

Familial Clusters of Coronavirus Disease in 10 Prefectures, Japan, February–May 2020

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The overall coronavirus disease secondary attack rate (SAR) in family members was 19.0% in 10 prefectures of Japan during February 22–May 31, 2020. The SAR was lower for primary cases diagnosed early, within 2 days after symptom onset. The SAR of asymptomatic primary cases was 11.8%.

As of May 31, 2020, Japan had reported >16,800 confirmed coronavirus disease (COVID-19) cases and 890 related deaths. The cluster-based approach is one of the pillars of control measures in Japan (1). Sixty-one clusters were documented in healthcare facilities, restaurants, workplaces, and music venues during January–April 2020 (2). However, the transmission within households, one of the highest-risk settings, has not been fully investigated.

A meta-analysis of 43 studies showed that the pooled household secondary attack rate (SAR) was 18.1%, and heterogeneity ranged from 3.9% to 54.9% (3). Heterogeneity of SAR could occur because of variations in susceptibility to infection (3), variations in exposure (4), and variations in infectiousness. The primary cases of infectiousness defined by age, sex, and symptoms were less studied in the different settings. Furthermore, there were few reports of SAR among asymptomatic

primary cases (3,5,6). Therefore, we estimated the SAR of COVID-19 and assessed the effects of age and sex of primary cases, symptoms of primary cases, and the time between diagnosis and symptom onset for primary cases on infectiousness in familial clusters.

The Study

Among 47 prefectures in Japan, 10 prefectures (Aomori, Akita, Gunma, Tochigi, Toyama, Shiga, Okayama, Kochi, Saga, and Kagoshima) (Appendix Figure 1, <https://wwwnc.cdc.gov/EID/article/27/3/20-3882-App1.pdf>) that showed a relatively low COVID-19 prevalence posted laboratory-confirmed cases and contact-tracing results on their websites (Appendix Table 1). In this study, we collected basic characteristics of cases from the reports issued during February 22–May 31, 2020, on those websites. The websites did not provide characteristics of uninfected close contacts or details of residence of family members. During the study period in Japan, doctors provided diagnoses of COVID-19 by using real-time PCR and reported cases to healthcare centers. These centers listed close contacts according to whether they spent >15 min in face-to-face contact and conducted follow-up by telephone for ≥ 14 days to monitor their symptoms.

Persons who had any COVID-19–related signs/symptoms, such as fever, cough, and fatigue, were categorized as having symptomatic cases. Asymptomatic cases were those without any symptoms at diagnosis. During this study period, all confirmed case-patients were hospitalized after they were given a diagnosis. Suspected case-patients and asymptomatic close contacts self-quarantined at home. Healthcare centers in 8 prefectures performed PCRs for close contacts regardless of their symptoms. One prefecture did not show the strategy of PCR testing for asymptomatic contacts, and 1 prefecture performed PCRs for symptomatic contacts, such as persons who had fever and respiratory symptoms.

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In this study, we defined a primary case as the first case to show development of symptoms and to be diagnosed in a family or the first diagnosed asymptomatic case in a family who had an apparent history of contact with a nonfamilial COVID-19 case-patient. We defined secondary cases as laboratory-confirmed cases from the list of close family contacts of primary case-patients. Because websites provided only symptoms at diagnosis, we could not identify presymptomatic cases. We calculated SAR as the proportion of secondary cases of family close contacts among the total number of family close contacts and determined the SAR, risk ratio, and 95% CI, stratified by the characteristics of the primary case-patients. We compared the SAR before and after the declaration of the state of emergency on April 16. All statistical analyses were conducted by using Stata version 14.0 (StataCorp, <https://www.stata.com>).

During February 22–May 31, 2020, the 10 prefectures reported 306 primary cases and 775 family close contacts from 306 families. Eighty-seven primary cases were associated with 147 family secondary cases (Table 1; Appendix Figure 2). The overall SAR was 19.0%. Among 28 asymptomatic primary cases, 7 caused family clusters (Table 2; Appendix Table 2), and the SAR was 11.8%. Eight prefectures that tested

for asymptomatic contacts showed an SAR that was 1.77 times higher than the SAR for 2 prefectures that used a nontesting strategy. The age-stratified SAR was higher for persons 60–69 years of age (36.5%) and persons <20 years of age (23.8%) than for persons 20–29 years of age (13.3%), persons 30–39 years of age (20.4%), persons 40–49 years of age (10.1%), and persons 50–59 years of age (16.1%) (Table 2).

