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Original Research

Temporal trends in voluntary behavioural changes during the early stages of the COVID-19 outbreak in Japan

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ABSTRACT

Objectives: This study evaluated the characteristics of individuals with voluntary behavioural changes (cancellation and postponement of bookings) during the early stages of the coronavirus disease 2019 (COVID-19) outbreak in Japan. In addition, the temporal trends of these changes were captured.
Study design: A cross-sectional analysis and a time series analysis were conducted.
Methods: A nation-wide retrospective panel survey was conducted at the end of March 2020 (n = 1052). Odds ratios for cancellations/postponements with respect to individual characteristics were calculated in the analysis. To determine the temporal trend, the incidence ratios were compared throughout the time series analysis for four time periods: period 1, before the announcement of the Public Health Emergency of International Concern (PHEIC) from the World Health Organisation (WHO) (January 1–31); period 2, after the announcement of PHEIC (February 1–26); period 3, after the announcement of school closures by the Japanese government (February 27 – March 11); and period 4, after the announcement of the pandemic by the WHO (March 12–31).
Results: In total, 72% of respondents cancelled or postponed their bookings at least once, and about half of the changes occurred in period 3. Elderly individuals' changes in gatherings were, on average, 5.9 times (95% confidence interval [CI] 1.9–17.9) higher than those of young individuals. The incidence rate of change in gatherings during period 3 was 7.11 times (95% CI: 5.16–9.81) higher than in period 2 and 3.15 times (95% CI: 2.25–4.43) higher than in period 4. Significant interaction terms were observed in age and residential city size, but not sex, of the respondents.
Conclusions: A significant proportion of the Japanese population voluntarily changed their behaviour during the early stages of the COVID-19 outbreak, and the government's announcement of school closures was a key trigger during this time.

Introduction

The novel coronavirus disease 2019 (COVID-19) outbreak caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has resulted in many deaths and severe economic losses worldwide. The World Health Organisation (WHO) declared the outbreak to be a Public Health Emergency of International Concern (PHEIC) on January 31, 2020, when the number of globally confirmed cases reached 9826[1] (Japan: 12 cases[2]). The total number of infected cases is still showing an increasing trend and was >16.8 million globally[3,4] (Japan: approximately 34,500 cases[2]) as of July 31, 2020. A considerable number of countries implemented a forcible lockdown in individual cities or nationwide to prevent the spread of SARS-CoV-2. For example, China implemented a lockdown at the end of January, whereas Italy, Spain and the UK did so on March 9, March 14 and March 17, respectively. New York in the US was locked down on March 22.[5] Such lockdowns are supported by penalties to violations of the restrictions.

While the COVID-19 vaccine is still under development, subsequent waves of COVID-19 outbreak are likely to occur, and the overall duration of the COVID-19 pandemic could continue until

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2022.[6] With the projection of prolonged or intermittently occurring outbreaks and in the absence of pharmaceutical interventions, maintaining physical distance is crucial in preventing the transmission of SARS-CoV-2;[7] hence, voluntary behavioural changes are extremely important.[8] Unfortunately, the roles of voluntary behavioural changes during the pandemic, especially in its early stages, have remained unknown because surveys targeting individual behavioural changes are lacking. Unlike other countries, Japan did not adopt any lockdown measure. Instead, Japan has heavily relied on voluntary behavioural changes and cooperation.[9] This provides a unique case study to reveal insights into COVID-19 policymaking.

This study used data from a nationwide online questionnaire survey conducted in Japan at the end of March 2020.[10] Individual characteristics of those who voluntarily cancelled or postponed their bookings (e.g. trips, leisure activities or gatherings) to prevent transmission of the coronavirus are described. Furthermore, the temporal trends in voluntary behavioural changes are clarified. In this analysis, the announcement of school closures by the Japanese government on February 27, before the declaration of a state of emergency, was a focus time point. This study evaluated how the school closure announcement triggered a change in behaviours.

Methods

Two epidemiological analyses were conducted. First, a cross-sectional analysis took place to identify the characteristics of individuals who cancelled or postponed their bookings due to the COVID-19 outbreak. Second, a time-series analysis to evaluate the temporal trends of voluntary changes in behaviours was performed.

Questionnaire survey

An online nationwide retrospective panel survey in Japan between March 23 and March 30 was implemented. Thus, respondents were asked to recall behavioural changes (i.e. booking types and dates) based on memory. The details of this survey have been described in a previous study.[10] Briefly, the survey aimed to reveal various changes in the lives of individuals and data collected included: (1) individual or household characteristics; (2) changes in booking behaviour and other daily life activities; and (3) factors for behavioural changes and consequences caused by COVID-19 at the early stage of the outbreak in Japan. In total, valid data were collected from 1052 respondents.

