Polarized nature of the COVID-19 pandemic in Japan: associations with population age structure and behaviours

Junko Okumura 1,2

Abstract

Background: Although the scale of the coronavirus disease (COVID-19) pandemic was relatively small in Japan compared with the rest of the world, the polarisation of areas into high- and low-COVID-19-incidence areas was observed among the 47 prefectures. The aims of this study were not only identifying the factors associated with the polarised COVID-19 pandemic in Japan but also discussing effective preventive measures.

Methods: This was an ecological study using online survey data which was cross-sectionally conducted by the author. A total of 6000 respondents who resided in 10 low- and 10 high-COVID-19 incidence prefectures, with a wide gap in terms of COVID-19 incidence, in Japan were recruited. Data on COVID-19 cases and geodemographic information were obtained from official government sites. Statistical analyses were conducted to compare variables between the two areas and age groups.

Results: This study revealed that age influenced people’s behaviours and perceptions, except one behaviour of wearing facemasks. The major factors significantly associated with the cumulative number of COVID-19 cases per 100,000 people were ‘commuting by private automobile’ (adjusted odds ratio [AOR], 0.444; 95% confidence interval [CI], 0.394–0.501), ‘commuting by public transportation’ (AOR, 6.813; 95% CI, 5.567–8.336), ‘washing hands’ (AOR, 1.233; 95% CI, 1.005–1.511), ‘opening windows regularly’ (AOR, 1.248; 95% CI, 1.104–1.412), ‘avoiding crowded places’ (AOR, 0.757; 95% CI, 0.641–0.893), ‘non-scheduled visits to drinking places’ (AOR, 1.212; 95% CI, 1.054–1.392) and ‘perceived risk of contracting COVID-19’ (AOR, 1.380; 95% CI, 1.180–1.612). These factors were strongly associated with age groups.

Conclusions: Effective preventive measures for COVID-19 transmission can be developed by understanding the characteristics of populated areas, such as public transportation infrastructure and younger people’s movements and behaviours in relation to the population age structure to contain the current epidemic and protect the most vulnerable elderly people.

Keywords: Behaviour, COVID-19, Japan, Perception, Population age structure
Background
In December 2019, coronavirus disease (COVID-19) emerged in Wuhan city, located in Hubei Province, the People’s Republic of China [1]. In Japan, the first case of COVID-19 was reported on 16 January 2020 [2]. The number of reported cases increased gradually, reaching 4111 cases on 6 April 2020. To control the COVID-19 outbreak, the government of Japan declared a state of emergency in seven prefectures on 7 April 2020 and extended it to all 47 prefectures on 16 April 2020 [3, 4].

Although, the scale of the COVID-19 epidemic was relatively small in Japan, compared with that in the rest of the world [5], the polarisation of areas into high- and low-COVID-19-incidence areas were observed among the 47 prefectures. On 6 April 2020, the cumulative number of reported cases in Iwate and Tottori prefectures were zero, while those in the Tokyo metropolis and Osaka prefecture were 1130 and 428, respectively. By 15 April 2020, the numbers were zero and one in Iwate and Tottor prefectures, respectively; however, those in Tokyo and Osaka have doubled [6]. The reported deaths attributed from COVID-19 were relatively small in Japan compared to the USA; as of 6 April 2020, the cumulative number of deaths in Japan and the USA were 97 and 8358, respectively [6, 7].

The epidemiological data monitored continually raised multiple questions. Was the polarisation due to differences in population density? Were there any other factors that widened the gap? Did Japanese cultural factors, such as people’s awareness on issues related to COVID-19 and subsequent changes adopted in daily practices, influence the incidence of COVID-19? In addition, how does the age structure of the population influence people’s preventive behaviours and perceptions, widening the gap in COVID-19-incidence rates between the bottom 10 (low-incidence areas) and top 10 (high-incidence areas) prefectures? To answer these questions, this study aimed to identify the possible factors associated with the incidence gap between low- and high-incidence areas to establish more effective advocacy measures for managing COVID-19, considering the Japanese population’s age structure.

Methods
Recruitment of the respondents
This was an ecological study using online survey data of behaviours and perceptions which was cross-sectionally conducted by the author. The respondents were recruited from Rakuten Insight, an online research company in Japan with 2.3 million research respondents comprising a survey panel. The respondents generally receive a certain amount of Rakuten points (equivalent to a few United States dollars), which can be availed for online shopping at the Rakuten shopping site. According to a ranking of cumulative incidence reported daily by the Nihon Hoso Kyokai [6], the bottom and top 10 prefectures, as of 23 April 2020, were selected from the 47 prefectures in Japan. Before the survey began, it was anticipated that the number of COVID-19 cases might rapidly increase even in areas with zero reported cases. Therefore, these areas were also included. However, at the end of the survey, one prefecture still had zero reported cases of COVID-19.

The author then requested that the online survey site be accessible until the number of respondents living in each prefecture reached 300. The sample size was not decided using population-based proportionate sampling; rather, it was decided with intention to maximise the number of participating individuals aged ≥60 years and 18–29 years. Based on the respondent’s age, they were categorised into six age categories: 18–29, 30–39, 40–49, 50–59, 60–69 and ≥70 years old.