With increasing time from symptom onset to diagnosis, the SARs in households increased from 11.6% (≥ 2 days) to 40.0% (≥ 14 days) (Table 2). When the data were stratified for analysis by the number of household contacts, 4 household contacts showed the highest SAR (25.7%). After a quarantine at home was requested from the government on April 16, the SAR increased from 17.4% to 21.0%, but the risk ratio did not reach statistical significance.

Conclusions

This family cluster analysis in the 10 prefectures of Japan showed that the overall SAR of the family cluster was estimated to be 19.0% in Japan. Meta-analysis from 43 household transmission studies estimated a SAR of 18.1% (3): 3.9% in Singapore (7), 4.6% in Taiwan (8), 10.3%–54.9% in China (9–12), and $\approx 30\%$ in

Table 1. Characteristics of primary and secondary case-patients in households of familial clusters of coronavirus disease in 10 prefectures, Japan, February–May, 2020*

| Characteristic | Primary | Secondary |
|--|------------|------------|
| No. case-patients | 306 | 147 |
| Sex | | |
| F | 152 (49.7) | 82 (55.8) |
| M | 153 (50.0) | 64 (43.5) |
| Unknown | 1 (0.3) | 1 (0.7) |
| Age, y | | |
| 0–19 | 11 (3.5) | 28 (19.0) |
| 20–29 | 48 (15.7) | 14 (9.5) |
| 30–39 | 36 (11.8) | 16 (10.9) |
| 40–49 | 58 (19.0) | 8 (5.4) |
| 50–59 | 57 (18.6) | 24 (16.3) |
| 60–69 | 43 (14.1) | 29 (19.7) |
| 70–79 | 31 (10.1) | 14 (9.5) |
| >80 | 22 (7.2) | 14 (9.5) |
| Unknown | 0 (0) | 1 (0.7) |
| Contact history to COVID-19 nonfamilial cases | | |
| No | 146 (47.7) | 147 (100) |
| Yes | 159 (52) | 0 |
| Unknown | 1 (0.3) | 0 |
| Symptom | | |
| Symptomatic | 271 (88.6) | 103 (70.1) |
| Asymptomatic | 28 (9.2) | 39 (26.5) |
| Unknown | 7 (2.3) | 5 (3.4) |
| Median time from symptom onset to diagnosis, d (IQR) | 6 (4–9) | 5 (2.5–9) |
| Confirmed date of primary case | | |
| On or before April 16 | 179 (58.5) | NA |
| After April 16 | 127 (41.5) | NA |
| Policy of testing for asymptomatic contacts | | |
| No testing, 2 prefectures | 54 (17.6) | 16 (10.9) |
| Testing for asymptomatic contacts, 8 prefectures | 252 (82.4) | 131 (89.1) |

*Values are no. (%) unless otherwise indicated. COVID-19, coronavirus disease; IQR, interquartile range; NA, not applicable.

Table 2. Characteristics of primary cases in households and SAR categorized for households of familial clusters of coronavirus disease in 10 prefectures, Japan, February–May, 2020*