Changes in booking behaviours

In this study, cancellations or postponements of bookings as behavioural changes against the spread of COVID-19 were the main focus. In the questionnaire survey, respondents were asked to report cancellations/postponements of bookings and detail initial dates of changes. Nine types of bookings were included, which were further classified into four categories: (1) domestic tourism and business trips; (2) international tourism and business trips; (3) leisure activities, such as eating out, music concerts, sporting events and cinema trips; and (4) mass gatherings (e.g. joining a party).

The Japanese government declared a state of emergency due to COVID-19 on April 7, 2020, when the number of globally confirmed cases reached 1,279,722[11] (Japan: 4341[2]). The declaration enabled prefectural governors to take stronger preventive actions, instruct residents to stay at home, and restrict the operation of schools and other facilities, although there were no enforcements or legal penalties. Because the declaration was made after the online survey, all observed cancellations/postponements in this study occurred voluntarily, without any enforcement.

Major public announcements

Three major public announcements by the WHO and Japanese government, which took place before declaring the state of emergency in Japan, were considered in this study. The first was the PHEIC announcement by the WHO on January 31, the second was the announcement of temporary school closures by the Japanese government on February 27, and the third was the COVID-19 outbreak being declared a pandemic by the WHO on March 11. Information, including dates, on these three major public announcements was not provided to respondents.

COVID-19 data

In evaluating the relationships between the reported number of confirmed COVID-19 cases and cancellations/postponements of bookings, infection data were obtained from the website of the Ministry of Health, Labour and Welfare.[2] It should be noted that these data do not contain the number of individuals who tested positive at airport quarantine.

Individual characteristics

When investigating the relationships between individual characteristics and voluntary cancellations/postponements of bookings, the following three individual characteristics were focused upon: sex (male and female), age (15–39, 40–59 and ≥60 years) and city size of residence (large-, middle- and small-sized cities). Large-sized cities included Tokyo (23 wards), Yokohama, Kawasaki, Saitama, Chiba, Sagamihara, Nagoya, Kyoto, Sakai, Osaka and Kobe. Middle-sized cities indicated those ordinance cities other than the aforementioned large-sized cities. All other cities were classified as small-sized cities. In addition, several other characteristics were also considered, including educational level (high school, university/college and graduate school), occupation (employee, non-regular employee/others, unemployed and students), household income (<3000k, 3000k–4999k, 5000k–9999k and ≥10000k Japanese Yen), marital status (no: never married/bereavement/divorce, and yes: married), living with a junior high school-aged or younger member in the household (yes and no) and living with an elderly person (≥65 years) in the household (yes and no).

Statistical analyses

In the cross-sectional analysis, the associations between individual characteristics and cancellations/postponements were examined by calculating the odds ratios (ORs) and 95% confidence intervals (95% CIs) using logistic regression analysis.

For the time-series analysis, cancellations/postponements observed between January 1 and March 31 were investigated and classified into four time periods: period 1, before the PHEIC announcement (January 1 to 31 [31 days]); period 2, after the PHEIC announcement (February 1 to 26 [26 days]); period 3, after the school closure announcement (February 27 to March 11 [14 days]); and period 4, after the pandemic announcement (March 12 to 31 [20 days]). The incidence rate ratios (IRRs) and 95% CIs of cancellation/postponement events were then calculated for the four categories of cancellations/postponements by comparing with the rate in period 2 (reference), based on a Poisson regression model. The IRRs of confirmed COVID-19 infection cases were also calculated. Furthermore, cancellations or postponements of bookings may show interaction effects between individual characteristics

and time periods. To confirm this, the statistical interaction between each characteristic and time variable was evaluated at a significance level of 0.10 by including a corresponding interaction term in the Poisson model.[12] Subsequently, stratified analyses by individual characteristics were conducted. SPSS software (IBM Inc., Japan, version 26.0J) was used in all analyses. A *P*-value <0.05 was considered to be statistically significant.

Results

Characteristics of the 1052 respondents are shown in Table 1. The sex and city/town size categories were almost equally distributed. In terms of age and occupation, 74% of respondents were in the core working-age population (20–60 years) and 41.2% were classified as company employee/officer/self-employed.

Fig. 1 shows the numbers and percentages of cancellations/postponements of bookings. Among all respondents, 573 individuals (54%) cancelled or postponed at least one booking (within the nine major bookings categories) before the end of March 2020.

Table 1
Characteristics of respondents (respondent n = 1052).