Data collection and variables
An original questionnaire was developed with advocacy messages provided by the Japanese government [3, 4, 8, 9]. The study variables included the town of residence; socio-demographic characteristics (age, occupation, number of household members by age category), knowledge of COVID-19 (symptoms, preventive measures, source of information), lifestyle (means of commuting, places regularly visited, travel destinations) and perceived risks. The online survey site was accessible to eligible respondents from 1 May to 6 May 2020. However, the number of respondents in the 20 target prefectures reached the target by midnight of 1 May 2020. Based on the cumulative number of COVID-19 cases per 100,000 people on 2 May 2020 (hereafter referred to as CASES per 100,000 on 02/05/2020), the study areas were subdivided into low (bottom 10) and high (top 10) incidence areas. There was no difference between the sub-divided areas and the division of the original area of the survey panel (Fig. 1). In addition, data published online, such as the cumulative number of reported COVID-19 cases on each index date [6], proportions of age-specific population by sex and population density in each target prefecture, were obtained from the official statistical data of Japan [10].

Data analyses
Spearman’s rank correlation coefficient was used to test correlations among ‘population density’, ‘proportion of population aged 65 years and over’ and ‘cases per 100,000 population as of 2 May 2020’ by using official statistics [10]. All the variables collected from respondents were weighted with population by sex and age of each target area [10] when the statistical tests were conducted. Pearson’s chi-squared (χ²) test, Student’s t test
and Mann-Whitney U test were used to compare variables between the groups (areas with low- and high-COVID-19-incidence, and age group of 18–59 years and ≥ 60 years). Univariate binomial analyses were conducted to test associations of behaviours and perceptions with age group. Univariate and multivariate binomial analyses were conducted to identify areas with associated factors for high COVID-19 incidence per 100,000 on 02/05/2020. Odds ratios (ORs) and adjusted odds ratios (AORs) were then derived with a 95% confidence interval (CI). The level of significance was set at p < 0.05. Data were analysed using SPSS software version 22.0 for Windows (IBM Corp., Armonk, NY, USA).

**Ethics**

The study was approved by the Ethical Review Board of the Institute of Tropical Medicine, Nagasaki University (authorization number of 200409235). Each respondent was informed about this study, and they had all the rights and means to cancel their entry. The respondents who provided consent to respond to the questions clicked the ‘Continue’ button to proceed with the process. Only the responses of those who completed the self-administered questionnaire were uploaded as survey data. Anonymized data were provided by Rakuten Insight for these analyses.

**Results**

**Correlations between demographic data and COVID-19 incidence**

CASES per 100,000 on 02/05/2020 in the low- and high-incidence areas were 1.2 (interquartile range [IQR] 2.4) and 12.6 (IQR 4.3), respectively. Additionally, CASES per 100,000 on 02/05/2020 was negatively correlated with the proportion of the population aged ≥ 65 years (the Spearman’s rank correlation coefficient, −0.701; p < 0.05). Population density was lower in the low-incidence area (174.9 population/km²; IQR 227.9 population/km²) than in the high-area (1338.7 population/km²; IQR 3385.6 population/km²). Population density was associated with the number of cases per 100,000 people, except in some areas such as Hokkaido (prefecture A). The Spearman’s rank correlation coefficient was 0.645 (p < 0.001) (Fig. 1, Fig. 2, Table 1).
Characteristics of respondents and areas

Altogether, responses of 6000 respondents were recorded with representation from 20 prefectures in Japan. Table 2 provides both unweighted and weighted characteristics. There was no difference in the sex ratio between the low- and high-incidence areas ($p = 0.301$). In low- and high-incidence areas, the mean of the household size were 3.2 persons/household (95% CI 3.2–3.3) and 3.0 persons/household (95% CI 3.0–3.1) respectively ($p < 0.001$); and the mean of the number of family members aged $\geq 60$ years in low- and high-incidence areas were 1.3 persons (95% CI 1.2–1.3) and 1.1 (95% CI 1.0–1.1) respectively ($p < 0.001$). Employment status varied between the two areas ($p < 0.001$), and the proportion of people out-of-work in the low-incidence area was 21% while in the high-incidence area was 17%. Moreover, the median for respondent age in the low-incidence area was 55 years old which was older than the high-incidence area (median 51 years) ($p < 0.001$).

Behaviours and perceptions by age categories

In both low- and high-incidence areas, more than 94% of people wore facemasks, and there was no difference in the rate of ‘wearing facemasks’ by age group ($p = 0.631$ and $p = 0.301$, respectively). All the other variables (behaviours and perceptions) stratified by age categories, depicted in (Fig 3(1–13)), were significantly different between low- and high-incidence areas ($p < 0.001$).

