

# Journal Pre-proof



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

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**Short communication****Title**

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

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Journal Pre-proof

**1 Abstract****2 Objectives**

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

7

**8 Study design**

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

10

**11 Methods**

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

17

**18 Results**

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

22

**23 Conclusions**

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

27

**28 Keywords**

29 Japan, COVID-19, Social network service, contact experience with COVID-19 cases

30

**31 Introduction**

32 The World Health Organization (WHO) officially declared the outbreak of coronavirus disease 2019  
33 (COVID-19) to be a pandemic on March 11, 2020. Since the first deaths were reported in early  
34 January [1], as of May 6, 215 countries and territories have confirmed COVID-19 cases, with  
35 3,595,662 cases and 247,652 deaths reported worldwide [2, 3]. In response, the Japanese prime  
36 minister, Shinzo Abe, declared a state of emergency in 7 of the 47 prefectures on the evening of  
37 April 7 [4], and this was extended to become nationwide on April 16 [5] due to a gradual increase  
38 in polymerase chain reaction (PCR)-positive COVID-19 cases with an untraceable pathway of  
39 infection. The declaration had limited legally enforceable measures, which is different from the so-  
40 called 'lockdowns' (e.g. city blockades with penalties) that have been in place in the US, the UK,  
41 France, Germany, Italy and India, and it is essentially driven by the voluntary restraint of the  
42 residents in Japan [4]. In this sense, Japan has a unique Japanese-style lockdown policy based on  
43 the voluntary efforts of residents to weaken the spread of the infection, with no penalties for going  
44 out or commercial activities.

45

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

58

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

## 66 **Methods**

67 COOPERA used LINE's chatbot system to request (1) basic characteristics of participants, including  
68 age, gender, occupation, medical history, preventive actions and postcode, and (2) health  
69 conditions, including current and past month's symptoms (presence or absence of fever, strong  
70 feeling of weariness or shortness of breath) and duration of these symptoms. In particular, we  
71 focused on fever in this study. Participants with any COVID-19-related symptoms were asked  
72 additional questions about their contact experiences with COVID-19-infected individuals, and, if  
73 yes, they were asked about their relationships with these individuals (e.g. if they were colleagues,  
74 classmates or family members). Participants with any COVID-19-related symptoms were followed-  
75 up daily and those without any symptoms were followed-up once every 4 days. COOPERA recruited  
76 participants either via the QR code page on the prefecture's website or via the banner at the top of  
77 the screen. We used data from 1,386,330 participants who lived in the Tokyo metropolitan area,  
78 including Tokyo, Kanagawa and Saitama prefectures, between March 27 and May 5, 2020. In these  
79 prefectures, the declaration of emergency was in effect from April 7. In addition, the Governor of  
80 Tokyo, Yuriko Koike, requested cessation of nonessential or/and nonurgent travel from/to other  
81 prefectures and requested that individuals stayed at home from March 25 [11]. Due to the LINE  
82 Corporation's policy, users (and the COOPERA participants) are restricted to individuals aged  $\geq 15$   
83 years old. Participants who reported contact with a COVID-19-infected individual when the  
84 relationship was with a family member who did not live in the same household or was with some  
85 other person (i.e. not a colleague or classmate) were excluded from the analysis. Proportions were  
86 plotted after taking a rolling 7-day-window average with confidence intervals (CIs) derived from  
87 1000 bootstrap iterations. To examine the change points in the proportion, a piece-wise linear  
88 regression model was fitted with (at most) ten knots [12]. The difference in slopes before and after  
89 the estimated change point(s) was tested using the Davies test [13]. For those who had multiple  
90 answers, only the first answer was extracted. It should be noted that the populations of Tokyo,  
91 Kanagawa and Saitama prefectures were 13.9, 9.20, and 7.34 million, respectively, as of March  
92 2020.