| Variable | No. (%) primary cases | No. family contacts | No. secondary infected cases | No. symptomatic secondary infected cases | No. asymptomatic secondary infected cases | SAR, % (95% CI) | Risk ratio (95% CI) |
|--|-----------------------------|---------------------------|---------------------------------------|---|--|--------------------|------------------------|
| Overall | 306 (100) | 775 | 147 | 103 | 39 | 19.0 (16.3–21.9) | |
| Sex | | | | | | | |
| F | 152 (49.7) | 408 | 68 | 50 | 14 | 16.7 (13.2–20.6) | Referent |
| M | 153 (50.0) | 366 | 79 | 53 | 25 | 21.6 (17.5–26.2) | 1.29 (0.97–1.73) |
| Unknown | 1 (0.3) | 1 | 1 | 0 | 1 | NA | NA |
| Age, y | | | | | | | |
| <1–19 | 10 (3.6) | 42 | 10 | 7 | 3 | 23.8 (12.1–39.5) | Referent |
| 20–29 | 48 (15.7) | 135 | 18 | 15 | 2 | 13.3 (8.1–20.3) | 0.56 (0.28–1.12) |
| 30–39 | 36 (11.8) | 103 | 21 | 15 | 6 | 20.4 (13.1–29.5) | 0.85 (0.44–1.66) |
| 40–49 | 58 (19.0) | 139 | 14 | 9 | 5 | 10.1 (5.6–16.3) | 0.42 (0.20–0.88) |
| 50–59 | 57 (18.6) | 155 | 25 | 13 | 9 | 16.1 (10.7–22.9) | 0.68 (0.35–1.30) |
| 60–69 | 43 (14.1) | 85 | 31 | 20 | 10 | 36.5 (26.3–47.6) | 1.53 (0.83–2.81) |
| 70–79 | 31 (10.1) | 53 | 11 | 10 | 1 | 20.8 (10.8–34.1) | 0.87 (0.41–1.85) |
| >80 | 22 (7.2) | 63 | 17 | 14 | 3 | 29.4 (23.2–36.2) | 1.13 (0.58–2.23) |
| Contact history with nonfamilial COVID-19 cases | | | | | | | |
| No | 146 (47.7) | 357 | 91 | 64 | 24 | 25.4 (21.0–30.3) | 1.90 (1.4–2.57) |
| Yes | 159 (52.0) | 417 | 56 | 39 | 15 | 13.4 (10.3–17.1) | Referent |
| Unknown | 1 (0.3) | 1 | 0 | 0 | 0 | NA | NA |
| No. household contacts per primary case | | | | | | | |
| 1 | 88 (28.8) | 88 | 17 | 15 | 2 | 19.3 (11.7–29.1) | Referent |
| 2 | 75 (24.5) | 150 | 26 | 16 | 8 | 17.3 (11.6–24.4) | 0.90 (0.52–1.56) |
| 3 | 82 (26.8) | 246 | 47 | 32 | 13 | 19.1 (14.4–24.6) | 0.90 (0.60–1.63) |
| 4 | 35 (11.4) | 140 | 36 | 27 | 8 | 25.7 (18.7–33.8) | 1.33 (0.80–2.22) |
| ≥5 | 26 (8.5) | 151 | 21 | 13 | 8 | 13.9 (8.8–20.5) | 0.72 (0.40–1.29) |
| Symptoms | | | | | | | |
| Symptomatic | 271 (88.6) | 661 | 136 | 98 | 33 | 20.6 (17.6–23.9) | Referent |
| Asymptomatic | 28 (9.2) | 93 | 11 | 5 | 6 | 11.8 (6.1–20.2) | 0.57 (0.32–1.02) |
| Unknown | 7 (3.6) | 21 | 0 | 0 | 0 | NA | NA |
| Time from symptom onset to diagnosis, d, n = 271 | | | | | | | |
| 0–2 | 30 (11.1) | 65 | 4 | 3 | 1 | 11.6 (5.1–21.6) | Referent |
| 3–7 | 130 (48.0) | 319 | 63 | 42 | 21 | 19.8 (15.5–24.5) | 3.21 (1.21–8.51) |
| 8–14 | 94 (34.7) | 230 | 51 | 40 | 8 | 22.2 (17.0–28.1) | 3.60 (1.35–9.6) |
| >14 | 17 (6.3) | 45 | 18 | 9 | 9 | 40.0 (25.7–55.7) | 6.50 (2.36–17.93) |
| Confirmed date of primary case | | | | | | | |
| Feb 22–Apr 16 | 179 (58.5) | 448 | 78 | 57 | 16 | 17.4 (14.0–21.3) | Referent |
| Apr 17–May 31 | 127 (41.5) | 328 | 69 | 46 | 23 | 21.0 (16.8–25.9) | 1.21 (0.90–1.61) |
| Policy of testing for asymptomatic contacts | | | | | | | |
| No testing, 2 prefectures | 54 (17.6) | 138 | 16 | 12 | 1 | 11.6 (6.8–18.1) | Referent |
| Testing for asymptomatic contacts, 8 prefectures | 252 (82.4) | 637 | 131 | 91 | 38 | 20.6 (17.5–23.9) | 1.77 (1.09–2.88) |

*COVID-19, coronavirus disease; NA, not applicable; SAR, secondary attack rate.

the United States (13) and Norway (14). In addition, the SAR of asymptomatic primary cases was 11.8% in our study, which was higher than the 0%–4.4% reported in a limited number of previous studies (6,15). The SAR heterogeneity might have been dependent on the surveillance protocol for asymptomatic contacts. The studies in the United States (13) and Norway (14), which had high SARs, detected secondary cases by using serologic tests. Our study also indicated that 8 prefectures that tested for asymptomatic contacts showed a 1.8 times higher SAR than did 2 prefectures that tested only for symptomatic contacts. A low proportion of diagnoses of asymptomatic cases might underestimate the SAR.