When the behaviours and perceptions were compared by age group, ‘younger age group (aged 18–59 years)’ and ‘older age group (aged $\geq 60$ years)’, the respondents in older age group adhered to preventive practice as compared to the other group. The odds ratios of ‘avoiding closed spaces with poor ventilation’, ‘avoiding crowded places’ and ‘avoiding close contact setting’ were 1.719 (95% CI 1.534–1.926), 2.308 (95% CI 1.781–2.333), and 1.961 (95% CI 1.764–2.180) respectively. Regarding ‘washing hands’, respondents in the older age group were more likely to adhere to this practice than the younger age group.

Table 1 Geographical and demographical characteristics of the study area

| Population density (population/km$^2$) [10] | Low-COVID-19-incidence area, $n = 10$, Median (IQR, Min–Max) | High-COVID-19-incidence area, $n = 10$, Median (IQR, Min–Max) |
|-------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------------|
| Population density (population/km$^2$) [10] | 174.9 (227.9, 80.3–509.4) | 1338.7 (3385.6), (66.9–6354.8) |
| Cumulative COVID-19 cases per 100,000 population as of 2 May 2020 [6] | 1.2 (2.4, 0–5.0) | 12.6 (4.3, 6.6–33.7) |
| Proportion (%) of population aged 65 years [10] | 30.0 (2.1, 27.7–33.8) | 25.9 (3.4, 22.7–29.1) |

IQR interquartile range, Min minimum, Max maximum
### Table 2 Characteristics of respondents by study area (un-weighted and weighted)

| Characteristic                  | Un-weighted | Weighted | p value a |
|---------------------------------|-------------|----------|-----------|
| **Low-COVID-19-incidence area, n = 3000** |             |          |           |
| **High-COVID-19-incidence area, n = 3000** |             |          |           |

| Sex                              | Un-weighted | Weighted | p value a |
|----------------------------------|-------------|----------|-----------|
| Female (n, %)                    | 1363 (45%)  | 1597 (53%) | 0.301     |
| Male (n, %)                      | 1637 (55%)  | 1403 (47%) |           |

| Household size (mean, 95% CI)    | Un-weighted | Weighted | p value a |
|----------------------------------|-------------|----------|-----------|
| Low-COVID-19-incidence area       | 3.3 (3.3–3.4) | 3.2 (3.2–3.3) | < 0.001   |
| High-COVID-19-incidence area      | 3.0 (3.0–3.1) | 3.0 (3.0–3.1) |           |

| Number of family member ≥ 60 years old | Un-weighted | Weighted | p value a |
|----------------------------------------|-------------|----------|-----------|
| Low-COVID-19-incidence area             | 1.1 (1.0–1.1) | 1.3 (1.2–1.3) | < 0.001   |
| High-COVID-19-incidence area            | 0.9 (0.9–1.0) | 1.1 (1.0–1.1) |           |

| Employment status (n, %)              | Un-weighted | Weighted | p value a |
|---------------------------------------|-------------|----------|-----------|
| Employed                              | 1574 (53%)  | 1215 (41%) | < 0.001   |
| Unpaid (homemaker, eldercare, etc.)   | 284 (10%)   | 552 (18%)  |           |
| Self-employed                         | 121 (4%)    | 103 (3%)   |           |
| Part-time job                         | 393 (13%)   | 437 (15%)  |           |
| Student                               | 119 (4%)    | 119 (4%)   |           |
| Out-of-work (including retired)       | 509 (17%)   | 643 (21%)  |           |

| Work in healthcare setting (n, %)     | Un-weighted | Weighted | p value a |
|---------------------------------------|-------------|----------|-----------|
| Employed                              | 281(9%)     | 193 (6%)  | 0.003     |
| Unpaid (homemaker, eldercare, etc.)   | 284 (10%)   | 509 (17%) |           |
| Self-employed                         | 121 (4%)    | 103 (3%)  |           |
| Part-time job                         | 393 (13%)   | 437 (15%) |           |
| Student                               | 119 (4%)    | 119 (4%)  |           |
| Out-of-work (including retired)       | 509 (17%)   | 643 (21%) |           |

| Age (median), (IQR, Min–Max)          | Un-weighted | Weighted | p value a |
|---------------------------------------|-------------|----------|-----------|
| Low-COVID-19-incidence area            | 45 (34, 18–87) | 55 (31, 18–87) | < 0.001   |
| High-COVID-19-incidence area           | 47 (34, 18–89) | 51 (31, 18–89) |           |

IQR interquartile range, Min minimum, Max maximum

a p value is based on the Chi-squared test, t test and Mann-Whitney U test

---

**Legend**

- Low area
- High area

- Proportion of "YES" in each age group in Low area (%)
- Proportion of "YES" in each age group in High area (%)

### Fig. 3 (1–13) Behaviours and perceptions between low and high COVID-19 incidence areas by six age groups. Low: Low-COVID-19-incidence-area; High: High-COVID-19-incidence-area. All the graphs are based on weighted figures; from (1) to (11), the sample size: 6000 respondents; (12) and (13), the sample size is based on commuting respondents: 3547 respondents. a p value is based on the chi-squared test.
other group (OR 1.914; 95% CI 1.592–2.300). The major practices and perceptions that older age group responded as ‘NO’ were ‘commuting by public transportation’ (OR 0.257; 95% CI 0.216–0.306), ‘opening windows regularly’ (OR 0.732; 95% CI 0.661–0.812), ‘non-scheduled visit to drinking places’ (OR 0.291; 95% CI 0.254–0.333), ‘perceived risk of contracting COVID-19’ (OR 0.615; 95% CI 0.546–0.693) and ‘being afraid of transmitting COVID-19 to others’ (OR 0.543; 95% CI 0.486–0.607) (Table 3).

