Behavioral factors associated with SARS-CoV-2 infection in Japan

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Abstract
Background: The relative burden of COVID-19 has been less severe in Japan. One reason for this may be the uniquely strict restrictions imposed upon bars/restaurants. To assess if this approach was appropriately targeting high-risk individuals, we examined behavioral factors associated with SARS-CoV-2 infection in the community.

Methods: This multicenter case–control study involved individuals receiving SARS-CoV-2 testing in June–August 2021. Behavioral exposures in the past 2 weeks were collected via questionnaire. SARS-CoV-2 PCR-positive individuals were cases, while PCR-negative individuals were controls.

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Results: The analysis included 778 individuals (266 [34.2%] positives; median age [interquartile range] 33 [27–43] years). Attending three or more social gatherings was associated with SARS-CoV-2 infection (adjusted odds ratio [aOR] 2.00 [95% CI 1.31–3.05]). Attending gatherings with alcohol (aOR 2.29 [1.53–3.42]), at bars/restaurants (aOR 1.55 [1.04–2.30]), outdoors/parks (aOR 2.87 [1.01–8.13]), at night (aOR 2.07 [1.40–3.04]), five or more people (aOR 1.81 [1.00–3.30]), 2 hours or longer (aOR 1.76 [1.14–2.71]), not wearing a mask during gatherings (aOR 4.18 [2.29–7.64]), and cloth mask use (aOR 1.77 [1.11–2.83]) were associated with infection. Going to karaoke (aOR 2.53 [1.25–5.09]) and to a gym (aOR 1.87 [1.11–3.16]) were also associated with infection. Factors not associated with infection included visiting a cafe with others, ordering takeout, using food delivery services, eating out by oneself, and work/school/travel-related exposures including teleworking.

Conclusions: We identified multiple behavioral factors associated with SARS-CoV-2 infection, many of which were in line with the policy/risk communication implemented in Japan. Rapid assessment of risk factors can inform decision making.

KEYWORDS
coronavirus disease 2019 (COVID-19), health risk behaviors, public health and social measures, risk factors, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

1 | INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has resulted in substantial morbidity and mortality globally.1 Japan has been no exception, but the relative burden of COVID-19 after 2 years has not been as severe as in many other countries, with fewer cumulative cases and deaths relative to the population despite its aging population.2 Many factors may have contributed to this, such as the tireless efforts of public health centers in extensive contact tracing including backward tracing (source investigation), high mask-wearing adherence, maintaining greater physical distance, and strict infection prevention and control measures at health-care/long-term care facilities.3,4 Among these, one intriguing hypothesis is the unique policy with a focused approach targeting restaurants and bars to reduce business hours at night and prohibiting the serving of alcohol.5 As the Japanese government’s response against COVID-19 is based on the Act on Special Measures for Pandemic Influenza and New Infectious Diseases Preparedness and Response, Japan has declared a state of emergency several times during the course of the pandemic.6 However, unlike many other countries, there were no strict restrictions imposed on individual citizens such as lockdowns and obligatory curfews. Rather, there were voluntary requests to stay at home and engage in basic infection prevention measures such as proper mask wearing/hand hygiene. In comparison, restaurants and bars were ordered to suspend business if they cannot operate without serving alcohol, to stop serving alcohol, and to reduce business hours at night until 8:00 p.m. in prefectures with high transmission. Non-compliant businesses were disclosed publicly. This specific approach towards restaurants and bars was based on individual case data and cluster investigations with a theoretical rationale that dining or drinking alcohol at restaurants and bars with others (i.e., social gatherings involving food or drinks) provides occasion to interact face to face for a prolonged period without masks and that the influence of alcohol can further lead to laxity of infection prevention measures.7 Also, an increase in the frequency and proportion of cases with no history of close contact8 made containment through cluster investigation increasingly challenging and highlighted the lack of understanding regarding risk factors for infection at the community level. These circumstances led to the need to confirm through epidemiological data, with inclusion of a control group, whether behaviors such as social gatherings are indeed risk factors for SARS-CoV-2 infection to inform public health policy and provide evidence-based risk communication. Therefore, we initiated a multicenter case–control study to evaluate risk factors associated with SARS-CoV-2 infection, focusing on social gatherings involving food or drinks. We examined various social settings and further explored other behaviors as potential risk factors.