Characteristic	n	(%)
Sex		
Male	532	(50.6)
Female	520	(49.4)
Age group in years		
15–19	72	(6.8)
20–29	168	(16.0)
30–39	206	(19.6)
40–49	221	(21.0)
50–59	185	(17.6)
60–64	111	(10.6)
≥65	89	(8.5)
City/town size		
Small	318	(30.2)
Middle	317	(30.1)
Large	417	(39.6)
Educational level (being in/graduated)		
High school	340	(32.3)
University/College	661	(62.8)
Graduate School	51	(4.8)
Occupation		
(Employee) Company employee/officer/self-employed	433	(41.2)
(Employee) Public servant/organisation employee	50	(4.8)
(Employee) Faculty member of school or college/university	15	(1.4)
(Non-regular employee/Other) Part-time job	145	(13.8)
(Non-regular employee/Other) Others	33	(3.1)
(Unemployed) Housewife	167	(15.9)
(Unemployed) Unemployed (including pensioner)	112	(10.6)
(Students) Student	97	(9.2)
Household income in JP Yen		
<3000k	254	(24.1)
3000k–4999k	293	(27.9)
5000k–9999k	387	(36.8)
≥10,000k	118	(11.2)
Marital Status		
Never married/bereavement/divorce	517	(49.1)
Married	535	(50.9)
Living with a Junior high school-aged or younger member in the household		
No	837	(79.6)
Yes	215	(20.4)
Living with an elderly person (≥65 y) in the household		
No	759	(72.1)
Yes	293	(27.9)

The net percentage of cancellations/postponements was 72%, excluding 260 individuals who did not have any booked activity. The category with the largest number of cancellation/postponement was gatherings, followed by eating out and domestic tourism trips. Examining the net percentage of cancellations/postponements, the highest was observed in sporting events (94%) and the lowest was noted in eating out (only 39%).

Table 2 shows the estimated associations between the three main individual characteristics (sex, age and city size) and cancellation/postponement of bookings. The percentages of cancellations/postponements were similar across sexes, and statistically significant ORs were not observed for any booking type. In terms of age, only bookings for cinema trips and gatherings show significant differences across age groups, in which cancellations/postponements were higher in the middle-aged (40–59 years) and elderly (≥60 years) groups than those in the young group (15–39 years). Cancellations/postponements of cinema trips and gatherings in elderly individuals were 4.2 times (95% CI: 1.3–13.2) and 5.9 times (95% CI: 1.9–17.9) higher, respectively, than those in young individuals. Regarding city size, domestic and international business trips were more likely to be cancelled or postponed for individuals living in large-sized cities (3.4 times [95% CI: 1.1–10.3] higher for domestic trips and 12.5 times [95% CI: 1.2–128.7] higher for international trips) than those living in small-sized cities. However, city size was not associated with other cancellations/postponements. Thus, cancellations/postponements of bookings did not show remarkable differences in terms of sex or residential city size of the individual for most of the nine booking types. The ORs with respect to other individual characteristics are shown in Supplementary Table S1. Individuals who had a higher educational level, were married or were living with a child of junior high school-aged or younger were more likely to cancel or postpone their bookings.

Fig. 2 shows the cumulative numbers of cancellations/postponements and confirmed COVID-19 infection cases. An exponential increasing trend of cancellations/postponements was observed by the end of February; this increasing trend started earlier than the increasing cumulative infection cases. Period 1 (January 1–31) accounted for 2.4% of the total cancellations/postponements (n = 35), period 2 (February 1–26) accounted for 17.9% (n = 258), period 3 (February 27–March 11) accounted for 50.0% (n = 721) and period 4 (March 12–31) accounted for 29.6% (n = 427). The cumulative numbers of cancellations/postponements stratified by characteristics (sex, age and city size) are shown in Supplementary Fig. S1. Similar trends of increasing numbers of cancellations/postponements after the announcement of school closures were observed across all characteristics.

The numbers and IRRs of reported confirmed infection cases and cancellations/postponements for the four time periods in the time-series analysis are shown in Table 3. Compared with Period 2, the IRR of confirmed COVID-19 cases were 5.06 times (95% CI: 4.22–6.07) higher in period 3 and 12.43 times (95% CI: 10.55–14.63) higher in period 4. In contrast, the IRRs of cancellations/postponements in period 3 were higher than those in period 4. In particular, the IRRs of gatherings were 7.11 (95% CI: 5.16–9.81) in period 3 and 3.15 (95% CI: 2.25–4.43) in period 4.