**Factors associated with COVID-19 incidence**

Table 4 depicts the major factors associated with ‘CASES per 100,000 on 02/05/2020’ in the low- and high-incidence areas. The univariate binomial analyses indicated that all variables, except ‘avoiding crowded places’ and ‘wearing a mask’, were significantly associated with CASES per 100,000 on 02/05/2020, and they contributed to the difference in incidence. After adjusting for all variables, except ‘avoiding the 3 Cs (Cs: closed spaces with poor ventilation, crowded places and close contact setting, such as close-range conversations)’, the variables that showed significant positive associations with high-incidence area were ‘commuting by public transportation, such as trains, subways and buses’ (AOR, 6.813; 95% CI, 5.567–8.336), ‘washing hands’ (AOR, 1.233; 95% CI, 1.005–1.511), ‘opening windows regularly’ (AOR, 1.248; 95% CI, 1.104–1.412), ‘non-scheduled visit to drinking places’ (AOR, 1.212; 95% CI, 1.054–1.392) and ‘perceived risk of contracting COVID-19’ (AOR, 1.380; 95% CI, 1.180–1.612). The factors that were significantly negatively associated with high-incidence areas were ‘commuting by private automobile’ (AOR, 0.444; 95% CI, 0.394–0.501) and ‘avoiding crowded places’ (AOR, 0.757; 95% CI, 0.641–0.839).

**Discussion**

According to the definitions established by the World Health Organization and the United Nations, when more than 21% of a population is aged ≥65 years, the society is called a ‘super-aged society’ [11]. In Japan, the proportion reached 28% in 2019 [10]. This study revealed the existence of a significant negative correlation between ‘CASES per 100,000 on 02/05/2020’ and the proportion of the population aged ≥65 years in Japan. The correlation coefficient with the cumulative COVID-19 cases per 100,000 population on 2 May 2020 was −0.701 (p < 0.001). In the 10 prefectures with low COVID-19 incidence, the median proportion of the population aged ≥65 years was 30%, and the proportions in 4 of the 10 prefectures exceeded 30% (Table 1, Fig. 1). Furthermore, in the same area, the proportion of younger people (18–29 years) was extremely low, with a median of only 9.8%. Their proportion in nine of the 10 prefectures was less than 10%. The proportion above makes it clear that there was a polarization of population age structures between the low- and high-incidence areas.

Besides population density, the polarized nature of the COVID-19 pandemic in Japan was associated with age specific people’s behaviours and perceived risk of contracting COVID-19. As shown in Fig. 3 and Table 3, ‘age’ influenced people’s behaviours and perceptions, except regarding ‘wearing face masks’. Older adults are less likely to commute by public transportation and to visit places where alcohol is served than younger people. In addition, they are more likely to wash hands and to avoid the 3 Cs, even though their perceived risk of contracting COVID-19 was relatively lower than that among younger people. In contrast, the proportion of individuals from the population group of aged 18–29 years who avoided all the 3 Cs was < 30% in both areas, despite the higher perceived risk of COVID-19. The proportion was far less than the target set by the Japanese government of 70% to 80% [4].

The variables of the 3 Cs should be discussed along with the means of commute and behaviours linked with alcohol intake. In low-COVID-19-incidence area, public transportation was not convenient because of insufficient infrastructure. Therefore, it is common for residents in such areas to use their private cars to commute. In contrast to the low-incidence area, high-incidence area had developed public transportation networks commonly used for commuting. The characteristics of public transportation in high-incidence area are well described in Table 4. In addition, ‘non-scheduled visit to drinking places’ was positively associated with high-incidence area, whereas ‘commuting by private automobile’ was negatively associated with the area. These two variables strongly influence the incidence of COVID-19, as shown in Table 4. In addition, ‘non-scheduled visit to drinking places’ was positively associated with high-incidence area, while ‘going eat’ was insignificantly associated with the high-incidence area. Generally, in the drinking spots, people may have difficulties to avoid 3 Cs, particularly avoiding close-contact setting such as close-range conversations. Also, under an influence of alcohol, people are less likely to practice preventive measures due to impaired normal judgements by the alcohol intake [12].