2 | METHODS

2.1 | Study design and setting

Our study, Factors Associated with SARS-CoV-2 Infection And The Effectiveness of COVID-19 vaccines (FASCINATE study), is a multicenter case–control study in health-care facilities in Japan with two objectives: (1) to elucidate risk factors associated with SARS-CoV-2 infection and (2) to estimate the effectiveness of COVID-19 vaccines.
Participating health-care facilities are routinely testing outpatients using polymerase chain reaction (PCR) to diagnose SARS-CoV-2 infection. For this report, data from six health-care facilities in the Kanto region (Tokyo and neighboring metropolitan prefectures) on individuals recruited during June 8–August 1, 2021, were analyzed.

2.2 Inclusion and exclusion criteria

Individuals who were tested for SARS-CoV-2 were included. Exclusion criteria were (1) individuals younger than 20 years (as alcohol drinking is illegal for these individuals), (2) individuals who did or could not consent to participate in the study, (3) individuals who could not complete the questionnaire by themselves, (4) individuals who had already participated in this study, (5) individuals who required immediate treatment, and (6) individuals with history of close contact (because an infection, if confirmed, is most likely due to this specific contact rather than exposures asked about in the questionnaire). For this report, we excluded asymptomatic individuals and individuals vaccinated at least once as COVID-19 vaccination can influence behaviors.

2.3 Questionnaire and classification of cases/controls

A paper or web-based questionnaire (according to individual preference) was administered before PCR results were available to avoid social desirability bias, where individuals who test positive may be less likely to report potentially high-risk behaviors. The questionnaire was optimized based on a pilot study done at two sites. We defined social gathering as getting together with one or more persons that does not cohabitate with the participant. Cases were defined as PCR-confirmed SARS-CoV-2 positive individuals, while controls were defined as PCR-negative individuals.

2.4 Data analysis

Logistic regression to identify associations between behavioral risk factors and SARS-CoV-2 infection was conducted adjusting for age group, sex, presence of comorbidities, educational attainment, place of residence, past SARS-CoV-2 infection, health-care facility in which SARS-CoV-2 testing was done, and calendar week. These potential confounders were determined a priori. Data analyses were performed using STATA version 17.0.

3 RESULTS

3.1 Participant characteristics

A total of 992 symptomatic individuals were enrolled from six medical facilities during the study period; we excluded 44 due to unknown symptom onset, 16 due to being tested ≥15 days after symptom onset, and 154 due to being vaccinated (Figure 1). The final analysis included 778 individuals with 266 (34.2%) positive cases. The median age (interquartile range [IQR]) was 33 (27–43) years, 386 were males (49.6%), and 182 (23.4%) had comorbidities (Table 1): 758 (97.4%) were Japanese nationals and most foreigners were from East Asia.

3.2 Factors related to 3Cs and five situations in the past 2 weeks

Since early in the pandemic, the Japanese government has been promoting avoidance of the “3Cs,” representing (1) closed spaces, (2) crowded places, and (3) close-contact settings, which are considered high-risk based on characteristics of early clusters. These “3Cs” were easy for the public to remember and the World Health Organization also began promoting this message. Additionally, since fall 2020, the government started to promote avoidance of “five situations,” namely, (1) social gatherings that include alcohol consumption, (2) large group gatherings that involve eating and/or drinking for an extended period of time, (3) conversing without a mask, (4) cohabitation in small living quarters, and (5) relocating to a different area. We first examined factors among the above that could be measured (Table 2). Those who attended large gatherings that involve eating and/or drinking for an extended period of time in the past 2 weeks had particularly higher odds of infection compared with those who did not (adjusted odds ratio [aOR] 2.36 [1.38–4.05]).

3.3 Association between social gatherings with food/drinks in various settings in the past 2 weeks and SARS-CoV-2 infection