93

## 94 **Results**

### 95 *Characteristics of participants*

96 Table S1 in the supplementary material shows the basic characteristics of the participants. In total,  
97 121,375 of 1,386,330 respondents (8.76%) reported that they had a COVID-19-related symptom,  
98 and among them, 2937 (0.21%) reported having been in contact with a COVID-19-infected  
99 individual; these individuals were defined as the contact group. In addition, among the contact  
100 group, 2570 (93.1%) participants reported that the COVID-19-infected person with whom they had  
101 contact with was a colleague or classmate, while 207 (7.50%) reported that it was a family member  
102 in their household.

103

104 *Comparisons of fever rate*

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

118

119 (Figure 1 here)

**120 Discussion**

121 This is the first study to examine the real-time COVID-19 epidemic in Japan stratified by contact  
122 experience and relationship with COVID-19-infected persons by using a surrogate indicator (i.e.  
123 fever). The proportion of those who had a fever showed an increasing trend in the contact group,  
124 followed by a stable trend between April 17 and 24 (10–17 days after the declaration of the state  
125 of the emergency on April 7 among the prefectures in this study). However, the proportion of  
126 individuals with fever in the in the non-contact group, which corresponds to infections of unknown  
127 transmission route, steadily increased throughout the study period. In addition, the proportion of  
128 those experiencing fever among the group who had contact with infected family members living  
129 together and the group who had contact with infected colleagues or classmates continually  
130 increased; the gap between these two groups was greatest at around April 27. There were no  
131 special events around April 27 that would have impacted the time trend other than the declaration  
132 of emergency that was issued on April 7. This evidence implies that the declaration may have  
133 reduced the number of contacts mainly at workplaces and classrooms, with an approximate 2-  
134 week time-lag and the epidemic was moved to the domestic transmission phase because most  
135 people were staying in their homes. This impact of the declaration was effective during the initial  
136 stage, but approximately 2 weeks after the declaration, workers staying home were exposed to the  
137 risk of the infection (measured by a fever) as the number of community-acquired infections with  
138 an unknown route of transmission started to grow.

139  
140 This study has several limitations. First, fever is one symptom, although not an absolute indicator,  
141 of COVID-19 infection. Second, the number of participants who reported having contact with an  
142 infected individual and with an infected family member living in the same household was  
143 approximately 1/50 and 1/500, respectively, of the total number of participants who reported no  
144 contact with infected individuals (see Figure S1 in the supplementary material). Therefore, it  
145 should be noted that the proportion may not be stable on some days due to a small number of  
146 respondents. Third, the difference in available information about the symptoms of family members  
147 and those of colleagues and classmates might be a source of bias (e.g. information on family  
148 members was easy to obtain, but that of classmates and colleagues was relatively difficult). Other  
149 limitations are discussed extensively elsewhere [10, 14].

150  
151 In conclusion, given that Japan has a unique and weak lockdown policy with limited legally  
152 enforceable measures, the results of this study provide a useful insight for preparing for second or  
153 third waves of COVID-19 without enforcing a strong lockdown in other countries, such as Europe,  
154 the US and in low- and middle-income countries.



**155 Figure legends**

156 Figure 1: Plot of the rolling 7-day-window average of the proportion of participants who had a  
157 fever with bootstrap confidence intervals. The left pane is a comparison between contact/non-  
158 contact groups and the right pane is a comparison between the relationship status of the  
159 participant with the COVID-19-infected persons.

160

161 Supplemental Figure 1: Number of respondents at each time period, stratified by contact  
162 experience and relationship with the COVID-19-infected individual. The left and right panes are the  
163 denominator and numerator for the plotted proportion in Figure 1, respectively.

164

165

**166 Author statements**

167

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174

*175 Ethical approval*

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178

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184

*185 Competing interests*

186 Hiroaki Miyata reports a grant from the Ministry of Health, Labour and Welfare of Japan, and  
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189

*190 Author contributions*

191 All authors took responsibility for the integrity of the data and the accuracy of the data analysis. All  
192 the authors made critical revisions to the manuscript for important intellectual content and gave