We showed that SAR was higher for persons <19 years of age and ≥60 years of age than for other age groups. High infectivity for the younger age group (6) and the older age group (4) was reported from South Korea and China, as in our study, but most other studies did not show significant differences in SAR by age of primary case-patients (9,13). Age-dependent infectivity might be associated with household lifestyles, family structure, and clinical conditions (9). Meta-analysis showed that the sex of the primary case-patient was not associated with transmission (5).

If primary cases were detected ≤2 days of symptom onset, the SAR was lower than that for primary cases detected >2 days after symptom onset. This

finding was related to the low SAR for case-patients who had a contact history because they could receive PCRs, as close contacts did earlier, and might have had a short time of exposure to family members. Our results were concordant with previous studies showing an increased risk for transmission as the contact duration was prolonged (4), as well as the effect of quarantining index case-patients when symptoms were reported (10).

The first limitation of our study is that symptomatic cases diagnosed during the presymptomatic period might have been classified as asymptomatic cases. Second, the number of asymptomatic cases might have been underreported because of different testing protocols among prefectures. Third, we might have misclassified the primary cases if a coprimary case existed or the direction of transmission between asymptomatic cases and symptomatic cases was not clear.

In summary, our study results provide us with useful implications of the high SAR of asymptomatic primary case-patients and contacts with long exposure times to primary case-patients. Self-quarantine and rapid isolation of confirmed case-patients from households after symptom onset might be needed to reduce transmission in families.

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About the Author

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Familial Clusters of Coronavirus Disease in 10 Prefectures, Japan, February–May 2020

Appendix

Appendix Table 1. Websites of 10 prefectures tested for familial clusters of coronavirus disease, Japan, February–May, 2020*