Regarding the perceived susceptibility to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the proportion of individuals who perceived was higher in the high-incidence area than in the low-incidence area. The government of Japan has aggressively promoted advocacy campaigns to prevent COVID-19 since February 2020 [3, 9, 13], and respondents residing in high-incidence areas seem more stimulated with a daily increase in new COVID-19 cases [14, 15]. However, the
Table 3  Associations between behaviours/perceptions and age groups

| Respondents’ behaviours and perceptions | Weighted n = 6000 | Numbers (%) of respondents aged 18–59 years n = 3514 | Numbers (%) of respondents aged ≥ 60 years n = 2487 |
|----------------------------------------|-------------------|------------------------------------------------------|------------------------------------------------------|
| Commuting by private automobile        |                   |                                                      |                                                      |
| No                                     | 2011 (57%)        | 2023 (81%)                                           |                                                      |
| Yes                                    | 1503 (43%)        | 464 (19%)                                            |                                                      |
| OR (95% CI)<sup>a</sup>               | ref               | 0.307 (0.272–0.346)<sup>***</sup>                   |                                                      |
| Commuting by public transportation     |                   |                                                      |                                                      |
| No                                     | 2729 (78%)        | 2316 (93%)                                           |                                                      |
| Yes                                    | 784 (22%)         | 171 (7%)                                             |                                                      |
| OR (95% CI)                            | ref               | 0.257 (0.216–0.306)<sup>***</sup>                   |                                                      |
| Washing hands                          |                   |                                                      |                                                      |
| No                                     | 440 (13%)         | 173 (7%)                                             |                                                      |
| Yes                                    | 3074 (88%)        | 2313 (93%)                                           |                                                      |
| OR (95% CI)                            | ref               | 1.914 (1.592–2.300)<sup>***</sup>                   |                                                      |
| Practicing cough etiquette             |                   |                                                      |                                                      |
| No                                     | 1029 (29%)        | 922 (37%)                                            |                                                      |
| Yes                                    | 2484 (71%)        | 1565 (63%)                                           |                                                      |
| OR (95% CI)                            | ref               | 0.703 (0.630–0.784)<sup>***</sup>                   |                                                      |
| Opening windows regularly              |                   |                                                      |                                                      |
| No                                     | 1614 (46%)        | 1335 (54%)                                           |                                                      |
| Yes                                    | 1900 (54%)        | 1151 (46%)                                           |                                                      |
| OR (95% CI)                            | ref               | 0.732 (0.661–0.812)<sup>***</sup>                   |                                                      |
| Avoiding all 3 Cs<sup>b</sup>          |                   |                                                      |                                                      |
| No                                     | 2121 (60%)        | 1097 (44%)                                           |                                                      |
| Yes                                    | 1393 (40%)        | 1389 (56%)                                           |                                                      |
| OR (95% CI)                            | ref               | 1.928 (1.737–2.139)<sup>***</sup>                   |                                                      |
| Avoiding closed spaces with poor ventilation |      |                                                      |                                                      |
| No                                     | 1279 (36%)        | 621 (25%)                                            |                                                      |
| Yes                                    | 2235 (64%)        | 1865 (75%)                                           |                                                      |
| OR (95% CI)                            | ref               | 1.719 (1.534–1.926)<sup>***</sup>                   |                                                      |
| Avoiding crowded places                |                   |                                                      |                                                      |
| No                                     | 901 (26%)         | 360 (15%)                                            |                                                      |
| Yes                                    | 2612 (74%)        | 2127 (85%)                                           |                                                      |
| OR (95% CI)                            | ref               | 2.038 (1.781–2.333)<sup>***</sup>                   |                                                      |
| Avoiding close-contact setting         |                   |                                                      |                                                      |
| No                                     | 1798 (51%)        | 866 (35%)                                            |                                                      |
| Yes                                    | 1715 (49%)        | 1620 (65%)                                           |                                                      |
| OR (95% CI)                            | ref               | 1.961 (1.764–2.180)<sup>***</sup>                   |                                                      |
| Non-scheduled visit to drinking places |                   |                                                      |                                                      |
| No                                     | 2317 (66%)        | 2162 (87%)                                           |                                                      |
| Yes                                    | 1197 (34%)        | 325 (13%)                                            |                                                      |
| OR (95% CI)                            | ref               | 0.291 (0.254–0.333)<sup>***</sup>                   |                                                      |
| Going to eat                            |                   |                                                      |                                                      |
| No                                     | 1208 (34%)        | 1139 (46%)                                           |                                                      |
| Yes                                    | 2306 (66%)        | 1348 (54%)                                           |                                                      |
| OR (95% CI)                            | ref               | 0.620 (0.558–0.689)<sup>***</sup>                   |                                                      |
| Perceived risk of contracting COVID-19 |                   |                                                      |                                                      |
| No                                     | 708 (20%)         | 723 (29%)                                            |                                                      |
| Yes                                    | 2806 (80%)        | 1763 (71%)                                           |                                                      |
| OR (95% CI)                            | ref               | 0.615 (0.546–0.693)<sup>***</sup>                   |                                                      |
| Being afraid of transmitting COVID-19 to others |     |                                                      |                                                      |
| No                                     | 909 (26%)         | 973 (39%)                                            |                                                      |
| Yes                                    | 2604 (74%)        | 1514 (61%)                                           |                                                      |
| OR (95% CI)                            | ref               | 0.543 (0.486–0.607)<sup>***</sup>                   |                                                      |
| Wearing facemask                       |                   |                                                      |                                                      |
| No                                     | 217 (6%)          | 134 (5%)                                             |                                                      |
| Yes                                    | 3296 (94%)        | 2352 (95%)                                           |                                                      |
| OR (95% CI)                            | ref               | 1.156 (0.926–1.442)                                  |                                                      |