Results of the stratified analysis by individual characteristics are shown in Fig. 3. No significant interaction was observed between sex and time period. In contrast, significant interaction terms were observed across age groups and city sizes. In period 3, the IRRs for domestic trips were higher in the young group (15–30 years) than in the middle-aged group (40–59 years) [P for interaction: PI = 0.09] and older age group (≥60 years) [PI = 0.03]. A similar trend was also observed with respect to leisure-related bookings in period 3. Regarding interaction effects between time

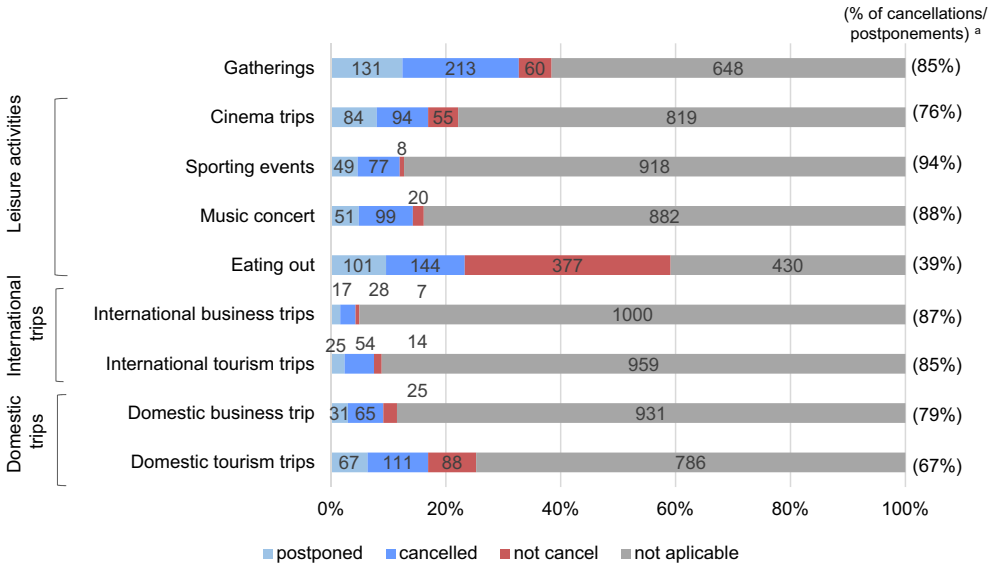

Fig. 1. Numbers and percentages of cancellations or postponements of bookings (respondents n = 1052). The percentages in the parentheses on the right side are the rate of cancellations or postponements in respondents, excluding those who answered not applicable.

Table 2
Numbers and odds ratios (ORs) for cancellations or postponements of bookings according to individual characteristics (sex, age city size) in the cross-sectional analysis (n = 1052).

Individual characteristics	n	(%)[a]	OR	n	(%)[a]	OR	(95% CI)	n	(%)[a]	OR	(95% CI)
Sex	**Men**			**Women**							
Domestic trips											
Tourism	93	(62.8)	ref	85	(72.0)	1.5	(0.9–2.6)				
Business	76	(77.6)	ref	20	(87.0)	3.5	(0.5–7.1)				
International trips											
Tourism	51	(87.9)	ref	28	(80.0)	7.3	(0.2–1.7)				
Business trip	35	(87.5)	ref	10	(83.3)	7.0	(0.1–4.3)				
Leisure activities											
Eating out	130	(41.9)	ref	115	(36.9)	0.7	(0.6–1.1)				
Music concert	70	(88.6)	ref	80	(87.9)	7.8	(0.4–2.4)				
Sporting event	73	(94.8)	ref	53	(93.0)	18.2	(0.2–3.0)				
Cinema trip	87	(75.0)	ref	91	(77.8)	3.0	(0.6–2.1)				
Gatherings	183	(83.2)	ref	161	(87.5)	4.9	(0.8–2.5)				
Age	**15–39 y**			**40–59 y**				**≥60 y**			
Domestic trips											
Tourism	50	(68.5)	ref	90	(65.2)	0.9	(0.5–1.6)	38	(69.1)	1.0	(0.5–2.2)
Business	22	(84.6)	ref	65	(80.2)	0.7	(0.2–2.4)	9	(64.3)	0.3	(0.1–1.5)
International trips											
Tourism	21	(77.8)	ref	39	(86.7)	1.9	(0.5–6.5)	19	(90.5)	2.7	(0.5–15.1)
Business	14	(87.5)	ref	27	(87.1)	1.0	(0.2–5.9)	4	(80.0)	0.6	(0.0–8.0)
Leisure activities											
Eating out	50	(34.5)	ref	143	(39.3)	1.2	(0.8–1.8)	52	(46.0)	1.6	(1.0–2.7)
Music concert	50	(87.7)	ref	77	(86.5)	0.9	(0.3–2.4)	23	(95.8)	3.2	(0.4–27.7)
Sporting event	34	(89.5)	ref	73	(94.8)	2.1	(0.5–9.1)	19	(100.0)	NE	0
Cinema trip	46	(65.7)	ref	100	(78.7)	1.9	(1.0–3.7)	32	(88.9)	4.2	(1.3–13.2)
Gatherings	73	(76.0)	ref	196	(85.6)	1.9	(1.0–3.4)	75	(94.9)	5.9	(1.9–17.9)
City type	**Small**			**Middle**				**Large**			
Domestic trips											
Tourism	58	(65.9)	ref	50	(70.4)	1.2	(0.6–2.4)	70	(65.4)	1.0	(0.5–1.8)
Business	25	(67.6)	ref	28	(80.0)	1.9	(0.7–5.6)	43	(87.8)	3.4	(1.1–10.3)
International trips											
Tourism	18	(81.8)	ref	19	(76.0)	0.7	(0.2–2.9)	42	(91.3)	2.3	(0.5–10.4)
Business	8	(66.7)	ref	12	(85.7)	3.0	(0.4–20.4)	25	(96.2)	12.5	(1.2–128.7)
Leisure activities											
Eating out	69	(39.2)	ref	75	(40.3)	1.0	(0.7–1.6)	101	(38.8)	1.0	(0.7–1.5)
Music concert	41	(85.4)	ref	39	(86.7)	1.1	(0.3–3.6)	39	(86.7)	1.1	(0.3–3.6)
Sporting event	37	(94.9)	ref	44	(89.8)	0.5	(0.1–2.6)	45	(97.8)	2.4	(0.2–27.9)
Cinema trip	54	(78.3)	ref	57	(76.0)	0.9	(0.4–1.9)	67	(75.3)	0.8	(0.4–1.8)
Gatherings	107	(86.3)	ref	97	(80.8)	0.9	(0.3–1.3)	140	(87.5)	0.9	(0.6–2.2)