193 final approval of the manuscript. The opinions, results, and conclusions reported in this paper are  
194 those of the authors and are independent from the funding bodies.  
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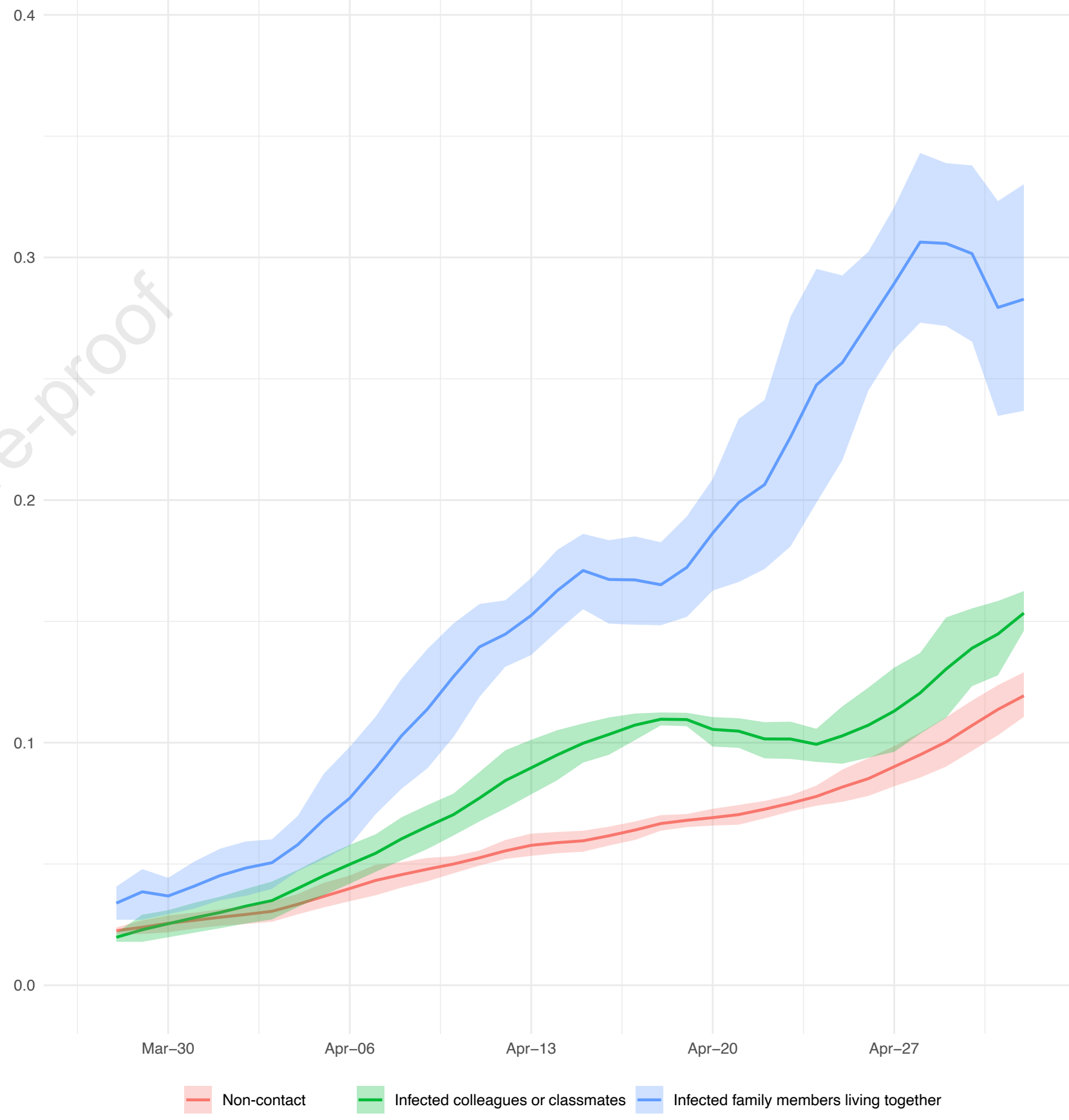
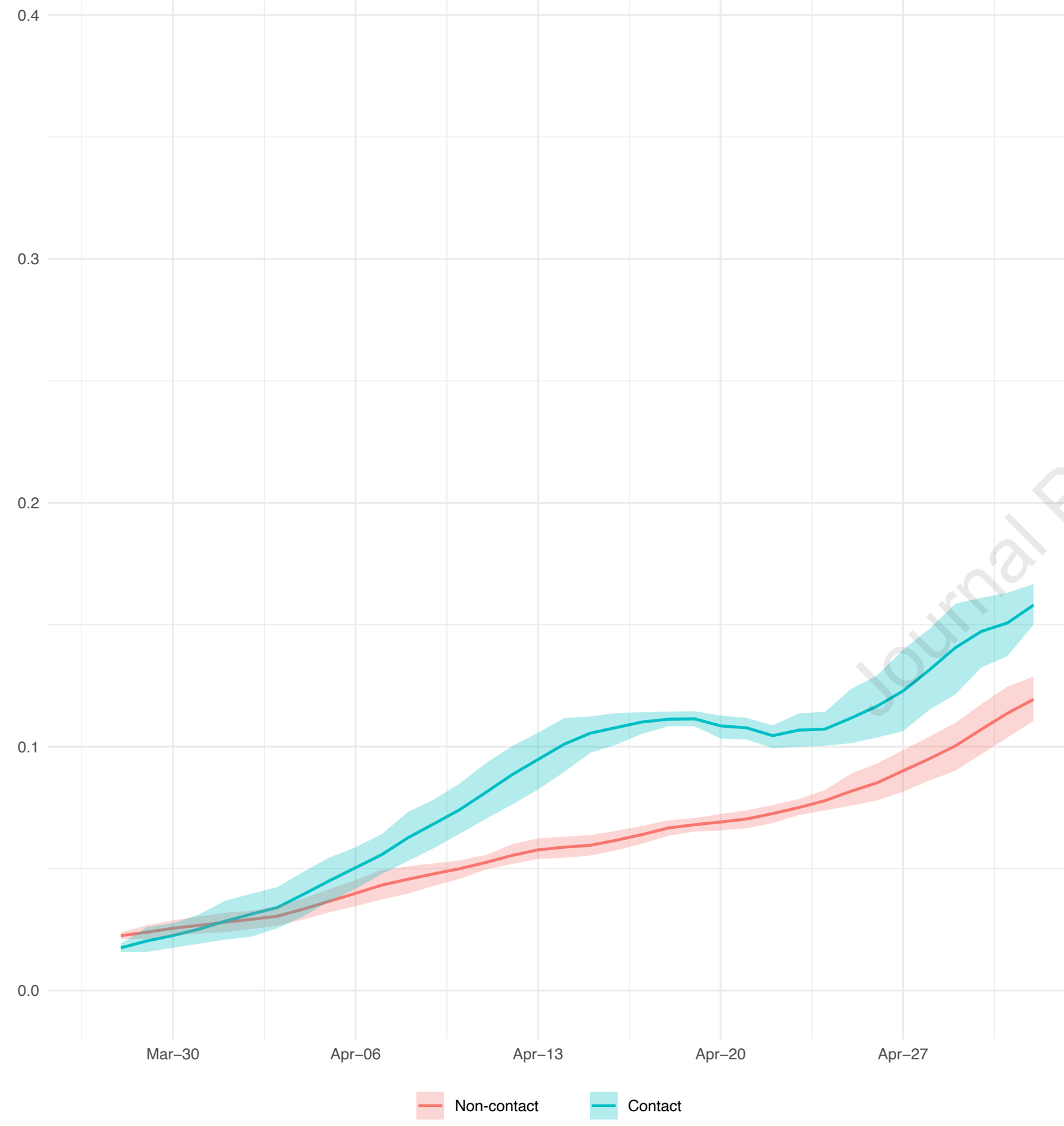
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232

Proportion



## Highlights

Following a weak lockdown, the transmission route of COVID-19-related symptoms changed.

COVID-19 monitoring responses from over 120,000 social networking service users in Japan were used for analysis.

The emergency declaration prevented infections in the workplace and increased domestic infections.

Even lockdown with limited enforcement may prevent the spread of infection.