*p < 0.001

<sup>a</sup>Univariate binomial analyses were conducted to calculate odds ratios (ORs) (95% confidence interval [CI])

<sup>b</sup>Avoiding all 3 Cs meaning that avoiding ‘closed spaces with poor ventilation’, ‘crowded places’ and ‘close contact setting’, such as close-range conversations
Table 4 Univariate and multivariate binomial analyses of factors associated with high COVID-19 incidence area

| Respondents’ behaviours and perceptions | Numbers (%) in low-COVID-19-incidence area | Numbers (%) in high-COVID-19-incidence area | Numbers (%) in low-COVID-19-incidence area | Numbers (%) in high-COVID-19-incidence area | Univariate binominal analysis for high-COVID-19 incidence area OR (95% CI) | Multivariate binominal analysis for high-COVID-19 incidence area AOR (95% CI) |
|----------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------------|------------------------------------------------|
| Commuting by private automobile        |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 1553 (52%)                               | 706 (24%)                               | 1304 (44%)                               | 663 (22%)                                | 0.369 (0.330–0.413)**                        | 0.444 (0.393–0.501)**                        |
| Washing hands                          |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 2579 (86%)                               | 2693 (90%)                              | 2650 (88%)                               | 2736 (91%)                                | 8.695 (7.151–10.573)**                       | 6.813 (5.567–8.336)**                       |
| Practicing cough etiquette             |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 2012 (67%)                               | 2078 (69%)                              | 1961 (65%)                               | 2088 (70%)                                | 1.213 (1.089–1.352)**                       | 1.014 (0.890–1.155)                        |
| Opening windows regularly              |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 1541 (51%)                               | 1409 (47%)                              | 1590 (53%)                               | 1359 (45%)                                | 1.362 (1.230–1.507)**                       | 1.248 (1.104–1.412)**                       |
| Avoiding all 3 Cs                     |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 1112 (37%)                               | 1364 (45%)                              | 1476 (49%)                               | 1415 (47%)                                | 1.226 (1.108–1.357)**                       | 1.059 (0.912–1.229)                        |
| Avoiding closed spaces with poor ventilation |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 1189 (40%)                               | 988 (33%)                               | 1001 (33%)                               | 899 (30%)                                 | 1.170 (1.050–1.305)**                       | 0.757 (0.641–0.893)**                       |
| Avoiding crowded places               |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 742 (25%)                                | 702 (23%)                               | 641 (21%)                                | 620 (21%)                                 | ref                                          | ref                                          |
| Avoiding close-contact setting         |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 1604 (54%)                               | 1355 (45%)                              | 1401 (47%)                               | 1264 (42%)                                | 1.203 (1.087–1.333)**                       | 1.106 (0.972–1.259)                        |
| Non-scheduled visit to drinking places |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 2098 (70%)                               | 1927 (64%)                              | 2344 (78%)                               | 2135 (71%)                                | 1.448 (1.288–1.628)**                       | 1.212 (1.054–1.392)**                       |
| Going eat                              |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 1086 (36%)                               | 1028 (34%)                              | 1209 (40%)                               | 1138 (38%)                                | ref                                          | ref                                          |
| Perceived risk of contracting COVID-19 |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 964 (32%)                                | 847 (28%)                               | 1000 (33%)                               | 882 (29%)                                 | ref                                          | ref                                          |
| Being afraid of transmitting COVID-19 to others |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 2036 (68%)                               | 2153 (72%)                              | 2000 (67%)                               | 218 (71%)                                 | 1.201 (1.076–1.339)**                       | 0.933 (0.807–1.080)                        |
| Wearing facemask                       |                                           |                                           |                                           |                                           | ref                                          | ref                                          |
| Yes                                    | 215 (7%)                                 | 171 (6%)                                | 186 (6%)                                 | 166 (6%)                                  | ref                                          | ref                                          |
| *p < 0.05; **p < 0.01; ***p < 0.001*

Based on the cumulative number of COVID-19 cases per 100,000 population as of 2 May 2020, the 20 studied prefectures were divided into low (bottom 10) and high (top 10) areas.

AOR adjusted odds ratio, OR odds ratio, CI confidence interval; ref: reference category

*aAvoiding all 3 Cs means that avoiding ‘closed spaces with poor ventilation,’ ‘crowded places’ and ‘close contact setting,’ such as close-range conversations

*bAvoiding all 3 Cs, includes the broken down three behaviours. Therefore, this variable was excluded from the multivariate binomial analysis.
higher perceived susceptibility does not motivate the younger population to practice preventive measures as aforementioned.