CI, confidence interval; NE, not evaluated.
[a] The percentage was calculated as follows: cancellations/postponements numbers divided by the total number of participants, excluding the those who did not have scheduled events.

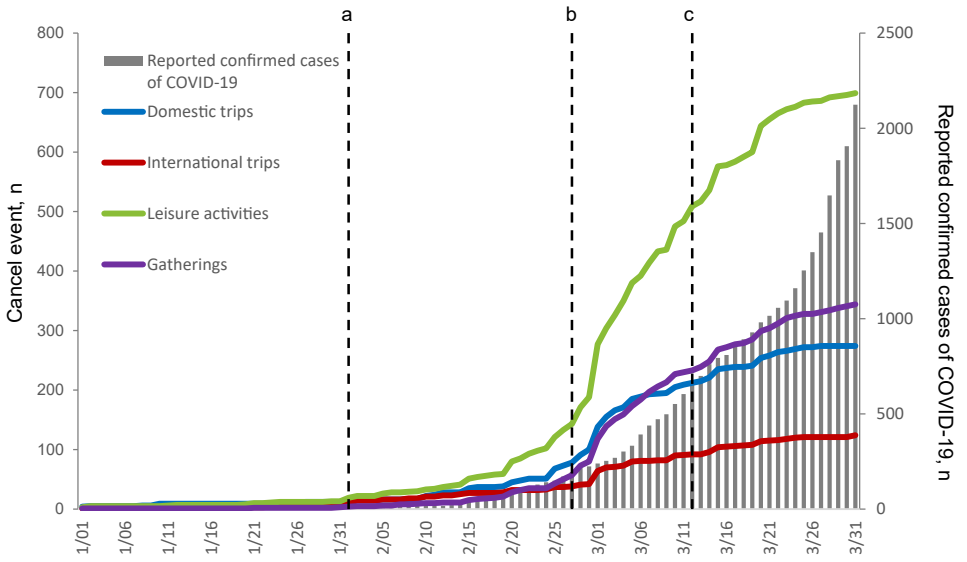

Fig. 2. Cumulative numbers of cancellations or postponements of each booking group and reported confirmed COVID-19 cases. The dashed lines 'a' is the day of announcement of Public Health Emergency of International Concern by the World Health Organisation (WHO), 'b' is the time of the Japanese government announcement about school closures (February 27, 2020), and 'c' is the day of announcement about COVID-19 outbreak as a pandemic by the WHO (March 12, 2020). COVID-19, coronavirus disease 2019.

Table 3
Numbers and incidence rate ratios (IRRs) of reported confirmed cases of COVID-19 in Japan and cancellations or postponements of four booking categories in four time periods in the time-series analysis.

	Total events, n	Period 1 (January 1–31 [31 days])			Period 2 (February 1–26 [26 days])		Period 3 (February 27–March 11 [14 days])			Period 4 (March 12–31 [20 days])		
		n (%)	IRR	95% CI	n (%)	IRR	n (%)	IRR	95% CI	n (%)	IRR	95% CI
Reported confirmed cases in Japan	2124	12 (0.6)	0.06	(0.04–0.11)	159 (7.5)	ref	433 (20.4)	5.06	(4.22–6.07)	1520 (71.6)	12.43	(10.55–14.63)
Cancellations/postponements												
Domestic trips	274	12 (4.4)	0.16	(0.09–0.31)	61 (22.3)	ref	136 (49.6)	4.14	(3.06–5.60)	65 (23.7)	1.39	(0.98–1.96)
International trip	124	7 (5.6)	0.20	(0.09–0.45)	30 (24.2)	ref	54 (43.5)	3.34	(2.14–5.22)	33 (26.6)	1.43	(0.87–2.34)
Leisure activities	699	13 (1.9)	0.09	(0.05–0.16)	120 (17.2)	ref	351 (50.2)	5.43	(4.42–6.68)	215 (30.8)	2.33	(1.86–2.91)
Gatherings	344	3 (0.9)	0.05	(0.02–0.17)	47 (13.7)	ref	180 (52.3)	7.11	(5.16–9.81)	114 (33.1)	3.15	(2.24–4.43)

CI, confidence interval; COVID-19, coronavirus disease 2019.

periods and city sizes, the IRRs for international trips were higher for individuals living in large-sized cities than the IRRs for those in small-sized cities in period 3 (PI = 0.03). The IRRs for leisure-related bookings were lower in respondents from middle-sized cities than IRRs for those in small-sized cities in Period 3 (PI = 0.03) and period 4 (PI = 0.09). It was noted that the initial IRRs of cancellations/postponements in period 2 differed across age groups and city sizes. In period 2, the IRRs for cancellations/postponements in all four booking categories were lower for the young group (15–39 years) than other age groups. In terms of city sizes, in period 2, the IRRs for domestic and international trips were lower for individuals residing in middle-sized cities, the IRRs for leisure-related bookings were lower for those in small-sized cities, and IRRs for gatherings were lower for respondents in large-sized cities. The results of interaction and stratified analysis by other individual variables are shown in Supplementary Fig. 2. Different IRRs for cancellations/postponements of some bookings were observed with respect to certain characteristics, particularly household income.

Fig. 4 shows the percentages of triggers for changes in bookings. During the survey, about half of the respondents reported that recommendations from government were a trigger for changing their bookings (answered as agree/fully agree, 47%); however, approximately one-quarter of respondents did not agree that recommendations from the government were trigger for changing their bookings.

Discussion

This study revealed differences in voluntary behavioural changes (cancellations/postponements of bookings) across individual characteristics and between four key time periods in the early stages of the COVID-19 outbreak in Japan. During the early stages, even though no enforcement of physical distancing measures were implemented, 72% of respondents voluntarily changed their behaviour at least once. The announcement of school closures by the government was a key trigger for the initiative of behavioural changes across all age groups.

The observed high percentage (72%) of cancellations/postponements is roughly consistent with the observations of two recent studies: a cross-sectional survey conducted on 11,324 Japanese individuals at the end of March reported that 85% of respondents maintained physical distance,[13] and a two-wave panel survey (wave 1, end of February; wave 2, beginning of April)

