Communicable Disease Branch Tuen Mun Hospital | Hong Kong Department of Health deCODE genetics | Alan K.L. Tsang et al        |
| HongKong/VM20066524/2020  | EPI_ISL_539814 | 2020 Jul 21 | Communicable Disease Branch Tuen Mun Hospital | Hong Kong Department of Health deCODE genetics | Alan K.L. Tsang et al        |
| Iceland/99/2020           | EPI_ISL_417768 | 2020 Mar 10 | The National University Hospital of Iceland REGIONAL VRDL/ICMR-RMRC BBSR Takayuki Hishiki | Takayuki Hishiki Kanagawa Prefectural Institute of Public Health Takayuki Hishiki Kanagawa Prefectural Institute of Public Health | Hishiki et al                 |
| India/OR-RMRC164/2020     | EPI_ISL_455764 | 2020 May 7  | Immunogenomics lab, Institute of Life Sciences, Bhubaneswar | Institute of Environmental Science and Research (ESR) | Sunil Raghav et al           |
| Japan/Hu_DP_Kng_19-031/2020 | EPI_ISL_420889 | 2020 Feb 14 | Takayuki Hishiki Kanagawa Prefectural Institute of Public Health | Institute of Environmental Science and Research (ESR) | Hishiki et al                 |
| NewZealand/20VR3045/2020  | EPI_ISL_456402 | 2020 Apr 25 | Wellington SCL | Institute of Environmental Science and Research (ESR) | Matt Storey et al            |
| Virus name                        | Accession No.  | Collected       | Originating laboratory                  | Submitting laboratory                      | Submitted by                       |
|----------------------------------|----------------|-----------------|----------------------------------------|--------------------------------------------|------------------------------------|
| Portugal/PT0163/2020             | EPI_ISL_453879| 2020 Mar 28     | unknown                                | Instituto Nacional de Saude (INSA)         | Borges et al et al                 |
| Spain/MD-ISCIII-201738/2020      | EPI_ISL_419237| 2020 Mar 7      | Fundacion Jimenez Diaz                 | Instituto de Salud Carlos III             | Iglesias-Caballero et al           |
| USA/CA-CZB-1237/2020             | EPI_ISL_454657| 2020 May 12     | County of Santa Clara Public Health Department | Chan-Zuckerberg Biohub                     | CZB Ciahub Consortium et al        |
| Wales/PHWC-3180E/2020            | EPI_ISL_446492| 2020 Apr 11     | Wales Specialist Virology Centre       | Public Health Wales Microbiology Cardiff    | Catherine Moore et al              |
| Wales/PHWC-32B6E/2020            | EPI_ISL_446656| 2020 Apr 14     | Wales Specialist Virology Centre       | Public Health Wales Microbiology Cardiff    | Catherine Moore et al              |
| Wuhan/HB-WH1-131/2020            | EPI_ISL_454910| 2020 Mar 2      | Wuhan Chain Medical Labs (CMLabs)      | State Key Laboratory of Biotherapy of Sichuan University | Baowen Du et al                    |
| Wuhan/WIV04/2019                 | EPI_ISL_402124| 2019 Dec 30     | Wuhan Jinyintan Hospital               | Wuhan Institute of Virology, Chinese Academy of Sciences | Peng Zhou et al                    |

Appendix Figure 1. Coronavirus disease (COVID-19) pandemic waves in Hong Kong, China. Number of cases with different epidemiologic links are shown. Arrow indicates the outbreak that occurred in the fitness center in Hong Kong in March 2021. This Figure is modified from the one available from the School of Public Health, The University of Hong Kong (https://covid19.sph.hku.hk/).
Appendix Figure 2. COVID-19 cases epidemiologically linked to a fitness center. The number of daily detected cases, daily detected asymptomatic cases, and reported onset dates in the studied period are shown. The first reported case was detected on 10 Mar 2021.