Older adults are considered vulnerable to COVID-19 in terms of susceptibility and severity once infected by SARS-CoV-2 [16]. This does not necessarily mean that they are the main source of virus transmission, because once an older person gets infected, his/her mobility will be lowered due to an increased risk of severe illness and/or death [16, 17]. The source of transmission, except in clinical settings, might be much younger individuals. Compared with the low-incidence area, the high-incidence area had more individuals aged 18–29 years. Younger people are more likely to be asymptomatic and transmit SARS-CoV-2 due to their numerous social activities [18–21]. Thus, it may not be entirely wrong to conclude that younger people are the source of COVID-19 transmission. Additionally, in Japan, the observed gap between low and high COVID-19 incidence was associated with the population age structure as discussed earlier. The results of this study suggest that age-specific strategies should be established, and an approach to fill the gaps in the understanding of preventive measures should be subsequently developed.

This study has some limitations. The sample size was not decided by population-based proportionate sampling; instead, it was decided with the intention to maximise the number of participating individuals aged ≥60 years and 18–29 years. Therefore, each prefecture sample was weighted using age-specific proportions of the population by sex and size. As only 300 samples were collected from each prefecture, it was challenging to analyse each prefecture situation; therefore, all analyses were carried out using aggregated data from low- and high-incidence areas and younger and older age groups. This study covers up to 87-year-olds and 89-year-olds in low- and high-incidence areas, respectively. The author believes that many older people who could not be included in this study are less active due to an age-related state of frailty; thus, their ability to prevent COVID-19 should be much less than that of the study respondents except the cases who contracted COVID-19 as a nosocomial infection while staying at day-care centres or hospitals. Therefore, it is necessary to keep it in mind when the study implications are interpreted. However, it is very challenging to access older individuals for interviews in Japan.

Conclusion
There were differences in preventive behaviours and risk-related perceptions between young and older adults. Commuting measures were strongly associated with COVID-19 incidence, and they seemed related to being in crowded and closed spaces with poor ventilation along with visiting drinking spots. Effective preventive measures for COVID-19 transmission, particularly advocacy campaign, can be developed by understanding the characteristics of populated areas, such as public transportation infrastructure and younger people’s movements and behaviours in relation to the population age structure to contain the current epidemic and protect the most vulnerable elderly people. Finally, in Japan, the rates of wearing facemasks in both low- and high-incidence areas were very high (94% in both areas), with no statistically significant differences between the rates. This study could not test its efficacy in containing COVID-19, although, several studies have shown its efficacy [22–24].

I hope that the variables collected through this study such as the proportions of those who adhere to the preventive practice and who perceived risk might be useful for establishing mathematical models to project the direction and magnitude of COVID-19 infection in Japan as realistic parameters.

Abbreviations
3 Cs: Closed spaces with poor ventilation, crowded places and close contact setting, such as close-range conversations; AOR: Adjusted odds ratio; CI: Confidence interval; COVID-19: Coronavirus disease; IQR: Interquartile range; OR: Odds ratio; SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2

Acknowledgements
The author would like to thank Professor Koichi Monita for providing some valuable comments and the respondents for completing the self-administered questionnaires. In addition, the author would like to thank Editage (www.editage.com) for English language editing.

Author’s contributions
This work was completed solely by JO. JO conducted the literature search, conceived and designed the study protocol, managed all administrative matters with the online research company, performed that data analysis and interpretation and wrote the manuscript. The authors read and approved the final manuscript.

Funding
This research did not receive any specific grant from any funding agencies.

Availability of data and materials
The data sets are written in Japanese. They are available upon reasonable request.

Declarations
Ethics approval and consent to participate
The study was approved by the Ethical Review Board of the Institute of Tropical Medicine, Nagasaki University (authorization number of 20040923S). Each respondent was informed about this study, and they had all the rights and means to cancel their entry. The respondents who provided consent to respond to the questions clicked the ‘Continue’ button to proceed with the process. Only the responses of only those who completed the self-administered questionnaire were uploaded as survey data. Anonymized data were provided by Rakuten Insight for this analysis.

Consent for publication
It is not applicable, because this research article does not include any individual respondent data, such as images, videos or voice recordings.

Competing interests
The author declares that she has no competing interests.
References

1. World Health Organization. Novel coronavirus (2019-nCoV) situation report -1. Available: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200121-strep-1-2019-nCoV.pdf?sfvrsn=20a99c10_4. Accessed 10 Feb 2020.

2. Ministry of Health, Labour and Welfare. The first case of pneumonia related to Novel coronavirus (2019-nCoV) in Japan. Available: https://www.mhlw.go.jp/stf/newpage_0062008.html. Accessed 3 Apr 2020.

3. Ministry of Health, Labour and Welfare. Basic policies for novel coronavirus disease control (revised on April 7, 2020). Available: https://www.mhlw.go.jp/content/10900000/000620733.pdf. Accessed 23 Apr 2020.

4. Ministry of Health, Labour and Welfare. Basic policies for novel coronavirus disease control (revised on April 16, 2020). Available: https://www.mhlw.go.jp/content/10900000/000624195.pdf. Accessed 25 Apr 2020.

5. Iwasaki A, Grubaugh ND. Why does Japan have so few cases of COVID-19? EMBO Mol Med. 2020;12:e12481.

6. Nihon Hoso Kyokai [NHK]. [Special website for Novel coronavirus, reported disease control (February 25, 2020)]. Available: https://www3.mhlw.go.jp/jp/content/001468. Accessed 10 Feb 2020.