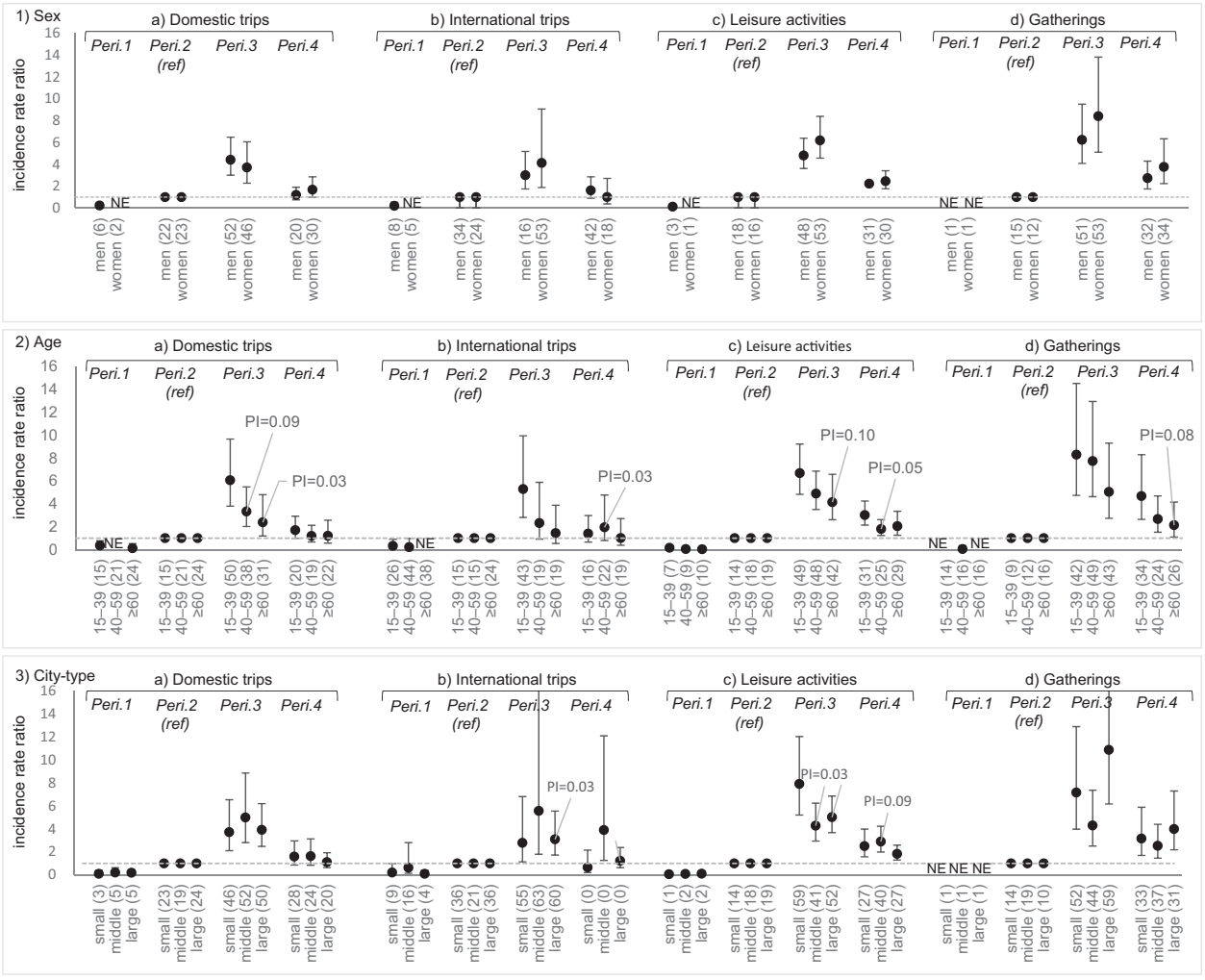

Fig. 3. Incidence rate ratios (IRRs) of cancellations or postponements in each booking group stratified by sex (1), age (2) and city size (3). The numbers in the parentheses are the percentage of those in each period. Cancellations or postponements in period 2 were referenced for the analysis. Vertical bars represent 95% confidence intervals. Period 1 is from January 1–31, 2020, period 2 is from February 1–26, period 3 is from February 27 to March 6 and period 4 is from March 7–31. PI is a *P*-value for interactions between time period and individual characteristics (sex, age city size). The reference groups for interaction analysis were men, age 15–39 years and small city size. NE, not evaluated.

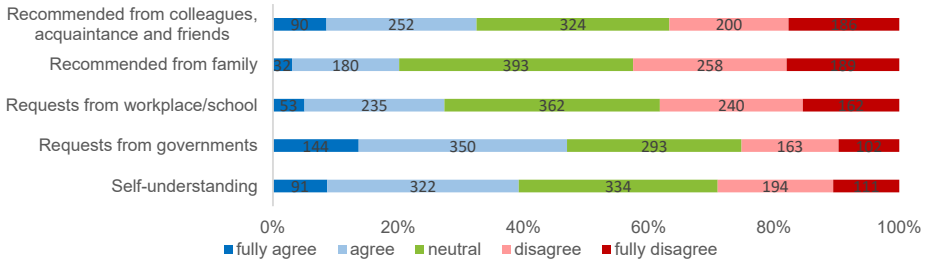

Fig. 4. Number and percentage of possible triggers for changing behaviour (respondents n = 1052).

investigating the implementation status of five recommended measures by WHO in Japan showed that 67.4–82.2% of respondents maintained physical distance.[14] In contrast to these two studies, the current investigation focused on the cancellation/postponement of bookings. Although it is unclear whether the proportion of cancellations/postponements determined in this study (72%) is sufficient to prevent virus transmission, this finding has provided evidence of the basic behavioural characteristics of individuals who will voluntarily prepare for the expected new wave of the pandemic. Many countries have implemented extreme restrictions, which may not be sustainable for a long period because of the resulting detrimental effects on human lives, society and the economy.[15,16] To respond to intermittently occurring outbreaks of COVID-19 in a sustainable manner, human behavioural changes are crucial.[7,8] Although there are differences in cultural and social backgrounds across countries, the results of this study are

important. Cross-country learning is essential to better prepare for future pandemics.

Furthermore, this study has revealed temporal changes in behaviour, which sharply increased after the announcement of school closures by the Japanese government. The declaration of school closures did not directly restrict activities for all Japanese individuals; however, the announcement was an important trigger for initiating behavioural changes against the spread of COVID-19. A previous study reported that risk perception impacts individual preventive behaviour, but paradoxically, the risk perceived by individuals was not necessarily correlated with the actual risk.[8] One international comparison study further showed that belief in the efficacy of health behaviours was related to the COVID-19 voluntary compliance behaviours, but perceiving oneself as vulnerable and the perceived severity of catching COVID-19 was of little importance.[17] In the present study, the incidence of increasing behavioural changes started earlier than the increasing number of confirmed COVID-19 cases (Fig. 2). Moreover, another study, in which the effects of non-pharmaceutical interventions were evaluated across 131 countries, reported that school closures were associated with reduced time-varying reproduction number (R) of SARS-CoV-2.[18] In contrast, this study has clarified a different role of school closure (the first national-level countermeasure for COVID-19 in Japan) in encouraging voluntary behavioural changes in a certain proportion of the population. In other words, school closures might be a key trigger for voluntary behavioural changes in a variety of activities planned at the early stages of the pandemic.

Several studies have been conducted on the basis of online surveys to monitor perception and psychological responses during or after the COVID-19 outbreak. For instance, compliance and mental health were measured in Italy,[19] knowledge and perceptions were monitored in the US and UK,[20] and psychological responses, behavioural changes and public perceptions were evaluated in Wuhan and Shanghai, China.[21] Because these countries/cities implemented a forced lockdown in the early stages of the outbreak, the evidence, in which the real voluntary behavioural changes are measured in the early stages, is insufficient. Some international comparisons were made with respect to physical distancing, washing hands and wearing face masks.[22] Because behavioural changes may not be the same across countries, further extensive intercountry comparisons should be conducted. In addition, in Germany, a weekly COVID-19 Snapshot MOnitoring system, named COSMO has been implemented. This system has been routinely measuring public perceptions of risks, protective and preparedness behaviours, and public trust.[23] It is worth establishing a similar continuous monitoring system to capture behavioural changes.

In this study, elderly and middle-aged individuals were more likely to cancel or postpone their bookings than younger individuals, particularly for leisure-related bookings and gatherings. This finding is consistent with a previous study in Japan, which reported that younger individuals (age <30 years) were reluctant to implement proper prevention measures.[13] In the present study, such behavioural changes across age groups were also observed in period 2 (as the reference time period [i.e. before the announcement of school closures]): the percentage of young individuals cancelling or postponing their leisure-related bookings was 14%, which was lower than that of the elderly group (19%) (Fig. 3). However, after the announcement of school closures (period 3), young individuals increased their cancellations/postponements (49%) more than the elderly group (42%). Thus, young individuals perceived the infection risks later than the elderly population, and an intensive alert/messaging campaign aimed at younger individuals would be important during the early stages of an outbreak. Regarding other characteristics, such as residential city size, educational level, occupation, household income and living with an elderly person, significant differences were identified for cancellations/postponements; although there was no clear tendency, time lags for behavioural changes existed across these individual characteristics. No significant differences in behavioural changes were observed between men and women, although women were more likely to make behavioural changes than men (Table 2). A study in the US reported that women adhere more to preventive health practices, such as social distancing and handwashing, than men in the spread of coronavirus.[24] This tendency was also reported in another study.[17] Further investigations are recommended to identify specific determinants of behavioural changes.

This study has several limitations. First, although the respondents were selected by matching the distributions of age, sex and residential regions with those of the whole population, some respondents may not answer the questionnaire for various reasons, such as being unwilling to provide their personal information or having no time to answer the survey. As a result, selection bias may exist in this study, and the estimated cancellation rate may be potentially higher than in real situations. However, we compared the IRR between the time before and after school closures; thus, the effects of such selection bias were minimised, particularly in our time-series analysis. Second, this study relied on human memory to recall behavioural changes (i.e. booking types and dates). Human memory may involve recall bias, even though retrospective surveys have been widely applied.[10] Using a buffer period (minimum: 14 days) for assessing each public announcement in the time-series analysis has weakened such bias of recalling the dates; however, the bias is not zero. Further studies are required on the basis of the panel approach to robustly and quantitatively evaluate the continuous trend of behavioural changes by reflecting dynamic behavioural decision-making mechanisms. Lastly, extensive intercountry comparisons should be conducted to derive more scientifically sound evidence for supporting policy decisions against the current and future pandemics.

Conclusions

This study was an initial attempt to reveal voluntary behavioural changes at the early stages of the COVID-19 outbreak in Japan, emphasising that the observed behavioural changes occurred without any forced physical distancing measures, which could be applicable globally. The government announcement of school closures was identified as a key trigger for behavioural changes in Japan. These temporal trends should be continuously monitored and updated to help governments implement cost-effective and effect-maximising policy measures.

Author statements

Ethical approval

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Competing interests

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2021.01.002.

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