We further examined the association between social gatherings that involve eating and/or drinking in various settings and SARS-CoV-2 infection (Table 2). The odds of infection increased with increased frequency of social gatherings; those who attending social gatherings three or more times had higher odds of infection compared with those who did not (aOR 2.00 [95% CI 1.31–3.05]). We examined this association in detail, specifically by presence of alcohol, location of gathering, and time of day. The odds of infection were substantially higher among individuals who attended social gatherings with alcohol at least once compared with those who did not (aOR 2.29 [95% CI 1.53–3.42]). Social gatherings without alcohol were not associated with infection. When we compared the location of social gatherings, the odds of infection were higher among individuals who had gatherings only at home (aOR 2.10 [95% CI 0.92–4.77]), visited bars or restaurants (aOR 1.55 [95% CI 1.04–2.30]), and had gatherings involving food/drinks outdoors/at parks (aOR 2.87 [95% CI 1.01–8.13]), all compared with those who did not. Moreover, the odds of infection among individuals who attended social gatherings at night were double that of those who did not (aOR 2.07 [95% CI 1.40–3.04]). Attending social gatherings only in the daytime was not associated with infection.
3.4 | Association between other behaviors related to food/drinks in the past 2 weeks and SARS-CoV-2 infection

To compare the above findings on social gatherings that involve eating and/or drinking, we examined whether other behaviors related to food/drinks were associated with SARS-CoV-2 infection (Table 2). Unlike social gatherings, the odds of infection were not higher among individuals who visited a cafe with others (aOR 1.08 [95% CI 0.75–1.57]), ordered takeout (aOR 0.80 [95% CI 0.56–1.15]), used food delivery services (aOR 1.40 [95% CI 0.97–2.01]), and ate out by oneself (aOR 0.79 [95% CI 0.54–1.13]), all compared with those who did not.

3.5 | Association between size, duration, and mask wearing among participants of social gatherings in the past 2 weeks and SARS-CoV-2 infection

The government requested individuals attending social gatherings involving food/drinks to limit these gatherings to five people and to less than 2 hours and to consider use of masks except for when consuming food/drinks. We assessed whether these factors were indeed associated with infection (Table 2). Specifically, those who attended a social gathering involving food/drinks and/or went to a cafe with others in the past 2 weeks were asked how many people attended the gathering, how long the gathering continued at maximum, and when the attendees had their masks on (cafe use was included here as we hypothesized that it also provides occasion to talk face to face for a prolonged period without masks). The odds of infection were higher among individuals who attended gatherings of five or more people (aOR 1.81 [95% CI 1.00–3.30]) and for individuals who attended for 2 hours or longer (aOR 1.76 [95% CI 1.14–2.71]), both compared with those who did not attend gatherings. Regarding mask wearing, the odds of infection were higher among those who did not wear a mask or took it off when seated (aOR 4.18 [95% CI 2.29–7.64]). This association was similar when the mask-wearing practices of other attendees at the gathering was assessed (aOR 3.74 [95% CI 2.13–6.55]).

3.6 | Association between type of mask used in the past 2 weeks and SARS-CoV-2 infection

Three types of masks are mainly used among the public in Japan: medical/surgical masks, cloth masks, and polyurethane masks. The Japanese government recommends use of medical/surgical masks rather than cloth or polyurethane masks based on a computer simulation model, but epidemiological data were lacking. Therefore, we examined the association between mask type and infection (Table 3). The odds of infection were higher among individuals who used cloth masks (aOR 1.77 [95% CI 1.00–3.30]) and slightly higher among individuals who used polyurethane masks (aOR 1.47 [95% CI 0.91–2.38]), both compared with those who used medical/surgical masks. When we stratified dichotomously by whether the participants attended social gatherings or visited a cafe with others, the aforementioned association between infection and cloth or polyurethane mask use compared with medical/surgical mask use was only present among individuals who attended social gatherings or visited a cafe with others.
3.7 | Association between behaviors not related to food/drinks in the past 2 weeks and SARS-CoV-2 infection

We next looked at behaviors that do not involve eating/drinking that are considered to be risk factors based on case/cluster investigations in Japan7 (Table 4). The odds of infection were not higher among individuals who attended indoor events and gatherings (aOR 1.45 [95% CI 0.76–2.76]) and outdoor events and gatherings (aOR 1.34 [95% CI 0.67–2.69]), both compared with those who did not. The odds of infection were lower among individuals who went to department stores and shopping malls (aOR 0.64 [95% CI 0.45–0.91]) compared with those who did not. In contrast, the odds of infection were higher among individuals who attended karaoke with others (aOR 2.53 [95% CI 1.25–5.09]) and individuals who visited a gym (aOR 1.87 [95% CI 1.11–3.16]), both compared with those who did not.

3.8 | Association between behaviors related to work/school and travel in the past 2 weeks and SARS-CoV-2 infection

We lastly examined whether behaviors related to work/school were associated with SARS-CoV-2 infection (Table 4). The odds of infection...
| Activity/Situation                                                                 | Test-positive, n (%) | Test-negative, n (%) | Crude odds ratio (95% CI) | Adjusted odds ratio (95% CI) |
|-----------------------------------------------------------------------------------|----------------------|----------------------|---------------------------|-----------------------------|
| Having a conversation at a close distance (within arm’s reach)                    |                      |                      |                           |                             |
| No                                                                                | 142 (53.4)           | 283 (55.3)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 124 (46.6)           | 229 (44.7)           | 1.08 (0.80–1.45)          | 0.92 (0.65–1.30)            |
| Closed spaces with poor ventilation/air exchange                                  |                      |                      |                           |                             |
| No                                                                                | 225 (84.6)           | 460 (89.8)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 41 (15.4)            | 52 (10.2)            | 1.61 (1.04–2.50)          | 1.24 (0.76–2.03)            |
| Large gatherings that involve eating and/or drinking for an extended period of time |                      |                      |                           |                             |
| No                                                                                | 221 (83.1)           | 471 (92.0)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 45 (16.9)            | 41 (8.0)             | 2.34 (1.49–3.68)          | 2.36 (1.38–4.05)            |
| Crowded places                                                                    |                      |                      |                           |                             |
| No                                                                                | 189 (71.1)           | 378 (73.8)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 77 (29.0)            | 134 (26.2)           | 1.15 (0.83–1.60)          | 1.03 (0.71–1.50)            |
| Cohabitation in small living quarters                                             |                      |                      |                           |                             |
| No                                                                                | 250 (94.0)           | 472 (92.2)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 16 (6.0)             | 40 (7.8)             | 0.76 (0.41–1.38)          | 0.77 (0.39–1.53)            |
| Frequency of social gatherings attended that involved eating/drinking             |                      |                      |                           |                             |
| 0 (did not attend)                                                               |                      |                      |                           |                             |
| Did not attend                                                                    | 75 (28.9)            | 208 (41.8)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| 1 alcohol                                                                         | 38 (14.6)            | 85 (17.1)            | 1.24 (0.78–1.97)          | 1.37 (0.81–2.31)            |
| 2 alcohol                                                                         | 42 (16.2)            | 73 (14.7)            | 1.60 (1.00–2.53)          | 1.60 (0.94–2.72)            |
| ≥3 alcohol                                                                        | 105 (40.4)           | 132 (26.5)           | 2.21 (1.53–3.19)          | 2.00 (1.31–3.05)            |
| With alcohol                                                                      |                      |                      |                           |                             |
| 0 (did not attend)                                                               |                      |                      |                           |                             |
| Did not attend                                                                    | 74 (28.8)            | 207 (41.8)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| 1 alcohol                                                                         | 38 (14.8)            | 111 (22.4)           | 0.96 (0.61–1.51)          | 0.93 (0.56–1.55)            |
| 2 alcohol                                                                         | 42 (16.2)            | 73 (14.7)            | 1.60 (1.00–2.53)          | 1.60 (0.94–2.72)            |
| ≥3 alcohol                                                                        | 145 (56.4)           | 177 (35.8)           | 2.29 (1.62–3.23)          | 2.29 (1.53–3.42)            |
| Location of social gatherings attended that involved eating/drinking              |                      |                      |                           |                             |
| Did not go out to eat                                                             |                      |                      |                           |                             |
| Did not go to restaurants/bars                                                  |                      |                      |                           |                             |
| Restaurants/bars                                                                  | 134 (57.0)           | 239 (50.0)           | 1.55 (1.11–2.18)          | 1.55 (1.04–2.30)            |
| Outdoors/parks                                                                   | 10 (4.3)             | 10 (2.1)             | 2.77 (1.11–6.93)          | 2.87 (1.01–8.13)            |
| Time of day of social gatherings attended that involved eating/drinking           |                      |                      |                           |                             |
| Did not go out to eat                                                             |                      |                      |                           |                             |
| Did not go to restaurants/bars                                                  |                      |                      |                           |                             |
| Restaurants/bars                                                                  | 134 (57.0)           | 239 (50.0)           | 1.55 (1.11–2.18)          | 1.55 (1.04–2.30)            |
| Outdoors/parks                                                                   | 10 (4.3)             | 10 (2.1)             | 2.77 (1.11–6.93)          | 2.87 (1.01–8.13)            |
| Visiting a cafe with others                                                       |                      |                      |                           |                             |
| No                                                                                | 140 (58.1)           | 306 (64.3)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 101 (41.9)           | 170 (35.7)           | 1.30 (0.95–1.78)          | 1.08 (0.75–1.57)            |
| Ordering takeout                                                                  |                      |                      |                           |                             |
| No                                                                                | 160 (64.5)           | 291 (60.8)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 88 (35.5)            | 188 (39.3)           | 0.85 (0.62–1.17)          | 0.80 (0.56–1.15)            |
| Food delivery                                                                     |                      |                      |                           |                             |
| No                                                                                | 149 (58.7)           | 309 (63.5)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 105 (41.3)           | 178 (36.6)           | 1.22 (0.90–1.67)          | 1.40 (0.97–2.01)            |
| Eating out by oneself                                                            |                      |                      |                           |                             |
| No                                                                                | 150 (59.1)           | 281 (57.6)           | 1 (1.00–1.00)             | 1 (1.00–1.00)               |
| Yes                                                                               | 104 (40.9)           | 207 (42.4)           | 0.94 (0.69–1.28)          | 0.79 (0.55–1.13)            |

(Continues)
were not higher among individuals who have work/school (aOR 1.01 [95% CI 0.60–1.69]) and who attended work/school full time (aOR 1.11 [95% CI 0.65–1.90]), compared with those who did not or who attended work/school part time. As millions of people commute each day in metropolitan prefectures in crowded trains, many were afraid of being infected on these trains, but the odds of infection were not higher among those who used trains to commute (aOR 0.84 [95% CI 0.57–1.24]). Teleworking was also encouraged by the government.

### TABLE 2 (Continued)

| Maximum number of people attended including oneself | Test-positive, n (%) | Test-negative, n (%) | Crude odds ratio (95% CI) | Adjusted odds ratio (95% CI)* |
|---------------------------------------------------|----------------------|----------------------|---------------------------|------------------------------|
| Did not go out to eat/drink or to a cafe          | 61 (28.6)            | 169 (39.2)           | 1                         | 1                            |
| <5 people                                         | 112 (52.6)           | 213 (49.4)           | 1.46 (1.00–2.11)          | 1.31 (0.86–2.00)             |
| ≥5 people                                         | 40 (18.8)            | 49 (11.4)            | 2.26 (1.36–3.77)          | 1.81 (1.00–3.30)             |

| Maximum time spent                                | Test-positive, n (%) | Test-negative, n (%) | Crude odds ratio (95% CI) | Adjusted odds ratio (95% CI)* |
|---------------------------------------------------|----------------------|----------------------|---------------------------|------------------------------|
| Did not go out to eat/drink or to a cafe          | 61 (25.4)            | 169 (36.3)           | 1                         | 1                            |
| <2 h                                              | 51 (21.3)            | 118 (25.3)           | 1.20 (0.77–1.86)          | 1.01 (0.61–1.65)             |
| ≥2 h                                              | 128 (53.3)           | 179 (38.4)           | 1.98 (1.37–2.87)          | 1.76 (1.14–2.71)             |

| Mask wearing (study participant)                  | Test-positive, n (%) | Test-negative, n (%) | Crude odds ratio (95% CI) | Adjusted odds ratio (95% CI)* |
|---------------------------------------------------|----------------------|----------------------|---------------------------|------------------------------|
| Did not go out to eat/drink or to a cafe          | 61 (25.0)            | 169 (36.4)           | 1                         | 1                            |
| Wore at all times except when eating/drinking     | 28 (11.5)            | 72 (15.5)            | 1.08 (0.64–1.82)          | 0.96 (0.53–1.73)             |
| Took mask off when food/drink was served          | 100 (41.0)           | 185 (39.9)           | 1.50 (1.02–2.19)          | 1.29 (0.84–2.00)             |
| Did not wear one/took mask off when seated        | 55 (22.5)            | 38 (8.2)             | 4.01 (2.42–6.66)          | 4.18 (2.29–7.64)             |

| Mask wearing (others)                             | Test-positive, n (%) | Test-negative, n (%) | Crude odds ratio (95% CI) | Adjusted odds ratio (95% CI)* |
|---------------------------------------------------|----------------------|----------------------|---------------------------|------------------------------|
| Did not go out to eat/drink or to a cafe          | 61 (26.2)            | 169 (37.1)           | 1                         | 1                            |
| Wore at all times except when eating/drinking     | 20 (8.6)             | 51 (11.2)            | 1.09 (0.60–1.97)          | 0.96 (0.49–1.86)             |
| Took mask off when food/drink was served          | 89 (38.2)            | 190 (41.8)           | 1.30 (0.88–1.91)          | 1.12 (0.72–1.74)             |
| Did not wear one/took mask off when seated        | 63 (27.0)            | 45 (9.9)             | 3.88 (2.40–6.28)          | 3.74 (2.13–6.55)             |

aAdjusted for age group, sex, presence of comorbidities, educational attainment, place of residence, past SARS-CoV-2 infection, health-care facility, and calendar week.
bIndividuals may or may not have history of gathering at home.
cIndividuals may or may not have history of gathering at home, restaurants, and bars.

### TABLE 3 Association of SARS-CoV-2 infection with type of mask used

| Type of mask used regularly | Test-positive, n (%) | Test-negative, n (%) | Crude odds ratio (95% CI) | Adjusted odds ratio (95% CI)* |
|-----------------------------|----------------------|----------------------|---------------------------|------------------------------|
| Medical/surgical mask       | 134 (55.6)           | 340 (69.4)           | 1                         | 1                            |
| Cloth mask                  | 53 (22.0)            | 82 (16.7)            | 1.64 (1.10–2.44)          | 1.77 (1.11–2.83)             |
| Polyurethane mask           | 53 (22.0)            | 68 (13.9)            | 1.97 (1.31–2.98)          | 1.47 (0.91–2.38)             |
| No mask                     | 1 (0.4)              | 0 (0.0)              | N/A                       | N/A                          |

| Type of mask used regularly (individuals who did not report attending social gathering or visiting a cafe with others) | Test-positive, n (%) | Test-negative, n (%) | Crude odds ratio (95% CI) | Adjusted odds ratio (95% CI)* |
|-----------------------------------------------------------------------------------------------------------------|----------------------|----------------------|---------------------------|------------------------------|
| Medical/surgical mask                                               | 33 (61.1)            | 114 (68.7)           | 1                         | 1                            |
| Cloth mask                                                          | 11 (20.4)            | 32 (19.3)            | 1.19 (0.54–2.61)          | 1.48 (0.51–4.29)             |
| Polyurethane mask                                                   | 10 (18.5)            | 20 (12.1)            | 1.73 (0.74–4.05)          | 0.75 (0.24–2.37)             |
| No mask                                                             | 0 (0.0)              | 0 (0.0)              | N/A                       | N/A                          |

| Type of mask used regularly (individuals who reported attending social gathering or visiting a cafe with others) | Test-positive, n (%) | Test-negative, n (%) | Crude odds ratio (95% CI) | Adjusted odds ratio (95% CI)* |
|---------------------------------------------------------------------------------------------------------------|----------------------|----------------------|---------------------------|------------------------------|
| Medical/surgical mask                                               | 98 (53.9)            | 219 (70.9)           | 1                         | 1                            |
| Cloth mask                                                          | 42 (23.1)            | 46 (14.9)            | 2.04 (1.26–3.30)          | 2.03 (1.16–3.56)             |
| Polyurethane mask                                                   | 41 (22.5)            | 44 (14.2)            | 2.08 (1.28–3.39)          | 1.62 (0.91–2.89)             |
| No mask                                                             | 1 (0.6)              | 0 (0.0)              | N/A                       | N/A                          |

aAdjusted for age group, sex, presence of comorbidities, educational attainment, place of residence, past SARS-CoV-2 infection, health-care facility, and calendar week.

For the table 2 and 3, please note the following:
- Maximum number of people attended including oneself
- Maximum time spent
- Mask wearing (study participant)
- Mask wearing (others)
- Type of mask used regularly
- Type of mask used regularly (individuals who did not report attending social gathering or visiting a cafe with others)
- Type of mask used regularly (individuals who reported attending social gathering or visiting a cafe with others)
but the odds of infection were not lower among individuals who teleworked/attended online classes almost 100% of the time (aOR 0.99 [95% CI 0.51–1.91]), compared with those who did not. When asked about travel-related factors, the odds of infection were higher among individuals who reside in an urban location (aOR 3.46 [95% CI 1.52–7.84]) or visited an urban location (aOR 2.43 [95% CI 1.15–5.16]).
Indeed, individuals who engage in high-risk behaviors may benefit from wearing medical/surgical masks. We could not evaluate associations with any mask use, as the mask-wearing adherence was high.

We identified some factors unrelated to social gatherings, namely, karaoke and gym use, which are also known to be hotspots for clusters.7 Shopping at department stores and shopping malls was negatively associated with infection. This may have been because individuals in metropolitan areas visit department stores to buy products for use at home, although there have been reported clusters in these settings.21 Unlike in previous reports from the United States and France,18,22 we did not find a negative association between teleworking and infection, which may reflect the difference in the magnitude of epidemics or the amount of physical contact at the work place.

These findings collectively indicate that, although epidemiological evidence was scarce at the time of implementation of the targeted policies in Japan, the policies appropriately targeted high-risk individuals and activities/situations. Our results highlight the importance of rapidly assessing and identifying modifiable behavioral risk factors for SARS-CoV-2 infection and of informing risk communication and shaping public health policy with targeted approaches tailored to each country’s situation, in addition to universal recommendations. Targeted approaches can have substantial financial consequences to individuals, so appropriate social security and welfare policies should be paired with restrictions imposed.

This study had several limitations. First, biases inherent in observational studies such as recall bias and residual confounding are possible. Second, controls may have been infected with other viruses due to similar exposures, which can underestimate the odds ratio (Supporting Information). Third, our primary analyses were complete case analyses. However, when we did sensitivity analyses to impute missing exposure variables in each analysis, findings were similar. Finally, identified risk factors may be country/region/culture-specific and time-dependent due to changes in COVID-19–related policies and behaviors, as well as emergence of SARS-CoV-2 variants.

In conclusion, we identified multiple behavioral factors associated with SARS-CoV-2 infection, particularly in various settings of social gatherings. These factors may be country/culture-specific and time-dependent due to changes in COVID-19–related policies and behaviors, so continuous monitoring in various settings is important to inform decision making.

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AUTHOR CONTRIBUTIONS
Takehi Arashiro: Conceptualization; data curation; formal analysis; investigation; methodology; project administration; resources; software; visualization; funding acquisition. Yuzo Arima: Conceptualization; formal analysis; methodology; resources; supervision. Hirokazu
Muraoka: Investigation. Akihiro Sato: Investigation. Kunihiro Oba: Investigation. Yuki Uehara: Investigation. Hiroko Arioka: Investigation. Hideki Yanai: Investigation. Naoki Yanagisawa: Investigation. Yoshiko Nagura: Investigation. Yasuyuki Kato: Investigation. Hideaki Kato: Investigation. Akihiko Ueda: Investigation. Koji Ishii: Investigation. Takao Ooki: Investigation. Hideaki Oka: Investigation. Yusuke Nishida: Investigation. Ashley Stucky: Formal analysis; visualization.

DATA AVAILABILITY STATEMENT
Individual-level data of patients included in this manuscript after de-identification are considered sensitive and will not be shared. The study methods and statistical analyses are described in detail in Section 2 and throughout the manuscript.

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REFERENCES
1. World Health Organization. Coronavirus disease (COVID-19) pandemic. 2021. Accessed April 4, 2022. https://www.who.int/emergencies/diseases/novel-coronavirus-2019
2. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Infect Dis. 2020;20(5):533-534. doi:10.1016/S1473-3099(20)30120-1
3. National Institute of Infectious Diseases. Active case investigation on COVID-19 cases (In Japanese). 2021. Accessed April 4, 2022. https://www.niid.go.jp/niid/ja/2019-ncov/2559-cfeir/10800-01.010
4. Tanaka A, Yamamoto S, Miyo K, et al. Seroprevalence of antibodies against SARS-CoV-2 in a large national hospital and affiliated facility in Tokyo, Japan. J Infect. 2021;82(4):e1-e3. doi:10.1016/j.jinf.2021.01.010
5. Cabinet Secretariat, Government of Japan. COVID-19 information and resources: measures to be taken based on the basic response policy. 2020. Accessed April 4, 2022. https://corona.go.jp/en/emergency/
6. Cabinet Secretariat, Government of Japan. Summary on the state of emergency due to COVID-19 (In Japanese). 2020. Accessed April 4, 2022. https://ora-corona.go.jp/news/news_20200421_70.html
7. Furuse Y, Sando E, Tsuchiya N, et al. Clusters of coronavirus disease in communities, Japan, January-April 2020. Emerg Infect Dis. 2020;26(9):2176-2179. doi:10.3201/eid2609.202272
8. Tokyo Metropolitan Government. Updates on COVID-19 in Tokyo. 2020. Accessed April 4, 2022. https://stopcovid19.metro.tokyo.lg.jp/en/monitoring
9. National Institute of Infectious Diseases. National Institute of Infectious Diseases: Case-control study to evaluate behavioral risk factors of SARS-CoV-2 infection: preliminary report of a pilot study (In Japanese). 2021. Accessed April 4, 2022. https://www.mhlw.go.jp/content/10900000/000807662.pdf
10. Williamson EJ, Walker AJ, Bhaskaran K, et al. Factors associated with COVID-19-related death using OpenSAFELY. Nature. 2020;584(7821):430-436. doi:10.1038/s41586-020-2521-4
11. Hawkins RB, Charles EJ, Mehaffey JH. Socio-economic status and COVID-19-related cases and fatalities. Public Health. 2020;189:129-134. doi:10.1016/j.puhe.2020.09.016
12. Ministry of Health, Labour and Welfare. Information on health and medical consultation. 2020. Accessed April 4, 2022. https://www.mhlw.go.jp/stf/covid-19/kenkou-iryousoudan_00006.html
13. World Health Organization. Considerations for implementing and adjusting public health and social measures in the context of COVID-19. 2021. Accessed April 4, 2022. https://www.who.int/publications/i/item/considerations-in-adjusting-public-health-and-social-measures-in-the-context-of-covid-19-interim-guidance
14. Cabinet Secretariat, Government of Japan. COVID-19 response: efforts to prevent the spread of infection (In Japanese). 2020. Accessed April 4, 2022. https://corona.go.jp/proposal/
15. RIKEN Center for Computational Science. Prediction and prevention of SARS-CoV-2 droplet infection in indoor environment (In Japanese). 2021. Accessed April 4, 2022. https://www.r-ccs.riken.jp/wp/wp-content/uploads/2021/03/210304tsubokura.pdf
16. Chang S, Pierson E, Koh P, et al. Mobility network models of COVID-19 explain inequities and inform reopening. Nature. 2021;589(7840):82-87. doi:10.1038/s41586-020-2923-3
17. Fisher KA, Tenforde MW, Feldstein LR, et al. Community and close contact exposures associated with COVID-19 among symptomatic adults ≥18 years in 11 outpatient health care facilities—United States, July 2020. MMWR Mortal Mortal Wkly Rep. 2020;69(36):1258-1264. doi:10.15585/mmwr.mm6936a5
18. Galmiche S, Charmet T, Schaeffer L, et al. Exposures associated with SARS-CoV-2 infection in France: a nationwide online case-control study. Lancet Reg Health Eur. 2021;7:100148. doi:10.1016/j.lanepe.2021.100148
19. Tokyo Metropolitan Government. Results of the online questionnaire to young people in Tokyo (In Japanese). 2021. Accessed April 4, 2022. https://www.metro.tokyo.lg.jp/tosei/hodohappyo/press/2021/05/25/20.html
20. Bundgaard H, Bundgaard JS, Raaschou-Pedersen DET, et al. Effectiveness of adding a mask recommendation to other public health measures to prevent SARS-CoV-2 infection in Danish mask wearers: a randomized controlled trial. Ann Intern Med. 2021;174(3):335-343. doi:10.7326/M20-6817
21. National Institute of Infectious Diseases. Proposal on infection prevention measures to owners, employees, and occupational health staff of department stores and shopping malls (In Japanese). 2021. Accessed April 4, 2022. https://www.niid.go.jp/niid/ja/diseases/ka/corona-virus-2019-ncov/10579-covid19-18.html
22. Fisher KA, Olson SM, Tenforde MW, et al. Telework before illness onset among symptomatic adults aged ≥18 years with and without COVID-19 in 11 outpatient health care facilities—United States, July 2020. MMWR Mortal Mortal Wkly Rep. 2020;69(44):1648-1653. doi:10.15585/mmwr.mm6944a4

SUPPORTING INFORMATION
Additional supporting information may be found in the online version of the article at the publisher’s website.

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