7. World Health Organization. WHO coronavirus disease (COVID-19) dashboard. Available: https://covid19.who.int/?gclid=Cj0KCQjw6PD3BRDPARIsA N8pHuF9haAvxQvmgsqSj6xOlusiQYQ1qjU6Jo58B1fVahH3ZV7RoaA uQeELaw_wC. Accessed 25 June 2020.

8. Ministry of Health, Labour and Welfare. Basic policies for novel coronavirus disease control (February 25, 2020). Available: https://www.mhlw.go.jp/content/10200000/000603610.pdf. Accessed 20 Mar 2020.

9. Ministry of Health, Labour and Welfare. Basic policies for novel coronavirus disease control by the Government of Japan (Summary). Available: https:// www.mhlw.go.jp/content/10900000/000617686.pdf. Accessed 2 Apr 2020.

10. Ministry of Internal Affairs and Communications Statistics Counselor. e-Stat, population census. Available: https://www.e-stat.go.jp/en/stat-search/?page=1. Accessed 3 Apr 2020.

11. Tahara Y. Cardiopulmonary resuscitation in a super-aging society—is there an age limit for cardiopulmonary resuscitation? Circ J. 2016;80:1102-3. https://doi.org/10.1253/circj.CJ-16-0307.

12. Sobngwi-Tambekou JL, Brown TG, Bhatti JA. Driving under the influence of alcohol in professional drivers in Cameroon. Traffic Inj Prev. 2016;17(Suppl 1):73–8. https://doi.org/10.1080/15389588.2016.1199867.

13. Prime Minister’s Office of Japan; Ministry of Health, Labour and Welfare. Please cooperate in measures against infectious diseases. Available: https://www3.mhlw.go.jp/stf/newpage_08906.html. Accessed 3 Apr 2020.

14. Ministry of Internal Affairs and Communications Statistics Counselor. e-Stat, population census. Available: https://www.e-stat.go.jp/en/stat-search/?page=1. Accessed 23 Apr 2020.

15. Cowling BJ, Ng DM, Ip DK, et al. Community psychological and behavioral risk management strategy and potential therapeutic options for the COVID-19 pandemic. Infez Med. 2020;28(suppl 1):57-63.

16. Rothe C, Schunk M, Stransch M, Sothmann P, Bretzel G, Froschli G, Wallenboeck R, et al. Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. N Engl J Med. 2020;382(10):970-1. https://doi.org/10.1056/NEJMc2 001468.

17. Wu JT, Leung K, Bushman M, Khatre N, Niehus R, de Salazar PM, et al. Estimating clinical severity of COVID-19 from the transmission dynamics in Wuhan, China. Nat Med. 2020;26(4):506-10. https://doi.org/10.1038/s41591- 020-0822-7.

18. Klonbichler A, Kresse D, Yoon S, Lee KH, Effenberger M, Shin JL. Asymptomatic patients as a source of COVID-19 infections: a systematic review and meta-analysis. Int J Infect Dis. 2020;98:180–6. https://doi.org/10.1016/j.ijid.2020.06.052.

19. Rothe C, Schunk M, Sothmann P, Bretzel G, Froschli G, Wallenboeck R, et al. Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. N Engl J Med. 2020;382(10):970-1. https://doi.org/10.1056/NEJMc2 001468.

20. Huang L, Zhang X, Zhang X, Wei Z, Zhang L, Xu J, et al. Rapid asymptomatic transmission of COVID-19 during the incubation period demonstrating strong infectivity in a cluster of youngsters aged 16–23 years outside Wuhan and characteristics of young patients with COVID-19: a prospective contact-tracing study. J Inf Secur. 2020;8(16):e1–e13. https://doi. org/10.1016/j.jinf.2020.03.006.

21. Castagnoli R, Votto M, Liciari A, Brambilla I, Bruno R, Perlini S, et al. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in children and adolescents: a systematic review. JAMA Pediatr. 2020;174(9):882–9. https://doi.org/10.1001/jamapediatrics.2020.1467.

22. Eikenberry SE, Mancuso M, Iboi E, Phan T, Eikenberry K, Kuang Y, et al. To mask or not to mask: modeling the potential for face mask use by the general public to curtail the COVID-19 pandemic. Infect Dis Modell. 2020;5: 293-308. https://doi.org/10.1016/j.idm.2020.04.001.

23. Tinupathi R, Bharathidasan K, Palabindala V, Salim SA, al-Tawfiq JA. Comprehensive review of mask utility and challenges during the COVID-19 pandemic. Infez Med. 2020;28(suppl 1):57-63.

24. Goh Y, Tan BYQ, Bhartendu C, Ong JY, Sharma VK. The face mask: how a real protection becomes a psychological symbol during Covid-19? Brain Behav Immun. 2020;88:1–5. https://doi.org/10.1016/j.bbi.2020.05.060.

Publisher’s Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:
• fast, convenient online submission
• thorough peer review by experienced researchers in your field
• rapid publication on acceptance
• support for research data, including large and complex data types
• gold Open Access which fosters wider collaboration and increased citations
• maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions