Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Short Communication

Trend change of the transmission route of COVID-19–related symptoms in Japan

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ABSTRACT

Objectives: The Japanese prime minister declared a state of emergency on April 7 2020 to combat the outbreak of coronavirus disease 2019 (COVID-19). This declaration was unique in the sense that it was essentially driven by the voluntary restraint of the residents. We examined the change of the infection route by investigating contact experiences with COVID-19–positive cases.

Study design: This study is a population-level questionnaire-based study using a social networking service (SNS).

Methods: To assess the impact of the declaration, this study used population-level questionnaire data collected from an SNS with 121,375 respondents (between March 27 and May 5) to assess the change in transmission routes over the study period, which was measured by investigating the association between COVID-19–related symptoms and (self-reported) contact with COVID-19–infected individuals.

Results: The results of this study show that the declaration prevented infections in the workplace, but increased domestic infections as people stayed at home. However, after April 24, workplace infections started to increase again, driven by the increase in community-acquired infections.

Conclusions: While careful interpretation is necessary because our data are self-reported from voluntary SNS users, these findings indicate the impact of the declaration on the change in transmission routes of COVID-19 over time in Japan.

Introduction

The World Health Organization officially declared the outbreak of coronavirus disease 2019 (COVID-19) to be a pandemic on March 11, 2020. Since the first deaths were reported in early January,[1] as of May 6, 215 countries and territories have confirmed COVID-19 cases, with 3,595,662 cases and 247,652 deaths reported worldwide.[2,3] In response, the Japanese prime minister, Shinzo Abe, declared a state of emergency in 7 of the 47 prefectures on the

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evening of April 7,[4] and this was extended to become nationwide on April 16[5] owing to a gradual increase in polymerase chain reaction–positive COVID-19 cases with an untraceable pathway of infection. The declaration had limited legally enforceable measures, which is different from the so-called 'lockdowns' (e.g., city blockades with penalties) that have been in place in the US, the UK, France, Germany, Italy and India, and it is essentially driven by the voluntary restraint of the residents in Japan.[4] In this sense, Japan has a unique Japanese-style lockdown policy based on the voluntary efforts of residents to weaken the spread of the infection, with no penalties for going out or commercial activities.

In infectious disease control, capturing the real-time epidemiological situation is a key factor to control the spread of the infection. To address this issue, COOPERA (COvid-19: Operation for Personalized Empowerment to Render smart prevention And care seeking), a new healthcare monitoring system, has recently been launched in a collaboration with the Kanagawa prefectural government and LINE Corporation as a way to monitor the spread of COVID-19 and associated societal factors.[6] LINE provides Japan's largest mobile messenger application, with 83 million monthly active users (covering 65% of Japan's total population). COOPERA asks participants about their individual information, including medical and psychiatric conditions, and contact experiences with other individuals. In response to the given information, COOPERA provides personalised assistance, such as telephone consultation for participants who report serious symptoms.[7] Data collected by COOPERA have been used to monitor the real-time situation of COVID-19 and its usefulness for medical decision-making has already been shown.[8–10]

In this study, we focus on the change of association between COVID-19–related symptoms and (self-reported) contact experience with COVID-19–positive cases over time, including before and after the state of emergency. In particular, we investigate the time trend of (1) domestic infections (i.e., within-household infection) and (2) community-acquired infections with an unknown route of transmission. In addition, by examining the impact of the voluntary Japanese-style lockdown policy, this study provides a useful insight not only for Japan but also for other countries that are preparing to relax their lockdowns in the near future.

Methods

COOPERA used LINE's chatbot system to request (1) basic characteristics of the participants, including age, gender, occupation, medical history, preventive actions and postcode, and (2) health conditions, including current and past month's symptoms (presence or absence of fever, strong feeling of weariness or shortness of breath) and duration of these symptoms. In particular, we focused on fever in this study. Participants with any COVID-19–related symptoms were asked additional questions about their contact experiences with COVID-19–infected individuals, and if yes, they were asked about their relationships with these individuals (e.g., if they were colleagues, classmates or family members). Participants with any COVID-19–related symptoms were followed up daily and those without any symptoms were followed up once every 4 days. COOPERA recruited participants either via the QR code page on the prefecture's website or via the banner at the top of the screen. We used data from 1,386,330 participants who lived in the Tokyo metropolitan area, including Tokyo, Kanagawa and Saitama prefectures, between March 27 and May 5, 2020. In these prefectures, the declaration of emergency was in effect from April 7. In addition, the Governor of Tokyo, Yuriko Koike, requested cessation of non-essential or/and non-urgent travel from/to other prefectures and requested that individuals stayed at home from March 25.[11] Owing to the LINE Corporation's policy, users (and the COOPERA participants) are restricted to individuals aged $\geq$15 years. Participants who reported contact with a COVID-19–infected individual when the relationship was with a family member who did not live in the same household or was with some other person (i.e., not a colleague or classmate) were excluded from the analysis. Proportions were plotted after taking a rolling 7-day window average with confidence intervals derived from 1000 bootstrap iterations. To examine the change points in the proportion, a piece-wise linear regression model was fitted with (at most) ten knots.[12] The difference in slopes before and after the estimated change point(s) was tested using the Davies test.[13] For those who had multiple answers, only the first answer was extracted. It should be noted that the populations of Tokyo, Kanagawa and Saitama prefectures were 13.9, 9.20 and 7.34 million, respectively, as of March 2020.

Results

Characteristics of the participants

Table S1 in the supplementary material shows the basic characteristics of the participants. In total, 121,375 of 1,386,330 respondents (8.76%) reported that they had a COVID-19–related symptom, and among them, 2937 (0.21%) reported having been in contact with a COVID-19–infected individual; these individuals were defined as the contact group. In addition, among those in the contact group, 2570 (93.1%) participants reported that the COVID-19–infected person with whom they had contact with was a colleague or classmate, whereas 207 (7.50%) reported that it was a family member in their household.

Comparisons of fever rate

Fig. 1 shows the proportion of participants reporting a fever at each study time point, stratified by contact experience (left) and relationship with the COVID-19–infected individual (right). The daily proportion of participants experiencing fever was higher in the contact group than in the non-contact group throughout the study period. Between April 17 and 24, there was a significant change ($p < 0.001$), with no upward trend in the contact group; however, after April 24, the proportion with fever in the contact group started increasing again and was parallel to the non-contact group. In terms of the proportion of individuals experiencing fever, stratified by the relationship with the infected persons, the proportion remained higher in the group with infected family members living together than in the group having contact with infected colleagues or classmates throughout the study period. The difference between the group having contact with infected family members living together and the group having contact with infected colleagues or classmates has widened since March 30 (1.71 times higher in the former group) and peaked on April 27 (2.56 times higher in the former group).

Discussion

This is the first study to examine the real-time COVID-19 epidemic in Japan stratified by contact experience and relationship with COVID-19–infected persons by using a surrogate indicator (i.e., fever). The proportion of those who had a fever showed an increasing trend in the contact group, followed by a stable trend between April 17 and 24 (10–17 days after the declaration of the state of the emergency on April 7 among the prefectures in this study). However, the proportion of individuals with fever in the non-contact group, which corresponds to infections of the unknown transmission route, steadily increased throughout the study period. In addition, the proportion of those experiencing fever among those

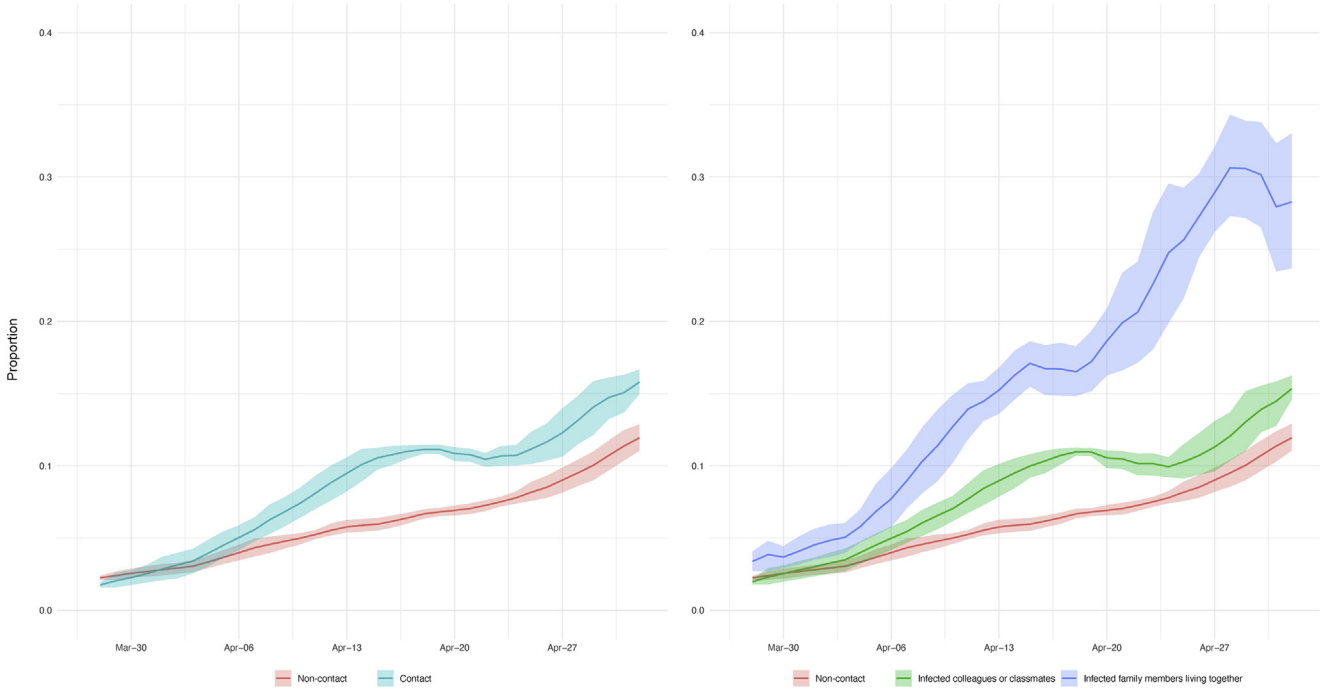

Fig. 1. Plot of the rolling 7-day window average of the proportion of participants who had a fever with bootstrap confidence intervals. The left pane is a comparison between contact/non-contact groups, and the right pane is a comparison between the relationship status of the participant with the COVID-19–infected persons. COVID-19, coronavirus disease 2019.

in the group who had contact with infected family members living together and the group who had contact with infected colleagues or classmates continually increased; the gap between these two groups was greatest at around April 27. There were no special events around April 27 that would have impacted the time trend other than the declaration of emergency that was issued on April 7. This evidence implies that the declaration may have reduced the number of contacts mainly at workplaces and classrooms, with an approximate 2-week time lag, and the epidemic was moved to the domestic transmission phase because most people were staying in their homes. This impact of the declaration was effective during the initial stage, but approximately 2 weeks after the declaration, workers staying home were exposed to the risk of the infection (measured by a fever) as the number of community-acquired infections with an unknown route of transmission started to grow.

This study has several limitations. First, fever is one symptom, although not an absolute indicator, of COVID-19 infection. Second, the number of participants who reported having contact with an infected individual and with an infected family member living in the same household was approximately 1 of 50 and 1 of 500, respectively, of the total number of participants who reported no contact with infected individuals (see Fig. S1 in the supplementary material). Therefore, it should be noted that the proportion may not be stable on some days owing to a small number of respondents. Third, the difference in available information about the symptoms of family members and those of colleagues and classmates might be a source of bias (e.g., information on family members was easy to obtain, but that of classmates and colleagues was relatively difficult to obtain). Other limitations are discussed extensively in the studies by Yoneoka[10] and Nomura.[14]

In conclusion, given that Japan has a unique and weak lockdown policy with limited legally enforceable measures, the results of this study provide a useful insight for preparing for second or third waves of COVID-19 without enforcing a strong lockdown in other countries, such as Europe, the US and low- and middle-income countries.

Author statements

Ethical approval

Ethical approval was granted by the Ethics Committee of Keio University School of Medicine, under authorisation number 20190338.

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Competing interests

H.M. reports a grant from the Ministry of Health, Labour and Welfare, Japan and K.M. reports personal fees from Janssen Pharmaceutical Companies of Johnson & Johnson, Japan outside the submitted work. All other authors declare no competing interests.

Author contributions

All authors took responsibility for the integrity of the data and the accuracy of the data analysis. All the authors made critical revisions to the manuscript for important intellectual content and gave final approval of the manuscript. The opinions, results and conclusions reported in this article are those of the authors and are independent from the funding bodies.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2020.08.020.

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