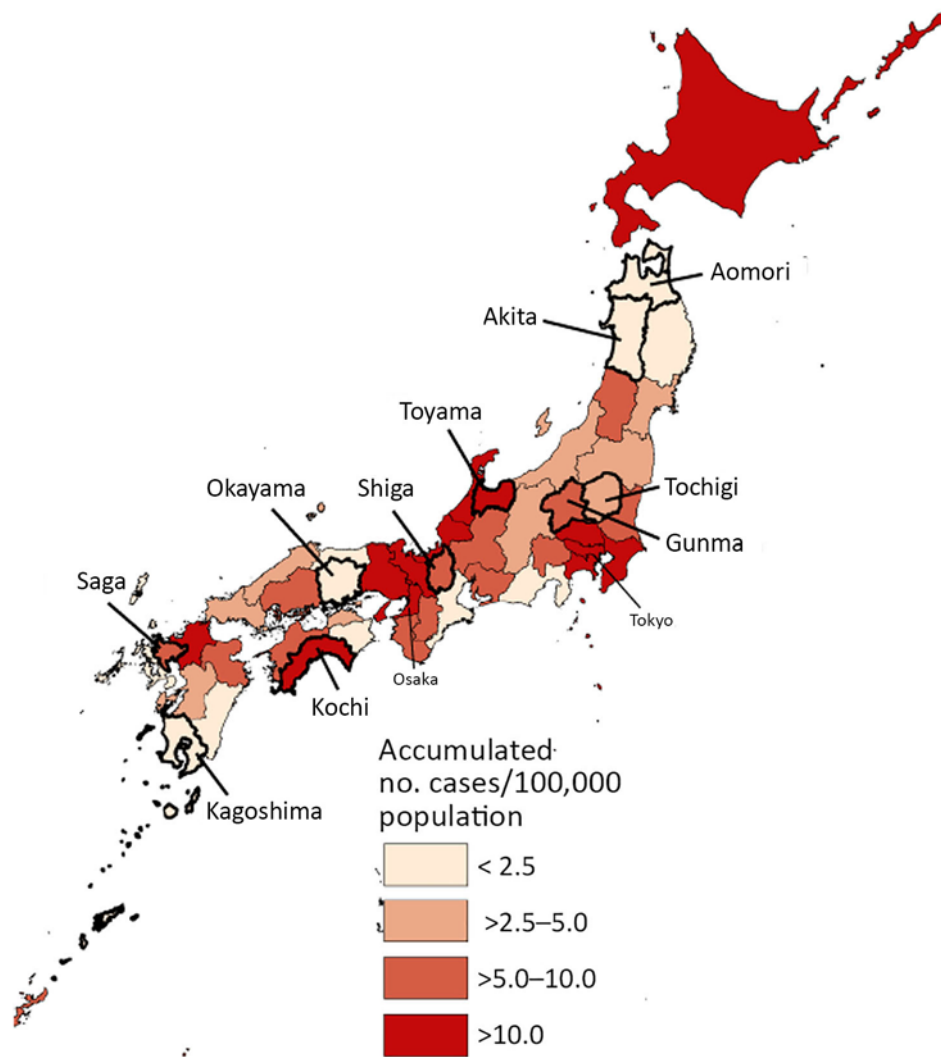
| Prefecture | URL |
|------------|---|
| Aomori | https://www.pref.aomori.lg.jp/welfare/health/wuhan-novel-coronavirus2020.html |
| Akita | https://www.pref.akita.lg.jp/pages/archive/47957 |
| Gunma | https://www.pref.gunma.jp/07/z87g_00016.html |
| Tochigi | http://www.pref.tochigi.lg.jp/e04/welfare/hoken-eisei/kansen/hp/coronakensahasseyoukyou.html |
| Toyama | http://www.pref.toyama.jp/cms_sec/1205/kj00022166.html |
| Shiga | https://www.pref.shiga.lg.jp/ippan/kenkouiryohukushi/yakuza/310735.html |
| Okayama | https://www.pref.okayama.jp/page/667843.html |
| Kochi | https://www.pref.kochi.lg.jp/soshiki/130401/2020022900049.html |
| Saga | https://www.pref.saga.lg.jp/kiji00373220/index.html |
| Kagoshima | https://www.pref.kagoshima.jp/ae06/kenko-fukushi/kenko-iryō/kansen/kansensho/coronavirus.html |

*All websites were cited on July 22, 2020.

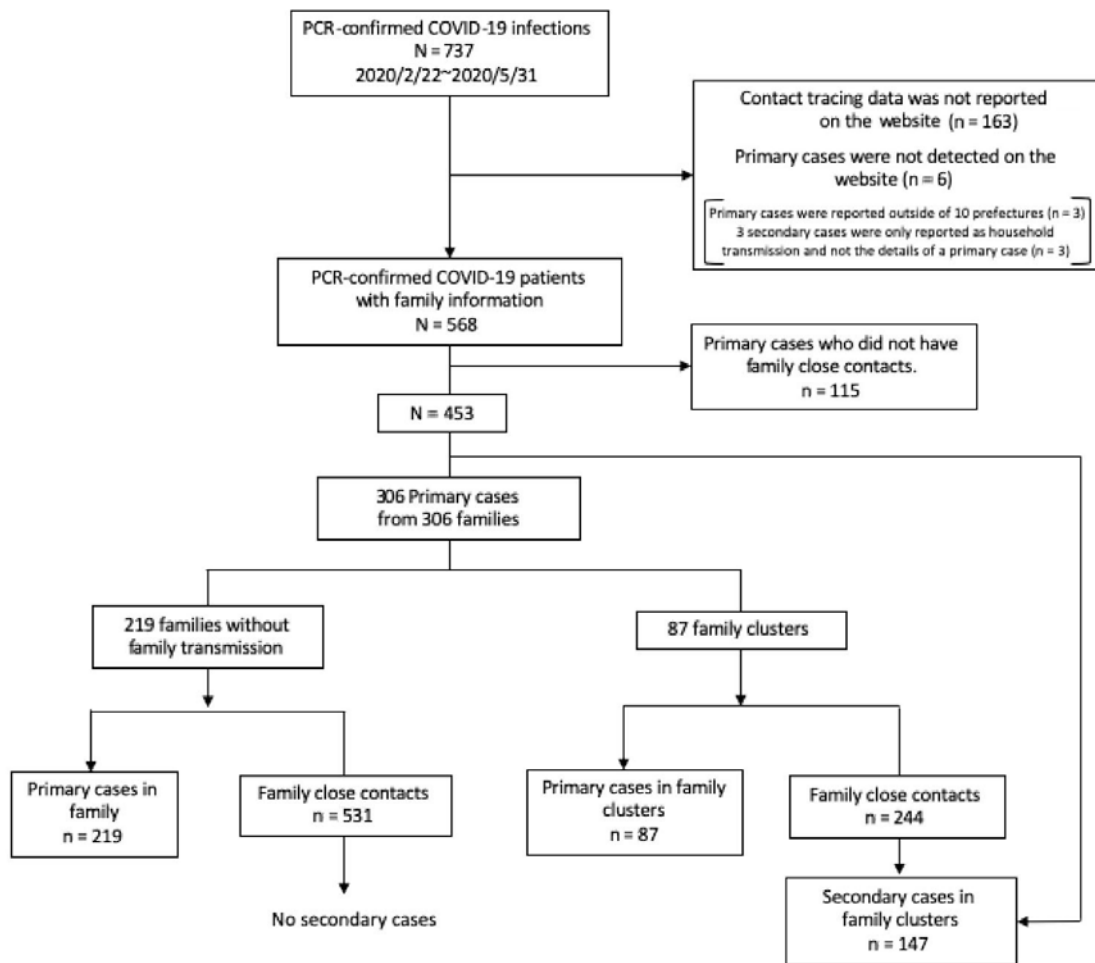
Appendix Table 2. Family transmission by asymptomatic case-patients in families 1–7 tested for familial clusters of coronavirus disease, Japan, February–May, 2020*

| Family | Cluster | Case-patient age, y/sex | Days since diagnosis of primary case | | | | | | | | | | | | | |
|--------|--------------|----------------------------|--------------------------------------|----|----|----|----|----|----|---|---|---|---|---|---|---|
| | | | -7 | -6 | -5 | -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | School | <1/F | | | | | | | | | x | | | | | |
| | | 10/F | | | | | | | | | | | | | | |
| 2 | School | <1/M | | | | | | | | | x | | | | | |
| | | 40/M | | | | | | | | | | | | | | |
| | | 30/F | | | | | | | | | | | | | | |
| | | 80/M | | | | | | | | | | | | | | |
| | | 70/F | | | | | | | | | | | | | | |
| 3 | Hospital | 60/M | | | | | | | | | x | | | | | |
| | | 80/F | | | | | | | | | | | | | | |
| 4 | Hospital | 50/M | | | | | | | | | x | | | | | |
| | | 20/F | | | | | | | | | | | | | | |
| 5 | Nursing home | 80/F | | | | | | | | | x | | | | | |
| | | 60/M | | | | | | | | | | | | | | |
| 6 | Nursing home | 80/F | | | | | | | | | x | | | | | |
| | | 80/M | | | | | | | | | | | | | | |
| 7 | Restaurant | 60/M | | | | | | | | | x | | | | | |
| | | 60/F | | | | | | | | | | | | | | |
| | | 80/F | | | | | | | | | | | | | | |

*Blue, duration of symptoms; dark gray, case-patients were not included in nonfamilial clusters (e.g., school, hospital, occupational status); empty space, not applicable; orange, diagnosis; x, primary case in a family. Age: <1 (<1–9 years); 10 (10–19 years), 20 (20–29 years), 30 (30–39 years), 40 (40–49 years), 50 (50–59 years), 60 (60–69 years), 70 (70–79 years), 80 (≥80 years). Primary asymptomatic cases in families 1 (<1/F), 2 (<1/M), 3 (60/M), 4 (50/M), 5 (80/F), 6 (80/F), and 7 (60/M) were diagnosed through outbreak investigation of other clusters, such as a school, nursing home, hospital, and restaurant.



Appendix Figure 1. Locations of 10 prefectures tested for familial clusters of coronavirus disease and accumulated number of cases/100,000 population, Japan, February 22–May 31, 2020.



Appendix Figure 2. Study participants tested for familial clusters of coronavirus disease, Japan, February 22–May 31, 2020. COVID-19, coronavirus disease.