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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Behavioural responses and anxiety symptoms during the coronavirus disease 2019 (COVID-19) pandemic in Japan: A large scale cross-sectional study

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ABSTRACT

Background: This study explored the behavioural responses and anxiety symptoms of the general adult population in Japan during the ongoing coronavirus disease 2019 (COVID-19) outbreak.
Methods: A web-based cross-sectional survey was conducted between 12th and May 13, 2020. Quota sampling was used to attain equal gender and age distributions representative of the Japanese population.
Results: A total of 4127 complete responses were analysed. Higher educational level (B = 0.045, $p = 0.002$) and household income (B = 0.04, $p = 0.009$) were associated with a higher increase in preventive measures when comparing before and after the state of emergency was declared. The highest reported social anxiety was a feeling of fear (65.6%), followed by embarrassment (43.8%), keeping infection a secret (41.3%), avoidance (41.3%), and stigma (25.5%). A total of 86.1% of the respondents reported moderate to severe anxiety. The partial least square-based structural equation modelling (PLS-SEM) revealed that being female has the greatest effect (B = 0.246, $p < 0.0001$) on higher current preventive measures, followed by social anxiety (B = 0.119; $p = 0.001$) and State-Trait Anxiety Inventory scores (B = 0.153; $p < 0.001$). Perceived susceptibility (B = 0.033, $p = 0.020$), knowing someone who have been diagnosed with COVID-19 (B = 0.097, $p < 0.001$), higher income (B = 0.079, $p < 0.001$) and educational level (B = 0.045; $p = 0.004$) all had a small but significant effect on influencing levels of preventive measures.
Conclusions: A moderate level of preventive practices found in this study indicates the need to encourage behavioural change to limit the spread of the coronavirus. The provision of mental health services is warranted as anxiety symptoms are prevalent.

1. Introduction

In late December of 2019, an epidemic now known as coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), broke out in Wuhan, Hubei Province, China, and has resulted in an epidemic throughout China (Chan

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et al., 2020; Wang et al., 2020). The new coronavirus rapidly spread across many countries neighbouring China in Asia, including Japan, which was the second country to report a confirmed coronavirus case outside mainland China. The first coronavirus case in Japan was reported on January 16, 2020. By mid-March 2020, Japan had the third-highest number of coronavirus cases in the world outside of China (WHO, 2020a), with the majority of them being linked to the Diamond Princess Cruise ship. On April 7, 2020, the country declared a one-month state of emergency for Tokyo and six other prefectures. By April 13, over two thousand COVID-19 confirmed cases and 42 deaths have been identified in Tokyo (Yoneoka et al., 2020). On April 16 the declaration was extended and the *Government* of *Japan* declared a nationwide state of *emergency*, which was subsequently lifted on May 25, 2020. During the nationwide state of emergency, movement across prefectural borders was prohibited. Along with the declaration of the nationwide state of emergency, implementation including closure of public places, avoid mass gathering, and other basic counter-infection measures such as keeping a distance, wearing a mask, and frequent hand washing were encouraged. In Japan, a forced lockdown is not possible by law. Further, there are no penalties for non-compliance. Therefore, people's behavior and obedience are extremely important for the flattening of the COVID-19 curve (Tashiro and Shaw, 2020) and warrant investigation.

The COVID-19 pandemic not only resulted in high mortality and morbidity, it also poses a serious psychological threat and has also resulted in numerous behavioural changes. The emergence of infectious diseases such as SARS (severe acute respiratory syndrome) (Vijaya et al., 2005), MERS (Middle East respiratory syndrome) (Jang et al., 2019), the Ebola virus (Jalloh et al., 2018), and the 2009 influenza A (H1N1) **epidemic (Rubin et al., 2009)** have shown that monitoring the psychological and behavioural responses of the public has vital importance in controlling outbreaks. In addition, understanding psychological and behavioural responses of the public during infectious disease outbreaks is important for addressing the well-being of the lay public and providing insights into the development of health promotional messages (Abraham, 2009).

It was noted that over the past few decades, Japan has not experienced any serious damage from new infectious diseases, such as the 2009 H1N1 influenza (flu) pandemic, SARS, MERS, or the Ebola outbreak (Muto et al., 2020). A recent study in Japan conducted in late March 2020, just before the *Government* of *Japan* declared a state of *emergency* in relation to coronavirus *identified prompt* behavioural changes, including social distancing, hand washing, and coughing etiquette among the public, as well as some gaps in preventive action (Muto et al., 2020). Subsequently, little has been reported regarding the prevention behaviour of the Japanese public throughout the COVID-19 epidemic. As the coronavirus emergency in Japan is rapidly evolving, continuous assessment and monitoring of infection prevention measures are warranted to help to improve control measures in the population. Examining public responses to the evolving COVID-19 pandemic is important to understand public confidence in their ability to adopt or sustain recommended measures (Seale et al., 2020).

Although this is not the first time that the public in Japan has experienced in infectious disease outbreak, the current COVID-19 pandemic has taken a heavy toll on the mental health of most people in Japan (Shigemura et al., 2020). A*nxiety* surrounding a pandemic could result in detrimental functional disruptions on social and individual levels, and may also exacerbate poor health (Stangl et al., 2019). In European countries such as Spain (Rodriguez-Rey et al., 2020) and Italy (Mencacci and Salvi, 2020), the United States (Jacobson et al., 2020), and Australia (Stanton et al., 2020), social distancing and lockdown restrictions resulted in an increased incidence of anxiety symptoms during the COVID-19 pandemic. In a recent systematic review of evidence of global research works and findings in relation to the prevalence of stress and anxiety during the COVID-19 pandemic, empirical evidence from the Japanese population is unavailable (Salari et al., 2020). The lack of evidence from Japan warrants proper assessment of anxiety symptoms among the Japanese population.

Despite numerous studies having reported findings on COVID-19-related anxiety and behavioural responses, study liking the role of anxiety on preventive behaviours is lacking. It is hypothesized that a certain level of anxiety may enhance prevention behaviour during infectious disease outbreaks (Lau et al.,2003; Leung et al., 2004, 2005; Rubin et al., 2009). One of the first studies linking anxiety and preventive behaviour during the COVID-19 pandemic was conducted in Taiwan, where a higher anxiety was associated with higher uptake of prevention measures against COVID-19 (Wong et al., 2020a). Nonetheless, a study in China reported that public anxiety during the COVID-19 outbreak did not influence preventive behavioural change (Liu et al., 2020). More conclusive findings are warranted to understand the association between anxiety and preventive behaviours during the COVID-19. Such information is highly desired to facilitate public health psychobehavioural intervention on *COVID-19* best *practices*.

The purpose of this study, therefore, was to provide an overview of behavioural responses and anxiety symptoms among the general public in Japan during the COVID-19 pandemic. This study also explored behavioural changes related to the COVID-19 pandemic, whereby differences in preventive measures before the *Government* of *Japan* declared a state of *emergency were compared with the preventive measures during the survey period. Further we also explore the potential predictor of change.* As Japan's emergency law is unique and different from that of many other countries where the law does not allow the national or local government to enforce lockdowns (Tashiro and Shaw, 2020), investigation emphasising behavioural change in preventive measures would be helpful to provide better insight to address gaps in sustainable preventive measures. *Thirdly, this study* investigated the influence of anxiety symptoms on prevention practices. Partial least squares (*PLS*) regression was used for model and hypothesis testing.

2. Methods

2.1. Study participants and survey design

We conducted a large cross-sectional web-based survey using online questionnaire between 12 and 13 May 2020. Large sample size survey may provide more accurate mean values especially the current study acquired retrospective measurement of preventive measures before the *Government* of *Japan* declared a state of *emergency*. A commercial survey company, Cross Marketing Inc. Japan, was tasked with carrying out the survey. The survey link was sent to a pool of approximately 2 million registered individuals residing in Japan. *Quota sampling* was used to attain equal gender and *age* distributions representative of the Japanese population, based on statistics from the Labor Force Survey, Ministry of Internal Affairs and Communications. Monetary incentive was given upon completion of the survey.

2.2. Ethical considerations

This study was approved by the Research Ethics Committee of Nagasaki Prefectural Institute of Environment and Public Health (No. 2020-6-1). The survey participants were informed of the purpose of the study prior to their participation and had the option to withdraw from the survey at any time. The participants were informed that their participation was voluntary, and informed consent was obtained using an online consent form that the participant had to actively agree to. This method of consent was approved by the ethics committee. The data are completely anonymous.

2.3. Instruments

The survey consisted of questions that assessed 1) demographic background, perceived susceptibility to COVID-19, and COVID-19 experience/knowing someone who has been diagnosed with COVID-

19; 2) preventive measures against COVID-19; 3) social anxiety related to COVID-19; and 4) the State-Trait Anxiety Inventory (STAI-6). The questionnaire was adopted and modified from previous studies (Wong et al., 2020a, 2020c; Wong and Alias, 2020b).

The question of perceived susceptibility questioned participants about their likelihood of being infected with SARS-CoV-2, with the response options "not at all", "not high", "high" and "very high". The question about preventive measures consisted of five sections (11 items), namely personal protection (3 items), cough etiquette (4 items), contact precautions (2 items), voluntary quarantine (1 item), and prompt reporting (1 item). The response options were on a four-point Likert scale, with the items scored as 1 (not at all), 2 (rarely), 3 (sometimes) or 4 (all the time). The possible total prevention score ranged from 11 to 44, with higher scores representing higher levels of preventive practices. Participants were asked to rate their current preventive practices (preventive measures during the survey period) and to recall their preventive practices carried out before the *coronavirus emergency declaration on the* 16th *April 2020*.

The social anxiety section consisted of questions about feelings of fear, avoidance, keeping a secret, embarrassment, depression and stigma associated with the COVID-19 outbreak (5 items). The items in the social anxiety section were self-developed. Answer options were on a four-point Likert scale, with the items scored as 1 (strongly disagree), 2 (disagree), 3 (agree) or 4 (strongly agree). The possible total negative emotion scores ranged from 5 to 20, with higher scores representing higher levels of negative emotions.

Anxiety was measured using the six-item state version of the State-Trait Anxiety Inventory (STAI-6) (Marteau and Bekker, 1992; Hou et al., 2015). The respondents rated the frequency of experiencing six emotional states, namely being calm, tense, upset, relaxed, content and worried, concerning the current COVID-19 outbreak. A four-point scale was used (1 = not at all, 2 = somewhat, 3 = moderately, 4 = very much). The scores on the three positively worded items were reverse-coded. The total summed scores were prorated (multiplied by 20/6) to obtain scores that were comparable with those from the full 20-item STAI (giving a range from 20 to 80) (Marteau and Bekker, 1992). Scores of 44 or above were defined as indicating moderate to severe symptoms (Knight et al., 1983; Leung et al., 2005).

3. Statistical analyses

Means and standard deviation were calculated for preventive measures, social anxiety and STAI scores. Independent paired *t*-test was performed to test demographic differences in preventive measures, social anxiety and STAI scores. Effect sizes were calculated using Cohen's *d*. Cohen's d effect size (small d = 0.2, medium d = 0.5, and large d = 0.8 effect sizes) were used to assess the significant effects.

3.1. Structured equation modelling

Structural equation modelling (SEM) is a multivariate statistical analysis technique used to define causal relationships. Partial least squares structural equation modelling (PLS-SEM) is the preferred SEM method when the research objective is prediction. It can model multiple independent variables and handle multicollinearity among the variables. PLS-SEM was selected in this study because it could handle both formative and reflective indicators for latent variables; secondly, it requires minimum measurement scales; thirdly, it is capable of handling data that is not normally distributed.

PLS-SEM was used to quantify 1) the demographic disparities in differences in preventive measures, comparing current measures and those before the state of emergency was declared and 2) the contributing factors (socio-demographics, COVID-19 experience, perceived susceptibility, social anxiety, and STAI) of current preventive measures. A bootstrapping approach was used to evaluate the significance of associations in the proposed models. This technique assesses the reliability of the dataset and the statistical significance of the coefficients and the error of the estimated path coefficients (Chin, 1998). The bootstrapped significance calculation was performed in SmartPLS software version 3.2.8 (SmartPLS GmbH) (Ringle et al., 2015). In the models, preventive measures and social anxiety were multi-item measures and all other independent variables were single item constructs. The preventive measures and social anxiety were considered formative constructs. In testing measurement model, the relationships between formative constructs and indicator variables (outer weight) were tested. *Variance Inflation Factors* (*VIFs*) was used to detect collinearity among *predictors in the least squares regression model. The discriminant validity was evaluated using the heterotrait–monotrait* (HTMT) *ratio.*

4. Results

A total of 4134 responses were received; after data cleaning, 4127 complete responses were analysed in this study. Fig. 1 shows the trend of the number of daily new cases in Japan from the beginning of the COVID-19 outbreak, the date of the declaration of the state of coronavirus emergency in Japan and the survey period. A summary of the characteristics of the respondents is provided in the first and second columns of Table 1. As shown in the first and second column of Table 1, there was a fairly equal distribution of male (49.5%) and female (50.5%) respondents. A slightly higher proportion of participants were of age 41–50 years (23.9%) and 61–70 years (20.5%). The lowest responses were received from participants of age 20–30 years (16.4%). The great majority had a university degree (46.6%) and an annual household income of 4,000,001–8,000,000 Japanese Yen. Most of the respondents were from Eastern (36.7%) followed by Western (34.3%) regions. A total of 29.1% reported knowing someone infected with SARS-CoV-2 and the majority (70.9%) responded "not at all/not high" in perceived susceptibility to getting infected with SARS-CoV-2.

4.1. Preventive measures

Fig. 2 shows the proportion of "all the time" responses in preventive measures against SARS-CoV-2 infection during the time of the survey and before the state of coronavirus *emergency*. The mean total and standard deviation (SD) for the current total preventive measures score was 24.63 (SD ± 6.29). The median was 25 (interquartile range [IQR], 21 to 29). The third column of Table 1 showed demographic disparities in the mean total preventive measures scores. Mean total preventive measures were significantly higher in females than in males. The youngest age group, 20–30 years, reported the highest total preventive measures scores. An increase in the total preventive measures score was seen as the annual household income increased.

All the scores for preventive measures against SARS-CoV-2 infection before the state of emergency were reported to be lower than the current preventive measures. The highest increases in preventive measures between the period before the state of emergency and the current preventive measures were seen for wearing masks, avoiding group gatherings and avoiding proximity. The mean (SD) total preventive measures score before the state of emergency was 21.27 (SD ± 7.54), while the median was 22 (interquartile range [IQR], 16–27). There is a significant increase in the overall mean total preventive scores comparing before and after the state of emergency (Cohen's d: 0.48, mean difference = 3.3, 95% CI 1.42–2.21, $p < 0.001$). The differences in total prevention practice score between current practice and those before the state of emergency by demographics are shown in the fifth column of Table 1. Males reported a higher increase in prevention practices compared to females. Participants of younger age, higher educational level and higher income reported a higher increase in preventive practices. Fig. 3 shows the results of the bootstrapping method for demographic disparities on changes in preventive measures. Of all of the demographic characteristics, educational level (B = 0.045, p = 0.002) and household income (B = 0.04, $p = 0.01$) had a significant and

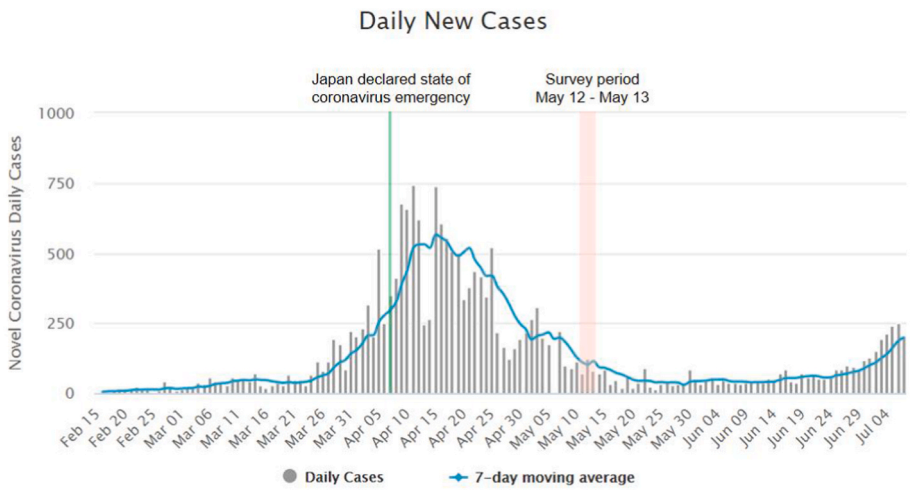


Fig. 1. Data collection period of the study and the trend of confirmed cases of COVID-19 in Japan.

positive influence on the increase in preventive measures comparing before the state of emergency was declared to the current situation.

4.2. Social anxiety

Fig. 4 shows the responses to the level of agreement concerning social anxiety related to SARS-CoV-2 infection. The highest reported "agree/strongly agree" responses were feelings of fear (65.6%), followed by embarrassment (43.8%), keeping a secret (41.3%), avoidance (41.3%), and stigma (25.5%). The mean (SD) for the social anxiety scores for the overall sample was 11.8 (SD ± 3.3), and the median was 12 (IQR 10–14). As shown in the sixth column of Table 1, the mean total social anxiety scores showed small differences across all demographic characteristics, except age groups. The age group 61–70 years showed the lowest mean total social stigma score (11.08, 95%CI 10.88–11.27), whereas a higher total score was reported among the youngest age group 20–30 years old (12.32; 95% CI 12.07–12.57).

4.3. The State-Trait Anxiety Inventory (STAI)

Using a cut-off score of 44 for the STAI score, a total of 86.1% (n = 3553) (95% CI 85.0–87.1) of the respondents reported moderate to severe anxiety. The mean STAI scores were significantly higher in females (60.47; 95%CI 59.92–61.02) than in males (56.68; 95%CI 56.13–57.22), and highest in participants with a junior college or vocational school education. There is a significant gradual increase in STAI scores as age increases. Inverse association between STAI scores and income was observed (Table 1, right column).

4.4. Association between anxiety and preventive measures based on PLS-SEM

Results of the measurement model indicated that for the preventive measure construct (with 11 indicators), all indicators had a significant outer weight. Nevertheless, in the social anxiety construct (with five indicators), one of the indicators (embarrassment) was excluded due to non-significant outer weight. The VIFs for all indicators were below 2.5, indicating that all indicators belonged to these two constructs were adequately independent. Discriminant validity assessment through HTMT ratio of correlations method also indicated that all HTMT values *were lower than* the most restrictive *threshold* (*0.85*) proposed by Kline (2011) (Kline, 2011), thus *indicating* adequate *discriminant validity*.

The PLS-SEM in Fig. 5 shows the hypothesized associations between the demographics, COVID-19 experience, perceived susceptibility, social anxiety, STAI scores, and current preventive measures against SARS-CoV-2. All structural model paths were statistically significant except age. Of all the factors, gender (being female) has the greatest effect (B = 0.246, $p < 0.0001$) on higher preventive measures during the survey period. Other significant demographics influencing preventive measures include higher income (B = 0.079, $p < 0.001$) and educational level (B = 0.045; $p = 0.004$). The model also showed that perceived susceptibility (B = 0.033, $p = 0.020$) and COVID-19 experience (B = 0.097; $p < 0.001$) influence preventive measures. As hypothesized, social anxiety (B = 0.119; $p = 0.001$) and STAI (B = 0.153; $p < 0.001$) have a strong positive effect on higher preventive measures. Results for adjusted R^2 indicated this model explained 14.3% of the total variance in intention vaccination (data not shown).

5. Discussion

This study investigated the changes to preventive behaviour of the public and psychological impact during the on-going COVID-19 pandemic in Japan on the 12 and 13th May 2020, during the period when the *Government* of *Japan* declared the coronavirus state of emergency. The study provides important and timely information for health authorities, enabling them to continuously curb the current COVID-19 pandemic in Japan.

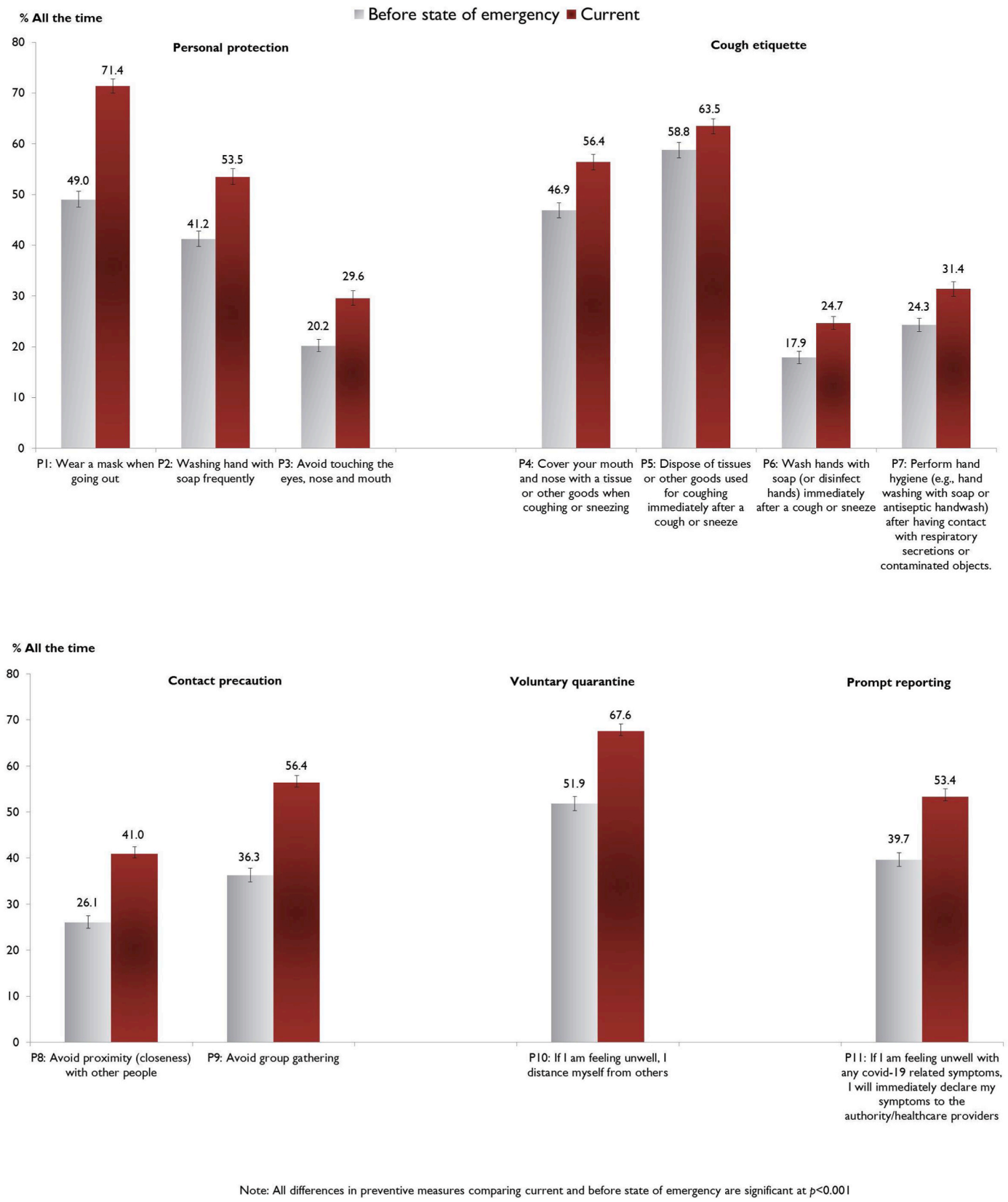
During the state of emergency in Japan, the people were instructed to stay at home except when carrying out important tasks such as purchasing food and daily supplies, or seeking medical care. Schools were closed, instructions from the authorities were released urging the cancellation of large sporting and cultural events, and people were warned to avoid crowds in enclosed and unventilated spaces. Of all of the preventive measures investigated in this study, the highest proportion reported wearing masks during the survey period. In Japan, mask-wearing was a cultural norm, even before the coronavirus outbreak. The culture of mask-wearing has long become a fashion statement, especially among young people in Japan, which may contribute to not many reporting difficulties with practicing wearing mask. Nonetheless, findings show the need to improve cough etiquette, contact precaution, voluntary quarantine and prompt reporting among the general public. Such practices were reported even lower before the government announces the state of emergency. One possible factor contributing to gaps in preventive measures found in this study could be that the public health measures implemented by the government to mitigate coronavirus do not come with *penalties* for non-compliance. This is in contrast to other Asia countries such as China (Zhong et al., 2020) and Malaysia (Azlan et al., 2020; Wong et al., 2020b), and in European countries (Bellato, 2020; Usleghi and Liedholm, 2020) where non-compliance resulted in fines and imprisonment; hence, higher preventive measures

Table 1
Prevention practices, social anxiety and STAI scores by demographic characteristics (N = 4127).

Demographics	N (%)	Total current preventive measures scores	Total preventive measures score before emergency declaration	Differences in preventive measures scores (Current-before emergency declaration)		Total social anxiety scores	STAI scores
		Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Cohen *d* (95% CI)	Mean (95% CI)	Mean (95% CI)
Gender							
Male	2043 (49.5)	23.00 (22.71–23.28)	19.47 (19.14–19.81)	3.53 (3.26–3.80)	0.49 (−1.11-1.93)	11.67 (11.53–11.81)	56.68 (56.13–57.22)
Female	2084 (50.5)	26.23 (26.00–26.47)	23.05 (22.75–23.35)	3.18 (2.94–3.43)	0.51 (−1.09-1.95)	11.93 (11.79–12.06)	60.47 (59.92–61.02)
Age group (years)							
20-30	675 (16.4)	25.14 (24.66–25.63)	21.13 (20.54–21.73)	4.01 (3.52–4.49)	0.56 (−0.99-1.97)	12.32 (12.07–12.57)	57.12 (56.14–58.09)
31-40	800 (19.4)	24.18 (23.72–24.64)	20.86 (20.31–21.42)	3.32 (2.89–3.74)	0.45 (−1.18-1.93)	11.93 (11.70–12.16)	58.01 (57.13–58.88)
41-50	985 (23.9)	24.50 (24.09–24.91)	21.33 (20.85–21.82)	3.17 (2.81–3.53)	0.46 (−1.17-1.91)	12.05 (11.84–12.26)	58.77 (57.98–59.57)
51-60	822 (19.9)	24.58 (24.16–25.00)	21.57 (21.09–22.06)	3.01 (2.61–3.39)	0.45 (−1.17-1.93)	11.69 (11.48–11.91)	59.70 (58.82–60.57)
61-70	845 (20.5)	24.87 (24.49–25.24)	21.44 (20.97–21.91)	3.43 (3.05–3.80)	0.56 (−1.00-1.95)	11.08 (10.88–11.27)	59.04 (58.19–59.90)
Highest educational level							
Senior high school and below	1232 (29.9)	24.10 (23.75–24.46)	21.25 (20.83–21.66)	2.86 (2.55–3.17)	0.18 (−1.65-1.94)	11.91 (11.73–12.09)	59.47 (58.76–60.19)
Junior college or vocational school	972 (23.6)	25.44 (25.06–25.82)	22.04 (21.58–22.50)	3.40 (3.03–3.77)	0.98 (−0.16-2.26)	11.87 (11.67–12.08)	60.04 (59.22–60.86)
University	1923 (46.6)	24.56 (24.28–24.85)	20.91 (20.57–21.26)	3.65 (3.38–3.92)	0.32 (−1.41-1.93)	11.70 (11.70–11.90)	57.30 (56.74–57.86)
Annual pre-tax household income (Yen)							
2,000,000 and below	671 (16.3)	23.93 (23.42–24.44)	21.28 (20.71–21.85)	2.65 (2.23–3.07)	0.37 (−1.32-1.92)	11.80 (11.54–12.06)	60.04 (59.06–61.02)
2,000,001–4,000,000	1126 (27.3)	24.47 (24.11–24.84)	21.34 (20.91–21.78)	3.13 (2.79–3.47)	0.46 (−1.16-1.93)	11.81 (11.62–12.00)	59.10 (58.36–59.85)
4,000,001–8,000,000	1590 (38.5)	24.71 (24.41–25.01)	21.02 (20.65–21.39)	3.69 (3.39–3.99)	0.54 (−1.03-1.95)	11.86 (11.71–12.01)	57.91 (57.30–58.52)
>8,000,000	740 (17.9)	25.34 (24.90–25.79)	21.74 (21.18–22.29)	3.61 (3.17–4.04)	0.52 (−1.07-1.95)	11.66 (11.42–11.91)	58.98 (57.03–58.93)
Region							
Northern	1051 (25.5)	24.49 (24.10–24.88)	21.27 (20.81–21.73)	3.22 (2.87–3.57)	0.46 (−1.17-1.93)	11.91 (11.71–12.11)	59.16 (58.39–59.93)
Eastern	1513 (36.7)	25.19 (24.88–25.50)	21.39 (21.01–21.78)	3.80 (3.49–4.11)	0.55 (−1.01-1.95)	11.54 (11.37–11.70)	58.36 (57.71–59.01)
Western	1417 (34.3)	24.14 (23.81–24.47)	21.10 (20.71–21.48)	3.05 (2.74–3.35)	0.44 (−1.20-1.92)	11.96 (11.79–12.13)	58.31 (57.64–58.97)
Central	146 (3.5)	24.65 (23.66–25.65)	21.95 (20.68–23.23)	2.70 (1.81–3.59)	0.39 (−1.30-1.93)	12.24 (11.72–12.76)	59.68 (57.83–61.53)

were reported among the public.

In our investigation, the mean total score for current preventive measures and those before the state of emergency was declared was 25 and 21, respectively, out of a maximum score of 44, indicating a moderate level of prevention behaviour among the study population. We found that behavioural change and preventive measures greatly increased when comparing those before the state of emergency; the most prominent increase was wearing a mask, avoiding group gatherings, and proximity. These correspond to wearing a protective mask, avoiding close proximity, and *stay*-at-*home* directives issued during the state of emergency. Of note, younger people and those of higher education and higher income levels reported a greater increase in preventive measures, implying the need to enhance behavioural change among the older age people and the lower socio-economic groups in Japan. *The higher*



Note: All differences in preventive measures comparing current and before state of emergency are significant at $p<0.001$

Fig. 2. Proportion of 'All the time' responses for behaviour change before and after the emergency announcement (N = 4127).

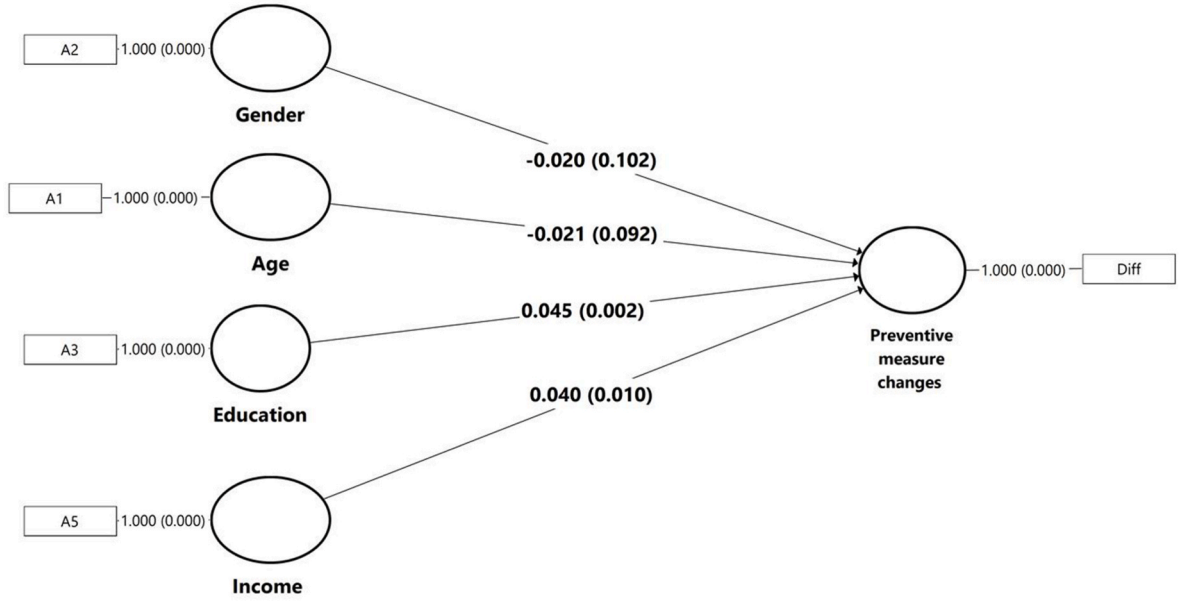


Fig. 3. The Partial Least Square-Structural Equation Modelling (PLS-SEM) model of demographic factors influence the increment in preventive measures against COVID-19.

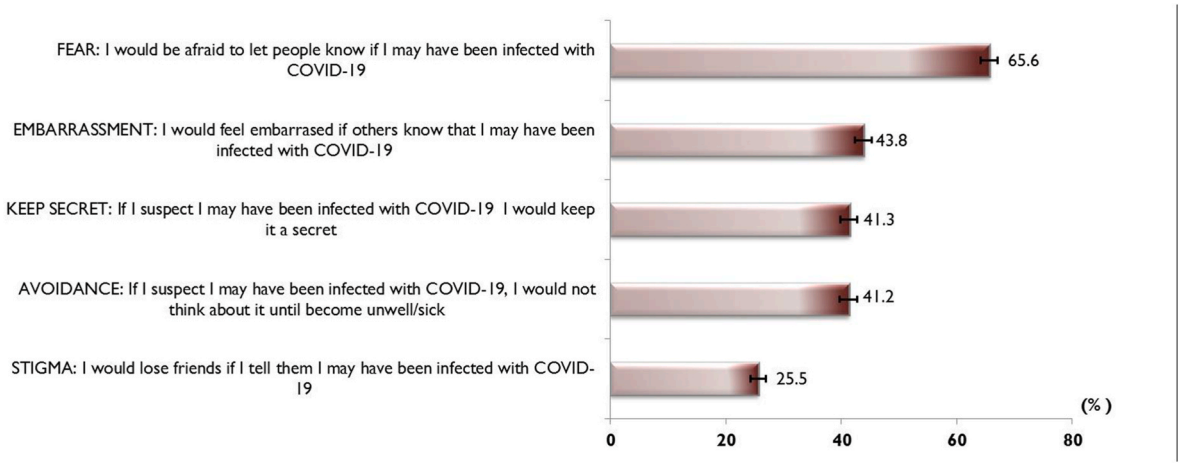


Fig. 4. Proportion of 'Agree/Strongly agree' for social anxiety (N = 4127).

preventive measures among younger people found in this study is in line with a recent study that reported young adults generally comply and receptive to *COVID-19* public health measures (Nivette et al., 2020). As studies showed that high knowledge of COVID-19 translates into good prevention practices (Li et al., 2020a; Mohammed et al., 2020), it is likely that young people are more knowledgeable as they are efficient in receiving correct information and translating the information into actions. Further, a study in the U.S. found that people with a college education and those with higher incomes were more knowledgeable about COVID-19 (Clements, 2020), this perhaps explains higher prevention practices among the higher socio-economic participants in this study. The demographic disparities in preventive practices changes found in this study provide important insights into recommendations for addressing the inequalities in prevention gaps across a range of socio-economic *backgrounds in Japan*.

This study provides empirical evidence of social anxiety, namely fear, embarrassment, keeping secrets, avoidance and the stigma associated with being infected with the coronavirus among the Japanese public. Prompt health-seeking behaviour is encouraged by the Japanese government throughout the pandemic. One of the most important containment measures in Japan during the peak of the pandemic was undertaking the *screening* of potential *COVID*-19 cases by focusing on potential and identified clusters. The public must have a positive mindset and be willing to undergo testing if they suspect that they have been associated with the identified infection cluster. Throughout the history of infectious disease outbreaks such as Ebola, SARS and MERS-CoV, there is mounting evidence of stigma and discrimination directed toward persons infected with or even perceived to be linked to the outbreak (Person et al., 2004; Farag et al., 2016; Kelly et al., 2019). Likewise, in the current COVID-19 pandemic, fear and stigma have been of major concern in China since the beginning of the outbreak in Wuhan (Ren et al., 2020). The consequences should not be undermined, a reluctance to get medical help or delayed reporting to hospitals were among the most serious implications, leading to serious negative health outcomes (Person et al., 2004; Kane et al., 2019; Kelly et al., 2019). Other possible deleterious impacts include a heightened reluctance to socialise again, denying individual or group social acceptance, and even fuelling social inequalities. Among some of the suggested public health emergency response efforts to reduce disease-related stigma during infectious disease outbreaks are monitoring misperceptions in the

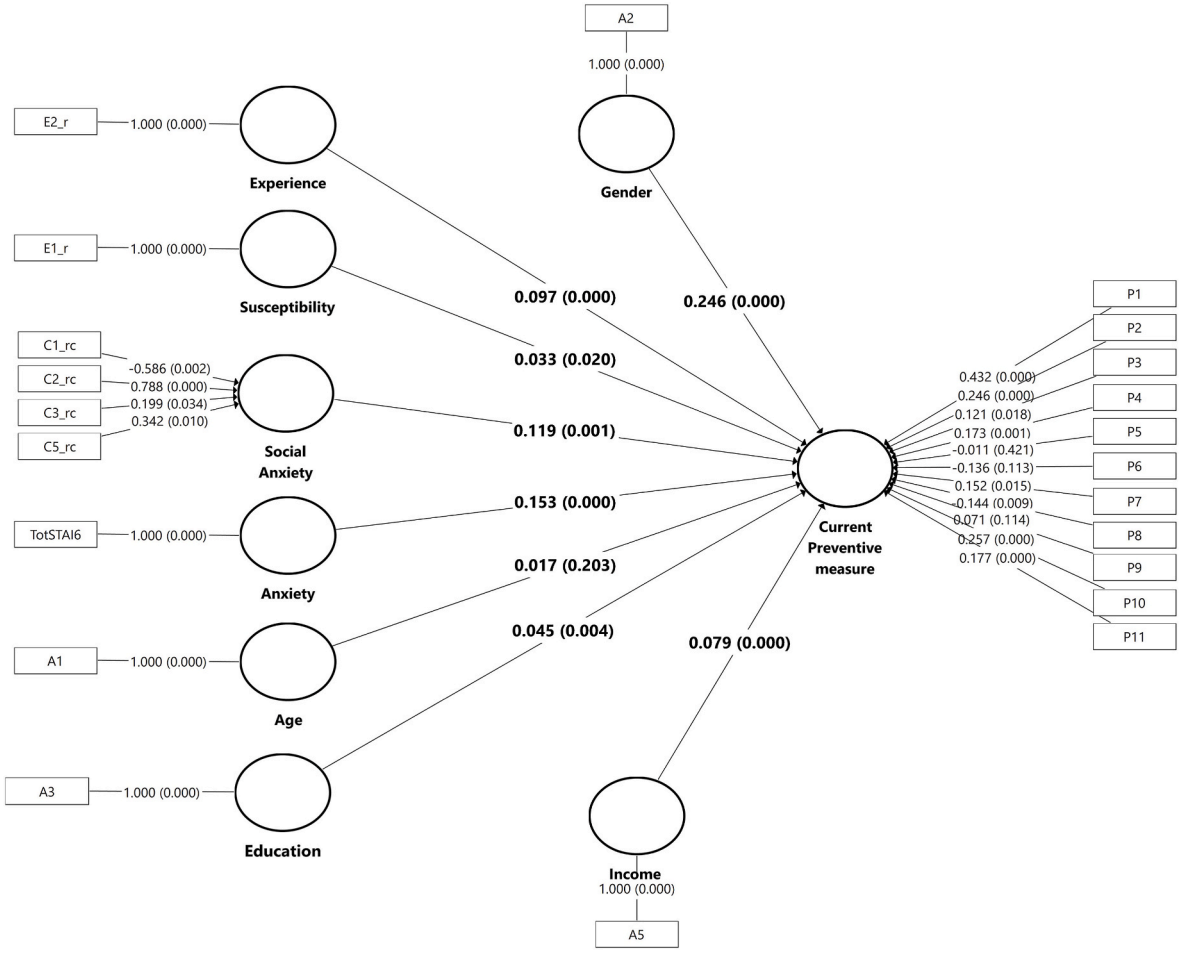


Fig. 5. Research Model Using PLS Path Modelling for Factors Influencing current preventive measures against COVID-19.

community regarding real risks, public messaging and community campaigns to fight stigma, as well as engagement with government and community leaders to counter stigmatisation (Fischer et al., 2019); these can be adapted and used to address stigma and negative attitudes in the current ongoing COVID-19 outbreak. Another important highlight of the finding was that younger participants expressed a higher level of social anxiety, implying that *tailoring interventions* for this *population* are necessary.

The finding that 86% of study participants reported moderate to severe anxiety during the study period shows the enormous mental health impact of the COVID-19 outbreak on the public in Japan. On the 13th May 2020, the total number of confirmed COVID-19 cases in Japan had reached over 15 thousand, including cruise-ship related cases, with over 600 fatalities (WHO, 2020b), which could be a reason for the high level of anxiety among the study participants. The proportion of moderate to severe levels of anxiety using the *STAI-6 questionnaire* among the Japanese sample in this study is higher than that reported in Iran (68.0%) during the COVID-19 pandemic (Wong et al., 2020c). Comparatively, Iran was more severely impacted with its total confirmed cases, amounting to over one hundred thousand, with over 6000 deaths as of 13th May 2020 (WHO, 2020c). Of note, a study in China reported 78.3% of individuals to have high anxiety levels (a score of 40 or higher) according to the State scale of the State-Trait Anxiety Inventory (*S-STAI*) and 76.7% high levels of Trait scale (T-STAI) (Lin et al., 2020). A study in Italy conducted between April and May 2020, with over 30,000 deaths during the study period, reported anxiety rates of 63% among the public (Prete et al., 2020).

In this study, *women* were found to be *more vulnerable* to *anxiety* than males, likewise found in the studies from China (Lin et al., 2020) and Italy (Prete et al., 2020), thereby implying the need for gender-specific psychological intervention. This greater psychological impact of disease outbreaks on females corresponds to numerous psychiatric epidemiology findings, namely, that women are significantly more likely than men to develop anxiety symptoms when exposed to traumatic events (McLean et al., 2011). As old age increases the risk of COVID-19-related infection and mortality (Li et al., 2020b), our survey also found that the proportion with moderate to severe *anxiety was* greater with *increasing age. It is interesting to note that* in contrast to social anxiety, the anxiety level assessed using STAI scores was higher among the older age groups. *We also found an inverse association between* income and *anxiety levels.* Various reports similarly noted that the lower-income public was more impacted by the coronavirus outbreak (Walker et al., 2020; Roberton et al., 2020). In Japan, lower-income households are mainly non-regular workers, and many were reported to have suffered income loss during the pandemic (The Japan Times, 2020), which contributed to higher economic stress, and the consequent higher levels of anxiety. The findings of the present study suggest the necessity to provide mental health support for lower-income households to tackle any psychological distress associated with the pandemic.

In this study, the *PLS-SEM modelling revealed that* anxiety levels followed by social anxiety have a strong effect on preventive measures during the survey period. The finding of this study is in accordance with a previous study which found that people reporting higher preventive behaviours during infectious disease outbreaks have higher levels of anxiety (Lau et al., 2003; Leung et al., 2005; Rubin et al., 2009). Our finding is also in accordance with the most recently published study conducted in Taiwan during the COVID-19 break (Wong et al., 2020a). As *anxiety* is a normal emotion that *causes* increased behavioural

responses, some anxiety is clearly warranted, especially if it pushes people to take precautions against contracting or spreading the novel coronavirus. However, considering that excessive anxiety could lead to psychological and mental distress and depression, it is important to monitor the community's psychobehavioural response throughout the pandemic. Support for mental and pscychosocial well-being services should be made available to provide help for people with excessive psychological distress.

The model also implies that people who reported knowing someone who has been diagnosed with COVID-19 and a high perceived susceptibility reported higher preventive measures, which could be due to a variety of reasons. The first of these is the perceived increased risk of contracting the disease because they may have been in contact with the infected person, while the second is witnessing the challenging *ordeal* that COVID-19 patients go through may encourage practicing prevention against the coronavirus. Being female and having higher education and household incomes were associated with higher preventive measures during the data collection period; this provides insight for targeted *interventions* on different *sociodemographic* groups.

The present study has several limitations that need *to be considered* when interpreting the findings. The first limitation concerns the nature of online surveys using social media as a method to reach out to the respondents, in which the representativeness of the population may be of concern. The second limitation pertains to the cross-sectional nature of the study, even *though we were able to identify* associations between social anxiety and anxiety levels *and* prevention measures. However, we could not infer cause *and* effect. Third, the responses were based on self-reporting and may be subject to self-reporting bias and a tendency to report socially desirable responses. More importantly, the responses on preventive measures before the state of emergency may be subjected to recall bias. Nevertheless, the use of large sample survey has the advantage of providing an accurate assessment. It is also important to note that, the social anxiety scale used in this study was self-developed. Despite having a good multicollinearity and discriminant validity, the scale should undergo reliability and validity assessment conducted in a larger and diverse sample of participants. Another potential bias of this study is the use of single-item indicators in PLS-SEM. Nevertheless, there has been a considerable debate over the use of single-indicator constructs, and a report indicated that single items perform as well as multi-item scales (Diamantopoulos, 2012; Petrescu, 2013). Despite the aforementioned limitations and the need to be cautious in the interpretation of the results of this study, the large sample size and the vast demographic features of study respondents *provide important insights into the* understanding of the behavioural responses and anxiety symptoms of the population of Japan during the COVID-19 epidemic.

7. Conclusion

The current study identified considerable gaps in preventive measures against COVID-19 that *serve as guidance to inform strategies and recommendations for achieving optimal preventive practice against SARS-CoV*-2 infection in Japan. The social anxiety fueled by the COVID-19 pandemic, namely fear, embarrassment, keeping infection a secret, avoidance and stigma, was clearly evident. Our findings also suggested that COVID-19 has substantially affected the mental health of the general public in Japan. The significant influence of social anxiety and anxiety levels on preventive measures suggest that governments' authorities should provide messages to promote a higher *sense* of how *serious* the pandemic is in order to enhance preventive measures and the importance of strictly adhering to the public health measures implemented by the government. The key policy implication of the present study is that the provision of *psychological* supports for people who are at a high risk of mental problems associated with the outbreak.

CRediT authorship contribution statement

Guoxi Cai: Investigation, Data curation, Writing - original draft, Writing - review & editing. **Yulan Lin:** Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Yixiao Lu:** Investigation, Resources, Validation, Writing - review & editing. **Fei He:** Investigation, Writing - review & editing. **Kouichi Morita:** Investigation, Resources, Validation, Writing - review & editing. **Taro Yamamoto:** Investigation, Resources, Validation, Writing - review & editing. **Kiyoshi Aoyagi:** Investigation, Resources, Validation, Writing - review & editing. **Toshitsugu Taguri:** Investigation, Resources, Validation, Writing - review & editing. **Zhijian Hu:** Investigation, Writing - review & editing. **Haridah Alias:** Formal analysis, Writing - review & editing. **Mahmoud Danaee:** Formal analysis, Writing - review & editing. **Li Ping Wong:** Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing.

Declaration of competing interest

None.

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